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Kharkiv, Ukraine • 20–21 May 2021

Editors • Dmytro Goncharenko and Viktor Sopov

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Preface: Proceedings of the 5th International Scientific and PracticalConference "Innovative Technology in Architecture and Design" (ITAD-2021)

V International Scientific and Practical Conference "Innovative Technologies in Architecture and Design" was held May 20-21, 2021, at the Kharkiv National University of Civil Engineering and Architecture. This conference has been held annually since 2017. 715 participants from 12 countries took part in the work of ITAD-2021.

Innovative technologies, constantly appearing in architecture and design, contribute to the improvement of the social and economic basis of consumers' lives. In this case, previously known technologies can be used, but in a new, innovative quality or technologies of today, a priori, they bear the meaning of innovation. Thus, there is a rethinking of the ways of interaction, communication, solution and implementation of project tasks in the practice of architects and designers. The thematic areas of the sections identified in the conference cover the issues of humanization of the architectural environment in the context of European integration, innovative approaches in the formation of modern architecture and design, renovation of the architectural environment and its objects in the context of modern trends, as well as aspects of urban and socialsystems that allow the most complete disclosure of the actual problems in application to innovativetechnologies in architecture and design.

All articles published in these proceedings have been critically selected and peer-reviewed by experts in the field. This reviewing process has reduced the number of articles (132 from 258 articles) but has raised the proceedings' quality.

Chief of Editor,

Dr. of Techn. Sci., Prof. Viktor Sopov

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Directions and Guidelines for the Development of Contemporary Architectural Science

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Abstract. The purpose of the study is to streamlining the picture of the development of modern architectural science in the confrontation between the Modern and Counter-Modern movements against the background of the polarization of Modernism and Postmodernism. To achieve this goal, we analyzed the stages of development using conceptual grids – functional, spatiotemporal, informational, and canonical. The reformist ideas of the CIAM and UIA congresses provoked changes in development and initiated the search for new vectors and landmarks. The analysis of these landmarks revealed the presence of separate branches other than modernism and postmodernism. New directions of architectural science (Ekistics, Arcology, and Critical Regionalism) were born on this basis. We have developed the principles of Urban Synergetics, which complemented this series. One of its methods allows to considering the general picture of the development of architectural science and art from the standpoint of cyclical self-organization. It is associated with the successive alternation of Romanticism, Modernism, Classicism, and Postmodernism. These areas developed according to the Vitruvian triad and its dynamic version – strength, utility, perfection, and beauty. This approach opens up prospects for defining new landmarks of development, contributes to the return of architecture to the status of tectonic and plastic art. We have proposed a system of genre architectural design to revive this status. It includes architectural topics, rhetoric, tropics, and poetics. The research diagnoses the current state and predicts the development of architectural science.

INTRODUCTION

In his treatise, Vitruvius, for the first time, generalized and formed an idea of architectural science. It combined practice, theory, and art – a kind of reflection of his immortal triad: strength, usefulness, and beauty [1]. Despite constant transformations over more than two millennia, this triad has retained its paradigmatic significance for the development of modern architectural science. The confrontation of Modern and Counter-Modern movements in architecture with their Modernist and Postmodernist orientation today accompanies this development [2, 3]. Intermediate directions and styles with own theories arise against the background of collisions between them [4]. In this research, we tried to organize the overall picture of the development of modern architectural theory and practice. For this, we analyzed existing concepts and proposed a new method of cyclical self-organization of this development.

FORMULATION OF THE PROBLEM

Today we do not have a clear enough picture of the formation and development of architectural science and art. The internal order and general features of the opposing parties at different stages of development are not sufficiently studied. Assessment of dynamic and natural transformations of mosaic and collage picture of the development becomes an urgent problem of critical analysis and synthesis of scientific achievements and losses of the modernist and postmodernist era. On the other hand, the problem of revealing the hidden harmony between the coexistence of

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individual movements and directions, with the cyclical unfolding of their successive and gradual changes, also needs attention.

CONCEPTS OF CONTEMPORARY ARCHITECTURAL THEORY AND PRACTICE DEVELOPMENT

We began to study this problem with the historical and philosophical works of Oswald Spengler. He studied the Physiognomy of individual cultures and civilizations as of the influence of microcosmic and macrocosmic forces in them. The internal microcosmic forces of historical development manifested themselves in the chaos of polarization and confrontation of specific phenomena and events. Their cyclical external development (childhood, adolescence, maturity, and old age) determined the macrocosmic order of any culture development (spring, summer, autumn, and winter) [5].

Some directions of development of philosophical thought revealed the cyclical and confrontation of Romanticism and Classicism, their connection with the accompanying Modernism and Pragmatism [6]. Umberto Eco also pointed to the fleeting signs of the cyclical development of artistic styles. He believed that Postmodernism and Mannerism, which are opposed to Historicism and Modernism, were at any epoch [7]. Moisei Ginzburg, the first in modern architecture, noticed the universal cyclical order of any historical style development. They go through the stages of their birth, constructiveness, harmony, and picturesqueness [8]. The macrocosmic cyclical nature of development became the basis for the formation of a new direction of architectural science – Urban Synergetics [9]. There we propose a new order of gradual development of various worldviews and their stylistic features in the form of a chain - Romanticism, Modernism, Classicism, and Postmodernism.

Such an ideal development interacts with various microcosmic forces in real conditions. Because of this, the general picture of the development of modern architectural theory and practice acquires a patchwork, and at best, mosaic or collage character. Microcosmic disunity, antagonism, and an eclectic mix of different theories and practices greatly complicate the analysis of their physiognomic features. As a result, various conceptual approaches to the analysis of ways at contemporary architectural science development arise.

Among them the ideas of Sigfried Giedion on the continuity and stroboscopic of space and time of architecture [10]. Sigfried Giedion considered the development of architectural modernism through the prism of worldview changes in the natural sciences and plastic arts (Einstein's theory of relativity, paintings of Cubism and Futurism, Neoplasticism, Purism, and Suprematism). Sigfried Giedion saw in these revolutionary transformations a close connection with the macrocosmic changes of spatial representations in the millennial history of architecture. He discovered a cycle of gradual transition from volumes in space to interior space and then from the free arrangement of volumes to the mutual penetration of external and internal spaces in the development of classical and modernist architecture. In other words, he imposed a spatiotemporal grid of cyclical macrocosmic order on the microcosmic changes of many new spatial ideas. The city center of Saint-Die (Le Corbusier, 1946) was the first example of spatial planning. Le Corbusier demonstrated mastery of all three concepts in the architecture of the Chapel in Ronchamp (Fig. 1).

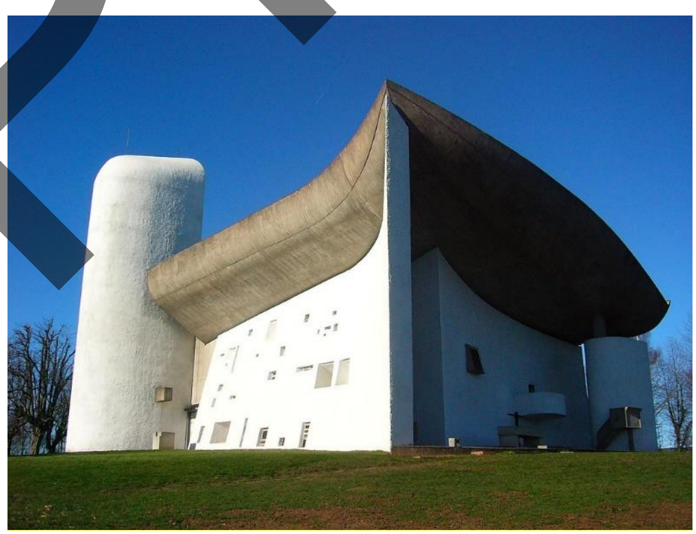

FIGURE 1. Chapel in Ronchamp, Le Corbusier, 1954 [13]

The use of space-time grids was not accidental. Sigfried Giedion worked for a long time at CIAM, where functional became the basis for theoretical analysis and urban planning practice. These grids summarized 28 years of CIAM research and helped identify new directions and dominants of architectural development. Some scientists believe that CIAM has not created the theory [11]. At the same time, CIAM has developed the program, goals, and forecasting methods. Prominent masters of the modern movement understood that the future theory should include the third component of the Vitruvian triad – beauty. Ernesto Rogers, Eero Saarinen, and others emphasized this [12].

However, CIAM was very careful about the problems of the new aesthetics. CIAM began to consider aesthetics only at the VI Congress in 1947. It became the basis for discussion and the emergence of a confrontation between young architects and masters at subsequent congresses. Perhaps the theory of functionalism remained incomplete due to insufficient attention to beauty. Functionality replaced beauty, and ethics replaced aesthetics.

In 1948, the congresses of the UIA (International Union of Architects) began their work in parallel with CIAM. The congresses of these creative unions faced similar problems in confronting Modernism and Postmodernism. Unlike CIAM, the UIA congresses did not have a single leadership that would follow the development of postmodern theories and practices of the Counter-modern movement. One of the main goals of the UIA congresses was to maintain links between, on the one hand, UN international organizations with their concepts of environmental security, climate change, the added value of culture, and on the other hand, between the architectural community in different parts of the world.

Information exhibitions of architectural achievements were the main events of the congresses. At the exhibitions, congresses participants informed others about achievements and discussed ways of the architecture and urban planning developing. The activities of the congresses resembled an information network, in the nodes of which it was possible to be acquainted with many ideological changes in the architecture and urban planning development. Sometimes the theme of congresses reflected the search for new landmarks: “Architecture at the Crossroads” (1953, Lisbon; 1993, Chicago), “Present and Futures. Architecture in Cities” (1996, Barcelona), “Architecture of the 21st Century” (1999, Beijing) and others. Some congresses promulgated charters. One of them (1999, Beijing) had a philosophical rationale and saw the future in a holistic movement towards integral architecture and in the return of architecture to the field of plastic arts. Sometimes congresses participants mentioned beauty in passing. They asked the question: How can beauty correspond to modernity and take a timeless form? (2002, Berlin). Today, moratoriums, declarations, and UIA charters need further research. Everyone understands that the information network of questions and answers cannot outline all the collisions of the Modern and Counter-modern movement and many possible ways of development.

One of the famous masters of modern architecture proposed a grid of canons for the study of important buildings and structures, the work of prominent architects and their theories, which became turning points and landmarks of development [14]. Peter Eisenman organized a "careful reading" of these architectural works in the analysis of diagrams. He sought a conceptual expression of the relationship between whole and part. He sought a conceptual expression of the relationship between pairs of concepts (fragment-whole, subject-object, and space-time) in specific architectural works. Peter Eisenman organized a "careful reading" based on Pierce's pragmatic philosophy. The interaction of three types of signs (icon, symbol, and index) forms any text and language. Peter Eisenman identified three stages of critical transformations of Modernism. The first stage rethinks the principles of Modernism and theory in the specific works of prominent masters (Luigi Moretti, Ludwig Mies van der Rohe, Le Corbusier, and Louis Kahn). A meticulous analysis of their projects and diagrams focused on the transitions from the abstractness and integrity of Modernism to the fragmentary and incomplete form of Postmodernism, from the critique of Classicism and Modernism to the joint use and superimposition of their spatial and temporal grids (Fig. 2, 3) [14].

FIGURE 2. Farnsworth House, Plano, Illinois, USA, Ludwig Mies van der Rohe, 1945–1951 [15]

FIGURE 3. Palace of Congresses for Strasbourg, Le Corbusier, 1962–1965 [16]

The second stage involved the work of Robert Venturi, James Stirling, and Aldo Rossi. It orientated concepts and theories towards rethinking the iconic and symbolic in the architecture of "ducks" and "ornamented barns" – Robert Venturi (Fig. 4), inversion of the materiality of forms – James Stirling (Fig. 5), purification of historical forms, and architectural typology based on analog thinking – Aldo Rossi (Fig. 6). The third stage was a turning point in the canonical projects of Rem Koolhaas, Daniel Libeskind, and Frank Gehry. They saw the future in the rupture of space and time, its infrastructural and undulating interconnectedness – Rem Koolhaas (Fig. 7), the abandonment of axial space, and the opposition of symbol and index in the architectural image – Daniel Libeskind (Fig. 8). The reorientation towards the harmonization of symbol and index in diagrams of digital and analog thinking formed the fundamental basis for changing the paradigm of historical precedents – Frank Gehry (Fig. 9). The tortuous path from the samples of classical, modernist, and postmodern architecture made critical turns that determined the ten landmarks of the evolution of modern architecture, architectural theory, and practice.

FIGURE 4. Vanna Venturi House, Chestnut Hill, Philadelphia, USA, Robert Venturi, 1962–1964 [17]

FIGURE 5. University of Leicester, England, James Stirling, 1959–1963 [18]

FIGURE 6. Ossuary and the Cemetery of San Cataldo in Modena, Italy, Aldo Rossi, 1971–1978 [19]

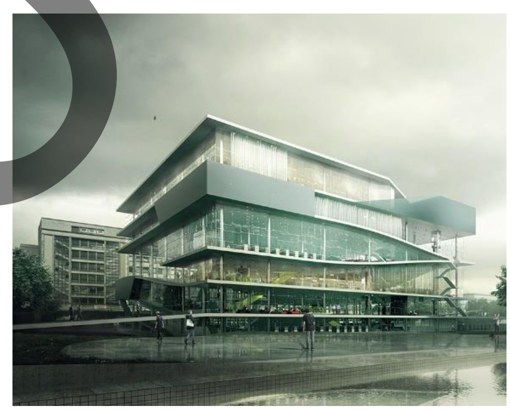

FIGURE 7. Jussieu Library in Paris, France, Rem Koolhaas / OMA, 1992 [20]

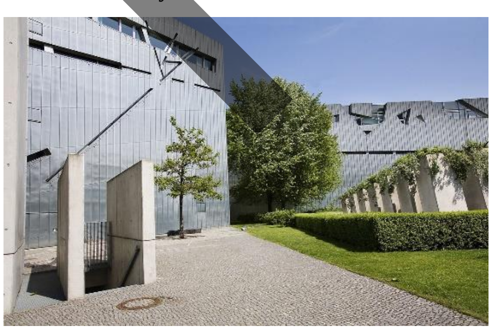

FIGURE 8. Jewish Museum Berlin, Germany, Daniel Libeskind, 1989–2001 [21]

FIGURE 9. Peter B. Lewis Building, Cleveland, USA, Frank Gehry, 2002 [22]

Many studies have contained ideas for constructing a general picture of evolutionary transformations. Some of them presented this picture as an evolutionary tree, although it is more like ocean currents (Fig. 10) [23]. In other studies [2], the diagram resembles four straits – Populism, Neo-rationalism, Productivism, and Critical Regionalism in the delta of the confluence of two streams of Modern and Counter-modern movements. Some theorists see future development in the intermediate space of absolute architecture between Modernism and Postmodernism [4]. The ideas of archipelago and island architecture – Oswald Mathias Ungers, Rem Koolhaas and others [4] (Fig.11), as a mixture of integral abstraction and fragmentary reality distinguish them from utopias of 10-20 years and 60-70 years of the twentieth century. They stand aside from postmodernist concepts such as The Collage City (Colin Rowe) and The City Palimpsest (Antoine Grumbach) and form an original concept of the dialectical city. Ekistics has developed a new independent direction of contemporary architectural science. Constantinos A. Doxiadis combined the ideas of "polis" and "urbs" and classical and modernist ideas about the city with the postmodern mass culture of completely urbanized areas. Arcology by Paolo Soleri, Critical Regionalism by Kenneth Frampton, and Absolute Architecture by Pier Vittorio Aureli adjoins the "border areas" of Modernism and Postmodernism.

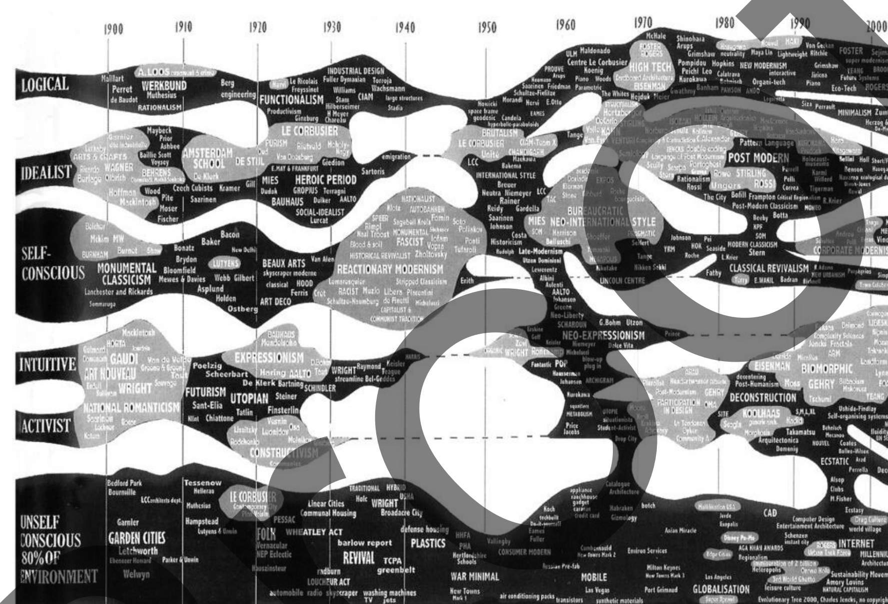

FIGURE 10. Jencks' Theory of Evolution, an Overview of 20th Century Architecture [23]

FIGURE 11. New Welfare Island Project, Roosevelt Island, New York, NY (Aerial perspective), Rem Koolhaas, Zoe Zenghelis, 1975-76 [24]

Urban Synergetics also offers one of the possible directions and guidelines for updating architectural theory. Among them is the concept of merging chaos and cosmos as a way to constructively transformation of the continuous urbanization clutter into a renewed urban space [9]. These transformations occur under the influence of macrocosmic and microcosmic forces. The first forces determine the cosmic cycle of development with consistent and gradual transitions from the original romantic ideas through their modernization to the new classics. The development cycle ends with a postmodern mixture of previous stages, which becomes the basis for the emergence of the next level of development with new romantic ideas. The internal microcosmic ordering of this cycle includes mutual polarization of Romanticism and Classicism, on the one hand, and Modernism and Postmodernism on the other. The crisis confrontation and struggle between Modernism and Postmodernism is softened and wavy due to the transitional nature of Romanticism and Classicism.

The synergetic picture of directions and styles of contemporary architecture acquires an image of a complicated landscape. Hills (Modernism), ravines (Postmodernism), and slopes (Romanticism and Classicism) form it. The landscape resembles Filaret's drawing [25]. The dynamic development diagram contains harmonic sinusoidal lines that unfold over time. The life of one generation (approximately 25 years) becomes a unit of scaling the development process (Fig. 12). The idealized diagram reflects the real historical development. Approximately 50 years passed between the surges of utopian thinking and the emergence of new architectural ideas – in the 1920s and 1970s, that is, two generations changed. The work of the CIAM and UIA congresses also depended on the change of generations. The diagram can help in diagnosing the current state and predicting the future development of modern architectural theory and practice.

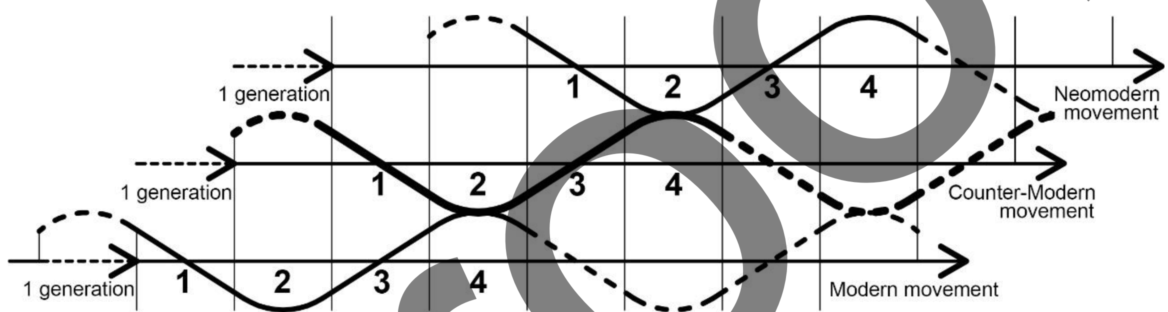

FIGURE 12. Polarization and cyclicity of directions and movements of contemporary architecture development: 1 – Romanticism, 2 – Modernism, 3 – Classicism, and 4 – Postmodernism

Urban Synergetics proposes to evaluate each stage and direction of development in the coordinates of the Vitruvian triad, or more precisely, its modifications. Horatio Greenough thought about turning this triad into a notebook. He focused on the concept of "perfection" of architectural objects, which today is becoming a full-fledged attribute of dynamic development [26]. The static triad of Vitruvius received a new dynamic form: strength, utility, perfection, and beauty. It quite accurately describes not only the microcosmic but also the macrocosmic dynamics of development. New romantic ideas, which are pragmatically and utility used in Modernism, give strength to this development. New Classicism grinds and perfects modernist ideas and forms. Rethinking classical ideas and returning to the ideals of beauty in historical styles stimulate the development of Postmodernism. This approach complements and expands the boundaries of architectural theory with the aesthetic category of perfection. It creates conditions for the return of contemporary architecture to the lost status of plastic and tectonic art. Urban Synergetics proposes to make this turn the path of implementation of a new genre system of architectural and urban design.

This system includes four genres: architectural topics, rhetoric, tropics, and poetics. The architectural topic focuses on the detection of "Genius Loci" and the saving of historical traditions in the urban environment. Architectural rhetoric reflects the aesthetic demands of mass culture and urbanization. She uses both eloquent and mundane artistic images of mass construction in areas of influence of urban frameworks. Artistic images of the architectural tropics provide the aesthetic expressiveness of ultra-large urban structures that compete with natural landscapes. These artistic images use stylistic figures – paths (metaphors, metonymies, etc.) to enhance aesthetic significance. Architectural poetics occupies the last stage of the system of genre design. It orients architects to search for new unprecedented forms on a planetary scale. Utopia is the most effective means of forming artistic images of the future artificial environment of man.

CONCLUSIONS

Thus, the general picture of the development of contemporary architectural science requires a careful study of turning points, azimuths, and landmarks on the way to finding new ideas. Theorists and practitioners have carried out this search in the public space of the CIAM and UIA congresses. They found new landmarks through grids that described the spatiotemporal, functional, informational, and symbolic landscapes of transformations of architectural theories and practices. The confrontation and conflicts between Modernism and Postmodernism reflected the microcosmic chaos and macrocosmic tectonics of these landscapes. Interaction of cosmos and chaos, the research of microcosmic and macrocosmic forces, abstractions, and realities have become new landmarks of contemporary architectural science development. Within the Urban Synergetics, we have developed a model of cyclical self-organization of trends and styles. In addition, we have proposed an original system of genre design. The Vitruvius-Greenough tetrad creates a "topographic basis" for orientation in the "landscapes" of contemporary architecture development. Due to this, the architecture will regain the status of plastic and tectonic art. We plan to continue researching this problem in its connection with the sustainable development of settlements and communities.

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Application of Universal Design Principles for Public Buildings and Spaces in Pandemic Age

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Abstract. The paper gives coverage on the providing universal design approaches in the public building design regarding the pandemic risks. It is proved that universal design principles meet the requirements of counteracting to the SARS-COV-19 pandemic. The effectiveness of their use as a way to control virus spreading is proved by practical examples. There are considered the examples of providing architectural and information universal accessibility of public buildings in Ukraine and abroad.

INTRODUCTION

The humanization of the physical environment is impossible without ensuring universal accessibility for all groups of the population. The main types of accessibility of buildings are architectural and information accessibility. The complete and safe accessibility can be provided by the means of universal design as it is described in Ukrainian construction codes.

Author of the Universal Design (UD) conception, Ron Mace – an architect, a founder and program director of the Center for Universal Design in North Carolina State University's School of Design – stated that UD is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design [1].

Adherence to the principles of universal design in the design of public buildings, as those that ensure the complete right of use by different groups of people, is of particular relevance regarding today's global challenges, one of which is the SARS-COVID'19 pandemic.

Designing safe, comfortable environment, especially in case of the buildings with high attendance, is possible through a comprehensive approach. This approach can be provided at implementation UD principles.

The main principles of Universal design, developed by Ronald Mace are as follows [1, 2]:

1- Equitable Use; 2 - Flexibility in Use, 3 - Simple and Intuitive Use; 4 - Perceptible Information; 5 - Tolerance for Errors; 6 - Low Physical Efforts; 7 - Size and Space for Approach and Use.

The application of principles of UD in architectural and design practice meets the following goals of Universal design (Tab 1).

Common definition of UD accepted for Ukrainian building codes on inclusiveness gives the idea of universal design as the design of buildings and structures, suitable for use by all the groups of people regardless of age, ability or situation, without additional adaptation [3]. However, it does not exclude application the special equipment for certain groups of individuals with disabilities. UD tools aim at universal equal accessibility of spaces and services.

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TABLE 1. Goals of Universal design (according to [3])

Name of goal	Definition
Body Fit	Accommodating a wide a range of body sizes and abilities
Comfort	Keeping demands within desirable limits of body function and perception
Awareness	Ensuring that critical information for use is easily perceived
Understanding	Making methods of operation and use intuitive, clear and unambiguous
Wellness	Contributing to health promotion, avoidance of disease and protection from hazards
Social Integration	Treating all groups with dignity and respect
Personalization	Incorporating opportunities for choice and the expression of individual preferences
Cultural Appropriateness	Respecting and reinforcing cultural values, and the social and environmental contexts of any design project

Within the context of pandemic adhering to UD principles helps to provide safe architectural and information accessibility to the public environment. When residential buildings have limit access in as our private spaces, public spaces, in particular public buildings become the places of spreading the virus [4].

During over the year of the facing COVID’19 pandemic as the global challenge, there have been discussed the issues of architectural and design approaches to control the situation. Much attention is paid to the UD approaches in learning methods [5, 6], design the learning environment [7] and solving accessibility problems for older people and people with disabilities [8]. Several researches and reports are devoted to the safety of working spaces [9-11].

Our previous publications highlighted the aspects of information accessibility the health care facilities [12] and UD approaches for open public spaces [13], where some aspects of the current issue were covered.

AIM AND SCOPE OF RESEARCH

The aim of the research was to determine the way of implementation the universal design (UD) principles in the context counteraction to spreading airborne droplets, including COVID’19.

The scope of the research was the key features of universal accessibility and the main issues with accessibility of public buildings revealed by authors’ audit in the city of Rivne (Ukraine) during September-November 2020 and March-April 2021 as well as experience of application UD approaches to public buildings design in pandemic age.

MATERIALS AND METHODS

We made photo fixation of the details of the buildings for illustration the main problems or the implementation UD principles. There were used the experimental methods such as measurement-based testing, and theoretical methods of hypothesis and analysis.

During the audit there had been applied tape measure and laser rangefinder to measure linear parameters of structural elements, bubble level tool to measure the slopes of ramps etc., questionnaire for checking the main parameters of inclusive accessibility.

RESULTS AND DISCUSSION

Main issues of architectural and information accessibility of public buildings

In today's world, global challenges we face due to pandemic COVID’19 led to the need in creation safe and comfortable environment, which is more vital than ever. The tools of universal design for providing the uniform access to any spaces and services at simultaneous safety and protection from infection, can be illustrated by examples of public buildings with high attendance, e.g., health care facilities, social services, transport facilities, shopping centers and other [14]. Regardless the substantial differences in the functional peculiarities of the different types of buildings and subsequent variation in the application of UD principles, several common problems can be considered.

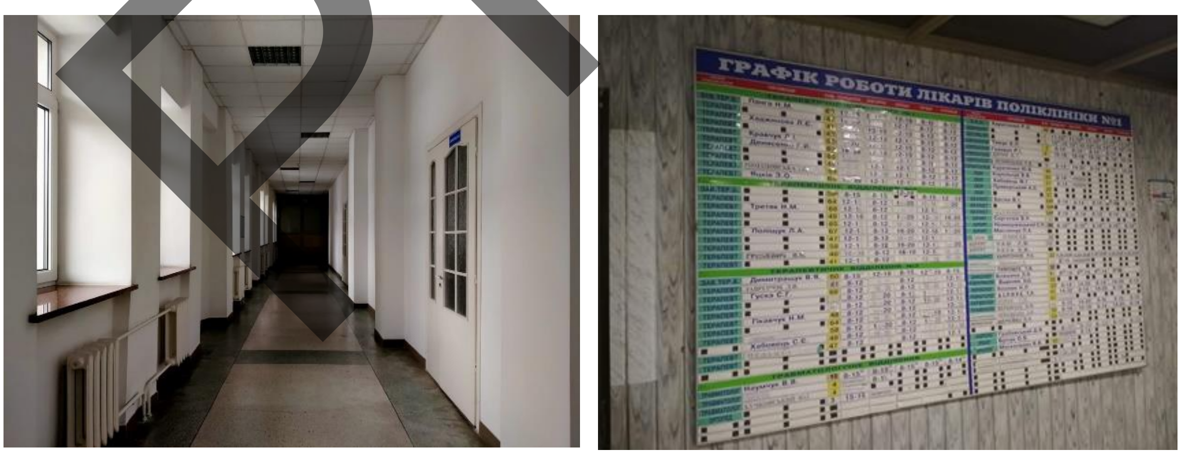
The audit of accessibility for some public building including City council, policlinics, shopping centers etc. in the city of Rivne revealed the main accessibility problems, which make the huge obstacles for the personnel and visitors, increase people's contacts and even crowding, therefore, it may affect the growth of infected persons. It may be caused by the need in physical or information assistance.

The most common problems of architectural accessibility of the buildings under research are related to inaccessible entrances due to the absence or irrelevant size and slope of ramps, improper width of the doors, corridors and other spaces, absence of elevators and other problems with vertical communications, the parameters of sanitary facilities, which do not meet the requirements for persons with disabilities, and so on (Fig. 1).

a) b)

FIGURE 1. The common problems of architectural accessibility by the case of health care facilities: the absence of ramp or ground level entrance to Rivne central city hospital, no visible name of the building (a) and limited access to reception of the city hospital (b). Photos by N. Lushnikova

Regarding information accessibility, there should be mentioned the absence of developed wayfinding systems in buildings and the surrounding area; illegibility or lack of required information, and vice versa, overloading with diverse information, visual clutter; limited use of internationally accepted icons that usually simplify the wayfinding process; lack or absence contrasting and tactile navigation (Fig. 2). It should be also mentioned insufficient adhering to accessibility standards (Fig. 3 and 4).



a) b)

FIGURE 2. The common problems of information accessibility by the case of health care facilities: the absence of wayfinding system in the hospital (left) and complicated timetable of doctors' visiting hours (right). Photos by N. Lushnikova

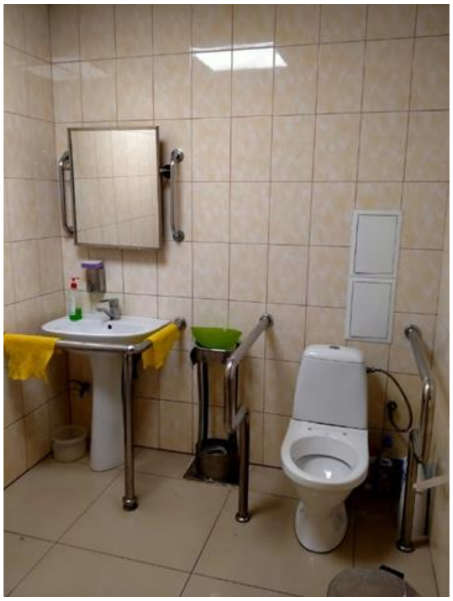


FIGURE 3. Improper design of sanitary facilities and irrelevant application the items by the case of inclusive bank office. Photos by N. Lushnikova

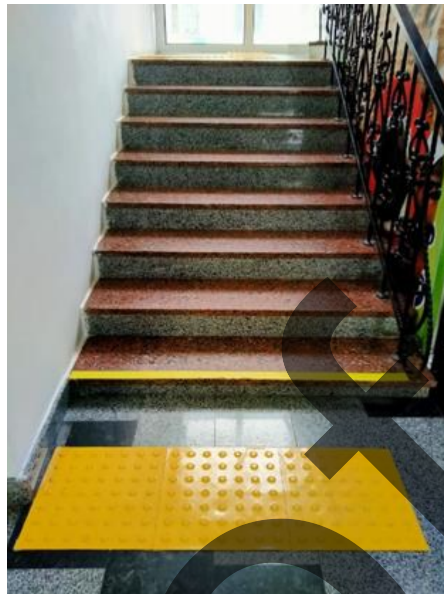


FIGURE 4. Irrelevant contrasting safety yellow leading edges in policlinic (vertical contrasting marks are absent). Photos by N. Lushnikova

Implementation of the UD principles within the context of pandemic challenges

At this stage of the research there had been highlighted the examples of values to architectural and information accessibility of public buildings from the point of meeting UD principles (see Tab. 2). There had been selected the examples that have direct impact on spreading the viruses, moslty airborne, at close contact [15]. Therefore, it is recommended to avoid three Cs – crouded spaces (many people nearby), close-contact settings (in particular, close-range conversations) and confined and enclosed spaces (with poor ventilation) [15]. The examples of the implementation of UD principles are given in Fig. 5-11.

FIGURE 5. The entrance is easily accessible and has signage directing people to short-cuts through the building, (photos by N. Lushnikova)

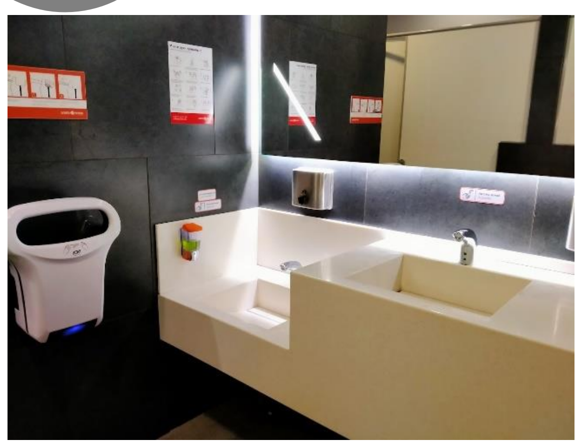


FIGURE 6. Wash basin designed in two levels (c) (photos by K. Kosiuk)

TABLE 2. The implementation of Universal Design principles in context of pandemic challenges

#	Name of principle	Content	Example of principle implementation	Value
1	Equitable Use	The design is useful and marketable to people with diverse abilities	Arrangement of the entrance flush with the ground without the use of stairs and ramps, the use of automatic sliding doors (Fig.5)	People with different mobility level do not contact with contaminated surfaces (handrails, door handles); they don't require assistance of other people to get access to the building
2	Flexibility in Use	The design accommodates a wide range of individual preferences and abilities	Arrangement of equipment, furniture at different levels, height adjustment, adaptation of space to the needs of low mobility groups the ability to receive services and pay for them, online shopping (Fig.6)	Ability to work, learn to shop, use services remotely, without contact with other people or flexible application according to needs
3	Simple and Intuitive Use	Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level	Presence of indoor and outdoor navigation, contrast in color, tactile surface indicators on floor (Fig.7)	Intuitive use prevents crowding and problems with orientation
4	Perceptible Information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities	Availability of information stands with readable information, legible signs, information accessible for Braille readers, universally accessible web-pages and navigation applications (Fig.8)	Efficiency of providing services and getting information, absence or minimization of contacts with other people
5	Tolerance for Errors	The design minimizes hazards and the adverse consequences of accidental or unintended actions	Placing the disinfectants, contrast marks at floor for keeping distance and translucent surfaces (Fig. 9)	Reducing the risk of infection, and if required, the possibility of disinfection
6	Low Physical Efforts	The design can be used efficiently and comfortably and with a minimum of fatigue	Universally accessible sanitary facilities, equipment that can be used with the least efforts, minimization of repetition of actions (Fig.10)	Use of systems that respond to light, voice, movement, heat, easy access/exit to the building without efforts
7	Size and Space for Approach and Use	Appropriate size and space are provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility	Providing a sufficient width of corridors, halls, stairways, (Fig.11)	Reduction contacts between people to keep required social distance

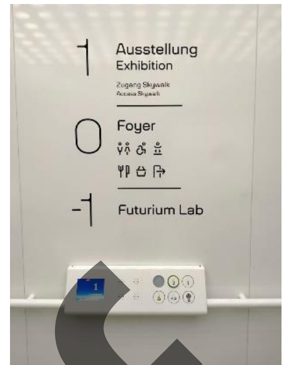


FIGURE 7. Emergency exit doors, clearly visible for different groups of people; photos by N. Lushnikova

FIGURE 8. Design code for wayfinding system in the museum, Berlin, photos by N. Lushnikova

FIGURE 9. Contrast and tactile navigation on the floor is a warning about the staircase on the way (photos by N. Lushnikova)

FIGURE 10. The combination of two functions - washing and drying hands – minimizes physical efforts (photos by N. Lushnikova)

a) *b)*

FIGURE 11. Providing appropriate space for different activities at the information-resource center of the Ukrainian Catholic University, Lviv (a) and places for wheelchair users at the stadium tribune Lviv Arena (b), (photos by N. Lushnikova)

Case studies on implementation the principles of universal design in the pandemic age

The pandemic forced the adaptation of the public buildings to the long-term restrictions and limitations. There are given the examples of the public buildings and spaces, which have compulsory plates with reminding information about wearing masks at the entrance zones (Fig. 12). Contrast between letters and background, using easily readable icons, eye level placing the information, which also marks the transparent plate of glass door can serve as an example of application of several UD principles of simple and intuitive use and perceptible information. Automatic sanitizer dispenser systems permit to avoid contacts with the surfaces during hands treatment and do not require need to apply any physical efforts. That meets the principles of flexibility in use and low physical efforts. The installation of wash basins at different levels meets the principles of equitable use, size and space for approach and use.

Even at the post-pandemic age the requirements of Cs tend to keep for a long term. Architects and designers face the challenges of the pandemic and post-pandemic ages. The main idea of changes in planning the interiors in public buildings is to minimize the contacts the personnel or visitors, application of different types of stationary, mobile partitions systems, flexibility in planning (Fig. 13) [22, 23]. However, the changes in architectural design approaches are supposed to be more dramatical both real time and long-term perspective [23, 24].

FIGURE 12. The cases of UD principles application to counteract the viruses spreading in a shopping center. Information stickers reminding about wearing g mask, a contrast to the transparent revolving door (a); automatic sanitizer dispenser station (b) (photos by N. Lushnikova)

CONCLUSIONS

There had been studied the peculiarities of accessibility and implementations of universal design principles in design of public buildings as a respond to pandemic challenges. In the context of the current global problems the following road map of movement to architectural and information accessibility of existing public buildings can be outlined:
1 - carrying out audit of accessibility of public buildings and the surrounding open public spaces,
2 - completing the questionnaires of all groups of users,
3 - development of the design project on improvement the accessibility and meeting the UD principles,
4 - project implementation starting with the most urgent stages (e.g. entrance accessibility, horizontal and vertical circulation, universal sanitary facilities, etc.).

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"Semantic Field" of European Romanticism Architecture

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Abstract. The problem of romanticism in European architecture is one of the least studied in architectural theory. The "symbolism" of the architectural language is one of the fundamental qualities of the architecture of romanticism. It was during the period of romanticism that the term "speaking architecture" first appeared and the first ideas about the architectural language were formed. The article is devoted to the consideration of the semantic field of the architecture of romanticism and is based on the semiotic representation of architecture as a linguistic structure. Architecture is seen as a text in which links are established between symbolic form and its meaning. The authors propose a research model in which the architectural form is presented in the form of a three-part structure, including morphological, semantic and phenomenological components of the form. The hypothesis is put forward that the artistic language of the architecture of the Romantic era manifested itself in a specific palette of meanings and senses. The study is based on identifying the main semantic aspects in the semantic space of the architecture of romanticism: stylistic, spatio-temporal, functional, constructive-technological, mytho-poetic, compositional-syntactic. The applied classification allows us to consider the architecture of the Romantic era in all the richness and originality of its content characteristics. The architecture of romanticism is characterized by narrativeness, expressiveness, entertainment, symbolism. The study examines such important characteristics of the architectural language of romanticism as metaphor, irony, paradox, sublime rhetoric of architectural texts. The territorial boundaries of the study are limited by the architecture of France, England, Germany.

RELEVANCE OF RESEARCH

At present, the discussion of the semantic field in architecture seems to be a key question for the architectural theory of any era, and especially Romanticism. It is impossible to talk about the integrity of the style and its language without discussing the meaning and symbolism of the forms used. The "symbolism" of the architectural language is one of the fundamental qualities of the architecture of Romanticism. It was during this period that the term "speaking architecture" first appeared and the first ideas about the architectural language were formed. The lack of knowledge of the symbolic language of romanticism makes the study of the topic under consideration relevant.

THE STATE OF THE ISSUE

As early as the beginning of the 19th century, an interest in the topic of language and especially in its symbolic component there arose. Ideas about language began to form in the second half of the 18th century within the framework of philosophy, aesthetics and literature by such authors as J. W. Goethe, K. P. Moritz, F. Schelling and others. A symbol for them is a sign, the meaning of which has not been agreed upon in advance; on the one hand, it is intuitively perceived, but on the other hand, it is never fully comprehended; further on, the symbol is the whole, the perfect image; a symbol is a sign that cannot be translated with the help of other sign systems. I. G. Herder, K. P. Moritz, H. Mayer, G. F. Creuzer, K. W. F. Solger see the specific character of the symbol in the fusion of meaning and being. Romantics believed that every work of art is a symbol. They showed great interest in sign systems in art ("The Symbols of Dreaming" by G. H. Schubert, "Symbols and Mythology" by G. F. Creuze. W.-H. Wackenroder wrote about the wonderful languages of nature and art, Novalis - about the cipher and grammar of the language nature [1], K. P. Moritz spoke about the "higher languages" of nature, art, music, mythology, poetry [2]).

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Romantics thought of culture as an endless creative process, global communication. From this view follows the concept of "speaking architecture" and the importance of the symbolic component in the romantic concept of architectural form.

It was in the depths of Romanticism that the concept of "speaking architecture" was born. K. N. Ledoux wrote: "If artists want to follow the symbolic system common to any work, they acquire the same fame as poets ...". And further, with his characteristic categorically, Ledoux proclaimed the universal obligation of symbolism of the architectural form: "If artists want to follow the symbolic system ... then their works should not contain a single stone that would not speak to the eyes of passers-by" [3, p. 88]. This idea was comprehended and actively developed in architecture only in the second half of the twentieth century.

At the turn of the 19th and 20th centuries, a number of important semiotic concepts were developed: sign, meaning, and sign relations (Charles Sanders Pierce 1839-1914), Gottlob Frege (1848-1925), Edmund Husserl (1859-1938), Ferdinand de Saussure (1857-1913), Charles William Morris (1901-1979), Jakob Johann von Uexküll, (1864-1944).

In the USSR, semiotics developed within the framework of the Moscow-Tartu semiotic school, headed by Yu. M. Lotman.

Since the second half of the 20th century, all the main sections of philosophy have experienced at least the stylistic influence of the philosophical and linguistic lines of thought. The 1960s saw the heyday of French structuralism, one of the influential trends in the development of the concept of language. The main figures in the history of the movement are Ferdinand de Saussure, Roman Jacobson, Claude Levi-Strauss, Roland Barthes, Jacques Lacan, Michel Foucault.

Based on their ideas, the research of the language of modern architecture was carried out by: Niels Luning Prak [4], Charles Jencks [5], Umberto Eco [6], A. Rappaport, G. Somov [7], V. F. Markuzon, A. Ikonnikov, E. Remizova [8], and others. However, in their works, which form the theoretical basis for the study of the architectural language, we will not find an analysis of the architecture of the period of romanticism. This period, due to its complexity and blur, remains outside the field of vision of researchers. Let us set ourselves the task of outlining the circle of those semantic aspects that determine the semantic field of the architecture of European romanticism.

METHODOLOGY

Our research scheme is based on the model of the concept of architectural form proposed by A.G. Rappaport in the form of a three-part structure that isolates the morphological, semantic and phenomenological components of the form. In this model, one of the components, namely the **semantic** one, presupposes work in the semiotic space of architecture [7, p. 71]. Semiology studies the phenomena of culture, which for it are the essence of a **system of signs**. Extending this provision to architecture, it can be argued that architectural phenomena can be read as texts, i.e., they have **semantics, syntax and morphology** [8]. When analyzing the semantic component of an architectural form, the relationship between symbol and meaning is considered. A. Rappaport points out that "the richness of architectural forms is their symbolic meaning" [7, p. 75]. The symbolic form is always expressed through certain morphological characteristics.

Yu. Lotman noted that the symbolic experience of architectural forms is based on an appeal to the memory of culture, to its coding systems [9]. The culture memory contains a large number of morphologically fixed symbols [10]. Since this model and these concepts are universal, we will apply these concepts to consider the substantive aspects of the architecture of romanticism.

RESULTS OF RESEARCH

Born within the framework of the doctrine of the Enlightenment, romanticism, in fact, became the antithesis of a rationalistic worldview. During the formation of the romantic method in European architecture (1780s - 1870s), the new language of architecture "pushed its way", "affirming" new symbolism and new compositional methods of its expression. The new goals and values of the era were to be expressed in architecture.

The total striving for freedom in all spheres of creative life is the main paradigm of the Romantic era. "Romanticism was the wide artistic direction, which was based (for the first time in the history of art!) A creative method that proclaimed freedom or even arbitrariness as its main principle" [11, p. 13]. The principle of anti-normativity of art was a reflection of this overarching idea for romanticism.

The substantive aspect of the romantic worldview was realized with the help of the integral principles of romantic art and architecture - **anti-normativity, historicism, creative universalism, a tendency to synthesis, "organic", symbolism of the architectural language**.

When it comes to innovations in architecture, we understand that the **architect uses a method that is new** compared to the previous period. Here we have the right to assume that **at the turn of the 18th-19th centuries, a romantic method of design and thinking emerges and develops,** which is different from the normative-rationalistic method characteristic of Classicism. Describing the semiological process in historical development, Umberto Eco in his book “The Absent Structure” points out that “the use of certain codes is dictated by ideology and circumstances, while the entire sign system is constantly being rebuilt on the basis of the experience of decodification and the whole process appears as a forward movement semiosis” [6, p. 526].

Based on these philosophical and semiotic ideas, we hypothesize that the artistic language of the architecture of the Romantic era was fixed in a characteristic, specific palette of values and meanings. To describe the artistic language of Romanticism, we propose the following generalizing classification, in which we single out six semantic aspects inherent in architectural objects: **1 - stylistic, 2 - spatial-temporal, 3 - functional, 4 - constructive and technological, 5 - myth-poetic, 6 - compositional–syntactic aspects.**

Understanding architecture as a text, let us consider these semantic aspects consistently in relation to the architecture of romanticism, reinforcing examples from the architectural practice of the second half of the 18th -19th centuries.

The stylistic aspect (1st aspect) - reveals the complex, synthetic meaning of the form, and allows, by a number of its symbolic features, to determine the belonging of an object to a particular stylistic direction. And if the attribution of this or that object to the style of Classicism or Gothic is not particularly difficult, then the attribution of the object to romanticism is much difficult. There are a number of reasons for this. First, romanticism in architecture does not have features of stylistic certainty and presupposes a certain vagueness of morphological, semantic and phenomenological features. Secondly, in the Romantic era, there were a huge number of non-styles. The denial of order and the unification of classicism reveals the most important feature of romanticism - its anti-normativity. The focus on antiquity, preached by the classics, was replaced by an interest in exotic cultures, the Gothic heritage, and the search for national roots in architecture. Various architectural trends in architectural theory, from utilitarianism to moralism and historicism, championed the new aesthetics of romanticism. [12].

Revealing the various features of the romantic orientation of the form presupposes a special research procedure that makes it possible to identify romantic features in a number of architectural objects. For example, structures so different in their morphological descriptions as the building of the royal residence in Brighton, the Vendome Column in Paris and the building of the Crystal Palace in London can be stylistically characterized as a romantic trend. The morphological characteristics of these buildings directly depended on the ideological characteristics of romanticism, the manifest features of the romantic method, cultural and historical context, the state of development of building technologies and structures. And only the procedure for decoding this complex mixture of meanings makes it possible to isolate the stylistic features of romanticism in the structures listed above.

Any architectural object is conceived, realized and exists in a certain space-time coordinate system. **Determining the time and place of building** (2nd aspect) involves the attraction of a whole arsenal of knowledge about the evolution of culture, about the stylistic and national features of architecture at certain stages. The time frame of the Romantic era in European architecture is quite wide and is determined from the 80-90s of the XVIII to the 60-70s of the XIX centuries. We have already written that “in the Enlightenment and Romantic epochs attitude to the past changes and takes on new forms. The nostalgia of a bygone era creates fantastic images. Romantic language original, as architects refer us to epochs which are not yet known and far removed. Fantasy, guesses, dreams form the basis of cycles of engravings by Giovanni Battista Piranesi “Antiquities of Rome,” “Prisons”, paintings by J. P. Panini, memorials projects crypts, gardens and parks with ruined constructions, etc. In the romantic genre there is a high proportion of freedom. An architect is not held back by the rules of style, because he does not know them yet. The language of architecture becomes very diverse, polysyllabic and free” [10, p. 102].

It is natural that various national schools of romanticism had many manifestations. Reading the symbolic meaning of the form at a certain space-time section allows us to attribute specific structures to both the Romantic era and the interpretations of national schools. The time and place of construction also determined the choice of historical prototypes and the way they were interpreted. For example, the preference for English Gothic in combination with oriental motives was determined by the colonial foundations and conquests of Great Britain. (Fig. 1-2).

Correlation of form and function (3rd aspect) can be interpreted as a symbolic correlation. In the process of the evolution of the architectural form, a system was developed for assigning fairly stable formal features to certain functions. The typology of residential, church, and palace buildings that developed before the 19th century is rapidly increasing in the era of Romanticism. Such types of structures as a theater, a stock exchange, a library, a museum, a hospital are finally emerging. However, the functions formed on the basis of new technologies (railway stations, international industrial exhibitions, factories, etc.) require the development of a new architectural and typological catalog, since they do not have prototypes in the past. Their iconic forms are created by transferring the historical form to the present and assigning new meanings to them, or by inventing a new form.

FIGURE 1-2. John Nash, Royal Pavilion, Brighton, 1823. Façade Source: [13] and interior, Source: [14].

To an even greater extent, the symbolism of forms is manifested in the projects of the early 19th century, based on social utopias. Projects-manifestos appear, designed to express some ideal idea of new forms of dormitory and its organization with the help of architecture. Thus, a large number of projects created by E.-L. Boullee [15], fit into a single concept of an ideal city, similar to city Chaux by K.-N. Ledoux. Representatives of French revolutionary architecture enriched the language of architecture by introducing many structures with an "unconventional function" into it. They developed, for example, a type of "burial" architecture: E.-L. Boullee - a project of a tomb for Hercules, a cenotaph in the form of a truncated cone, Newton's cenotaph, an Egyptian-style cenotaph, K.-N. Ledoux - cemetery project, J.-J. Lecques - "Tombs of the most famous and learned men". Newton's cenotaph (1784) became the prototype for what we might call astronomical structures: House of the cosmopolitan Leon Vaudoyer (1790), the Temple of Immortality and the House of the hermit Sobre, the Temple of the Earth dedicated to the highest wisdom (1790), the Temple of Equality and the Palace of Justice by J.-J. Lecques (1794), Newton cenotaphs by P. J. Delespin (1785), J.-J.-P. Gay and C. T. Labadier (1800), (Fig. 3-5).

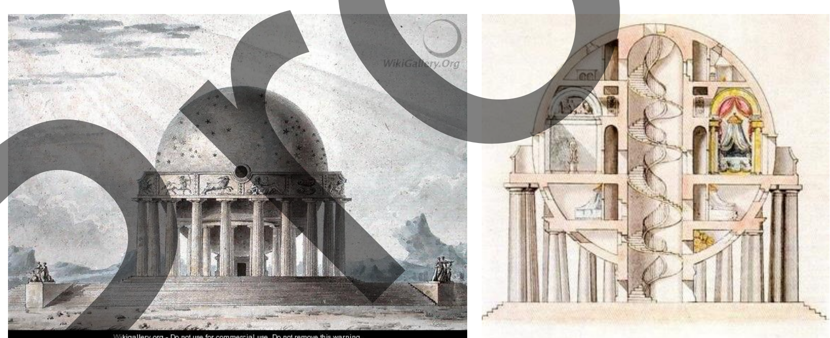


FIGURE 3. Antoine Laurent Thomas Vaudoyer. Design for a House for a Cosmopolite, 1783. Source: [16] and section Source: [17].

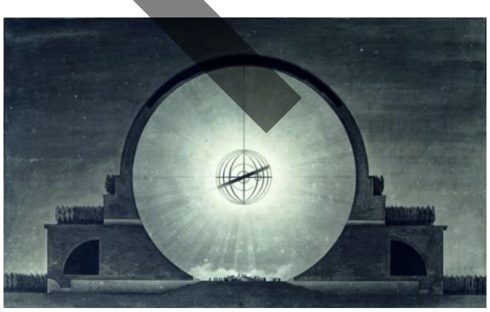


FIGURE 4. Étienne-Louis Boullée. Cenotaph of Newton, 1784. Source: [18].

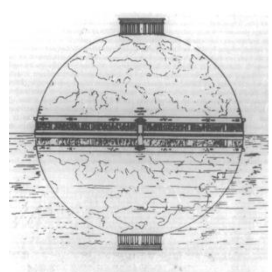


FIGURE 5. Jean Nicolas Sobre. Design for a Temple of Immortality, 1802. Source: [19, p. 315, pic. 11].

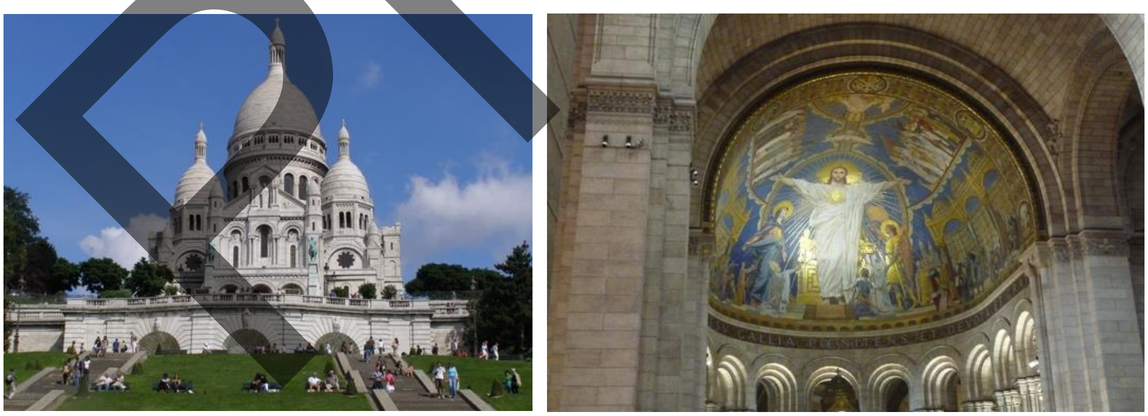
Of considerable interest is the semantics of structures, which are assigned a memorial or ideological function. These are countless triumphal arches, columns, pantheons, temples of Glory during the Empire period. The most famous of them: the Vendome Column (Fig. 6), Triumphal arches on the Place de la Carousel (Fig. 7) and the Place de la Star in Paris (Fig. 8), Valhalla near Regensburg architect L. von Klenze. The ideological meaning of these objects is recorded not only in the solemn form of these objects, which remind us of certain historical monuments of ancient Rome, but also in the reliefs that tell about the military events of modern times.

FIGURE 6. J.-B. Lepère, J. Gondoin. Vendome Column, Paris, 1810. (photo Remizova O., 2000).

FIGURE 7. Ch. Percier, P. F. L. Fontaine. Triumphal arches on the Place de la Carousel, Paris, 1808. (photo Remizova O., 2015).

FIGURE 8. J.-F. Chalgrin. Triumphal arches on the Place de la Star, Paris, 1836. (photo Remizova O., 2015).

In the era of Romanticism and further in the era of Eclecticism, there is a process of "designating" a certain style of function of a building or a separate room. Goryunov V. S. and Tubli M. P. write that "there was, for example, a tradition associated with literary associations to use Gothic forms to decorate the interiors of libraries, offices, oriental motifs – for place baths, smoking rooms" [20, p. 53]. European church architecture, castles, park pavilions were built mainly in the forms of the Gothic, government buildings and banks - in the forms of the ancient classics. By the second half of the 19th century, the idea of reviving national identity on the basis of national cultures had become one of the dominant ideologies. This was reflected in the choice of style for the buildings of the London (architect Ch. Barry, 1857), (Fig. 10) and later the Budapest (architect Steindl Imre, 1885) (Fig. 11) parliaments in the forms of Gothic or the Sacré-Cœur Basilica on Montmartre in Paris in the forms of novelism and remote symbols of Southeast Asia (architect P. Abadie, 1875-1914), (Fig. 9).



a) b)

FIGURE 9. P. Abadie. Sacré-Cœur Basilica on Montmartre, Paris, 1875-1914. a) Façade (photo Kudryashova I., 2010), b) interior (photo Remizova O., 2015).

FIGURE 10. Ch. Barry. Palace of Westminster, 1840. Source: [21]

FIGURE 11. I. Steindl. Hungarian Parliament Building, Budapest, 1885-1904. (photo Remizova O., 2020).

An architectural structure has a set of symbols that express and read as **constructive and technological meanings** (4th aspect). Such types of structures as "basilica" or "cross-domed temple" imply the use of certain spatial-structural schemes. Until late Romanticism, structures were not self-sufficient elements of an architectural text, but were included in a complex, but holistic symbolically stable system, with a mythology prevailing in culture (basilica, portal, vault, dome). In these complex space-symbolic complexes, such separate parts, for example as a dome, have the meaning not only of construction, but also of the celestial vault. In the era of the formation of the architectural language of Romanticism, the construction loses its esoteric and mythological content, and begins to mean only itself. For the first time, architecture dares to demonstrate the construction of a "bare" frame so clearly (the library of St. Genevieve (1850) and the National Library (1868) by H. Labrouste in Paris). In 1851, in Hyde Park, J. Paxton built the England pavilion at the World's Fair. The idea of demonstrating the structure in this building was so total that its implementation gave rise to one of the most famous myths of the century - the myth of the Crystal Palace. What usually happens with famous buildings happened - the Crystal Palace became a symbol of itself. D. E. Arkin wrote that “The Crystal Palace was only a demonstration of new building possibilities. Experiencing in front of the palace the same excitement that a man of modern times experienced at the sight of the first steamers, iron bridges, the first electric lamps, and later - the first airplanes" [3, p. 240]. Thanks to this, it also became a symbol of modernity and technical progress, although all its structural details were richly decorated with stylized elements of order architecture.

The constructive features of the building sometimes predetermined the choice of style, which was based on a purely external correspondence to certain historical forms. So for the "decoration" of frame structures, elements of the Gothic were used, and the uniform division of the facades was "decorated" like the Renaissance.

The mytho-poetic aspect (5th) is one of the most difficult aspects of symbolic knowledge about architecture. It is impossible not to agree with A. Rappaport that “in the architectural substance, spirit and matter are fused with meaning. Devaluation of an architectural form consists in the reflective exhaustion of its meaning. When we see in the form only the historical style, only the technical and functional calculation, only the conventionality of the language or the irony of the author, we comprehend its meaning, but this meaning is reduced to something other than the form itself; the latter, remaining its conventional sign, loses its vitality. In order for the substantiality of the form not to be destroyed by its semantic interpretation, or for the semantic interpretation to be inexhaustible, it must send the viewer to inexhaustible semantic contexts. It is this semantic inexhaustibility that the myth possesses" [7, p. 146].

The category "**myth**" is one of the most important in the culture of Romanticism. Yu. Lotman pointed to the **opposition of mythological and historical thinking** in culture. Historical thinking, characteristic of romanticism, is, in his opinion, a conscious attempt to imitate mythological consciousness by means of non-mythological thinking [22, p. 537]. In this regard, the role of mythological consciousness in the culture of Romanticism appears in a rather unexpected perspective. On the one hand, the romantic worldview is trying to decisively destroy the myth of the "triumph of reason", on the other hand, the attempt to create a new myth of "total freedom" is based on the historical perception of culture. Sending their aesthetic ideal to the space of the inexpressibly distant **future**, the romantics drew inspiration from the historical past of culture. The culture of Romanticism was not inclined to create a "language of proper names", but was inclined to reconstruct those already lost by the culture. This restoration of the lost connections facilitated the process of their rational processing and the assignment of certain meanings to them. Thus, in the case of Romanticism, we are rather dealing with an imitation of a myth outside the mythological consciousness than with the period of true creation of myth, which were, for example, the post-revolutionary period of the Soviet Avant-garde or the culture of Western European modernism.

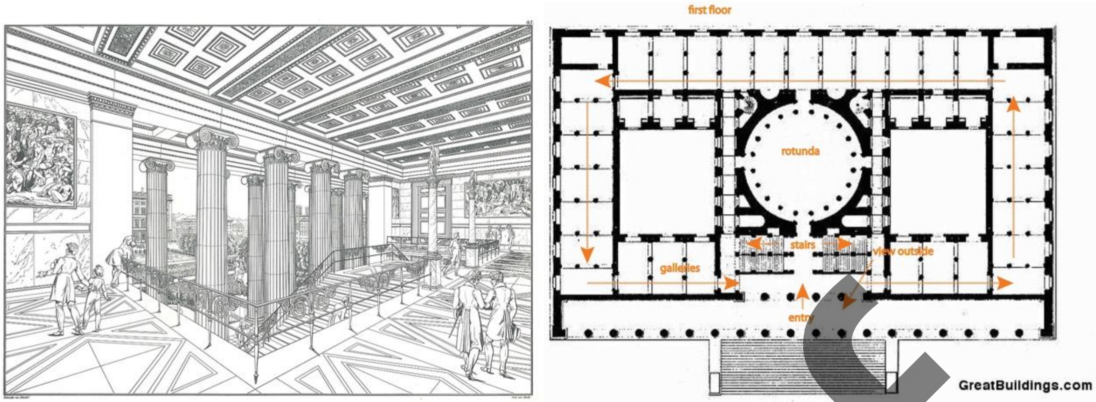
An attempt to reconstruct the elements of mythological consciousness manifested itself in a unique way in architecture. In the era of French revolutionary classicism, the creation of an innovative language of architecture was declared. Considering in this context the works of the famous French architects E.-L. Boullee and C. N. Ledoux, it is necessary to point out the fundamental difference in their methods of creating a symbolic series of their works. E.-L. Boullee had a rather metaphorical, historical thinking, and C. N. Ledoux demonstrated a mythological approach in a number of his works. E.-L. Boullee, driven by the idea of creating ideal containers for ideal functions (metropolis, museum, library, cenotaph, lighthouse), turned to the symbolism of ancient cultures. Its expressive figurative system, based on the translation of cultural tradition, even nowadays allows to decipher the inherent system of symbols. In the project of Cenotaph Newton E.-L. Boullee, the sphere has a threefold meaning: the chthonic symbol of the circle, the symbol of universal gravitation, the symbol of immortality. In other projects, the sphere likewise personifies loneliness, justice, equality, wisdom, etc.

In contrast, C. N. Ledoux constructs his system of symbolic meanings in a paradoxical way. Developing his own architectural language, he uses architectural forms, for which completely different meanings are assigned in culture, to broadcast essentially everyday contents (the house of the keeper of the fields, the house of the cooper, the house of the coal miner). To introduce a new language, C. N. Ledoux uses a kind of architectural commentary vocabulary, in which he assigns his own system of meanings to certain forms. But this vocabulary is very local. It applies only to the work of C. N. Ledoux himself. This is evidenced by the fact that K. N. Ledoux's attempt to rewrite the symbolic tradition has remained a unique rudimentary branch in the history of architecture. The myth always rises above the individual consciousness and a truly new mythology is needed to create a new language in architecture. This became, for example, the mythology of the twentieth century for the architecture of modernism [23-25].

"Reading" the structure of the building is provided by **the compositional and syntactic aspect** (6th). The clarity of the spatial structure is one of the criteria for architectural quality. The architecture of the Romantic era is characterized by the correspondence of external and internal, the search for artistic and expressive means of combining form and content. E.-L. Boullee and C. Ledoux also possessed clear structural thinking. Also among the best works of the era, demonstrating the clarity of the spatial structure, can be attributed to such works of K. F. Schinkel as the building of the Berlin Museum and the palace in Oreanda, Valhalla near Regensburg L. von Klenze, the building of the Burgtheater in Dresden G. Semper [26], (Fig. 12).

FIGURE 12. G. Semper. Burgtheater in Dresden, 1841. (photo Remizova O., 2008).

So in the building of the Berlin Museum, Schinkel develops a clear, holistic composition. The center of the rectangular building is occupied by a rotunda. Light enters it from above, through a round opening. The long row of eighteen Ionic columns on the façade mimics the shape of the Greek stand. A wide staircase leads to the museum, stretching along the entire facade. Visitors climb it first to the open lobby, from which an impressive panorama of the city opens up, and then to the rotunda. The halls of the art gallery form a suite around two open courtyards that fix the longitudinal axis of the structure. (Fig. 13).



a) b)

FIGURE 13. K. F. Schinkel. Altes Museum, Berlin, 1824-28. a) Perspective rendering of interior. Source: [27] and b) schema of plan**.** Source: [28].

Characterization of the features of the symbolic field would be incomplete without identifying such characteristics as the metaphoric nature of the language, "irony", "paradox", the sublime rhetoric of architectural texts. The architecture of the romantic era as a literary text was characterized by such qualities as "irony", paradox, elements of play. V. L. Glazychev noted the presence of these qualities in the creative method of K. N. Ledoux: “One gets the impression that in the works of Ledoux, for all their seriousness, a powerful playful beginning can be traced. This is a game subordinated to the idea of "speaking architecture", the idea of "expression" and therefore not free, but still a game - with a pure form" [29, p. 359]. At first glance, romantics' penchant for irony seems illogical, since the romantic creator is characterized by immersion in the material, and irony presupposes an element of detachment, the position of an “outside observer”.

Romanticism is universal, it stands for overcoming any intolerance, any narrowness. Play and paradox unleash consciousness, simultaneously destroying any stereotypes, include such elements of the human psyche as intuition, insight, fantasy, so highly valued by romantics.

The importance of irony and paradox was comprehensively substantiated in the aesthetics of Romanticism. F. Schlegel was a master of paradoxes and substantiated his addiction to them: “All higher truths of any kind are completely trivial, therefore there is nothing more necessary than to constantly give them a new and as paradoxical expression as possible, so as not to forget that they are still there and that, in fact, they are never fully expressed" [30, p. 21]. Irony is the most important hypostasis of romanticism. F. Schlegel noted that it "arises when the flair for the art of life and the scientific spirit are combined, when the complete philosophy of nature and the complete philosophy of art coincide with each other ..." [31, p. 69].

CONCLUSIONS

The analysis shows that the extraordinary capacity of the architectural texts of romanticism is explained by the special position of the architecture of the late 18th - 19th centuries among other arts, its inclusion in the symbolic context outside the architectural range - ritual, everyday, religious, ideological. In this regard, it is obvious that the proposed system for highlighting symbolic aspects is not exhaustive, but only describes the main meaningful levels of reading the architectural form. In relation to the considered era of Romanticism, this means the appearance of such semantic aspects as fame, triumph, memory, technical progress, the development of building technologies, etc. Their further analysis will expand and deepen our understanding of the language of European romanticism.

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Formation of Viewing Points in Historical Settlements

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Abstract. The article covers the issue of assimilation of natural factors in ancient settlement and buildings, multi-level usage of viewing points in various landscape conditions, as well as their impact on the angle of perception and intensity of the colour. The paper also discuses the role of differentiation and sacredness in the process of choosing of viewing points from the perspective of a dominant. Historical options of existence and living of people in the conditions of a natural landscape are analyzed taking into account the visual perception of the surrounding environment in relation to the horizon line and gravitational laws. The study is devoted to the process of perception and understanding of the term of the visual perception of the landscape as the main characteristic function of human survival and self-defense in nature.

INTRODUCTION

From the point of view of various levels, the perception of buildings and objects is impacted by conditions of settlement and is historically formed by the rugged topography. Development and colonization of lands by humans was, first of all, conditioned by safety reasons. Preservation and development of lands was the direct decisive factor of use of certain territories at the level of the animal instinct. Using of flora and fauna as a main source of human food resulted in development of the system of social settlement, development, and exploitation of useful resources.

The next important factor of multi-level use of lands was the archaic division at the level of the religion and understanding of the sacredness that led the society to a certain differentiation of use of spaces and environments. Usage of the natural topography and conditions of living caused the necessity of multi-level use of the landscape as such what resulted in future in multistorey housing. Limitations of communication in settlements at the visual level raised the understanding of eliteness and exaltation. Development of dominant lands added some defensive and territorial aspects to the special perception of objects by humans. These factors motivated and resulted in restrictions of territories with further development of their defensive functions that transferred into settlements in future. Necessity of visual observation of the surroundings led to the use of natural and man-made defensive objects.

ANALYSIS OF RECENT PUBLICATIONS ON THE SUBJECT

The analysis of recent scientific researches in this area shows that the topic of development of territories in ancient settlements at the level of choosing of viewing points in the process of their enlargement is not sufficiently covered. In his publication, the researcher V. Vecherskyi covers problems of preservation of the historical image of a city, describes stages of evolution of theoretical views on the activity aimed at preservation of the image of the historical part or, vice versa, its reconstruction, in particular the change of the historical panorama, the system of dominants [1]. Ya. Vermenych touches theoretical and methodological problems of the urban science in the historical context and notes that historical cities act as peculiar areas of the positive energy left to us as a legacy, which contain encoded secrets of the efficient interaction of humans with the nature [2]. The scientist N. Shebek covers principles of harmonization of ancient settlements in Ukraine in the context of development of the modern design of the architectural space [3]. Scientists Kuzmych V., Pavliv A., Petrovska J. write about the problem of harmony of the city

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image that is being solved by architects in many big cities of the world. In the process of design of modern public territories, architects face the task of organization of the panoramic or spot-view program of the exterior perception of the city [4]. In their study, V. Kuzmych and Yu. Petrovska considered the role of view points in the multilevel angular perception of the urban environment and the types of urban spaces. Issues of differentiation of angles of perception of the visual panorama and disclosure of the concept of the panoramic scan of the urban environment were also touched upon [5]. The scientific publication “Architectural and spatial environment in the historical settlements of regional significance” by O. Subbotin considers historical settlements as an object of preservation of their unique individual architectural appearance in new socio-economic conditions. The author points to the historical value and important role in the organization of their architectural and spatial environment. At the same time, O. Subbotin notes that the issues of the position of the level of landscape view points and their relationship with the horizon line has not been studied yet [6]. The importance of dominant architectural objects in formation of the urban structure of utopian settlements is partially disclosed in the article by A. Fedak. The author analyzes the general plan of the city called Sun, described in the treatise of the utopian philosopher T. Campannella (1623). The city has a radial circular structure, and the street network is formed of seven circles of residential buildings. The central object is the Temple of the Sun, located at the highest point and being the tallest and most decorated building of the utopian settlement. This Temple has a sacral and ideological significance not only in formation of the utopian idea, but also in development of the architectural plan of the settlement itself [7]. Authors V. Kuzmych and Yu. Petrovska presented some aspects of this study in their reports at international scientific and practical conferences “Viewing points in the evolutionary process of formation of historical settlements” and “The role of viewing points in the urban structure of the city”. At the same time, issues of location of the level of landscape viewing points and their interconnection with the horizon line are still not sufficiently studied [8; 9].

AUTHOR CONTRIBUTIONS

The article is written by two scientists – V. Kuzmych and Yu. Petrovska – and expands previous published studies on the perception and harmony of the urban environment, organization of panoramic viewing sites for observation of the city, since it is especially important in conditions of the complex terrain of historic cities and adds even higher aesthetic value to cities providing them with the possibility of creating existing view points that promote tourism.

This research aims to disclose the issue of development of natural factors in ancient settlements and buildings. Vasyl Kuzmych described the different levels of use of species points under different landscape conditions, as well as their influence on the angle of perception and color intensity. He analyzed the influence of climatic factors and sources of natural light on the formation of the living environment, touched upon the issue of use of dominant structures as a means of psychological influence. Yuliana Petrovska presented graphically designed schemes of location of residential buildings in the landscape, described the objects of scientific research and touched upon the issue of sacredness in the choice of view points from the position of a dominant.

BASIC THEORY PART

The use of natural caves as housing facilities led to creation of artificial cavities in the rocks and organization of the living environment for primitive people. Original accesses to caves were spontaneous and did not envisage arrangement of any communication passages or paths. Subsequently, this type of settlements transformed into a more organized social way of building and organization of housing in conditions of mountain settlements.

Assimilation of underground spaces of human settlements with the use of natural materials became a basis for development of the construction in general. Looking back at the archaic times, when people did not engage in production of construction materials, we can observe the cave-based or underground system of assimilation of the space for settlements of people. One of the examples of such settlement is Vardzia cave monastery of 12-13th centuries on the south of Georgia in Javakheti. It stretches along the left bench of Kura River, having the total length of about 900 meters. The sheer side of the mountain hosts a variety of premises, such as churches, chapels, living rooms and so on, which were built inside the wall at the depth of 50 meters with its height reaching eight floors (figure 1).

Temperature, climate, and hydrological conditions of living were of the utmost importance. At first, the issue of lightning or solar exposure was not solved, except for the fire that initially had the function of cooking food. Later on, people started to use holes, openings, cracks that increased the comfort of the housing. When humans left underground settlements, the new stage of building man-made overground habitation premises began. Relying on the experience of usage of holes, people started to use and adapted the usage of the window as such. Invention of the window not only allowed to provide for internal natural lightning, but also visually broadened the perception of the external exterior space. Therefore, the usage of partially open space acquired the utilitarian meaning.

FIGURE 1. Vardzia cave monastery of 12-13th centuries on the south of Georgia in Javakheti [Drawing by V. Kuzmych]

Construction of religious buildings took place in conditions of the rugged relief. Temples were located on landscape dominants and focused the viewer's attention on the inner spiritual and psychological state, beliefs or religion. Such examples are quite common for the peoples and culture of Tibet, where mountain monasteries were built very actively (figure 2). Later on, the perception of relief inaccessibility and observation of dominants was adapted to buildings of rock monasteries in Greece. The access to them was possible only with the help of rope hoists what required a lot of efforts. Unlike the Tibetan monasteries, where communication routes were organized along narrow paths, in conditions of the Greek mountain monasteries or other structures of mountain dominants the primary load fell on the physical strength of a human. In each of the mentioned options, the visual and observational dependence remained the dominant one, what was dictated by the territorial and food production base.

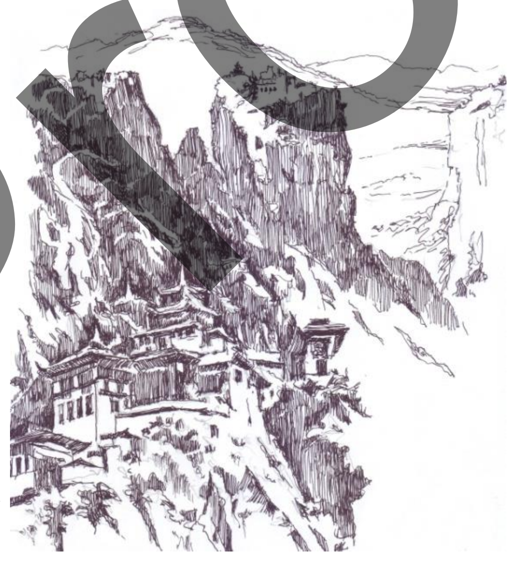


FIGURE 2. Monastery in a mountainous area in Tibet [Drawing by V. Kuzmych]

The geology and relief-and-vertical connection between the residential levels remained an important aspect. They were consciously interpreted as a floor or level of housing, leading to the development of communications, since paths were organized as variable planar levels. Steps acted as a mechanism for balancing of gravitational features characterized by a gradual change in the height of the position on the terrain. Stairs on the terrain served as a prototype of level-sensitive communication aspects of perception of the surrounding environment. The possibility and availability of fixation of a person's physical position at higher points and heights resulted in understanding of the territorial diversity and inaccessibility.

Another object of evolutionary changes was the creation of artificial dominant structures such as pyramids. Many of these buildings have a multifunctional purpose.

In archaic conditions, the use of dominant buildings rising above the general linear settlement was a method of psychological influence, namely the domination above the viewer. Such method was used for the caste division of the society and use of slave labour. Non-standard character of building solutions was characterized by a large number of people involved in the construction process. In order to provide for the required height of temples, large areas were used that acted as a basis for sacral buildings. Dimensions of the foundation of a temple were visually multiplied by the height. This psychological method is still used in construction today. The massiveness of ecclesiastical objects was underlined by the height. The overall visual perception of an object was possible only at a great distance from it reducing the visibility of small parts. When someone approached the building, he or she automatically needed to change the viewing angle and raise the head and eyes. For the purpose of such contemplation, the visual image excluded a great spherical mass of the sky. The eyes were fixed on blocks, parts, details. The close distance perception was opposite to the panoramic one. A quick change of the height position led to the quick change of the angular capture of the horizon. At a certain level, the notion of tribunes formed that envisaged power over people masses. For example, the North Acropolis that is now a part of Tikal National Park in Guatemala is one of the most ruined ancient cities of the Maya civilization. Its golden age fell on the seventh century of the Christian Era. Its complex included various buildings, such as temples, altars, pyramids that had a common large stone foundation. The main square surrounded by ancient buildings was located in the center of the city. This architectural complex includes 37 buildings located around the Maya pyramid that reached thirty two meters in height and was one of the oldest in the city. Stone columns and altars were situated in rows on the square near the foundation of the acropolis. Tikal was one of the biggest cultural, political and residential centers of the Maya civilization. The monumental architecture in this place started to appear already in the fourth century BC (figure 3).

FIGURE 3. The North Acropolis of Tikal National Park in Guatemala [Drawing by V. Kuzmych]

Stepped pyramids were widely used as a tool of the vertical comparison of the social opposition. These buildings helped to express signs of financial prosperity and psychological superiority, what contributed to the stratification and differentiation of the society. The social gradation was emphasized by the forms of pyramidal structures, where the social status showed the level and wealth of a person in the society. The example of the amphitheater helps to better understand the social stratification and public subordination in the context of access to information. The change of a physical position or limitation was subject to the status differentiation and visual or acoustic access. The amphitheaters in Greece and Rome strengthened the unifying role of the society and at the same time contributed to a certain stratification of it. This technique was used in theaters, amphitheaters and other sports and spectator facilities (figure 4).

FIGURE 4. Roman amphitheater in Bulgaria [Drawing by V. Kuzmych]

Grandiose and multifunctional buildings were built on the territories with a large amount of stones of different densities as the main building material that ensures the durability and long-term operation. The world's pyramidal structures were focused on the social differentiation and psychological impact on the masses. The social status was emphasized with the help of the construction, while the caste affiliation had a visual and psychological impact. Construction of utilitarian aesthetic structures that served as a demonstration of the greatness of certain cultures and religions was based on certain religious beliefs and convictions. These buildings were accompanied by utilitarian aesthetic and artistic aspects or acoustic and visual features.

In the Middle Ages, the methods of using the height of the terrain in construction of defensive structures were preserved. Areas where the dominant position of the terrain offered the presence of planes for construction were actively cultivated. This was especially true of fortification complexes that also performed the defensive or sacred function in addition to the housing one. This approach allowed for a separate isolated living and the possibility of observation of distant spots. The use of high-rise buildings, including towers or rocks, played an important role in observation of the surrounding environment.

When one changes the vertical position in landscape situations, the perception of similar perspectives will be totally different since other component parts of territories become included. In this case, the angular capture and the depth of the horizon were important directly impacting the factor of survival. Judging from the example of defensive objects of the castle construction, not only the strength of walls and banks was important, but also the possibility of visual observation of surroundings. In these cases, defensive-and-lookout or observation towers were widely used. They gave the possibility to deeply investigate the surrounding territories that leveled out the factor of unexpectedness during the city sieges. The conscious use of multi-level viewing points had not only the visual and aesthetic function, but also the utilitarian and defensive function. The character of the relief and the nature of the landscape provided the additional choice of viewing positions and the possibility of proper observation over the surrounding space.

Complication and limitation of physical accessibility provided for the defensive function of a building. In these cases, it was important to have observation towers that allowed to increase the radius or angle of observation. In the time of absence of optical devices, such construction techniques together with the arrangement of viewing platforms played an important role in high-rise observation facilities. Palace complexes were also considered as fortifications. The Escorial complex in Spain was built in the 16th century as a monastery. It served as a palace and a fortress at once. Its location on the hill provided a comprehensive visual coverage of the surrounding area. Landscape features were successfully used in the construction. A large number of windows allowed for the circular defense and panoramic observation. Religious buildings organically fit into the planning structure of the complex (figure 5).

FIGURE 5. The Escorial in Spain. Royal family vault [Drawing by V. Kuzmych]

There are construction objects with rock temples or monasteries erected in extremal conditions and in inaccessible zones what was reasoned by needs of survival and organization of household. However, such physical inaccessibility was compensated by peculiar non-standard views of the horizon. The Alcázar of Segovia is one of the examples of such medieval fortresses. Alcázar is a local traditional name of a castle. In the past, it played a role of the royal residence for a certain period of time. The castle is located on the outskirts of the modern city and at the edge of the rock above the confluence of two rivers. in Spain The first mention of the Alcázar is dated by the 12th century. At that time, it was just a wooden fortress. In the times of the Ancient Rome, a small military fortification was located on its place. During the reign of the King Alfonso VIII of Castile, stone walls of the fortress were built, and the castle of Segovia became one of the most inaccessible in Spain. Nowadays, the visitors of this castle can enjoy the best panoramas of Segovia and its surroundings, having climbed on the highest tower of the castle (figure 6).

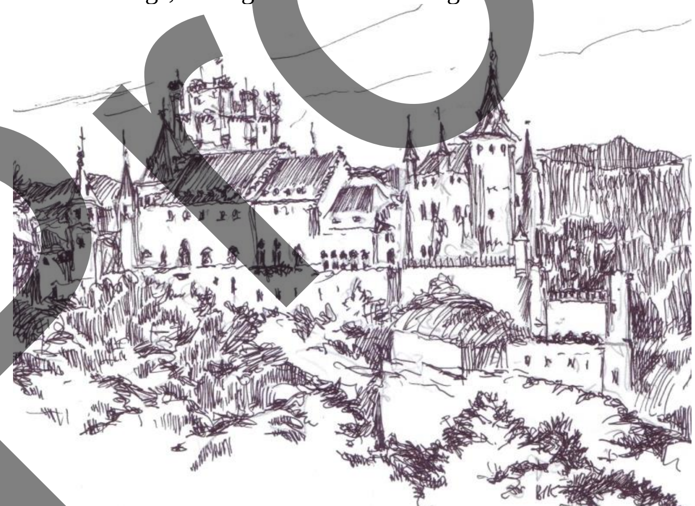
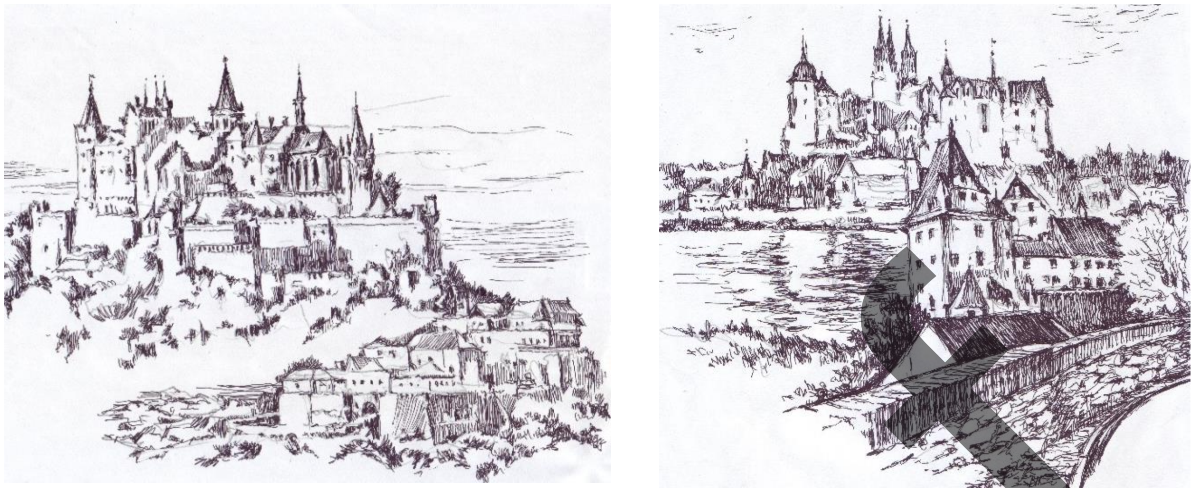


FIGURE 6. Alcázar Fortress of Segovia in Spain [Drawing by V. Kuzmych]

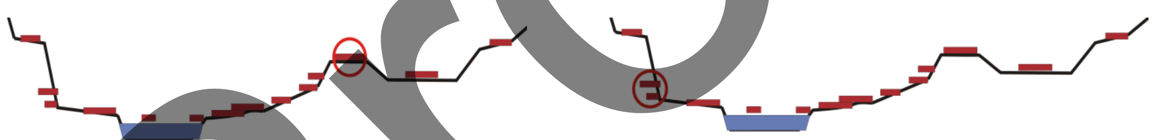
The presence of small building plots in conditions of the mountainous terrain and access to water resources led to the consolidation of the city planning structure and development of the sacred and defensive function. An additional role was played by the insolation of the territory and presence of the fertile land, where vineyards were often cultivated and cultivation of cereals was the crucial factor. The large observation radius of agricultural sites was of great importance, what can be well observed in the territory of Italy. In addition to the defense function, arrangement of viewing points also had the agricultural importance. Along with this important option of building of cities, settlements that combined functions of transport arteries on reservoirs and rivers also existed. Sea routes allowed to organize the trade communication (Figure 7a, 7b).



(a) (b)

FIGURE 7. Medieval castles on the landscape dominant:
a) Location on the hill b) Location above water [Drawing by V. Kuzmych]

The authors demonstrated the schemes of location of residential buildings on the terrain. Staying of a person in a certain environment is conditioned by the ability to visually perceive a certain panorama. The diagram illustrates the options for location of buildings in relation to the terrain. The use of these location conditions is stimulated by the nature of the terrain and the hypsometric situation of the terrain, what is actively included and used as a condition of staying in certain visual characteristics (figure 8).



a) b)

FIGURE 8. Layouts of residential buildings on the terrain: a) layout of housing on the mountain; b) layout of housing in the rocks [Author's schemes]

CONCLUSION

The common patterns of preservation of dependence between the angle of object observation and the linear distance to the object impose their tonal correlations of colouristic values. Linear and tonal correlations, angles of focusing on the object and sharpness of perception have a significant meaning in this process. Accordingly, while observing the viewing points at a small distance we obtain a more contrast detailed correlation oriented at a precise tonal perception of the object that includes a maximum number of tonal colour contrasts. In this case, angles of perception of architectural objects will be bigger, so they are often followed not only by the change of position of the eyeball, but also by the change of the angular position of the head. The observer is forced to lift up the head thus focusing the eyes at the specific fragment of the object. In the process of choosing of the viewing point that is aimed at demonstration of specific details, the elevation view is planned with the maximum expression of certain information about the architectural object. In this situation, the point of the overall perception of the building is important.

The presence of viewing points in the urban structure of the city gives the possibility of the tonal and dimensional correlation of the surrounding horizon. The eye focus is changing continuously adjusting the angle of focusing and sharpness of the vision to the specific observation object, thus balancing the energy flows coming into the eyeball.

Enrichment of colour flows of different temperature regimes and visual balancing of the observation panorama are taking place in the tonal context. A human can better absorb different-frequency energy flows by keeping the balance between contrast and nuance correlations. The spherical nature of the observation mechanism gives the eyesight stereoscopy a number of indisputable advantages that are reflected in the overall contemplation of architectural objects and panoramas. By leveraging different-wave visual flows, a human obtains the maximum flow of energy balanced signals having the therapeutic action. Therefore, in the process of design planning of the urban space it is important to adhere to planning and standardizing common patterns and insolation requirements.

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The Phenomenon of the Street as a Polysemantic Spatial Element of the City Planning Structure

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Abstract. For a long time the street performed purely functional duties in shaping urban environment. Historically, it was the trajectory of the transport and people flows, but not only, since the street symbolized the border between the private home space and a variety of public urban spaces. It was conventionally responsible for the links between major city spaces, connecting functions and social groups. However, the modern street is not only an integral part of the city planning structure but also a multidimensional city element, which unites functional, spatial, compositional and other aspects, related to the continuous improvement of the city functioning efficiency as a living space, where each new architectural intrusion in the historic context of the city, which has extensive legacy, is related to complex changes. In the modern city, a modern person seeks to improve their comfort and safety. The architecture opens up the horizons for creating, studying and their implementation in the streets formation, which are necessary for the development and enhancement of the modern city structure in connection with the contemporary conditions and needs.

INTRODUCTION

The problem of comfortable street environment emerged as early as in ancient cities. Transport continuously suppressed and limited passers-by, and upon the invention of the automobile, it became a full master of the city, imposing its rules and requirements. By the middle of the twentieth century, centennial pedestrian rules had been destroyed. Original intentions, types and classification of streets evolved, information content intensified while compositional, spatial and functional relations became more complicated.

During the evolution of historically formed major cities there emerge various problems to be solved to improve city structures. A *living organism* of the urban environment as a complex functional and spatial system of the interrelated parts of the city shape is the continuously changeable spatial model of the existence and activities of its population (similarly to the living tissue that develops due to the growing number of cells, urban *tissue* develops owing to the multiplication of blocks, where streets are intercellular links). The needs of a modern city are growing and getting increasingly steadily complicated: transport traffic is intensifying, construction development is becoming more and more dense etc. Architects have long been looking for the solutions to city planning problems in the projects of future cities. For instance, in the ideal city design, Leonardo da Vinci was the first to suggest dividing the street into several levels for the rational distribution of functions: engineering infrastructure, pedestrian and transport traffic flows. This idea, supported by the leading creators of later periods, e.g. in the future city design, L. Hilberseimer actively developed the idea of the vertical street, and he is still thought-provoking for the creators of the contemporary urban street network.

Nowadays, the urban space is distributed extremely disproportionately compared to the volume of traffic. The "imposed automobile mobility" leads to higher expenses (financial, time etc.) and covering long distances to the newly developed cultural and domestic facilities, located in the city outskirts. That means that on the whole, the most important city planning tasks of the contemporary city are: the improvement of transport availability, integration of the urban space, the reduction of the structural-and-planning disagreements. City planning structures of large cities have complex infrastructure, which unites separate subsystems: composition, spatial, functional, transport etc. in the harmonious whole, where the safe and reliable population mobility is one of the top tasks. In this system, buildings

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and facilities are equal in their interaction, as well as the space of the streets, crossroads and squares, where the street is a long, city traffic oriented system, designed for dynamic space, which is contrasted with a closed intimate space of the yard.

A space of modern city street is a multilevel phenomenon, as it forms a system of interrelated spaces. Any street is embedded in the city space and composition, in the structure of cultural-esthetic impressions and architectural and art values. Ultimately, the street as an element of the urban structure is the main public communicative space that unites not only physically or functionally, but also semantically all objects of the city structure, constantly for decades to centuries.

Research Relevance and Novelty

Currently, it is possible to observe a trend for the revival of urban commercial activities, accompanied with the construction of the corresponding facilities and the organization of respective spaces. The topic of multipurpose street spaces in the structure of the modern city is a most burning one. Street space in the structure of the contemporary city planning environment is an integral part of not only compositional, functional, transport and aesthetic city structure, but also the most important element of its communication structure.

Numerous studies of the architecture theorists from Leonardo da Vinci, C. Sitte [4] to E. Grushka [3], V. L. Antonov [1, 2] and S. O. Shubovych [6] etc., describe the specifics of the street spatial organization (V. V. Kratyuk, N. H. Polyakov), single out the stages of its development (E. Grushka), the ways of space formation and interaction in the city structure (C. Sitte), planning specifics of forming the city structure (V. L. Antonov), artistic features of shaping the composition and space (S. O. Shubovych).

Urban environment is a complex functional spatial system of inherently interrelated parts of the city. This system involves equal interaction among buildings and facilities, as well as the space of streets, crossroads and squares, where the street, as a long, city traffic oriented space, contrasts to the closed intimate space of the yard. For a long time the street performed purely functional duties in shaping the urban environment. Historically, it was the trajectory of the transport and people flows, but not only, since the street symbolized the border between the private home space and a variety of public urban spaces. It was conventionally responsible for the links between major city spaces, connecting functions and social groups.

The rapid development and change of modern large cities complicates their perception as a single unified ensemble. Once, relatively small sizes of cities enabled not only visual embracing of its composition and the silhouette from afar, but also easy navigation in its structure: according to the location of landmarks and noticeable facilities as well as according to the changes in street spatial gradations. The most ancient urban settlements, which appeared in the VII-VI millennia BC, were not actually cities in our modern, and their spatial arrangement was formed by mutual location and relations between streets and squares. Streets and squares appeared in settlements much later, and ancient Greeks created the prototype of a square – the agora, while ancient Romans *discovered* a street as one of the vital elements of the city structure.

Types of street spatial organization

Historically, the classification of streets as urban communication lines, was understandable and simple. Streets were main or secondary, where the former performed the role of the compositional city structure drivers. There are various examples to prove that and they are well known. Suffice it to recall “Cardo” and “Decumanos”, and the memory draws a number of rectangular structures of Roman camp towns or a great “triple-ray” city planning ensembles of Rome, Versailles, Petersburg, or a complex composition of Ringstrasse in Vienna. The historic development of cities defined not only different street compositional systems but also their functional and spatial types, meanings and influence, which they have on the overall city planning structure.

The street is a spine of urban life, which, along with squares, is an essential urban space. It is a unified public space with established and enforced urban common public rules. Considering the phenomenon of the street space, it is possible to conclude that a street serves the foundation for the city integrity as a spatial structure and the city as an urban community. An important part in street arrangement is played by the regularities of the spatial structure of squares, since the space of any street may be made of several local units, similarly to a square. However, the street, unlike the square, has a vital urban and psychological feature, i.e. dynamics. The street space conveys certain meaning and, in addition to the main communicational intention, it performs additional functions: navigation, encouragement of the movement or refusal from it, expectation and preparation for getting into the space of the new environment. That way, depending on the nature of meaning the street space may have different features.

Guiding spaces (or spaces with guiding properties) are those of streets, which have diverse and aligned dynamics. Street guidance property is in person's continuous perception of the street space as familiar, understanding their whereabouts in a recognizable area within the city. When traveling across the city and changing visual landmarks, a person has a feeling that the environment is familiar. In the general system of person's orientation in the city environment three groups of spaces are actively used: landmarks, panoramas and routes established in personal memory. Streets are considered to be the best ones, whereas the most spectacular orienting and guiding factor is a street space bending, which promises a new view and impressions after the turn. Prominent dominant points in the skyline that appear in streets serve as distant landmarks.

The historic development of cities determines not only different compositional systems of streets but also their functional and spatial types, significance and impact that they have on the overall city planning structure. The history of street formation, which involves its functions, significance, scale stereotype and information load, even if these gradually evolve, defines the contemporary street *dimension*: its appearance, life pace, emotional spirit, and architectural space composition.

Street spatial structure as a communicative element

Within the topic of this study, it is worth dwelling on the aspect of street forming as a part of the city communicative structure, which changes with time. A street is a complex of space and composition elements, formed along the line of communication. This is not merely the vector of transport or pedestrian flows and traffic, but this is the environmental space for a modern person. The architectural composition and spatial meaning of streets depend on the layout of spatial objects and architectural organization of the space where segmentation and disruptions, rhythmic and proportionate combinations, scale stereotypes that create three-dimensional gradations and emotional perception. The study of the history and development of cities enables to roughly divide them into several spatial types, which determine the main principles of urban spaces organization.

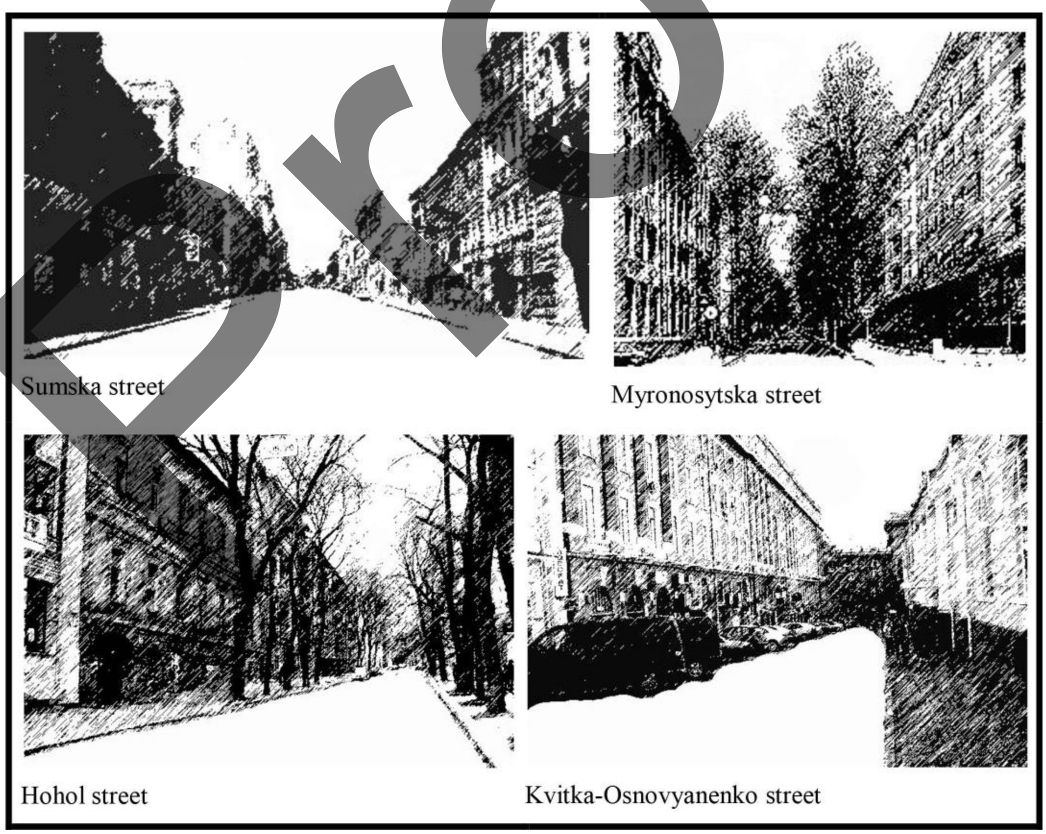

FIGURE 1. Views of a *corridor* street structures in the historic part of Kharkiv city. Author's drawings by author's photos

The spatial structure of a historic street is a *corridor street* with continuous flanking built up area determined by the need to manage and arrange blocks and build the hard road. Corridor-type development shapes the street only visually and unites street facades, but it does not provide an integral and appealing architectural and spatial solution. Vivid examples of such streets can be found in the historic hillside part of the center of Kharkiv: Sumska, Pushkinskaya, Korolenko, Rymarska, Myronosytska, Kvitka-Osnovyanenko, Hohol and others, where the continuous built-up front is perceived as protective "screens" of their composition and architectural solution (fig. 1 and fig. 2).

A corridor street may be transformed into another type, an *anfilade street* (ensemble), where the space is formed by a number of united *corridor* sections, local formations with essential urban planning and psychological features – dynamics and rhythm (pulsing and breathing). Such a street type was formed later and was better developed, since its emergence was due to the need of complex spatial, artistic, esthetic and compositional architectural spatial forms. The examples of these structures may be found in Kharkiv in Skrypnyk street, Radnarkomivska street, Romen Rolana street, Damilevskoho street, Nauky avenue (former Lenina avenue) etc. (fig. 3).

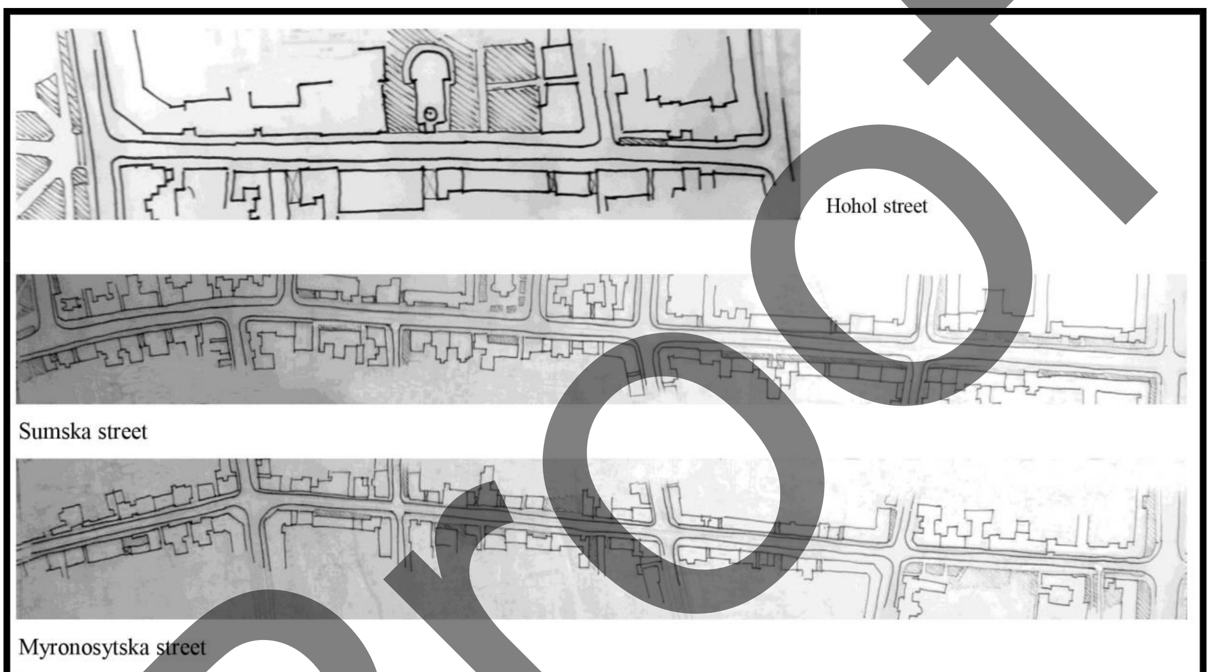

FIGURE 2. Schematic plans of corridor street structures in the historic part of Kharkiv city. Author's drawings

Romen Rolana street and Nauky avenue run from the major historic urban space, the ensemble of Svobody square, which use their magnificent variable-size portals to gradually transit from the scale of the square to the scale of Nezalezhnosti (Pravdy) avenue, and further to a street or avenue, respectively. For example, Nauky avenue, which use to have a boulevard structure with clear green wedge, a working alley and small recreational areas, is a range of architectural space complexes. The spatial composition of the avenue begins from a picturesque Derzhprom ensemble and flows into the facilities of medical and radio-electronics universities, a lyceum, hotels (National and Myr), the facilities of design institutes (Hyprostal, Kharkivproyekt, Kharkivrekonstruktsiya etc.). This composition results in the bright spatial complex of the Nativity Church. Each *participant* of this space chain has their special three-dimensional solution, function, structure, meaning and significance. They are united by one thing only – the integral architectural spatial image of the street as an anfilade of spatial ensembles, comprising a single compositional axis within the city structure (figure 4).

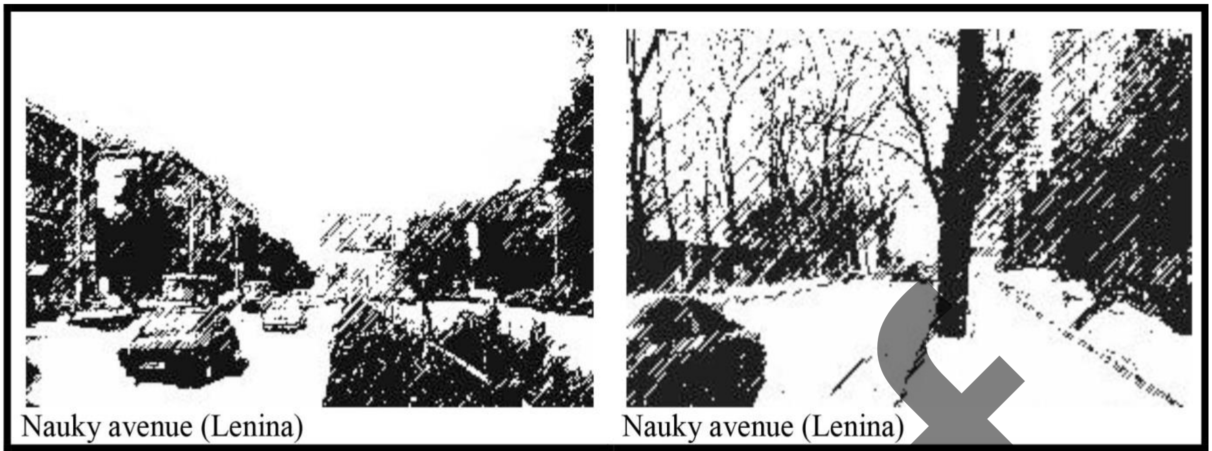

FIGURE 3. Views of an *anfilade* (ensemble) street structures in Kharkiv city. Author's drawings by author's photos

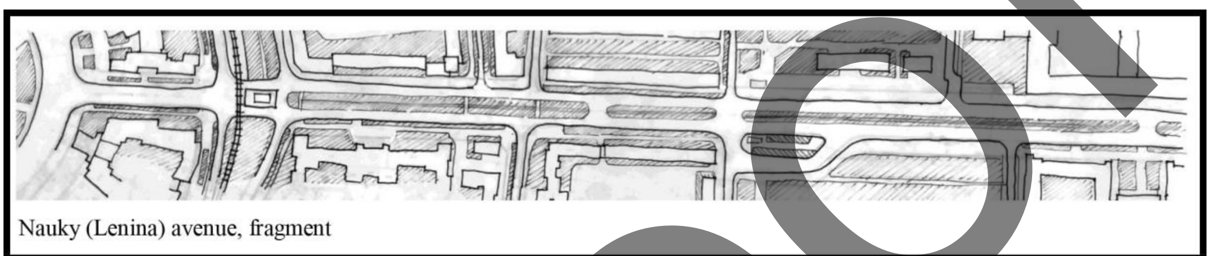

FIGURE 4. Schematic plan of an *anfilade* (ensemble) street structures in Kharkiv city. Author's drawings

Another transformation of a classical corridor street is *a boulevard (alley) street*, which historically emerged as a *promenade* – the central walking area, complemented with a clear cut green wedge with a walking alley, various recreational spaces and grounds. This street type united the two above ones: the classical corridor street and an anfilade (ensemble) street with a recreational area, spatially and compositionally. It enabled the diversification of architectural street patterns, providing them with *natural breathing* and coloring, as well as the emotional balance to city dwellers. The samples of these architectural space structures beyond the historic center of the city of Kharkiv include Yurieva boulevard, Moskovskyi avenue (the *Alley of Giants*, which unites a multi-kilometer line of industrial facilities within the city from bicycle to tractor plant), and Nezalezhnosti avenue (former Pravdy avenue), in the historic part of the city (figure 5 and figure 6).

FIGURE 5. Views of a *boulevard (alley)* street structures in Kharkiv city. Author's drawings by author's photos

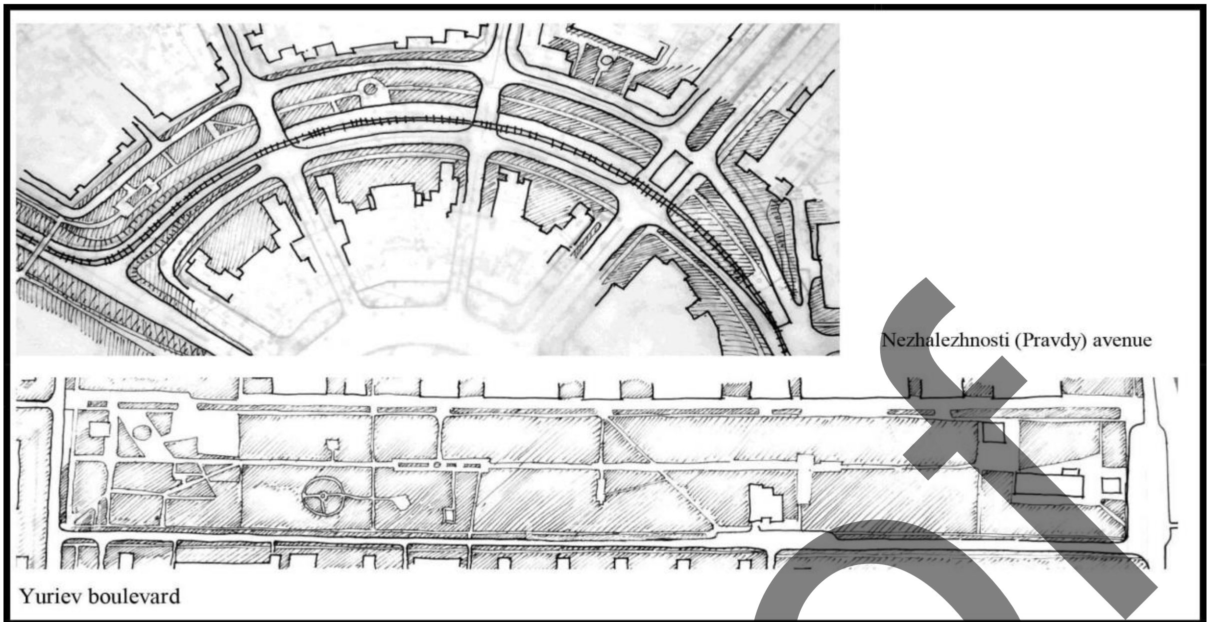

FIGURE 6. Schematic plans of a *boulevard (alley)* street structures in Kharkiv city. Author's drawings

However, in the twentieth century, the traditional corridor street with two sidewalks, flanked with high-rise buildings, disappeared. Modern city development started creating new types of public spaces – a living urban space – that one of flows: the flows of people, events and actions, communication of citizens. At the same time, historic streets were adapted to the growing transport traffic. Currently, the central street of the city aims at organizing the increasing public, automobile and pedestrian traffic flows more efficiently. Thus, it is evident that some streets are becoming very busy and even overloaded, while others, vice versa, are losing their once busy life, growing emptier and quieter. On the other hand, free space enables to travel more easily to remote streets or facilities. That way, the concentration of city dwellers increases in certain parts of the city and in some streets of its center. In a modern city, the issue of orientation and related anxiety and fear, which indicate the close relations between the feelings of balance and comfort, is nearly impossible. A person is supported with the presence of other people, special city facilities play the navigating role: layouts, determining the person's location within the city or its central part space; street names and building numbers, which may play a decorative role and be a part of the line of recognizing the space; as well as signs on public transport stops. For instance, in Kharkiv, it is possible to identify personal whereabouts within the structure of the city center using navigation schemes on public transport stops.

Street functional types

Streets are classified according to their functions. They comprise certain types, categorized by their special compositional and spatial structures. The variety of functional processes within the city requires the diversity of spatial forms. A street is not only the road, a linear unit of the urban infrastructure, sided or flanked with rows of buildings and facilities, green and industrial premises, in other words, it is a public space. In central streets thousands of pedestrian and transport flows cross daily, as this is the circulation system of a modern city, the main transit way, one of the essential hot spots, a meeting point and a ground for large-scale city events. Every new manifestation of the human functional space activity, regardless of its complexity, finds its niche in the city environment, and, respectively, in shaping the spatial structure of the modern city.

Considering city evolution and development, it is possible to divide them into two types, which determine major principles or organizing urban spaces: 1. cities with irregular, free planning; 2. cities with regular planning, built according to a designed model. However, it is to be kept in mind that a city is a *living being*, its spatial model and human activities change continuously (similarly to a living tissue that develops due to the multiplication of cells, the urban *tissue* develops due to the multiplication of blocks, where streets are intercellular linkages). The similarity of organic and urban systems was noticed in 1963 by professor E. Grushka, who compared the structure of sprawling medieval cities with a muscular tissue cross-section. Therewith, street environment ensures the exchange and distribution of products, raw materials (trade) and information. The street space enabled products distribution throughout the city. Streets performed the social communication function for city dwellers. That way, any street can be regarded as the city intercellular fluid, whose main feature is the exchange and *gluing* of various elements into a unified integrated structure [5].

Historically, the main formed types of streets were: commercial, city and neutral lines. The most common and important type of street space was a commercial street with commerce being its core activity. A commercial street unifies the urban environment, *nourishes* its blocks with everything they need. It is to be noted that a craftsmen street with workshops on the first floor has a peculiarity – a bending flow from one shop to another (across or along the street flow). In turn, the longitudinal flow is here secondary and it is determined by the street parameters: its length and width. A street is normally rather narrow and includes a number of blocks. An urban street emerges when the city that benefits from commerce is interested in this activity, while its participation is manifested in providing the space (site) within the city [5]. Examples of such urban streets are the so-called *long markets*. E. Grushka showed the evolution of such space, which served as the road to the castle. It was gradually built up on both sides: at first (in the IX-X cc.) with huts, between which there still were big gaps, then (in the XII c.) there appeared denser lines of buildings, and, eventually (in the XII-XIV cc.), in the middle of this space there emerged a city public center with a church, a town hall and a system of commercial squares [3].

Street classification, types and categories

Streets are classified according to their functions and they are divided by types and categories, which reflects their spatial structure. Thus, they may be: city, town or village. City/town streets, in turn, are classified as follows: the main city/town trunk street, a district trunk street, a major street, a local street, an inter block street, an inner block street, a residential street, a tram and pedestrian street, a pedestrian street, and a bicycle lane. Village streets: main streets, residential streets and passages.

Streets are also divided into types: alley, boulevard, embankment, descent, access road, road, entrance, ring road, line (lane), ray, trunk, quay, perspective, square, passage, avenue, by-street, crossing, hillside, territory, passageway, cul-de-sac (dead-end street), street, motorway. Street names and their types are quite abstract. Moreover, street appearances change along with the urban development and the erection of new buildings. A by-street, for example, may stop being so, but the name can stay the same.

Streets are categorized: from large trunk streets and roads to residential, park and even bicycle lanes. The main streets are normally highlighted within transport-pedestrian and pedestrian ones, and they underlie the architectural development plan of the city center. Central streets may be divided into four main types: in the blocks with micro-district units, in the blocks with perimeter development, in the residential estate blocks and pedestrian ones. The diversity of functional processes in the city leads to the development of the diversity of spatial forms. Each new manifestation of human functional space activity of any complexity finds its niche in the urban environment.

CONCLUSION

The architectural and space arrangement of the city street and road network composition is one of the essential areas of modern city planning and reconstruction, related to the solutions of the most topical transport and environmental problems. The abundance and variety of architectural composition solutions for city streets encourage conservation and renovation of the integrity of the city development tissue, considering the already formed patterns of modern urban social and commercial functions.

The future of the street is in its varied significance, in the contemporary image of the urban space, as well as in understanding the history of the street and the city on the whole and its modern changes, which it undergoes: life styles change, residential and industrial built-up areas are scattered. Instead traffic intensity and mobility increase while the transport and pedestrian systems get more complicated. Hence, streets are embedded into the system of various public spaces, which are sensitive to the competition within the city center. A modern street is a multilevel phenomenon, as it forms a system of interrelated spaces, it is a complex structure of micro-spaces with its inner ways and vectors, life paces, as well as information and time perception.

The *polysemy* of the street as a spatial element within the communication structure of a modern city is related to its significance and historic value, and it depends on the city space, where streets are interwoven at different levels, scales and cultural – esthetic contexts that cannot be understood without understanding the integrated structure of the city ensemble. Any street is embedded in the city space and composition, in the structure of cultural-esthetic impressions and architectural and art values, in the road network and city development strategy, in the functional structure of spaces for recreation, residence, work, commerce, engineering etc.

A street is a communicative form of an urban space, which has its own configuration, architecture and history, as well as serves a meeting place. It is impossible to realize the meaning and spatial composition of a modern street ignoring the consideration and analysis of its history, partially determined by its function (commercial, craftsmen, office etc.), even if it has changed with time. The structure of the modern city implies equal significance of the pedestrian and transport flows, since they are the parts of the single urban frame. The organization of the multi-faceted functioning of urban street network spaces is among the most important issues of modern city planning, development and reconstruction, related to the solution of the most burning transport and environmental problems. The polysemy of the spatial composition of city streets promotes the conservation and renovation of the integrity of the city tissue, considering the already formed patterns and contemporary social and commercial urban functions.

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Predictive Component of the Architectural Stylistic Formation Depending on the Realities of Society

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Abstract. Stylistic peculiarities are the attributes of society at the crossroads of history, socializing with certain cultural and political events. The impetus to change the style and trends in society can be characterized by various features of the original source: technical progress or the emergence of new designs and materials, architecture in general and in its branches, philosophical trends, even military movements. By the method of interpolation and superimposition of the process of historical change of styles on the socio-economic structure of society, three general principles of formation and development of stylistic differences in architecture and design are obtained. The principle of gradual development - the style arises, develops, reaches its peak and gradually declines, this process can be represented in a graphical interpretation - a bell-shaped Gauss curve. The principle of the pendulum - the obsolete style is replaced by a style with completely opposite features, like the movement of the pendulum - from one extreme point to another, and then back. The principle of the spiral - the development and reminiscence of architectural styles is progressive and upward at each new stage of social development, repeating previous styles at another level. With a conscious understanding of the historical development of changes in architectural styles, we can predict the next stages of evolution of styles change, prepare for them and, if possible, integrate into various forms of culture, art, technology and other spheres of human life.

PROBLEM AND RELEVANCE

The problem of the research is the complexity of the layers of mixed factors influencing the emergence and change of styles, variations and accents in the stylistic features of different countries given the realities of society of the relevant time and place. The global process of change of architectural styles is accelerating with geometric progression. To comprehend it in form and essence, to imagine the experience of the millennial history of human civilization through the stylistic prism of the material shell of the function – a complex task that a number of researchers are trying to solve using different concepts and authorial experience [1].

Style, in whatever field of culture it is studied, is certainly a symbolic and aesthetic category, developing according to its laws, concepts and principles. Stylistic features are the attribute of society at a certain point in history, socializing with relevant cultural and political events [2]. Some impetus to change of the style and trends in society can be characterized by various features of the original source: technical progress or the emergence of new designs and materials, architecture in general and its branches, philosophical trends, even military movements. For each direction you can find and trace its origins and relevance. By exploring the development and change of architectural styles, science makes it possible to predict the next steps in the evolution of this complex process, prepare for them and, if possible, integrate into various forms of culture, art and even technology.

Usually, states have socialized the artistic space according to certain doctrines of culture, while individual authors-creators have differentiated artistic manifestations according to taste and market characteristics. Such trends have also often been the source of the historical essence of the moment [3]. Along with the well-known styles and in parallel

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with them there were also various stylistic directions and currents. Some prominent personalities could create without fitting into the dominant style of their time. Thus, a separate current or even a separate direction was formed.

2. MAIN SECTION

Stylistic differences are most evident in the architectural environment that always surrounds humanity. Whatever field of activity and profession the individual belongs to, he is under the constant influence of this environment. A person is simultaneously the author, user, observer of his environment [4].

The history of architecture began at the dawn of human existence. Let us pay special attention to an important aspect - the tendency of acceleration inherent in the process of changes in architectural styles. Ancient Egyptian civilization ruled for three millennia, not counting the other two millennia of the pre-dynastic period. The strong statehood of Egypt allowed the creation of certain images of the era and buildings that have stood the test of time. The heyday of ancient Greek culture lasted almost a millennium and a half, Roman and Byzantine cultures - about 800 years. And then the process of changing one architectural style by the others begins to accelerate almost exponentially. In the period from the 19th century and to this day the styles are changing rapidly and coexist in large numbers and diversity [5].

The number of styles that have emerged over the five millennia of human existence is vast. But it is always not just architecture – it is a complete set of stylistic changes in all spheres of life, because the stylistic component – one of the many influences of the combinatorics of politics, technical development, subcultures, general philosophy of society. Hybridity in society generates hybridity in art and in general lifestyle.

Analysis of the emergence and development of architectural styles and changes from one style to another with the interpolation to the historical and cultural process allowed us to derive three basic principles that determine the patterns of stylistic changes in societies [6].

The Principle of Gradual Development

Any style has stages, or steps of development: it arises, develops, reaches its peak and gradually fades away. The next style usually appears when the previous one starts to decline. Sometimes the next style originates in the depths of the previous one and develops almost in parallel with the predecessor. Styles can successfully exist for centuries or just a few years. The graph shows the duration of a style and the corresponding curve, which shows the indicator of the characteristics of the style – its origin, culmination and decline. Regardless the duration of its domination, each style inevitably unfolds in time according to the principle of gradual development, which graphically corresponds to the bell-shaped Gauss curve (Figure 1, Figure 2).

With a characteristic general graphic pattern of the curve, each individual style has its own individual features of development, culmination and decline, which depend on many factors. Some styles and trends seem to appear suddenly, which can be reflected on the chart by a steeply growing, almost vertical line. There may be a mirror trend, when the style slowly acquires its characteristics, but disappears almost suddenly. Other styles have existed for a long period of time, represented by a curve that slowly grows and declines. The process can take so long that during this time several other styles and directions might have time to appear, develop and disappear.

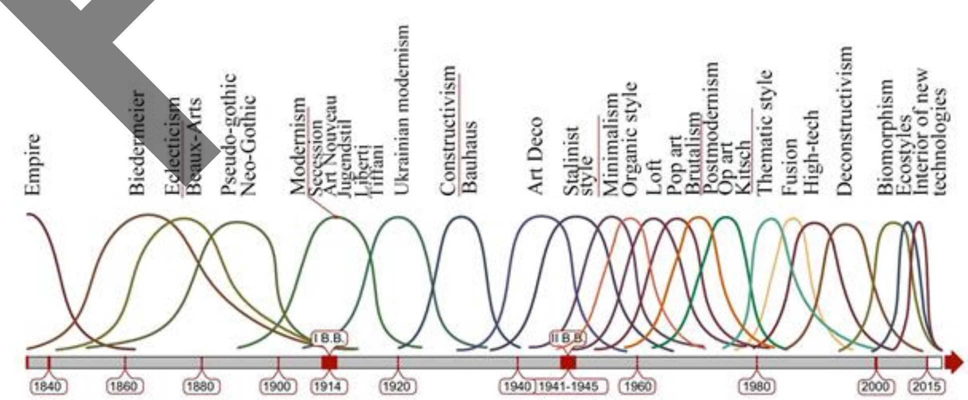

FIGURE 1. Gradual development of architectural styles from 5th century BC to present. Source: Author

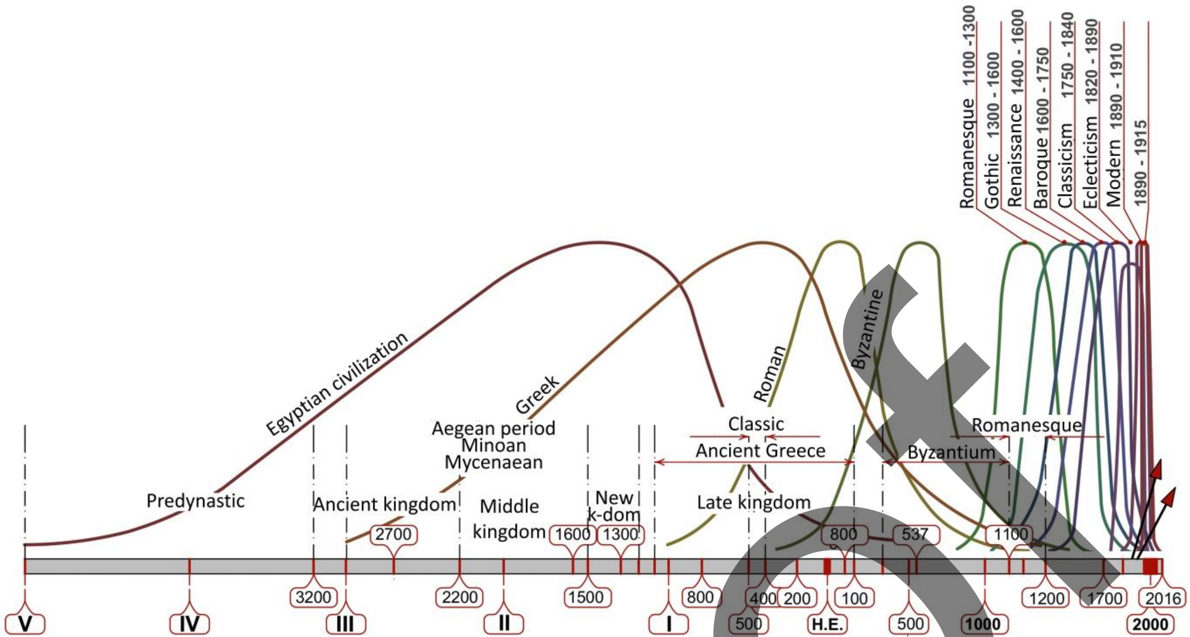

FIGURE 2. Gradual development of architectural styles from the middle of the 19th century to present. Source: Author

Pendulum Principle

The second principle of style development concerns the change of properties and characteristics of style, such as scale, decorativeness, characteristic geometric shapes, lines, etc. It is these features that make it possible to distinguish one style from another. Just as the pendulum moves from one extreme point to another, and then back, the qualities of architectural styles change. The outdated style is replaced by a style with completely opposite features.

To illustrate, let us take the most expressive stylistic feature – decorativeness, which is the main visual characteristic for the perception of architectural scale and form in general. Baroque, one of the most decorative styles, was replaced by classicism. And, at the highest stage of its development, the so-called strict classicism, declared a complete rejection of any decorative manifestations in the decoration (Figure 3). The beginning of the twentieth century was marked by the emergence of a new style, which in different countries received different names: secession, Art Nouveau, Liberty, Jugendstil, modern and others. The style was based on straightly rich decorative techniques. The previous decorative style was suddenly replaced by rationalism, constructivism and functionalism, that strongly rejected decorative techniques in general. That is, the pendulum of history swayed and moved to its second opposite point. But after a while, the pendulum reverses – tired of "clean" surfaces and the simplicity of combining volumes, the decor returns, this time in the Art Deco style. In Ukraine, which at that time was part of the Soviet Union, a decoratively rich style is also established - Soviet monumental classicism, or Stalin's empire style, often with national regional elements in the decor. It is replaced by laconic Soviet minimalism, and then again there is a transition to the architectural style, which provides decorativeness – that is, to postmodernism.

The Spiral Principle

Any social phenomenon in its development moves forward and upward, as if in a spiral. This means that, having disappeared or found itself on the periphery, the phenomenon will eventually return to the life of society, but in a new round of the spiral of social development. The development and reminiscence of architectural styles also occurs based on the principle of a spiral (Figure 4). The most striking example is the situation with the use of classical order systems and planning decisions. The classic order originated in Greece during its heyday. The architects of ancient Rome took as a basis the work of the Greeks and added a simpler order – Tuscan, and more complex – Corinthian [1]. Thus, the first stage of returning the classic order to public use took place. And then, after a long break, there came the time of the Renaissance, and there was a new return of the classical order. The next, the most powerful breakthrough of the ancient classics took place from the middle of the eighteenth century to the middle of the nineteenth - triumphantly passed through Europe, the American continent and Asia, and then went out of use and returned as the foundation of neoclassicism of the early twentieth century. In the middle of the twentieth century (already in a new round of social development, going in a spiral) the classical order was called to life again thanks to postmodernism. The order system remains popular in our time in the form of modern neoclassicism.

Let us note that the classical style, with the inevitable use of the order system and symmetry, appeared in those periods of state formation, when empires ruled, when there was a strengthening of power, often authoritarian. The style seems to become the very symbol of empire, power, the militaristic essence of the state. It can be stated that to some extent it is the personification of statehood; used mainly for the formation of squares, public buildings, buildings of official departments. Even when used in private homes, mainly by persons involved in power and for the visual expression of this power.

The revival of some features of the Egyptian style became apparent in Napoleonic France after attempts to conquer Egypt. This was followed by the spread of an empire style with Egyptian theme throughout Europe. In each country, these themes had different manifestations and features. For example, in the features of the English master of furniture Thomas Hope, who used elements of Egyptian furniture, stylizing them to the style preferences of the time, this trend is clearly traced. Later, the reminiscence of the Egyptian style was reflected in some of the following styles: art deco, some branches of the monumental classicism of the twentieth century and, finally, in the modern interpretation. Today's architects and designers also sometimes use expressive decor elements appealing to Egyptian civilization.

Another, no less expressive style – Gothic style. The path of its development is as follows: three hundred years of Gothic style – a break of 500 years – pseudo-Gothic of the 19th century – neo- and pseudo-Gothic of the 20th century – a modern interpretation. Gothic style appeals to the mysterious Middle Ages, romance, mystery, some mysticism, often used as a direction by parallel "dark" subcultures. It can be noted that the appearance of elements of these bright styles is evident in those periods of society formation, when there was a turbulent economic and political situation, pre- and postwar periods. The attraction to Gothic stylistic features, fascination with mysticism, allegories, symbolism was also inherent during the transitional unstable periods in society.

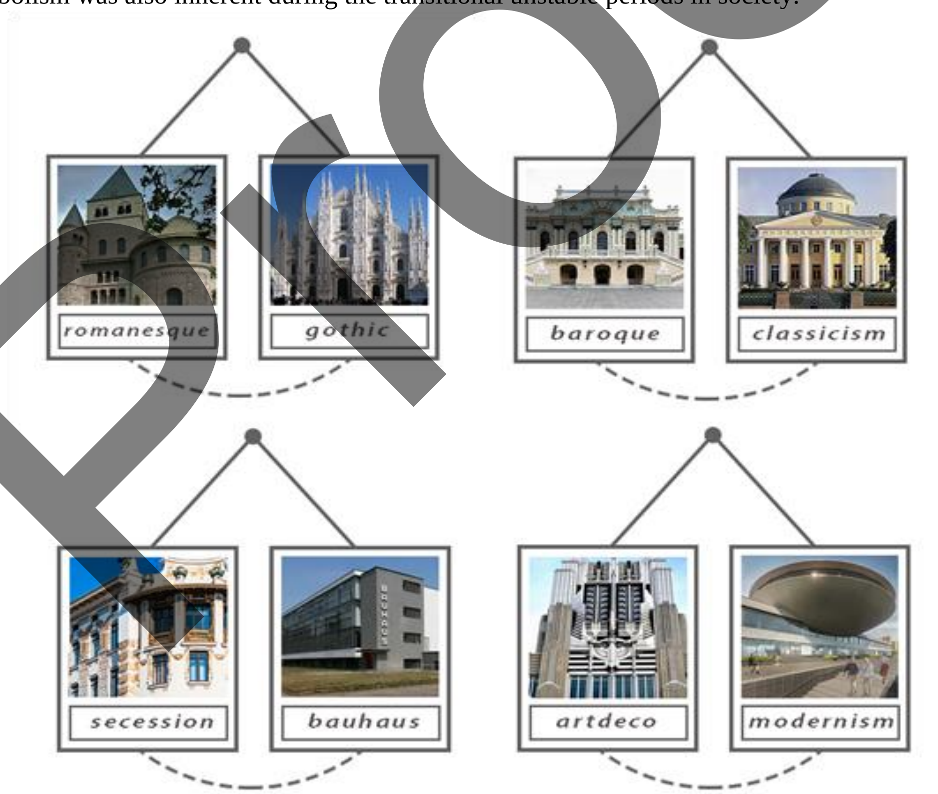

FIGURE 3. Style changing on the bases of decoration, based on the principle of the pendulum. Source: Author

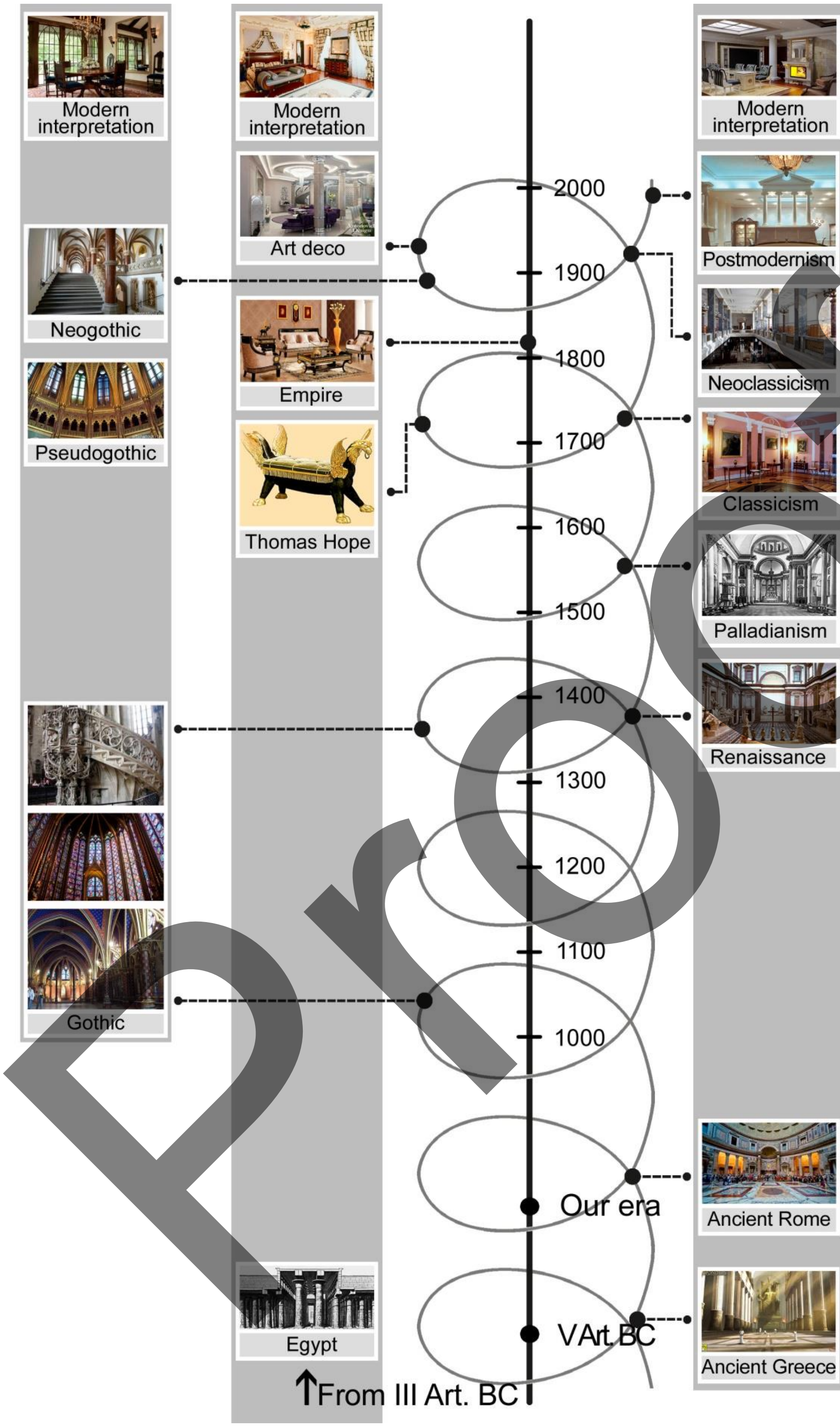

FIGURE 4. Graphic model of development and reminiscence of spiral styles. Source: Author

The Byzantine style found its continuation in the architecture of Kievan Rus [7], then in the neo-Byzantine style, which originated in the first half of the nineteenth century in Western Europe, reached its peak and almost ended in the early twentieth century. The genesis of the origin of the Byzantine style appeals to Eastern Christianity, the church as such in a broad sense. And the peaks of this style are present in those countries and periods when there was a strengthening of religious influence on state institutions of power, even when it comes to completely secular buildings.

You can also follow the trend of the spiral in the so-called "paper architecture". These vivid conceptual projects, known all over the world, often became the beginning of some major trends in stylistic movements, ahead of their time. But they were not implemented under certain economic, political and technical circumstances. You can trace these projects from the ideal cities of the Renaissance - the concepts of Da Vinci – the search for the avant-garde of the twentieth century – futurism in 50-60 yrs. of the twentieth century. Nowadays, with the development of IT technology and computer design, these futuristic dreams have moved towards virtual art in all walks of life. Such futuristic "paper" fantasies in architecture, design and technology arose in those periods of society when thought, philosophy, aesthetics were ahead of the technical possibilities of the time, or the general demands of society or the country did not meet these projects.

Today, the general picture of the phenomena of the modern world resembles hybridity in the socio-political life of mankind, when culture in general seems to be against totalitarianism, but the algorithm governs creativity, often becoming a new control of the modern era. The general reality indirectly or directly affects the state of social consciousness, manipulating the demands of social individuals to cultural products. At present, we see the diversity of different stylistic means, that are consciously or subconsciously adjusted by different cultures and subcultures. With the development of technology there is an active intercultural dialogue of countries and civilizations. This gives new opportunities, movement trends, both positive and negative. Stylistic features in different countries lose their national features, causing the problem of global leveling of stylistic features.

CONCLUSIONS

By the method of interpolation and superimposition of the process of historical change of styles on the socio-economic structure of society in the simultaneous interval of different regions, three general principles of formation and development of stylistic differences in architecture and design are obtained. Such principles are: *the principle of gradual development, the pendulum principle and the spiral principle*. With a conscious understanding of the path of historical development of style changes under various influences, it is possible to predict the stylistic processes that occur today. The structure of each work of art correlates certain canons of cultures, embedded local mechanisms of conflict and interactions. By studying the development and changes of architectural styles, science makes it possible to predict the next steps in the evolution of this complex process, prepare for them and, if possible, integrate into various forms of culture, art, technology and other spheres of human life.

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Implementation of Innovative Technologies by Foreign Specialists in the Process of Industrial Engineering in the USSR (1920s-1930s)

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Abstract. The implementation of innovative technologies by "foreigners" into industrial engineering in the USSR in the 1920s and 1930s was insufficiently covered. The consequences of their work were considered in the works of M. Meerovich, D. Khmelnytsky, E. Konisheva and others. The amount of project work during the first five years, when the course of industrialization was announced, was huge. The government passed a resolution to attract architects, builders, and technologists from abroad, who practically tried to implement comprehensive programs of urban planning and, accordingly, social protection of the young country's population in the USSR. Fascinated by social transformations, foreign specialists worked with Soviet architects for about 10 years, implementing "large-scale construction" projects, implementing the ideas of social responsibility of the architect in the design process, understanding the personal role of a specialist on the construction site of the first "industrial giants". However, under the influence of the dominant Soviet ideology, disputes arose between foreign experts and Soviet design organizations, lively discussions over the interpretation of the methods of accelerated construction, economics and innovation. In the late 1930s, the press formed a derogatory assessment of the role of foreign experts in the implementation of innovative technologies. They: architects, builders and technologists tried to combine the capabilities of different political systems and introduce a common understanding of innovation processes, but none of them managed to get used to the Soviet system and contributed to the departure, and Soviet architects for a long time remained under the ideological illusion of collective activity and responsibility.

1. INTRODUCTION

The movement towards accelerated and innovative production in the early twentieth century offered society standardization, new materials, technologies and forms of consumption, which became the basis for the implementation of alternative concepts in architecture and urban planning. After the First World War, the logic of "planning", which was developed in the United States by Henry Ford and transferred to architecture by Louis Kahn, applied to all spheres of life. Despite the fact that initially Ford's ideas concerned only the reorganization of the process of production and use of labor resources, Fordism transformed society into a large conveyor belt, which eventually became a society of comprehensive typology and maximum efficiency.

Industrial planned construction in the USSR began to gain momentum in the second half of the 1920's as a result of the supply of foreign equipment on concession terms to provide the USSR with advanced technologies. At the same time, numerous Soviet specialists are being trained in Europe, where they have been sent by the country to get

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acquainted with innovations. However, the course of industrialization required the accelerated acquisition of advanced skills directly on the construction site, as the most effective way to overcome construction backwardness. The beginning of this process was the process of attracting specialists from abroad.

In 1925, the USSR proclaimed a course for "socialist industrialization" of the country, and in 1927 issued a decree on the use of all possible resources for the development of heavy and especially military industry, that process should start the accumulation of vast resources and skilled labor of various ranks in the USSR. At the same time, a secret resolution was adopted "On the involvement of specialists from abroad" [1, p. 223–225] and in Europe and the USA special organizations for recruiting the necessary professionals have started working. Already in 1928–1929, the influx of foreigners, mostly Germans, became a mass phenomenon. Many famous German architects - Bruno Taut, Peter Behrens, Hans Pelzig, Ernst May - were members of the pro-Soviet society "Friends of the New Russia" founded in 1923 in Berlin. At the time, the Soviet Union was considered the country of the architectural future, attracting celebrities such as Le Corbusier and Erich Mendelssohn. Bruno Taut traveled to the USSR several times, starting in 1926, and since 1932 as a member of the Working Group for the Study of the Soviet Planned Economy (ARPLAN) and articles in the journal Das neue Russland (1923–1933). The magazine also published Ernst May, Walter Gropius, David Arkin, and Mark Ginzburg.

Germany was a leader in the rationalization of construction through typization and standardization - "Typisierung, Normierungb und Rationalisierung" in the 1910s, and in 1927 was established "State Society for the Study of Economics in Construction and Housing", whose members were politicians, scientists and architects W. Gropius, E. May, B. Taut, M. Wagner, etc. The purpose of this company was to combine organizational, methodological and technical solutions for the implementation of innovative construction.

2. MISSION OF FOREIGN SPECIALISTS IN THE USSR

In the USSR during the first five years there was a backwardness and lack of innovative experience in design and urban planning, which led to appeals to "foreigners" to solve several tasks: 1) to make the necessary adjustments to projects made by Soviet specialists, 2) to implement innovative methods in design and planning, 3) to develop and implement standard projects of residential buildings, 4) to take measures for rationalization and standardization using the latest advances in construction, 5) to ensure clear planning and distribution of work among all participants in the construction process, 6) introduce the experience of social responsibility for the implementation of the project solution and transfer of the author's support experience. If the purpose of inviting "foreigners" was clear to the Soviet authorities, then the invited specialists were constantly in the process of reflecting on their complex mission.

First of all, Ernst May and Bruno Taut, who for many years were city advisers on construction in Germany, were of interest to the Soviet authorities [3, p. 16]. Thus, in 1929, Ernst May was invited to work - an effective organizer of large urban projects in Frankfurt am Main, where he introduced an innovative reconstruction of a large city through a system of autonomous housing estates and the introduction of affordable housing. As a covert communist and positioning himself as a neutral specialist, he arrived in the USSR in 1930 with a group of architects and engineers. In the same year, because of the invitation of the Russian-German Society “Culture and Technics”, he visited Moscow, Leningrad, and Kharkov to give lectures, talks, and consultations, where he delivered such reports on urban planning and housing in Germany as "Urban planning and housing in Germany", "Rationalization of housing construction", etc. [4, p. 116]. From September 1931, Ernst May began working in the design organization "Standartderzhproekt", where he contributed to the introduction of current-conveyor design method, developed in Germany. In five months, his design method has shown significant efficiency. One of the group's employees, W. Schwagensteidt, wrote: “We have worked out the area between Novosibirsk and Kuznetsk, the giant coal basin of Siberia. We have designed six cities on the spot in detail enough, most of which will be built this year ... "[5]. In a very short time, E. Maya's group created projects for the construction of many new cities and towns. Thus, being convinced of the "civilizational mission" in the USSR, Ernest May demonstrated the full range of rationalization: design of tape standard buildings, typification of residential sections, rationing of building materials, calculation of the calendar plan, clear division of construction and support work between contractors and specialized organizations, rationalization of delivery of materials and equipment to the construction site, mechanization of works.

Following Ernest May, in 1930 came Bruno Taut, who, working in Magdeburg, created a department of long-term planning, and in Berlin - residential complexes, the construction of which was carried out by the Joint-Stock Non-Profit Society for Housing, Savings and Construction (1924).

Swiss architect Hannes Meyer with the Bauhaus striking group "Roth Front" joined the group of designers in the "Standard State Project" [6, p. 54–63], where he led the development of urban projects for Siberia and the Far East [5]. As an active architect, he became a professor at the Higher Institute of Architecture and Civil Engineering, a consultant to the Giprogor Design Institute, a member and professor of the newly organized Academy of Architecture, and even a member of the All-Union Organization of Proletarian Architects. [6]

The line of the industrial architect Albert Kahn was well embodied on the Soviet basis. His idea of innovative housing as typical, mass and economic, in the 1920's and 1930's at this time was spreading in Germany, where the main leaders were M. Wagner, E. May, W. Gropius. Albert Kahn's activity in the USSR is shrouded in fog, information about his cooperation with the Soviet government (1928–1932) is practically absent [7, p. 46].

An example of the creation of the machine-building giants in Detroit by the Albert Kahn's architectural firm "Albert Kahn Inc.", thanks to the author's technology of current production, was especially important for the program of industrialization in the USSR, which fully corresponded to the vector of the country. The key in construction was the author's method of Albert Kahn - the creation of the current design and construction of industrial giants. However, the situation between the United States and the Soviet Union was strange and even dangerous for both sides. Objects proposed to Albert Kahn for development had a strategic nature, that means they were deeply classified and, as a result, there was little mention of Derzhproektbud's activities in Soviet special literature, although it was the world's largest design bureau with branches in Leningrad, Kharkiv and others. cities. Albert Kahn became the Soviet government's chief consultant on industrial and military construction. The Kahn's branch in Moscow employed 25 American architects and engineers and about 2,500 other employees. For comparison: Albert Kahn Inc. staff in Detroit, usually numbered about 400-500 architects, engineers and draftsmen [7].

Albert Kahn's group received the first order - a project of a tractor (tank) plant in Stalingrad. The official information body of the USSR wrote: "... The production of tanks and tractors have a lot in common" [8, p. 13.]. As early as 1930, the plant was rebuilt, and structures made in the United States were transported and assembled within six months. Industrial facilities grew like mushrooms, with the same architecture of direct horizontal forms, but "foreigners" did not care, especially since the architectural expressiveness was a consequence of the introduction of the technological process. In the USSR as a whole, Albert Kahn designed and built more than 500 industrial facilities and equipped them with advanced innovative equipment. A complete list of industrial facilities of Albert Kahn Inc. in the USSR was compiled by D. Khmelnytsky from scattered reports in Western sources [8, p. 7].

3. INFERENCES AND DISAPPOINTMENTS

The state of project activity and the organization of construction in the USSR was a shock to the "foreigners" who worked side by side with Soviet specialists. Swiss architect Hans Schmidt explained that "project realization for a Western architect is an important part of his work and takes first place in the budget of his working time… In the case when the architect works exclusively on the project, he shows virtuosity and skill only in the art of presenting his graphic idea visually. But the project by the nature of its figurative influence is significantly different from its realization. Only the conscious need to control the realization of the plan protects the architect from such a discrepancy between the plan and its implementation. This is the way in which our architecture is freed from paper filing " [9, p. 37]. This aspect was the basis of lively discussions between Soviet architects and "foreigners", who saw the reason for the innovation backwardness in the USSR in the dominance of the artistic meaning of architectural activity. "An architect detached from his project seems to soar in the air like an idealistic angel, singing psalms inspired by some modern books on architecture, and drawings made in the design office give the impression that this office exists mainly to give good illustrative material for magazines "[10, p. 40–43]. It can be assumed that over time, such discussions began to seem too bold to be covered in the press, and amount of those who risked attracting attention by defending their own opinions became much smaller for various reasons. In the mid-1930s, discussions came to naught, giving way to a program to approve the "general line of the party," which concerned all spheres of life. Thus, the Soviet vision of the European innovation process, which was based on the idea of reforming society, was based not on reforming society, but on the project process, which was based on government procurement and constant debt for construction, which turned the project process into meaningless and unproductive work, redesign and work "on mistakes". In the magazine "Das neue Frankfurt" in the article "Building new cities in the USSR" E. May, described the state of design business in the USSR, writes that design concepts "arise in the process of society formation, therefore, it is impossible to give a design recipe, which in use will provide one by mature social relations "(From Ernst May. The building never stood in the UDSSR Das neue Frankfurt. July 1931 (11), p.17-131, 17).

The main disappointment for "foreign" specialists was the inability to see at least partially the real results of their work. Among the many urban planning schemes, about ten have been agreed, some of which have been partially transferred due to a lack of certain factors (geological, economic, urban). In the mid-1930's, professional journalism, under the influence of ideological guidelines, formed not only a biased but also a humiliating assessment of the role of foreign experts in the introduction of innovative technologies in the USSR. "Soviet architects made a difficult mistake, allowing May to design and build without any critical analysis of his work," - writes OM Mastakov, a staff member of E. May's team [12, p. 60]. Such statements are very common in unanimous answers that foreign experts who were involved in the work of Soviet industrialization "due to ignorance of our economy and lack of understanding of our policy could not make understanding in resolving issues" [13, p. 6].

Incompatibility with common sense and the indisputable realities of the system put foreign experts in front of a choice: to continue working in such conditions or not. When innovative construction technologies began to be established in the USSR and "foreign" architects and experts were no longer needed, the Soviet leadership abruptly terminated cooperation. Thus, according to the revealed data: 33 specialists invited to the USSR (excluding their families) were involved in repressions, 20 of them were shot (or died in the camps) [3, p. 96]. In the press in the late 1930's, all mentions of foreign experts virtually disappeared from public view. Later, the Soviet ideological system ideologically transformed the foundation of production technology, which was so persistently introduced by A. Kahn, E. May, B. Taut, H. Meyer, and others. High demands on accelerated construction were met by the inability of project crews in the USSR to introduce new technologies.

4. CONCLUSIONS

The high demands for accelerated construction of the first five-year plan were met by the inability of Soviet architects to apply new technologies in design and construction. This experience was brought from Europe and the United States by groups of specialists, but it was very difficult for them to work - difficult conditions, unclear laws or their complete absence and strange bureaucracy. The shock for "foreigners" was the process of project implementation without author's supervision and support. This is exactly what European specialists set out to do, pointing out the reason why Soviet architects lagged behind - the dominance of artistic design in their work over the expediency of activity. But all the design decisions of leading "foreign" specialists were subject to a comprehensive critical analysis by Soviet architects, which hampered the implementation of innovative technologies.

From the second half of the 1930's the formation of a totalitarian state in all spheres of life gained momentum. Experts lacked professional arguments to disagree with the views of Soviet colleagues. In endless discussions, foreigners were accused of having a "bourgeois" and "capitalistic" worldview; their guidelines were considered alien to the Soviet way of life, and in their protection of the architect's social responsibility and consumer rights the tricks of "bourgeois sabotage" were seen [Konysheva 34-35].

The defeats of "foreigners" in the development of "industrial giants" in the USSR during the 1920s and 1930s prove the paradox of the system of which they became a part when they came to support the economy of the young state. Immersed in Soviet construction, experts encountered many problems that affected their professional activities: 1) the difference in approach to design in the capitalist and socialist economic model, 2) the inability of the architect in the Soviet system to be a creative feature, due to ideological superstructure, 3) the understanding of Soviet architects of architecture as an art, not as an organization of life. All this became a burden on the way to overcoming innovative methods in design and construction, but "foreign" specialists persistently implemented their experience in improving the production system of the USSR without success.

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The Analysis of Some Morphological Properties of the Architectural Environment, Based on Information-Theoretic Approaches

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Abstract. This work is dedicated to the research of the informational character of the perception processes, and its correlation with the characteristics of artifacts, for example, the perception of the "image-background" situation in the color and the contour and silhouette characteristics of the architectural objects. In this work the results are presented of the research of the principles of comfortable perception of the "image-background" color situation, based on the identified patterns of color harmony in the process of analyzing the masterpieces of architecture and art. Also there are the researches of the informational structure of the process of perceiving contours and silhouettes of the architecture masterpieces, which were held based on the informational analysis of the architectural artifacts.

INTRODUCTION

The object of researching the character of information processes of the human's visual mastering of the environment, including the artificial one, is a complex system, the elements of which are under-researched patterns of visual perception with its two planes or subsystems (the image-reflecting and the emotional-evaluative functions) and the formal morphological properties of the objects of environment, including the artifacts, and some patterns of the historical and cultural processes.

The group of researchers who have worked on this problem under the leadership of Prof. V. Kravets, have conducted field research of a significant for correct conclusions number of artifacts of different types and genres of human creative activity, such as architecture, urban planning, applied, decorative and pictorial art and the character of the development of cultural processes which had created them.

The experimental research of the object materials was done regardless of the type and genre of the artifacts and dealt with the primary carriers of visual information, such as: color and light characteristics of their morphology, contours, silhouettes, shapes and masses of the perceived objects excluding the forming reading in the process of perceiving the semantic information, inherent in the whole images of these objects.

Also, the aim of experimental research was assumed to be tracing the ratio of the informativeness of the main stages of sensory and perceptive mastering of the visual field, which is the base of further "reading" the morphological, and later the semantic senses, inherent in the objective "picture" of perceived objects.

Prof. V. Kravets has researched the structure of color harmony in the artifacts of different ages, nations and genres; together with L. Gorbatenko [1] they studied the structures of constructing a color-tone palette of realistic painting; V. Kravets and N. Ignatyeva [2] have researched the structure of color palettes of architectural polychromy and the principles of historical development of the color culture; V. Kravets together with O. Fomenko [3] and K. Aksyonov [4] have conducted research of the informativeness ratios in the contours of the silhouettes of architecture masterpieces; together with G. Petukhova [5] they have studied the structures of synthesis of the spaces and masses

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in architecture masterpieces; V. Kravets, A. Mosendz [6] and S. Pykhtin [7] have researched the evolution of the elements of architectural vocabulary in relation to the development of biogenetical species.

V. Kravets and O. Fomenko have experimentally discovered similar processes of the perception treating color situations “image-background” and the informational characteristics of changing of the plasticity of contours, the silhouettes of the masterpieces of architecture, where the rows of Fibonacci were “working”.

Prof. V. Kravets with a group of researchers have conducted an experiment, revealing the informativeness ratios of the main perception phases in the “image-background” situation, which helped to reveal the harmonizing metric “steps” of the informativeness ratios in the threshold units of color distinction.

THE RESULTS OF THE STUDY

V. Kravets has researched the palettes of 564 coloristic masterpieces of architecture, design, applied and pictorial art of different genres, ages and countries, and of the nature of Ukraine (in the most stable weather conditions in different times of the year) to reveal some patterns of the color harmony in development of already known researches by many scientists and artists.

V. Kravets has developed the methodic of spectral examination of the color flows, reflected from the artifact objects, based on the color scale of native pigments of 108 color-distinction rapids. He has established new structural informational patterns of the color harmony and specified quantitative and structural hypotheses of former researches.

In the palettes of researched artifacts and coloristic characteristics of the nature masterpieces (flowers, minerals, birds, landscapes) there were found and distinguished two crucial components – the color spectrum, which is responsible for the informational diversity of the palette, and the color tint, which is responsible for the integrity and unity of the whole composition [8].

Both these components realize the necessary requirements for the whole palette: in the diverse, qualitatively different elements of the color harmony composition the colorism implies the search of similarities, of closeness, which is realized by the quantitative domination of one element through the dose of the color tint. In similar, qualitatively close elements the colorism implies the search of diversity, of distancing, which is realized by the quantitative variety of saturations or a qualitative chromaticity shift. These two provisions are considered by V. Kravets to be the base of coloristic [8].

Unity assumes the common in the different. So, colorism assumes unity as one of the foundations of the harmony. The dialectical pair of unity is diversity. Analysis has shown that the chromaticities of the local spots, shifted towards the dominant, are the sum of the dose of the dominating color tint component and some doses of the saturations of the equidistant components of contrasting color spectrums.

The further analysis finds out the doses of these components by distracting the local color tint spots from the chromaticity saturations, or by representing the chromaticity of the local spots by the sum of the color tint of pc and ps components of contrasting spectrums. The chromaticity chart of the contrasting harmonical composition, as well as the nuancing one, can be represented as a sum of a certain harmonical function with periods equal to the difference of Δl chromaticities of static contrasting spectrums, the maximum amplitude of which is defined by the equal saturations p of their components, and the curve, corresponding to the dose and tone of the dominating color tint. The analytic expressions, approximating both curves, look like this.

For the dominant (Gaussian curve) [9]:

$$p_1(l) = p_c n e^{-(al - l_c)^2} + C_1$$

where n is the quantity of basic chromaticities; p_c is the average dose of the dominating chromaticity, included in the local spot of the other chromaticities, so it is the dose of the color tint; a is the parameter, which is inversely proportional to the Δl of the color tint and is defining the nuance of the dominant; C_1 is the level of achromaticity; l_c is the color tone of the dominant color tint [8].

For the curve of the static contrasting spectrum (harmonical function):

$$p_2\,(l) = \frac{p_s}{2}\sin(nl - l_d) + \frac{p_s}{2} + C_2$$

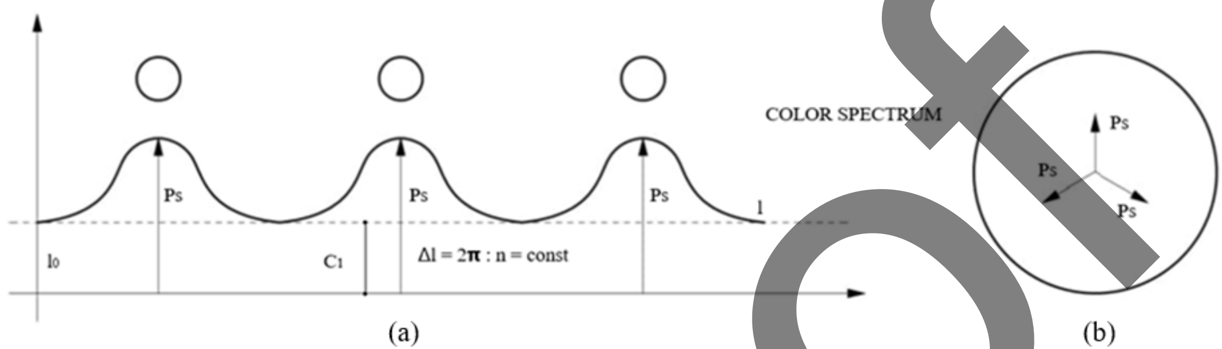
where p_s is the maximum p of the static contrasting spectrum; l_d is the shift of the harmony on the l axis, which is defining the color tone of the basic chromaticities of this spectrum; C_2 is the level of achromaticity [8].

The saturations curve of any harmonical spectrum is approximated by the expression:

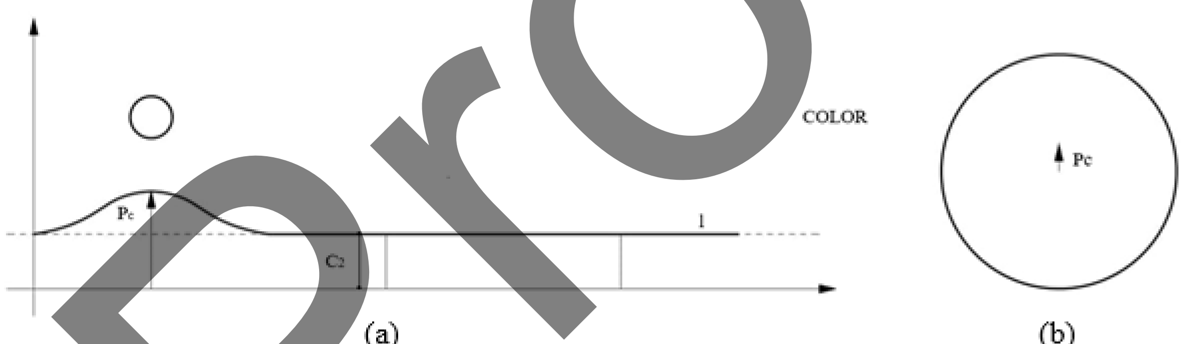
$$p(l) = np_c e^{-(al - l_c)^2} + C_1 + \frac{p_s}{2}\sin(nl - l_d) + \frac{p_s}{2} + C_2$$

By changing the parameters p_c, p_s, n, a, l_c, l_d, C_1, C_2 it is possible to receive a curve which will correspond to any type of the great number of harmonical palettes. Changing p_c, p_s gives a nuancing or a contrasting spectrum [8].

The multiplicity of informational spectrums (the harmonical functions sin) forms the pivot color space, which is the "cashbox" for harmonies. It holds an ordered multiplicity of chromaticities, which is isomorphic to a group. This is the Abel [10, 11] symmetry group for the color space. (Fig. 1-4)



$$p_s(l) = \frac{p_s}{2}\sin(nl - l_d) + \frac{p_s}{2} + C_1$$



$$p_c(l) = p_c n e^{-(al - l_c)^2} + C_2$$

FIGURE 1. The terms of the chromaticities of the harmonical palette (p_s is the saturation of the spectrum elements; p_c is the saturation of the color tint; l_d is the color tone of the first element; n is the number of elements of the spectrum; C_1 and C_2 are the levels of achromaticity): (a) – the ideal charts of spectral structure of the added elements of the harmonical palette; (b) – diagrams of their chromaticities [8]

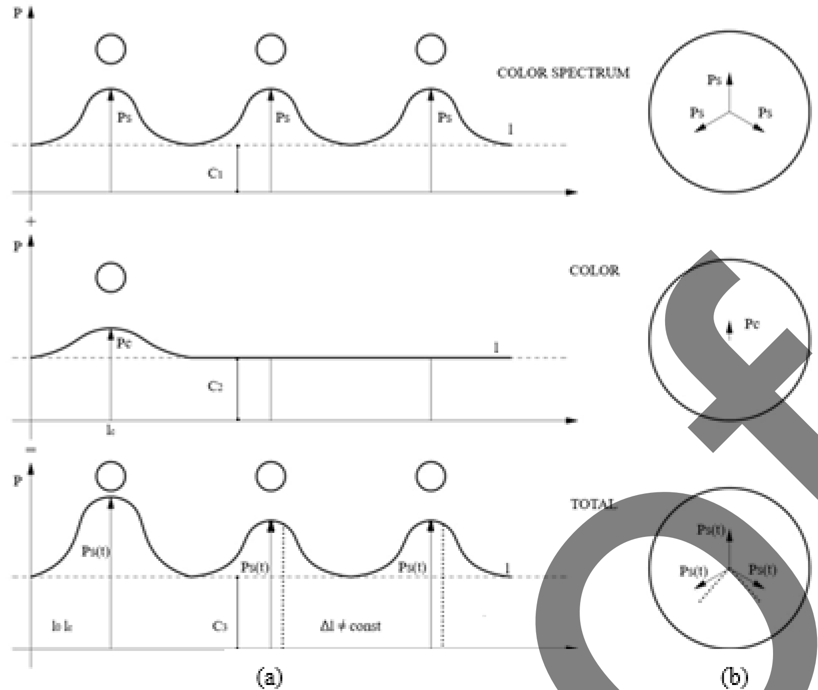


FIGURE 2. Contrasting dynamic spectrums with the color tint: (a) – the ideal charts of spectral structure of the added elements and their sum; (b) – diagrams of the chromaticities of the added elements in the contrasting spectrum [8]

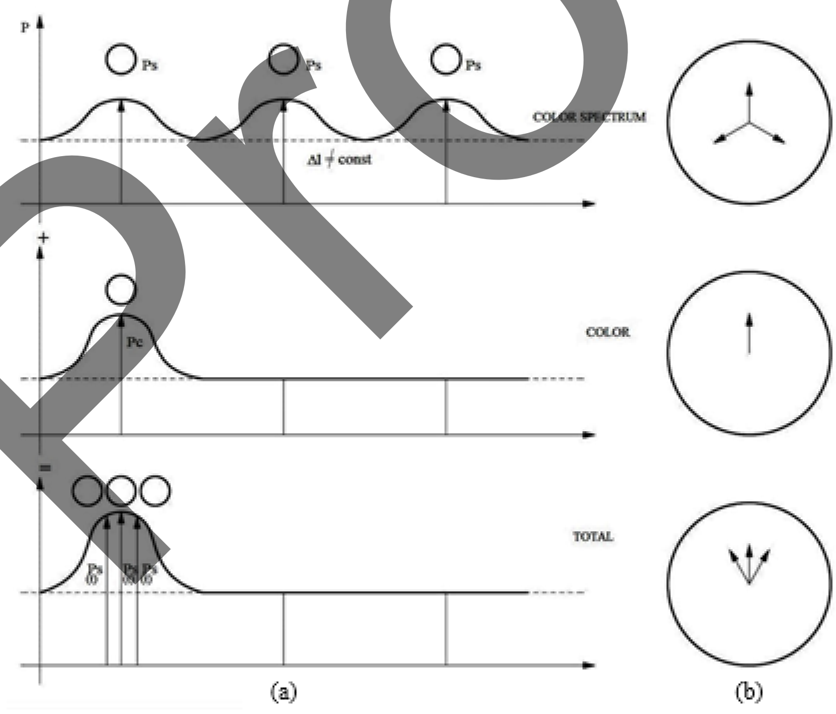


FIGURE 3. Nuancing harmonical spectrums: (a) – the ideal charts of spectral structure of the added elements and their sum; (b) – diagrams of the chromaticities of the added elements in the nuancing spectrum [8]

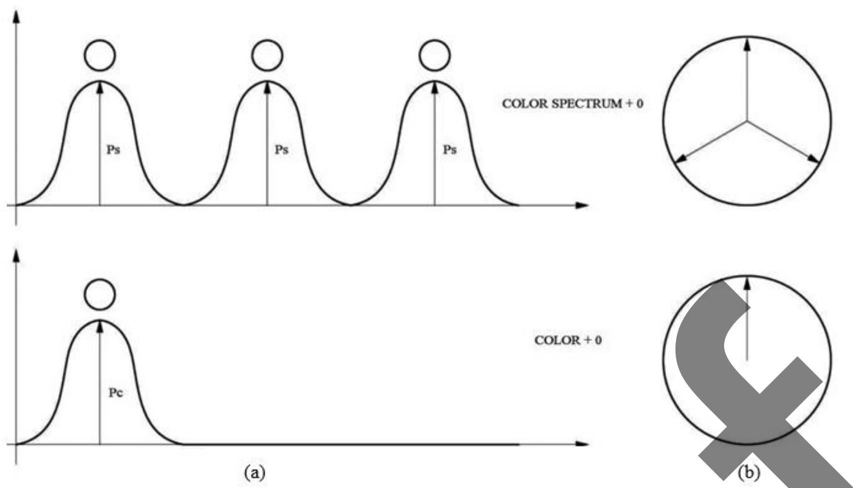


FIGURE 4. Degeneration of harmony: (a) – into variegation with $p_s \longrightarrow$ max, $p_c = 0$; (b) – into sameness and monotony with $p_c \longrightarrow$ max, $p_s = 0$ [8]

Received for the first time, the results allowed to conduct one more important stage of exploring the possibilities of color and color harmony – to impact the efficiency of the process of perception, which, as known from psychological researches, consists of four phases: detection (minimum sensibile), distinction of informational features (minimum separabile), identification (comparison with a standard) and recognition (minimum cognoscibile) [12].

The experiment was supposed to define the most comfortable color characteristics of the situation "image-background" for every perception phase. It allowed to discover the most comfortable zone in the color set of variants [13].

The data of the experimental research can be expressed by dependency graphs of the efficiency of aforementioned operation to the informativeness of the chromaticities system of the background and image. On the ordinate axis were laid the efficiency and the reliability of the perception phases, on the abscissa axis were laid the values of the informative ratio "image-background": dissonance contrasts, harmonical contrasts, harmonical nuances, achromatic contrasts, achromatic nuances, the fusion of the image and background. The efficiency of detection was measured by the number of images and its speed. Detection is most efficient when the dissonance light and color characteristics of the image and background are maximally ripped apart. When the color characteristics of the image and background were contrasting, but harmonical, detection was realized quite reliably, but less successfully. In the case of nuancing harmony the efficiency was lowered (equal to the results with light contrasts and with color saturation $p \longrightarrow 0$ and even $p=0$). The minimal efficiency was received with $\Delta l \longrightarrow 0$ and $\Delta B \longrightarrow 0$, where l is the color tone, and B is the saturation [8].

Distinction was registered using the same data as detection. The results of researching the phases of detection and distinction turned out to be close, but not identical. The curve of distinction subsides slower, with dissonance values of Δl, ΔB it has a slightly less value. The reliability of identification rises with a reverse direction of change of chromaticities ratio "background-image": the more active the difference becomes, the more the contrast, the sharper the dissonance, the lower is the reliability of identification. A slight decrease in informativeness of the pair "background-image" rises the efficiency of identification. A similar chart is reflecting the efficiency of the analysis of details, plastic and texture inside of the silhouette. The distinctions of the silhouette are mostly efficient in the case of contrasting harmony, and identification and analysis (identification of inner details) – in the case of nuancing harmony, even in the achromatic version. This way, the curves of detection and distinction – on one side, and of identification, analysis and classification – on the other side, reflecting the efficiency of different perception phases, subside towards each other [8].

Their intersection lies on the area of the ratios of the background and image chromaticities, which reflect the zone of the most comfortable perception. These ratios are a manifestation of the most distinctive states of the color harmony. So, the data of the given research confirm the hypothesis of the comfort of the harmonical color situation "image-background" for the most important act of cognition – perception [8].

Unlike the research which was described by V.Kravets earlier, when the experiment was conducted in the conditions of the color palettes: dissonance contrast, contrasting harmony (Δl=27; Δl=36; Δl=54), nuancing harmony

(Δl<27), achromatic spectrum, the continuation of the experiment explores a more thorough and detailed continuation of the “image-background” situation (Fig. 5).

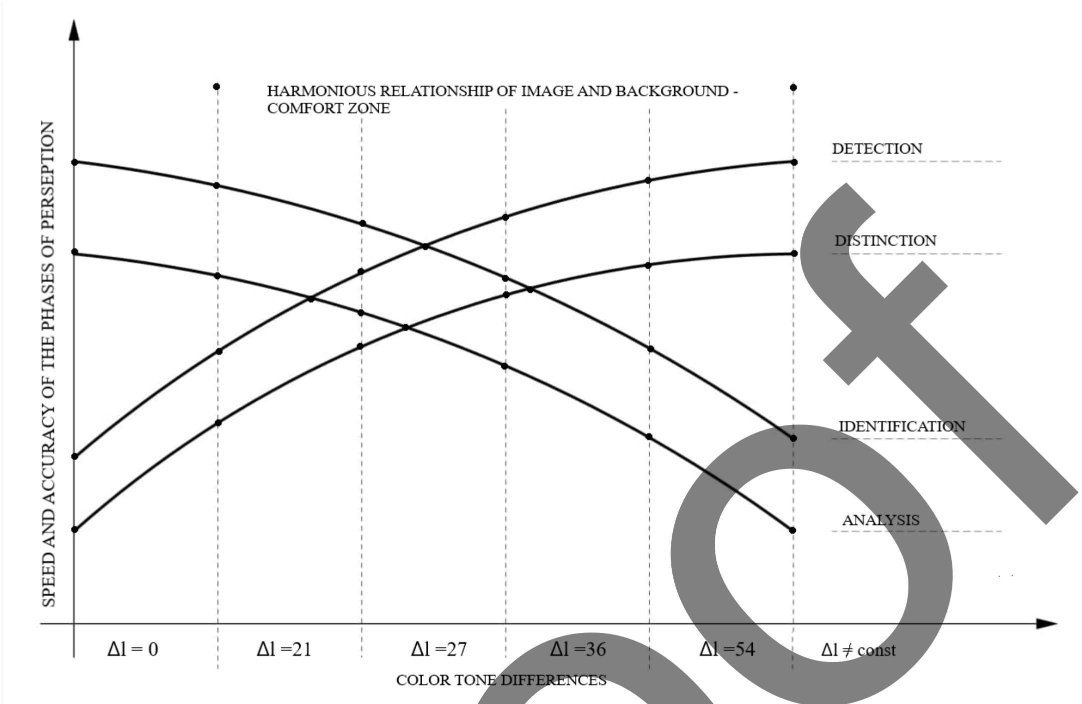


FIGURE 5. The dependence of the efficiency of perception phases to the organization of color information in the compositional invariant “image-background”

The new experiment proved the influence of dissonance pairs in the “image-background” situation in the gaps between earlier received data Δl=27 - Δl=36 - Δl=54, in which the dissonance pairs were provoked.

The additional experiment allowed to specify the results of the past research at the expense of increasing of the number of variants of the proposed color relations “image-background”. It turned out that the increase and decrease of the efficiency of perception phases are reflected not by a linear function, but a natural logarithm function, which makes it close to the essence of Claude Shannon’s formula [14] , and the curve of this function is close to the patterns chart of Weber-Fechner [15].

All of these results testify that there is a clear symmetric organization of the main palette of the color harmony – a spectrum with a constant difference step Δ in three variants Δl=54, Δl=36, Δl=27, making harmonical pairs, triples and quads. The global space of color harmony is built on Abel’s symmetry groups (this fact was also confirmed in N.Ignatyeva’s research under the guidance of V.Kravets, who discovered the existence of this symmetry in the color cultures of the world) [2].

Interesting results were received by O.Fomenko and V.Kravets in the research of informational saturation of the three perception phases in more than 200 masterpieces of architecture. The quantitative analysis of informativeness of silhouette characteristics of the architectural shape, the definition of quantitative parameters of psychophysiological comfort of perception of the architectural environment (perception of the silhouette characteristics of the objects of architecture) has shown the accordance between the informativeness of the perception phases (detection, distinction, identification) and the patterns of Fibonacci’s “golden row”, which reflects the structure of dynamics of the harmonical processes of steady development (Fig. 6).

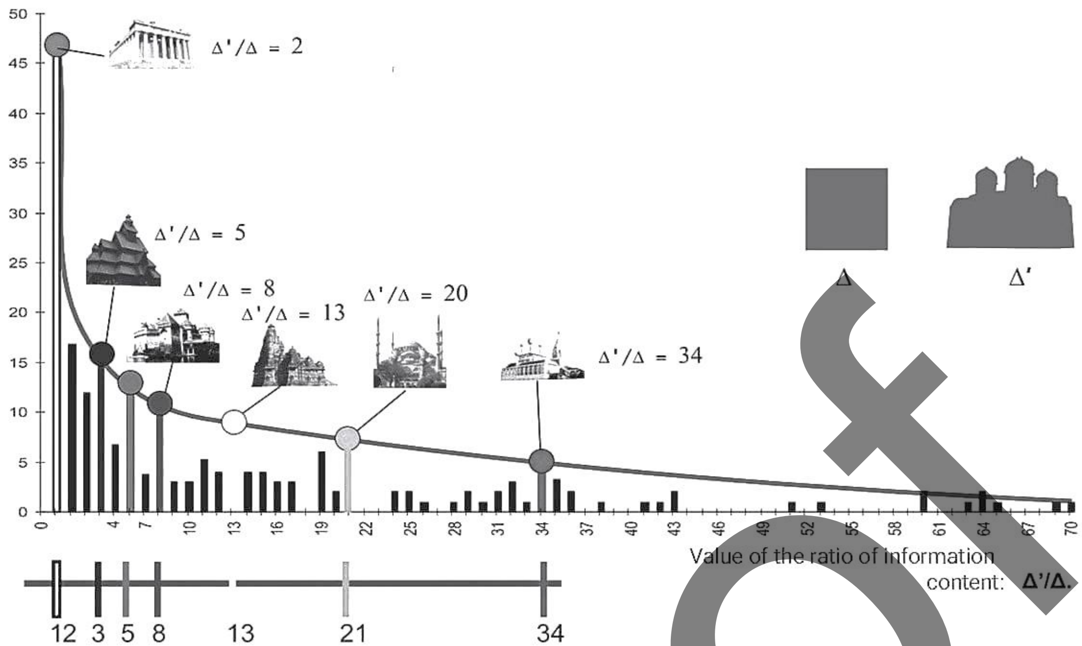


FIGURE 6. The comfortable border parameters of the morphological informativeness (the contour of the silhouette, the ratio analysis of constant and stable information) of architectural objects. On the abscissa axis there is the informativeness data, on the ordinate axis – the number of samples [16]

K. Aksenov under the guidance of O.Fomenko has conducted similar researches of the ratios of informational saturation of the silhouettes of architecture masterpieces and their details [4].

It is interesting that, considering primary units of color distinction information and the visual units of perceiving the curvature of silhouettes, in both cases, the quantitative changes were corresponding to the patterns of the golden row. Abel's symmetry is constancy, and Fibonacci's row is steady development, which is the reflection of the system theory.

The point circular symmetry of Abel's groups [17, 18]. reflects such phase states of the systems, which have reached maximum constancy in their development. These characteristics fully correspond to the results received by V. Kravets and N. Ignatyeva.

The dynamic symmetry (using the wording of the Common system theory by Y. Urmantzev – catenary, one-dimensional [19]) corresponds to the symmetry of Fibonacci's "golden row", where each member of the row contains the symmetry, inherited from all previous members, which corresponds to the results received by V. Kravets, O. Fomenko, K. Aksenov, G. Petukhova, L. Gorbatenko, A. Mosendz and S. Pykhtin, revealed in different genres of artistic activity.

CONCLUSION

The results of the conducted researches can, if used carefully and literately, provide comfortable conditions for the primary stage of visual mastering of the environment. Further the authors have found possibilities of correct usage of the obtained results in development and application of them in specific recommendations on the environment enhancement, which allows to enrich the environment, especially the industrially constructed urban one, with necessary light, color and plastic information.

The humanistic principle of the visual environment organization consists of corresponding its structures to the principles of dynamic system steadiness. By organizing a system strategy of using the received results of the research, corresponding to the principles of the environmental approach, it can be possible to expect refining of the more and more "harsh" technocratic environment on the humanistic principles.

Using the received results will help, for example, to plastically enrich the "dystrophic" informativeness of the silhouettes of separate buildings, ensembles and whole cities, and also to create a comfortable, plastically rich color environment, which corresponds to the nature and climate conditions as well as the national and cultural traditions.

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Spiritual and Material Aspects of Eco-villages

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Abstract. Civilizational processes of recent decades contribute to the emergence of large cities. Absorbing villages and towns, they merge into megacities. The urban environment of cities and megacities is characterized by sharp spatial gradations and differences, contrast of volumes, disharmony with the environment. In order to improve the human living environment, the city must be complemented and balanced by a measured and calm, harmoniously combined with nature architectural environment of rural settlements. Close harmony with the environment is characteristic primarily of ecovillages. Living and production activities of the inhabitants of eco-settlements are safely integrated into the natural environment. Communities of ecovillages profess the ideal of equality between man and other forms of life, in which man does not try to dominate nature. The development of eco-settlements based on the preservation of cultural heritage, together with the improvement of the ecological condition of the territories, can partially solve the problem of restoration, preservation and use of architectural and cultural monuments. Such processes are usually possible with the support of relevant government agencies and NGOs. The creation of such eco-settlements has prospects and interests both in Ukraine and in Poland, as on the territory of Ukraine there is a large number of palace and castle complexes with a common history for these two peoples.

Formulation of the problem

Reckless human activities, accompanied by the destruction of natural resources and environmental pollution, have brought the planet's biosphere to a critical state. Preventing the global environmental crisis is the most important task of humanity today. The problem of human survival is a problem that has come with progress. Progress has brought not only a breakthrough in engineering and production technology, but also the deterioration of the ecological state, which is unparalleled in its scale. The problems of ecology faced by the globalized world force us to look for alternatives in the way of life, way of thinking, human behavior. Along with scientific research, discussions, conferences on improving the environmental situation through the use of alternative energy sources, modern farming methods, reducing livestock, etc., there are communities that, united around a common idea, change the world around them, or better say, try to live in harmony with nature.

Analysis of recent researches and publications

D. Simberloff, G. Keflit, Yu.A. Zlobin, T. Geerdal and others addressed the issue of the ecological crisis and ways to overcome it. The problems of revitalization and preservation of traditional architectural heritage were dealt with by a number of scientists, in particular: M.V. Bevz, O.V. Rybchynskyi, R.I. Mohytych. The problem of revitalization of palace and castle complexes is covered in the work of U.B. Polutrenko. The authors of this study propose to combine the problems of ecology and preservation of cultural monuments: the restoration of palace and castle complexes through the creation of eco-settlements on their territory.

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Novelty

Eco-settlements based on the preservation of cultural heritage were established in Europe. Their activities allow to partially solve the problem of restoration, preservation, and later operation and use of architectural and historical objects. Given the large number of palace and castle complexes in Ukraine, such an experience can be interesting to follow and, according to the authors, will give impetus to the development of both domestic and foreign tourism. Such projects can unite artists of the Ukrainian and Polish peoples, who have many objects of common culture and history.

The main material presentation

The idea of eco-settlements arose as a protest against rules, norms, standards. Today, the history of eco-settlements goes back to the settlements of religious communities (Old Believers, Amish), who lived in harmony with nature and with themselves, producing products without surplus and consuming it without excess. Another attempt to create eco-villages belongs to the subculture – hippies. Hippies have tried many lifestyles and alternative businesses, including communes, joint ventures, holistic medicine and healthy eating. They paid attention to the environment to emphasize the responsibility of each person to the planet and future generations.

Ecovillages can be considered as integral formations, based on the "tripod table", which balances the practical efforts aimed at creating a social and personal space and an ecologically healthy lifestyle [1].

Ecological settlement is defined by a stable community, whose views are aimed at the harmonious coexistence of nature and man. The main goal of such a community is to create an economically, socially and ecologically sustainable community that lives in harmony with nature with minimal harmful or no environmental impact.

Ecovillage (according to Robert Gilman) is determined by the following criteria [2]: scale; signs of human activity safely integrated into the natural environment; duration.

Settlements should be on the scale of human perception (usually 50 to 500 members, although there are exceptions), which are designed to be full to provide their members with food, production, leisure, social opportunities and trade. The harmless integration of community members into the environment is aimed at supporting the normal development of a person's physical, emotional, mental and spiritual abilities. Studies show that stable villages often do not exceed 30 houses, or about 75 people, which has a positive effect on maintaining a sense of friendly community.

Eco-settlements are characterized by all the signs of human activity in a balanced proportion: work, housing, recreation, social life, which is the imprint of the whole society in miniature. Ideally, the number of jobs in the village corresponds to the working population, but it is assumed that some villagers may work outside it, and, conversely, some jobs will be occupied by people living outside the ecovillage.

The human activities of the inhabitants of ecovillages are safely integrated into the natural environment. The ideal is of equality between man and other forms of life, in which man does not try to dominate nature, but rather finds a suitable place in it. Cyclical use of material resources instead of a linear approach (single use, typical in most cases for industrial society) with the use of recycling, use of alternative energy sources (solar, wind, etc.), non-use of toxic and harmful substances – the characteristics of production of ecovillages.

The concept of the duration of eco-settlements is unlimited in time, as a principle of sustainability, which requires a certain integrity of its members.

According to the socio-economic system, the following types of eco-settlements can be distinguished in the world today: on the basis of worldview principles and philosophical teachings (Rudolf Steiner, Mirra Alfassi, Oberto Iraudi); artistic; generic; modern; settlements-producers of organic products, based on the preservation of cultural heritage.

Ecovillages on the worldview of nonviolence in recent years are quite common. The French community of La Borie Noble has been living according to Gandhi's philosophy for 45 years. The non-violent community founded the settlement of Lanza del Vasto after meeting Gandhi in 1948. The community grows the necessary food and provides itself with household items: bread, cheese, vegetables and ceramics. Silence is the inner state of the inhabitants of an ecovillage.

A typical example of an eco-settlement of esotericists is a spiritual community that settled in northern Italy near Turin. Damangur was founded in 1975 by Oberto Irodi. Many people come to Damangur to visit the "Temple of Mankind" – a unique temple complex, which attracts a large number of tourists with its works of art.

Rudolf Steiner's anthroposophical teachings were a challenge of the time and found their realization in agriculture, art, pedagogy, philosophy, architecture and way of life. Anthroposophical settlements became the first conscious eco-settlements, which were based on a strong philosophical foundation, which presupposes harmony with nature, the universe and oneself. The highest step of R. Steiner's philosophy was the creation of a visible image of the harmony of man and the universe, which was embodied first in the wooden and later in the concrete Goetheanum.

Artistic ecovillages include Vallede Sensaciones – an ecovillage located in Spain in the mountains of Andalusia, is not really a community, because only the main team lives there permanently. Vallede Sensaciones presents itself as a laboratory where a place has been created that is set up through creative and ecological design to feel the connection with nature.

The principles of sthapatya-veda, feng shui are used to choose the location and create ancestral settlements, as well as biolocation research and ecology, geotectonics, geomorphology, geochemistry, hydrogeology, botany and the state of the soil [3]. Living in such ancestral estates presupposes observance of the statute, which includes abstinence from alcohol, tobacco, consumption of vegetarian food and certain rules of conduct.

The modern ecovillage, which has a prospect to follow, was built by a Latvian millionaire on the outskirts of Cesis. Having bought 30,000 hectares of forest in a hilly area, he built the "City of the Sun", where special rules apply and people lead a completely different way of life as opposed to the inhabitants of urban areas. The rules of the modern eco-settlement do not regulate the personal life of the settlers or their beliefs, they are related to the attitude to plants and animals.

Ecovillages as a producer of organic food are widespread in Canada, they are focused on the production of environmentally friendly products, which are in great demand in the country and, accordingly, generate income.

Eco-settlements based on the preservation of cultural heritage can partially solve the problem of restoration, preservation and later operation and use of palaces and castles, which is often associated with unprofitability of large buildings that are far from highways and developed infrastructure, have no electricity and water supply, sewerage. Revitalization of architectural and urban monuments involves the harmonious reconstruction and change of functional purpose of premises and buildings, creating optimal conditions for their preservation, restoration and use.

The experience of such settlements in Europe already exists. To preserve the castle in Tondorf, the community created an eco-village in it for the noble purpose of preserving the historical heritage. Community members are usually creative individuals who, despite the preservation of a historical monument, need to be realized in a certain atmosphere of like-minded people. The eco-village of Tondorf Castle is located on the northern edge of the Thuringian Forest between the European Capital of Culture Weimar and the capital of the Thuringian city of Erfurt [4, 5].

The community is organized as a cooperative and owns not only the castle in Tondorf in Thuringia, but also 15 acres of land. The settlement does not have strict requirements for lifestyle or spiritual orientation. Approximately 60 residents adhere to the ecological principles of living and productive activities. Large and varied open spaces stretch between the castle's outbuildings, residential and the castle itself, and together with the landscape, form one of the pearls of the so-called "Tuscany of the East" – a cultural landscape that grew over the centuries in the heart of Thuringia [6]. The community has dedicated itself to preserving the castle and related 15-acre property.

The main emphasis in this eco-village is on the revitalization of the castle complex and the revival of the regional and cultural landscape of Thuringia. Accordingly, the castle should be accessible to the general public, and therefore, its territory and premises should be restored to make the cultural heritage known to the public.

In recent years, the community has renovated numerous living rooms, built a catering kitchen and started breeding beekeeping, created workshops for repair work on the Castle Bridge, built the first section of the new water supply network. Several hundred fruit trees and shrubs have been planted.

Cooperative actions of members of the eco-community and private loans were the basis for financing this project [7]. Dividends are also brought by events organized by the eco-community for the general public - festivals, concerts, Sunday cafes and more.

Given the large number of palace and castle complexes in Ukraine and their condition, this experience is a model to follow. Preservation and restoration of architectural and historical monuments through the creation of eco-settlements on their basis, in addition to improving the ecological condition and revitalization of palace and castle complexes, can play an important role in the development of both domestic and foreign tourism and recreation and improve international relations of Poland and Ukraine, which have many objects of common history.

Tereshchenko Palace with a park in the village of Chervone, Andrushivka district, Zhytomyr region, Palace of the Sangush princes in the Baroque style in Izyaslav, Khmelnytsky region (Fig. 1, 2), built in the Neo-Gothic style, von der Austen-Saken Palace with a park in the Kyiv region, Lange Palace in the village of Napadivka, Lipovets district, Vinnytsia region, Skarbek Castle in the village of Zaklad, Mykolaiv district, Lviv region (Fig. 3, 4), the Palace in Tulchyn, Vinnytsia region, the Dakhovsky Palace in the village of Leskove, Monastyrsky district, Cherkasy region, the Muravyov-Apostol's estate in the village of Khomutets, Poltava region, Popov's estate in Vasylivka, Zaporizhia region, Dzhuryn Fortress in Ternopil region could become not only a decoration of Ukraine, but also cultural and spiritual centers with self-sufficient farms and the basis for the development of recreational and tourist structure of the country and Eastern Europe.

FIGURE 1. Tereshchenko Palace in the village of Chervone, Andrushiv district, Zhytomyr region [7]

FIGURE 2. Sangushkiv Palace in the Khmelnytsky region [8].

FIGURE 3. Lange Palace in the village of Napadivka, Lypovets district, Vinnytsia region [9]

FIGURE 4. Castle of Count Stanislav Skarbek in the village of Zaklad, Mykolaiv district, Lviv region (author's photo)

CONCLUSION

Settlement of eco-communities in old abandoned castles and estates has many advantages both for the development of tourism in the region and for the preservation of the cultural heritage of the country as a whole. These facilities, with proper organization, can become private schools, nursing homes, sanatoriums. The organization of architectural space by communities of eco-settlements around historic buildings will significantly reduce the burden on the local budget and economically revitalize the surrounding areas.

The development of eco-settlements based on the preservation of cultural heritage will help solve the problem of restoration, preservation and use of architectural and cultural monuments, and the common Ukrainian-Polish history of these sites plays an important role in tourism and recreation and international relations.

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Features of the Redevelopment of Industrial Areas in Ukraine

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Abstract. Dynamic transformations in the modern environment cause changes in all spheres of social life. Thus, economic and social production processes, characterized by a gradual transition of society from the industrial to post-industrial period, have radically changed the conditions for carrying out activities of many industrial enterprises. In urban areas, there is a significant number of abandoned industrial zones which are not involved in the life of the city and even hinder the functioning of its infrastructure, cause an ecological, architectural and aesthetic imbalance. At the same time, globalization processes require creating and developing new functional areas – residential, office, entertainment ones. In this aspect, the issue of redevelopment of industrial areas is extremely relevant for modern megacities.

INTRODUCTION

The economic crisis, transformation of the sectoral structure of the Ukrainian economy with an increase in the share of the non-production sphere has led to an industrial recession. This resulted in such problems as extensive industrialization, high concentration of abandoned industrial real estate, inefficient use of industrial areas, worn-out infrastructure, poor quality of residential real estate as part of industrial zones, and environmental instability. It became obvious that most of urban areas do not meet modern requirements and require significant changes [1].

The present situation calls for transformation in all aspects of life, in particular, technologies, since industrial facilities and territories, being targeted at the needs of the past, have become inefficient, and, as a result, lost their significance. The territory adjacent to industrial facilities which are not in operation gets cluttered over time, which, first of all, has a negative impact on the environmental situation. That is why there is a need to convert such facilities. During the conversion, the demolition of obsolete buildings is not always envisaged; in most cases, the developer is inclined towards reconstruction. With the help of redevelopment, it is possible to obtain new areas since conversion is one of the key elements of redevelopment and provides for a change in the purpose of districts and zones within the city.

Modern Ukrainian cities face a lot of problems associated with spatial development – these are density of housing, lack of improvement of residential and recreational areas, low level of transport infrastructure development which does not correspond to the load. In addition, a high proportion of industrial and warehouse areas are chaotically located in the center of the city, occupying huge territories, which hinders housing development, limits expansion of the city infrastructure, and also significantly affects economic sustainability. The issue of restoration of degraded industrial

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areas with worn-out buildings and large spatial resources should be the key issue when considering a way out of this situation [1].

With a critical level of saturation of the real estate market, the development tends to be multi-format, entrepreneurs of the real estate market can increase profits only by looking for ways to reduce costs, including the consideration for territorial resources, optimization of existing processes, development of unique project concepts, etc.

At the same time, in the context of modern trends in the development of large cities, industrial areas with obsolete and economically unprofitable facilities become an obstacle to ensuring the process of sustainable development. For this reason, cities that have entered the post-industrial era require new ways to improve their infrastructure, those directly related to the process of redevelopment and significant investment [2].

The goal of transforming industrial areas in cities is to improve the quality of the urban environment and raise the standard of living of city dwellers based on the most efficient use of these areas [3].

In broad terms, redevelopment of industrial zones is a process which implies improving their planning structure, including a more rational use of an industrial area with an increase in its utilization rate; identifying land resources and intensifying their use by increasing the building density; improving transport links and liquidating inactive industrial enterprises; enhancing the architectural qualities of buildings; reducing the harmful effects of enterprises on the environment.

We can say that redevelopment is a process of secondary, as a rule, complex development of a territory (its renewal), the process of transforming existing real estate objects on the territory (mainly based on the old facilities) into completely new ones, often with a change in their functional purpose [4, p. 59].

Industrial zone redevelopment is one of the world's most popular tools for transformation of urban space. However, in Ukraine, this process is not of systemic nature and does not have a comprehensive implementation strategy. At the same time, the analysis of foreign practices show that redevelopment can give a significant impetus to rational and sustainable development of the city. This is the formation of a new space for the emergence of real estate objects, business entities, space for communications, development of creative spheres.

Redevelopment of areas is a complex activity aimed at changing the existing development, which is carried out with the help of large capital investments (inflows) in the reconstruction, renovation, major overhaul, demolition, re-equipment, improvement of the environment, the result of which is a positive effect in terms of the economic, social and environmental aspects [5].

In turn, the activity on redevelopment of industrial areas is subdivided into three main types [6]:

complete redevelopment, which involves an entirely new development of the area and facilities – starting with changing the intended purpose of the land plot and approval of a new land management project and ending with laying modern engineering networks and organizing new transport routes. In this case, industrial enterprises are converted into shopping or shopping and entertainment centers, specialized or grocery supermarkets, business centers, and logistics hubs. With the complete redevelopment of industrial areas, it is mandatory to conduct marketing research, create an investment project concept, develop an effective architectural idea, and carry out a financial analysis of the market. Thus, with this type of redevelopment, only the land plot is used in full as the spatial basis. Complete redevelopment of industrial facilities is the most capital-intensive method. It requires significant costs for development of an investment project since the volume of necessary investments is equal to the amount of costs for implementation of a new project plus the costs of changing the intended purpose of the site and clearing the area from existing buildings and structures [6];

partial redevelopment, which is carried out through reconstruction of industrial areas and industrial facilities with modernization or partial renovation of the existing engineering and transport infrastructure. In this case, it is always necessary to change the functional purpose of the land plot since the future project is implemented within the framework of the already existing designated purpose or with slight adjustments to it. As a result of such investment activities, new office and warehouse or logistics hubs with administrative buildings are built to replace inefficient industrial buildings. Partial redevelopment ranks second in terms of costs [6];

adaptive redevelopment, which, as a rule, does not provide for serious modernization and structural changes of existing industrial facilities. As a result of these measures, the administrative buildings of an enterprise or separate workshops are formed. According to this principle, grocery or construction supermarkets as well as small office complexes are often brought together. In this case, most often, the transport infrastructure does not change radically. Adaptive redevelopment is the most profitable in terms of time and financial investment [6].

Redevelopment of industrial real estate has significant advantages: high ceilings, huge windows, the possibility of free planning, availability of electrical and thermal power, convenience of access roads, parking lots, etc. [2, p. 60].

The analysis of the Ukrainian and foreign practices of transforming the urban environment has made it possible to identify the main prerequisites for the transformation of urban industrial areas:

- low quality of functioning of industrial buildings and structures, which is caused by a long period of operation;
- irrational zoning, which does not ensure the environmental, sanitary and transport safety of the population;
- need to restore the historical value of architectural monuments and old city districts;
- transition to social integration and stimulation of the investment process as levers of economic growth management [3].

The choice of a new functional purpose for the object to be reconstructed is determined by a number of factors:

- urban planning and compositional characteristics of the object: functional purpose of the territory on which the object is located; inclusion of the object in the ensemble; the city-forming role of the object;
- urban-planning, historical and architectural, cultural value;
- value of the object as a whole or of its parts (facades, bearing structures, individual elements);
- primary purpose;
- space-planning characteristics: structural scheme; spacing and spanning of structures; floor height, number of storeys; type of fenestration; roof configuration;
- orientation of existing window openings with respect to the cardinal directions;
- materials of vertical and horizontal elements of the supporting system, enclosing structures, roofs [7].

Historically, the starting point for using redevelopment is considered 1952, when, in America, the first projects were elaborated. They became the main driving force for the revitalization of dilapidated and irrationally used areas. During this period, companies which began to buy up small outdated enterprises, demolish houses and build new economically attractive real estate in their place appeared [8, p. 182]. One of the world's best examples of successful redevelopment is the reconstruction of the former London Docklands (UK).

In Ukraine, redevelopment is at an early stage of its evolution. The reason is that the state does not pay due regard for implementing redevelopment projects. The initiators are most often private investors and development companies, in contrast to the United States, where the main coordinators of such projects are municipal governments [7].

The current structure of most Ukrainian cities is characterized by a low quality of housing and recreational areas, high share of industrial and warehouse areas in the city center, and transport problems (the level of development of the transport infrastructure does not correspond to the load, not keeping pace with the growth in the number of cars in cities). The development of new technologies, growth of incomes of city dwellers and changes in their needs put forward new requirements for the quality of the urban environment [3].

Today, Ukraine has formed its own conceptual model for the development of industrial areas, which considers the specifics associated with the remaining legacy of the planned economy and adopts the best practices of European countries (Fig. 1).

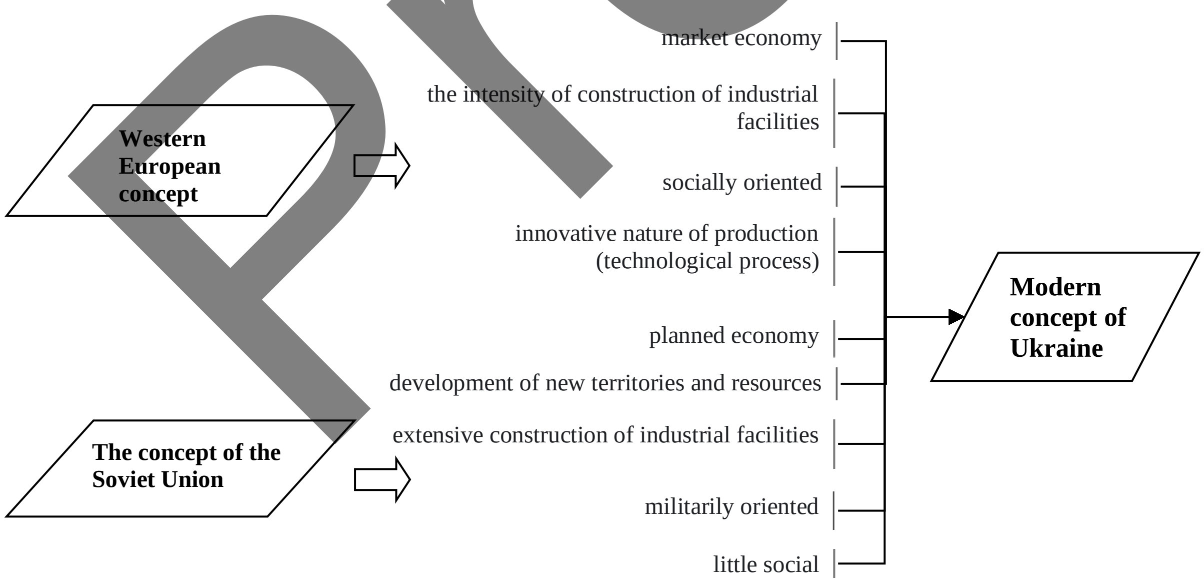

FIGURE 1. Conceptual model of restructuring of territories of industrial facilities of cities of Ukraine [9]

Ukraine has experience in redeveloping industrial facilities according to the principle of the best and most efficient use of real estate objects. This implies choosing the purpose which provides for gaining a maximum profit. The leading cities of Ukraine in this sphere are Kyiv and Kharkiv. Industrial facilities were converted into shopping and entertainment centers, cultural facilities, and business centers. However, we are talking about individual objects, not about the complex reconstruction of industrial zones in cities [1].

In Kyiv, a fairly popular and well-developed segment of the redevelopment of industrial areas is the partial reconstruction of individual buildings and areas with their conversion into new objects of the real estate market, namely: industrial facilities, warehouses – into shopping malls (SEC Mega Market, SEC Bilshovyk, SC Caravan, HorodOK, Promenada Center); administrative buildings of factories – into office centers (Business Center Mayak); unfinished industrial workshops – into an outlet store (Macros), etc. Such projects do not require significant capital, land clearing, changes in the designated purpose of the land.

Investment and construction projects related to the redevelopment of industrial land use (facilities) in the city management system are characterized by significant risks, given their high capital intensity, elaboration for a particular territory and influence of other internal and external factors. That is why such investment activities should be supported by exceptional dynamism of management to ensure their high-quality implementation and the required level of their profitability, as well as sustainable development of urban areas. At the same time, the development of industrial zones in the city through redevelopment can be efficient in terms of the economic development of the territory, but only upon interrelated solution of problems of urban planning, employment of the population, environmental protection and corresponding transformations in the social sphere and the administrative legal system of large cities [5].

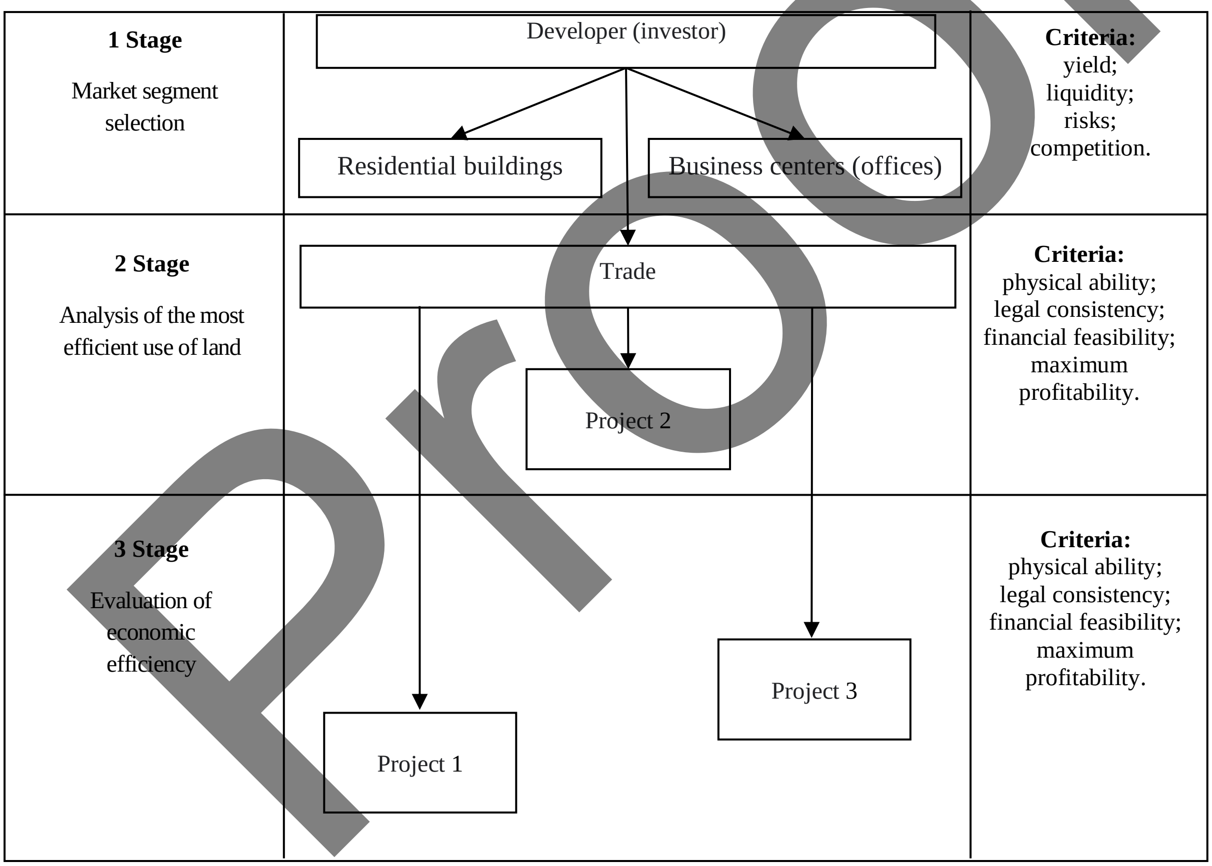

FIGURE 2. Algorithm for selection and evaluation of redevelopment project [2]

Thus, in order for the redevelopment (renovation) of large industrial areas to be attractive to investors, the city authorities must act as full-fledged partners and take on a number of obligations, namely: introduce special investment rules and mechanisms, e.g., significantly reduce the time for consideration and approval of relevant projects (relocation of industrial facilities, changing the purpose of land, construction of a new real estate object, etc.), provide tax incentives (tax holidays) for this period, take on the organization and pay part of the costs of relocating production facilities, and after the completion of the investment project, within the specified time limits, to transfer the ownership of the land plot to the investor without share participation.

The practice of encouraging investors (developers) at the implementation of projects for former industrial areas is widespread in foreign countries, in particular in the United States. For example, in the state of New Jersey, local governments with the support of the Environmental Protection Agency offered investors to cover 75 % of the cost of industrial clearing from the local budget. In Ohio, investors are allowed to pay taxes based on the value of the old building and structures during 15 years after the redevelopment. The State of Missouri offers up to 100 % loan financing to clear the land plot and prepare for a new construction. In the United States, there is also the TIF (Tax Increment Financing) program, according to which the payment of taxes by developers is deferred, and subsequently the costs of clearing the territory are covered from the sum of the unpaid taxes [10, 11].

As a result of such measures, in particular, stimulation of investment activity and renovation, most non-functioning enterprises are converted into commercial objects (which is proved by the analysis of the trend of implemented redevelopment (renovation) projects of industrial land use in Kiev), which will lead to an increase in the local budget revenues due to land tax.

CONCLUSIONS

Thus, one of the most urgent tasks of urban land use in post-industrial society is activities related to redevelopment and renovation of industrial areas. Conversion of warehouses, production and other industrial facilities into commercial real estate objects is an extremely important measure that will facilitate an improvement in environmental, economic and aesthetic indicators of the city.

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Multifunctionality as a Definitive Sign of Modern Ecological Settlements

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Abstract. The work examines one of the directions of the implementation of the "New ecological paradigm" (1978, W. Catton, R. Dunlap) through the creation of ecovillages. The concept of ecovillage is considered as a voluntary cohabitation of a group of people united by the idea of creating an ecologically clean-living space and based, as a rule, on the concept of sustainable development and organization of organic agriculture.
The change in the concept of the approach to the organization of ecovillages in the period 1950-2020 is shown. From complete isolation from society with the primitive manual labor of producing vital goods and products to the creation of autonomous eco-cities operating on the principles of sustainable development using modern waste-free technologies for the production of energy, products and goods, in complete harmony with the environment and humanity. A characteristic feature of modern ecovillages is their multifunctionality. It manifests itself in all aspects – from architecture to life support.

INTRODUCTION

Throughout the history of mankind, there some examples of nations who recognized the need for harmony between the environment, society, and the economy. Concept of sustainable development starts in the 1970s. The process was a logical necessity for making urgent decisions aimed at restoring the balance in the planet ecosystems and finding the solutions.43

In addition, global warming, climate change (earthquakes,floods,tsunami, etc.), increased anthropogenic impact have led to the disruption of the natural balance.[1].

The systemic crisis of modern society is caused by socio-ecological problems, which are owing to demographic processes, the growth of urbanization, reforms in health care, education, a decrease in social protection of the country's population, an increased number of health issues due to the polution, etc. [2 -3].In this regard, the "New Ecological Paradigm" put forward in 1978 by the American sociologists W. Catton and R. Dunlapa and became more relevant today than ever before [4]. The basis of this paradigm is the intrinsic value of the environment, care not only for new generations, but also for all living things on the planet, which requires biophysical restrictions on all types of human activity, which should be aimed at creating a system of post-material values. One of the most effective ways to implement this approach is the creation of city's that may act as a living biome.

The concept of "ecological settlement" in the standard representation means a secluded settlement that have been created by a group of people united by the idea of creating a living biome. This idea is based, on a conceptual rule, of sustainable development and space organization of organic urban structure .

The emergence of the first ecovillages dates back to the early 60s and associated with the "hippie" movement, who created communes for cohabitation and, thus, isolated themselves from the outside world. Those communes became the first prototypes of the ecovillages.

The organization of such ecovillages proceed according to the following principles:

- a healthy lifestyle (hardening, prohibition of smoking, alcohol, obscene language, etc.);
- subsistence farming (manual methods of land cultivation, careful forest management and land use, prohibition of

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the use of pesticides, fertilizers, etc.);

- autonomy and striving for self-sufficiency (organic farming technologies, production of household items, exchange of goods with the outside world).
- minimization of energy consumption.

The process of development ecovillages, have formed the following principles: harmonious interaction with nature with minimal impact and low impact on the environment and reducing the ecological footprint of human activities.

An analysis of the history of the development of ecovillages indicates significant changes in their organization that took place in the period 1950-2020.

If the beginning of the creation of the first ecovillages is associated with an attempt to put into practice an alternative economic models in the form of “communities” and “communes” and the disclosure of the inner world of man. Some of the modern ecovillages are based on the use of the latest technologies in construction, communication, life support, etc. Today, four types are distinguished. eco-villages (Fig. 1): eco-villages - communities where people create a sustainable lifestyle with their own specific rules and principles (developed during check-in); family estates - self-sufficient settlement for one or several families; transition towns - integrated use of the principles of a renewable economy at the cities level through transformation into "green" megacities; eco-cities of the future (projects) - a city-structure with the possibility of autonomous existence.

(a) (b) (c)

(d)

FIGURE 1 Types of ecovillages: a) ecovillage – Photography by Dmytro Sopov; b) family estates – Photography by Olena Protsenko; c) transition towns (Bosco Verticale, Milan, Italy) – Photography by Thomas Ledl, [5]; d) Floating Eco-city - Project Author Dmytro Sopov

The growth rate of the urban population can be judged by the fact that in 1800 the population of cities was 2%, in 2000 - 50%, and by 2050 it is predicted that it will be about 70% of the world's inhabitants. Urbanization also entails a deepening of the contradictions between the human environment and nature. All this forces progressive humanity to look for ways out of this crisis situation. In our opinion, there are two parallel directions that have the same goals – to minimize the negative impact in the environment: transformation of existing cities into living nature biomes and the construction of a new one that going to operate in a closed cycle of reproduction of energy and material resources. An example of the first path is a number of cities around the world, which over the course of ten years have been able to significantly change their appearance and reduce the burden on the environment in accordance with the index of "green" cities [6]: Vancouver (Canada); Stockholm (Sweden); Copenhagen (Denmark); Oslo (Norway); San Francisco (USA), etc.

Already today, a number of eco-cities projects are being implemented using innovative technologies, operating in accordance with the principles of sustainable development: Masdar (UAE); Great City (China); Nye (Denmark); Neapolis Smart EcoCity (Cyprus), etc.

Thus, our tomorrow largely depends on whether it will be possible to transform cities into such a state so they would not destroy their habitat, but would become a part of nature, forming together with it an ecosystem.

MULTIFUNCTIONALITY OF MODERN ECOVILLATIONS

A characteristic feature of modern ecovillages is their multifunctionality. It manifests itself in all aspects - from architecture to life support. When creating ecovillages, it is required to take into account the climatic and landscape features of the construction site, using flexible "modules" that can change when external parameters change.

Multifunctionality in architecture is due to the flexibility of space, the ability to change the shape and volume, location (mobility) of the architectural object (Fig. 2).

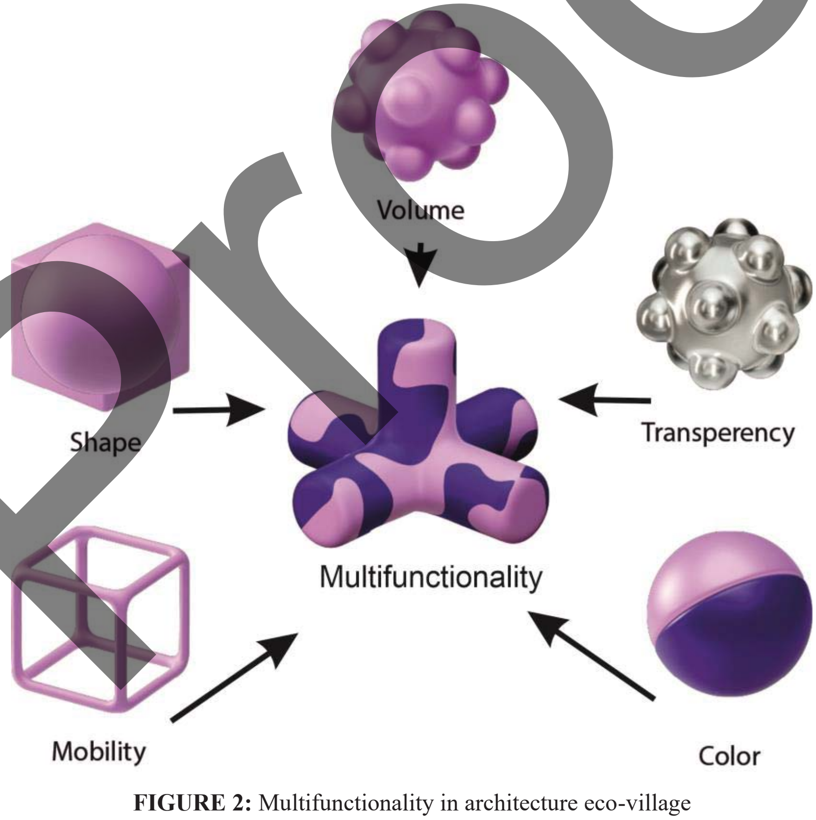


FIGURE 2: Multifunctionality in architecture eco-village

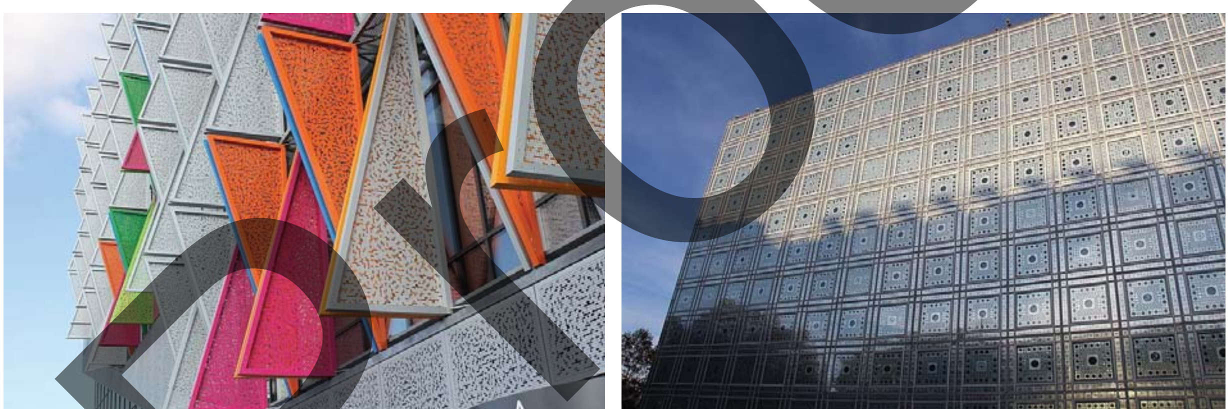
The change in the shape and volume of the architectural space lies at the heart of kinetic architecture, the ideas of which were fragmentarily embodied in the Middle Ages, but it is now becoming widespread due to the possibility of implementation through the use of technologies based on natural kinetic forces: air movement, solar radiation, pressure drops etc.

There are two types of kinetic buildings - with a movable frame and a movable facade. A striking example of a movable frame are the projects of the Mobile house of the British company Ten Fold Engineering [7] and the dynamic house D* Haus by David Ben Granberg and Daniel Wolfson [8]. Examples of buildings with movable façade or movable frame are shown in Fig. 3.

(a) (b)

FIGURE 3. Buildings with a movable façade (a) and movable frame (b)
(a) One Ocean, South Korea [9]; (b) Hudson Yards Plaza, New York [10]

To date, many buildings with movable facades have already been built. The most famous are the Campus of the University of Southern Denmark in Kolding (arch Henning Larsen) and the building of the Institute of the Arab World in Paris (architect Jean Nouvel). The facades of both buildings are moved by the natural energy of heat and light (Fig. 4).



(a) (b)

FIGURE 4. Buildings with a movable facade
(a) Campus of the University of Southern Denmark in Kolding (architect Henning Larsen) [11]; (b) Institute for the Arab World in Paris (architect Jean Nouvel) [12]

Expanding the range of building materials allows you to solve the problem of controlling the directivity and intensity of lighting. More and more widely used "transparent" concretes [13], allowing to significantly save electricity and create soft diffused lighting in the room on a hot sunny day. Progress in glass production technology makes it possible to produce several types of glass composites (Smart-glass), the principle of which is based on photochemical phenomena and changes in transmission properties when external conditions change: luminous flux (photochromism), temperature (thermochromism), electric voltage (electrochromism). In addition, the glass can be self-cleaning, be a source of sound (sound glass) or, at the right time, become a screen for demonstrating video images (touch glass). Thus, glass are not only a source of light, but also perform a number of other functions.

Modern ecovillages should not only be adapted to local landscape and climatic conditions, but also provide comfortable living conditions. The life support of the ecovillage is also based on the principle of multifunctionality using the latest advances in science and technology. Here multifunctionality is based on the principles of sustainable development and manifests itself in a single complex of production, consumption and efficient utilization of material and energy resources.

The emerging trend of a systematic transition from an urbanized environment to the creation of eco-cities capable of adapting to changes in environmental characteristics is aimed, first of all, at minimizing the stress on the natural landscape and forming a sustainable ecological balance.

Using the capabilities of modern technologies for the production of energy and material resources allows such a transition to be carried by way stable and safe development. This will make it possible to transform the environmental, cultural and recreational environment into full-fledged public spaces with a natural landscape. The optimal way of such a transition is the division of megacities by park and forest areas into several settlements with their own infrastructure (the so-called horizontal type of city). However, the existing shortage of favorable territories for the formation of this kind of eco-cities limits the possibilities for such development. In recent years, two directions of the transition to eco-cities have been traced. The first is the development of vertical green cities [14-15], the concept of which is based on a framework structure consisting of several basic elements:

- increasing the efficiency of the use of renewable energy sources in all spheres of life support and functioning of cities;
- spatial planning and compactness of the architectural and landscape space;
- maximum landscaping of the entire free space;
- a combination of various options for using the urban environment.

Green city projects are already beginning to be actively implemented: Great City in China, Masdar in the UAE, Gothenburg in Sweden, San Juan in Puerto Rico, Melbourne in Australia, etc.

The complexity and high cost of construction on land due to geographic and climatic conditions (permafrost zones, swampy and annually flooded territories, deserts, mountains, high seismicity, etc.) predetermined the development of the second direction of designing and creating eco-cities - network settlements on floating platforms and artificial islands.

The advantages of such cities are due to economic (for design and construction on water there is no need to buy or rent land), environmental (all settlements on water are based on the use of renewable energy sources: sun, wave energy, sea currents, etc.), functional reasons (mobility - the ability to move and change its location, waste-free production in a closed cycle, widespread use of modern technologies, autonomy). In addition, the organization of the natural landscape frame allows you to use a creative approach with the ability to recreate almost any natural areas of the Earth.

Currently, a large number of floating cities are being developed, designed and are already starting to be implemented: the modular city Eco Atlantis in China (AT Design Office, London), Noah's Ark (architects Alexander Joksimovic and Elena Nikolic, Serbia), "city of photosynthesis" X SEA TY (bureau X-TU, France), eco-polices LilyPad and Aequorea (architect Vincent Callebaut), etc.

In fact, such cities are multifunctional ecosystems of the coexistence of a large number of people in harmony with the environment and without limiting interaction with the rest of humanity. As a rule, they are a system of modules, each of which is also multifunctionally and can exist autonomously. This approach provides high security for the entire city and its individual elements.

CONCLUSIONS

The main goal of creating ecovillages is to live unite with nature. Their design includes not only living space for habitation, but also public spaces such as - cultural centers, research and university campuses, medical, sports and hotel complexes with high-tech equipment. In most projects, the population of eco-cities is no more than 100,000 people, which implies pedestrian accessibility of social, cultural, educational and tourist hotel and recreational complexes. The structure of the communal services of a modern ecovillage is a unified life support system equipped with technological modules for autonomous energy, heat, water supply and sewerage, climate control, utilization of biowaste and other systems for effective autonomous functioning with a minimum load on the environment. The techniques of green architecture are widely used: landscaping of facades, roof gardens, winter gardens, assimilation of a building with the surrounding landscape, natural shaping and embedding into the relief.

Modern economic and environmental crises, intensifying natural disasters, and the threat of global pandemics increase the socio-ecological tension of society. The way out of this crisis situation is the need to move from a consumer society to sustainable development, which should form a single favorable socio-ecological environment, characterized by the correspondence of natural, socio-economic, political, spiritual conditions, the state of health of the population to the needs of society. Under these conditions, a new model of interaction between man and the natural environment is becoming more and more popular in the form of creating a multifunctional ecosystem “city - environment”, which exists in harmonious unity with nature while fully meeting the modern human needs of the XXI century.

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Humanization of HR Management of Construction Companies Based on Innovative Management Concepts

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Abstract. The article discusses the practical aspects of the implementation of the principles of humanization in a certain construction company, which, in opinion of the authors, is an opportunity for construction companies to organize efficient activities and increase their investment attractiveness with no significant expenses. The purpose of the study is to find the internal reserves of a construction company through the practical implementation of the Lean Construction principles in construction facilities, i.e., assembling a creative team within the staff that will promote the efficient functioning of the enterprise and will form the basis for the development of innovative solutions. For this purpose, the study carried out an analysis of the scientific works on the issues of economy humanization and socialization, changes in the team process, management of the labor potential of the company in order to identify problem issues and set specific objectives for the practical implementation of the Lean Construction principles by assembling a creative team at a construction company. In this view, the authors propose to organize a close relationship of operational control and the measures to attract workers to show creativity and initiative, to develop an effective mechanism for organizing a creative climate on the example of a construction company. Based on the needs identified at the enterprise through filling in the questionnaire, specific changes to the design of incentive measures are proposed for implementation. The system of personnel promotion, the motivational package composition, promoting not only material stimulation, but also climate change in the team, and the objectives of the motivation package are suggested. The authors emphasize creativity increase taking into account the specifics of the activities of a construction company and attempt to create initiative groups in the field environment. The work shows the connection of operational control, carried out at the enterprise on a regular basis, with the involvement of staff in solving the tasks of the enterprise. For this purpose, draft documents for carrying out the operational control, execution of construction works, taking into account the proposals of the workers, have been developed. In opinion of the authors, knowledge of the possibility of obtaining a positive assessment, or appropriate stimulation, a sense of involvement in the main objectives of the enterprise will enhance the identity, level of socialization and self-actualization of workers. The authors believe that the following LC suggestions may be successfully implemented in construction companies whose main goal is the complete use of internal reserves, minimization of losses of the enterprise. The task that needs further research should be to evaluate the practical value and effectiveness of the received suggestions and make a decision on their implementation.

INTRODUCTION

At the heart of this concept of humanization is the creation of respect, care and reciprocity between management and employees to ensure a people-centered policy and the further innovative development of the enterprise [1]. Lean project management or lean construction is a modern innovative management concept enabling construction companies to organize efficient activities and providing the opportunity to increase their investment attractiveness without significant expenses, as the attraction of investments in the construction business is currently a priority task for all managers of enterprises. In addition to the possible resistance of employees to changes, the complexity arises in the process of practical implementation of concepts. During the transformation of their operating model, these

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changes also occur in the values and culture of the organization. The practical aspects of assembling a creative climate is a complex issue that deserves special attention.

The purpose of the study is finding the internal reserves of the construction company through the practical implementation of Lean Construction principles, hereinafter – LC, at construction facilities, namely assembling a creative team within the staff that will contribute to efficient functioning and will form the basis for the development of innovative solutions.

Creativity organization, initiative enhancement and labor potential unlocking are addressed in the works of foreign and domestic scientists such as M. S. Doronina [2], C. Antony [3], A. Hirshi, V. K. Herrman [4], R.Waterman, T. Peters [5], O. Chupyr [6], S. YP Choi [7], K. V. Biletska [8], O.O. Romanovskyi [9], D. Zervas [10] etc. Thus, M. S. Doronina studied modern tendencies of humanization of labor and socialization of the economy and defined the notion of "socialization" as a triune process of social development of a person, collective, enterprise and the economic system of the country as a whole [2]. In the case of achieving a high level of socialization of the results of activity, the role of human increases, that is, there is a humanization of the management process. In a study by T. Peters and R. Waterman, one of the components of humanization of labor is the increase in the level of awareness of the team and the “transparency” of the internal organizational activities [5]. C. Antony considered mediation of changes in the team process and their diversity as important components of the company’s innovation policy [3]. A. Hirshi and A. Herrman, when considering protean career orientation, professional identity and self-sufficiency, have established that it is preceded by changes in identity and self-realization, but not vice versa [4]. The model of scientifically grounded system of planning of social development of personnel was designed and proposed by O. Chupyr [6]. The authors emphasize the need to define social priorities and use the quantitative method of their determination. The systematization of literary sources confirms the growth of human’s role in the management process and the need for changes in the team process and allows us to assert that these measures are carried out within the framework of innovative management concepts. One of these concepts is LC. The authors consider it necessary to pay more attention to the practical aspects of the implementation of the task of increasing the level of personnel socialization by way of creating united teams, groups and assessing their initiative by example of the construction enterprises.

Main body

As the environment is prone to change, construction companies need to respond quickly to such changes and adapt to new conditions. Construction companies find promotion of their own development more and more difficult, so they attempt to use survival strategies. One of the main tasks of Lean Construction is internal reserves management and minimization of losses. This necessitates the creation of mechanisms for managing the creative potential of the enterprise, as the human capital assets are currently the most important factor in improving efficiency.

Having established the strategic purpose of using LC to ensure survival of an enterprise, its manager faces problems of its implementation at all levels of management. The authors propose a plan of activities combining all levels of enterprise activities in order to increase creativity and initiative of workers on the example of a construction company. It necessary to clearly establish the place of the motivational mechanism in the implementation of the strategy and tasks for successful practical implementation (Fig.1).

First of all, it is necessary to create conditions that contribute to an increase in the values of creativity and initiative of the enterprise personnel.

Secondly, it is necessary to create a system of incentives for personnel, therefore, the issue of developing a motivational package promoting not only the material stimulation to activity, but also the climate change in the team.

Thirdly, it is proposed to organize a close connection between operational control in construction and the involvement of workers in innovation activities, to encourage initiative.

Implementation of the tasks established in Stage 1 (Fig. 1) is based on conducting a questionnaire survey of employees at all levels of management in order to determine the needs of enterprise personnel, priorities, on data analysis and the development of a motivational package. 78 respondents, employees of two construction organizations took part in the survey. Among them, there are 13 managers, employees and builders, 25 people respectively. Based on the results of the survey conducted at the construction company (Fig.2), the following was established:

- subordinates give a worse assessment of the situation at the enterprise than managers;
- physiological needs and safety is the first thing important for subordinates;
- a group of developmental factors is more desirable for workers than for managers;
- management personnel pays more attention to the improvement of the social status;
- management staff does not have a high desire for career growth and development.

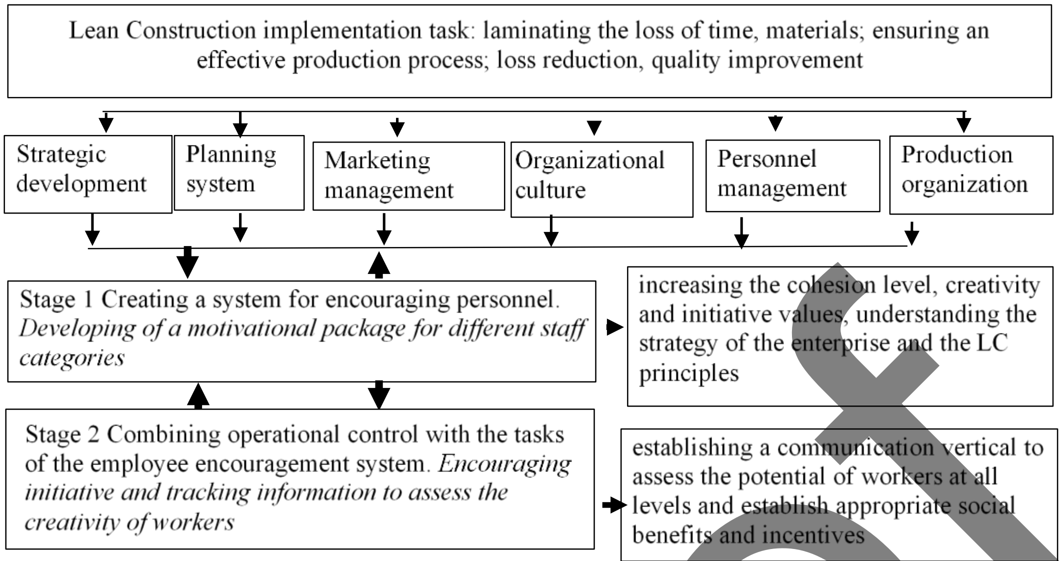

Figure 1. Interconnection of the Lean Construction implementation and the motivational mechanism tasks.

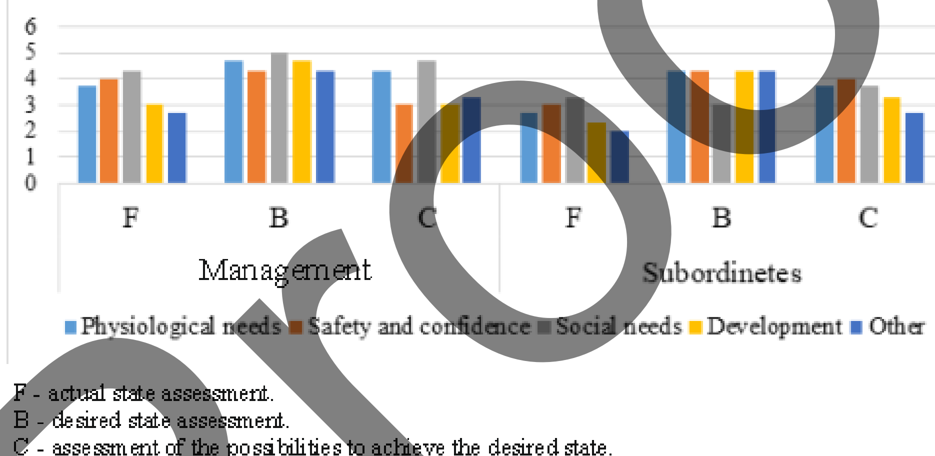

Figure 2. Determination of personnel attitudes toward enterprise development by management levels

Demotivation of workers is seen, however, the questionnaire allows to identify needs and to encourage workers to look for creative approaches to improve the efficiency of the enterprise. In case of successful implementation of the initiative proposed by a worker of any category, this worker will receive a bonus. Based on the results of the study, components of the motivation package and the specific interests of various categories of personnel have been developed. The results are shown in Table 1.

TABLE 1. Composition of the Motivational Package Based on the Results of the Questionnaire.

Categories of workers	**Components of the motivational package %**						
	RC*	**Bonuses**	**Food**	**Travel / car**	**Training**	**Loans**	**FR****
Top management	40,0	83,3	20,0	33,3	59,4	16,7	9,3
Mid-level management	50,0	73,3	20,0	26,7	52,3	56,7	9,3
Qualified specialists	70,0	63,3	10,0	24,2	55,3	13,3	9,3
Workers	70,0	40,0	20,0	26,7	76,5	43,3	9,3

*RC – reimbursement, compensation of expenses for medical treatment
**FR – financial aid for rest

Based on the needs identified by the company, it is proposed to introduce the following changes in approaches to the new management style:

– encourage team members to submit their proposals to address the issues of enterprise development at all levels of management;

– focus on the root of the problem. Solve not only urgent problems, but to allocate time to find the main symptom. At this stage, it is important to take a step back and expand the vision;

– provide time for "thinking" to resolve issues. If the manager gives their team time and space to think, this effectively affects the outcome and increases the level of team involvement [2];

– encourage experimenting. Innovation is an iterative process, focusing on improving the existing ones, it is possible to enhance professional identity and self-sufficiency [6].

It is clear that the implementation of these principles must be carried out in the field conditions (at a workplace), which causes complexity. Their implementation is closely related to control. Therefore, it is suggested for every enterprise to develop a specific document form and a plan for the control frequency and link them with measures to enhance creativity at workplaces [10]. Thus, at the enterprise under study, forms of daily, weekly, and monthly control of information on the construction progress at on construction sites are used. The results reflect the number of employed workers, the number and time periods of the machinery and equipment of the subcontractors used, and remarks of the foreman and the site chief engineer. Items of information: special cases, workers, labor protection, condition and equipment, decision on the construction site, decisions required from the management, work with subcontractors, other comments, as well as the proposals of employees to the head of the facility. Observations by the chief construction engineer on the points: site visitors, works performed, special events, days ahead of schedule (lag), architect's work, availability of customers, weather conditions, tasks requiring solution, site order placement, other comments, and propositions are submitted to Chief Engineer. Examples of documents are given in Tables 2-3.

TABLE 2. Weekly report on the progress of the construction schedule taking into account proposals.

No. of works under the schedule	**Work code**	**Phase of work**	**Type of work**	**Participant of work**	**% readiness of work**		**Deviations from the schedule**		**Early work schedules**		**Actual work schedules**	
					Under the schedule	**Actual**	**Lag**	**Ahead of schedule**	**Start**	**Finish**	**Start**	**Finish**
27	24.10	Finished	Earthworks	General contractor	100	100	-	-	14.02	30.02	13.02	30.02
Received propositions												

Foreman ________________________

TABLE 3. Daily report based on proposals.

Facility____ Date_______

By own efforts of the enterprise			**Through efforts and funds of subcontractors**	**Equipment of the enterprise being used**	
Specialties	**Qty: Employees**	**Qty: Workers**	**Subcontractors**	**Name**	**Qty**
Chief Engineer	1		No	Not used	-
Foreman	1		No	Not used	-
Controller	1		No	Not used	-
Installers		14	No	Not used	-
Equipment operators		12	No	Not used	-
Concrete workers		3	No	Not used	-
Propositions					--

Head of the facility _________

The form of the documents may be different. Operational data on the daily value of works are submitted to the economic department (if it is a large enterprise, and to a specialist, depending on the size of the enterprise). The information on the initiatives of the personnel is submitted to the project manager or the head manager and in this way the communication vertical is formed. In the course of the works execution, and especially after their completion, the head must conduct an analysis of personnel activities, an assessment of creative capabilities of specific individuals to create the necessary conditions for access to the motivational elevator.

CONCLUSION

The following should be emphasized from among the submitted results of the survey:

- low initiative, for example, 108 workers participate in finishing works, the duration of works is 168 days, and there are only 16 suggestions registered;
- the received suggestions concern not only the improvement, enhancement or reduction of certain types of construction works, but also the solution of problems in the field of labor protection, improvement of sanitary and hygienic conditions, of which problems the management has not yet been informed;
- the majority of initiatives relate to wages, logistics and work site arrangement.

From the survey results given, low initiative should be noted. This result is due to the specifics of construction works performed in accordance with the state construction standards and other standards and rules. The received proposals concerned not only the improvement or reduction of certain types of construction works, but improvement of sanitary and hygienic conditions, which was not communicated to the management before. The bulk of the initiatives concerned logistics issues and workplace organization, which in turn helped reduce losses in the enterprise.

Only after gaining knowledge about the future rewards, some employees have a desire to be involved in the process, but most of them have neglected them because of distrust. Problems in logistics and job organization define a range of tasks for management, the solution of which helps to reduce losses in the enterprise. There are divergences between ideological orientation and practical application, therefore special attention should be paid by the leadership for explanatory work with the personnel. The task that needs further research is evaluating the practical value and effectiveness of the proposals received and the decision to implement them. However, a manager needs to keep in mind that the LC implementation is a complex task and cannot yield high results when introducing changes only in certain functional areas.

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Large Housing Estates in Ukraine: Challenges of Post-Socialist Transition

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Abstract. Large post-socialist standardized housing estates of living blocks typology were built under communism during the 1950-80s in every city along with the territory of the former USSR. The concept of centralized planning ideology and the amount of prefabricated large housing estates in Soviet cities solved the problem of the demand for dwellings in the post-war social situation. The contemporary living environment of large post-socialist housing estates features low quality of dwelling and territories. This paper is focused on the analysis of the actual problems, which emerged in the living environment of large-scale panel housing estates, challenges of post-socialist transition and future possibilities of urban regeneration. The research methodology is based on the case study analysis of prefabricated large housing estates in 4 Ukrainian cities. Research shows the ways of urban regeneration of large housing estates in Ukraine.

INTRODUCTION

The central goal of the research is to investigate the living environment of low quality in residential areas in the cities, which mutually need improvement and regeneration in the scope of future sustainable urban development. The most problematic questions are being raised during the last decades about the marginal and post-socialist prefabricated large housing estates built during the 1950-80s in Eastern Europe and Ukraine is among them.

The centralized planning system of the ‘new’ cities, prefabricated panel housing construction, typical projects of living blocks for new housing estates, formed the main approaches by Soviet socialism ideology in the development of the cities in the USSR during 1930-1991. Post-war living environment received phenomena of *micro-district (microrayon)* planning system as large housing estates in all post-socialist cities. Prefabricated panel housing construction prevailed in the housing typology in the development of the cities. The statistical data of construction of housing according to the typical projects in the USSR showed the next dynamics: 1958 – 77 %; 1960 – 88 %, 1965 – 95 % [1].

The general quality of the living environment of areas with typical housing estates decreased, and there is a tendency today of quality decreasing as low functionality of public spaces near the blocks; low quality of the buildings and technical services; high energy losses; low safety of the environment in the neighbourhoods; anonymous transits across the territory of the area. The state-of-the-art shows that local studies [2, 3] do not consolidate around the development of complex approaches for urban regeneration strategies.

The country received the same challenges in the areas of panel housing blocks as socialist ‘heritage’ of the prefabricated living environment as other post-Soviet countries. The capital of Ukraine Kyiv has got 63,8% of typical housing among all housing in the city; data in other Ukrainian cities are as follows: 81,8% – Donetsk [4, p. 6-7];

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85,2% – Kharkiv. Actual scientific discussion of the features of typical mass housing living areas deals with technical indicators and methods [5-7]; possibilities of reconstruction of living blocks and territories of mass housing [8-10]; challenges on the renovation of the first mass housing series (1950-60s) [11-13]; safety of living environment [14]. The goal of the paper is to analyze the actual problems, which arose in the living environment of large-scale panel housing estates in Ukraine and the future possibilities of their urban regeneration.

RESEARCH METHODOLOGY AND DATA

Research Methodology

The research comprises the case studies of prefabricated housing estates in Ukraine in cities: Lviv – 0,76 m citizens (2016), Kharkiv – 1,45 m citizens (2015), Dnipro – 0,97 m citizens (2017), Lutsk – 0,21m citizens (2017). The case studies are the biggest panel housing estates: in Lviv – large post-socialist housing estate Sykhiv (151 371 residents in administrative district, 2011); in Kharkiv – Saltivka (385 000 residents, 2010); in Dnipro Peremoga (75 000 residents); in Lutsk – Zavokzalnyj (58 000 residents). The territory of living area Sykhiv occupies 390 hectares, Saltivka – more than 700 hectares, Peremoga – 225 hectares, Zavokzalnyj – around 150 hectares.

The system of *micro-district planning design* was implemented here as the main approach in Soviet prefabricated housing development. The research looks at the historical development of prefabricated housing in Ukraine, used typologies in housing construction. The observations of the case studies are built as follows: (a) the usage of the environment near the living blocks; (c) transit territories; (d) functioning of the inner courtyard open spaces; (e) the functional interventions to the large housing estates.

Prefabricated Housing in the Soviet Union: Historical Background

The beginning of prefabricated housing construction in the Soviet Union was in the 1930s when few industrial technologies were implemented into practice employing German architects [15]. The process of prefabrication increased to mass amounts only after 1954. Khrushchov declined at the All-Union Conference of Builders, Architects and Workers in the Building Materials Industry, in Construction Machinery and Road Machinery Industries and in Design and Research Organizations on December 7th, 1954 [15], that the effectiveness of the construction industry could be fulfilled only using standardization.

The strategy of prefabrication aimed: 1) to have the smallest probability of nonstandard decisions in design and construction of buildings; 2) to design the smallest amount of project series from typical elements; 3) to use typical projects (serial projects) in the cities all over the Soviet territories; 4) to centralize the design activity in State design institutes. Nevertheless, the centralized design and construction industry developed the approach of the typical projects during 1954-1991, especially in mass housing. This approach was based on the implementation of a more complicated typology of panel housing, their parts and elements in a centralized design.

Prefabricated Mass Housing Typology in Ukraine

The development of prefabricated mass housing typology of industrialized construction in Ukraine during the second part of the XXth century received the next stages:

(1) 1955-1969: development of the first new housing estates with spacious planning of the living area with micro-district approach [16]; construction of 5-9 storeys slab housing; design of typical projects (series) for housing prefabrication;

(2) 1970-1989: development of living areas of mass housing estates using regular (perimeter, linear) and non-regular (spacious, combined) planning types [17, p. 96]; design of building block-part, semi block-part, block-elements instead of typical buildings; design of prefabricated housing with a different configuration of the plan (long ribbon-curve building, ‘zigzag’ plan type buildings, ‘hexagonal planning structure’ [18, p. 22-23]; cascade compositions with 9, 12, 16, 18, 22-storied buildings [16]; high-storied buildings-towers.

Case Studies in Ukraine: Lviv, Kharkiv, Dnipro, Lutsk

Ukraine was one of the largest republics with the population that was decreasing and increasing during different historical periods with the total change from 29 m (1926) to 51,7 m (1989), and 42,8 m (2016). The last population data are preliminary, excluding the temporarily occupied territories of the Autonomous Republic of Crimea, and Sevastopol.

Among the biggest cities of Ukraine which represent Ukraine are Lviv (0,76 m citizens, 2017), Kharkiv (1,45 m citizens, 2017), Dnipro (0,99 m citizens, 2019), Lutsk (0,217 m citizens, 2020). The scale of large post-socialist housing estates differs accordingly to the scale of the city. Thus, the biggest panel housing estates are the next: in Lviv – Sykhiv (151 371 residents in the administrative district, in Kharkiv – Saltivka (385 000 residents), in Dnipro – Peremoga (75 000 residents), in Lutsk – Zavokzalnyj (58 000 residents).

Lviv: Sykhiv, the 1970-80s.

Large-scale housing estate Sykhiv is the biggest living area in Lviv with prefabricated large-panel multistoried housing developed during the 1970-80s in the southern part of the city (Fig. 1). The territory of living area Sykhiv occupies 390 hectares and had been designed for 120 000 residents. This large socialist housing estate was divided into 4 planning zones, which comprised 12 micro-districts in total. Each micro-district was planned for 7 000-10 000 residents.

(a) (b)

FIGURE 1. Large housing estate Sykhiv (Lviv, Ukraine) with prefabricated large-panel multistoried housing (1970-80s): (a) masterplan; (b) large-panel 9-storeyed living blocks of typical project 84 series; source: co-author Oksana Chabanyuk, 2003.

The system of micro-district planning design is the main approach in Soviet prefabricated housing development. The micro-district is a structural planning element of the living area consisting of living blocks, social services (kindergartens, schools), green areas, sports facilities etc.

Multi-family buildings in Sykhiv were built according to the typical project of a large-panel 9-storeyed living block of number 84 project series (Fig. 1(b)). The master plan implements the free (open) planning system of housing in the territory. The 16-storeyed living towers tried to make the composition and image of the living environment not monotonous. The typical series project was developed into several variations by State Design Institute “Mistoproekt” (City Design) that allowed improvement of the planning typology of blocks and receiving the most comfortable flats according to the norms and standards.

The administrative district Sykhiv, which was created in 2001, comprises the housing estate Sykhiv and the nearest territories around it with an official population of 151 371 residents (2011). The density of the living area started to receive new 5-17 storied housing from 2000 on the empty territories. Such examples of partial densification became possible after the changes in urban policies, norms and regulations, which were in use in the Soviet version long after the collapse of the USSR.

The new commercial areas with trade centers were constructed on the neighbouring to the living area open spaces during 2000-2021. Sykhiv is undergoing the implementation of a pilot project of complex insulation of the post-Soviet prefabricated housing blocks under the coordination of GIZ office in Ukraine from 2018 that gives a significant positive example for other cities.

Kharkiv: Saltivka, 1970-80s.

Large-scale housing estate Saltivka is the biggest living area in Kharkiv, with large-panel multi-storeyed housing, developed during the 1970-80s, in the north-eastern part of the city. The territory of living area Saltivka (Saltovka) occupies more than 700 hectares. The growth of population showed in 1977 – 250 000 residents [19], 2010 – 385 000 residents. The construction of Saltivka was performed according to the phases of micro-districts plan development till the late 1980s. New living blocks were built during the last 15 years on the empty territories of Saltivka. Being the largest socialist housing estate in Ukraine it comprised 22 micro-districts (Fig. 2). Each micro-district was developed for 17 500 residents on average.

The typology of prefabricated buildings in Saltivka uses the typical projects: large-panel 5-, 9-, 12-, 16-storeyed living blocks with linear, semi-linear and tower structures (Fig. 3(a)). The most used typical project that was used for the development of living estate is number II-57 series (Fig. 3(b)). The planning system of housing in the territory is designed in the free (open) planning (Fig. 3(a)). The micro-district planning includes social services, green areas few sports facilities.

(a) (b)

FIGURE 2. Large housing estate Saltivka in Kharkiv, Ukraine, 1970-1980: (a) – scheme of micro-districts in Saltivka; (b) – aerial view on micro-districts in Saltivka [19].

(a) (b)

FIGURE 3. Micro-district 605 in Saltivka, Kharkiv, Ukraine, the 1970s: (a) - 3D model; (b) - large-panel 12-storeyed living blocks, typical project II-57 series; source: co-author Oksana Chabanyuk, 2017.

New commercial areas with trade centers were also constructed in Saltivka, Kharkiv, during 2000-2021. Saltivka receives new housing construction as spots in the existing post-socialist planning structure. The increase of the density in the large housing estate occupies old open spaces.

Dnipro: Peremoga, 1971-1982

Peremoga is one of the largest housing estates of prefabricated multi-storey buildings in Dnipro, but they are small in comparison to similar living areas in other cities. Peremoga was built during 1971-1982 in the southern part of the city near the bank of the Dnipro River in an artificially formed site (Fig. 4). The territory of Peremoga large housing estate covers 225 hectares. It is designed for 75 000 inhabitants and consists of two planning zones Peremoga-1-2-3 and Peremoga-4-5-6. The entire residential area of Peremoga consists of four main micro-districts with an area of 18, 19, 23, 33 hectares and two classic micro-districts with a full complex of public services with an area of 43 hectares each.

The project was developed by the State Design Institute "Dniprotsivilproekt" (Dnipropetrovsk Civil Design) and the author's team was awarded the USSR State Prize in 1983 for high architectural, spatial and functional qualities of the complex of typical large-panel buildings (Peremoga-4-5-6) [20]. This area has a distinct spatial and compositional character: a wide boulevard towards the Dnipro, a dominant group of houses-towers, an 800-meter "house-wall", a variety of main spaces and silhouettes.

(a) (b)

FIGURE 4. Large housing estate Peremoga in Dnipro, Ukraine, 1971-1982: (a) – scheme of micro-districts in Peremoga; (b) – 3d model and aerial view on district Peremoga; source: co-author Iryna Shvets, 2021; photo from google/maps.

Several series projects of large-panel 9-, 12-, and 16-storey residential buildings were used in the development of the Peremoga district (Fig. 5), as well as an individual project of monolithic 28-storey buildings. The architects tried to achieve diversity and visual comfort by plastic solutions of facades, colour solutions, the well-thought-out composition of open spaces and buildings. The complex of social services was at that time the most developed in comparing to other living areas of the city (cinema, the first supermarkets, etc.).

(a) (b)

FIGURE 5. Prefabricated large-panel multistoried housing in Peremoga, Dnipro, 1971-1982: (a) large-panel 16-storeyed living blocks, typical project 1-464D-E193 series; (b) large-panel 12-storeyed living blocks (96 series) and 9-storeyed living blocks (1-464D series); source: co-author Iryna Shvets, 2021.

Among the areas of large-panel housing, which are in the peripheral zone of the city, Peremoga remains the most prestigious in Dnipro. The proximity to a large recreation area on the bank of the Dnipro River significantly improves the quality of living in the large housing estate Peremoga. This factor attracts modern developers to develop vacant plots more actively as well as to increase the density of buildings within the district with new residential complexes (Fig. 6). During 2000-2020, the level of improvement of green zones along the riverbank and the variety of new recreational and sports facilities is the highest in the city. At the same time, the situation with the level of spatial environment and social comfort within the residential area is typical, all the problems that exist in other cities are revealed here.

(a) (b)

FIGURE 6. New housing in the large housing estate Peremoga built during 2010-2020, Dnipro: (a) housing and a park Pryberezhnyi, 2019; (b) monolithic 28-floor housing (1980) and new housing blocks (2020); source: co-author Iryna Shvets, 2021.

During 1991-2021 there were built 7 residential housing estates from 9 to 16 floors and commercial facilities in the area and around the large housing estate Peremoga. The functions of public buildings and premises are changing, some of them are declining, and some service functions are appearing on the ground floors instead of residential apartments. Spontaneous functions (garages, cellars, dovecotes) appeared in residential groups as early as the 1980s and 1990s; in the 2000s small business, even sacred objects in the building extensions, later new playgrounds and sports grounds; as well as chaotic car parking (Fig. 7). There are attempts by residents to improve the living environment, which, however, do not achieve sufficient effect. Free and open planning of housing groups, high population density and heterogeneity (social segregation) are likely to have a negative impact on this.

FIGURE 7. Transformations of the functions of the interior space of residential groups in Peremoga, Dnipro: sports ground, commercial functions, a temporary temple in the building extensions, chaotic parking, changes on facades; source: co-author Iryna Shvets, 2021.

Lutsk: Zavokzalnyj, 1970-80s.

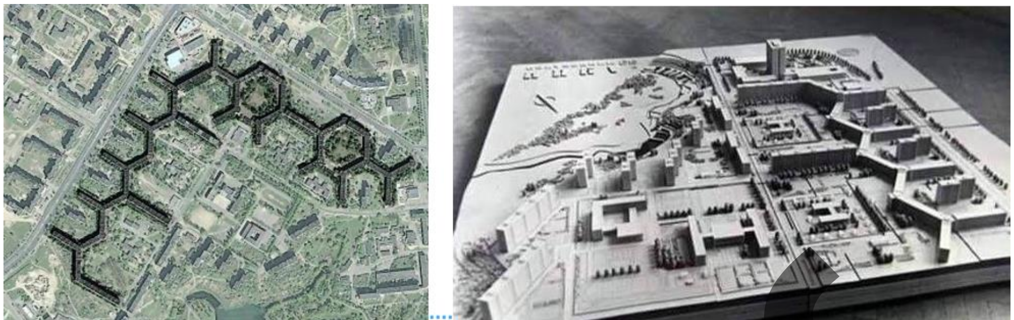
Large residential area Zavokzalny is the largest multi-apartment residential area in the city of Lutsk, which is formed of prefabricated large-panel and brick 5-9-storey sectional buildings. There were a tank track and military and civil airfields in the postwar years on the territory of the district. In the early 1970s, the city authorities initiated a construction decision of a silk factory, cardboard and roofing plant, and a synthetic leather factory, which was located around. During the 1970s and 1980's the large housing estate developed in the north-eastern direction and was named Zavokzalny as it was located behind the central station of Lutsk. Today the territory of the residential district occupies about 150 hectares, it is intended for 58 000 inhabitants and is divided into 3 micro-districts (33, 40, 55).

Typical block sections (corner, rotary, ordinary) number 87-094 and 94-082 project series, developed by the Central Research Institute of Housing in Moscow and put into use by the Lviv and Donetsk branches of the Dipromist (State Institute of Urban Design) of the Ukrainian SSR, were used for the construction of the micro-districts in the large housing estate Zavokzalny. Adaptation of standard projects to the area was carried out by a team of architects of the Volyn branch of Dipromist under the leadership of Vasyl Malovytsia (Fig. 8). The territory of the residential area is saturated with social infrastructure. The project of the 1970s provided the location of the city's central bus station, market and recreation park with an area of 19,34 hectares.

(a) (b)

FIGURE 8. Zavokzalny residential area, Lutsk: (a) 9-storey brick houses number 87-094 project series; (b) 9-storey panel houses number 94-082 project series; source: co-author Inna Abramiuk, 2018.

In 1969, under the leadership of V. Malovytsia, an extraordinary project of the world's longest residential building was developed for the 33rd district of the Zavokzalny large housing estate. The architects managed to get spacious hexagonal courtyards and a rhythmic structure of the quarter due to the chain blocking off the three-beam individual block section with an arched passage and built-in public spaces on the ground floor and a typical ordinary section of the number 87 project series. The residential building was built in 1980, at the time of completion its length was 1,75 km (Fig. 9). The micro-district was included in the national list of landmarks in the 1980s.



(a) (b)

FIGURE 9. Residential building “honeycomb” in residential area Zavokzalnyj, architect W. Malowycja: (a) aerial view; source: Google Maps, 2021; (b) 3D model; source: archive of the Volyn branch of Dipromist (State Institute of Urban Design), 2021.

Architects of the workshops of the Volyn branch of Dipromist (R. Metelnyckyj, A. Bidzilia, J. Shewchuk, A. Zaworotynsky, O. Kowalchuk, J. Senyk) have been making changes to the decoration of facades of serial buildings by saturating them with decorative details since the mid-1970s. balconies, loggias, attics, vertical articulation of walls (Fig. 10).

(a) (b)

FIGURE 10. Residential building “honeycomb” in residential area Zavokzalnyj, architect W. Malowycja: (a) aerial view; source: Google Maps, 2021; (b) 3D model; source: archive of the Volyn branch of Dipromist (State Institute of Urban Design), 2021.

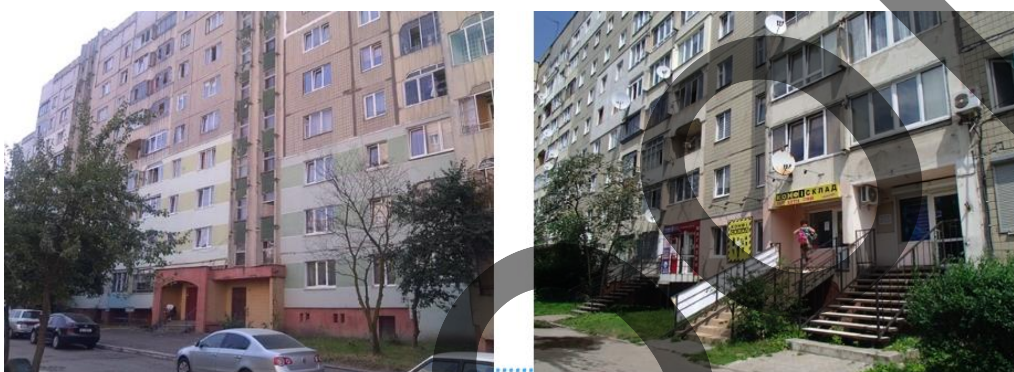
For the last 30 years in already existing quarters of the Zavokzalny in Lutsk free territories are actively built up with housing blocks, tower type housing and closed yards-quarters with provided public service premises, pharmacies, parking lots, playgrounds and sports grounds, recreation areas. Modern housing is reduced to a height of 9 floors. Processes affecting existing buildings are as follows: fragmentary insulation and cladding of facades, the ground floors extensions with trade and public service facilities, extensions with sacred buildings, placement of kiosks for trade, garages on recreation areas. These changes decreased the creative achievements of architects of the last century and affected the general aesthetics of the large housing estate.

Case Studies Analysis Results

The observations of functions and living processes, which were made in large multistoried housing estates Syhiv (Lviv), Saltivka (Kharkiv), Dnipro (Peremoga), Lutsk (Zavokzalnyj) built in the 1970-80s, prove lack of comfort in the living environment in this area. The living environment here received negative and low quality functional, social, psychological, and discomfort features. The problems in the living environment and the reasons for their occurrence are described lower.

The usage of the environment near the living blocks is ineffective and inappropriate, which leads to the appearance of unused lands. These are the territories of the inner space of the living quarters, which are not used for the needs of the inhabitants, or their usage is not defined. Transit territories appear under the condition of open space in the living area and quarters with the open planning scheme. Transit territory in this case means that the functional process starts or finishes outside the margins of the living space of the inner courtyard of the quarter. The combining of inconsistent functions leads to the appearance of functional conflict points in the inner courtyard open spaces, because of imposition or proximity in the environment of inconsistent functions and form functional conflict environment. There is a difficulty in creating in the inhabitants' the feeling of being the owner of the living environment, that they are responsible for the shared territory that belongs to the living block. Being the owner of the apartment, he has not become the owner of the courtyard.

The challenges of quality in prefabricated housing: (a) poor state of housing infrastructure facilities, lack of counting equipment in district heating system for each living block; (b) heat losses in the multistoried blocks during cold seasons; (c) general low quality of common premises in the block: staircases, elevators, entrances, cold loggias, roofs, technical levels; (d) installed windows by the residents to the balconies and loggias; installed insulation of the facades only on the surface of the walls, which belong to one owner by himself (Fig. 11(a)); built extensions to the flats of the ground and first floor that cause the changes of the facade in the building; (e) formal and informal non-systematic transformations of the residential function to commerce on the ground floors of multistoried housing blocks (Fig. 11(b)).



(a) (b)

FIGURE 11. (a) installed insulation of the facades by the owners of the apartments, Sykhiv, Lviv; (b) Transformations of the residential function to commerce on the ground floors of multi-storey blocks, 115 Chervonoyi Kalyny Av., Sykhiv, Lviv; source: co-author Oksana Chabanyuk, 2017, 2018.

CONCLUSION

The selected case studies show spatial, social and technical problems in the living environment of large-scale post-socialist estates. The data of these areas (population, territory) allow us to affirm that the case studies represent current conditions of low quality in other huge living districts in the cities throughout Ukraine as well as other areas with prefabricated housing. The living environment built in the 1970-80s had become low quality during the last 30 years of use, while it had not been benefitted from the strategic regeneration process during the post-socialist transition.

The use of innovative experiences for future regeneration would improve the quality of the living environment of the prefabricated areas. Among the economic situation in the country that does not allow implementing the multidimensional strategies for urban regeneration in the living areas with prefabricated housing built during the 1950-80s in Ukraine.

The results may contribute to the area of development of administrative mechanisms of interaction between consumers of panel housing estates and architects, city authorities in Ukraine. Urban regeneration of post-socialist housing estates should aim for the improvement of the quality of the living environment, its livability and safety. Thus, the perspectives of urban regeneration of large housing of the Socialist era are (a) complex functional interventions (space and blocks); (b) urban regeneration program; (c) sustainable redevelopment.

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Psychogeography as a Reflection of Cognitive Urbanism

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Abstract. The article considers the emotional impact of the environment on society and the formation of cities. The scientific direction – cognitive urban planning is considered. Analyzed the history of the formation of psychogeography as a science that combines the components of urban planning, psychology, urban planning, philosophy and sociology. The interdisciplinary experience of the impact of modern technologies on humanity in general and urban planning in particular is studied. The tendencies of city formation in the XXI century are revealed. The main directions of urban research of the present and prospects of urban development in the context of globalization are determined. Analyzed the history of the formation of psychogeography as a science that combines the components of urban planning like psychology, urban planning, philosophy and sociology. Revealed the interdisciplinary experience of the impact of modern technologies on humanity in general and urban planning in particular is studied. The tendencies of city formation in the XXI century. The main directions of urban research of present and future urban development in the context of globalization are identified.

Architecture is not a medium of personal expression for me. However, for me there was never any doubt that architecture must contribute to society's progress and ultimately to our individual and collective wellbeing.

Zaha Hadid, architect

INTRODUCTION

Urbanism exists at the intersection of dozens of sciences. One such science is psychogeography – a trend in social psychology and philosophy that studies the psychological impact of the urban environment on humanity. Cognitive urban planning is a system of scientific knowledge that combines ideas from sociology, psychology, geography, culturology and other disciplines for use in architecture, urban planning and design. The city shapes a person's life from dozens of sides, invades his personal space. The cultural, psychological and spatial separation of the individual and the territory is so conditional that its analysis requires great effort. Many urban planners, architects, historians and psychologists of past centuries have studied the comprehensive impact of the city on humanity [1]. For example, Yuval Noah Harari, an Israeli military historian-medievalist, professor of history at the Hebrew University of Jerusalem, analyzes in his research the formation of humanity, the development of society and its existence in the past and future, including living conditions in different periods [2-4].

The German thinker Georg Simmel was one of the first to look at the modern city as an urgent problem and began to study it. In 1901 he published his book "The Metropolis and Mental Life" [5]. According to Georg Simmel, the city is a space of atomization and alienation, which at the same time gives freedom due to the special anonymity of the city. Georg Simmel transformed sociology into the science of modernity and made the inner life of man the direction of the science of society. He was interested in the spirit of the times and he tried to describe it by looking at everyday human existence. Simmel was the first sociologist to think about consumption and money, about fashion and tourism, about love experiences and perceptions of time. Nevertheless, the most important thing for future urban planners is

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that he began to consider the big city as the quintessence of modern life. Psychogeography, as a field of sociology and philosophy, explores the psychological impact of the city on man. However, at first this concept had a different meaning. The term "psychogeography" was proposed in 1953. in the article "Collection of rules of new urbanism" by Ivan Shcheglov, a member of the "Lettrist International" – a cultural and political movement from which grew a creative group of situationalists. Situationalism as a political movement emerged in France in 1957 and was revealed during the events of May 1968, when student speeches escalated into a multimillion strike.

Psychogeography of Guy Debord

One of the founders of psychogeography is Guy Ernest Debord – a French philosopher, writer and director [6, 7]. Together with young supporters, he formulated methods of exploring the city that went beyond the utilitarian perception of megacities. Counterculture opposed capitalism, and the society of the revolution of consciousness opposed the society of consumption. In this space, at the intersection of bold ideas of the time, psychogeography appeared. Numerous followers regularly rethink the historical and cultural significance of this period. Initially, psychogeography was the embodiment of rebellion. However, political significance was replaced by cultural, psychological and urban meanings. Today, psychogeography is a set of practical methods for harmonizing urban space in terms of the psychology of the citizen and his emotional state.

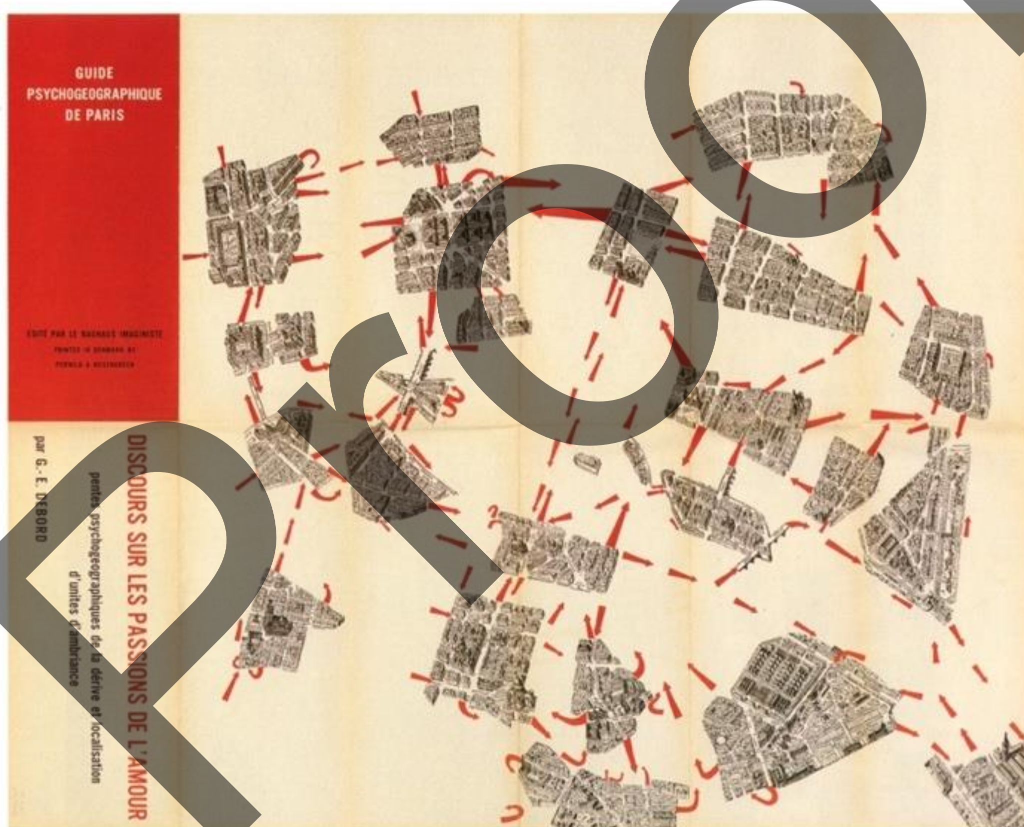

FIGURE 1. Psychogeographical map of Paris by Guy Debord, 1957 (by Phil Gyford) [8]

The architecture and landscapes of major European cities, both in the mid-20th century and now organized similarly. Now and before the city imposes certain rules on a person – the usual routes, the same places, the same transport. At the same time, people feel the usual similar emotions. For the creators of psychogeography, the city was a testing ground for the revolution. Situationists changed their approach to it, created non-traditional maps, manifestos, posters, guides. Situationalists changed the concept of "flannel", turning a person from a free passerby to a revolutionary. The literary image of the flannel gradually merged with the image of the conscious citizen. This union became interesting to urban planning. The dream of the situationists was a unitary urbanism: full of free places for free people. Residents of the metropolis walk approximately the same routes every day. The same people walk in the same parks and squares, visit the same restaurants and cafes, go to work on the same roads. Guy Debord drew up flexible urban research rules – the creation of practical "situations" that would be different from the usual for city residents. It was necessary to record feelings, collect information of objective and subjective nature, discuss it with satellites and make conclusions. The concept of "performance" meant not a spectacle as an alienation, the lack of participation of people in each other's lives and the urban environment. Guy Debord presented psychogeography as "the study of the exact laws and specific consequences of a consciously or unconsciously organized environment that affects human emotions and behavior." He pointed to the need to create a critical discipline at the intersection of psychology, social theory, geography and art history. Research practice "dérive" was developed as a method of cognition. The French word "dérive" can be translated as "drift" or "stream". The researcher-psychogeographer explores the territory of the city without a predetermined route (Fig. 1) [8]. Subjective and objective data that can be collected during drift have a direct emotional impact on a person. Within the framework of the newly created discipline, the emotions and behavior of people in the urban environment and the specific impact of urban objects on society are important. Thus, from specific studies of situationists, full of dubious philosophy, we can move to direct psychological tools of interaction with the city.

The Modern View

Interest in psychogeography from time to time arose among scientists in various fields. Today, when marking your favorite architectural monuments, cafes or street art on Google Maps, we involuntarily rely on the experience of psychogeographic maps. Thanks to QR codes, Google Maps users can create quests, describe objects, and form their own tourist routes. The study of space, the discovery of new spaces, the creation of art objects today are practical tools of drift. The modern city, full of impossible speed, lives with clearly defined schedules and rhythms – these features of today are a new stage of psychogeographic research. In recent years, the main meaning of the existence of cities has changed significantly. This phenomenon was especially noticeable due to the impact of the global pandemic COVID-19 in 2020–2021. This is undoubtedly reflected in the current architecture and urban planning. Many researchers recognize the role of sacred and spiritual meanings as key in the formation of urban space. Today in the urban discourse, there are less and less topics related to the cultural codes of urban spaces, their perception and the ability of man to overcome their own boundaries. Globalization erases the identity of cities, including spiritual ones. We will see more globalization in the future – more robots, artificial intelligence, virtual reality technologies and more. Humanity lives in the illusion of progress and neutrality of technology. However, the ability to get more information about the world does not always lead to the most rational decisions. Smartphones, smart homes, speech and image recognition technologies, augmented reality control our attention and activity. Modern urban planning and communication technologies are actively used to subjugate citizens, colonize free spaces, and distribute order and discipline. Cities are becoming smarter: they are growing with cameras, sensors, telecommunications hubs. Life in a modern metropolis is inextricably linked with being in the information flow. Subjective perception of the city, tracking emotions and the impact of living conditions for the inhabitants of the metropolis becomes a working tool of psychotherapy.

Why does the place where we live have such an effect on our well-being? What is a house in terms of psychology? Sigmund Freud claimed that this is the womb «We came from there and want to return there, because it is safe, warm and there is food». Carl Jung compared the house to a cave. Both interpretations imply that the primary function of a home is to provide a roof and protection. The need for security American psychologist Abraham Maslow placed on the second level of his pyramid. On the first – physiological needs. Maslow can be called the first evolutionary psychologist. His pyramid of needs is a common name for a hierarchical model of human needs, which reflects one of the most popular and well-known theories of motivation – the theory of the hierarchy of needs. The idea was first set out in The Theory of Human Motivation (1943). In more detail – in the book "Motivation and Personality" (1954) [9]. Its pyramid explains how the house and living area affect a person's happiness. After gaining security, there is a need for communication, self-identification, self-esteem and realization of their dreams (Fig. 2) [10].

Architecture can worsen or minimize threats to the well-being of life. It is very important what our houses, streets, districts, public buildings look like, and how they are designed. In addition, not only from an aesthetic point of view, but also from a psychological one. Attractive homes, neighborhoods and public spaces improve the quality of life and smooth out the stress of working days. Usually, society is immersed in their worries and does not notice the influence of the environment on mood. However, it is quite tangible. Architects and urban planners should think more often about how to make the space in which we live more comfortably.

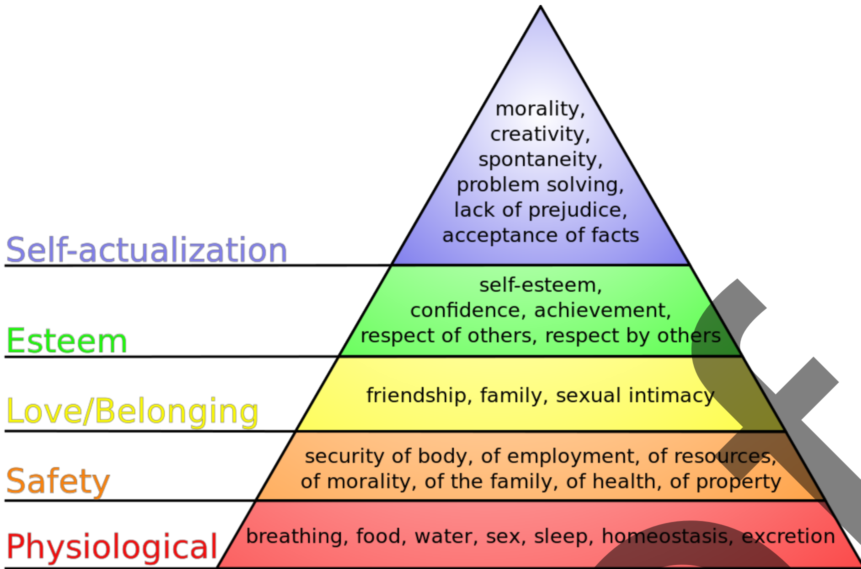

FIGURE 2. Hierarchy of needs – the Maslow`s pyramid, 1954 (by J. Finkelstein) [10]

Research of Scientists of the XX-XXI Centuries

In 1961, Jane Jacobs, a prominent Canadian-American writer, activist, urban planning theorist, and one of the founders of the new urban movement, published "The Death and Life of Great American Cities" [11]. This book was written 60 years ago, has long been a classic, but still has not lost its revolutionary significance in the history of understanding the city and city life. It was in this work that for the first-time arguments were consistently formulated against urban planning, which is guided by abstract ideas and ignores the daily life of citizens. According to Jacobs, a living and diverse city, based on spontaneous order and various mechanisms of self-regulation, is much more viable than the implementation of any urban theory, no matter how thoughtful and rational it may seem. We can clearly see this in the aerial photographs of the world-famous photographer Johnny Miller.

Perceptions of beauty and comfort are always changing, new generations of architects and urban planners are entering the scene, economists are creating new concepts, and environmentalists are focusing on new threats, each stage of fleeting intellectual fashion becomes part of the city's history. Ideas about urban development do not go back in time with their time. They are physically embodied in the urban landscape, layered and affect each other – the urban residents in the first place. Professor of the University of Pennsylvania Witold Rybczynski in his work "Makeshift Metropolis: Ideas about Cities" (2010) describes the main details of the intellectual constructor from which the modern city is assembled [12].

Today, most of humanity lives in cities. However, what is a city today – a place or an idea? What does the city do in general? By what signs can we identify a modern metropolis? British writer, director of the Museum of Design in London, architectural historian, urbanist Deyan Sudjic in his work "The Language of Cities" (2017) [13] describes the hidden forces that shape the urban space around us – from the names of streets and landmarks to a sense of community that unites Londoners, Istanbulites or Mexicans. The book "Urban Code: 100 Lessons for Understanding the City" (2011) [14] formulates these patterns: revealed hidden relationships, invisible forces and unwritten rules that affect how citizens move, rest, gather together and adjust to the urban environment.

Happiness in the urban environment is possible, says English historian and urbanist Leo Hollis. You just need to learn to understand the city and properly use the opportunities provided to man. In the book "Cities are good for you: the genius of the metropolis" (2013) [15], he criticizes the city and considers the concepts of disunity and inequality, terrible ecology, transport collapse, demonstrative consumption, inhuman rhythm and loss of moral norms.

American sociologist and economist Richard Florida, best known as the author of the theory of the creative class, analyzes society as an important component of modern cities. According to his research, the key factor in the successful economic development of cities and regions is the creative elite. Along with cultural development, one of the factors of success of the Florida regions also highlights the level of tolerance. He notes the direct relationship between the number of non-traditional sexual orientation, bohemians and immigrants on the one hand and creative personalities on the other. Richard Florida explains this by saying that an open and tolerant environment attracts creative people, where they have freer in their actions and self-expression. In his works "The New Urban Crisis: How Our Cities Are Increasing Inequality, Deepening Segregation, and Failing the Middle Class-and What We Can Do About It" (2017) [16] and "The Rise of the Creative Class" (2019) [17] he focuses on issues related to innovation and its impact on public life.

Well-known Canadian scientist, specialist in cognitive neuropsychology and psychogeography Colin Ellard in his work "Places of the Heart: The Psychogeography of Everyday Life" (2015) [18], considers how the urban environment contributes to the development of mental disorders? Why is the appearance of unremarkable boring buildings harmful to health and simple little houses attract attention? Is it good to live in a smart city? Where is it better to create and where to work? Can technology change our relationship with space? Based on the results of many experiments, statistics and his own observations made in the course of psychogeographic research around the world, Colin Ellard looks anew at the usual relationship of people with space and says what needs to be done to make cities better.

"Me ++: The Cyborg Self and the Networked City" (2004), one of the latest books by American architect and design theorist William J. Mitchell [19], focuses on the impact of wireless technology, global communication and the miniaturization of technology on everyday life – clothing, ways of moving, architecture and urban planning, ideas about time and space. According to William J. Mitchell, wireless networks do not just make our lives richer and more comfortable – they change it fundamentally. Today we are already at the beginning of a new stage of human evolution. We already live in the city of the future – in a virtually continuous media space, with the ability to contact anyone at any time and receive any media content. It is not just a technical revolution – it is a radical change in our daily lives. The works of urban and media theorist, University of Melbourne professor Scott McQuire "The Media City: Media, Architecture and Urban Space" (2008) [20] and "Geomedia: Networked Cities and the Future of Public Space" (2016) [21] answers the questions, what stage of urban development is going through today and what changes will wait us in the future.

We can see the connection between urban planning and such scientific disciplines as psychology, sociology, philosophy, etc. in many works of art: literature, painting, graffiti, etc. Many vivid philosophical caricatures were painted in the twentieth century by the famous Danish cartoonist Herluf Bidstrup.

A well-known representative of the urban impact on society is Banksy – a world-famous British street art artist of the early XXI century. Banksy always points to sore spots, even when it comes to problems in his home country. In 2011 in London, there was an inscription of his authorship "Sorry! The lifestyle you ordered is currently out of stock" (Fig. 3) [22]. This graffiti is located on the wall of one of the houses in the business district of the city. Such a good place for the image allows you to see the picture even from a great distance from the windows of office buildings. The inscription is a satire on the decline of the English economy. His works are often accompanied by "subversive" epigrams, which contain sharp and powerful comments on the social and political aspects of modern society.

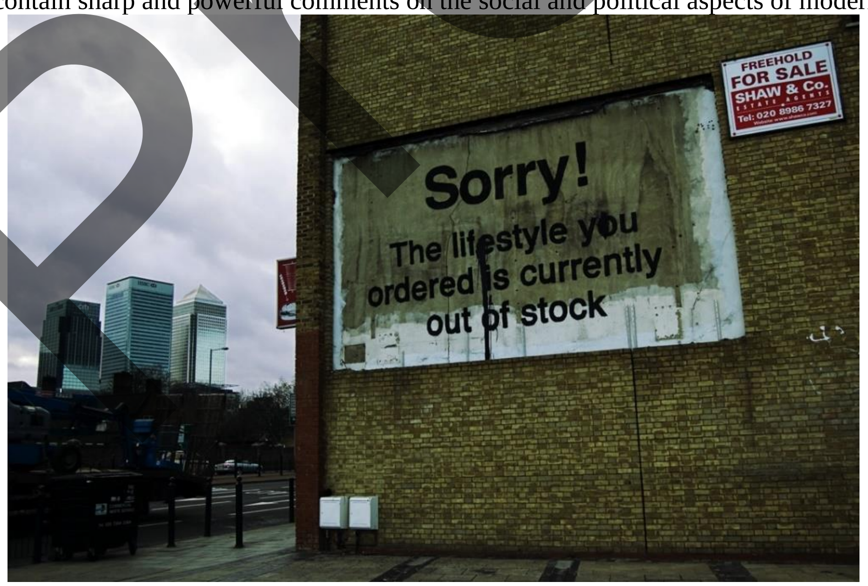

FIGURE 3. Banksy. "Sorry! The lifestyle you ordered is currently out of stock", London, 2011 (photo by Jordi Martorell) [22]

Psychologist Paul Keedwell devotes his research to the hidden psychological aspects of living in an urban environment and their impact on the ability to enjoy life. A striking example is the book "Headspace: The Psychology of City Living" (2017) [23]. More and more people prefer to live in an artificial urban environment. The difference between them and our desire for nature increases the stress of citizens – almost imperceptibly, but quite significantly. The psychology of architecture tells us how life in a brick and concrete world affects our thoughts, feelings, and behavior. Paul Keedwell talks about how to look at your home, street, neighborhood and the whole city in a new way and adapt to changing living conditions, how to inspire and unite people in an urban environment with a constantly growing population, how to create conditions for psychological recovery through architecture and how architectural solutions can cause anxiety, loneliness, and depression.

Today, at the beginning of the XXI century, Ukrainian architects-scientists also continue to study the topic of human impact on the environment of cities and the peculiarities of urban planning and urban planning of Ukraine. These are doctors of architecture: Danylov S.M. "Methodological bases of modeling the city as a dynamic system" (Kharkiv) [24], Pavliv A.P. "Impulse-based theory in the concept of urban development of a large city" (Lviv) [25], Vadimov V.M. "Features of spatial planning in the context of integrated urban development in Ukraine" (Poltava) [26] and others.

CONCLUSION

Research on the key role of emotions in managing our daily behavior also restructures our understanding of psychogeography and how the environment affects us. The idea that the environment affects our feelings and our feelings affect our desires is not new in itself. However, the discovery of the deep relationship between thoughts and feelings suggests that the extent to which these influences change our behavior and well-being has been greatly underestimated. Recent advances in neuroscience speak to an even closer relationship between our inner selves and the structures and technologies that surround us. Modern technology provides great opportunities for scientists to explore how the environment affects our feelings and mood. It is also a new tool in the work of urban architects. The knowledge gained by mankind over the last 100 years through experiments in the field of cognitive sciences allows us to get a more detailed idea of the structure of the thought process. Thanks to this we can predict and explain the behavior of society in everyday life. Modern devices that can read our minds by the heartbeat, breathing or movement of our eyes surround us. Undoubtedly, in the future such technologies will be able to create certain spaces in cities and influence the cognitive development of the population. The custom of creating an environment designed to influence the feelings and behavior of people originated in ancient times. Even before other components of our civilization were formed, such as written communication, urban construction and even agriculture. These components are traditionally considered to be the most important factors that triggered the processes that led to the formation of humanity in its modern form. Wherever a person is: at home, at work, in schools or recreation areas, he interacts daily with the built environment. One way or another, we understand that the space around us influences the thoughts and actions of society. People often go to a certain place because they want to feel its influence (for example, a church or an amusement park). Society perceives the architecture of the city on an emotional level. This perception affects actions inside buildings, streets or public spaces.

Now psychogeography is a cultural and philosophical tool of interaction with the city, supplemented by psychotherapeutic methods. We are able to analyze how local cultural features can block urban change, in what conditions tolerance is formed, what are the points of influence of modern technologies and globalization. The interconnection of modern technology, architecture and sociology can make a great contribution to the future of urban planning. Observation of the life of public spaces demonstrates that a comfortable urban environment is determined not so much by landscaping or design objects, as by the direction of the performance of urban life by organizing a life scenario. Collaborations of specialists in urban planning and psychology have the opportunity to improve approaches to urban design and create comfortable living conditions for new generations. In the XXI century, cognitive urbanism is becoming one of the most important areas of development of modern interdisciplinary research in the field of urban planning. Today, concerned citizens of the world want to understand how space works and even do something to improve it. This is due to the realization that humanity is at the beginning of great changes. Urbanization, overpopulation, climate change and the energy balance of the planet – all this prompts to reconsider the principles of urban development. It is necessary to look for new ways to organize the urban structure so that it helps not only to live but also to maintain mental health. At the same time, the stimulus to transform the living space is given by new technologies, such as the Internet and smartphones, which allow you to communicate at a distance, exchange ideas, images and even convey your mental and psychological mood.

Today more than ever, the ability of urban planning to influence the psychological state of humanity is relevant. During the World Pandemic COVID-19, society feels this especially vividly. Intentionally or accidentally, but one way or another, streets, buildings and spaces make you feel and reflect. A person becomes happier when he smiles in response to the joyful smile of the interlocutor. The same effect can be created by cities and at the same time be the same joyful interlocutor for their inhabitants. These relationships are embedded in the human body in the form of nerve chains designed to enable people to share experiences with each other, to adequately respond to risks and opportunities. These nerve chains also help to respond to the content hidden in the environment.

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Ontology of Postmodern Architecture in Western and Eastern Europe - from the Concept of Emulation to the Theory of Co-discovery

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Abstract. This study examines the role and place of Eastern Europe and the countries of the former "Socialist Bloc" in the emergence and development of postmodernism in architecture. The article presents facts about autonomous and original critique of modernism that took place east of the "Iron Curtain". Important factors of early postmodernism in Eastern Europe originality are: isolation from Western influences and a highest level of "protest potential" (associated with utilitarian, extremely modernist buildings on typical projects). The problem of identifying Eastern Europe as a place of postmodernism co-origin, is in the lack of theoretical works similar to the books of R. Venturi and A. Rossi in the West. This is due to the fact that within authoritarian regime and a planned type of economy, criticism of architectonic practices was tantamount to criticism of the state and was not allowed by censorship. Therefore, the processes of emergence of postmodern ideology in Eastern Europe architecture of 1970s - 1990s are primarily related to the very practice of design and construction. The article gives some examples. Considered data allow to talk about possibility of revising traditional ideas about the origin of postmodernism and the place of Eastern Europe in this regard. It seems more correct to interpret this role as co-creation, rather than borrowing.

INTRODUCTION

In present theory of architecture there is a generally accepted scheme for the spread of postmodernism. According to it, this style was the result of a critical rethinking of Modernism principles in North America and Western Europe. The ideological foundations of postmodernism were laid by the books of Robert Venturi [1,2] and Aldo Rossi [3], which appeared almost simultaneously on both sides of the Atlantic in the late 1960s. Due to the lively spread of new architecture in the United States, it was even sometimes called the "American style". The basis on which postmodernism grew was the oversaturation of urban space with rationalist architectural forms caused only to functions [4,5]. The more the pragmatism of the environment was removed, the more it was receptive to the ideas of greater entropy and accessible sensuality.

We can agree with Robert Venturi's remark that it was American cities, mostly devoid of old historical substance, that most expressed this excessive pragmatism and oversaturation with rationality, which came with the boom of "International style". However, such favorable conditions for the critique of modernism have also developed in another part of the world. Since the mid-1950s, the Soviet bloc has undergone a process of extreme rationalization and typification of architecture. Probably, it was here that modernism reached the maximum of pragmatism and came closest to ideas of radical functionalism of the early twentieth century. At that time, A. Loos expressed the wish that the profession of an architect be completely supplanted by the profession of an engineer.

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RESULTS AND DISCUSSIONS

The practice to construct most buildings on the basis of so-called "typical projects" that was common in the "socialist camp" countries created much more favorable conditions for criticizing the foundations of the modernist vision of the environment than variations of Mies van der Rohe's office building stereotype in Western cities centers. When the books of R. Venturi and A. Rossi, which for the first time substantiated the need to go beyond the modernist design paradigm, appeared radical utilitarianism in the USSR had fifteen-year history. Although Western functionalist architecture did not have a gap for Stalin's neo-classicism, which defeated the Soviet constructivist movement in the 1930s and lasted until Khrushchev came to power, the next wave of typical construction more than made up for it. Even if we doubt this, it is need to note, that radical utilitarianism in the Soviet bloc continued to dominate even at a time when the postmodernist movement was already actively developing in the West during the 1980s. In this regard, it would be strange to assume that in the presence of the same, and probably more favorable, conditions in Eastern Europe there is no sentiment of a critical attitude towards the existing modernist paradigm.

However, along with these similarities, there was a significant difference. What really distinguished the two "camps" was the opportunity to freely express critical thoughts about the surrounding reality, especially if it was related to the activities of the state. Since all design and construction in the Soviet system belonged to the state, doubts about the correctness of architecture meant doubts about the correctness of the state course and ideology of the ruling regime. Thus, if the theoretical works of Venturi and Rossi became the beginning of the postmodern movement in the West, nothing like this could have happened in the East. The crisis of modernity was experienced here latently, outside the public sphere.

All this, however, did not mean that the absence of theory leads to the absence of practice. Not all phenomenon require a previously announced manifest to occur. At the very least, such a manifesto may arise afterwards. In this regard, the question is: what can be the theory of a critical rethinking of modernism in Eastern Europe in the 1970s and 1980s, if we write it now? And is it correct to think that postmodernism came here as an imitation of the West after the end of the Cold War [6]? Obviously, to answer this question, it is necessary to consider some practical material, which is the only one that can testify the emergence of the postmodernist movement not only on the western side of the Iron Curtain.

In order to experience the true status of postmodern formation within the Soviet bloc, it's worth to consider the most representative construction that took place here that time. Despite the dominance of "typical" projects, in some exceptional cases, it was allowed to design "individual" projects ailso with the consideration of local specifics. [7,8] In the mid-1980s started the designing of the main vacation residence for the Soviet leaders - the state dacha №11 "Zorya" in the Crimean oblast of the Ukrainian SSR, better known as the "dacha in Foros" (architect A. Chekmarev). The place became world known during the coup d'etat attempt in the summer of 1991, which caused the collapse of USSR. It was here President Gorbachev was imprisoned and isolated.[9]

From an architectural point of view, the building, which was built in the second half of the 1980s, was the antithesis of modernism and the opposite of the prevailing "typical projects" style. If modernism was characterized by rectangular monumental forms with flat roofs, abstractionism and strict connection of form with function, here we see a purely postmodern object. The main architectural plot of the building is formed by a combination of a huge sloping roof and massive arches on the facade. The arcade motif is supported in dormer windows and driveway to the seashore. The presence of these elements, however, does not make the building look like any historical sample. It does`t imitate any style of the past. Large arched elements on the entrance and sea facades have no practical function and exist only for decorative purposes. Massive tent-like roofs, which hide sizable attics, are covered by accentuated bright material, strengthening traditionalist associations, becoming a key element of the whole design.

The use of such a project, undoubtedly critical to modernism, for the most representative structure in Soviet Union - the residence of the leader, is a strong indication of a changed notion of valuable and important architectural form. Design of Foros dacha was undoubtedly not the premiere of a new style in USSR, it was the result of a larger change in the architectural experience that had already been accumulated at that time.

An example of such an experience is the phenomenon of the so-called "Carpathian style" in Western Ukraine. The definition of "Carpathian" is a diplomatic disguise that was supposed to hide the revival of traditionalist methods of local architecture. As far as the 1970s, some traditionalist techniques began to be brought back into architecture - sharp long roof slopes, the use of untreated stone, linear frames and geometry of wooden architecture origin. However, this change did`t have the character of reproduction, but a completely original interpretation, in which traditionalist elements are synthesized with modern ones. "Carpathian style" was used only in special cases when it was possible to avoid "typical" projects. This, on the one hand, helped to increase the prestige and social significance of such buildings, and on the other hand was already evidence of prestige. The first houses of this type began to appear in the 1970s, without any theoretical basis. There is still no "Carpathian style" manifesto or any work that would explain its basic principles, recommendations or design techniques. "Style" remained an intuitive feeling of a certain local group of architects, which corresponded to the general critical sentiments about the practice of modernism. Examples of buildings that have emerged in this way are the 130-seat restaurant in Truskavets, which was built in 1980 (architect A. Shuliyar), the "Pearl of the Carpathians" hotel in Slavske built in 1987 (architect M. Obidniyak), and so-called Furniture House in Lviv 1985 (architect Z. Pidlisnyi) and others. In addition to individual objects, this style became the basis for entire architectural ensembles, such as the public-museum complex in Zvenyhorod near Lviv (architect M. Trylovskyi and the bureau "Silgosproekt"). The architectural vocabulary of the complex includes sloping, tent roofs, arched windows, rough stone masonry, interpretations of medieval towers, sculptural groups in a realistic manner and more. The specificity of the object also facilitated ambiguity and complexity which are attributes of postmodernism. The construction of the complex was dedicated to the 900th anniversary of the first mention of Zvenyhorod in the medieval chronicle. Therefore, its visitors had to see not only the "function" - a museum, school, etc., but also a some materialized memory of the place. Visions of ancient fortifications and historical events were to somehow reappear here, but so as not to deceive the viewer with props and forgeries. Therefore, the challenge arose to create an architectural event, meaningful enough to reflect both the present and the past. In the Soviet system, the present was supposed to be a demonstration of the achievements of socialist society, but the past here became a kind of intrigue. In traditional Marxist-Leninist ideology, the pre-communist past was seen only as a chain of injustices, exploitation, and the pathology of class society. The real positive history began from the moment when proletariat seized power. Therefore, in Soviet culture from the very beginning, it was customary to portray the history before the October Revolution of 1917 in negative shades. It looks inconceivable for Stalin or Khrushchev times, some cultural products in which the pre-revolutionary past was glorified and shrouded in a halo of patriotic nostalgia for the lost "golden age." In the complex in Zvenyhorod, the distant feudal past serves as a memory of the splendid legend of Old Rus`. Monumental sculptural figures of medieval characters have the same inspiration as the statues of proletarians and peasants of traditional Soviet art. Moreover, it equally shows the representatives of different stratas of feudal society. All this shows that, as in Western postmodernism, there was a process of positive rethinking of the past and a breaking whith the linear "progressive" ideology of modernism, which saw history as a movement of continuous improvement. However, if in the West, not determined by Marxist ideology, this was easier to achieve, here, in conditions of ideological unambiguity, such rethinking was an evidence of a strong critical attitude against modernism, only latent, not openly voiced.

The "Carpathian style" in Western Ukraine also meant a protest against the "international style", with its globalistic unification of architectural form. Locality has become more attractive and valuable than a sense of unity with the world, which is also a feature of postmodern thinking.

If such processes took place on the territory of USSR itself, then even more favorable conditions for postmodern experiments were in the Eastern European countries of the Soviet bloc [10,11], where the level of liberalism was higher. For example, in the Polish People's Republic, the Roman Catholic Church enjoyed much more freedom, and even built some new churches. After World War II, there was a process of building Polish church structures in the territories previously belonged to Germany. Sacred buildings appeared in the bedroom suburbs and needed some special interpretation. The latent protest against monotonous architecture of the bedroom suburbs was closely connected with the protest against the whole system. In communist countries even loyal church represented a different reality and value system. Therefore, the architectural contrast with the buildings erected by the state had its significance here in the hidden struggle of the two ideologies.

An example of postmodernism-feature building is the Church of St. Mary the Queen of Peace in Wroclaw. The design of the building was created in 1980-81 (architect W. Jarząbek), constructed by the mid-1990s. The strusture is, in all respects, contrasting with the surrounding buildings - in color, shape, orientation. Located in a green area between the typical blocks of flats, the church is designed in the form of a large rectangle with truncated corners; red brick walls have a dynamic character. Sharp elements protrude from it across the perimeter, they are covered with sloping roofs and decorative elements of white color - reminiscent of the traditional Gothic masonry. Sloping roofs play an important role in the architectural image of the building, they gradually turn into a motif of culminating completion at the top of the bell tower in the form of a diamond with a cross. Architectural design does not have unambiguous references to history. Formally, the building remains within the framework of abstract geometry. However, this geometry is used to form shapes that are not directly related to functions; their goal is to create a representative, sublime and solemn mood, ambiguous but tangible allegories with Gothic. Additionally, the building does not have an unambiguous insight in terms of design. If modernism was characterized by "skin on the bones" morphology, when the glass shell revealed to the viewer the truth about the structure, then on the contrary - the constructive nature of the church remains blear. In the midst of extremely clear and predictable boxes of the bedroom suburb, appears an indefinite and mysterious object with a complex and ambiguous content, associated with the present and the past at the same time. The inner structure of the building is also full of complexity, decorative elements of stained glass, which, however, are interpreted in an individual manner, without imitation of any historical samples.

Such objects, created to the east of the "Iron Curtain", give an example of the fact that here, in some way, there was also a protest against the overflow of modernist buildings into living space. Moreover, an analysis of their architecture suggests that this protest had very similar to postmodernist proposals in the West.

All these considerations lead to the problem of theoretical definition of postmodern architecture phenomenon in Eastern Europe of this period, complicated by the absence of public intellectual discourse that would be similar to North American and Western European. Professional journalism (primarily Soviet) was reduced mainly to reports on the implementation of five-year plans and socialist emulation, general statements about improving the quality, quantity of housing and "environmental approach". [13] According to official propaganda, Soviet architecture was opposed to capitalist one as better to worse, as more progressive and socially oriented to bourgeois, distorted by class inequality and exploitation. Only during the so-called Perestroika some critical remarks begin to appear in the public sphere, but no manifestos or theoretical works to constitute a new vision of architecture. Calls for "individualization" and "humanization" were used only for journalistic purposes to meet the party's general call for criticism of shortcomings and "distortions." In the last years of the USSR's existence, with the growing economic crisis and disintegration processes, the problems of architectural style have receded into the background. Again, they were activated only in the new independent states that emerged in the place of the Soviet Union, and only after a long period of social and economic crisis. Western-style postmodernism has not become popular here. From the 2010s, a non-modernist trend began to recover, which did not bear the imprint of belonging to any separate "camp" and had a globalized character.

Thus, the architectural experiments for searching an alternative to modernism that took place in Eastern Europe during the 1970s - 1990s remained an isolated and little-determined phenomenon of a postmodern nature. They were alienated from the generally accepted idea of the postmodernism history and later in 1990-2000 hidden behind the vague definition "post-Soviet architecture" [14,15], or "historicism". [16]

In this context, it is worth to look back to the question: what is characteristic of the protest against modernism in Eastern Europe in comparison to Western postmodernism? What is common and what is different between them. How reasonable is the possibility to combine both into one phenomenon in the history of architecture? Although the common features have already been mentioned above, their mentions concerned specific architectural techniques. Therefore, it is necessary to assess their appearance in a broader sense - as manifestations of a strategy to combat the shortcomings of modernism. It can be said that Eastern Europe in the 1970s and 1980s also did not feel the potential to combat the oversaturation of space with modernism within the framework of a "progressive" model of history. In other words, there was no another style on either side of the Iron Curtain to replace modernism as a successor. Therefore, the search focused on memories of the past and, as a result, a distancing from the "progressive" model. In terms of morphology, postmodernism has not offered anything fundamentally new. It only allowed to go beyond the system of modernist prohibitions not to use decor and not to use forms without functional purpose. This was done by the use of traditionalist motifs and pre-modern architecture, but without literal iteration of some styles. The fact that projects of this kind appeared both in the West and in the information-isolated East almost simultaneously testifies to its historical regularity.

Along with these similarities, it is need to note the differences. As already mentioned, one of them was that postmodern architecture in Eastern Europe did not have its own manifesto and philosophical and theoretical basis. Here it was an intuitive phenomenon, expressing the common feeling of a large group of architects, without their visible connection. The Carpathian Style and Gorbachev's residence in Foros were designed within a single Ukrainian Soviet Republic, but their creators acted in complete isolation. The similarity of the results is related to the same starting point - the protest against modernism and the same method of implementation of this protest - the involvement of pre-modern metaphors and plots.

Another distinguishing feature is the lack of irony that Western postmodernists have so strongly emphasized. [17,18] Irony, ambiguity, and complexity were seen as signs of overcoming ideological determinism, a system of obligatory views that modernism insisted on. In the East, the struggle against the obligation to anything has given way to a new obligation to "humanize" buildings with traditionalist symbols. Here it is necessary to note an important point. Eastern European protest against modernism was organically included in protest against the communist system and the authoritarian government. In the West, the protest against modernism was only a protest against modernism and had no deeper social dimensions.

As a result, postmodern architecture in Eastern Europe has at some point acquired the character of not always secure dissent movement, for which excessive irony and fun playfulness were not natural. Some predictability in the design that arose in this way should not be seen as a flaw, but as evidence of the will to prevail over the enemy system - not only over views on the style of form but the man way of living in general. Postmodern architecture in Eastern Europe, therefore as politicized, is tantamount to an anti-government poster or a dissident démarche that can have dangerous consequences for participants. The heroic pathos of such an act is incompatible with irony, which here can only spoil the impression of sincerity of intention. It is significant that in this regard, there was even an intellectual trend of criticism of Western postmodernism in post-Soviet circles.[20]

These facts, however, do not in any way indicate that this form of protest against modernism, although different in appearance, has less value. The pleasure of stylistic irony is simply replaced by the joy of desacralization and dismantling of the oppressive social system. Eastern European postmodernism is often altruistic. If in the West, the grotesque images of Las Vegas are strongly tied to and exist for commercial gain, in Eastern Europe, even during the economic crisis, customers sometimes incur additional costs to install a sloping roof or tower-shaped accent. Having no direct commercial benefit, all this was to distinguish the building in the modernist space as "our one among strangers".

Another difference is the predisposition to symmetry and obvious compositions. This feature was acquired by Eastern European postmodernism together with the whole complex of anti-modernist symbolism. The past in Eastern Europe in the late twentieth century seemed much more romanticized than it was even in the books of Venturi and Rossi. The whole pathos of the destruction of the communist system was built on "return." There was no new ideology or goal. The main goal was to "return" to "normality", and "normality" itself was in the pre-communist past. Thus, in Eastern Europe, postmodernist buildings are often a way of transfer into the past - a retrospectivism, which simply could not be fully realized due to a lack of relevant professional skills and building materials.

CONCLUSION

This article suggests that the current theory of the origin and development of postmodernism is incomplete. It mostly does not take into account the processes that took place in Eastern Europe and the countries of the so-called "socialist camp". However, it is here were protest potential against the congestion of space by modernist architecture has accumulated to a much greater extent. The specificity of ideologically determined authoritarianism, which limited critical statements about the dominant doctrine in the field of design and construction, did not allow Eastern European architecture to develop its own philosophical and theoretical principles, similar to Western ones. Nevertheless, at the practical design level, there were active postmodern experiments. Examples of these experiments are: Gorbachev's dacha in Foros, a number of churches in Poland, or the so-called "Carpathian style" in western Ukraine. The presence of architecture with postmodern features to the East of the so-called "iron curtain", which limited or even blocked the exchange of information between the West and the East, should be seen as an additional sign of its independence. In this regard, the theory of postmodernism needs to be clarified and changed. The region of Eastern Europe should be seen as a place where, in parallel with the West, occured critical rethinking of modernism and the creation of postmodern forms. In understanding the origin of this style, it should be considered as more correct - the concept of co-opening of postmodernism in different parts of then divided world, and not just borrowing it from the West.

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Classical Order Interpretation in Lviv of the Independence Era in View of the World and National Practices

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Abstract. In the late 20th – early 21st century, classical order undergoes significant morphological changes and is given various interpretations. The morphological analysis aims to study the change in order structure throughout the period under examination and identify the principles of its use in architecture. The article establishes a connection between ways in which classical order was applied to the facades of the independence-era buildings in Lviv and other Ukrainian and foreign cities of the same period relying on the research conducted and using facades' drawings. The completed morphological analysis consists of a modular and proportional analysis of order, analysis of order elements interpretation, comparative analysis en masse, and identification of the varieties of classical order interpretation on the facades of buildings to study its morphological transformations.

INTRODUCTION

In the early 1990s, when Ukraine gained its independence, postmodern architecture was growing in popularity throughout the country, including the city of Lviv. In Lviv, like in other cities of the former socialist camp countries, architects return to classical order and apply its new interpretations to the facades of buildings. During the independence era, classical order is often changed and transformed; thus, the discussion of order morphology of said period continues. Another issue contributing to the conversation is whether classical order interpretation in Lviv architecture is a unique phenomenon or whether similar processes can be found in the world and national practice.

DISCUSSION

The Preconditions for the Use of Classical Order and Its Interpretations in Independent Ukraine

In the former Soviet countries, where constructivism was a predominant trend until the 1990s, architectural development started falling behind the European trends. As a result, the proclamation of independence of Ukraine became the point of return to traditional cultural values, which stimulated the development of approaches based on archetypes of historical legacy. In Lviv, like in other cities of the former socialist camp countries, architects return to classical order and apply its new interpretations to the facades of buildings. Moscow becomes the centre of new architecture, yet its postmodernism is transformed. The architecture is again linked to the official state policy. Various architectural elements, including order, are used as means of ascertaining the idea of a comeback to historical Moscow (Patriarch Residential Complex, 44 Malaya Bronnaya Str., Moscow, Russia (arch. S. Tkachenko, O. Dubrovskiy, O. Gritskevich, 1997 – 2002) (Fig. 1), Paveletskaya Plaza Business Centre, 2/2 Paveletskaya Square, Moscow, Russia (arch. M. Posokhin, S. Tkachenko, Ye. Liakisheva, et al., 1996 – 2003), et al.) [1].

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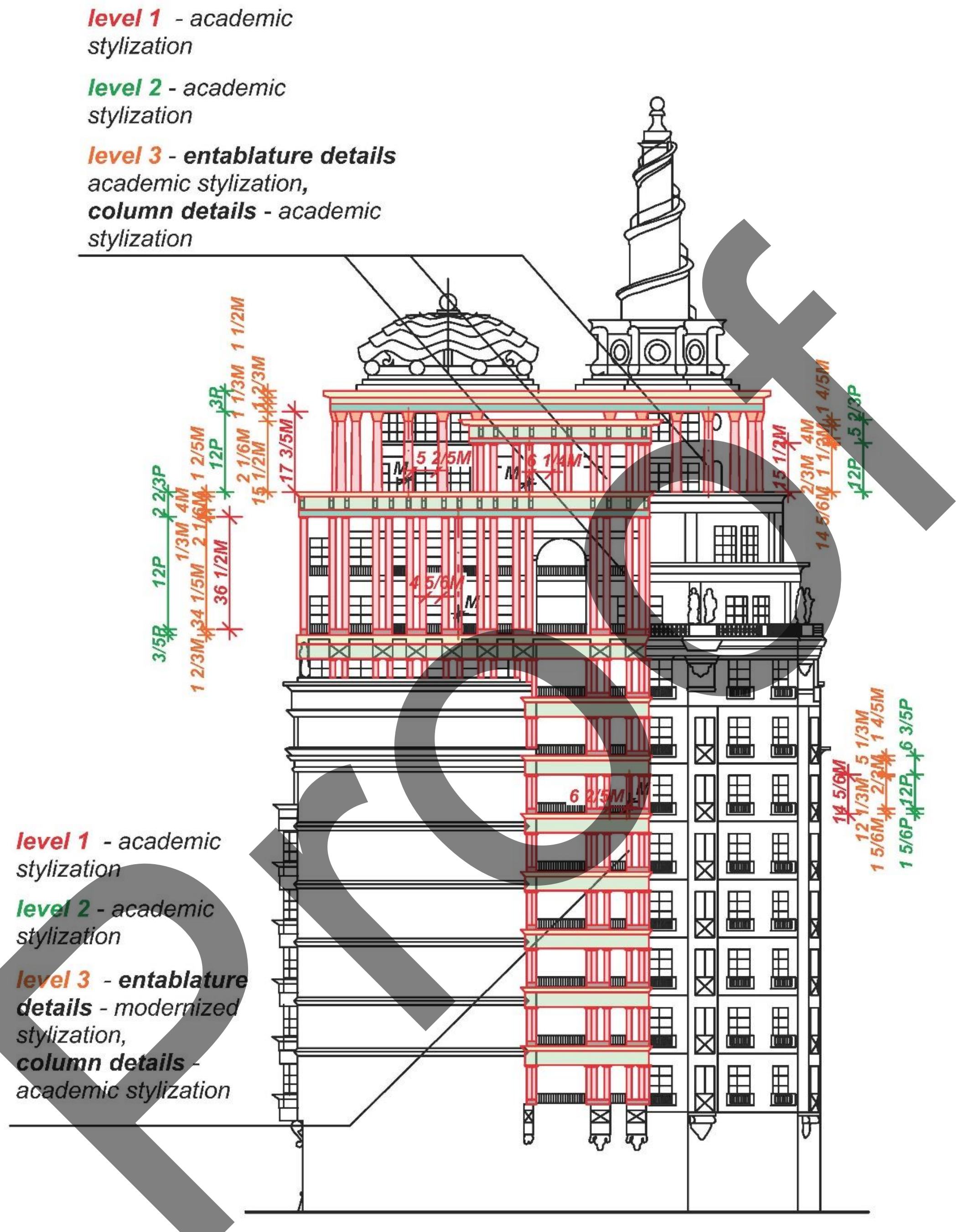

FIGURE 1. Patriarch Residential Complex, 44 Malaya Bronnaya Str., Moscow, Russia (arch. S. Tkachenko, O. Dubrovskiy, O. Gritskevich, 1997 – 2002). Source: drawing and analysis by A. Znak

Classical Order Interpretation in Lviv Architecture of the Independence Era

Order is a complicated system made of elements and details that are open to interpretation, i.e., the same facade may employ different interpretation methods on different levels. Three levels of morphological interpretation have been singled out, which are used to analyze classical order development: level 1 – the order system, level 2 – elements of the order system, and level 3 – details of the order system [2, pp. 36-37].

Let us have a look at the facade of a residential building at 3 Rusovykh Str. (Fig. 2). The avant-corps has two stylized order pilasters located at the same distance from the central axis of the facade. The intercolumniation is 5 1/4 M. To compare the intercolumniation and the proportions of stylized order, we refer to the Composite order that Vignola defines as all orders with capitals, which do not follow canonical structure and rules [3, p. 145]. The ratio of avant-corps pilasters height to the intercolumniation: $h_{pilaster}$: l = 13 1/4: 5 1/2 = 2,409 (according to Vignola h_{column}: l = 4,290). Thus, the pilaster ratio is changed on the order system level while the quality and quantity of pilasters remain unchanged, which points to academic stylization. Academic stylization is also used on the level of order elements interpretation as the quality and number of order elements are preserved, while the ratios between them undergo a change: $h_{pilaster}$: $h_{entablature}$: $h_{pedestal}$ = 12: 1 3/4: 1 3/4 (according to Vignola h_{column}: $h_{entablature}$: $h_{pedestal}$ = 12: 3: 4). Column elements and entablature underwent modernized stylization with changes introduced to element ratio and element quality on the level of order system. $H_{base\ of\ the\ column}$: h_{shaft}: $h_{capital}$ = 1: 8 3/4: 2 1/3 (according to Vignola $h_{base\ of\ the\ column}$: h_{shaft}: $h_{capital}$ = 1: 16 2/3: 2 1/3), for entablature – $h_{architrave}$: h_{frieze}: $h_{cornice}$ = 1/3: 1 1/4: 1/4 (according to Vignola $h_{architrave}$: h_{frieze}: $h_{cornice}$ = 1 1/2: 1 1/2: 2). However, the pedestal elements are academic stylization products with a change of element ratio – $h_{pedestal\ base}$: $h_{pedestal\ body}$: $h_{pedestal\ cornice}$ = 1/3: 1 1/6: 1/3 (according to Vignola $h_{pedestal\ base}$: $h_{pedestal\ body}$: $h_{pedestal\ cornice}$ = 2/3: 5 1/2: 3/4).

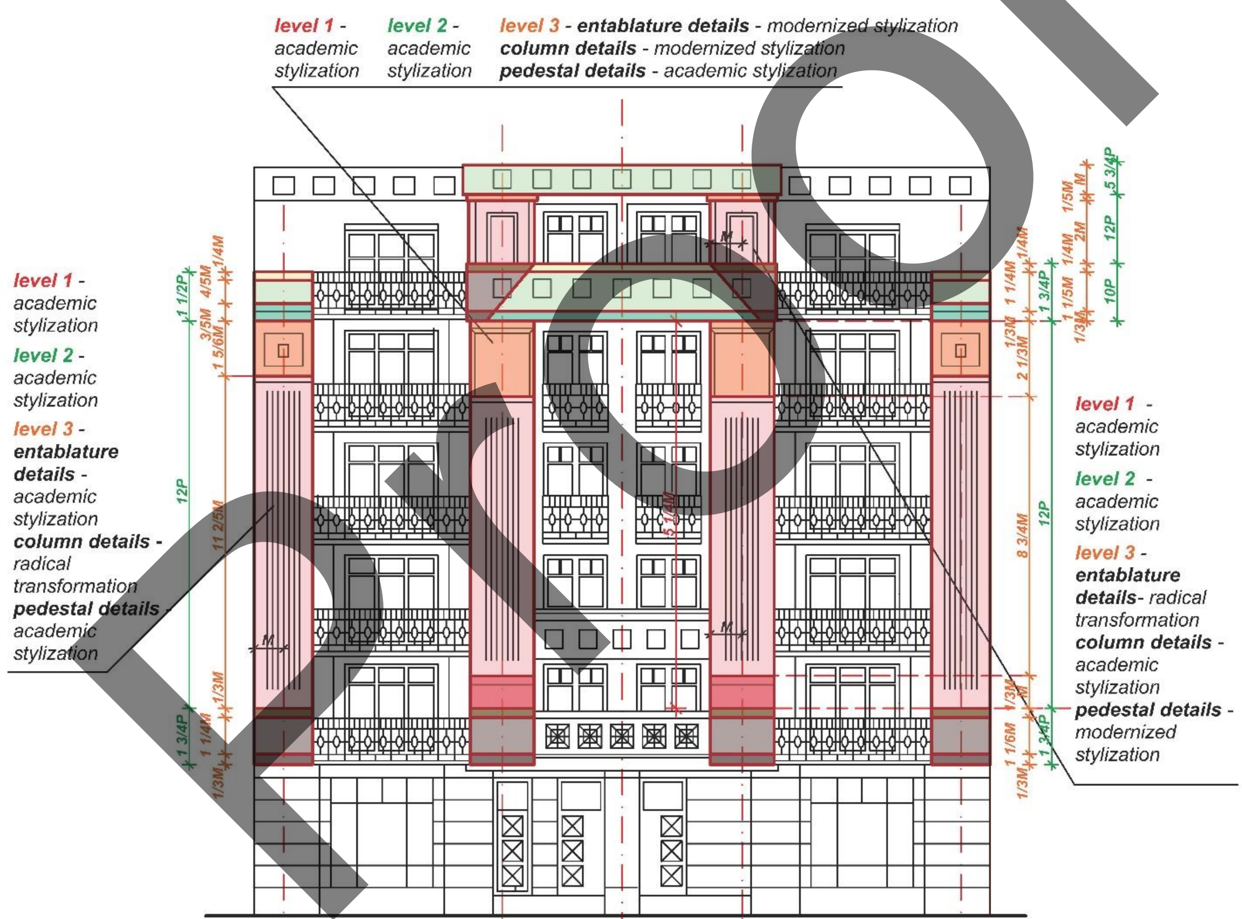

FIGURE 2. Residential building, 3 Rusovykh Str., Lviv, Ukraine (2012-2013). Source: drawing and analysis by A. Znak

Let us take a closer look at the former Ukrsotsbank building at 10 Mitskevycha Square (Fig. 3). The main facade employs astylar order – the facade plane is divided into three main parts: pedestal, column, and entablature. Since astylar order has no columns or pilasters and the facade is seen as a single whole, we observe a change of the number of elements and order quality and ratios, i.e., radical transformation employed on the level of order system interpretation. The first floor corresponds to the pedestal, the second and third floors – to the column and the fourth floor – to the entablature. The ratio between the main elements of the order (column, entablature, and pedestal) has been changed: h_{column}: $h_{entablature}$: $h_{pedestal}$ = 12: 9 1/3: 13 2/5. Thus, modernized stylization has been applied on the level of order elements interpretation since the quality and ratio of order elements are changed. Modernized stylization was used in entablature construction on the level of order system: the quality and ratio between the main elements – architrave, frieze, and cornice – are changed. $h_{architrave}$: h_{frieze}: $h_{cornice}$ = 1 3/5: 6: 2 1/3, and the column and pedestal are not divided into details; consequently, the interpretation happened only on the first two levels.

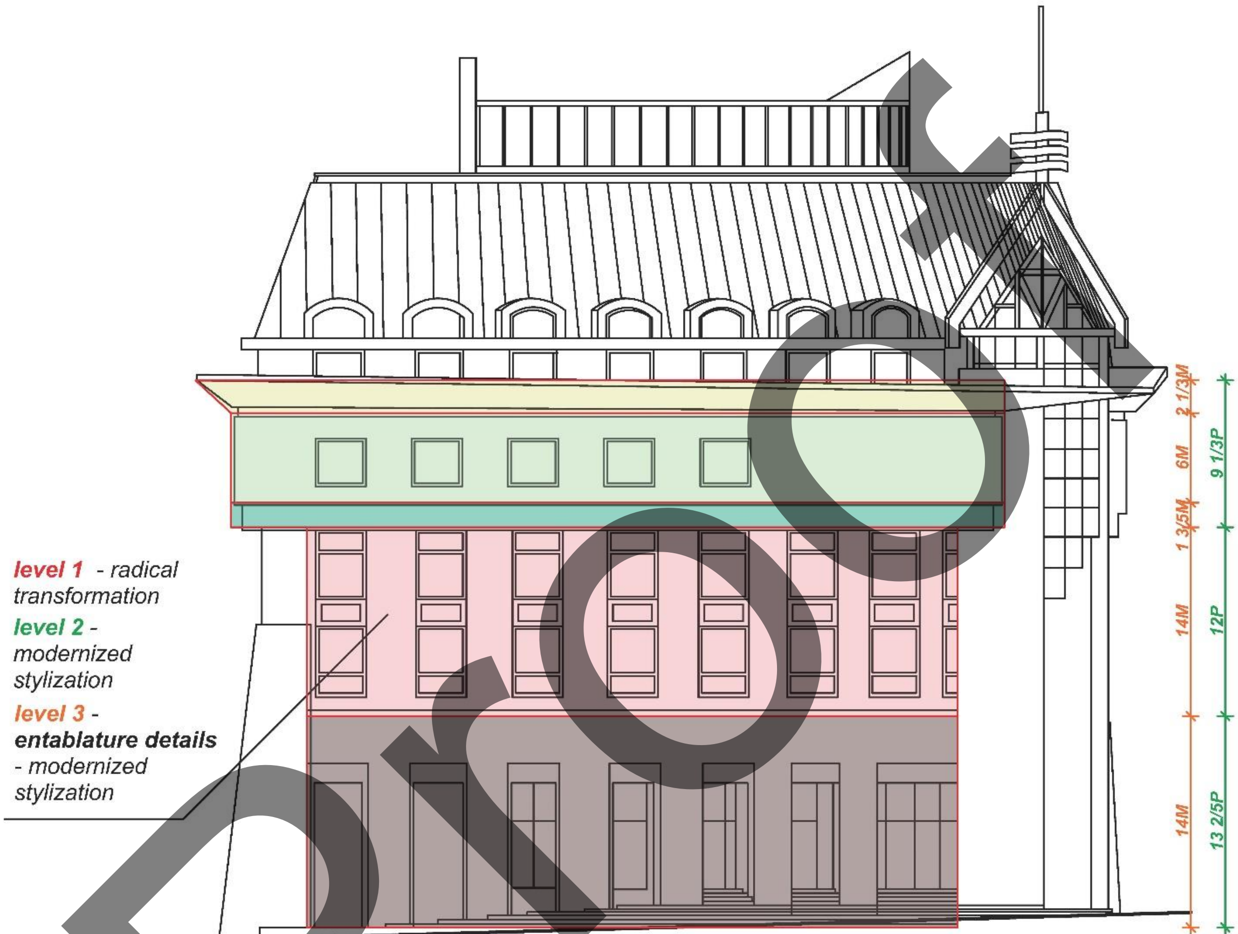

FIGURE 3. Former Ukrsotsbank building, 10 Mitskevycha Square, Lviv, Ukraine (arch. O. Baziuk, O. Ohonovskyi, with the participation of V. Shvets, V. Kniazyk, 1998-2005). Source: drawing and analysis by A. Znak

The morphological analysis of Lviv buildings of the independence era where classical order is applied showed that on the level of order system interpretation academic stylization (72 Heroyiv UPA Str.), modernized stylization (43a D. Vitovskoho Str.), and radical transformation (2 Voronoho Str., 7b Naukova Str.) were used. Interpretation employed on the level of order system element includes academic stylization (4 Kozelnytska Str.) and modernized stylization (72 Lychakivska Str.). Three interpretation methods are used on the level of order system: academic stylization (14 Soborna Str.), modernized stylization (8 Kubanska Str.), and radical transformation (4 Povstanska Str.).

Establishment of the Independence Era Architecture in Ukraine

Throughout the first decade of independence, the establishment and development of architecture were quite slow. The influences of Soviet architecture were still noticeable, yet the architects tried to show their country's independence and uniqueness using architecture. Starting from the 2000s, big cities, such as Kyiv, Lviv, Dnipro, Odesa, and Kharkiv already had a postmodern architecture that used classical order and its interpretation (Arkada Bank, 3 Olhynska Str., Kyiv, Ukraine (arch. Yu. Borodkin, O. Kovaliova, V. Pylypchuk, A. Borodkina, et al., 2001 – 2008) (Fig. 4), Citadel-2 Business Centre at 12 Sviatoslava Khorobroho Str., Dnipro, Ukraine (arch. O. Dolnik, S. Peschanyi, 1997 – 1999) (Fig. 5), Odesa Chornomorets Stadium reconstruction (Archproject MDM Architectural and Restoration Bureau, 2008 – 2011), Kharkiv Palace Hotel, 2 Nezalezhnosti Avenue, Kharkiv, Ukraine (S. Babushkin Architectural Bureau, 2010 – 2012), et al.).

FIGURE 4. Arkada Bank, 3 Olhynska Str., Kyiv, Ukraine (arch. Yu. Borodkin, O. Kovaliova, V. Pylypchuk, A. Borodkina et al, 2001 – 2008). Source: photo by A. Znak

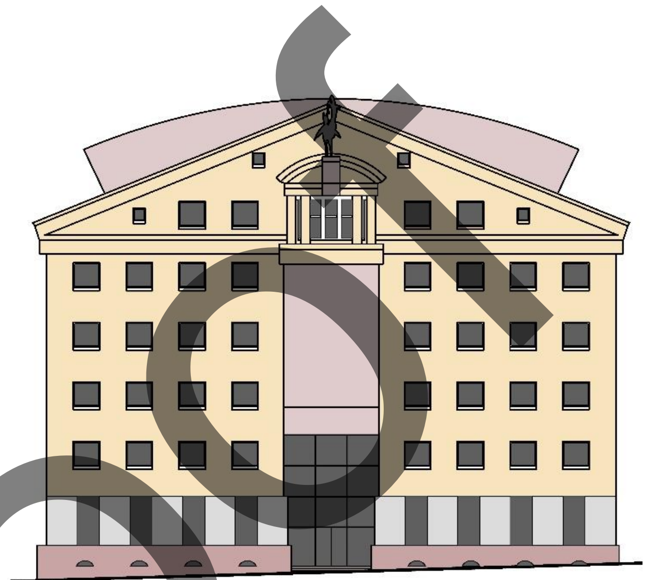

FIGURE 5. Citadel-2 Business Centre, 12 Sviatoslava Khorobroho Str., Dnipro, Ukraine (arch. O. Dolnik, S. Peschanyi, 1997 – 1999). Source: drawing by A. Znak

Let us look at Park Colonnade residential complex at 52b Starokozatska Street in Dnipro (arch. O. Dolnik, S. Filimonov, O. Podushkina 2001 – 2002) (Fig. 6). The facade features a massive reduced order with column-shaped oriel windows. The intercolumniation is 1 5/6 M. The column height to intercolumniation ratio is h_{column}: l = 12 3/5: 1 5/6 = 6,87. On the level of order system interpretation, the changes are introduced to the ratio of the main elements to their quality, i.e., modernized stylization was used. Modernized stylization was also used on the level of order elements since the quality and ratio between column, entablature, and pedestal are changed: h_{column}: $h_{entablature}$: $h_{pedestal}$ = 12: 2 1/4: 1 1/6 (according to Vignola h_{column}: $h_{entablature}$: $h_{pedestal}$ = 12: 3: 4). On the level of order interpretation, the changes were introduced to the number of column details (no base), quality, and the ratio of h_{shaft}: $h_{capitol}$ = 12 1/3: 1/4 (according to Vignola h_{shaft}: $h_{capitol}$ = 16 2/3: 2 1/3), which means that radical transformation was used. There are no interpretation levels of the entablature and pedestal as they are not divided into details.

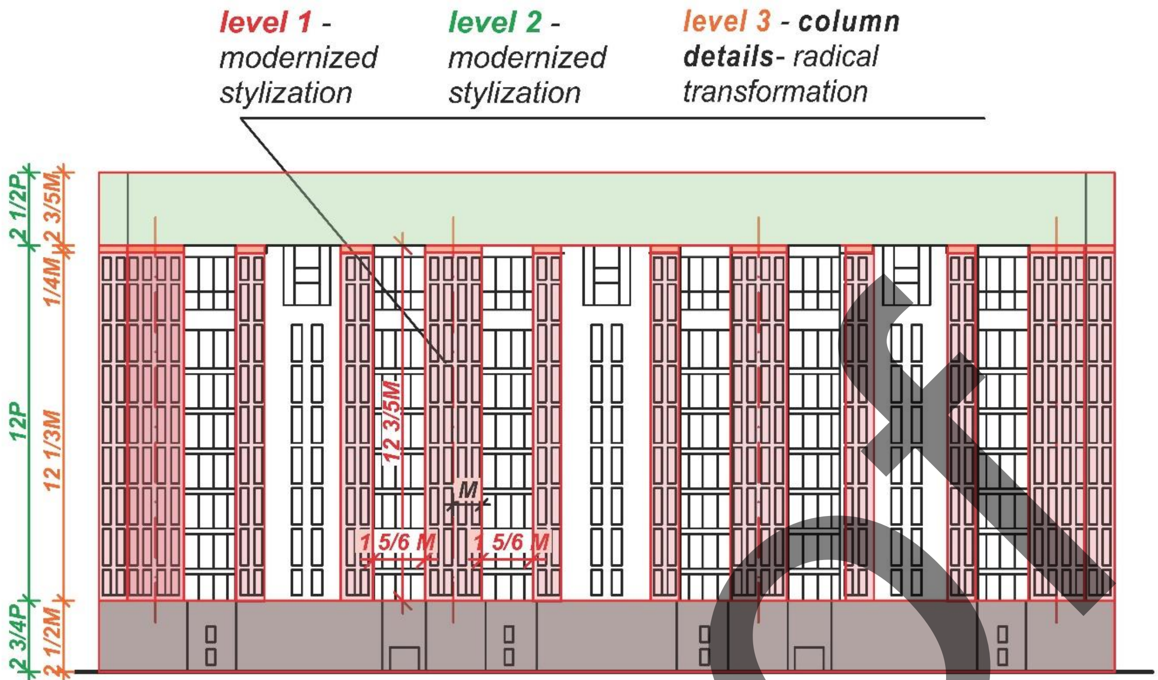

FIGURE 6. Park Colonnade residential complex, 52b Starokozatska Str., Dnipro, Ukraine (arch. O. Dolnik, S. Filimonov, O. Podushkina, 2001 – 2002). Source: drawing and analysis by A. Znak

The conducted analysis shows that in the early 21st century, Lviv and other big cities of the former Soviet Union (Kyiv, Dnipro, Kharkiv, Moscow, Saint Petersburg, and others) used academic interpretation (Galina Vishenskaya Opera Centre, Moscow, Russia, (arch. M. Posokhin, O. Velikanov, 2002)) and modernized stylization (Park Colonnade Residential Complex, 52b Starokozatska Str., Dnipro, Ukraine (arch. O. Dolnik, S. Filimonov, O. Podushkina 2001 – 2002)) on various levels of order interpretation – order system, order elements, and order details. Yet, unlike other cities, Lviv of the independence era did not have many buildings that applied order on their facade.

Classical Order in the Postmodern Architecture of the European Countries and the USA

At the same time, American and European architecture was still strongly influenced by postmodern architecture, which first emerged back in the 1960s as a reaction to monotonous, boring, and largely incomprehensible modern architecture. The postmodernists used the principles of play with historical shapes and often referred to classical order and its interpretations. To solve relevant architectural problems, they would often resort to the experience of previous centuries, borrowing shapes and images of those epochs.

It is established that at the time, countries of Western Europe and the USA were still using classical order and its interpretations. When applying order to classical facades, it was common to use academic stylization (Juniper Hill in Buckinghamshire, Great Britain, (arch. Q. Terry, 1999 – 2000)) and modernized stylization (Murcia Town Hall, Spain (arch. R. Moneo, 1991 – 1998), Denver Public Library, Colorado, USA (arch. M. Graves, 1995), Windsor Village Hall, Windsor, Florida, USA (arch. L. Krier, 1996 – 1999), city hall, Florida, USA (arch. P. Johnson, 1996)), while there are significantly fewer buildings with a radical transformation of the order in this period as compared to the 1970s-1980s (Art Museum, Milwaukee, Wisconsin, USA (arch. S. Calatrava, 1994 – 2001), Aurora Building, Turin, Italy (arch. A. Rossi, 1984-1986) (Fig. 7)).

The comparative analysis helped determine that for the American architecture characteristic on all levels of interpretation were modernized stylization (The Humana Building, Louisville, Kentucky, the USA (arch. M. Graves, 1982 – 1985), The Portland Building, Portland, Oregon (arch. M. Graves, 1982)) and radical transformation of the order on the facades of buildings (House in New Castle, Delaware, USA (arch. R. Venturi, J. Rauch, D. Scott Brown, 1978 – 1983), Piazza d'Italia fountain, New Orleans, Louisiana, the USA (arch. Ch. Moore, 1977)) which helped achieve an ironic and grotesque effect, while in the European architecture (France, Italy, Spain, and others) the dominant interpretations were academic stylization (Antigone Quarter, Montpellier, France (arch. R. Bofill, 1977 – 2000)) and modernized stylization (Centro Direzionale, Perugia, Italy (arch. A. Rossi, 1982 – 1988), Les Espaces d'Abraxas near Paris, France (arch. R. Bofill, 1982) (Fig. 8), Carlo Felice Theatre reconstruction, Genoa, Italy (arch. A. Rossi, 1977 – 1991)), where they became one of the ways of reviving the cultural heritage. Thus, the ways of classical order interpretation in postmodernism range from reproduction to radical transformation on various levels of interpretation.

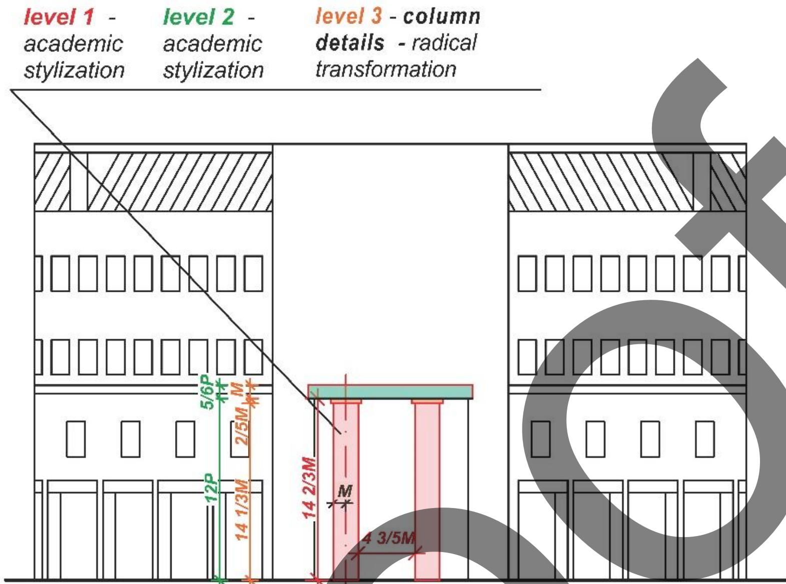

FIGURE 7. Aurora Building, Turin, Italy (arch. A. Rossi, 1984-1986). Source: drawing and analysis by A. Znak

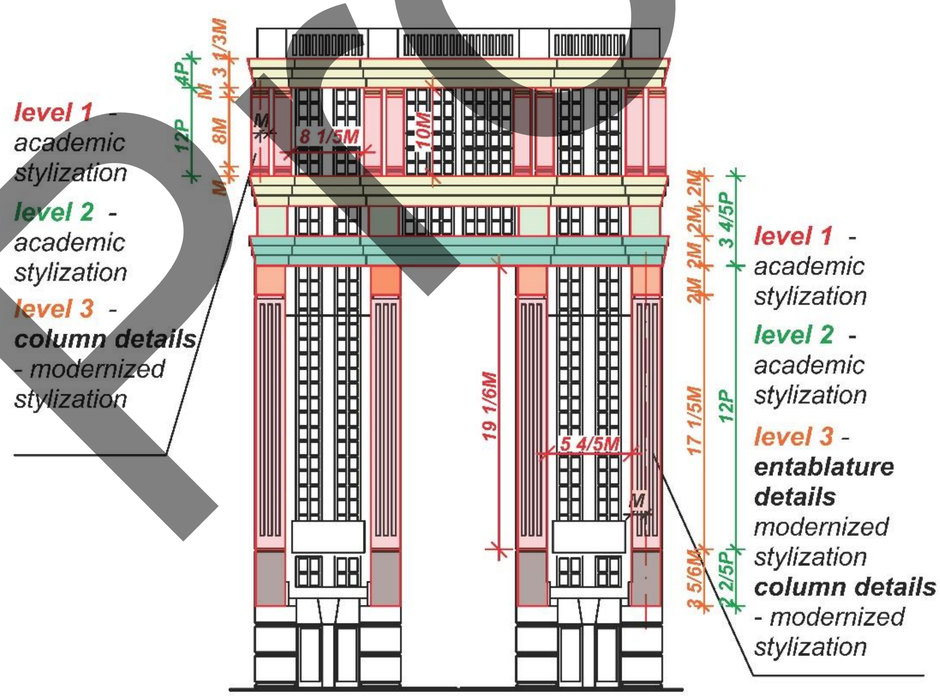

FIGURE 8. Les Espaces d'Abraxas "arch", Marne-la-Vallée, France (arch. R. Bofill, 1983). Source: drawing and analysis by A. Znak

CONCLUSIONS

In the independence era Lviv and across Ukraine in general, the order system is interpreted using academic stylization and radical transformation; order elements undergo modernized and academic stylization while order details interpretation includes modernized stylization and radical transformation. Comparative analysis reveals that, by and large, the interpretation of classical order applied to the facades of Lviv buildings of the independence era corresponds to order interpretation used in other European countries and the USA. Thus, it may be concluded that after Ukraine gained its independence in 1991, Lviv architects started following world trends in the classical order interpretation and coming back to its use in a modern version. Even though in the early 21st century, various methods of order interpretation were used on the facades of Lviv buildings – from reproduction to radical transformation, they are not characterized by dramatic solutions if compared to the world and national analogs.

Lviv architecture was generally in line with the world trends in the development and interpretation of classical order, which prompts the conclusion that the transformations of classical order in Lviv architecture of the late 20th-early 21st centuries should be treated only within the context of general architectural processes and understood as a reflection of shape-forming methods typical for that period of architecture development.

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The Genesis of Architectural and Spatial Design of the Western Ukrainian OSBM Monasteries

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Abstract. The authors have developed scientifically grounded provisions on the characteristics of architectural and spatial design of the Order of St. Basil the Great (OSBM) monasteries using territorial, temporal, and historical criteria and have identified the parameters and trends in their transformation amid current religious and social processes. Contributions have been made to the theory on spatial and shape-forming techniques used in the architectural and spatial design of the OSBM monasteries of Western Ukraine. The Basilian monasteries belong to different epochs and cannot be mapped out within a single stylistic trend. The origin of the monasteries is connected to several completely different waves of building activities with distinctive church and organizational, social and political, and economic foundations. On-site studies, analysis of archival materials, and photo evidence have been used to determine morphological elements of the dominant stylistics, design fabric, etc.

INTRODUCTION

The Basilian monasteries of Western Ukraine constitute an unevenly distributed bulk of objects, some of which are located on the territory of neighbouring countries. According to the research conducted by Basilian Father Roman Lukan, three Halychyna eparchies (Peremyshl, Lviv, and Stanyslaviv) have had 374 monastic buildings of the Order of Saint Basil the Great (OSBM) since ancient times [1]. Before WWII, the province of Halychyna had 17 OSBM monasteries (14 monasteries and three convents); Zakarpattia province had eight monasteries (including 2 in Slovakia and 1 in Hungary). Additionally, 34 monastic buildings of Basilian genesis functioned in the Volyn area (Volyn and Rivne regions), but after 1832 the monasteries were transferred into subordination of the Russian Orthodox Church. Another 4 OSBM monasteries out of the 16 ancient ones operated in the Kholm area before 1864. Thus, there were 441 Basilian monasteries in Western Ukraine, out of which only 28 functioned before the war.

The uneven geographical distribution of the Basilian monasteries in Western Ukraine goes hand in hand with different construction periods. Said differences are connected to the way Basilian centres emerged and disappeared. The oldest of them are located in Halychyna (the Saviour and Lavra monasteries of Peremyshl eparchy, St. Elijah monastery in Halych), Volyn (Dorohobuzh, Volodymyr, Dubno, Lutsk and others), and Zakarpattia (Uholka and Mukachevo). All those monasteries were built and actively developed throughout their existence, reflecting the peculiarities of the early stages in the history of the Union church. They are characterized by sharp lines and partial reinterpretation of the composition in line with the Latin tradition samples [2]. The Volyn monasteries, just like the Basilian monasteries, ceased to exist in the first half of the 19th century and belonged to the so-called Lithuanian province of the Order, distinguished by significant centralization of the structure and assimilation with the development of Roman Catholic Orders (Carmelites and Jesuits).

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DISCUSSION

The Spatial Design of the OSBM Monasteries

The architecture of OSBM monasteries in Zakarpattia emerges in its preserved form of the 18th-first half of the 19th centuries. The monasteries were built according to standard projects designed by the Austrian government during the rule of Maria Theresa (Mukachiv, Malyi Bereznyi, Máriapócs in Hungary, Krásny Brod in Slovakia). Such buildings are characterized by a single tall bell tower-dominant, usually in Baroque style, laconic sectioning, absence of cupola, and the use of clocks or round windows on the top level of the tower.

The architecture of Zakarpattia monasteries takes from Roman Catholic analogs. Basilian monasteries in Volyn combine the elements of two periods. The older period is connected to Byzantine (Volodymyr, Dorohobuzh), Renaissance (Derman, Mali Zahaitsi), and Baroque architecture (Pochayiv, Zahoriv, Korets, Biała Podlaska in Poland). The new period is associated with the imposed influences of Russian architecture and the Russian Orthodox Church on all ancient Basilian monasteries, which were transformed into Orthodox.

The Basilian monasteries of Halychyna are the most diverse in terms of the time of construction and cannot be outlined within a single stylistic trend. The origin of the Halychyna monasteries is linked to several completely different waves of construction activities with distinct church and organizational, social and political, and economic foundations. Halychyna, which was the last to adopt the Union, stood in stark contrast to the well-formed structure of the Basilian Order of Lithuanian province (Lithuania, Belarus, Volyn, Right-bank Ukraine). The Byzantine rite monks who kept their traditions followed the statutes of inner spiritual life, while the Basilian monasteries, like those of other Catholic orders, had a predominantly external social mission. This difference and the quantitative dominance of the Halychyna monasteries complicated the plans for simple inclusion of the newly joined monasteries into the Lithuanian province. Because Halychyna had a large number of small monasteries (sometimes with 1-2 monks), which was typical for the Byzantine rite, as well as large monasteries, the heads of the Union church had to think about their reorganization. The enlargement of former Orthodox monasteries on the territory of the Lithuanian province itself took about 100 years to complete. Reorganized Basilian centres looked like massive functional complexes, which, in addition to regular monk life functions (services, prayers, household duties, etc.), performed various other functions (education, publishing, pilgrimage with developed infrastructure, missionary work, and preaching). These transformations coincided with a relatively favourable situation for the Union church – military and political flourishing of Rzeczpospolita, its ally and patron. This was not the case in the 18th century when the Polish-Lithuanian Commonwealth was in decline (Fig. 1) [3, pp. 181-182].

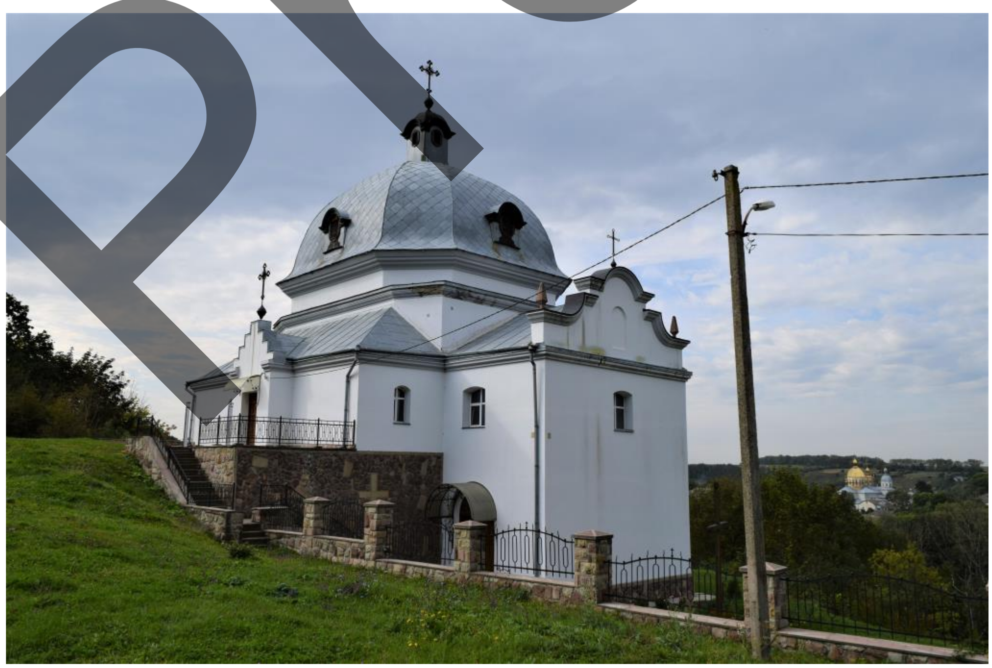

FIGURE 1. The Strusiv Monastery. Source: photo by I. Znak

When the Halychyna eparchy joined the Union, the Polish-Lithuanian Commonwealth was already experiencing a period of decline, which became even more exacerbated in the following decades. Limited financial resources and the dominant state policy of favouritism towards Roman Catholicism in Rzeczpospolita of the 18th century resulted in slower development and reorganization of the newly created Basilian monasteries. The situation did not improve after 1772 when Halychyna became part of the Austrian empire. The so-called Josef's reform implemented by the Austrian government in 1800 limited the monastic life significantly, contributing to the general stagnation of the OSBM Towards the end of the 19th century, Halychyna and Zakarpattia were the only regions in the world (with some rare exceptions) which had active Basilian monasteries. Yet, they were in a severe recession, on the verge of disappearing altogether.

Only sweeping reforms and efficient interference from the outside (the Dobromyl reform, early 1882) led to the Order's revival, which lasted until the 1930s [4]. Later on, however, due to fundamental geopolitical changes which happened to Eastern Europe and the transfer of the territories to the Soviet Union, the OSBM monasteries in the Ukrainian SSR, PNR, and ČSSR were closed. The liquidation of Basilian monasteries was largely completed by 1947, although the process was finalized throughout the 1940s-1950s. The OSBM monasteries were repurposed to serve medical, educational, museum, and other needs.

The unexpected fall of the Soviet system and the collapse of the USSR, accompanied by the active religious renaissance, resulted in the revival of Basilian life in Western Ukraine. Social enthusiasm and idealistic expectations formed around religious institutions in the 1990s resulted in new candidates for monks coming to monasteries. Simultaneously, the preserved monastic centres in Western Europe and the United States promoted the influx of well-trained people to the restored monasteries. Amid such highly favourable circumstances, the historical Basilian centres were restored and rebuilt, construction and renovation works were organized.

Therefore, we may say that Halychyna experienced three waves in the development of Basilian monastic complexes: the period after joining the Union – 18th century, the period after the Dobromyl reform – the 1890s-1930s, and the period after the Ukrainian Greek Catholic Church was restored – the 1990s-the 2000s. Each period had its historical character and was linked to a specific world view and, consequently, cannot be treated as a single architectural phenomenon (Fig. 2).

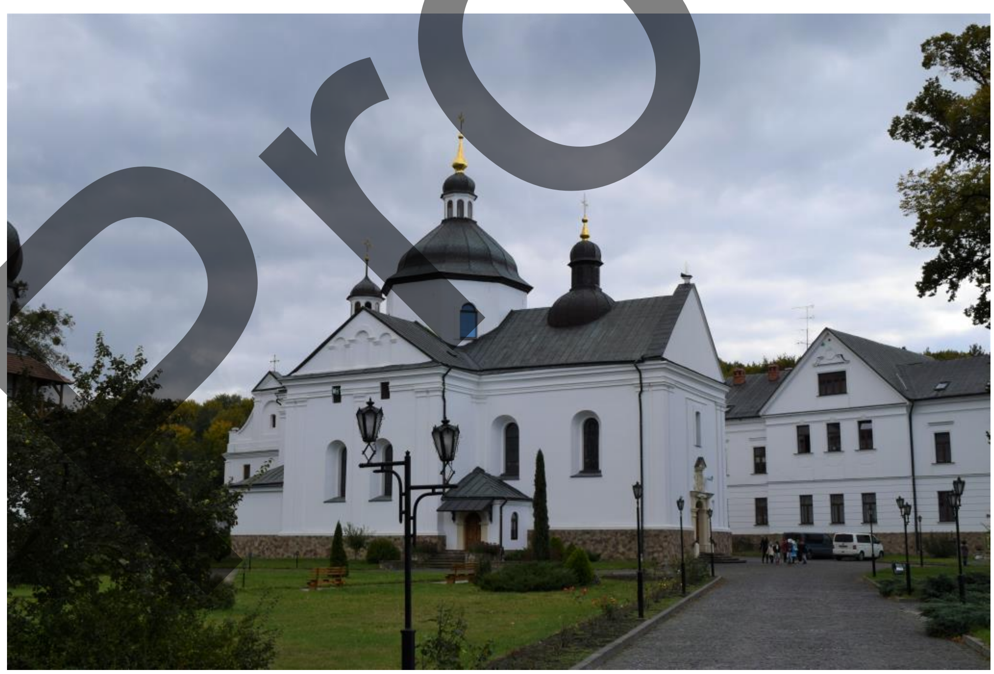

FIGURE 2. The Krekhiv Monastery. Source: photo by I. Znak

Territorial and Chronological Scenarios of the Architectural and Spatial Evolution of the Basilian Monasteries in Western Ukraine

In this context, the architectural and spatial design of the Basilian monasteries of Western Ukraine emerges as a non-homogeneous phenomenon that should be studied on the basis of chronological differentiation and territorial stratification. In view of the abovementioned, we may speak of five territorial and chronological scenarios within the Basilian architectural legacy of Western Ukraine.

The first scenario refers to the legacy of the Lithuanian province of the OSBM in Volyn, Rivne, and Ternopil regions, which may be supplemented by the Buchach monastery (Ternopil region). It reflects one of the earliest stages in the development of the Basilian Order, marked by the desire to follow Roman Catholic Orders both in the organization and, partly, in visual identification. Even though the documents and programme statements of the heads of Union church and OSBM of the period highlight the inherent connection with the traditions of the Eastern Church and the legacy of St. Basil, at the same time, the Basilian Order was seen as a universal organization of all Union monks, source of candidates for bishops and diocesan bishops. The predominant trends in architecture include basilica designs, often with bell towers, not typical for the Byzantine rite churches.

The second scenario deals with the first wave of transformation of the Halychyna monasteries after Peremyshl and Lviv eparchies joined the Union. Characteristic for the period was the confrontation for preserving Orthodox ways in the church and organizational structure of monastic life. The decisions of the Synod of Zamość contributed to the continued world view of Latinization with a more profound dogmatic foundation. Nevertheless, a significant psychological affiliation with the Byzantine and folk sacred tradition steered the Halychyna Basilian architecture towards the synthetic search for visual language, in which Eastern spatial markers (primarily the domes of main buildings) remain relevant. Besides, the spatial design of Halychyna monasteries retains a connection with the Byzantine foundation, with some minor adjustments to the new organizational and disciplinary needs.

The third scenario describes the strengthening of Basilian presence in Zakarpattia, influenced by the traditions of Theresian sacred buildings that were distinguished by significant unification of image and repetition of semantic elements. The OSBM monasteries had no specific Byzantine markers, as they did in Halychyna, and the architectural solutions of buildings had no notable Byzantine identity. Such a peculiarity of the Zakarpattia Basilian monasteries results from the plurality of religious life in the region, characterized by the presence of three main branches of Christianity and significant national and cultural diversity.

The fourth scenario of the architectural and spatial evolution of the Basilian monasteries in Western Ukraine is the legacy of rapid OSBM development after the Dobromyl reform [5]. Typical for this scenario is the establishment of oriental symbols as a valuable part of the general Catholic world. Within church organization, OSBM is no longer seen as the only counterpart of Eastern monasticism because of the creation of new Greek Catholic Redemptioner Order and the Studite Brethren and other orders at the end of the 20th century (the Salesians, the Franciscans, and Byzantine rite Jesuits). Simultaneously, within the OSBM itself, Ukrainian patriotic and Byzantine sentiments were becoming stronger and served as the antithesis to Polish Roman Catholicism.

The fifth scenario is the development of Basilian monasteries architecture after the revival of the Greek Catholic Church in the 1990s-2000s. It is known for the high appreciation of specific Byzantine spatial markers influenced by the Baroque tradition, which causes to associate this architecture with the Ukrainian identity. The reclaimed OSBM historical buildings undergo a transformation as well. The changes are particularly noticeable in those monastic complexes which developed according to the patterns of Latin sacred architecture or were strongly influenced by it, e. g. some monasteries in Zakarpattia.

All these aspects lead to a conclusion that the recreation of the architectural and spatial design of the OSBM monasteries in Western Ukraine cannot be treated within a single hypothesis focused on image, design, and functional entity. Moreover, the sources that mainly use the chronological and evolutionary method of presenting their findings do not reflect the specific architectural diversity, especially when old Orthodox monasteries were repurposed for modern needs. Most papers (see a detailed analysis below) belong to the realm of religious studies or history and do not have an explicitly defined architectural component. Even when they describe large-scale design and construction work (such as Krystynopil monastery), little information is presented about world view principles at the core of specific architectural solutions (Fig. 3).

A relatively small number of papers dealing with the design and planning of OSBM monasteries offer a retrospective look. In such articles, the authors often assume various architectural qualities of buildings by extrapolating them onto the existing canvas of historical styles and their development, without making any connection to the authentic materials. They would often explicitly record only the non-homogeneity of the material studied and a wide range of architectural and spatial solutions.

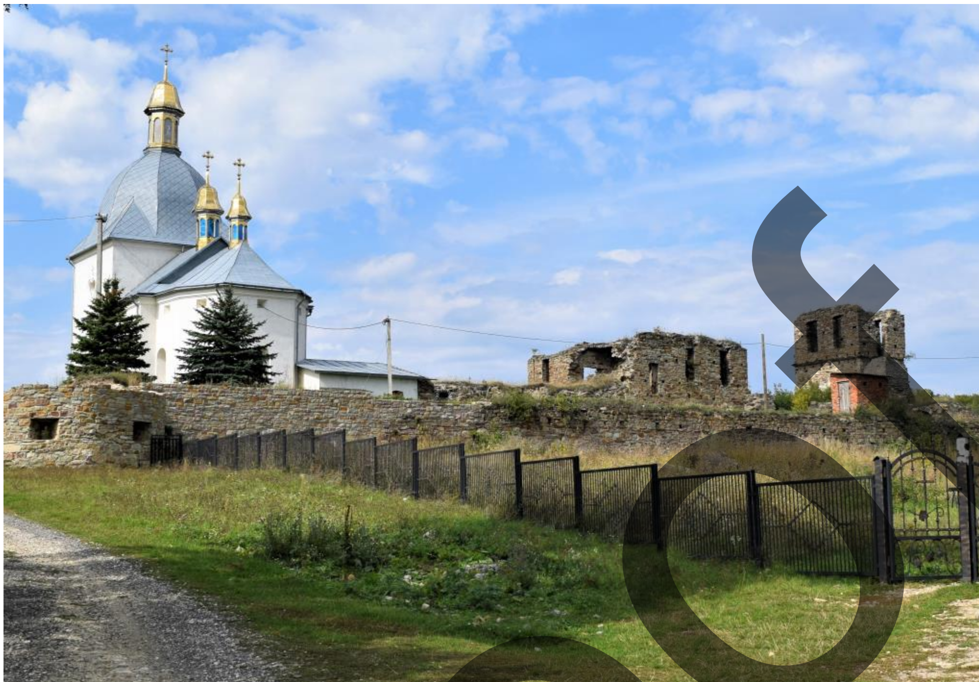

FIGURE 3. The Pidhora Monastery. Source: photo by I. Znak

Thus, upon analysis, we may divide all the sources on Basilian monasteries into three groups: a) territorial (different variants of architectural and spatial solutions depending on the subregion of Western Ukraine); b) temporal (different variants of architectural and spatial solutions depending on the time of construction); c) historical (different variants of architectural and spatial solutions depending on the degree of succession of the Eastern Christian tradition (stronger in Halychyna).

Another important aspect of the topic discussed is the interpretation of monastic complexes in a contemporary context. In Ukraine, both in academic and non-academic discourse, the popular opinion is that the authentic functions of these complexes should be restored. In the post-Soviet period, such views were regarded as a way to put the historical record straight and remedy the deformations created during the Soviet era. However, if we look at the operation of OSBM monasteries as sacral buildings and microsocial centres on the verge of the 20th-21st centuries, the restoration of the authentic functions could not happen as a mechanical process of coming back to the Second World War. Civilizational advancement means new conditions of the comfort of living conditions, economic activities, massive indulgences, creation of tourist infrastructure, etc. In such a way, the historical OSBM complexes have entered a new phase in the transformation of their spatial structure.

CONCLUSIONS

Since the genesis of architectural and spatial design of OSBM monasteries in Western Ukraine is uneven and fragmented and requires structuring, the study identifies five primary territorial and chronological scenarios: first – the legacy of the Lithuanian province; second – the first wave of the transformation after the 18th century; third – the increased presence of the Basilians in Zakarpattia; fourth – rapid development after the Dobromyl reform; fifth – development after the revival of the Greek Catholic Church in the 1990s-2000s.

It has also been identified that the spatial and architectural design of OSBM monasteries in each of these chronological scenarios has three dimensions of fragmentation: territorial (different variants of architectural and spatial solutions depending on the subregion of Western Ukraine); temporal (different variants of architectural and spatial solutions depending on the time of construction); historical (different variants of architectural and spatial solutions depending on the degree of succession of the Eastern Christian tradition (stronger in Halychyna).

Such a variety of source material and non-homogeneity of the tasks of modern interpretation of the OSBM monastic complexes indicate that the issues of preservation and replication of their architectural and spatial design constitute a comprehensive set of measures, including such necessary elements as the preservation of architectural and spatial arrangement of the OSBM monasteries which reflects the typical territorial and temporal scenarios and the adaption to current functional needs.

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The Role of Socialization of Architect Specialist in Formation of the Humane Architectural Environment

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Abstract. The authors of the article explore the features of humanization and social adaptation of architects as the main figure in the formation of a modern humane architectural environment. The study is based on the study of the requirements of modern employers in the architectural and construction industry of various forms of ownership. If earlier employers paid attention to the so-called hard skills (hard skills), which can be tested with a variety of exams, tests (these are professional competencies, knowledge of foreign languages, computer skills, etc.), now they prefer soft skills, universal competencies, which are difficult, and very often impossible to quantify. These very relevant skills include sociability, ability to work in a team, creativity, punctuality, balance, responsibility, ability to adapt to new conditions of the modern market and so on. The study and analysis of the requirements of employers led us to the conclusion that the most important are the qualities that we have conventionally designated for ourselves «The Formula of Three C»: communicability, creativity, corporatism. The article identifies psychological and psychophysiological signs of successful communication. The authors of the article suggest humane ways of soft socialization, which, firstly, meet the requirements of employers, and secondly, help young architects to adapt to various areas of future professional activity, give advice to help socialize future creators of humane architectural environment.

INTRODUCTION

The humanization of the architectural environment is a problem that has been solved for centuries, and contains a variety of methodological approaches and a comprehensive philosophical understanding. But all these methodological and creative professional achievements are united by the fact that the basis of any proposed solution for the problem is a person itself, its needs, its right for a comfortable life.

The humanization of the architectural environment is a synthetic problem, and takes into account modern achievements in ergonomics, philosophy, psychology, etc.

The central figure in the formation of a modern humanitarian architectural environment is a specialist architect, who himself has an urgent need and professional assistance in adapting to modern labor market requirements, which are being changed all the time, being filled with new problems that young professionals cannot always cope with. The research we suggest is aimed at solving the problem of socialization of graduates of educational institutions of architectural and construction profile, future specialist in this field [1].

The main problem of many young people in modern society is that they didn`t came up to a decision of what they want to achieve in their professional life, in their career. This uncertainty means that they devote most part of their free time not to self-development, but to computer games and entertainment.

According to HR portals, 52% of employers are looking for specialists with a minimum of work experience (from 1 year to 3), only 3% of employers would like to get a specialist with work experience from 5 years. Every fifth employer is ready to hire a young specialist without work experience, but this specialist must meet certain expectations of the employer, have certain qualities and abilities.

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According to Vitaly Mikhailov, the founder of the IT Staff recruitment agency, many domestic higher education institutions are obsolete both in terms of curricula and in terms of modern teaching methods.

Some educational institutions are already looking for and finding solutions to these challenges of modern labor market. Thus, a career planning laboratory, the main purpose of which is to respond in a timely and flexible manner to the needs of the labor market, its constantly changing structure, the emergence of new professions, has been successfully operating for several years at KSU «People's Ukrainian Academy». And the graduates of educational institutions - the closest feedback chain, potential partners, consultants and experts.

The experience of studying modern requirements of employers in the field of architecture and construction of the expert group of the Department of Ukrainian language and language training of foreign citizens, the authors of the article, shows that employers more and more often pay attention not to hard skills (professional knowledge, foreign languages, and computer skills), which can be checked by exams, testing, etc., but to soft skills (universal competencies that are difficult to verify quantitatively).

These skills, in which employers are very interested, include communicability, the ability to work in a team, or corporatism, creativity. To this must be added punctuality, balance, the abilities to learn quickly, to negotiate, to adapt quickly.

In general, there are a lot of researches related to the person`s social adaptation in modern science. The whole history of humanity development is a «global adaptive process that determines evolution»[2]. Social practice demonstrates a large number of adaptive strategies, which are reflected in the researches of V. Afanasyev, A. Berg, N. Wiener, G. Volkov, I. Miloslavskaya, L. Antsiferov, V. Markov, P. Anokhin, A. Georgievsky, K. Farby, E. Shapiro, V. Arshavsky, E. Bernstein, V. Sveridov, etc.

Among recent studies, the works of V. Konstantinov «Socio-psychological adaptation in a multicultural society»[3] and T. Graiva «Acculturation. Concepts, terms of ethnology, culturology, social sciences»[4] attract attention. Unfortunately, there is not much researches devoted to the problems of soft adaptation of young professionals. Therefore, the definition of soft adaptation, its characteristics, advice on the formation of certain skills soft skills indicate the novelty of this problem, which is the subject of our study.

MATERIALS AND METHODS

The experimental part of this study is that for several years we have been studying the requirements of employers in the field of construction and architecture (both public and private ownership).

We compared the data of those features of soft skills, which were given above with the data of a survey of specialists of the Ukrainian agency grc.ua in the fall of 2020. This survey showed that employers have significantly expanded the list of wishes and requirements for a potential employee in terms of soft adaptation.

Among the most important soft skills called by employers, who took part in the survey, were interaction with people (communicability), flexibility of mind (creativity), the ability to switch from one task and thought to another, teamwork (corporativism), emotional intelligence. In general, it looks like this:

- interaction with people – 65%;
- flexibility of mind – 59%;
- emotional intelligence – 58%;
- ability to form a personal opinion – 51%;
- ability to take a comprehensive approach to solving the problem – 48%;
- critical thinking – 48%;
- ability to listen and ask questions – 35%;
- creativity – 34%;
- customer focus – 29%;
- ability to negotiate – 19%.

Comparing the results of the survey mentioned above with the results of our study, we can identify 3 main groups of signs of soft adaptation, which we have identified as **«The Formula of Three C»**: communicability, creativity, corporatism.

So, the above signs of soft adaptation should be inherent to the young specialist, and their inoculation is the most important component of pedagogical activity, and they are the exact "soft skill", which is laid down in the requirements for educational programs of the Ministry of Education and Science of Ukraine. The most important tool of any social adaptation is communication, the level and content of which varies at different stages of life, depending on the communicative tasks that we solve in everyday life. It is difficult to imagine any professional activity without various communication with other people: it can be colleagues, customers, subordinates, managers and so on.

RESULTS

For successful communication, it is necessary to master a number of psychological, psychophysiological knowledges, and skillfully use them according to the situation.

Communication is a complex psychological and pedagogical phenomenon. Philosophy understands communication as a means of relationships, a means of human existence in various interactions with other people, sociology – as a special form of interaction and interpersonal relationships, in social pedagogy communication is the formation and development of contacts between people, the general interpretation of this concept – business relationships and friendly relations.

Forms of communication are various dialogues and polylogues. Dialogue is always constructive communication, which implies the obligatory achievement of a certain result, which in pedagogy is understood as the mastery of a new subjective experience. The subjective experience gained by the student in dialogic communication is for the student a kind of symbol of self-development, an internal stimulus of social activity.[5]

The latest research in this field allows us to formulate the basic principles of dialogic communication in higher education: the principle of partnership, which takes into account the interests of each participant, the principle of personalization, the principle of positionality, which transforms the teacher's superposition compassion, co-responsibility, the principle of individualization of business and interpersonal communication, the principle of actualization, which involves the transformation of attractive personal qualities of a student who is in a latent state, in the mode of active use in communication and activities.

The teacher`s task is to bring up the skills and experience of full communication in the student – not just talking, but a culture of communication. At first glance, the terms «talking» and «communication» are equivalent. But the depth of the essence of these concepts do not match.

Communication is not only the transmission of certain information, but also the maintenance of emotional contact, community; it is a great cultural value and even a source of joy. Communication is, first of all, the exchange of information, something spiritless, technocratic. Communication is not limited to the exchange of information, it is impossible to imagine without spirituality. The teacher must be ready for the various reactions of students to the proposed communication.

Dialogue can act as a blocker when the teacher is faced with inadequate activity of students, the presence of a negative attitude to the perception of certain events, facts.

A special form of communication is dialogue-silence. This is a kind of psychological influence. The most common in teaching practice is a dialogue-conversation, which has an introductory, informative purpose, dialogue-conflict, which carries the subject of debate, dialogue-criticism, which the teacher uses if he needs to critically analyze certain actions of students.

Let ourselves to give some advice that should be the key to a successful dialogue between teacher and student and form the future signs of sociability, fruitful communication in the professional sphere.

Criticism must be constructive and tactful. It can be encouraging: for example, «The problem is not solved, but it's okay, next time everything will be fine», reassuring «I hope that next time everything will be better», similar to «I remember when I was a student, I`ve been making the same mistakes», depersonalized (without reference to specific students); represent a concern «I am very concerned about this situation» and so on.

Our analysis eloquently shows that employers want to hire creative employees, who are able to offer not only innovative, but also non-standard solutions to problems. So, what is creativity in the modern meaning of the term? A large psychological encyclopedia interprets creativity as a level of creative talent, the ability to create as a relatively constant feature of personality. Creativity is, first of all, the ability of an individual to give birth to unusual proposals, to deviate from traditional patterns of thinking, to quickly solve problem situations.[6]

It is characterized by a willingness to produce fundamentally new ideas and is part of the structure of talent as an independent factor. Among the abilities of intellectual creativity, it is distinguished as a special type. Well-known psychologist A. Maslow believes that creativity is a creative orientation that is inherent in everyone from birth, but disappears in most under the influence of the environment.[7] Another well-known psychologist P. Torrens identifies the following signs of creativity[2]: a) hypersensitivity to problems, shortages or skills of knowledge; b) actions to identify problems, to find their solution on the basis of hypotheses, to test and change hypotheses, to form the results of the solution.

To assess creativity, various tests of divergent thinking, personal performance questionnaires are used. The study of factors of creative achievement is carried out in two directions:

1) analysis of life experience and individual traits of creative personality, personal factors;

2) analysis of creative thinking and its products – factors of creativity: speed, clarity, flexibility of thinking, sensitivity to problems, originality, ingenuity, constructiveness in solving problems.

In order to promote the development of creative thinking, you can use the initial situations, which are characterized by incompleteness or openness to the integration of new elements, while encouraging students to formulate many new questions.

Creativity and innovation are often indistinguishable. Meanwhile, the difference between these concepts is significant. This is stated, in particular, in Paolo Legrenzi's book «Creativity and Innovation».[8]

We must remember that the first enemy of creativity is stereotypical thinking. Here are its signs:

a) search for the right solution;

b) obsession with the original data;

c) focus on benefit;

d) focusing on only one issue;

e) checking only one hypothesis.

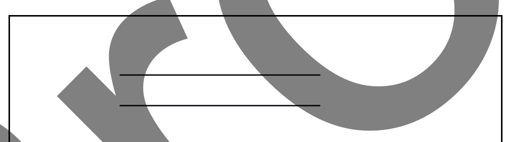
When it comes to innovation, the above features can be used. When it comes to creativity, following these rules can hurt, because in a creative attitude to solving the problem, we must take into account a lot of initial data, offer several options for solving the problem, which differ in efficiency, modernity, ergonomics, functionality and more. The proposed solution does not necessarily bring material benefits here and now, which is inherent in innovation, but has interesting prospects in the future, contains considerable creative potential.

Innovation is always empathic, because it is aimed at meeting the needs of a particular social group, when it comes to creativity, empathy does not play such a significant role as in innovation processes.

You need to define the ultimate goal: as you are focused on creativity, move away from templates, offer a variety of ideas, if you want to benefit from your activities, pay attention to meeting the needs of a particular social group.

There are two important questions: whether it is possible to check the degree of creativity and how to develop it. We offer as a sample a test to check creativity:

How many lines are at the picture?



The vast majority answers that there are 2 of them, but a person who thinks creatively will answer that there are three of them, taking into attention the space between the two lines.

Our advice for developing creativity: to take an active part in discussions, brainstorming, solving problems that do not have a clear solution in modern science.

We move to the last C from our formula – to Corporatism.

The most common definition of corporatism is a sense of belonging to a single group, in which each individual has common views and beliefs with the group.

Corporatism is the key to the security of a modern organization, consolidation in the dyad «man-organization».

The corporate spirit promotes the development of empathic communication, reflected in the famous formula of the musketeers "One for all, and all for one".

Some scientists distinguish two aspects of corporatism:

1) means of manipulation in team management;

2) the concept of the organization, which reveals the corporate spirit and values of the company. And only from the psychological maturity of the company's management depends on which aspect will dominate.

An essential component of corporatism is the influence of the team on the development of personality. In modern psychology, the term «corporate man» (Japanese *kaisha ningen*) is becoming more common. This is, above all, a person who is completely committed to his company, who shares the values of its corporate culture. A corporate person tries to achieve certain goals (stable guaranteed work, gain a certain status, advancement on a career ladder). And this is possible only within a certain company, because only within this company is the exchange of personal goals of the worker and the goals of the company.

At the beginning of his career, the employee does not have the proper competence, qualifications or desire to work for this company, which would allow him to be considered a corporate person. When he starts working, the worker makes a certain contribution, which is compensated by the company.

Later, acquiring higher competence, the employee shows a desire to meet the requirements of the company, there is a sense of responsibility and duty to it, that is, forged a sense of loyalty and collectivism, allows to consider the employee a corporate person. In return, the company guarantees stable work, payment in accordance with the status of the official ranks.

CONCLUSIONS

Our experiment, the results of the analysis of the obtained data allows us to conclude that soft socialization, soft skills are absolutely necessary for graduates, future professionals in the formation of a humane and humanitarian architectural environment.

In the process of our research, we identified the main features of the properties of the components of soft adaptation - creativity, communicability, corporatism.

Perspectives for future research are to study various aspects of soft skills, their systematization and adaptation to the needs of higher education and young professionals in the field of architecture and construction, in order to adapt them in modern society and the labor market.

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Museumification of Historical and Cultural Heritage Objects with the Purpose of Adaptation to Medical and Rehabilitation Centers

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Abstract. This article considers the problem of preservation of cultural heritage, due to the impossibility of using monuments for their intended purpose, which directly accelerates the destruction of buildings, which encourages the constant search for new features in terms of modern use of architectural and urban monuments, their role and status in our lives. One of the ways to revive the monuments of the historical and architectural environment and preserve the cultural memory of the nation is museumification, the process of which can take place in three main directions, each of which differs in content. Thus, the adaptation of historical and architectural monuments of Ukraine in medical rehabilitation centers may be extremely important, as the combination of these two areas (objects of monument protection and health care institutions) forms a kind of symbiosis. medical and psychological rehabilitation, which is catalyzed through the prism of cultural heritage sites of historical and architectural environment.

INTRODUCTION

The urgency of the topic is due to the need for a deeper understanding of the aesthetic, spiritual and sacred impact on human historical and architectural environment of medical rehabilitation centers created by museumification of cultural heritage sites for their further effective preservation and long-term functioning. The analysis of the existing bibliographic sources and theoretical developments proves that the effective solution is museumification, the methodology of which is currently insufficiently developed and covered in the scientific literature in the country. L. V. Prybega notes that «methodological principles of complex protection and restoration of objects of architectural and urban heritage have not been finally formed in Ukraine yet. However, the general state and trends in the development of monument protection methods in the country give grounds to claim that at the level of theoretical developments there are prerequisites for structuring the architectural monument protection methodology as a complex scientific discipline» [13, p.18].

The general structure of protection measures in relation to objects of immovable cultural heritage is covered in researches of V. I. Akulenko, I. O. Ignatkina. Some aspects of preservation of immovable monuments of Ukraine are considered by G. O. Andres, V. O. Gorbyk, G. G. Denisenko, P. I. Skrypnyk, Yu. V. Opalko. Issues of methods of protection and restoration of different types of monuments, as well as the principles of their maintenance and functional adaptation, considered in the works of O. V. Lesyk, L. V. Prybega, E. V. Mikhailovsky, Yu. S. Aseev, G. N. Logvina, B. L. Erofalova. The question of the historical environment is found in the theoretical works of K. Lynch, O. S. Shchenkov, E. E. Vodzinsky, O. Becker. The relationship between the emotional world of man and architecture has been repeatedly pointed out in the field of the study of architectural semiotics by A. A. Barabanov, Yu. S. Yankovskaya, and M. V. Puchkov; in the field of architectural theory – K. N. Ledu, J. O. Simonds, R. Arnheim, G. B. Minervin, G. A. Rappoport, A. V. Ikonnikov. In the field of psychological and psychophysiological research, this topic was voiced in the works of L. A. Kitaev-Smyk, M. Chernoushek, and R. Barker.

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The problem is the preservation of cultural heritage, due to the impossibility of using monuments for their intended purpose, which accelerates the destruction of buildings, which encourages the constant search for new features and does not lose its relevance. Therefore, identifying the peculiarities of the formation of architectural and spatial solution in relation to the adaptation of historical and architectural monuments of Ukraine, in particular monastic complexes, in medical rehabilitation centers is a task on the way to a partial solution to the preservation of national heritage. On the one hand, the spirituality and sacredness of the cultural heritage of the historical and architectural environment directly positively affect the mental state of patients, behavior and their psychosomatic health, and on the other - the adaptation of architectural monuments to new needs allows them to inspire life, due to the change of function and purpose of the object, rational rethinking of the architectural and spatial organization of museumified objects of cultural heritage of the historical and architectural environment (taking into account the needs and interests of the rehabilitator), which becomes determining factors in their further physical and moral preservation.

Object of research: objects of architectural and urban heritage.

Subject of research: museumification of immovable cultural heritage objects for the purpose of adaptation to medical rehabilitation centers.

The purpose of the study is to determine the principles of museumification of cultural heritage sites in connection with the adaptation of immovable architectural monuments in medical rehabilitation centers.

RESULTS AND DISCUSSION

The issue of preserving the national cultural heritage, namely the historical and architectural heritage of the country, acquires special significance during the hostilities in the East, the difficult conditions for the formation and strengthening of Ukrainian statehood.

It is known that after gaining independence, Ukraine begins to create its own state regulatory framework for the protection of historical and cultural heritage, the process of formation of which continues today. Both national and international theoretical ideas and developments, as well as accumulated practical experience were used for creation and development. Therefore, in Ukraine there is a legal regulation, which is the basis for the functioning of the state system of protection of cultural heritage sites, according to which the monuments located on its territory are subject to state protection [6]. The main provisions relating to activities in relation to immovable monuments are regulated by the Laws of Ukraine «On Protection of Cultural Heritage» [8] and «On Protection of Archaeological Heritage» [7], approved by the Verkhovna Rada in 2000 and 2004, based on which the Cabinet of Ministers adopted a number of orders and regulations regarding the monument protection sphere. However, some aspects of ownership of cultural heritage sites or land on which it is located, as well as protected areas are partially registered in the Civil Code of Ukraine. Non-governmental organizations for the protection of monuments are also important drivers for the preservation and protection of historical and cultural heritage.

Each country creates its own system of governance based on their historical experience, traditions and available resources. However, an important aspect of the effectiveness of any database on the protection and restoration of monuments by the state is compliance with international documents that combine theoretical and practical principles and achievements of international organizations involved in the protection of monuments (charters, conventions, recommendations, and other acts)., developed and approved by international organizations) [12]. Therefore, cooperation is an opportunity to exchange experiences, where international conservation organizations are catalysts for such cooperation. At the international level, the leading organizations that regulate the protection of monuments are: UNESCO (United Nations Educational, Scientific and Cultural Organization - United Nations Educational, Scientific and Cultural Organization), ICOMOS (International Council on Monuments and Sites) - International Council for Monuments and Sites) and ICCROM (International Center for the Study of the Preservation and Restoration of Cultural Property - International Center for Research in the Field of Protection and Restoration of Cultural Property) [12].

In determining the essence of museumification of cultural heritage sites in terms of adaptation, adaptation and change of the original function, as well as understanding the spiritual impact on the rehabilitator of historical and architectural monuments, it is necessary to rely on the legislation of the monument protection sector. There is no single definition of «protection» in the scientific literature and legislation. Nevertheless, all sources agree that protection is a set of measures taken at the national or public level to protect and preserve historical and cultural heritage and the historical environment as a whole, which includes accounting (detection, scientific study, classification, state registration), conservation, restoration, museumification, proper maintenance and use of monuments, i.e. a set of numerous activities to ensure the viability of the monument - its detection, accounting, research, physical preservation, modern use, promotion, long-term existence, etc.» [3, p.29].

Immovable cultural heritage sites can be the basis, among other things, for the creation of medical and rehabilitation areas and the use of historical and architectural environment for medical purposes. The analysis of domestic and foreign experience of monument protection measures in relation to the immovable cultural heritage indicates that the main prerequisites for the preservation of architectural monuments can be created only as a result of a comprehensive solution to the problems of their modern use [2]. L. V. Prybega notes that “the assertion of a comprehensive approach to the protection of cultural heritage sites requires a clear understanding of such a monument-protection category as the historical environment, which should be interpreted as a spatial-temporal field of human life, organized historically-inherited system of buildings and structures in the landscape conditions of the territory [13, p.19]. This issue is one of the most important problems in the protection of cultural heritage. Architectural monuments include objects whose authentic architectural form or material substance is evidence of human architectural and construction activities in the past, and in combination with the historically inherited spatial framework of the environment is a historical, scientific, artistic or other cultural value [13]. The return of monuments to their original functions is an effective means of preserving the objects of historical and architectural environment, but due to the passage of time and changes in the mentality of the Ukrainian people, this is not acceptable in most cases [2]. Thus, due to the impossibility of using memorial objects for their intended purpose, the destruction of buildings is accelerated, which encourages the constant search for new functions. Therefore, in the interests of the state and society, taking into account the economic feasibility of providing the necessary measures for the preservation and restoration of architectural and historical monuments, the optimal means of adaptation and direct preservation of immovable cultural heritage is recognized museumification interpreted in the Law of Ukraine «On the protection of cultural heritage» as «a set of scientifically sound measures to bring cultural heritage sites in a condition suitable for sightseeing» [12, p.41] and others. cultural and educational use. In contrast to the XXI century. In the works of Soviet scholars of the 1980s, «museumification» was defined as «the direction of cultural policy and the field of museum work, the essence of which is to transform immovable monuments of history and culture or natural objects into museum objects» and the purpose museumification was defined as «preservation and rational use in the system of cultural propaganda» [1]. But scientists note that there are additional difficulties in this area of activity, because «in solving this problem, the socio-cultural and architectural-artistic value of monuments and the requirements for their protection as a holistic architectural organism remain decisive» [2, p.32]. It is worth noting that the Venice Charter (1964) stated the inseparability of the monument from its environment, and Article 14 enshrined the need to preserve the integrity of attractions [14]. Maria Brych notes that “the complex nature and structure of monumental complexes and ensembles necessitated the search for special approaches to their protection and modern use in Ukraine. Monuments of Ukraine need to be used considering social efficiency, ensuring active technical measures of preservation and restoration» [3, p.16].

The term «museumification» is usually understood as the transformation of an immovable monument into a museum, although in fact the process can take place in three main directions, each of which differs in content:

1. the object of cultural heritage changes its primary function to a museum with a change in the subject of protection. This approach can be defined as the adaptation of the monument to the museum function and is characterized as a rather inefficient direction due to the neglect (shift of priority) of the historical and cultural value of the monument [3];

2. the object of cultural heritage changes its primary function to a museum with the preservation of the object of protection. This direction is temporary and the most common nowadays [3];

3. the object of cultural heritage itself becomes a museum exhibit in the system of general exposition of a specific landmark or historical and cultural environment. This method is most appropriate for the preservation of architectural and urban heritage, especially represented by large complexes [3].

It is worth noting that an important component of the process of cultural heritage protection is the functional adaptation of monuments and their inclusion in modern public life. The underestimated importance of the utilitarian use of monuments accelerates the destruction of even restored architectural heritage sites [14]. The research of O. V. Lesyk, Yu. S. Aseev, L. V. Prybega covers some issues and some problems in the use of architectural heritage sites. Until now, there have been various definitions of requirements for the functional adaptation of cultural heritage objects in conservation science. O. V. Lesyk notes that «the degree of structural and planning changes in the buildings that are being adapted should consider, first of all, the historical and architectural value of the architectural monument» [11]. In addition, when addressing the issues of modern functional use of the monument, it should consider its technical condition, architectural and typological features of layout and spatial planning, location, environmental and aesthetic features of the environment, the availability of transport communications and engineering equipment for creating comfort conditions [11].

Thus, a brief review and analysis of bibliographic sources suggests that for the revival of monuments of historical and architectural environment and preservation of cultural memory of the nation may be extremely important adaptation of historical and architectural monuments of Ukraine in medical rehabilitation centers, as the combination of these two directions (objects of monument protection and health care institutions) forms a kind of symbiosis of medical and psychological rehabilitation, which is catalyzed through the prism of cultural heritage sites of historical and architectural environment. In this combination, psychological rehabilitation, which is an integral aspect of any rehabilitation measures in general, occurs due to the sacredness and spirituality of monuments and is revealed through the material substance of the building, the layering of patina time environment, and adaptation of architectural monuments for medical rehabilitation centers due to the need to address issues of protection and modern use.

Returning to the question of the possibility of creating medical rehabilitation centers on the basis of immovable monuments of architecture, it is worth remembering that the evolutionary path of medical work and medical institutions is connected with monasteries. Christianity provoked the widespread spread of the hospital system. During the Middle Ages, which can be attributed to the second generation of medical and rehabilitation institutions, the architectural feature of medical centers is presented in the form of monastic centers, which took over the function of «ancient medical institutions», but differed in that they did not have conditions to maintain cleanliness and hygiene [10]. At the beginning of the IX century. medical part of the monastery was a leprosarium, located behind the monastery wall and consisted of small cells for the sick, a small chapel and a house for staff. From the beginning of the XI century. most monasteries already had their own hospitals (infirmary) for sick monks and hospitals for poor laity with facilities for basic medical care (e.g hospital buildings in the monastery of Cluny and the abbey of Saint Martin in France, the abbey of Fontevro in England, the monasteries of Mariental in Germany and other). Having gone through a difficult path of development, from kinovios (the first monasteries of hermits) to hospitale (shelters for the sick and suffering), the first large-scale Christian hospitals were like vaulted naves, similar to the naves of nearby cathedrals and had individual stylistic features depending on the region. The combination of spiritual and physical principles in treatment (prayers, worship, walks), new methods of recovery and rehabilitation, specialization of medical staff, etc. caused the emergence of block (pavilion) structure of buildings due to the gradual complication of planning schemes associated with functional processes. The blocks are halls for patients, chapel space, residential buildings for staff, utility rooms, large pantries [4]. These elements are combined by cloisters, galleries, corridors or small connections-transitions. Examples include the hospitals in Angers and Tonner, the Hospital of St. Mary in Chichester, and the Hospital of the Holy Spirit in Lübeck.

That is, one of the stages of development of medical rehabilitation centers was their adaptation in monastic complexes, combining the functions of hospital and shelter for the needy, while remaining a spiritual institution, the importance of architectural and spatial environment as an aid to healing and rehabilitation, understood and used in those days. It is known that in the psychological sense, architecture forms stable spatial reactions, human habits, images and concepts in its mental space, which not only consciously but also subconsciously affect human life and activity [16], and the spirituality and sacredness of cultural heritage. historical and architectural environment directly have a positive effect on the mental state of rehabilitators, psychosomatic health, intellectual and social development. A. V. Ikonnikov noted that the environment organized by architecture is unobtrusive, but constantly affects a person, his emotions, behavior [9]. Researcher M. Chernoushek notes: «The environment includes in addition to measurable physical and chemical quantities and psychological characteristics, which is expressed in what responses, feelings evoke in us the environment, accelerates or suppresses our actions» [15, p.44].

Thus, the combination of multifunctional architectural and spatial solutions of medical rehabilitation centers with the complex nature and structure of architectural monuments requires a particularly careful approach to creating the operating conditions of the object. However, considering/ considering the developments in the direction of preservation of cultural heritage, it is possible to identify the peculiarities of the formation of medical rehabilitation centers, created based on musemified objects of national heritage.

The principles of formation of the architectural and spatial organization of medical rehabilitation centers are based on the principles: accessibility, functionality, interactivity of space, identity, scientific authenticity and protection of cultural heritage.

The main methods of using immovable architectural monuments in medical rehabilitation centers are adaptation / adaptation, museumification, use for the original or close to the original purpose, as well as a possible combination of several methods.

The basis of architectural-spatial organization is the mutual placement of functional, volumetric and recreational-rehabilitation spaces, while maintaining a free environment that can be transformed according to needs, as well as maintaining visual perspectives with the organization of recreational and information-multimedia areas in viewpoints.

Spatial organization of medical rehabilitation centers can occur by dividing by: location, structure, territorial and compositional integrity, in which zoning is carried out according to the following compositional schemes: open, closed and combined.

According to the composition and organization of space, a scheme of movement and movement (linear (directed), circular (closed), radial, free and combined routes) is formed, which depends on the method of landscape use (integration, recomposition, reconstruction) and means of actualization of monuments. objects (translation, modeling, revitalization).

During the functional adaptation of the building it is necessary to avoid reconstruction and reconstruction and to give priority to the natural and cultural environment, to recreate the image in relation to the landscape, to dominate the authenticity of the building over interpretation, to ensure compositional unity. If it is impossible to adapt the three-dimensional structure of the monument to the required configuration, you should carefully compare the value of the historic building with the feasibility of any changes. Low-value buildings, which, for example, are part of the complex, are quite easy to adapt to another function, in contrast to the landmarks, which are better to find use that will not harm the material substance of the monument. Each case will have its own specifics, so the choice will be different each time, but it must be inclined to make a decision that makes the most of the potential of memorable objects, will correspond to their content and minimize damage.

However, at times, some new features impose requirements on the architect that are incompatible with maintaining the structure of the monuments. In such cases, a decent option is to build new facilities that will become part of the medical rehabilitation center, without being a monument. The addition of new features should not interfere with the accessibility of monuments and interact with modern society, as well as organically combined with the architectural form of the monument.

Thus, the principles of introducing new elements into the structure of monuments include: restrained intervention; abandonment of the concepts of demonstration of new volumes in order to preserve the existence of the material spirit of the monument, which should always remain in the center of perception.

The task of creating new additions that reflect the most common features of the object, O. S. Shchenkov refers to the field of reproduction of the iconography of the monument. The iconographic commonality of the old and the new in the monument should at the same time contribute to the organic combination and preservation of the meaningful characteristics of the image and be reproduced in the form of modern simplified forms that do not dominate the original form or imitate the original [17]. This approach is directly related to the principles of Camillo Boyto, who put the authenticity of the monument first, rather than its aesthetic component. The principles of C. Boyto include: stylistic difference between the original elements of the monument and the new volumes; the difference in material between the present and the added; refusal of detailing and ornamentation of new parts; marking of new inclusions with special inscriptions or symbols; display of old elements found during the restoration next to the monument; publicity and publication of decisions [5].

Thus, when introducing new elements and volumes into the structure of monuments, it is necessary to identify some artistic means, namely: maintaining the proportional dependence of mass to scale; subordination to the facade grid, taking into account the compositional division between the new and the original; creating a contrast between the artistically saturated material substance and the laconic geometry of new inclusions; application of surfaces with an excellent texture taking into account the change of tone; the advantage of using natural materials while preserving the difference between real and added. It is also worth noting the restrained nature of the new elements and volumes with a balanced level of contrast on several indicators of architectural form. For example, if the contour and color of new additions are made nuanced to the existing material structure of the building, the texture should be contrasting and vice versa.

CONCLUSION

As a result of the analysis of existing research, it can be argued that the problem of adaptation and adaptation of museumified cultural heritage sites in Ukraine, due to the impossibility of using memorial sites for their intended purpose, has not yet found a final solution despite the progress made in the field of restoration of monuments.

Based on the literature, it was determined that in terms of modern use of architectural and urban monuments, their role and status in our lives, depends on the continued existence and preservation of architectural heritage, but to implement the tasks of museumification of immovable historical and cultural monuments must be improved. methods of research of monuments, there is a significant legal and practical basis, which includes relevant documents and long-term targeted investments from the state and related organizations and institutions.

In the course of the work recommendations were formulated on the peculiarities of the formation of medical rehabilitation centers created by museumification of national heritage objects, namely: the principles of formation of architectural and spatial organization, the main ways of using immovable architectural monuments, characteristics of architectural and spatial organization of medical rehabilitation centers in the context of the historical and architectural environment, etc.

During the compositional analysis it was revealed that when introducing new elements and volumes into the structure of monuments, it is necessary to adhere to certain artistic techniques, namely: additions should correspond to the mass and scale; to obey the grid of the facade; to create the effect of contrast between the artistically saturated substance of the monument and the laconic geometry of the new inclusions due to the compositional division between the original and new elements; apply similar in tone, but different in texture surfaces; use natural materials with a restrained nature of new additions and a balanced level of contrast.

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Historical and Innovative Approaches to the Development of the Architecture of Club Buildings in Lviv

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Abstract. The traditions of club buildings of Lviv have a deeply-rooted history closely intertwined in its development with the activities of cultural and educational institutions that existed here since the 17th c. Clubs started appearing in Galicia back in the mid-19th century, and before World War II they constituted a network that uniformly embraced inhabited settlements in these territories. Community halls, "Prosvita" reading rooms, buildings of societies and unions all became real centres of cultural life. Now most club buildings in the city function in accordance with their designation, but social life has undergone changes, and that has affected the forms, location, and typology of these facilities. Approaches to the use of construction materials and functionality of the building spaces have changed as well. At the beginning they were built of traditional materials: rock, brick, and wood. The beginning of the 20th century livened up the construction movement and encouraged the wide use of glass, concrete, and metal. That did not just accelerate construction of specific facilities, but of the whole building quarters. The 21st century sets new challenges for us, requiring a more profound analysis of existing historical facilities as well as a search and processing of proposals that would meet modern requirements. Since mobility and multi-functionality of the environment, quick response of the club building owners to the changing needs of their users are of immediate interest now.

INTRODUCTION

Constant changes in the way and quality of life have been causing new forms of leisure time and cultural rest. In different times that led to the appearance of new types of spaces and buildings for the communication between different societal groups united by common interests. The goal of the research is to review the historical cultural and educational as well as club buildings of Lviv as well as to identify new facilities that have appeared in the recent years and are rapidly developing.

Currently, descriptions of some cultural and educational buildings and personalia related to their construction can be found in the research papers by V. Chepelyk [1], V. Vuytsyk and R. Lypka [2], O. Noha [3], I. Zhuk [4], Yu. Biriuliov [5], B. Cherkes and L. Hrytsiuk [6], V. Proskuriakov [7] and O. Stoyanovskyi [8], N. Bozhko and L. Tsubov [9], however, the issue of club functioning in modern city reality requires further study and discussion.

PRESENTATION OF THE CORE MATERIAL

Cultural and educational buildings started appearing in the Ukrainian territory at the beginning of the 17th century, and at first they were mainly of educational nature. Clubs appeared a bit later, in the mid-19th century, in cities they were founded by public organizations and unions that united people by common interests: within a certain circle, occupation, leisure, entertainment, sports, etc. In the villages clubs were mainly designed to disseminate culture and knowledge. Libraries, reading rooms, book stores, lecture and theatre rooms functioned there, different courses and hobby groups were organized there.

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One of the oldest cultural and educational facilities of Lviv is the Jesuit Collegium. At first monks stayed in wooden houses presented to them by Zofię Henclową in 1589. After the residence was transformed into a collegium, in 1608, they kept residing and teaching in those wooden buildings which were, though, modernized and enlarged. From 1610 to 1660 Jesuits build a majestic baroque cathedral of Saint Apostles Peter and Paul, following the sample of Il Gesù church in Rome. Only after its consecration the monks started building a brick collegium. However, the process was very slow, due to lack of materials and marshy soil that was to be dried and reinforced. Also, the plot was too narrow and did not allow placing all the facilities necessary for an educational institution there. Therefore, a decision was passed to carry out construction also behind the defensive walls. That led to new problems, since the level of soil near the cathedral and on the defensive walls was different. It was necessary to align the basements located at a different height. At the end of the 17th century the crowned hetman Stanisław Jan Jabłonowski joined in the process and introduced some changes into the previous design, and then construction started approaching its completion. Location of this educational institution close to the city boundaries enabled to create a powerful fortified monastery complex that did not only help with its appearance to fortify the city walls, but also conducted enlightenment activities. Built following baroque architecture principles, it impresses with its monumentality. Besides the very collegium, some utility premises and cells the institution also possessed a large library [10]. The graduates of this educational institution, well-known to the wide public, were hetman Bohdan Khmelnytsky and prince and voivode of Rus Yarema Vyshnevetsky. At the beginning of the 18th century Jesuits also built a school close to it. For a long period of time, until the 1773 cassation, the collegium carried out its activity without following the city's life and needs. However, after Jesuits, till 1848 the premises hosted the "governance office" ("hubernium") as well as almost all city government institutions. Probably, that influenced the overall accessibility of the object for the citizens, and there is some data proving that already in the late 18th – the first half of the 19th century some performances of professional theatre groups as well as local theatre groups were staged in the building of the former Jesuit collegium (Fig. 1).

(a) (b)

FIGURE 1. The building of the former Jesuit collegium. Photos by Yuliia Bohdanova: (a) General view, (b) Stone entrance portal.

In 1783 the Greek Catholic Seminary of Lviv was located there, and within its premises the tradition was shaped up to stage theatre performances and to arrange other cultural events organized with the involvement of the Ukrainian community of the city. It was here that the basis was laid down for further developments on the way to upbringing of future Ukrainian public and cultural figures who grew up and developed in Lviv. Thus, in 1838 Markiyan Shashkevych – the head of the society "Ruska Triytsia" and the initiator of publication of the almanac "Rusalka Dnistrova" – graduated from the Lviv Theological Seminary. For some time that place used to be the centre of gravity and enlightenment for Ukrainians, the cradle of their cultural life, until the community hall ("People's House") was built on the ruins of the old University, in 1852. The architecture of the buildings designed by V. Schmidt and S. Havryshkevych followed the biedermeier style. After the main hall designed by A. Opolsky was refurbished, there appeared the stage and front staircase for the public. Men's high school (gymnasium) with the Ukrainian language of studies functioned in the premises of the community hall, as well as different hobby groups and cultural societies, there was a library and a museum [11]. Up till 1945 that building was a sort of a club for the Ukrainian community of Lviv, with its active life. Political, economic and cultural issues related to its activity were settled there.

At the beginning of the 20th century Lviv and Galicia underwent rapid economic and cultural development. The construction industry was quickly moving to the highest level. Hundreds of buildings were erected, and they changed the city imparting it its current appearances. That was related to a good market situation and active demographic growth of the population which, over the period from 1890 to 1914, almost doubled. Lviv started the period of its flourishing which was primarily characterized by the growing construction investment, building of large administrative, public and residential buildings, solving of the urgent issues of utility infrastructure for sewerage and water supply, as well as development of hundreds of new streets and new urban development districts. That also gave an impetus for the changes in the planning solutions for cultural and educational buildings. Almost in each of them multi-functional rooms were arranged, for performances, debates and presentations, and later – for movies.

In many cities of Ukraine the modern style acquired national features, borrowing the motives from folk wooden construction − forms of roofs, window and door apertures with chamfered upper corner, maiolica filling pieces with national ornaments and other decorative elements of folk art. Modern national architecture in Galicia was initiated by I. Levynsky who worked with architect's T. Obminsky, O. Lushpynsky, V. Nahirny. He built the facilities that became the samples of the Ukrainian tradition embodiment, of which the best one is the building of the insurance company "Dnister" in Lviv, built in 1905 under the design suggested by I. Levynsky, T. Obminsky and O. Lushpynsky. This building of multi-functional designation contained the premises for the bank, several public societies, including for the Ukrainian sports union "Sokil" that got one of its first gyms there. Expressive silhouettes of the roof with a wooden tower became a characteristic attribute of the stylistic solution for the building. Later they were actively used in other facilities built to the order of the Ukrainian community: high school and bursa (seminary) of the Ukrainian Pedagogical Society (1906-1908), the House of the Academic Community (1905) and numerous community halls.

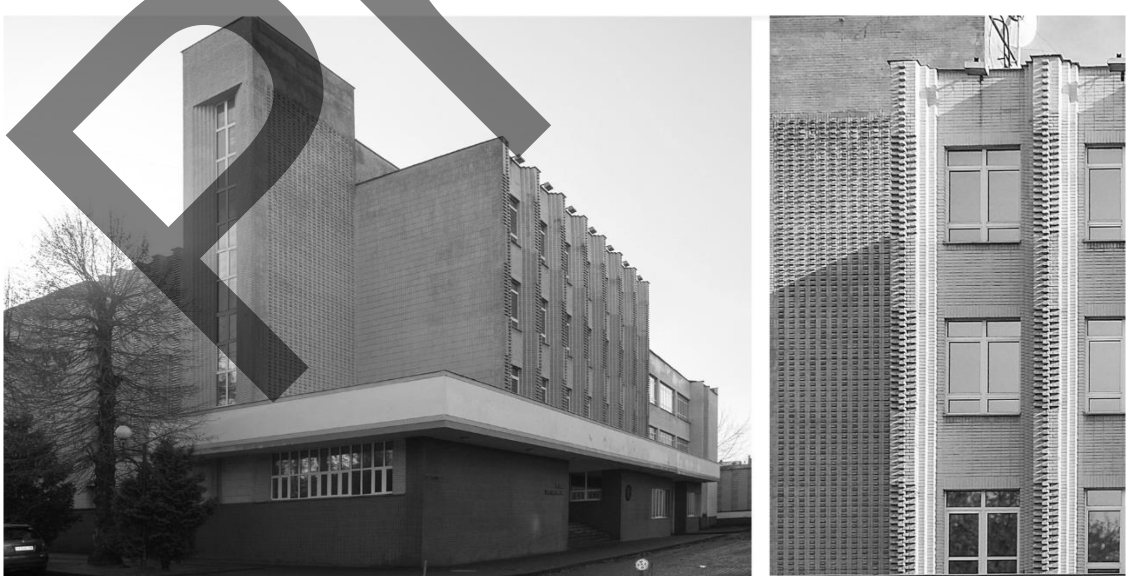
The architecture of interwar Lviv was erected in a very complex economic situation. At first that was the city reconstruction after the destructions of World War I, then – difficult recovery after the global economic crisis of 1929-1932. Due to this, the large number of buildings erected over a short period of active construction movement of the twenties (1925-29) and the second half of the thirtieth (1935-39) is impressive. At some period of time, being the capital of Galicia within the Austro-Hungarian Empire, Lviv had already got its huge economic development. Therefore, investment into its economy after World War I, taking into account its location in the east of the country, was not the state's priority. Lack of finance, economic and political instability, high unemployment rate remained important social problems. Due to this, Lviv was developed almost exclusively by the city government that advocated establishment of different societies and social organizations that had the money which they used to do some constructions following their own needs. However, in the period of the two interwar decades, the city still managed not just to develop its industry, but to build a large number of public and residential facilities.

Theoretical papers of the early 20th century stated that an individual, besides a place to work and to live where he stays after work, must also have some cultural rest, by communities of interest: by occupations, or by hobbies. The interwar period and the then-society could be characterized by an unconventional phenomenon that was never to be repeated again – when the workers deducted one percent of their salaries to collect the necessary amounts and to start construction of a common building for their cultural and leisure needs. In that way different social organizations or large companies built many different clubs in Lviv. The most famous of them was the House of Municipal City Workers. It was built by workers themselves in their free time after work. A competition for the design was announced, and the winners were T. Wrubel and L. Karasinsky who were among the most famous architects of the city at that time. The building occupied almost a whole plot, but for the small inner yard meant to provide lighting for the theatre room. The façade is not typical for the architecture of Lviv, since it contained the signs of "real architecture" from red unplastered brick, with the demonstration of Ferro concrete structural elements. In each club of that time there definitely had to be a cinema, therefore in May 1938 the administration of the institution addressed the city authorities asking to grant the permission to them. Thus, in 1938-1939 the cinema entitled "Światowid" functioned there [12] (Fig. 2).

(a) (b)

FIGURE 2. The House of Municipal City Workers. Photos by Yuliia Bohdanova: (a) General view, (b) Fragment of the brick decoration of the façade

The second famous interwar club was the House of Railway Workers, but, unlike the previous one, it was built of white unplastered brick. The only decoration on the walls of the building was volumetric laying. That was an example of the design done by a non-local designer, untypical as for Lviv. That was the architect and political figure R. Miller who headed the architectural division of the Warsaw Directorate of the Polish State Railroad and designed the railway buildings in the whole territory of Poland. It was from this office that in 1929 Lviv got the design of the House of Railway Workers. Since the area was located in the territory of the old Horodok cemetery, H. Zaremba, being in charge of the construction, had to carefully follow a long list of rules, that slowing down the facility construction. That is why the club was completed and put into operation only in 1937. It also had a cinema entitled “Roxy”, inspired, most probably, by Samuel Lionel “Roxy” Rotafel, a then-famous American film producer and impresario, founder of the Roxy Theatre in New York [13] (Fig. 3).



(a) (b)

FIGURE 3. The House of Railway Workers. Photos by Yuliia Bohdanova: (a) General view, (b) Fragment of the brick decoration of the façade.

Contrary to the general tendencies of producing rational and international architecture, Ukrainian community, particularly in the 1920s, tried to initiate the creation of public buildings to preserve national identity. It was manifested in the use of sloping roofs, identical to the folk architecture of the Carpathian region; adaptation and rethinking of the domes of Boyko and Lemko churches and imitation of general features of the Byzantine style. Examples of club buildings can be found in the creative work of the famous Ukrainian architect of the interwar period – Eugene Nahirny, who is better known as an unsurpassed master of sacred construction. His project of the People's House in Bohdanivka in Lviv, made in the 1930s, is an object of universal admiration. Its architecture boasts different types of windows: semi-arched, round, rectangular and pointed; a staircase surmounted with a grand dome; multiple fragments which create various associations with the traditional Ukrainian church. However, the realization of the project turned out to be strikingly different from the project itself. All the characteristic architectural features of the Ukrainian People's House, except for the sloping roof above the main volume, have been removed. The drawings show that it was to have a multifunctional 400-seat hall with a stage, a large number of public and educational spaces. Today this building basically functions as a dormitory. Moreover, several landlords share the premises on lower floors, facing Horodotska St., and therefore the original purpose of the People's House as a cultural and educational center fell into obscurity.

A lot of such cultural and educational club buildings were erected in interwar Lviv. They were of various sizes, located in different parts of the city and featured rich palette of styles for facade decoration. Gradually, for the construction of club buildings the reinforced concrete frame was introduced, which created large spaces for halls and recreational facilities. Furthermore, screening films in their premises contributed to the rising popularity of such clubs and attracted a large number of visitors.

The development of Houses (Palaces) of Culture, dedicated to prominent personalities, workers of various professions, pioneers and others is closely connected with the Soviet Union coming to power. They were often located in old cultural and educational institutions and clubs. For example, the House of Culture for Communications Workers and the House of Railway Workers have merely translated the names on the notices from Polish into Russian. Sometimes it was only the name which was changed, but the functional purpose of the object remained unaltered. The House of Soldiers was completed in 1961 and its premises were occupied by the Palace of Culture named after Yuri Gagarin. The House of Officers occupied the space of the People's House. The House of Municipal City Workers changed its name to the House of Culture for Tramway Workers. It should be noted that its high-quality architecture was comfortable and convenient, which made it so justly popular among the citizens. During 1976-1980, the decision was made to build the stage and auxiliary spaces behind it, which changed the length of the facade. However, the decoration of these new fragments replicated the techniques used for the original interwar building, so that the object organically blended into the environment and preserved its authenticity. Therefore, it resulted in the change of status from the Tramway Workers Club to a City Palace of Culture.

During the Soviet era, Lviv was undergoing extensive urbanization, rapid expansion of its geographic extent, the mushrooming of enterprises and residential neighborhoods, which needed club premises. Thus, in 1982, the Palace of Culture and Technology of the LORTA plant (Lviv Association of Radio Engineering Equipment) was constructed in the residential district of southwest Sriblyasty under the similar project which was used in Uzbekistan. Given the colder and rainier climate of Lviv, the architects make some important improvements to deep loggias by moving the load-bearing wall and introducing a curtain wall, significantly developed the space with the help of a balcony grid, enhanced the layout of lobbies and halls. By replacing the six-meter beams with nine-meter beams, it was possible to increase the area of the facility, which, at the time of completion of construction, received an award for the best public building in the USSR. Monumental art, artistic ceramics and glass were used in the design (Fig. 4). (According to news briefing of the architect of the project adaptation – Julia Gurinovich).

In 1984, not far from the park "Pohulyanka", south-east of the center, a large Palace of Pioneers and Schoolchildren was built under the project of Z. Pidlisny, A. Vashchak, M. Smetana and an engineer V. Sprysa. It consisted of three interconnected functional parts: entertainment, club and sport facilities. The first was conceived as the basis of the general three-dimensional composition and included halls for different purposes: a 500-seat theater with a stage, a 126 seat-film lecture hall for, a 138 seat-puppet theater and an exhibition hall. The club part of the building connected the entertainment and sports parts and had a wide space on the ground floor, which provided visual and functional connections between the main square in front of the building and the park area with a pond behind it. The south-east wing featured a gym illuminated by the ceiling light. The project also provided for an indoor swimming pool, which has never been realized. The building was built of brick and precast concrete. Terazite plaster, natural stone, aluminum, works of applied and decorative arts were used in its decorations. The main accents of the facade are three-dimensional concrete frames around the window openings and a balcony-terrace on the first floor of the entertainment part, which at the same time plays the role of a canopy over the main entrance and a colonnade of concrete pillars in the passage under the club spaces [14] (Fig. 5).

(a) (b)

FIGURE 4. The Palace of Culture and Technology of the LORTA plant. Photos by Yuliia Bohdanova: (a) General view, (b) Fragment of the façade decoration.

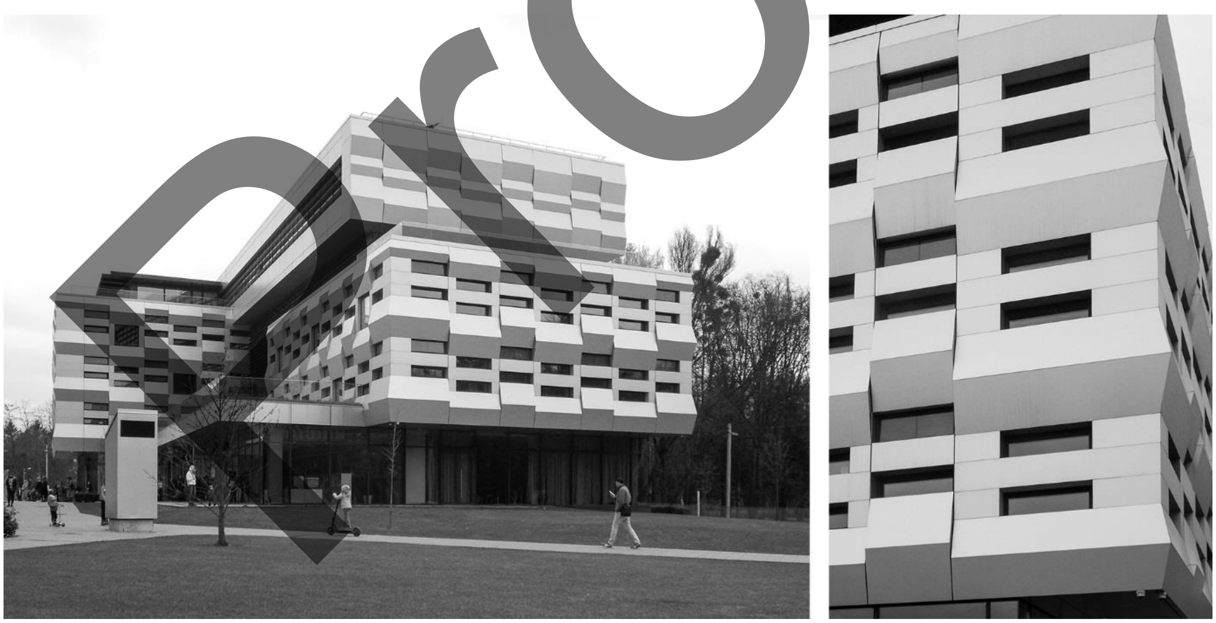
(a) (b)

FIGURE 5. The Palace of Pioneers and Schoolchildren. Photos by Yuliia Bohdanova: (a) General view, (b) Fragment of the façade decoration.

The first years of Ukraine's independence were characterized by a difficult economic situation, which drastically affected club facilities because state subsidy program has abruptly ended. Some clubs could not be revived, hence they have laid abandoned for years and finally collapsed. Nevertheless, the vast majority of them managed to survive by expanding their functions and pursuing flexible policies, although the consequences of such alterations were far from being positive. Leasing part of the premises has led to chaos, spontaneous redevelopment and cluttering of interior spaces. But having changed their names, most Lviv clubs still exist and are very popular with the citizens.

Society's demand for cultural institutions have fairly changed in the last decade. The typology of club establishments has expanded. A lot of people avoid attending big noisy events, they aim at communicating in small groups, discussing various issues, and learning together. As a result, there is a strong demand for modern small spaces for communication, acquisition of various knowledge and recreation. They are often housed in former apartments or shops and do not last long there. This temporality means that their interiors are equipped with partitions that are transformed to provide new functions. Thus, the first anti-cafe in Lviv, “CoMMuna”, was in close proximity to Rynok Square, the heart of the city. It was part of the cultural space for Lviv citizens where one could have a good downtime or work, drinking coffee and enjoying the evening city, because there were Internet cafes, anticafe, coworking space, business center, office, copy -center. It is worth noting that no food was served there because cultural and development activities were prioritised. However, in Lviv, drinking coffee is almost a cult and therefore the ubiquitous need never ceased to exist, so the idea was born to call this cultural space “anti-cafe”, because here in fact do not eat. The visitor does not pay for the services received, but only for the time spent in the premises.

Although the demand for large cultural and educational facilities, especially for schools, is still growing, the overall education construction market has seen modest growth performance over the next few years. In September 2017, the Metropolitan Andrei Sheptytsky Center (Fig. 6), which is hosted by the library at the Ukrainian Catholic University, was established. It boasts multiple classrooms, conference rooms, as well as cafe and shops. This is a modern education resources information center, which welcomes not only students of this educational institution, but anyone in Lviv. The project was originally developed by the German architectural firm Behnisch Architecten, and then adapted to local conditions by Chaplinskyy & Associates. The three-dimensional solution of the cultural center is designed in such a way that the object resembles a pile of books stacked on top of each other. This building was built in harmony with nature and their surroundings. After all, despite the novel materials and shapes of the background, it perfectly blends with the natural landscape of Stryiskyi Park. The facades of the Cultural Center show a lot of open concrete, thermal insulation, passive energy saving technologies. For example, large terraces, in addition to educational and recreational functions, are also thermal insulators that protect the building from heat and cold. There are also passive house shades on the facade of the building, which, at the same time, store light. The staff of the Ukrainian Catholic University state that the general idea of organizing the space here is to stimulate cooperation, because the building is completely transparent inside [15].



(a) (b)

FIGURE 6. The Metropolitan Andrei Sheptytsky Center. Photos by Yuliia Bohdanova: (a), General view, (b), Fragment of the façade decoration.

It should be noted that existing historic buildings are also undergoing adaptation. In the fall of 2018, the Center of Architecture, Urban Planning and Design “Tower” was opened in the powder tower, which is hosted by Lviv Regional

Organization of the National Union of Architects of Ukraine. It also hosts cultural events, exhibitions and projects related to architectural heritage.

In the premises of the tram depot, during the end of the 19th – the beginning of the 20th centuries, the project on the creative environment of the social hub for business communication "LEM station" is gradually being implemented. Interestingly, it got its named after the famous science fiction writer Stanislav Lem, who was born in Lviv. It is planned to create a complex with coworking spaces, startup boxes, halls for master classes and events, creative workshops, a center for children's development, a post office, an amphitheater, an eco-park, and a parking lot. First of all, there should be a place where Lviv residents can come, relax and spend a quality time, as well as get the opportunity to realize themselves. The main task is to transform the old tram depot into an innovative creative center, which will be a crossroads and the place for self-realization of artists, entrepreneurs, scientists and other representatives of the creative industries. LvivMozArt instrumental concerts, "Tlum and Kram" antiques fairs and other city cultural events are also regularly held here. Since 2018, there is a permanent exhibition of rare modes of transport "Retro-garage".

In early June 2015, the building of the Jam Factory in Pidzamche was purchased by the private foundation Harald Binder Cultural Enterprises to create a new cultural center there, unique to the city. There are plans to reorganize the area of the industrial facility into the Center for Contemporary Art - a non-profit cultural project with workshops, galleries, spaces, courtyard, cafes and technological premises. The main idea was the desire to experiment, to find first of all a typical model of regeneration of historical industrial objects, which would be suitable for Ukraine. Business and the arts must be combined here to serve the local community. To do this, the factory should host not only commercial events, but also non-commercial concerts, fairs, and a library. The jam factory, which will work in the new mode, should give impetus to the development of the entire territory of Pidzamche.

CONCLUSION

Current trends in society indicate that there is an urgent need for buildings and spaces for the cultural activities of many societies and organizations. It is therefore extremely surprising that existing historic sites which were designed and built for this purpose are often neglected, some parts of them are owned by some individuals which results in them losing their original function. This tendency becomes widespread matters of concern, as it destroys our historical memory by neglecting the landmarks of our culture.

Recently, due to the diversity of urban life, new forms of public communication are emerging, and so do new types of buildings in which such communication takes place. The social conditions of each socio-economic formation leave their mark on the type of building, give it a new social significance and structure. Therefore, in order to foresee the development of multifunctional cultural and educational facilities today, to determine their optimal functional structure and spatial solution of the auditorium venue, capable of hosting different events, it is necessary to know and to use the architectural experience of the past, when cultural and educational buildings and clubs were becoming the most popular, both in our area and around the world.

It is now common practice that the iconic historic sites, which have long lost their original function, are of general interest to potential investors. So as not to lose valuable cultural heritage sites of the city, a policy of integrating the monument into a new functional context is pursued. Among the most popular solutions are cultural and educational functions: media libraries, coworking, social hubs, art and cultural centers. Their main goal is to revive cultural communication and public life in the city. Thanks to modern materials and technologies, architects and designers have the opportunity to create flexible universal spaces that allow you to quickly respond to changing user demand and conduct a wide range of activities. Innovative approaches in the construction process allow to preserve iconic objects and introduce the architectural environment of the city into European and world contexts.

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Architectural Monuments in the Urban Structure as a Factor in the Humanization of a City: the Case of Jordan

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Abstract. Today, the humanization of the city is one of the most important tasks of the theory and practice of modern urban planning. We interpret the concept of "humanization" as a set of certain actions and tools aimed at creating an environment comfortable for a person to stay in it. One of the most important factors shaping the comfort of the environment are the factors of physical and visual accessibility for both city residents and tourists. The territory occupied today by the Hashemite Kingdom of Jordan has been on the verge of a clash of great civilizations of the past for thousands of years, and almost all participants in the long historical process have left their mark here. Today, Jordan's architectural heritage sites are either integrated into the structure of modern cities or are closely intertwined. Therefore, it is important to understand the meaning of architectural heritage sites integrated into the structure of our cities in addressing the humanization of the city. The theoretical approach is based on the concept of Universal Design and the criteria of the analysis of architectural heritage sites formulated by the authors. The methodological basis of the article was a full-scale survey of the architectural heritage sites of Amman and Madaba for physical and visual accessibility for people of different ages, social and national groups. The authors also analyzed how historical heritage sites affect the humanization of Jordanian cities in terms of a barrier -free built environment. It is established that architectural monuments are an important factor that stimulates the process of humanization of the city. The need to ensure free physical and visual access to the monument necessitates the adoption of measures by the city authorities, which at the same time improve the environment of the city outside the architectural monuments. These measures increase the level of humanization of the city as a whole and promote equal rights and opportunities for people with different physical needs, different age and social groups.

INTRODUCTION

The first attempts to theoretically comprehend the concept of humanization of the city belonged to European architects of the 1960s. Kevin Lynch in the epoch-making work "The Image of the City" (1960) introduced the concept of the connection between man and the urban environment and formed indicators of city quality that took into account human character and type of culture [1]. Theorists and urban planners have declared a departure from the modernist attitudes of urban development proclaimed by Le Corbusier, and recognized the value of the historic city. That is, from the very beginning, the introduction of the concept of "humanization of the city" was closely connected with the historical heritage. Such scientific works were the researches of Aldo Rossi [2], Manfredo Tafuri [3], Leona Krie [4].

A turning point in American urban theory was Jane Jacobs's "The Death and Life of Great American Cities" (1961). In the work the author opposed the modernist paradigm of city formation, as she believed that modernist approaches simplify the complexity of human life and advocated a large-scale and multifunctional urban environment [5].

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Since the 1970s, conferences on the humanization of cities have been held periodically under the auspices of UNESCO. The first United Nations Conference on Human Settlements, Habitat I, was held in Vancouver, Canada, in 1976 [6]. The conference acknowledged that "governments have begun to recognize the need for sustainable human settlements and the consequences of rapid urbanization, especially in the developing world". The next United Nations Conference on Human Settlements, Habitat II, was held in Istanbul in 1996. One of its most important theses was: "Although no two cities are the same, there are some shared requirements for their development in the twenty-first century, the most important being the need to give cities a human face" [7].

Today, UNESCO strongly advocates the humanization of cities, working to implement the 2030 Agenda for Sustainable Development and the New Urban Agenda. This topic was dedicated to the Third United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in October 2016 [8]. Irina Bokova, Director-General of UNESCO, said: "From the ancient cities of Mesopotamia, to the city-states of the Italian Renaissance and the vibrant metropolises of today, urban areas have been among the most powerful engines of human development… Creativity and cultural diversity have been the key drivers of urban success... Culture embodies the soul of a city, allowing it to progress and build a future of dignity for all". This recognizes the crucial role of the cultural environment, including architectural heritage, in the process of humanization of cities: "This vision has received new energy with the explicit recognition of the role of culture as an enabler of sustainable development, and as one of the key conditions to achieve Sustainable Development Goal 11 to "Make cities and human settlements inclusive, safe, resilient and sustainable" [9, p 5].

According to UNESCO, up to 3.9 billion people live in cities, half of the world's population. The number of urban population is expected to reach 5 billion by 2030 [10]. This creates serious challenges for professionals in various fields responsible for urban development. In "The Strategic Plan 2020-2023" Article 131 states that "Research indicates that persons with disabilities account for approximately 15 per cent of the world's population". At the same time, Article 132 states that "The New Urban Agenda recognizes the multiple forms of discrimination faced by persons with disabilities and emphasizes their rights… Sustainable Development Goal 11 emphasizes the importance of disabled persons in two specific targets: transport and access to public space. In the Strategic Plan, the social inclusion dimension places great importance on persons with disabilities [1, p 52-54].

Thus, the humanization of the city today appears as one of the most important tasks of the theory and practice of modern urban planning. Under the concept of "humanization" in this article, we interpret as a set of certain actions and tools aimed at creating an environment comfortable for a person to be in it. One of the most important factors that shape the comfort of the environment are the factors of physical and visual accessibility for both city residents and tourists [12].

In view of the above, the aim of the article is to show how architectural monuments, which are an integral part of the urban environment and important public places, are adapted for disable people. The authors also analyze how the physical and visual accessibility of these facilities helps to address the issue of humanization of cities in general. This question is studied on the example of Jordan.

METHODICAL AND THEORETICAL APPROACH

The territory occupied today by the Hashemite Kingdom of Jordan has been on the verge of a clash of great civilizations of the past for thousands of years, and almost all participants in the long historical process have left their mark here. Jordan has an exceptionally rich architectural heritage. 5 monuments are enlisted in the UNESCO World Heritage List, and 14 are on the Tentative List [13].

Objects of historical heritage were selected for analysis, which are currently: significant tourist attraction in Jordan and are visited by a large number of both domestic and foreign tourists; integrated into the urban structure of modern cities and directly affect the formation of the urban environment. These are the sites of architectural heritage in Amman (the Roman Nymphaeum, the Roman Theater, Aman Citadel) and in Madaba.

There are different approaches to analyze and solve the problem of humanization of a city: using traditional methods of spatial organization (like in Japan [14]), adaptation of "re-humazation" concept (like in Saudi Arabia [15]), but we have decided to use theoretical approach based on the concept of Universal Design (UD), which was formulated in the works of the American the architect and designer Ronald L. Mace [16]. By definition, R. Imre and P. Hall: "…universal design is a social movement primarily concerned with making products, environments and communication system usable to the greatest extent possible by the broadest spectrum of users" [17, p 14]. Among the 7 principles of UD, which were developed in 1997, the most important in the context our article are the principle 1 "Equitable use" (The design is useful and marketable to people with diverse ability), the principle 3 "Simple and

Intuitive Use" (Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level), the principle 4 "Perceptible Information" (The design communication necessary information effectively to the user, regardless of ambient condition the user's sensory abilities), the principle 7 "Size and Space for Approach and Use" (Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility) [18].

Based on the fundamental principles of UD, as well as documents and research on the accessibility of architectural heritage sites that have been developed in New Zealand [19], India [20], Turkey [21], Spain [22] the authors have developed a system of criteria for the analysis of selected architectural heritage sites in Jordan in terms of their compliance with the principles of UD: ease of finding an object in the city and ease of access to it; simple and intuitive way finding and orientation; pre-visit information available in accessible formats; horizontal and vertical accessibility; well designed and legible signage; interpretive information available in a variety of formats

We have also added a new criterion: significance of the selected architectural heritage site for surrounding areas or a city in general. The methodological basis of the article was a full-scale survey and analysis from the standpoint of Universal Design of the above objects for physical and visual accessibility for people of different ages and social groups, as well as analysis of publications on this topic. The authors also analyzed how historical heritage sites affect the humanization of the city as a whole in terms of the concept of a barrier-free built environment.

Jordan has demonstrated a interest in facilitating the social inclusion of persons with disabilities. Its political will has translated into the ratification the United Nations Convention on the Rights of Persons with Disabilities (CRPD) in 2008 becoming the eighteenth country in the world to commit to it without reservations [23]. According to Article 9 Convention, accessibility means: "To enable persons with disabilities to live independently and participate fully in all aspects of life, States Parties shall take appropriate measures to ensure to persons with disabilities access, on an equal basis with others" [24, p 4]. In 2007 the National Disability Strategy aimed at accommodating the rights and needs of persons with disabilities was introduces [23]. Now Jordan is considered to have "high human development" and ranked at 102th out of 189 countries on the Human Development Index [25].

According to modern researches up to 15 percent of the population of Jordan suffers from a disability, amounting to over 1,100,000 people. The country has already taken steps to adapt cities to the needs of people with disabilities. Research shows that only about 25% of public facilities in the capital city Amman are adapted for them [26]. But, what about selected architectural heritage sites?

ANALYSIS OF ARCHITECTURAL HERITAGE SITES

Amman is the capital of the Hashemite Kingdom of Jordan. From ancient times, the settlement was known as Rabbat-Ammon. Ptolemy II (4th centure BC) renamed Ammon to Philadelphia and under that name the city entered the Hellenistic period of Decapolis (Decapolis). Amman-Philadelphia transformed to the Roman city there temples and terms were built, Nymphaeum, a huge open space theatre. During the Gassanides era (7th century CE), Philadelphia was renamed to Amman. Since ancient times, we have several objects that have now become important tourist attractions of the capital of Jordan. The Amman Downtown is located at the centre of the city and well marked as cultural centre attracting both tourists and local population because of its cultural and historical significance [27].

Nymphaeum Archaeological Park (The Roman Nymphaeum) is the biggest architectural monument of its kind in the region and it was one of the main structures in the ancient city of Philadelphia. The Nymphaeum was the splendid fountain of Philadelphia and it was created towards the end of the 2nd century AD. The Nymphaeum was located near to the point where two colonnaded streets the Cardo and the Decumanu intersected. Now it is situated at Amman Downtown [28].

Restoration and rehabilitation project of the Roman Nymphaeum in Amman was implemented during 2014-2018 [29].The need for conservation works was due not only to the poor condition of the monument, but also to the bed condition of the surrounding area, 70% of whose inhabitants were dissatisfied with the quality of life there. That is why, one of the purpose of the restoration project was: "to rehabilitate the Nymphaeum and its surrounding area to prepare it for feasible tourism utilization that will benefit the community" [28].

Today we can interpret Nymphaeum Archaeological Park as one of the most comfortable historical site in Amman. The field study shows that it is not very easy to find an object in the city, because of complicated urban structure of Down Town, but the access to the site is convenient. Pre-visit information is available. Due to the small size of the site, the orientation is simple. The surface is solid and comfortable to move in a wheelchair. The wooden bridge is equipped with a ramp. The project provided the bilingual information boards with the text and figures from the project explaining different stages of project implementation and final results (Fig. 1). The area is perfectly illuminated in the dark time [29]. The implementation of this project improved and humanized the environment of the central part of Amman.

FIGURE 1. Nymphaeum Archaeological Park in Amman. The wooden bridge after being repaired and extended. It is equipped with a ramp. The project provided the information boards with the text and figures. *Photo by M. Al Haddad, 2021*

The Great Antique Theatre (the Roman Theatre, Amman Great Theatre) is another very important monument of this historic period. It is located at the bottom of the Fortress Mountain. This perfectly preserved amphitheatre is a symbol of Amman, and it had room to accommodate 6000 people. The theatre was built in the period 138-161 CE. The government of Jordan started restoring the theatre in 1957. Because of the practice of restoration at that time, none of the original material was used, but the final product was certainly impressive. Nowadays the Jordan Folklore Museum and the Jordanian Museum of Popular Traditions are housed in the western and eastern sections of the theatre. Besides it, The Great Antique Theatre reused for performances. As N. A. Haddad noted: "Conservation and restoration of theatres and odea can encourage many activities. These activities can infuse them with their full role as places of cultural and artistic creation, shared enjoyment, and emotional needs…" [30].

The Great Antique Theatre is situated at the Down Town of Amman next to Al-Nashemi str., so it is very easy to find and access it. Pre-visit information is available. Because this is the only object, the orientation is very easy here, it is facilitated by the relevant information signs. Disable people can easily get to the museums, as the entrances are equipped with ramps (Fig. 2), but it is impossible to get to the upper tiers of the theatre, to see it completely (Fig. 3).

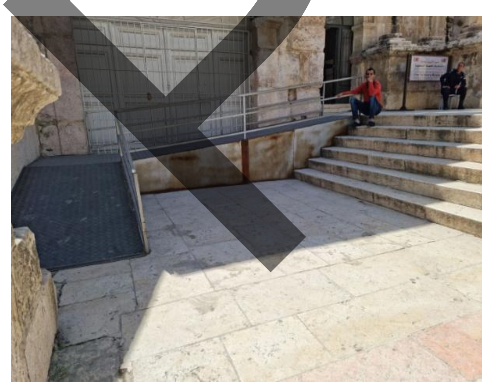

FIGURE 2. Entrance to the Jordan Folklore Museum equipment with the ramp
Photo by M. Al Haddad, 2021

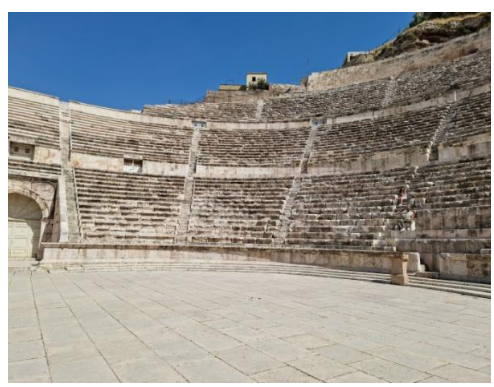

FIGURE 3. View of the spectator seats from the middle of the theatre, it is impossible to get to the upper tiers of the theatre for disable people
Photo by M. Al Haddad, 2021

The Citadel National Historic Site (Amman Citadel) is one of the oldest Amman's known sites. It is located on the top of one of the city's high hills at the Downtown of Amman. The Citadel is considered a very important historical site because of its long history of occupation by many ancient civilization. Most of the buildings are from the Roman, Byzantine, and Umayyad periods. The Citadel National Historic Site includes the ruins of fortress walls, the remains of the Roman Temple of Hercules, the Umayyad water cistern, Ayyubid watchtower, the Byzantine basilica and the Palace of Al Qasr. The first excavations were conducted at the Citadel between 1930 and 1938 by Italian archaeologists. Further work was carried out in the 1960s and 1970s by the Department of Antiquities of Jordan (DoA) and American Centre of Oriental Research (ACOR), as well as the British Archaeological Institute. The purpose of the study was to design a master plan for the beautification of the Amman Citadel and the development of an archaeological park. In 1991, excavations at the Citadel were resumed under the direction of ACOR and the DoA [31, p 40]. The Jordan Archaeological Museum is located on the territory of the complex, it was opened in 1951.

As the complex is located in the centre of Amman, so it is not difficult to find a way to it, especially by car. There are signposts to the citadel along the road. The approach to the entrance to Amman Citadel is made as a ramp, so it is accessible to people in wheelchairs (Fig. 4). Also the handicapped parking is provided. Pre-visit information is available in the modern visitor centre. It is easy to find ways, as there are signs and information on the territory. The surface is solid and accessible for movement on a wheelchair. There are information boards in two languages near each object (Fig. 5). As the founding site of Amman, the Citadel is a site of particular importance for the formation of the cultural identity of Jordan's capital. It is a symbol of Amman's multicultural heritage.

Researchers noted that: "Identity is narrative constructed in an ongoing dialogue with culture, heritage and history. They are related to each other… A number of objects that are preserved as heritage, date from specific epochs are also defines the contemporary character of the town identity… Heritage is a stock that inspired generations and also proposes ideas for future solutions. So heritage is almost portrait and formulate identities" [32]. According to N. Ujang "to secure identity is to ensure continuity in the physical, social together with meanings and attachment held by the people" [33]. This idea emphasizes the crucial significance of preserving place identity, because "the physical features and appearance play an important role in influencing the sense of place" [34]. They help make places more user-friendly, people can easily identify and navigate there. This idea is closely connected with the conception of the humanization of the city. That is why the idea "To re-connect the Monument with its original Roman urban context to complement the Roman Theatre, Odeon, and Amman Citadel that will regenerate the image of ancient Philadelphia" [28] is very relevant and timely for the preservation of Amman's identity and the humanization of the city's environment.

FIGURE 4. The approach to the entrance to Amman Citadel is made as a ramp, so it is accessible to people in wheelchairs
Photo by M. Al Haddad, 2021

FIGURE 5. The information board which is placed inside the Palace of Al Qasr
Photo by M. Al Haddad, 2021

The town of **Madaba** is located 33 kilometres south of the capital Amman. Madaba has a long history, dating back to as early as a settlement of the Bronze and Iron Ages. Its notable sites include the famous sixth-century Map of Madaba, a mosaic uncovered in the Church of St. George, an archaeological park and the Madaba Museum [35].

Madaba Atchelodgical Park (MAP) was established in 1992, after excavations and research undertaken in the 1970s and 1980s by the Studium Biblicum Francescanum at Mount Nebo. The work was completed by the same institution and ACOR, in co-operation with the DoA and with funds provided by the Italian government and US Agency for International Development (USAID). Madaba Archaeological Park includes several structures from the Roman and Byzantine periods, palatial buildings and churches, which are primarily located along the Roman road.

The World Bank supported Jordan with the Cultural Heritage, Tourism, and Urban Development Project (CHTUD) to promote tourism development in five cities (including Madaba). The project mainly focused on supplying the infrastructure needed to sustainably develop the sector. The project was approved in 2007 and closed in 2014. The aim of the project was to preserve the valuable archaeological heritage, revitalize the central part of Madaba by expanding its tourism potential for economic benefits and employment of the local community. The key objectives of the project for Madaba were to revitalize the historic core and improve the overall quality of the urban environment.

Today, Madaba boasts an excellent tourist infrastructure. Thanks to the project, many of the most important mosaics and archaeological discoveries were restored and protected by shelters (the Church of the Virgin, Hippolytus Hall, the Burnt Palace and Church of the Prophet Elias). Street infrastructure near the Greak Orthodox Church of St. George (the Church of Map), a primary attraction in the city, was successfully achieved and dramatically improved the aesthetics of the area. Orientation in the city is not difficult due to the created tourist path. It is possible to get a brochure in the Madaba Visitor's Centre which is situated in the heart of the city and close to the major mosaics. Information about the tourist path and the main attractions of the city are contained in this mentioned brochure. Objects are close to each other, well marked, so it is not difficult to find them. Pre-visit information is available near each object. Information about the site, its history and restoration activities are available in sufficient quantities at every archaeological site (Fig. 6). However, problems with vertical communications should be noted. If there are ramps at the entrance to some objects, like to the Greak Orthodox Church of St. George (Fig. 7), but beautiful mosaics of the Hippolytus Hall and the Church of Apostles remain inaccessible for disabled people due the lack of ramp near the entrances and in exhibition areas (Fig. 8).

FIGURE 6. The shelter and the information board in the Church of Holy Martyrs
Photo by S. Linda, 2019

FIGURE 7. Entrance to the Greak Orthodox Church of St. George equipment with the ramp
Photo by S. Linda, 2019

FIGURE 8. Beautiful mosaics of the Hippolytus Hall remain inaccessible for disable people
Photo by S. Linda, 2019

Sidewalks and streets in and around the city core and the tourist path were upgraded. Dar Al-Saraya was successfully rehabilitated and was listed in tourist brochures. Functional upgrading of the old bus station (Madaba City portal) was completed by the government with its own financing. So, the city revitalization helped to improve liveability in the historic core, fostering preservation of heritage assets and creating the necessary conditions to enable local economic development [35, p 58]. Accordingly, the implementation of projects to improve the environment of architectural monuments has become a powerful incentive for the humanization of the city as a whole.

The city of Madaba is a unique example of the incorporation of monuments of great cultural, religious, historical and political importance into a modern urban context. Improving the environment of architectural monuments and archaeological sites also means simultaneously improving the environment of the city for both tourists and locals.

RESULTS AND DISCUSSION

Our research shows that the architectural monuments located in the structure of Amman and Madaba are easy to find due to the good development of visual communication systems in cities. Most facilities have good access, although not all are equipped for disabled people (no ramps or special lifts). All objects are equipped with information systems about the object in accessible formats (availability of information in two languages, appropriate graphic design), exhibition spaces are equipped with information boards with detailed and accessible information about the history of the object, its significance, as well as the history of restoration.

However, not all facilities have sufficient equipment for disabled people to access them. If it is not a serious problem for open air architectural objects (Amman Great Theatre, Amman Citadel), then in relatively small enclosed spaces (churches of Madaba: the Church of Holy Martyrs, the Burnt Palace and Church of the Prophet Elias) the expositions are very difficult to see for people in wheelchairs. In fact, we realize that adapting these facilities to the needs of disabled people is a very complicated architectural and technical task, given into account the uniqueness of the facilities and the limited space. However, despite some shortcomings, we have seen that a lot has been done in recent years to improve the condition of architectural monuments and the spaces around them. This is, of course, an important factor in creating a positive image of the country in the world.

Amman and Madaba present different models of the incorporating of architectural monuments and archaeological sites into a modern urban context. Although in Amman these attractions form tourist places, in Madaba they are closely intertwined with the ancient urban fabric. This creates different scenarios for the impact of the monument on the urban structure of the city: the formation of a network of architectural monuments interconnected by a system of visual communication (Amman) and the "merger" of historical architectural objects with urban fabric (Madaba).

In both cases, improving the environment of monuments and adapting them to the needs of domestic and foreign tourism contributes to the overall improvement of the city environment. The city becomes clearer and more comfortable both for residents and tourists, which is an important sign of the humanization of the city environment. But: "Moreover, Madaba was elected as an international prototype for implementing tourism development projects in Jordan through investing the archaeological sites setting within the city fabric" [36].

CONCLUSION

Thus, architectural monuments are important factors that ensure the process of shaping the identity of the place, which is why their preservation and appropriate presentation is an important prerequisite for creating a recognizable and friendly environment of the city. Also, we have seen that architectural monuments are an important factor that stimulates the process of humanization of the city. The need to improve the environment of the architectural monuments contributes to the adoption of measures that simultaneously improve the environment outside the city: the creation of ramps, parking spaces for the disabled and other opportunities for free physical access to the monuments, saturating the city environment with information in different languages. These measures increase the level of humanization of the city as a whole and promote equal rights and opportunities for people with different needs.

Analysis of the environment of architectural monuments and archaeological sites in Jordan in terms of their physical and visual accessibility shows that Jordan has achieved great success compared to the short term. This shows that the protection of architectural monuments is an important part of public policy and it is regulated by a number of laws. The most important large-scale projects were implemented with the support of international institutions and financial organizations. This testifies to the recognition by the international community of the value of Jordan architectural heritage.

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Theatricalization in the Formation of Sacred Space

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Abstract. This article presents the matter of human need for theatricalization of architectural environment, in particular the sacred space. The analysis of common and distinctive features between theater and architecture, between theatrical space and architectural space, between play in theater and play in architectural space has been made. The article analyzes the use of traditional historical and modernist forms in the formation and dramatization of sacred space. The main examples of world architecture in which in one way or another theatrical techniques are used are presented. Some examples of sacred architecture of the modern era with the use of theatrical techniques are represented. The phenomenon of perception in certain visible figures of objects is an expression of a more general situation, an expression of a certain type of views or collective beliefs. Theatricalizations of traditional forms in modernist architecture are considered, which at the same time are not a complete rejection of modernist preferences, but also an attempt to reinterpret the geometry of traditional historical forms. The combination of the national landscape, local specifics of the author's vision and European established traditional forms of sacred space is presented. The contradictions in the perception of the traditional sacred space and the reading of the symbolism of its content, which is transmitted through the elements of dramatization, are considered. An attempt is also made to adapt the principles of modernism to the needs of the formation of a sacred space, in which, after the suspension of historical knowledge, the essence of the phenomenon under study is sought. Religion, art, science, language are presented as forms of human thinking about reality with forms of epistemologically understandable symbol. The need to take into account the relationship between certain forms and messages that are transmitted through them in the formation and dramatization of sacred space. Symbols pointing out not certain sacred reality, but certain intellectual tendencies, social situations or expressions of culture are singled out.

INTRODUCTION

"Theatricalization" - a term in the field of theater studies, which is the process of creating a holistic artistic image by the means of a makeup, clothing, wigs, accessories, lighting, music and noise design, etc. Theatrical action from ancient times to the end of the twentieth century was an exceptional, rare, one-time, and therefore exclusive phenomenon. In today's world, theatrical performance is not uncommon, there are many theaters and studios of various kinds, especially in large cities, but theatricality is acquiring the qualities of the human environment - it is becoming more and more festive, and it affects its perception and feeling, and therefore shapes it. behavior in the space of the city or a separate building. That is why the question of the theatricality of the human environment, and hence the architectural environment today is very important for research [3].

Back in the 1970s, under the influence of contemporary trends in architecture, focused on the environmental approach in the study of architectural and urban planning issues, the concept of theatricalization of the architectural environment appeared. This meant bringing the atmosphere of the play into the emotional-artistic and material-physical structure of the environment, the ambiguity of the interpretation of circumstances and patterns of behavior, image-compositional orientation into it conditionally "spectacular" perception [5]. In this context, first of all, the influence of folk and street theatrical performances on the urban environment in terms of their direction was researched.

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Among the few works of architects who have studied theatricalization of the architectural environment are the works of Alexander Rappaport, who explored the architectural environment of the Baroque and Classicism and identified the role of spectator and actor in the urban architectural space, concluded that architecture is a decoration of life and dictates human behavior. Moreover, the authors of many urban ensembles of the time researched here, such as Borromini and Bernini, use the stage perspective in the construction of real buildings or the calculation of Baroque compositions areas oriented on a privileged point of view from which the central perspective of stage decoration is built [13].

Thus, at all times the architectural environment, especially urban, had the features of theatricality, because it caused the appropriate impressions and feelings of the audience-actors: solemnity (office buildings), solemnity and sadness (memorial complexes), comfort and tranquility (ancient spiritual centers and monasteries), etc. These impressions programmed by the architect were formed, including through the application of the laws of perspective and techniques of optical illusions, which, in turn, can be seen as a manifestation of drama in architecture.

This dramaturgy and theatrical script of the architectural environment has long been characteristic not only of the architectural environment of the city, but also of the inner sacred space of the temple, where for an illiterate person revealed the whole history of biblical events and subconsciously evoke reverence for the temple ritual.

The architectural space designed for ceremonies and rituals is inherently theatrical, because it always corresponds to the church action-service functionally and symbolically. If the functionality of the space is solved in the design process, then the symbolism can be given to him both at the design stage and, with the help, of certain elements during usage. These elements can be compared to props - theatrical objects that help to reveal the idea of the play [2]. In the church it is also the vestments of the priest, the iconostasis, wall paintings, sculptural compositions, etc. along with the special light, the sound of the choir and the temple action itself. This way of synthesis, based on the visual changes of architectural objects and spaces with the help by the theatrical means: especially by performance, and the use of scenery, costumes, props, lighting, which contributes to the spectacle, visual appeal.

And yet, a special place in the process of dramatization of sacred space belongs to optical illusions, when the eyes see the image of one object, but the brain transforms it in its own way. Despite the fact that architectural techniques using the optical properties of visual perception have long been used by the artist to enhance the aesthetic perception of art works or architectural structures, since ancient Egypt, Greece and Rome, their use in the sacred space have not yet been fully explored, as well as unexplored methods of dramatization of modern sacred space, which is the purpose of this work.

The relevance of **the research topic** is due to the lack of scientific works on the use of theatrical performance in the sacred architecture.

This issue is closely related to the possibility of modernization of sacred architectural and construction traditions with its general theatricality, entertainment and everyday festivities.

Novelty. For the first time the sacred space is analyzed from the point of view of its theatricalization.

TEMPLE PERFORMANCE

As mentioned above, in the generally accepted definition of theatrical critics, "theatricalization" is a mean of creating a holistic artistic image that meets the objectives of architecture as a form of fine art. Many different components are involved in creating the image of the architectural object and the environment: urban location (significance of the location), shape, volume, color, details, (plastic facades, entrance, completion of the house), the texture of the surfaces, an area in front of a building, a monument, landscape, etc. It is obligatory to use works of monumental paintings, sculptures, solemn lighting in the dark, etc. in significant architectural objects. Thus, common to both theater and architecture, including sacred, is the combination of individual parts into a single wholeness, the synthesis of arts to create an appropriate image [16].

Theater is a living human experience and in the human mind, it, like painting and music, belongs to the sphere of the sacrum. However, already in the days of classic antic times began the stratification of the sacrum into purely sacred, sacrificial, clairvoyance or mysterious functions and theatrical art. This is a penetration of theatrical forms into the Christianity, which occurred in the VI century in Byzantium, when Hellenic culture, persecuted by Christian emperors, was under the threat of a complete decline. At the same time, certain aspects of this culture, including theatrical, were observed of the Christianity. So, for example, an iconostasis with central and side entrances, which, perhaps, resembles the ancient theater stage. It is obvious that these three entrances in Byzantium were originally the entrances to the temple, not to the altar. Nevertheless, from the middle of the 6th century, when the Hellenistic culture completely declined, these entrances were moved to the central nave and included in the altar partition, and a later iconostasis appeared. Thus, the templon becomes very similar to the stage of the ancient theater with its three entrances [9].

Any church service is a synthesis of the arts, as Paul Florenskyj wrote in the early twentieth century [17]. Temple performance is a synthesis of arts not only in the ancient traditional sacred space, but also in the modern one. And theatricalization play a significant role here, because it creates certain impressions even at the level of the architectural spatial form, enhance it with color and light [6].

From the early Christian period, the space of Christian temples was decorated with icons and wall paintings. In the art of Byzantium, a coherent system of painting was developed, which is of paramount importance for the ecclesiastical art of the Orthodox Church to this day.

One of the most important sources of changes in the shape of church buildings in the 20th century was the discussion of ecclesiologically correct forms of Liturgy. In an opinion attributed to Cornelius Gurlitt, was even claims that "the Liturgy governs the construction of the church" [8].

Sacred architecture of the 20th century was characterized by an unprecedented variety of artistic formulas. The reason for this was the emergence of new theological ideas and artistic concepts at the turn of the 20th century that contradicted traditional approaches. One of the important ideological phenomena that violated the foundations of church construction was the deferent theologian’s ideas about the positive meaning of desacralization. These ideas were denying the separation of existence into divine and secular parts. In architecture it led to the emergence of two mutually exclusive traditions: the preservation of the extraordinary shape of certain churches and trivializing others [7].

There were more such contradictory concepts that violated the uniformity of sacred objects of previous epochs. They concerned, among other things, the attitude towards beauty and symbols, changes in the liturgy and a possibility of using architectural modernism to create places of worship. Some architects supported the canonical values of ancient sacred architecture, while an increasing number of other artists tried to use radically new forms. Over the years, the logic and consistency in both groups of artists began to weaken, and the contradiction between "traditionalists" and "modernists" became more blurred.

The history of changes in sacred architecture included next period:

- contradiction between modernists and traditionalists values;
- the temporary domination of modernism;
- the postmodern counter-revolution;
- the current assertion of irrational values.

Different periods displayed cult transcendence, which is transmitted through a certain theatricalization of sacred space.

Describing this "cult mysterious ceremony", "falling out of the normal life of everyday life," as a result of which the "true presence of God among people" is manifested, we can talk about the spiritual reality.

This prompts the question of how this invisible reality manifests itself in the visible world, and especially how it influences the shape of the church buildings.

In the course of complex processes their objective nature is revealed, which means that certain features - also spatial forms of church buildings aren’t arbitrary, but exposed, uncovered. As in liturgical gestures, in church buildings reflected symbol of God's covenant with human.

Le Corbusier, who designed the Ronchamp Chapel (Fig. 1), is a good setting for the liturgy, the lay out of the environment allows it to be celebrated outside (thanks to the equipped external altar and pulpit), creates an atmosphere for individual prayer. Moreover, it is a theatrical space that attracts tourists, who thus way fall into the of realm religion and evangelization through art.

However, some reservations exist about this wonderful work. First, the building is far from the official traditions of the Roman Catholic Church. As a result of deviating from the basic traditional features of the temple, the building can serve virtually any religion, especially some universal meditative religiosity.

Secondly, the chapel is divided into a certain layout, traditional for Christian churches, which includes, among other things: a clearly marked and decorated entrance, a separate presbytery, ornaments that develop the usual art themes. Admittedly, it was decorated with a Marian figure and stained glass, but its interior doesn’t fit traditional iconographic programs [15].

The white chapel resembles a Greek temple in a deserted landscape, dedicated to long-forgotten gods and designed only to admire chapels beauty (Fig. 2). It seems that the building of Le Corbusier is an exquisite work of a genius architect, and it worships to the glory of God, through theatricalization.

Chapel in Ronchamp – absolutely free architecture. The only program is the organization of the mass. An indispensable element of this architectural solution is a landscape that opens up to four horizons (Fig. 2). And it is he who influences architecture. A true miracle of "visual acoustics". "Visual acoustics, expressed in forms. "Forms seem to radiate sounds or silence; some talk, others listen [4].

An amazing unity in the assessment of this building as an outstanding architectural work of our time. Ronchamp is a place of pilgrimage. People come here from all directions: by car, by train, by plane, on foot.

The plastic completeness of the forms of the church is brought to the level of sculpture. Of paramount importance for the composition is the variously used lighting, the nuances of light and shade in the interior with its combination of openings of different sizes with deep embrasures and various slopes, with a narrow gap at the point where the roof joins the wall. The system of openings and reflective planes gives a strong flux of light in each of the three half-domes, which rise above the roof and serve as a kind of "light-collecting" devices (Fig. 3). The architecture of the church, speaking "the language of pure forms in precise relationships", reveals Le Corbusier's special property of fusion of the plastic arts, their interpenetration and mutual enrichment [1].

The plan (Fig. 4), of the church already contains its plastic and spatial characteristics: curled chapels like shells, combined with the space of the church itself, and the outer altar zone extending beyond the building, which merges with the surrounding space. The building unfolds into nature smoothly, with that softness that gives it the naturalness of a living organism. The premises of the church are expanding towards the East. This movement is picked up and strengthened by the plasticity of the southern wall curvilinear in plan, which at its beginning, in the western part, has a considerable thickness and gradually narrows, as if coming to naught thanks to the cutting edge that completes it. The wall extends beyond the boundaries of the eastern facade and deviates to the side, pushing the boundaries of the church so that the entire gentle slope of the hill in front of the eastern wall with an altar under an overhanging roof (a place of gathering of pilgrims) is included in the architecture of the building.

The spatial relationship between a building and its environment is fundamentally different from the passive fusion of the building with the landscape, when the forms of the building seem to continue the terrain and grow out of it, and from the sharp opposition of the architectural structure to its environment. Hence the applicability of the concept of large architecture to a modest-sized building, in which the poverty of material resources becomes the basis of the richness of the composition [12].

Professionally analyzing components of the Ronchamp's chapel: the structure, plan (Fig. 4), section, general view, the important fact that the building is not a residential building, not a parliament, not an exhibition pavilion, but a church - it is a repository of the spirit not flesh.

The construction of the Ronchamp's chapel has amazing plastic delights. But, perhaps, the most interesting thing in this object is the presence of an external altar. Such a simple thing, but it is difficult to remember an analogue. There are front frescoes in Slavic churches. There are temporary structures for mass prayers when the porch becomes an altar. But the presence in the church of a specially created external altar, pulpit and lectern is news. The outer altar is quite simple, but under certain lighting it surprisingly takes the form of a fragment of Le Corbusier's paintings, with clearly defined figures of roughly crumpled shapes.

The sun came out and shadows created a three-dimensional painting. Such mystical transitions from architecture to sculpture and painting can neither be described nor fully comprehended. They work especially strongly from the eastern corner of the altar niche, where the curved wall slits into a small door leading inside. A few steps to the side, and the picture changes dramatically. The entire volume begins to work powerfully from the southeast corner. The shape is simplified: only white walls and two dark roofs are visible. It is here that associations arise with a dolmen, a hat, a mushroom, the bottom of a ship, etc. This corner point is the most memorable image of the chapel [14].

South side - change of scenery. A breakwater splitting the roof in half separates the picturesque picture of the eastern wall from the plane of the southern facade. The southern facade "works" with contrasts. High light tower to the left of the entrance; a dark heavy roof and a stunning white wall covered with a network of small windows. When the constructivists, came to Italy they were shocked by the role of detail in the architecture of the Renaissance. It was the detail that reconciled them with the Stalinist classics.

There are no drippers, no scoots, no edging on the southern facade of the chapel. Apparently, Le Corbusier understood this and therefore, he created "Modulor". On the south façade, the windows rhythmized by the modulator create an amazing feeling of its smallest detail. Between the wall and the bell tower, in a niche is the main entrance to the chapel. On the doors (gates) there is a single colored facade detail. This is an abstract painting (blue-red geometry) by the Master, symbolizing, perhaps, the divine origin of the Modulor system [10].

North side "national team" consist of four different parts. On the left is an open altar, over which a "piece" of dark roof hangs. Further, there is a wall with modular windows (close to the south facade). This part of the facade is crossed by a strange iron staircase, reminiscent of an emergency exit from a movie booth.

Figure 1. Hill of Notre-Dame Ronchamp Chapel. France. 1950-1955 [18].

Figure 2. Landscape surrounding of the Ronchamp chapel. France, 1950-1955 [19].

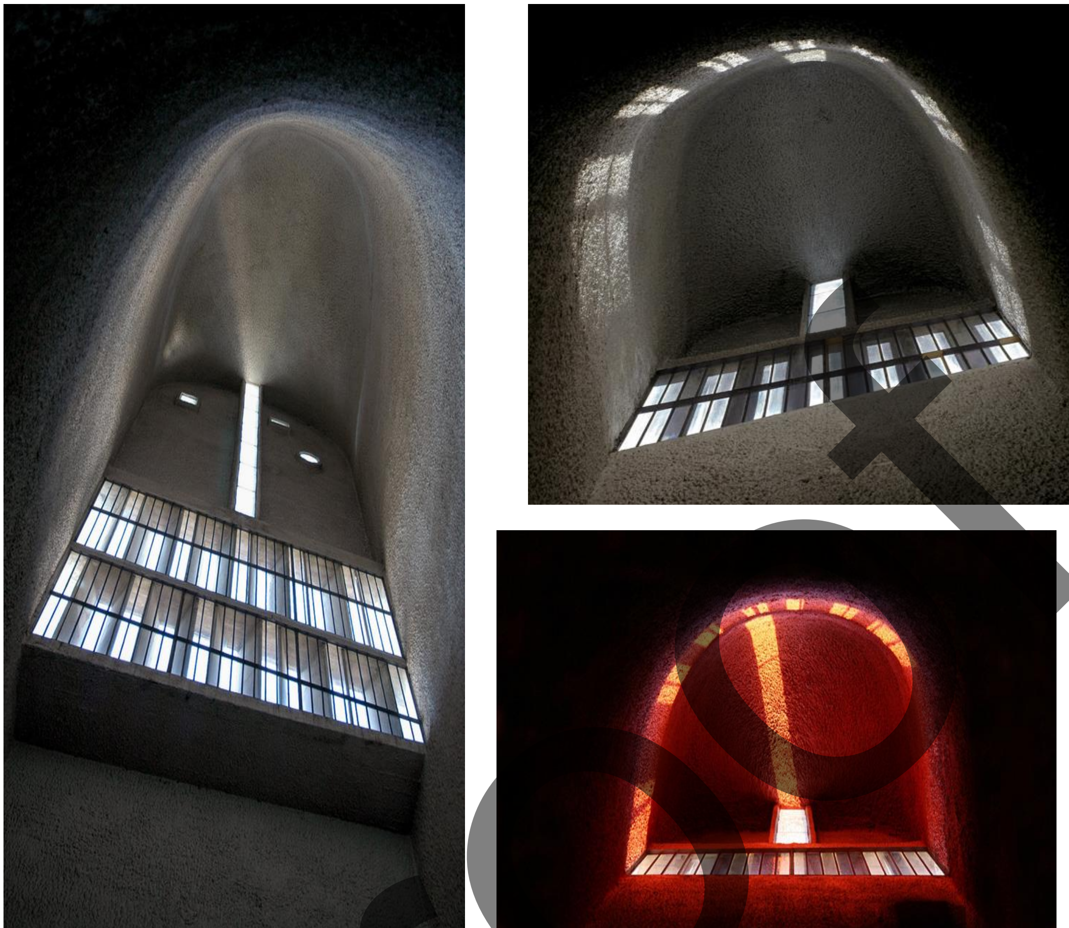
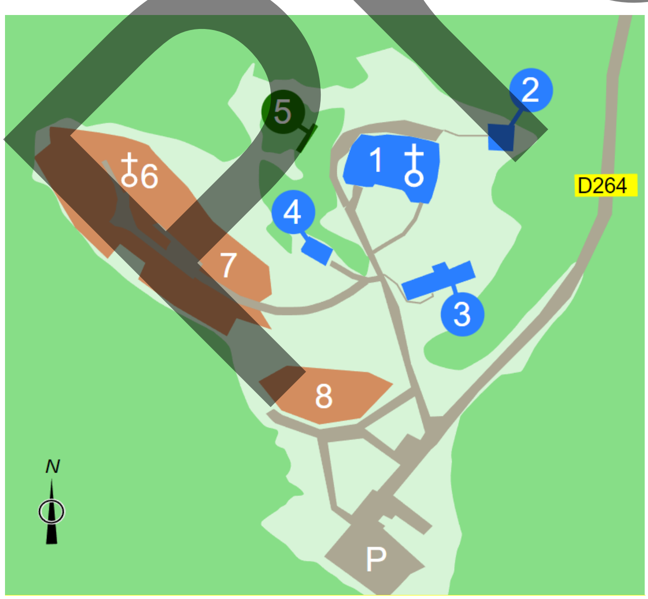


Figure 3. Three half-domes in the Ronchamp chapel (Photo ву L.Gnatiuk).



Map of the Notre-Dame-du-Haut
chapel site in Ronchamp
with all buildings and structures:
(1) : Notre-Dame-du-Haut chapel ;
(2) : pyramid of peace ;
(3) : pilgrim shelters ;
(4) : chaplain's house ;
(5) : campanile ;
(6) : chapelle Sainte-Claire chapel
(oratory of the convent) ;
(7) : Sainte-Claire convent ;
(8) : gatehouse (reception, exhibition
room).

Figure 4. Situational scheme. Ronchamp chapel. France. [20].

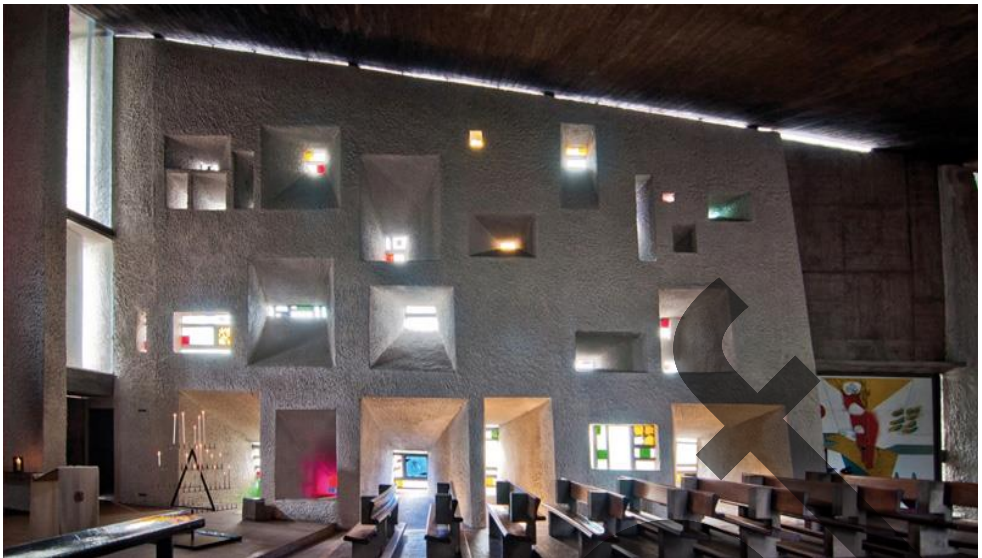


Figure 5. Interior of the Ronchamp chapel (Photo вy L.Gnatiuk).

Figure 6. Light "holes" in the Ronchamp chapel (Photo вy L.Gnatiuk).

Further, there are two semi-towers flanking the daily, working entrance to the chapel and a rounded wall extending to the western facade. The northern facade is clearly not ceremonial (business-working) [11].

The western side is characterized by a high semi-cylindrical light tower and a small stucco bulge, transmitting its form to the inner confessionals (Fig. 3). In front of the wall there is a strange sculptural font, which should receive water from the roof of the chapel when it rains. Water flows through a water cannon. This is the only analogy with Gothic, however, no chimeras. The water cannon is made in the form of long buffalo nostrils, apparently inspired by India, since Chandigarh was being built at the same time.

The interior of the chapel is a hymn to flowing spaces (Fig. 5). Light and shadow, in a relatively small room, generate hundreds of spatial sensations. Each step to the side reveals a new shape. These forms create an amazing mystical effect, and although this is not a traditional cathedral, one wants to pray here. Divinely sublime mood is created, first of all, by a series of openings in the south wall. Dark and light passes through narrow colored glass. Eight benches on a small dais, dimly lit by windows.

The east-facing benches are located in a large space, but when you sit on them, you find yourself in a kind of isolated mystical zone. Ahead is the altar, and in the distance is a window with a crucifix. The eastern facade, the one that has an altar on the outside, is covered, like the night sky, with a series of small "holes" (Fig. 6). These holes are so small that they are not visible on the facade. But they work very actively in the interior, especially on a sunny morning. An important detail: there is a thin, uneven gap between the roof and the southeastern walls. This slit creates the strongest light effect. Thanks to him, the huge roof does not press, but hovers over the interior.

This is probably a great chord to make the world happy, but without God, only through human creativity.

Rediscovering Christian values would help restore the spirituality that encompasses the dimension of creation.

The complex history of art and symbol in the history of sacred architecture of the twentieth century remains the subject of further research and reflection.

Modern architecture must inevitably take shape as a creative unity of diversity, as a combination of the mass and the unique, the rational and the emotional. Only then will it be able to fully satisfy the needs of a social person, which today are not simpler, but probably more complex and diverse than in the past.

CONCLUSION

Thus, the main task of theatricalization of the architectural environment, as in the theater itself is to create an appropriate holistic image. It's done by combining many things into a single whole: props, scenery, synthesis of different arts, lighting, music and noise effects, and so on. Today's architectural environment, as before, is designed for action - short-term or permanent. In the theater, the action can be repeated many times, while the action in the urban space takes place, as a rule, once, exclusively. At the same time, the modern architectural environment, especially the urban one, is more characterized by constant action, everyday festivities, and, consequently, its dramatization is increasingly becoming an art practice.

The identified is need to take into account the relationship between certain forms and messages, through which symbolic and artistic languages are transmitted in the formation of sacred space.

The sacred space of the temple is designed not only for human use, but becomes part of the cosmos, inviting art through symbols to be a sign of God's glory and a sign of the mystery of Christ for the assembled community.

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Visual Characteristics of the Built Environment for Quantitative Analysis of the Composition in the Space of the 3D Model

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Abstract. The article is devoted to the further development of compositional means of the formation of a harmonious material environment of human life. In our time, traditional means of composition and related concepts are not effective in solving modern problems in the process of designing large, time-deployed environmental objects. The emotional state and behavior of a person inside such objects are influenced by the visual characteristics of the environment, which are perceived from a certain point of view. Using computer technologies, it is possible to build a geometric model of human visual perception of the environment directly in the digital space to study the visual characteristics of the environment. Therefore, in this paper, it is proposed to supplement the terminological apparatus of compositional analysis of the built environment with the concepts that reflect the visual characteristics of the environment and can be quantified directly in the 3D model space.

INTRODUCTION

In architecture and design, the process of designing is often identified with the composition of the object. This concept means the internal structure of the object that is subject to a number of laws. The result of the composition is a certain effect on the viewer.

To realize the desired, it is necessary to know the laws of composition. That is why the composition is a basis of the professional training of future architects and designers, and the terms of compositional analysis are the basis of the professional language for these specialties. With the development of our ideas about architecture and the world in general, this language is constantly evolving, and certain compositional concepts are accentuated in different periods [1]. Traditional concepts, subordination, balance, axis, accent, proportions, etc., which successfully solve the problem of designing local, simultaneously perceived compositions, are not able to cope with large-scale time-deployed environmental objects, such as the city or even the interiors of large complexes.

With the advent of the environmental approach in architecture, the interest in the visual characteristics of the architectural environment emerged, as well as the interest in geometric designing of visual perception and quantitative calculation of related environmental characteristics emerged with the development of digital technologies.

The evidence of this is the emergence of the term isovist, which characterizes the visible space from a given point, as well as the software that allows calculating the various properties of isovists. This was made possible by the works of M. Benedikt [2], A. Turner with a group of scientists [3, 4], W. Suleiman, T. Joliveau and E. Favier [5], and others.

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Today, the study of visual characteristics of the built environment that affect human emotions and behavior is still relevant. And special attention is paid to the search for methods of their calculation and use in the practice of design using the space of 3D model [6, 7, 8, 9, 10].

The characteristic feature is the emergence of many concepts related to the description of visual properties of the environment, which researchers propose to use in the designing of the composition of the architectural environment [8].

However, it should be noted that such characteristics reflect the various properties of visible space and its relationship with the planes of objects that form it, almost without touching the visual qualities of the objects of the architectural environment. Also, many terms that sometimes mean the indicators of visual space, which are quite similar in content, complicate the understanding of their application in practice in the design process.

Therefore, it seems relevant to develop concepts and methods of quantitative analysis of visual characteristics, both space and objects that form it. In the meantime, it is advisable to identify a limited number of basic visual qualities of the built environment that have an emotional impact on the viewer for a clean and at the same time comprehensive presentation of the composition of the environment in the design practice and discussion of the environmental objects:

VISUAL CHARACTERISTICS OF THE BUILT ENVIRONMENT

We propose to supplement the compositional analysis of the environment with such characteristics as visual density, visual complexity of the silhouette, visual complexity of space, and visual fullness. These characteristics are related to the geometric properties of visual perception and can be formalized using mathematical methods to enable their quantification [11, 12].

Visual Density

Visual density reflects the strength of the impact of the visual content of space with material objects on a person. This characteristic depends on the total number of objects in the environment that come into view. The value of this number is calculated as the sum of the solid angles at which the objects are perceived from a given point of view.

Visual density of the environment is defined as the ratio of the total number of solid angles at all material objects in all possible or selected directions of visual perception from a given point of view to the solid angle formed by a full sphere (full solid angle) or a spherical sector. The values are calculated via solid angles and expressed in *steradians (sr)*:

$$P_v = \frac{S_0}{S_{sph}} \tag{1}$$

where P_v is the visual density of the environment, S_{sph} is the solid angle of the sphere or spherical sector, S_0 is the total number of solid angles on *n* material objects, which can be calculated as:

$$S_0 = \sum_{i=1}^{n} S_{0-i} \tag{2}$$

In doing so, the value S_{0-i} of each object is calculated separately in accordance with the previously proposed algorithm for determining the solid angles on the objects of the environment [12].

The calculation of the density can be performed for the area of the environment as a whole, selecting the entire sphere, or consider a separate spherical sector. In this case, S_{sph} will be equal to the solid angle on the selected part of the sphere; the total number of solid angles on *n* material objects will also be calculated only for this sector.

The calculated ratio, expressed in mathematical form, demonstrates how dense the object mass is, which can consist of houses, small architectural forms, design elements, interior items, etc. at visual perception from the chosen point of view.

Visual Complexity of the Silhouette

The visual complexity of the silhouette of the built environment characterizes the difficulty of reading the visible contour (silhouette) of material objects around us.

There are two proposed methods to determine this characteristic. The first one is based on the use of spherical coordinates of the points of visible contour of the environment, and the second one is based on the determination of linear and dihedral angles in the areas between the boundary points of the silhouette.

The first method provides for the determination of the spatial coordinates of the visible boundary points of the objects of the environment that are perceived by a person.

Using the first method, the sequence of automated determination of the complexity of the silhouette, according to the computer algorithm, is as follows:

1. Determination of the number and spherical coordinates of the boundary points of the silhouette, which are visually perceived from a given point.
2. Determination of the number of points with a contrasting heigh difference by the difference of deviation angles between successive points of the silhouette; the value of the difference level is set based on statistical analysis.
3. Determination of the number of places with a contrasting difference between points, repeated successively two or more times.
4. Determination of the horizontal length of the sections between the contrasting differences due to the difference of azimuthal angles.
5. Calculation of the ratio for each area defined in Step 4 to the length of the entire visible silhouette.
6. Determination of the level of uniformity of the silhouette by the value of the ratios calculated in Step 5.
7. Determination of the number of places with a small distance between the contrasting differences; the limits of the parameter of the visual distance are set based on statistical analysis.

In doing so, the complexity of the silhouette of the environment will be greater the more pronounced the following parameters:

- more boundary points of the silhouette;
- more points with a contrasting difference;
- higher level of a contrasting difference;
- more places with a contrasting difference between the points, repeated successively two or more times;
- greater uniformity of distribution of contrasting differences along the visible silhouette;
- more places with a small distance between the contrasting differences.

Based on the geometric model of visual perception, it is possible to determine the spherical coordinates of the points of the contour of the environment for the selected point of view and analyze the contour by the complexity:

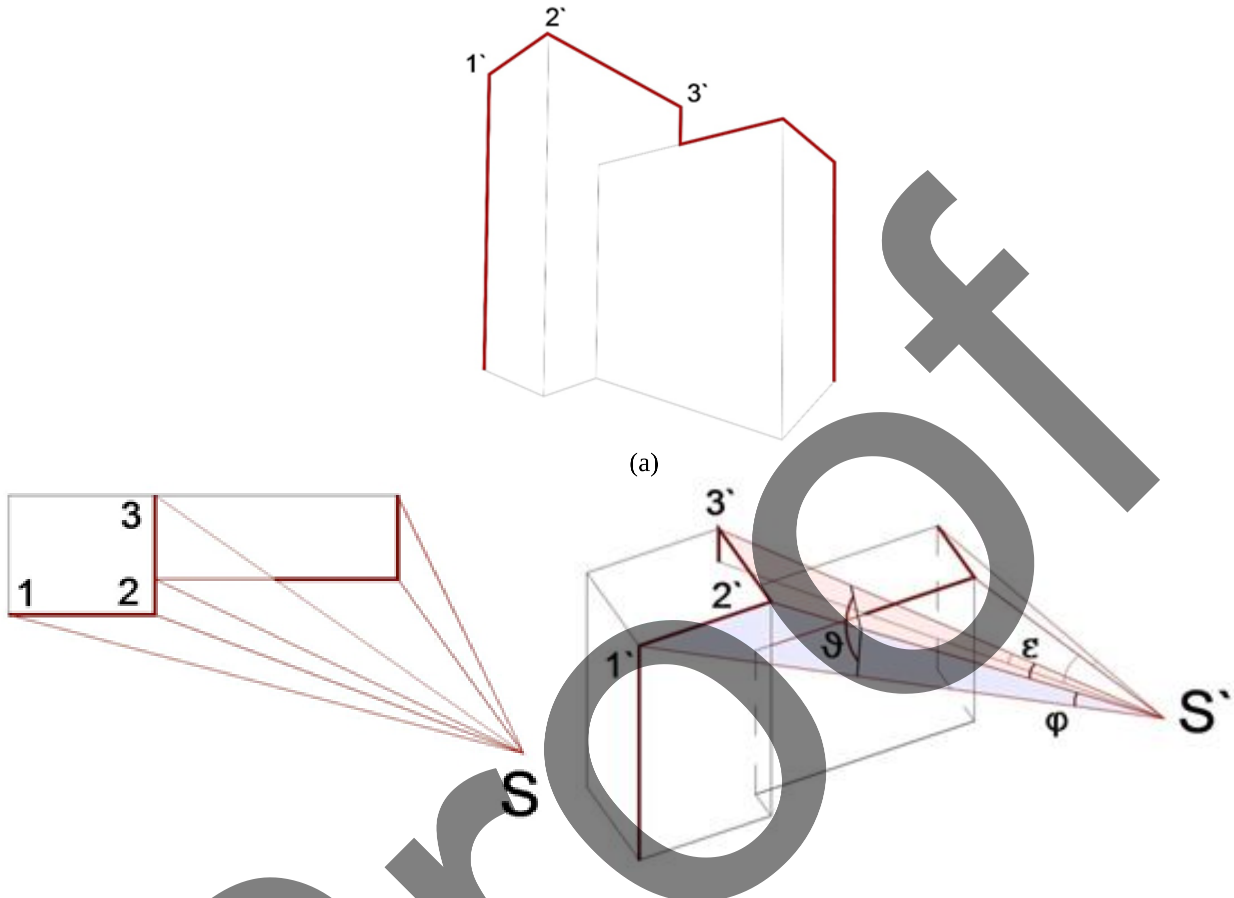
a) for the whole area of space (360°);
b) of a separate segment – 1/2, 1/3, /4, 1/8, etc. of the space around the viewer;
c) for a separate object, i.e., a building, a small architectural form, an interior object;
d) of a separate spatial level – a plan of visual perception (short-range, middle-range, distant);
e) of a separate high-level tier of visual perception (lower, middle, upper); for example, for the lower tier of the city, only the contours of the low in front or even high objects will be analyzed, while at the distant plan of the buildings that fall into this tier in terms of the height perception, the contours of the protruding canopies, awnings, small architectural forms will be analyzed as well.

However, this method of determination of visual complexity of the silhouette of the built environment has a certain disadvantage in determining the number of points with contrasting differences that are visually perceived from a given point. Therefore, the second method of calculating the visual complexity of the silhouette has been proposed. To use it, a 3D model of the built environment and determination of the contour of the environment that is visible from a given point, using the known computer algorithms, are necessary (Fig. 1a). If we connect each point of the visible silhouette with a point of view by a ray, we get many dihedral and linear angles in space (Fig. 1b). Each point of the contour will be characterized by two linear angles ε and φ on the adjacent sections of the contour, as well as a dihedral angle ϑ between the planes in which the abovementioned angles are located (Fig. 1c). It means that for each point of the contour, it is possible to determine one dihedral and two linear angles, the values of which in the complex will allow us to get an idea of the feeling of visual complexity in a given place of the silhouette of the built environment.

In this scheme, the level of filling of the contour of the environment with the inflection points is proposed to be calculated as the ratio of the number of defined points to the selected angle of perception of the environment, i.e., as a specific value of the number of silhouette points per one degree of perception:

$$p = \frac{N}{G} \tag{3}$$

where p is the level of filling of the contour of the built environment with the inflection points; N is the number of points of the silhouette in the selected area of the built environment; G is the central angle of the sector of space, including the selected area, in its maximum value can be equal to 360° and cover the entire space around the viewer.



(b) (c)

FIGURE 1. The construction of dihedral and linear angles in the analysis of the distribution of contour points of the built environment.

In such a case, the uniformity of distribution of the points of contour along the selected area will be determined by comparing the levels of filling of the contour with the inflection points on individual sectors of the selected area of the environment.

At certain values of the angles, close to the maximum and minimum values that characterize the point of the contour, it ceases to play an important role in the perception of the complexity of the silhouette. In Fig. 2a, the linear angle on the area between points 2 and 3 is quite small, that is why it is advisable to simplify the silhouette by removing point 2 from the contour (Fig. 2b). Similarly, the dihedral angle between the planes on which the angles on adjacent sections 3-4 and 4-5 lie, may also be perceived by the observer as insignificant (Fig. 2c); in this case, first it is necessary to remove point 4 from the general contour (Fig. 2d), then re-check the contour and remove point 3 due to the small value of the angle on section 3-5 (Fig. 2e). As a result, simplifying the silhouette, it is possible to solve the problem when determining the silhouette complexity of the environment, which occurs when it is calculated by the first method.

Simplification of the visual contour can be performed in an automated mode using software algorithms after statistical analysis to determine the limit values of linear and dihedral angles, beyond which the point of the contour can be removed from the overall silhouette.

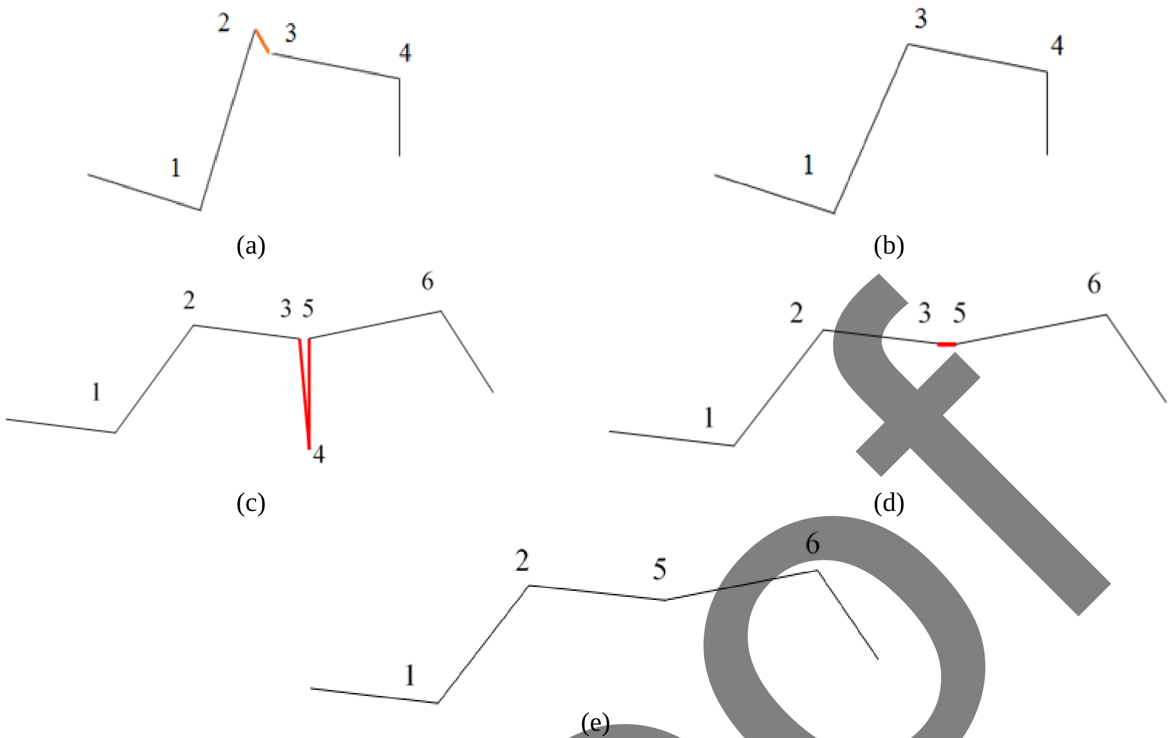


FIGURE 2. Simplification of the silhouette of the environment provided that the permissible level of error in the calculations is not exceeded.

Visual Complexity of Space

The visual complexity of space reflects the difficulty of reading the structure of space from a given point of view. It depends on the number of visible spatial layers. The more spatial layers of the environment are visually perceived by a person from a given point, the more complex the structure of the space in this place.

Based on the model of visual perception of space and using the algorithm for calculating solid angles on three-dimensional objects, in each case using software algorithms, it is possible:

- to determine the number of spatial layers that are visually perceived from a certain point;
- to determine the visible area of each layer, considering the solid angles;
- to express the visible area of each layer as a percentage of the area of the total space of visual perception;
- to determine the visual silhouette complexity of the environment for each spatial layer.

Visual Fullness

Visual fullness is defined as a characteristic that reflects the parameter of filling the built environment with composite elements, i.e., is a measure of the filling of the environment with the details. The value of fullness is calculated after the selection of a set of closed contours of the elements of the environment that are visible from a given point of view. When determining the level of fullness, it is necessary to conduct a statistical analysis resulting in the selection of the minimum level of the value of solid angle of perception the detail of the environment by the observer. If the detail of the environment is characterized by a solid angle that is less than the minimum allowable value, such detail should not be perceived as a separate object and therefore is not considered in the analysis.

CONCLUSIONS

The considered characteristics are distributed in the environment in a certain way according to the features of architectural and design compositions. Quantitative determination of each and identification of their optimal ratios provides the key to understanding the aesthetic quality of the built environment and can be used in software algorithms for design practice.

The proposed visual characteristics can be used to analyze the composition of historically formed environmental objects such as the city, as well as to include new elements in the existing environment and to form a new built environment. In the process of studying the composition of cities, it is possible to create certain maps with areas with higher and lower density, levels of complexity, and fullness at the same time, which will allow seeing the ratio of these characteristics in different parts of the city; and using the methods of statistical analysis and expert evaluation, it is possible to select their most optimal values to ensure the comfortable stay.

The study found that the characteristics of the built environment from the visual perception point of view do not depend on the absolute parameters of the objects (their size and distance between them) but the parameters perceived by the observer; the key role in quantification of characteristics of the objects of the external environment from the visual perception point of view is played by the location of the point of view, its distance from the objects of perception and their geometric position; due to the panoramic vision of a person, i.e., the ability to view the entire space around at once, the characteristics of the environment should be determined by choosing the environment around the viewer at the angle of 360º.

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Optimization of the Process of Designing High-rise Bioclimatic Buildings Using Renewable Energy

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Abstract. The article deals with a study to optimize the design process of high-rise bioclimatic buildings when using renewable energy in them. The main attention is paid to the process of determining bioclimatic means that do not have universal solutions, implementation algorithms and optimization tools in connection with their richly parametric nature. Realization of the advantages of bioclimatic approaches when integrating renewable energy into high-rise buildings is possible only when a structure is formed that can ensure the interaction of variable natural and climatic factors and modern engineering and design tools. The study offers a diagram of the process of forming such a structure. The interaction of solar renewable energy technologies with the climatic parameters of the building site and the space-planning solutions of buildings is analyzed. The structuring of the analysis of climatic conditions at the macro, meso and micro levels is proposed, which provides a logical sequence for choosing the optimal restorative energy resource and engineering and technical means when integrating into a high-rise building. The approbation of certain system provisions was implemented by optimizing the design solution for the integration of renewable solar energy into a high-rise building in Kyiv, Ukraine.
Keywords: renewable energy, bioclimatic high-rise architecture, solar energy, climate parameters

INTRODUCTION

Sustainable development requires constant efforts to create and implement solutions for energy efficiency, environmental friendliness [1]. The main goal of sustainable development is to conserve resources from generation to generation [2]. An implementation of sustainable development principles into modern high-rise construction has become an impetus for the search for new approaches to reduce the negative impact of high-rise buildings on the environment. An example of the formation of sustainable high-rise architecture is the emergence and development of bioclimatic high-rise architecture. It is based on the principles of adaptation to natural and climatic conditions and the use of available renewable energy resources, in accordance with the principles of the formation of natural systems [3, 4, 5]. It is clear that the space-planning solutions of modern skyscrapers are primarily aimed at ensuring structural stability, functional requirements, but rarely at solving the problems of the availability of renewable energy resources. This approach reduces the possibility of using natural renewable energy resources in full, taking into account the shift, the complexity of the impact of climatic factors [6] and ensuring the requirements for the reliability of the operation of power systems [7].

It should be noted that several dozen skyscrapers have already been built in the world, where energy needs are met through the integration of renewable energy systems into them. This design and construction experience today forms the basis of most research on the use of renewable energy in high-rise construction [8]. According to a study [9], the use of solar energy ranks first among renewable energy sources and is being introduced into the energy supply of modern high-rise buildings. The effective use of renewable energy, including solar energy, requires ensuring a threshold level of their resource based on an analysis of the energy potential of the area at the early stages

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of design [10]. Given the significant number of influencing factors when integrating renewable energy sources into high-rise bioclimatic buildings, it is important to identify opportunities for optimizing the design process. Taking into account the above, the aim of research is to identify and analyze the means of optimizing the design process of high-rise bioclimatic buildings using renewable natural resources using the example of solar energy.

MATERIALS AND METHODS

Design Process for Bioclimatic High-rise Buildings with the Integration of Renewable Energy Sources

Bioclimatic high-rise buildings should provide an effective link between anthropogenic and natural processes in the ecosystem of a modern metropolis with sustainable development. This approach is based on the creation of design solutions taking into account natural and climatic conditions with the use of modern knowledge and technologies for efficient energy supply of high-rise buildings in accordance with the requirements of bioclimatic architecture.

The organization of efficient energy supply of a high-rise bioclimatic building throughout its life cycle is an orderly interaction of related elements of the building and the external environment. Taking into account the dynamic nature of renewable energy resources, optimizing their potential with ensuring proper operation and maintenance, continues throughout the entire life cycle of a bioclimatic skyscraper. Building life cycle analysis, taking into account the integration of renewable energy into bioclimatic architecture, is a process from the beginning of design work and throughout all stages of construction and operation of the building. It provides for the inclusion and interaction of space-planning solutions, structural and engineering elements in the project of a high-rise building for the efficient use of renewable energy sources. For example, a similar interaction was analyzed when using renewable energy from the Sun in a high-rise bioclimatic building. Solar energy is the energy that the Earth receives from the Sun, primarily in the form of visible light and other forms of electromagnetic radiation. Solar energy is an important source of renewable energy with advanced technologies for its use. The efficiency of integration of various technologies for the use of solar energy in high-rise bioclimatic buildings associated with the influence of the main groups of factors: the features of engineering technologies, climatic parameters and space-planning solutions of buildings (Table 1).

Table 1. Interaction of solar renewable energy technologies with climatic parameters and space-planning solutions of buildings.

Renewable energy technologies		Technology features	Volumetric planning solutions	Climatic parameters
Systems of active energy production	Photovoltaic panels	Supporting (movable) structures for photovoltaic panels	Integration into external structures of facades, roofs	- Solar radiation intensity; - Direct solar radiation; - Scattered solar radiation; - Insolation duration; - Incidence angle of sun rays; - Taking into account the influence of wind and precipitation
	Thermodynamic system	Solar energy technology with a turbine generator	Technologically and functionally separate buildings	
Solar heating systems	Passive solar heating	Providing thermal mass/Trombe walls	Integration into a space-planning solution taking into account the duration of solar exposure	
	Active solar heating	Solar collectors with coolant circulation	Integrated on the cover, need technical rooms for system maintenance	

High-rise bioclimatic buildings provide for the use of solar power supply systems equipped with special engineering and technical means for their efficient operation. To meet the significant energy needs of high-rise buildings, it becomes necessary to place a significant number of solar systems on them to produce more energy. This makes it possible not only to increase the total production of the solar energy system, but also to reduce the cost of building and operating urban utilities to meet the needs of a high-rise building. The external location of the energy source – the Sun – to ensure the effective functioning of heliosystems, requires their location outside the building and, taking into account the movement of the Sun, affects the building's shape. Thus, along with the tasks of choosing and efficient placement of solar systems, which is more related to the engineering and technical aspects of design, there are questions of the influence of the applied solar systems on the architectural solution of the building.

The main design positions that may be affected by the integration of solar systems into a high-rise bioclimatic building are highlighted:

- volumetric-spatial form of high-rise buildings (integration into a volumetric-planning solution, into a geometric shape, facade plastic, texture and color);
- constructive solutions (use of additional structures, integration into the building structure (walls, roof, translucent structures, sun-protection elements)
- functional zoning (combining with the engineering and technical premises of the building, combining with the main premises of the building; functional operation is separated).

The tasks of integrating solar systems into a high-rise bioclimatic building at different levels of architectural and construction design require their correct comparison with the general design process. Let us highlight the following conditions for the integration of solar systems into a high-rise bioclimatic building:

- the most limited conditions for integration – during the reconstruction of an existing high-rise building for bioclimatic tasks with unchanged surrounding buildings and landscaping, when the space-planning, construction and engineering structure is formed;
- partially limited conditions for integration – when a high-rise building is at the stage of design development, but has a significant number of factors and influences limiting the use of solar systems;
- free conditions for integration – when a high-rise building is at the stage of design development without restrictions on orientation and shape parameters, and the tasks of integrating solar systems are priority.

In the process of designing solar systems for high-rise bioclimatic buildings, it is necessary to take into account the consistency of:

- general architectural concept of the building and the stylistic and compositional unity of the solar cooling design and methods of its integration into the structure of the building, compliance with the functional and typological characteristics of the building;
- constructive feasibility of the selected solar systems in accordance with the bearing capacity of structural systems – their stability, reliability, durability, ease of maintenance;
- ensuring regulatory requirements for heat protection, sun protection, illumination, noise insulation.

According to the above conditions, the principle of "permissible intervention" will be implemented, when one or another task of integrating solar systems into a high-rise building can be correctly implemented as a fragment of the corresponding stage of architectural design.

Systematization of Climatic Parameters for the Energy Supply of High-rise Bioclimatic Buildings

When designing solar equipment, data on the amount of total solar radiation, its components, frequency and conditions of receipt are taken into account. Climatic indicators (air temperature, precipitation, air pollution level, sky cloudiness, wind characteristics) affect the intensity and duration of direct, scattered and total solar radiation. Using a systematic approach, we will define and analyze the interaction of climate parameters and solar irradiation.

To optimize the process of selecting options for renewable energy in a high-rise bioclimatic building, let's define the following stages of climate analysis:

1) Macroclimatic analysis. Checking the types of renewable energy as potentially possible at the macroclimatic level, where, on the basis of resource maps and natural characteristics of the region, it is possible to immediately eliminate unpromising renewable energy technologies and leave potentially effective ones for further analysis.

2) Mesoclimatic analysis. A more detailed check of potentially efficient types of renewable energy (identified in the previous step). It is carried out for a given area, taking into account the analysis of climatic parameters at the level of the settlement. The interaction of design, technological and natural parameters is determined on the basis of the systematic approach presented above.

3) Microclimatic analysis. The functional, volumetric planning, urban planning, engineering and technical solutions of a high-rise building are being specified when modeling and calculating renewable energy resources, their capacity and location in the building. This stage of designing renewable energy in a high-rise bioclimatic building is carried out taking into account the microclimatic parameters of the environment.

RESEARCH RESULTS

In Ukraine, the requirements have been adopted, according to which, from 2020, all high-rise buildings must comply with an energy efficiency class of at least "B". One of the directions for ensuring a high level of energy efficiency is the use of regenerative energy supply systems. In Ukraine, there is practically no experience of using renewable solar energy in the construction of high-rise buildings, and isolated cases are a source of unique experience. For example, placing solar panels on the southern wall of a multi-storey building in Kiev, without taking into account the optimal angle of inclination with respect to the Sun, turned out to be ineffective, with a loss of 30% of power [11]. So, the design of renewable solar energy supply in high-rise buildings without a thorough analysis of the factors of influence leads to inefficient systems operation.

The research proposed in the article aimed at determining the optimal parameters of design solutions to ensure the efficiency of the use of renewable energy sources. The approbation of the system provisions defined in the article is realized by optimizing the design solution for the integration of renewable solar energy into a high-rise building in Kiev, Ukraine. The building in question is a high-rise building (height above 75 meters). The integration conditions are defined as partially limited conditions for the integration of solar systems, since the integration of solar systems into the building structure was not envisaged in the previous design stages.

Analysis of space-planning and engineering solutions of the building project

The high-rise building has a height of 78 meters, 26 floors, a compact form in the form of a rectangular prism, in the plan – a rectangle of 29.8 x 27.8 m. The functional purpose of the building is residential, with public facilities. The planning solution is a compact placement of residential premises along the perimeter of the building with an internal stiffness core with vertical communications Considering the space-planning solution of the building adopted for the project, the most rational option for integration into a building is the option with built-on geosystems on a flat roof of a building that is not in operation.

In the previous stages of building design, ensuring energy efficiency in the building, it was decided by insulating the outer shell of the building (walls, roof), using energy-saving translucent structures and engineering equipment. According to the calculations, the total amount of energy for the functioning of the building is 1552130 kWh per year.

The energy efficiency class of the building according to the design calculations "C" does not correspond to modern energy efficiency requirements. Therefore, the use of photovoltaic systems has been proposed to improve the environmental and energy efficiency of the building.

Analysis of Climatic Parameters and Environmental Influences Macroclimatic Level of Analysis

The climate of Ukraine in the direction from west to east is continental, that is, a significant difference in temperatures depending on the season, caused by the heating of the earth's surface in summer and its cooling in winter. The indicators of the total photovoltaic output power in Ukraine are from 2.8 to 3.8 kWh, which even exceeds the corresponding indicators from 2.6 to 3.4 kWh in Germany, which is one of the leaders in the use of solar energy in the world (indication data was obtained using Global Solar Altas [12]). So, a preliminary analysis of the parameters of solar irradiation shows the prospect of photovoltaic potential on the territory of Ukraine.

Mesoclimatic Analysis level

Kyiv has a humid continental climate, when the average temperature of the coldest month is lower (-3 °C) and at least 4 months a year the average monthly temperature is higher (10 °C). Precipitation is relatively evenly distributed throughout the year. In winter, rains and snowfalls are mainly associated with the passage of cyclones and associated fronts. A more detailed analysis of the climate of the city of Kyiv, taking into account the influence of climatic parameters on the efficiency of photovoltaic systems and the definition of the corresponding design solutions, is presented in Table 2.

Table 2. Influence of mesoclimatic parameters on the heliosystems operation (Kyiv, Ukraine).

Mesoclimatic parameters, Kiev, Ukraine	Influence on the efficiency of solar systems	Accepted design decisions
$\mathbf{n_1}$ outdoor temperature varies from -4.7 °C (winter) to +19.8 °C (summer)	Decrease in the efficiency of photovoltaic panels with decreasing temperatures	Integration of the total energy consumption of the building, taking into account the changes in the efficiency of the solar systems
$\mathbf{n_2}$ the amount of precipitation during the year ranges from 41 mm to 77 mm, the presence of snow cover ranges from 20 to 26 days in winter	Accumulation of snow on the surfaces of solar systems reduces the efficiency of its work	Protection from snowfall with a screen is provided. Inclination angle of solar panels allows self-cleaning of snow
$\mathbf{n_3}$ average relative humidity for the year – 74% with an even distribution throughout the year	High humidity affects the life of solar panels, can cause reversible (polarization) degradation of solar panels and corrosion of metal structures	Use of structures and technological solutions for solar systems with protection of elements from moisture is provided
$\mathbf{n_4}$ transparency coefficient at a turbidity factor tm <4.34 a = 0.91; b = 10; c = 0.45; at tm ≥ 4.34 a = 0.856; b = 16; d = 0.3	Particulate matter (PM) can reduce solar energy production through direct and indirect radiation as well as deposition on the surface of solar panels	Cleaning of the panel surface from dust is provided
$\mathbf{n_5}$ solstice altitude (latitude 52° north latitude) from 61°27 (21.06) to 14°33 (22.12)	Direct sunlight incidence on photovoltaic panels provides Maximum efficiency	A certain optimal inclination angle of solar panels for Kyiv is 36 degrees with an orientation to the south. Application of solar tracking systems
$\mathbf{n_6}$ the average cloudiness of the sky for the year is 4.3 points – the cloudiness doubles in the autumn-winter period	Increased cloudiness reduces solar output	The effective periods of operation of solar systems have been determined
$\mathbf{n_7}$ wind characteristics – average wind speed in January, 3.1–4 m/s, prevailing wind direction – northwest, west	As the height of the building increases, the wind load on the structures increases	Protection of solar panels from the prevailing wind is provided by the installation of a protective structure – a barrier from wind generators from the north-west side

Microclimatic Analysis Level

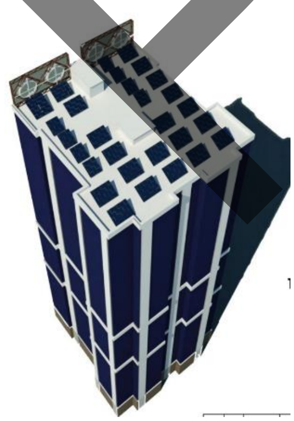

FIGURE 1. General view of the placement of solar modules on the roof of the building.

The high-rise building is not in the shadow of the neighboring buildings. The roof of the building was chosen to place the PV modules, where the following changes are envisaged to increase the efficiency of the PV modules: a technical floor for servicing solar panels, a "warm attic", a common exhaust duct on the technical floor, a flat covering with a slope of 6 degrees.

To form the structure of solar cells, adopting monocrystalline solar modules PSm-315M6 [13]. The modules are manufactured in Ukraine, certified according to ISO 9001:2015 standards, retain their efficiency at least 80% after 25 years. The output power of one PW module is 315 W, the module size is 1650 x 991x35 mm, the module area is 1.635 m^2. Frame made of anodized aluminum, front surface – tempered glass, back – multilayer coating. According to the optimal arrangement of modules on the roof surface, their number was 202 modules (Figure 1).

For a preliminary assessment of the solar irradiation parameters, the study used Global Solar Altas [12], where modeling is based on world databases from geostationary satellites and meteorological Sun position at each moment in time. Having established the corresponding parameters of the projected structure from monocrystalline solar modules in Global Solar Altas, let's obtain the value of the total output power of photovoltaic energy during the year 70.470 MWh (Table 3). The prospect of further growth in the development of solar energy can be realized through the use of more efficient solar modules, when applying the above project proposals, including through the use of trackers.

Table 3. Parameters of solar irradiation of the building site in Kyiv, Global Solar Atlas [12]

Map data	**Per year**	**Per day**	
Direct normal irradiation	1103	3.022	kWh/m^2
Global horizontal irradiation	1176	3.221	
Diffuse horizontal irradiation	569	1.559	
Global tilted irradiation at optimum angle	1380	3.780	
Terrain elevation	188		m
Air temperature	8.5		°C
System type			
Azimuth of PV panels	180		°
Optimum tilt of PV panels	36		°
Installed capacity	66		kWh
Total photovoltaic power output	72.672	0.199	MWh
Global tilted irradiation	1368	3.747	kWh/m^2

Thus, with the proposed design solution for the integration of solar panels, it is possible to provide a high-rise building with 4.54% of the annual energy consumption. The resulting energy can be used to maintain the operation of all elevators in the building or provide 37% of energy consumption for air exchange and air conditioning. The latter is especially important in summer with higher temperatures and increased use of air conditioning and ventilation systems.

In addition, for a preliminary analysis to optimize the operation of the designed structure of solar panels, it is important to determine the change in the distribution of the received energy during the year and during the day. Indication data was obtained using Global Solar Altas [12] and is presented as:

- a graph of the average monthly annual distribution of the total photovoltaic power output of the designed solar panel structure (Figure 2);

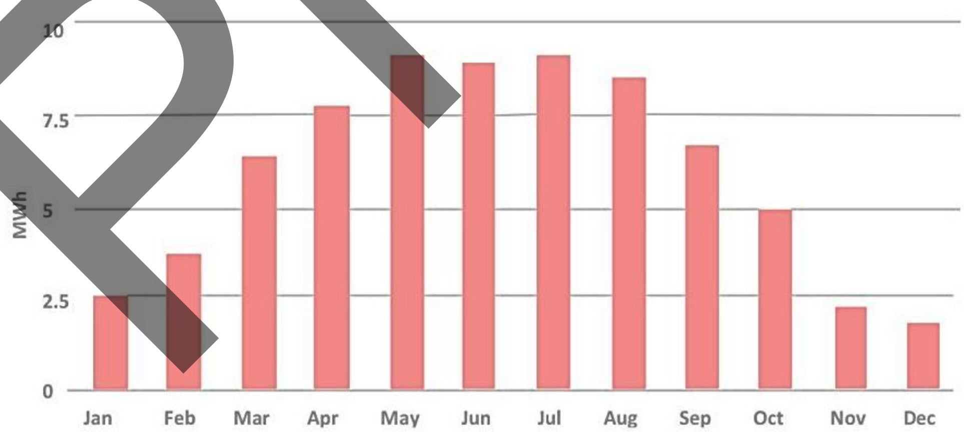

FIGURE 2. Total photovoltaic power output, monthly averages.

- average hourly profiles, showing the distribution of the total photovoltaic power output of the projected solar panel structure during the day on a monthly basis (Figure 3).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0-1												
1-2												
2-3												
3-4												
4-5						0						
5-6				0	2	2	2	0				
6-7			0	4	7	8	7	5	2			
7-8		0	6	12	16	16	15	13	10	5	0	
8-9	2	8	15	21	26	25	24	23	19	14	5	2
9-10	10	15	23	29	33	32	32	30	26	21	10	8
10-11	14	20	28	34	36	36	36	35	31	24	13	11
11-12	15	21	30	35	38	37	37	36	31	24	12	11
12-13	15	21	29	34	36	35	35	35	30	23	12	11
13-14	14	20	28	31	33	32	32	32	28	22	11	10
14-15	10	17	23	26	28	28	28	28	23	17	8	6
15-16	4	10	16	19	21	22	22	21	16	10	3	1
16-17		3	9	12	14	15	15	14	8	2		
17-18			1	4	6	8	8	6	1			
18-19				0	2	3	3	1				
19-20					0	1	0					
20-21												
21-22												
22-23												
23-24												
Sum kWh	85	133	208	262	298	300	295	279	225	163	76	61

FIGURE 3. Total photovoltaic power output, average hourly profiles.

The data obtained make it possible to estimate in time the input of solar energy into the energy supply of the building, to determine the system with the rational distribution of the renewable solar energy.

CONCLUSIONS

A growing trend of the present is the design of high-rise buildings with environmental requirements and sustainable development using renewable energy technologies [14]. The development of renewable energy in modern high-rise buildings is associated with solving energy efficiency problems during the operation of vertical structures of skyscrapers, which are characterized by an increased level of energy consumption. The study of the stages of development of energy consumption in high-rise buildings, determine the evolutionary movement of the integration of renewable energy [15]. At the current level of development, the task arises to ensure the accuracy of forecasting a renewable resource that will affect the improvement of the economic component of renewable energy projects [16, 17]. Analyzing and accounting for climatic parameters is becoming a means of improving efficiency in the design of energy efficient high-rise buildings [10]. This applies to various design stages, for example, in [18], means of accounting for climate change in the energy modernization of high-rise buildings are considered.

It should be noted that despite the versatile focus of work on the use of renewable energy in high-rise buildings, the means of multifactor optimization in the integration of renewable resources into bioclimatic high-rise buildings remain investigated. Bioclimatic high-rise buildings should provide an effective link between anthropogenic and natural processes in the ecosystem of a modern metropolis with sustainable development. The results obtained in the article make it possible to implement the ideas of bioclimatic high-rise architecture based on the adaptation of design solutions to natural and climatic conditions using available renewable energy resources. Thus, in the article:

- interaction of solar renewable energy technologies with the climatic parameters of the building site and the space-planning solutions of buildings is analyzed;
- structuring of the analysis of climatic conditions at the macro, meso and micro levels is proposed, which provides a logical sequence for choosing the optimal restorative energy resource and engineering and technical means when integrating into a high-rise building;
- approbation of certain system provisions is implemented by optimizing the design solution for the integration of renewable solar energy into a high-rise building in Kyiv, Ukraine.

The provisions presented in the article ensure the formation of a knowledge base, in the future form the basis of the "internal model" of an intelligent decision-making system for the integration of renewable energy sources into high-rise bioclimatic buildings.

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Universal Creative Methodology of Futuristic Formation of Sacred Architectural Objects

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Abstract. The main problems of stylistic formation of sacred objects, the main traditional international and national canons are identified. The actual components of the creative method of prognostic formation of sacred architectural objects are offered: principles – "object-counter-relief" and "object-sculpture", new conditions of the location of objects - in space and underwater, new types and subtypes of Orthodox churches. Conceptual design solutions of Orthodox churches based on compositional schemes of plans, images-symbols are presented. The methodology of prognostic design is based on the directions and currents of the theory of "informative architecture", developed by Tetiana Ladan for the creation of architectural objects for the future.

INTRODUCTION

The futuristic formation of sacred objects must preserve historically formed international and national canons and traditions. In fact, the general philosophy of "futurism" is closely connected with the architectural and artistic avant-garde, which usually breaks any canons and traditions. By rethinking the formative ideas of the avant-garde of the XX century, it is possible to invent new form-forming directions and trends to create modern forms of sacred objects and for the future while preserving canons and local traditions. But it is necessary to determine the trends in the development of sacred architecture in different periods of the architectural and artistic avant-garde: the times of modernism, postmodernism and the post-post era, in which attitudes to sacred objects were different and opposed.

Modernism of the first half of the XX century in the Soviet Union, in the East of Ukraine [1], was marked by the physical destruction of sacred objects, the de facto ban on their design and construction. In architectural objects of another function modernism focused artists on simple ascetic geometric shapes and elements (sphere, cylinder, cone, cube, parallelepiped). *Postmodernism* of the second half of the XX century began to exaggerate and ironically treat the form-forming elements, details, stylistic heritage in particular. In sacred architectural objects, architects similarly rethink the use of geometric shapes. *In the modern post-post era*, in the late XX – early XXI centuries, the ideas of modernism and postmodernism are rethought, but never developed a single concept of futuristic formation of sacred architectural objects, which would not be based on the style of past eras and their rethinking. This is primarily due to the established church canons and age-old traditions of design in styles.

RELEVANCE

The primary elements from which the formation of a sacred object (spatial three-dimensional form) is possible can become the basis for the "artistic engraving" of the object. The architect will become a sculptor, a jeweller artist who perceives the sacred object as a fragile spiritual shell containing an atmosphere of wonder and mystery. Therefore, the main issue is the feasibility of choosing a three-dimensional form for a particular area in the architectural or natural environment based on traditional international and national canons.

The traditional formation of objects of sacred architecture based on form-forming (compositional architectural-planning) international canons: the main types of plans of Orthodox churches – rotunda, tetra conch, longitudinal

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three-part and longitudinal nave, in tower form, cruciform; basic constructive schemes – columnless, columnar; clear functional-planning (three-part) organization of the plan, in connection with a schedule of movement during the stay in the temple, during services or processions [2].

Among these are the following traditional canons: recognizable symbolic outlines of architectural details and elements in the decoration of facades – visual rows of decorative, national ornaments, images of saints using various techniques (majolica, mosaic, fresco, stone carving), reliefs, bas-reliefs, sculptures cross-shaped niches or window openings with figurative or non-figurative images in stained glass. Modern architects of Ukraine, who create objects of sacred architecture, mainly turn to design in styles [3] in the traditional direction – historicism (new-style – the old style in new interpretation).

Creative methods of predictive futuristic sacred architectural objects can be:

1 The conversion from the style form-setting (new-style) and the conversion to address architectural-artistic conceptual form-setting based on the synthesis of arts ("genius loci", "informative architecture") [4, 5];

2 To strengthen the content of the canons should be used – the dominance of art parts, details and elements, symbols of folk ornamental forms [6], sacred space [7] and natural forms of shells [8];

3 An imagination idea when the concept is approved and the appearance of new ideas of the creation of sacred architectural objects – in connection to living people in the future – live in space or underwater [9];

4 Use of natural environmental materials and the change in design solutions in connection with 17 purposes of sustainability [10];

5 Creation of the philosophical concept of a sacred object based on design-projecting – the logo creation of the object, designation of its graphical sign-symbolic warehouse [11].

NOVELTY

In the formation of sacred objects, it is proposed to use simple geometric shapes in different angles (their combinations), spatial structures, modern achievements of science and technology, the latest technologies (hi-tech) with the composite building materials (combinations thereof) use. It is also recommended to create "sculptural compositions-counter-reliefs" (similar to experimental abstract "counter-reliefs" of the engineer-artist Volodimir Tatlin) or "objects-counter-reliefs" or "objects-sculptures".

If the traditional sacral object exists in the panorama of the city - it is habitually. If "object - counter-relief" and is anchor to the natural environment (rocks, waterfalls, trees), then are new opportunities for the implementation of sacral objects.

Similar to the dynamic baroque sacred compositions of the sculptor Johann Georg Pinsel, the compositional solution of the new sacral object is possible as the detail of space, with amplify, stylized and interpreted in a new way.

These principles of the design of sacred objects in the future will be the development of the ideas *"genius loci"* and the modern theory of the *"informative architecture"* in the synthesis of arts [3].

It is also necessary to change the traditional imagination to the conditions of the location of sacred objects: in the air – on the stylobate (our usual location), on the roof, on top of the mountain, rocks (unusual location); location on the water (rare location now and promising location in the future) and try to move to the conceptual design in unusual conditions of the location of sacred objects, which may be relevant in the future: in airless space - in space or underwater.

THE MAIN SECTION

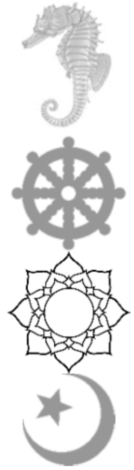
When designing a modern Orthodox church, it is recommended to keep the traditional internal planning structure of the church – triple (porch, middle church, altar). The compositional scheme of the plan can be formed with a bell tower, which is located in the structure of the temple, outside it and is higher than the temple, or located separately and intended to accommodate church bells, is lower than the temple. It is also possible to solve the temple without a bell tower. Construction materials can also have a degree of dominance; glass, wood, brick, metal, reinforced concrete. The degree of spaciousness of the three-dimensional solution of the temple can be adjusted according to the target design conditions.

During the experimental design in practical classes at the Kyiv National University of Construction and Architecture (KNUCA, Department of Architecture fundamentals and architectural Design) in the disciplines:

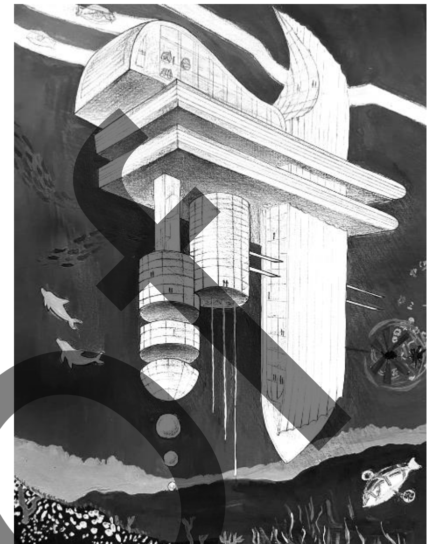
- *"History of Foreign Architecture (Soviet period)"* for 2nd-year students, lectures, practical classes: Associate Professor, PhD. Architecture – Tetiana Ladan ("biotechnical symbolism", a seahorse image is used, Figure 1).

- *"History of Ukrainian architecture and arts of the XX-XXI centuries"* for 3rd-year students, lectures, practical classes: Associate Professor, PhD. Architecture – Tetiana Ladan, ("technocratic and pictorial symbolism", Figure 2).
- *"Methods of reconstruction and architectural design of sacred buildings and complexes"* for 5th-year students (lectures: Professor, Doctor of Architecture – Oleg Sleptsov, practical classes: Associate Professor, PhD. Architecture – Tetiana Ladan), students developed concepts of reconstruction (Figure 3, 4) and new sacred objects (Figure 5).

a) center of spiritual development "Hippocampus", a Symbol of the religion of Buddhism, drawing by Victoria Muravska, 2nd-year student



c) symbols of objects and religions

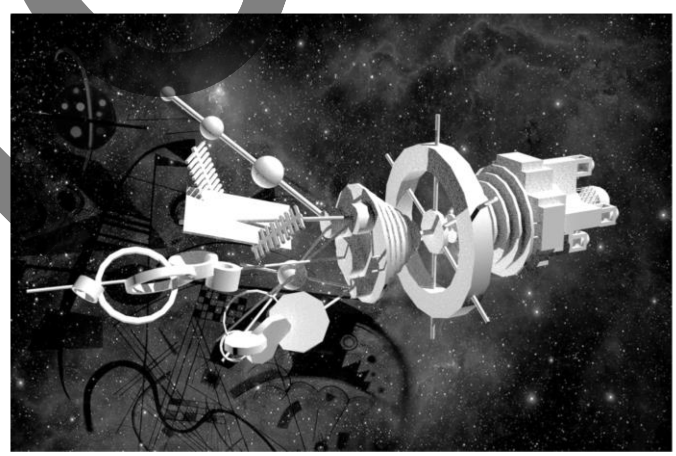


b) "Aquadzen" Research Center, a Symbol of the religion of Islam, drawing by Katerina Bulatova, 2nd-year student

FIGURE 1. Conceptual designs of sacred objects under water (a, b) based on the study of symbols (c), leader: Tetiana Ladan, Associate Professor, KNUCA, 2020 [12, 13].

a) research of the painting by artist Vasyl Kandinsky

b) research of the architecture of the Patriarchal Cathedral of the Resurrection of the Cross, Kyiv, by architect Mykola Levchuk



c) ark "KHATARI-2300", a Symbol of the religion of Christianity, drawing by: Kateryna Pedchenko, 3rd-year student

FIGURE 2. Conceptual designs of the sacred objects in space (c) based on the research of avant-garde painting and modern architecture (a, b), leader: Tetiana Ladan, Associate Professor, KNUCA, 2020 [13].

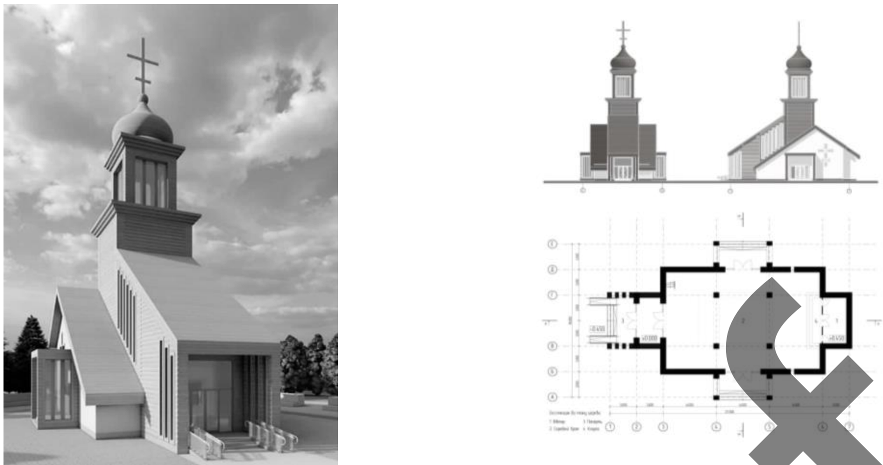
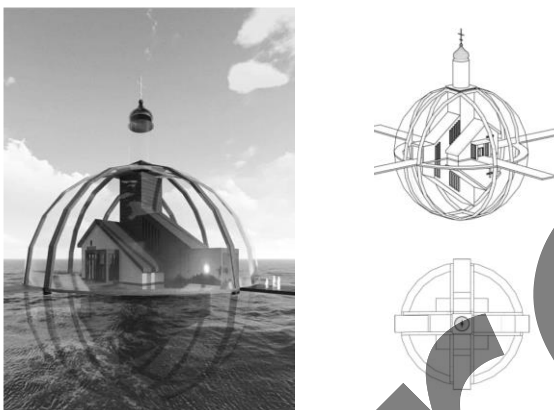
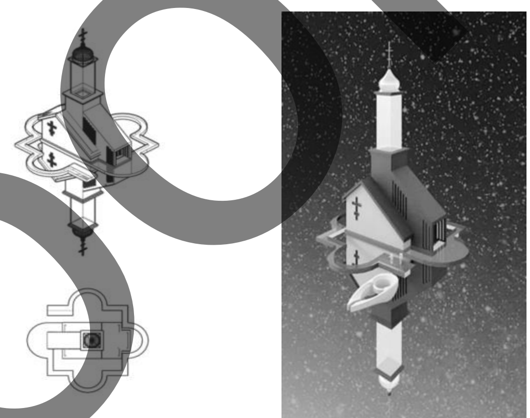


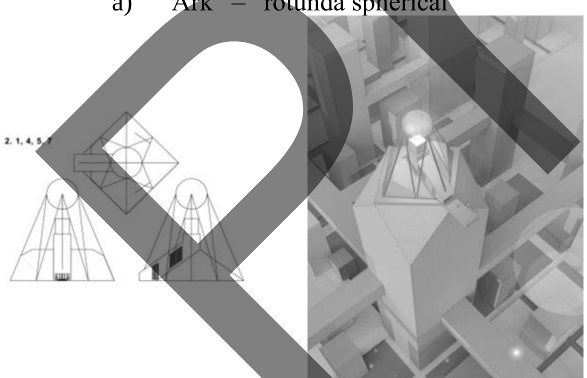
FIGURE 3. Orthodox church complex (fragment of the project), drawing by Anastasia Kharchenko, 5th-year student, leaders: Oleg Sleptsov, Professor, Boris Eerofalov, Professor; Igor Yakubovskiy, Docent; KNUCA, 2020 [13].



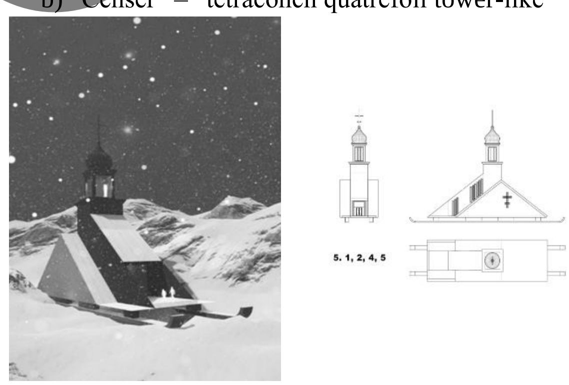
a) “Ark” – “rotunda spherical”



b) “Censer” – “tetraconch quatrefoil tower-like”



c) “Candle” – “square pyramidal”



d) “Angel's Wings” – “ship's prismatic”

FIGURE 4. Concepts of reconstruction of a sacred object according to compositional schemes of plans, images-symbols and types of a temple (a, b, c, d), drawing by Anastasia Kharchenko, 5th-year student, leader: Tetiana Ladan, Associate Professor, Oleg Sleptsov, Professor; KNUCA, 2020 [13]

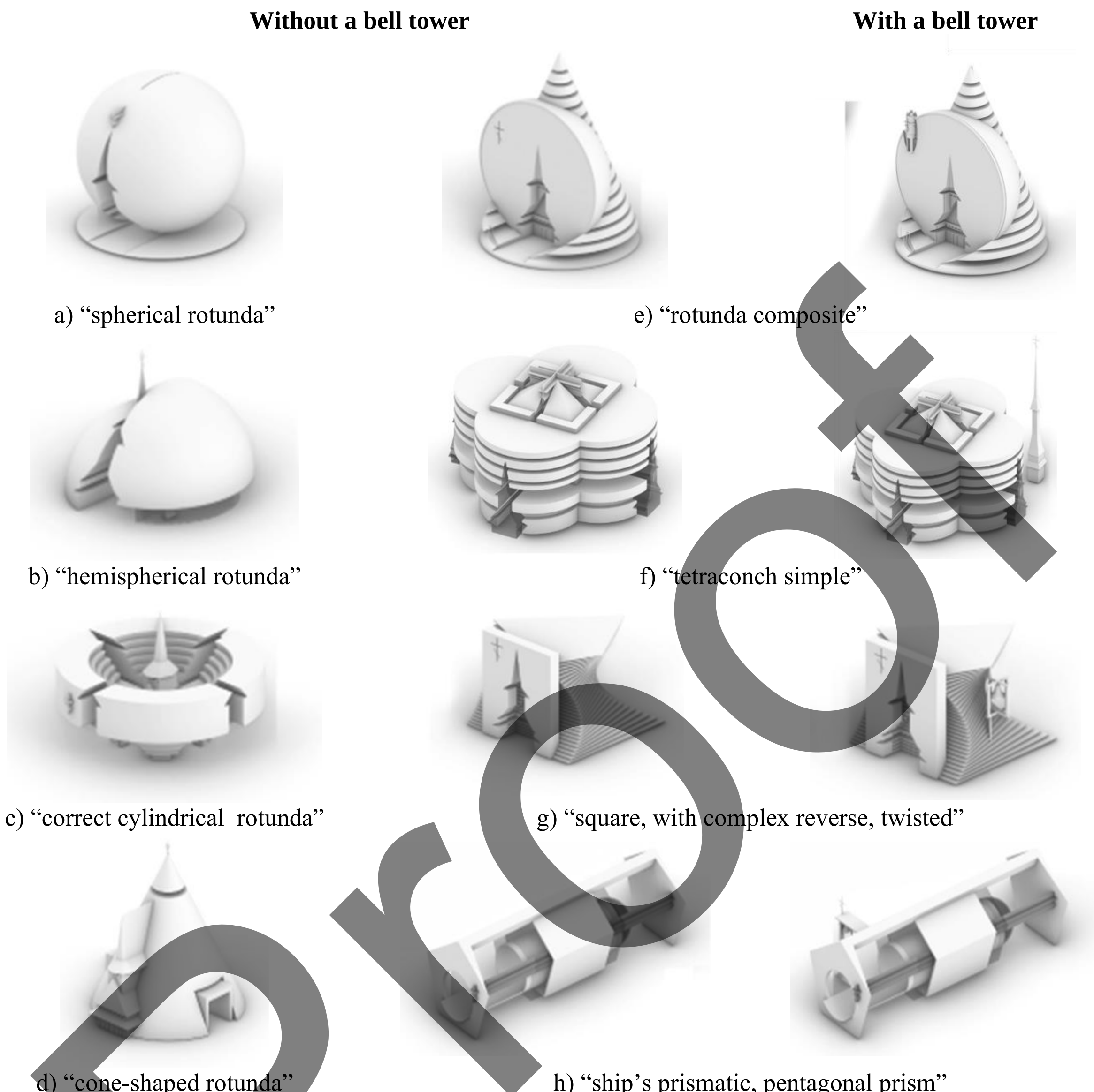


FIGURE 5. Concepts of new sacred objects according to compositional schemes of plans, images-symbols and types of a temple (without a bell tower, with a bell tower), drawing by Vladislav Tsvitok, 5th-year student, leader: Tetiana Ladan, Associate Professor, Oleg Sleptsov, Professor; KNUCA, 2020 [13].

On the basic compositional scheme of the "rotunda" plan (peripter or dipter) can be the 8 types of Orthodox churches formed.

1 "Rotunda".

1.1 *"Spherical"*, based on the use of one radius to form the volume of the building; it is also possible to create a protective shell around the building ("technocratic, biotechnical or geotechnical symbolism"). The image of the "ark" can be used as a protective shell or the image of the "globe" (Fig. 4, a), (Fig. 5, a).

1.2 *"Parabolic"*, based on the use of several radii to form the volume of the building ("biotechnical symbolism").

1.3 *"Hemispherical"*, in the form of a correct or incorrect hemisphere: with a horizontal base at the bottom or with an inverted base on top; including cut at an angle ("technocratic symbolism"), (Fig. 5, b).

1.4 *"Half-parabolic"*, in the form of a correct or incorrect hemisphere with a parabolic outline of the facade: with a horizontal base at the bottom or with an inverted base on top, including cut at an angle ("technocratic or biotechnical symbolism").

1.5 *"Correct cylindrical"*, including with angled top or bottom ("technocratic symbolism"), (Fig. 5, c).

1.6 *“Cone-shaped”*, with an extension to the bottom – symbolizes the stability of traditions or with an extension to the top – symbolic innovation or can be interpreted as a glass of the “holy grail” (“technocratic symbolism”), (Fig. 5, d).

1.7 *“Composite”*, using several forms: it is minimum to 3 forms recommended - to form a harmonious rhythmic or metric composition; including “drop-shaped” (“geotechnical symbolism”), in the form of a “balloon” (“technocratic symbolism”), with hinged support and support by cable structures (Fig. 5, e).

1.8 *“Complex inverse”* – for the formation of dynamic composition, based on the use of several irregular shapes (tilt axis): “incorrect” or twisted shapes of figures of rotation, “twisted” (“technocratic symbolism”).

Based on the compositional scheme of the “cross” plan, the following 3 types of Orthodox churches can be formed (“technocratic symbolism”).

On the basic compositional scheme of the “tetraconch” plan can be the 3 types of Orthodox churches formed [14].

2 “Tetraconch”. Organic temples for the era of the Hetmanate [15], in which the internal space and external form – a single whole [16].

2.1 “*Simple”*, a four-petalled plan, the central quadrangle is allocated neither in a plan nor in volume. A can see the volume of a temple in a proportion: a cube (Fig. 5, f).

2.2 *“Quatrefoil tower-like”*, in which the plan repeats the geometric shape of the square. A volume is dominant in the high-rise, topped by a dome on an octagonal or cylindrical central drum, wider than adjacent the four exedrae. The shape of the volume of the temple is the vertical parallelepiped, in the proportion of two cubes. It is also possible to create a sacred building in the image of “censer”, which directs prayers to all parts of space (Fig. 4, b).

2.3 *“Poltava”*, an intermediate type in which the quadrifolic forms is moderately expressed in external forms; the shape of the volume of the temple is a vertical parallelepiped, based on the proportion: one and a half cubes.

Semicircular exedra can have undercuts on different levels and act as bay windows, be terraces and bypass galleries around the square in the plan of the middle temple, surrounding the temple on the perimeter in a spiral – depending on the choice of static or dynamic solution of the temple.

Based on the compositional scheme of the “square” plan, the following 6 types of Orthodox churches can be formed, including tower.

On the basic compositional scheme of the “square” plan can be the 6 types of Orthodox churches formed.

3 “Square” (“geotechnical symbolism”).

3.1 *“Cubic”*, in which the height, width and depth of the temple are the same: “living cubic”, in which the height, width and depth are similar in size – in the proportions of the “living square”; the shape of the volume of the temple – based on the proportion: cube.

3.2 *“Rhombic”*, in which the entrances and the altar are located at the corners; the shape of the volume of the temple – based on the proportion: cube.

3.3 *“Prismatic”*, including e cut in the upper or lower parts; the shape of the volume of the temple – based on the proportion of vertical objects: a parallelepiped (height 1.5 or 2 squares), wedge.

3.4 *“Pyramidal”* in the form of a correct or incorrect pyramid – with a horizontal base at the bottom or with the inverted base at the top, including cut at an angle, the shape of the volume of the temple – based on the proportion: a pyramid, the height of which is adjusted according to the location of the object; in the conditions of development of big cities the idea of a skyscraper-candle on top of which the church as a flame – a symbol of embodiment of ardent faith, light and resurrection can develop (Fig. 4, c).

3.5 *“Composite”* – using several forms of rectangular volumes; it recommended to use three elements – to form a harmonious rhythmic composition; the shape of the volume of the church – based on the proportion of natural forms of crystals and minerals: “crystal”, “mineral”.

3.6 *“Complex reverse”*: “incorrect” or “twisted” (Fig. 5, g) to form a dynamic composition based on the use of several rectangular shapes.

There are no additional protrusions in the structure of the temple. The baths protrude outside the main volume of the middle temple.

The following 5 types of Orthodox churches can be formed and based on the horizontally elongated compositional scheme of the plan.

On the basic compositional scheme of the “ship’s” plan can be the 5 types of Orthodox churches formed.

4 “Ship’s” (“technocratic or biotechnical symbolism”):

4.1 *“Cylindrical”*, including a cut on the sides.

4.2 *“Prismatic”*, including a cut in the upper or lower parts.

The shape of the volume of the temple – based on the proportion of horizontal figures: “parallelepiped”, “triangular prism” – the mobile church can act in the image of the Angel who folds wings protects parishioners from troubles and natural cataclysms (Fig. 4, d), “pentagonal prism” (Fig. 5, h), “hexagonal prism”.

4.3 *“Streamlined”*, using curved wall surfaces.

4.4 *“Composite”* using several forms of horizontally extended at the same time. It is three elements recommended – to form a harmonious rhythmic composition; the shape of the temple volume – based on the proportion of the rhombus: “rhombic”.

4.5 *“Complex reverse”*: “incorrect” or “twisted” to form a dynamic horizontal composition based on the use of several longitudinal shapes.

Rhythmic divisions of facades using harmonious proportions based on “golden section”, “square, its diagonals and radii”, other harmonious relations. The large removal of the roof provides protection of majolica, frescoes on the facades of temples.

RESEARCH RESULTS

In the practical course of experimental design of futuristic sacred objects for the future in unusual living conditions – underwater and in space, quotations from relevant works of the avant-garde art (abstractionism by artist Vasyl Kandinsky) and of the Ukrainian sacred architecture (postmodernism by architect Mykola Levchuk) were to form future based on the synthesis of arts.

Sacred objects underwater focus on themselves as amazing underwater phytomorphic and zoomorphic creatures – “seahorse”, “algae”, “corals”, and show the ability to adapt to life in unusual conditions, to find harmony of forms in the underwater world, quickly navigating in the currents (Fig. 1).

Sacred objects in space demonstrate the possibilities of figurative thinking. In concept was a task of combining the architectural order (from work by Mykola Levchuk's architecture) and the chaos that may be present in works of abstractionists and resembles outer space (from the artist's work by Vasyl Kandinsky). The ring acts as a portal that divides these opposites into two poles, which are attracted to each other. Chaos reflects the movement forward to unfamiliar discoveries. Architectural order embodies the tail-turbine in the forms of a sacred object (Fig. 2).

Based on the proposed compositional schemes of plans, images-symbols and types of Orthodox churches (without a bell tower, with a bell tower) both the reconstruction of sacred objects (Fig. 3) and design of new objects (Fig. 4). The international and national canons, above-defined universal types of compositional schemes and three-dimensional forms of sacred objects can be used to form not only the architectural solution of an Orthodox church but also a church of another religion.

CONCLUSIONS

Sacred architectural objects are centres of restoration of psychic powers. By experimenting with the types, images, and three-dimensional shapes of temples for the future, we bring this future closer. Figurative address design based on architectural and artistic achievements of the avant-garde of the XX century and used quotations from architecture, arts and other fields, allow you to focus, in creating harmonious compositions of objects, on the main elements from which they are formed. Thus, on the examples of the experimental futuristic formation of sacred architectural objects, a creative method of prognostic design can be formed in the spirit of the development of trends and currents of the theory of “informative architecture” at the design stage of modern architectural objects and for the future [3].

Such experiments in the educational process at different levels of education (bachelor, master) allow you to reveal faith in yourself and help to reflect on the meaning of life and the content of their activities.

In the course of creative experiments, abilities suddenly open up where you do not expect them at all, and conceptual thoughts from students it is possible into quotes. “In my drawing I drew the house in the sea. So it has a beautiful shape in the middle of the sea. Living life in the world of the sea, the only dividing line between you and the water is a glass wall overlooking the coral reefs. Fish roam around your everywhere to the sound of waves hitting your home while being in complete peace in your city. Enjoy this beautiful nature, in which your Soul breathes and its beauty catches the eye” (Fouad Deburi, 2nd-year student, 2021). This concept was not a description of sacred architectural objects, but as an example of the formation of “sacred meditative thinking”.

The creative method of futuristic formation of sacred architectural objects is universal encourages the formation of individuals who study traditions, respect the achievements of the present and dream of a sustainable future, and most importantly – figuratively create and express their thoughts.

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Designing a Museum of Outstanding Personality as an Innovative Means of Revealing the Creative Potential of Architecture Students

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Abstract. The purpose of the study is to substantiate the feasibility of introduction into the training program for architectural education of a Course Project of An Outstanding Personality Museum. To achieve this goal, progressive trends in the design of exhibition buildings were analyzed, design task developed and the sites identified that are potentially suitable for setting up the experimental facility: the Hryhoriy Skovoroda Museum in Kyiv. Also, the project proposals made by students in cooperation with teachers were presented to the general public and discussed. The main results of the study are to clarify the challenges faced by the student in the process of performing such a task and the benefits of introducing a Course Project of an Outstanding Personality Museum in the bachelor's program in architecture. The practical significance of the research is to expand the list of objects of course architectural design and to improve the teaching methods.

INTRODUCTION

Nowadays, museums around the world are becoming powerful centers of culture, attracting various categories of visitors and developing dynamically. For example, according to the American Alliance of Museums, about 865 million people visit 16,000 US museums, which is an average of 2.3 million visitors a day. Museum buildings play the role of a kind of "time machine", able to transport the visitor into the past or future, and to establish a bridge between the living, the dead and the unborn [2, 3].Creating a design for a museum building allows the architects to fully demonstrate their talents, professional skills, knowledge and "out-of-the-box" thinking on the one hand, and show their personal comprehension of the historical, cultural and urban context on the other [4, 5]. This type of architectural design can also be applied in academic environment as an effective simulator for the professional training of architecture and urban planning students. Moreover, it's preferable that Ukrainian architectural schools pay more attention to the design of exhibition facilities. The lack of focus on this topic not only reduces the architectural typology encountered by students, but in long run widens the gap between Ukraine and the world leaders in museum work since the number of those wishing to get acquainted with any collection directly depends on the architectural environment in which this collection is exhibited.

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FORMULATION OF THE PROBLEM

The evolution of students' creative skills is rather a poorly explored aspect of academic education in the field of architecture and urban planning. The architecture school faces the challenge of involving students into the enchanting, deep and thrilling world of architecture in a short time; revealing a wide range of instruments used to design human living environment; encouraging the future architects to address not yet defined issues; stirring up the students' desire for personal fulfilment and longing for constant improvement. Achieving this goal requires extraordinary solutions. One of them is setting students tasks related to the implementation of socially significant values in their educational projects and purposeful selection of objects whose development stimulates associative thinking.

To test the effectiveness of this didactic technique at the Chair of Urban Planning of the Kyiv National University of Construction and Architecture (KNUBA), a kind of experiment was launched: students of bachelor's degree in architecture were invited to express the spiritual world of a prominent person in architectural space. The Hryhoriy Skovoroda Museum in Kyiv became the object of project development. The relevance of this topic is determined, on the one hand, by the approaching anniversary of the birth of the prominent Ukrainian philosopher, and on the other - the lack of a cultural center in the capital of Ukraine which would unite fans of his work and philosophy. Designing any modern museum not only helps students get acquainted with the basics of designing public buildings, but also encourages creative search. However, designing a museum devoid of a collection of material artifacts is a real challenge for the architect, especially when there is a need to use architectural means to express the worldview of a prominent person.

The experiment took place in the context of the known method of problem design [6]. The main stages of its implementation were as follows: identification of progressive trends in the design of exhibition buildings; acquaintance with the biography and works of Skovoroda; selection of sites potentially suitable for the location of the exhibition complex, taking into account the historical and associative links between the urban environment and the facts of life and the main ideas of the Philosopher; development of artistic concepts of the architectural space of the museum and scenarios for immersing visitors in the worldview of the Thinker; selection of means of artistic expression; implementation, protection and demonstration of designs; discussion of the obtained results and outline of further measures to improve the methodology of educational design of museums of prominent personalities.

PROGRESSIVE TRENDS IN THE DESIGN OF EXHIBITION BUILDINGS

In the second half of the 20th century, exhibition buildings began to be transformed into multifunctional complexes – centers of attraction for locals and tourists. For example, the Georges Pompidou National Center for the Arts and Culture in Paris (architects Renzo Piano and Richard Rogers, 1977) hosts lectures, music concerts, performances, and film screenings in addition to monographic and thematic exhibitions. A workshop for master classes was organized for children and teenagers. Kandinsky's library was opened for researchers of the history of modern art [7]. Small cinemas, children's research laboratories, interactive elements of the exhibition, which are organically integrated into the public space of the National Center for Science and Technology "NEMO" in Amsterdam (architect Renzo Piano, 1997) are designed to explain the laws of the universe and interest young people in research.

Museums, which for centuries were mostly monofunctional, are now becoming cultural centers with many functions. Exhibition areas are usually complemented by souvenir shops and restaurants. Exhibition buildings include cinemas, auditoriums, and children's research laboratories. Some museums have venues for public events and representative recreational spaces.

The Van Gogh Museum in Amsterdam, two wings of which were designed by famous architects Gerrit Rietveld (1973) and Kiso Kurokawa (1999), has not only a permanent and variable exhibition, a museum shop, an information office, and a museum café. It also boasts simulators, which help in understanding the content of the artist's research, arranged corners of children's art and special areas for photography with copies of exhibits.

Exhibition institutions are the first to try to introduce information technologies both in the exposition and in the three-dimensional solution of their buildings. For example, in the Museum of Cycladic Art in Athens, on the touch screen you can watch the sailing of Roman ships, get acquainted with the technology of glassmaking, learn something new about linear writing (a kind of Cretan calligraphy).

The Ars Elektronica Center Museum of Contemporary Art in Linz, Austria, founded in 1996, specializes in computer and media art. The building, designed by Treusch Architecture ZT GmbH, has the largest LED media façade in Europe. In the interior of the building, 4 projectors create a system of projections on the walls and floor (16 by 9 meters each). The credo of the museum is “Art. Technologies. Society”. From the exhibition you can learn how new technologies are changing our lives, in particular, how artificial intelligence is arranged, how cars can control themselves, how robots are programmed, how 3D printing works, how to process your own DNA with genetic scissors and much more. One of the most interesting places of the museum is the Deep Space 8K, where laser tracking and 3D-animation immerse visitors in a virtual world, where everyone has the opportunity to interact with the exhibits. In 2015, AEC opened a children’s research laboratory for 4-8-year-old visitors [8].

Since the creation of the Guggenheim Museum in Bilbao in 1997, designed by architect Frank Gary, the building itself has become the first exhibit in the museum’s collection, sometimes even provoking criticism. But now more and more famous architects are designing museums, creating iconic masterpieces [9]. For example, the complex of buildings of the Jewish Museum in Berlin, designed by Daniel Libeskind, not only tells the story of the Jewish people, but also educates in some way, giving visitors the opportunity to feel and partially share the suffering of Jews during World War II [10]. Architectural works of this level clearly reveal the connection between architecture, history and philosophy.

The latest design solutions reflect the expansion of the traditional mission of museums, which nowadays, in addition to the main function, focus on popularizing information about various spheres of life, stimulating children's interest in learning about the world and attracting the attention of all segments to cultural values and scientific achievements. The architectural space of modern museum complexes takes into account both the trend of transformation of exhibition buildings into places of communication, and the commercial component of their activities.

THE DESIGN OF AN OUTSTANDING PERSONALITY MUSEUM AS AN ELEMENT OF ARCHITECTURAL EDUCATION

The study of domestic and world experience in designing exhibition buildings has allowed to form a wide list of public spaces that turn the museum into a modern cultural center, interesting for different segments of the population. Due to the analysis of analogues, the following appeared in the projects of students in different combinations: exhibition halls for permanent and variable exhibitions, library, media library, cinema, cafeteria or cafe, information center, winter garden, meeting rooms, universal assembly hall, recreation area, storage, workshops, working rooms for museum staff, office and auxiliary premises.

Each student, in creative collaboration with project supervisors, developed their own concept and selected the means of artistic expression that would allow to fully embody in the spatial and plastic solution of the museum building the author’s understanding of Skovoroda’s thoughts.

Several locations in Kyiv were chosen to house the museum. Some of them are located in the areas which, according to documentary evidence, Skovoroda visited during his stay in the city. Most of these sites are located in the central part of Kyiv in the Podil area. Only an associative connection can be established between the other sections and the Thinker’s texts.

Some students have located the Museum in a historic area. In particular, four – in areas along Kyrylivska street on the historic hills of Tatarka. Among them is Mykhailo Klyshnaty, who took the concept of a difficult spiritual path, reproduced in the interior in the form of a labyrinth of mirror surfaces, as the basis of the design decision (Fig. 1). On the facade, the author placed the painting by Lisa Harris “Visitor”, the free abstraction of which supports the basic concept of the Museum. The works of deconstructivists, postmodernists, musical avant-garde, and Christian labyrinths of the 15th-17th centuries inspired the student to create an artistic image of the building and Skovoroda’s aphorism: “Not to worry about anything, not to worry about anything means not to live, but to be dead, because care is the movement of the soul, and life is the movement”.

Mykola Nikolayev (Fig. 2) decided to place the Museum on Kyrylivska Street, in symbolic proximity to the Museum of Modern Art, on the territory of an ancient quarry, from the clay of which a large part of Kyiv was built during the construction boom of the 19th century. The museum building is located at the foot of Mount Yurkovytsia, a valuable element of the historic landscape of Kyiv. The design takes into account all the restrictions imposed on construction in this protected area. The linear-enfilade structure of the Museum: from the utilitarian premises of the entrance group to the cozy, centric in shape, winter garden with a fountain, symbolizes the spiritual development of the Philosopher. This creates an opportunity for visitors to mentally walk this path next to Hryhoriy Skovoroda. The museum garden is visually connected to the surrounding landscape with the help of shop-window glazing. Due to this, Kyiv antiquity is included in the Museum’s exposition. Another means of forming a connection between the present and the past is the decoration of the facade of the Museum with corten-steel, which associatively combines the modern building with the historical context - the industrial use of the site in the 19th century.

Valery Mayer chose as the design site the site within the block of Nyzhnoyurkivska and Kyrylivska streets and Mylny Lane, which are in the north-western part of the historic Podil area. Now there is an abandoned industrial building there and the area has the potential for renovation with a change of function. The creation of the park and the regeneration of the pond will allow, in the future, to create public spaces and recreational areas near the cultural center – the Museum of Skovoroda. The design (Fig. 3) is based on the basic tenets of Skovoroda's philosophy – the existence of three worlds, each of which has a dual nature, one – visible (material), the other – invisible, idealistic, divine. The volume of the museum consists of two parts – the lower, static, heavy "material" and the upper – light, transparent, dynamic, which embodies the "divine beginning" of all things. By means of architecture, the student expressed his own understanding of the ethical teachings of Hryhoriy Skovoroda to find the path of man to love and happiness.

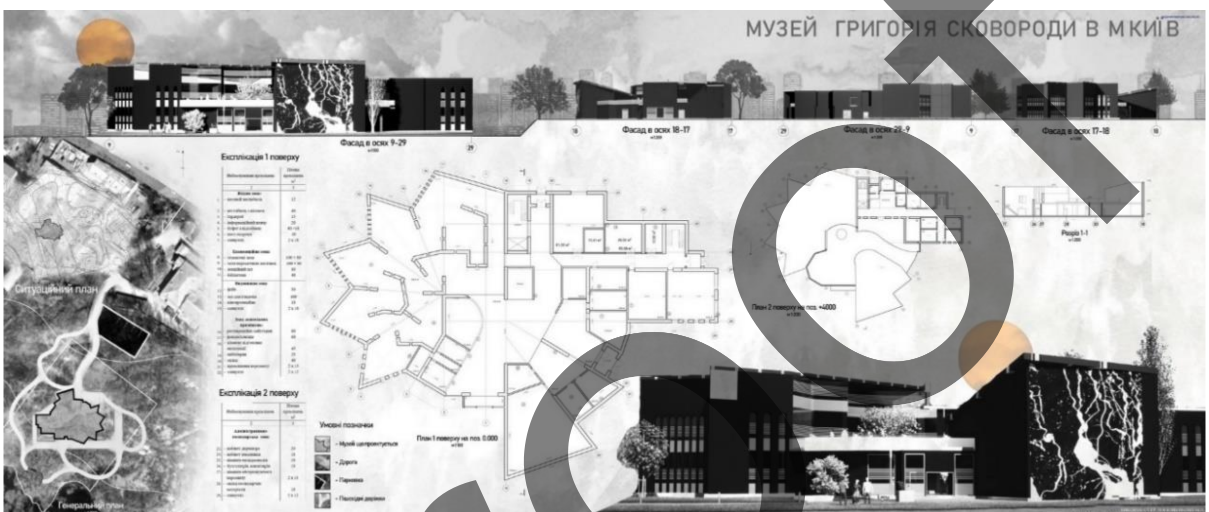

FIGURE 1. Design of Hryhoriy Skovoroda Museum in Kyiv. Student M. Klyshnaty, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

FIGURE 2. Design of Hryhoriy Skovoroda Museum in Kyiv. Student M. Nikolayev, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

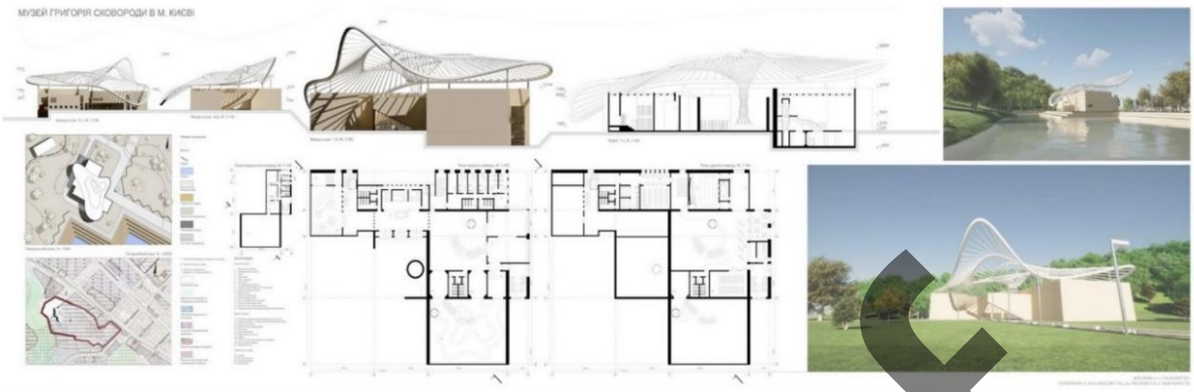

FIGURE 3. Design of Hryhoriy Skovoroda Museum in Kyiv. Student V. Mayer, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

Ruslan Siryk chose a site 1 km from the center of Podil, Kontraktova Square, factoring in the new street provided for in this area by the city master plan. The artistic image of the complex designed by him (Fig. 4) reveals the basics of Skovoroda's worldview: the central recreational space of the Museum corresponds to the inner "garden of the soul" hidden from outsiders. The garden not only unites the premises for visitors and employees into a single democratic whole, but also embodies the image of freedom, independent living and free thought of the Philosopher, who said: "The world chased me, but never caught me". On the other hand, the three-dimensional composition of the cultural center is based on a rethinking of the layout of ancient Ukrainian settlements, and some blocks of the building resemble stylized images of traditional Ukrainian housing. The green spaces of the courtyards evoke the lines of Taras Shevchenko's poetic work "The Cherry Orchard outside the House", and the association of the museum complex with the Ukrainian village of Skovoroda's time acquires its final integrity. The author pays special attention to the visual connections of the Museum`s premises with its surroundings – the historical landscape of Kyiv – first of all with Mount Yurkovytsia, towards which the main halls and recreational spaces are oriented.

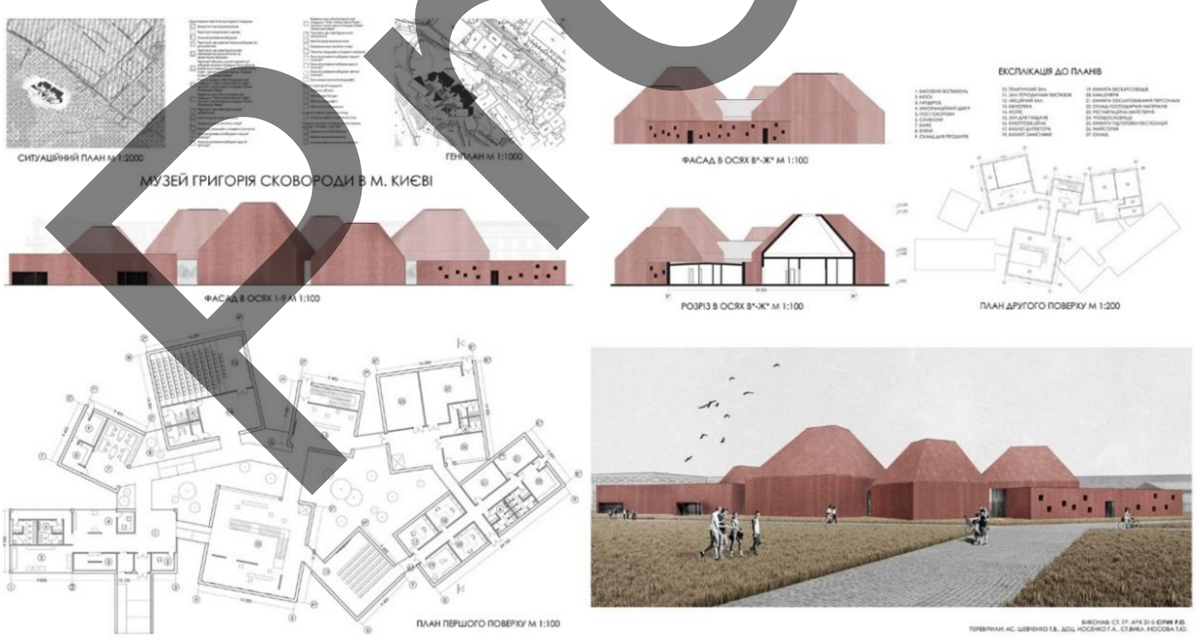

FIGURE 4. Design of Hryhoriy Skovoroda Museum in Kyiv. Student R. Siryk, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

Another design site is located on a historic street, Andriyivsky Descent, where the Yunost factory once operated, which ceased to exist a few years ago. Today, Andriyivsky Descent is not only a meeting place for artists, but also a public space that unites various cultural sites. The location of the Hryhoriy Skovoroda Museum in this place will allow expanding the functions of the citywide cultural center. This site was chosen by two students who proposed to place the Museum at a distance from the street. The ground floor in front of the main entrance will be decorated with geoplastics, retaining walls, landscaping and a stylized sculpture thematically related to the Museum.

The concept of Yehor Plyushch's design (Fig. 5) follows from Skovoroda's teaching about the three worlds. The first world (the world of the Bible) is represented by an exhibition hall in the form of a ramp, which embodies the biblical doctrine of moving to the heights of self-improvement and leads visitors through quotes, paintings and certain symbols up to the second floor. The second world (the world of man – microcosm), according to the Philosopher, is the most important, so in the design it is distinguished by a distinct architectural form. The third world (the general world, "where everything generated lives" – macrocosm). This world is embodied by the emotionally and informatively rich central premises of the Museum, which shows just how the big world is filled with various phenomena and experiences. The sloping roofs of the Museum are in tune with the slopes of Kyiv's streets and the relief of the hills and organically combine the new building with the historic urban environment.

Kateryna Rashkivska placed the Museum on the same site: between Andriyivsky Descent and Frolovska street. The main idea of the design (Fig. 6) was to reflect the breadth and universality of Skovoroda's worldview. The Philosopher's statement: "Take the top and you will have the middle" was the basis of the work. The student designed the building in the form of a bright and light volume, which is tactfully inscribed in the landform. From the point of view of symbolism, the museum building can be interpreted as a white mountain that complements the existing landscape. The white color of the museum walls symbolizes the memory of ancestors, the change of stages of existence, as well as Orthodoxy. The building looks festive and friendly against the background of Kiev's hillslopes. The building encloses the part of the territory where it is proposed to organize a public space to connect the entrance to the Museum with Andriyivsky Descent, where there is a lack of cozy recreational areas. The planning of the Museum includes a system of interconnected halls and galleries. The lobby flows into a series of exhibition halls with panoramic glazing, which allows you to include the historic environment in the interior of the Museum. The accent element of the main facade is the sun protection net, which continues on the roof of the building. The grid creates a rhythm with the help of cylindrical shapes suspended from the ceiling, which filter the light, dim it in the lobby and passages from one exhibition hall to another, creating a veil effect.

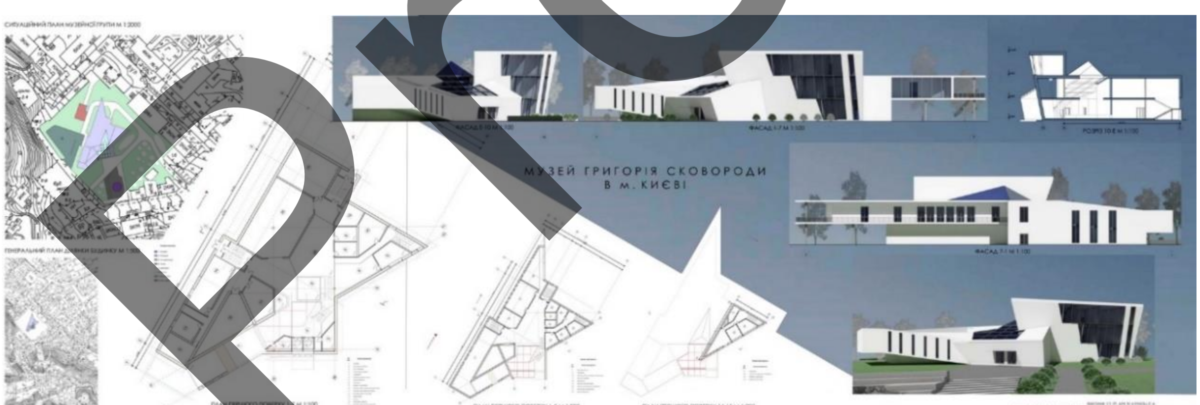

FIGURE 5. Design of Hryhoriy Skovoroda Museum in Kyiv. Student Ye. Plyushch, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

Heorhiy Parfenyuk chose for the museum design (Fig. 7) a site on Voznesensky Descent, the street that connects Old Kyiv with Podil. It is located in the historic area of Kopyriv Kinets, where in the days of Kievan Rus there was a trade and craft suburb. The monument of those times is the foundation of the 12th century church on the grounds of the National Academy of Fine Arts of Ukraine. The Museum is proposed to be located opposite the Academy. This would create a common public space in front of the entrance areas of both institutions. The part of the Museum turned towards the gully, opens onto a natural center and has an easterly orientation. In this direction museum visitors will move from the lobby to the exhibition halls. Hryhoriy Skovoroda's philosophy is reflected in the plan of the Museum: the linear construction of the exposition echoes the travels of Skovoroda, who at the beginning of the journey seeks and at the end finds the meaning of life. The same idea is reflected in the halls. They narrow in the direction of the entrance, because at the beginning of the path a person's knowledge is limited, and at the end of life his worldview expands significantly. Skovoroda's idea of several worlds is reflected in the two-world spaces of the halls and the atrium of the main lobby. This organization of space allows visitors to perceive the exhibits from several angles. The three-dimensional solution of the Museum provides for the rhythmic division of the facade from the street using colored glass inserts and the exit of the eastern facade to the gully with the help of open terraces.

FIGURE 6. Design of Hryhoriy Skovoroda Museum in Kyiv. Student K. Rashkivska, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

FIGURE 7. Design of Hryhoriy Skovoroda Museum in Kyiv. Student H. Parfenyuk, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

Kateryna Volokh designed the Museum siting it at the bottom of Andriyivsky Descent, at its intersection with Nyzhniy Val and Verhniy Val streets, successfully using an interesting landform (Fig. 8). Hryhoriy Skovoroda is an idealist, so it was decided that the Museum should be as airy as possible, light and not tied to something heavy and material. Temporary exhibitions will be held in a transparent gallery, which unfolds along the perimeter of the first floor and symbolizes the cyclical nature of human life. The permanent exhibition is to occupy the red cube in the center of the complex. It symbolizes man as the center of the universe – this is the main idea of Skovoroda`s philosophy. On the minus ground floor there are technical rooms that do not require natural light. On the second floor is a library, a conference hall, a cafeteria and two observation decks. The third floor is occupied by office premises.

Danil Pylypchuk chose for the Museum a nonoperating bus station on Zhytniotorzka Street. It is located in the very center of Podil, next to the Kyiv-Mohyla Academy where Hryhoriy Skovoroda studied. A feature of this area is the underground river under it. It is proposed to partially open it and create a public space near it, a relaxation area, a place where people can avoid the hustle and bustle of the city and be left alone with their own thoughts. This allows you to create a comfort zone for guests and residents of the city, which will help to penetrate into the spiritual heritage of the Thinker. The main urban idea of the Museum (Fig. 9) was the creation of a modern building, commensurate with the historic buildings of Podil. In accordance with the monument protection restrictions in force in this area, the height of the museum building is 27 m, the articulation of the facades takes into account the rhythm of the surrounding buildings. The configuration of the first floor repeats the existing layout of the blocks, and the second floor, thanks to its rotation of 45º relative to the first, has an ideal orientation for exhibition halls and art galleries with respect to the cardinal directions. The stylistic prototypes of the Museum were both the historical buildings of Kyiv and the residential quarters on Khoreva Street built in the 1970s. The terraced volumes of the museum serve as a transitional element between the enclosed spaces, the urban environment and the landscape of Kyiv hills.

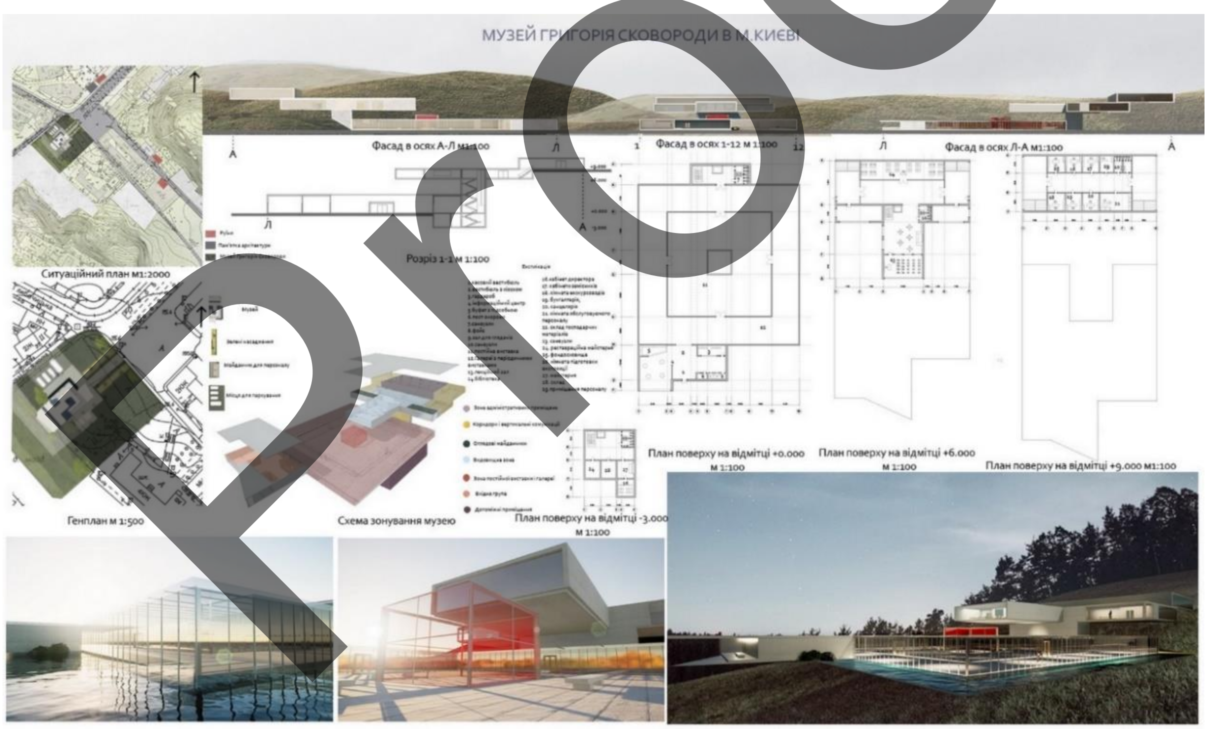

FIGURE 8. Design of Hryhoriy Skovoroda Museum in Kyiv. Student K.Volokh, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

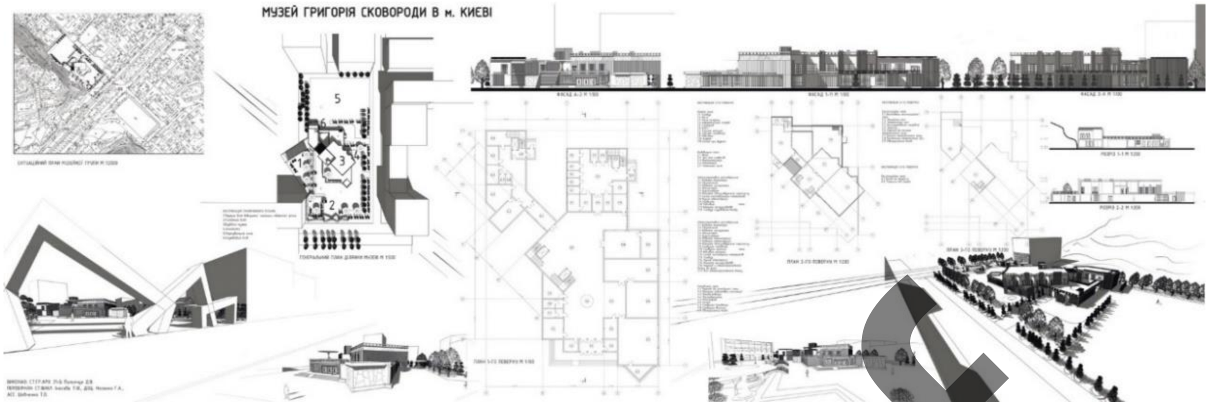

FIGURE 9. Design of Hryhoriy Skovoroda Museum in Kyiv. Student D.Pylypchuk, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

The site chosen by student Oleksandr Halipchak to develop the museum design (Fig. 10) is directly related to the history and spirit of Hryhoriy Skovoroda. The south-eastern part of Holosiivskyi Park is located on the plateau that separates the Museum of Folk Architecture and Culture in Pyrohovo and the Kytayiv Monastery. Between these two monuments of Ukrainian culture, tourist trails run through the park. Therefore, it was decided to develop this natural movement: to turn the park into a zone of art exhibitions and add a new center of gravity (the Skovoroda Museum). Thanks to this, it would be possible to create a single complex that would combine the Cossack Baroque (the main ensemble of Kytayiv Monastery was formed in the lifetime of Skovoroda, who visited there to see his brother Yustin), the wooden architecture and the main philosophical contribution of Ukraine to human development – Hryhoriy Skovoroda. To this cultural and historical potential of the territory should be added a spiritual connection: Skovoroda often lived in monasteries and secluded himself in the lap of nature, working on his writings. The landscape of Holosiivskyi Park encourages such self-deepening. The author's vision of the Baroque era was reflected in the image of the Museum. The dynamic and tense shape of the plan is balanced by straight, inert vertical lines of volume that connect the building to the ground as if it were growing out of it. The Ukrainian Baroque and the turbulent 18th century must be verified by a modern objective view of the past and the processes that surrounded the life of Skovoroda. The same logic is embodied in the construction of facades: the tension of the slots balances the non-glazed areas of the walls.

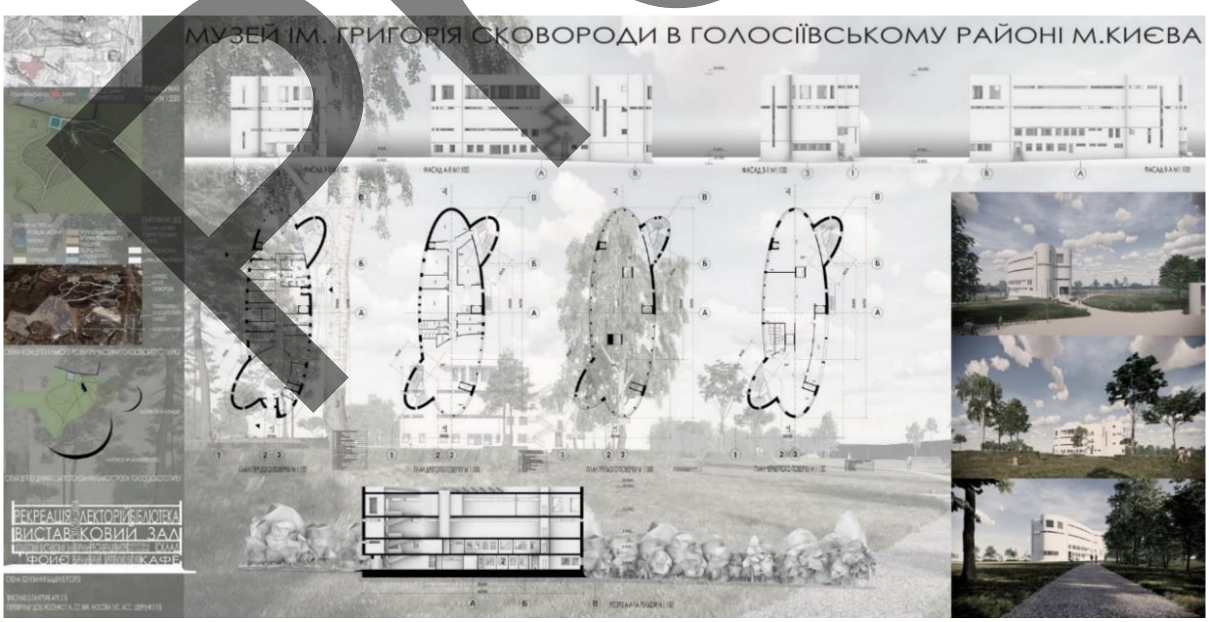

FIGURE 10. Design of Hryhoriy Skovoroda Museum in Kyiv. Student O. Halipchak, supervisors: Associate Professor H. Nosenko, Senior Lecturer T. Inosova, KNUBA

Victoria Loshak and Alina Konyuk followed the path of associative connection between the place chosen for the Museum and the Thinker's philosophy. They preferred the site on Ivan Vyhovsky Street in Vynohradar – a district of Kyiv, where gardens and vineyards have been grown since the second half of the 19th century. In memory of these gardens and the famous collection of poems by Skovoroda "The Garden of Divine Songs" the students proposed to place the Museum of the Philosopher here.

The spatial basis of Alina Konyuk's design is formed by a cylinder. According to the famous art theorist Vasyl Kandinsky: "... a circle, like a snake biting its tail, is a symbol of infinity and eternity ...". This is consistent with the symbolism of Christian art, where the circle is a symbol of heaven, holiness and eternity. According to the author, this form most closely corresponds to the image of the Museum of the outstanding Ukrainian philosopher.

According to Victoria Loshak, the Skovoroda Museum should become a place where a person can get acquainted with the teachings of the Philosopher in more detail and get one step closer to studying his own self. The search for happiness and the meaning of life has always occupied a significant place among the spiritual problems of mankind, because everyone strives to achieve inner harmony and be happy. Skovoroda believed that a person will not understand the world around him if he does not know himself. Most of the walls of the building have a rounded shape as the embodiment of movement in a circle – one of the most important, according to the Philosopher, principles of existence. The black and white colors of the facades of the Museum embody the opposites and symbolize the struggle of light and darkness, good and evil. The gray color of some details, as well as gray shadows express a combination of opposites.

The designs of the Hryhoriy Skovoroda Museum in Kyiv, developed by students of the KNUBA Department of Architecture, were exhibited to general public at the Center of Ukrainian Culture and Art in Kyiv. At the grand opening of the exhibition on February 4, 2021, the authors spoke about the main worldview ideas of the Ukrainian philosopher, which they embodied in their projects, the special aspects of creating museum complexes in the urban environment, the defining features of functional-planning and spatial solution of buildings, about the building systems and materials chosen by them, about elements of decoration of interiors of the Museum and adjoining public spaces. The management and leading professors of the Department supported the initiative of the Chair of Urban Planning and highly appreciated the work submitted for review.

The exhibition attracted the attention of the public, including members of the Organizing Committee of the public initiative "Hryhoriy Skovoroda-300", created to commemorate the anniversary of the birth of the famous Ukrainian. With their participation, a round table discussion was held at the Center of Ukrainian Culture and Art in Kyiv to exchange views on the work done and the further development of this cultural initiative. Careful consideration and discussion of student projects helped to outline the next steps both to promote the very idea of setting up a Hryhoriy Skovoroda cultural center in the capital of Ukraine and to deepen the understanding of the purpose of such an institution.

The exhibition of designs of Hryhoriy Skovoroda Museum in Kyiv was covered in the mass media [11]. The Center for Ukrainian Culture and Art in Kyiv organized an online exhibition of student works [12] and published an interview with the winner of the competition [13]. Even before the end of the first exhibition, the Chair of Urban Planning of KNUBA received two proposals for holding similar events. The statements of outsiders testify to the relevance of the proposal of the Chair of Urban Planning of KNUBA to include in the bachelor's program of architecture the project of an Outstanding Personality Museum. And the great attention to the results of creative cooperation of teachers and their students convinces students that even the implementation of a regular course project can turn into a remarkable event.

CONCLUSIONS

The study has confirmed the hypothesis that the design of a museum of outstanding personality is an effective means of revealing the creative potential of architectural students. The technique developed by us includes four stages. The first stage provides for a pre-project analysis, which includes a study of current trends in museum design; study of the biography and creative work of the outstanding personality concerned; selection of a site suitable for the location of the exhibition complex and associated with the relevant personality, and development of a design specification. The second stage involves finding the idea to be embodied in the design; development of the concept of the museum and the choice of means of artistic expression of the spatial and plastic solution. At the third stage, the actual design is carried out, i.e. the master plan of the site is developed; the functional-planning structure of the building is formed, which is based on the technology of museum work; the three-dimensional composition of the building is checked; the building and decorative materials are selected; intentions for landscaping and site finishing are recorded. The fourth stage is devoted to the exposition and discussion of projects, coverage of the received proposals in the media, analysis of the feedback from participants in the educational process and representatives of civic organizations.

The proposed method was tested in the process of course architectural design of the Hryhoriy Skovoroda Museum in Kyiv at the Chair of Urban Planning of the Kyiv National University of Construction and Architecture. The results obtained by us differ significantly from the consequences of the course project based on the usual teaching methods. The difference consists in the growing interest of students in the design process and the end result of their own work. This increases the variety and quality of developed design solutions, improves students' communication skills with members of the public, unforeseen by the traditional curriculum, and finally recognizes the importance of their efforts for society. All this testifies to the effectiveness of the methodology developed by us and encourages its use in the design of museums of other prominent personalities. In addition, we see the potential to improve the methodology itself, for example, by introducing a section on the interior design of individual museum premises.

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Semiotic Interpretation of Sign Forms in Architecture

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Abstract. Architecture is a communication where a language is formed to create architectural messages. Besides, the architectural message can be perceived and interpreted differently, from the point of view of the author and the viewer, or the recipient. The problems of perception of architectural objects from the point of view of communication between the architect and the consumer are considered here. The article discusses the basics of architectural semiotics. The main parts of architectural semiotics are considered: semantics, syntactics, pragmatics and grammar. Issues related to the nature of sign systems are traced. The main sections of architectural semiotics are considered, where several large and rather autonomous topics are distinguished, the knowledge of which will allow to operate more freely in the architectural language. Metaphorical features of architecture, its vocabulary, some symbolic and semantic possibilities of both historical and modern architectural language are determined. Similarly, despite the flexible interpretation and ambiguity of architectural metaphors, certain types are distinguished - these are simple metaphors, mixed metaphors and alluding metaphors. Thus, changes in short-lived codes of architectural language do not affect the slight mystery and, at the same time, the ambiguity of this image. This is the highest metaphorical level, where there is a fusion of elite and popular codes for reading the language of architecture on a subconscious level.

PROBLEM

The problem with the perception of architectural objects is the unexpectedness of its results. If architecture becomes an information program, a source of programming the flow of associations, emotions, thoughts for a person, the recipient participates in creativity along with the architect, acts as his associate. A common vision of the recipient and the architect occurs, when the product of architectural creativity is a product of aesthetic empathy for them. In order to be able to perceive objectively, the concept of a thesaurus (from the Greek - treasure) is used. The concept of thesaurus helps to determine the extent of information received by the recipient, to characterize the changes that occur with the recipient at different stages of their training. If the thesaurus of the recipient is insufficient, then, whatever the level of architectural information, it will not be perceived, and the consumer will not have any emotions and experiences. Thus, the value of architectural information depends entirely on the consumer's thesaurus. Therefore, it is expedient to form architecture from the point of view of the language of certain information created by the architect herself, using the semantic analysis of the form of architectural objects from the point of view of semiotic interpretation of sign forms.

RELEVANCE

Architecture reflects the social man, the reality around him, in his most basic and common spiritual aspirations. However, architecture is incapable of direct expression, it operates with signs and codes that the viewer must interpret and complete himself. What are the ways of communication in an architectural message? The language of architecture - what is it, with what signs is it easier to speak the language of architecture, is the whole language clear to the viewer? These and other questions are asked by the architect who creates the language of architecture of the future. The messages received by the consumer consist of sets of such elements, volumes, forms which create the general view,

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character of a separate building or ensemble of buildings. It is necessary to remember the dialectic of the original and the common. At the minimum redundancy of the information of the architectural message it will be hardly clear to the recipient, at the maximum redundancy it will be original and will not bring new information. The more original the object, the less clear it is, the common combination of architectural forms and volumes is devoid of novelty, carries zero aesthetic information.

MAIN SECTION

Modern architecture in its development seeks to follow the latest technical advances and maintain continuity. Therefore, now the trend of merging different disciplines is becoming more widespread. Architecture, as an area of socially oriented activity, is developing in the direction of involvement in the design process of sociology, psychology, economics, technical sciences. Therefore, there is a significant amount of interdisciplinary research that touches on issues of modern architecture from different angles. Much attention is paid to the phenomenology of architecture, the phenomenon of visual perception, color, the basics of composition. The issues of primary geometry in the details of the facade remain poorly raised. The architectural form is considered as a system, which is quite justified. But the role of individual elements of this system from the standpoint of informativeness is insufficiently studied. Especially since the communicative requirements for the architectural environment are growing every year. One of the reasons of the monotony of modern architecture is the lack of code with the help of which it could "speak". Therefore, it would be appropriate to use a semiotic search for a universal architectural language that will be understandable to both the artist and the consumer [6].

The categories of architectural language are based on the categories of semiotics. One of the founders and agitators of the semiotic approach in linguistics and culturology Y.M. Lotman identifies three different aspects of semiotics:

1. Semiotics as a scientific discipline, the object of which is the sphere of sign communication. From the point of view of classification of architectural signs in this direction the researches were conducted by - M. Benze, E. Arin, C. Jenks, Y. Edik, V. Magnano-Lampinioni, F. Shoay, I.A. Strautmanis, R. Krie, Kr. Alexander, A.V. Ikonnikov, U. Eco;
2. Semiotics as a method of the humanities, able to penetrate into various disciplines and deals not with the nature of the object, but with the method of its analysis. The study of architectural and semiotic methods of structuring the language of architecture was carried out by J. Broadbent, U. Eco, I.G. Lezhava, A.E. Korotkovsky, V. Markuzon, G.D. Stanishev, N. Park.
3. Semiotics as a "peculiarity of the scientific psychology of the researcher", the composition of his thinking, everything attracts the attention of the semiotics researcher, semiotized in his hands - such interpretations by architects and philosophers: U. Eco, K. Bont, P. Reeker [4].

There are two points of view on the possibility of analyzing the language of architecture and considering architecture as a language and text as a system that transmits information from the standpoint of semiotics, the science of the formation of meanings and meaning of forms, the legitimacy of analogies between architectural form and text. Some researchers believe that the application of semiotic and linguistic methods to space makes no sense and insist on sovereignty and complete independence of spatial activity and spatial experience. Others see architecture as a manifestation of linguistic reality, the "dictatorship of language," and believe that general semiotic models can give impetus to the development of architectural theory and can be directly applied in the analysis of architectural form.

The founder of structural linguistics is considered to be the Swiss linguist Ferdinand de Saussure, who expressed a number of fundamental principles that significantly influenced the further development of the science of signs. In particular, he identified three main aspects of the study of signs and sign system: syntax - internal, structural properties of sign systems, correct construction of signs; semantics - the relationship of signs to the determinant (meaning of signs) and pragmatics - usefulness, value of signs from the user's point of view.

Architectural semiotics also consists of three main parts: semantics, which deals with the semantic side of architecture; syntax, which is responsible for the relations of parts of the architectural form with each other and in relation to the whole; and pragmatics, which deals with the relationship between architectural form, an architect - its creator and "consumers" of architecture - people to whom this architecture is addressed. In architectural semiotics, another section is actively studied - architectural grammar, because the principles of formation of architectural language are quite different from the linguistic languages, and their grammar cannot be used in its pure form to solve architectural problems.

Architectural syntax refers to the section of architectural semiotics that studies the syntax of architecture, i.e. the structure of the combination of architectural elements and the rules of their formation and transformation regardless of their meanings and any functions of sign systems (buildings, ensembles, complexes and other architectural and urban formations). Architectural syntax is based on such pillars as the physical laws of gravity, the original geometry of the world, the optical laws of perception. In addition, it is influenced by the construction and technical capabilities of society. An architectural structure must be created according to certain rules of syntax:

- it should, in general, stand (including the so-called mobile architecture);
- it should have a top and a bottom;
- it should have a certain internal space;
- it should have certain types of window openings to connect the interior and exterior space;
- it should have certain types of structures, materials [3].

The spectator should, one way or another, see and feel it. If we are talking about an architectural object, which should be implemented, and not about the artistic and graphic composition, then when creating this object, we must consider the objective physical laws. The boundary of the development of construction capabilities of our society lies in basic physics. These basics dictate the basis of syntax. Architectural syntax has received a great deal of attention throughout the development of architecture, precisely because of the above-mentioned peculiarities, in contrast to the semantics and sometimes pragmatics, the values of which were fluctuating greatly. At the same time, different aspects of architectural syntax at different stages of language development were very different, as well as its relationship with other major components - pragmatics and semantics. In ancient times, the rules of construction of the buildings were clearly developed, and in many respects, especially in its applied part, were based on clear syntax. A distinctive positive feature of this time was the connection of syntactic rules with the semantics of the sign and the semantic field of the architectural whole. A well-known historical nonsense - the absence of the arch at the ancient Greeks - is explained by the fact that the arch did not fit into the semantic codes of Greek architecture. In this regard, it was excluded from the syntactic range, in contrast to the Romans, who left and actively used and developed this element. It was the arch that largely allowed them, based mainly on Greek and Etruscan architecture, to reflect their mentality, change the visual and semantic codes not through denial and violation, but via the continuity and further development of the architectural language of the order system of antiquity. Another distinctive feature of the ancient syntax was an abundance of rules that are clear to both professionals and the entire educated part of society and are based on the geometric and optical principles of harmony. The syntactic features of this type included: the principles of thinning the column, the principles of changing the distances between the columns, the ratio of the capital and the rest of the column, the proportional ratio of the frieze, cornice, base and more [3].

Architectural semantics implies the section of architectural semiotics which studies the rules of interpretation of signs and composition of meaningful expressions that can be seen and felt through the perception of architectural systems or complexes, i.e. architectural semantics studies architectural language and its components in terms of expressing specific content. The essence of semantic doctrine is the correspondence within a given system of certain signs to a certain semantic code. With a certain degree of conventionality, we can say that style is the only semantic space of architectural signs. The longevity of the style depends on the longevity of the architectural codes and on the relationship of the semantic field with the syntactic system. Apparently, the most consistent semantic principle of the architectural language of antiquity in history, was created in unity with the syntactic doctrine of architecture and was expressed in the form of an order system. The architectural signs of the order system had clear meanings, the boundaries of the reading codes were fixed within the framework of ancient culture. The combination and comparison of ancient orders gave not only semantic characteristics but was directly related to the syntactic features of buildings. The relevance of a particular order in a given case was clearly defined, and this, in turn, determined the system of proportioning parts and the whole, the use or non-use of individual elements and materials.

Architectural pragmatics implies the section of architectural semiotics that studies the relationship between architectural elements or architectural systems and their users. This section is closely related to the traditional questions of functional use of objects in architecture.

Considering the main sections of architectural semiotics, we can identify several large and rather autonomous topics, knowledge of which will allow to speak architectural language more fluently. These include metaphorical features of architecture, its vocabulary, some symbolic and semantic possibilities of both historical and modern architectural language. Despite the elastic interpretation and ambiguity of architectural metaphors, we can still distinguish certain types among them. These are: simple metaphors, mixed metaphors, alluding metaphors.

Simple metaphors include unambiguous metaphors that arise regardless of the difference of mentalities or local semantic codes. These metaphors are literal, straightforward. They can be both positive and negative (which is much more common in architecture). This is rather rare phenomenon in architecture, it occurs most often when in order to achieve any idea (often advertising) the method of excessive simplification of the visual code is used, reaching a literalism in its reading, to a kind of extreme infantility of the image. The most striking examples of this are booths selling donuts and hot dogs in the United States, created in active collaboration with experts in the field of commercial advertising. In the history of architecture, similar projects were made by professional architects (the project of the cowshed of C. N. Ledoux in the form of a cow in the XVII century). A simple metaphor carries clear, unambiguous information and can have not only negative but also positive emotions [4].

Mixed metaphors include images that combine a set of different simple metaphors. As the famous American architect and theorist Charles Jenks writes, "a mixed metaphor is strong, as anyone who studies Shakespeare knows" [3]. The more incredible the combination of ideas in the building, the more this building impresses our imagination and the longer it stays in our memory - the more its perception belongs to the type of mixed metaphors. Mixed metaphor includes both organic and surreal, rational, and other metaphorical effects. It allows you to combine both popular and elite visual codes, both positive and negative emotions. The more complex the mixed metaphor, the more attention it attracts.

But the strongest is an alluding metaphor. This metaphor is literal and not infantile. It's just a hint, a push to find your own associations. It creates an iconic sign and uses an associative flow. Changes in short-lived codes of architectural language do not affect the slight mystery and, at the same time, the ambiguity of this image. This is the highest metaphorical level, where there is an amalgam of elite and popular reading codes on a subconscious level. The most popular example of this type is Notre Dame du Haut in Ronchamp "which has been compared to all sorts of things, from white Mycenaean houses to Swiss cheese." The role of metaphors in modern architecture is very high. Despite the supposed subjectivity, invulnerability to conscious control, architecture is one of the most powerful metaphorical forms of communication.

Understanding architecture from the point of view of semiotics involves the analysis of types of architectural signs. In this case we are talking about the use of sign means - indexes, iconic signs, symbols, indicators and signals. Signs are usually less enduring, but those that "take root" in a culture tend to become symbols. As a rule, the meanings of the symbols are conventional, i.e. set in society by agreement. In addition, the volume of symbol values in quantitative terms is immeasurably greater than in the sign. But the viewer or interpreter is not always aware of the meaning of the installation on the perception of information from its source, because architecture is not music and not a living language. Its presence itself is perceived by the audience not as a deliberately organized message, but as a habitual environment, the perception and use of which is carried out subconsciously, as long as the subject does not face any difficulties.

Stereotype signs serve as a link in architectural communication. Stereotypes formed in the perception of architecture, from the point of view of psychophysiology, help individuals to actively form perceptual hypotheses and to categorize the sensory basis of experience. People always perceive a stereotype faster than true personality traits, because the stereotype is the result of many, sometimes accurate and subtle judgments. In this sense, the stereotype is always the result of collective experience, which is formed as a result of social activities of the group and transmitted to group members in the processes of "learning" and internal communication. The stereotype is formed in the form of a set of commonly used values of some object of the objective world for a given social group, which are more likely to be used by the interpreter from all the richness of the semantic background. The most informative form can lose emotionality for the viewer, even if the conditions of its perception have not changed. As known, in the process of informative perception of the stereotypical form (monotonous construction) broad areas of consciousness are less and less involved, the emergence of associations is suspended, the form ceases to be an accurate informative signal of its content. In such conditions, uniformly familiar forms cease to work as informative and become commonplace. Therefore, in order for the spatial form to serve as an informative stimulus that causes an aesthetic reaction, it must have in addition to the above qualities a certain "freshness", novelty, originality [4]. Charles Jenks, who was at the origins and developed the theory of postmodernism in modern architecture, writes: “Today, Architecture is still at a crossroads and architectural semiotics is one of the bridges that will help it get out of the "Island of Coincidence", where it was thrown after the crash of the "Ship of Modern Architecture", to the continent of the "Great Future", worthy of its “Great Past” [3]. The grammar of this new architecture is always provocative. It ranges from awkward drops to elegant wavy shapes, from torn fractals to emphatically neutral "information spaces".

American logician Charles Sanders Pierce classified the relationship between form and content of a sign in three ways. Pierce created a classification of signs, dividing them into three groups. To the first group he attributed iconic signs, that is, similar to the object they denote (an example is a portrait or photograph of a person). The second group is conventional (conditional) symbolic signs that have nothing to do with the object they denote, they are the majority of words in any spoken language. Finally, he referred to the third group as the so-called index signs. These are signs that are associated with the object they denote by the contiguity, that is, not being similar to this object, they nevertheless evoke certain associations with it [5].

Charles Jenks also proposed a division into three types of sign buildings, consisting of a stable complex of elements: index, iconic and symbolic. If we add to this division another type - new signs, then with the help of this classification you can describe almost all architectural objects. The role of a sign in architecture is extremely large and not yet fully understood, as shown in his semiotic analysis of a column by U. Eco. You can illustrate his position by showing the same element - a column, which acts each time in a different role. Thus, it can be:

- sculpture in the interior;
- the portico of a classical building;
- a monument on the square, the peristyle of an ancient temple;
- the building of the water tower;
- decoration on a square, support for stairs;
- elevator shaft, just a building [3].

Sign of index in architecture - "index sign", the action of which is based on the natural contiguity of the signifier and the signified. In architectural semiotics, the properties of an object have almost all forms, because they are physically related to other forms. The floors are naturally connected with the walls and foundations that carry it (the floor is the index of the wall), the external volume of the theater tells us about the presence inside of the space of the auditorium, grate, lobby. Index marks mean architectural signs that have an unambiguous reading, that are independent of anything or anyone, or have no architectural metaphor at all, or have one that is obvious to everyone. These are signs such as "entry-exit" signposts or pointers. In its pure form, index signs do not exist, as in colloquial language there is simply no noun. The architects of functionalism and constructivism had the desire to create index marks, when in the name of rationality and the desire to create architectural Esperanto, index architectural signs were processed. It should be noted that in a relatively short time, some of them have become quite widespread.

Iconic sign in architecture - a term intended to denote a sign, in the physical form of which a structural preference is preserved that means an object or pattern, a sign-copy. For example, all diagrams are structurally similar patterns. A photo of a person is an iconic sign. For example, engineering structures - bridges are completely similar to themselves. From the standpoint of the typology of architecture, the most iconic are historical religious buildings of almost all world religions. All historical religious buildings of Christianity, Islam, Buddhism, etc. were created not as places of gathering of people, but as places of communication of people with the god, as places of stay of the god on the earth. With all the variety of cultural codes of mankind, it can be noted that historical religious buildings are easily "read" by representatives of different subcultures, regardless of their religious affiliation. Even though the construction of each type of building was carried out in strict accordance with religious canons, they have much in common in terms of architectural language. They had a generally complex three-dimensional construction, a pronounced spatial vertical, rich decor (until recently). Iconic signs are metaphors used in architectural images. Metaphor - a specific borrowing of the image.

Sign symbol in architecture - is a more complex type of sign form. Its main qualitative difference from the sign is that the meaning of the symbol may be weakly or in no way semantically related (not motivated) to its physical form. The volume of symbol values in quantitative terms is immeasurably greater than in the sign. The same cultural symbol can exist for thousands of years, accumulating in its semantic structure more and more layers of meaning. The simplest example is the cross. The meanings are very contradictory - death, life, unity, beginning, center, cardinal points.

Architectural elements can be described as codes that can be used to express certain rules of architectural composition, logic and harmony, to understand the architectural message. The following classification of architectural codes is offered in the architectural message:

1. Technical codes. These include articulations related to construction: beams, columns, floor systems, sanitary systems of technical equipment. At this level there is no communication.
2. Syntactic codes. These are typological codes that relate to articulation via spatial forms (circular diagram, maze, etc.). As well as other syntactic conventions (stairs usually do not go through the window, the bedroom is usually located next to the bathroom).
3. Semantic codes. Material elements of the message - signs, combined with the help of code into sets, arranged and built according to certain laws of composition, architectural tectonics, documents [1].

CONCLUSION

Thus, owing to signs and codes, the architectural message enters a person through natural channels of perception. In the language of architecture, you can highlight the following classification of messages:

1. Reference function messages are designed to communicate something about a functional purpose.

2. Emotional messages in space are transmitted through various compositions with pronounced emotional characteristics.

3. Command messages in space are transmitted through various restrictions: the planning structure of the building, the stairs, the corridor, the room that dictates our movement, and other pragmatic reactions.

4. The actual messages that confirm the fact of communication, in architecture may include messages transmitted through such phenomena as night lighting of buildings, the deliberate organization of the view frame organizes the fact of communication.

5. A metalinguistic message that informs of other messages (bas-reliefs, murals, etc.).

6. The aesthetic function of the message in architecture is manifested in the deliberate demonstration of any feature of the building (geometric, picturesque, original) [1].

This way of applying the elements of the language of architecture in his study was conducted by Martin Kramp, a professor at the University of Stuttgart who set a goal with a group of students to study what "alphabet" the architect uses in his "conversation" with the public, how the viewer understands his idea, the idea embedded in a particular architectural object. It is a matter of defining the components and categories of the universal language of architecture. Aspects of this scientific direction are introduced in Kyiv National University of Construction and Architecture at the Department of Fundamentals of Architecture and Architectural Design based on lecture and practical material of the course "Theory of perception of the constituent elements of architectural objects".

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Innovative Tools for Implementing the Smart City Concept in Architectural Urbanism

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Abstract. The proposed development is devoted to the problems of implementation of Smart-oriented software and analytical tools based on Big Data in architecture and construction management. The goal of this toolkit is prognosis and monitoring of architectural components of the city as a dynamic system. Relevance of its implementation lies in optimizing the principles of functioning of the architectural structure of the city with the calculation of its impact on the processes of functioning of other urban subsystems. Experience of modernization of the obsolete housing stock on the territory of the former USSR has shown how domestic realities differ from the global European ones. This fact became a spontaneous motive for the development of the concept of innovative software product called "Program complex for modeling the city as a dynamic system", which is carried out at the department of innovative technologies design of the architectural environment of KNUCEA.

INTRODUCTION

The turbulent development of Smart City concepts and tools, which today can be observed practically all over the world, is provoked by several significant factors. Among them: globalization; technological and informational revolutions; severe resource deficit, environmental and demographic crises. As a result of the reciprocal application of the consequences of the above factors, modern megapolises no longer correspond to the formats of the new challenges we face. The crises experienced by large cities in the past were solved at the expense of increased exploitation of natural, social and man-made resources. Today it is obvious that natural resources can no longer be a subject of increased exploitation.

The concept of Smart City is an attempt to find an answer: how the city can survive and develop under the conditions of the need for a streamlined change in the principles of functioning of almost all of its subsystems. The unprecedented nature of these problems is the reason why there is virtually no unified understanding of what Smart City is in the world's scientific practice.

Today there is quite a bit of controversy, but the opinion recognized by most scientists and practitioners is that Smart City is a continuum of social, environmental and technological forces aimed at achieving a stable, long-term and comfortable life for residents. Digital technologies are considered as one of the most necessary tools to achieve such goals.

Foreign experience repeatedly demonstrates the need for implementation of smart technologies in the management of development of modern cities. However, in this case it should be particularly noted that for the realities of Ukrainian cities, copying of innovative approaches sooner or later will not give the expected results.

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THE RESULTS OF THE STUDY

The System-Dynamics of the City Modeling

Today, most of the world's great architecture schools are actively developing a focus on optimizing the functioning of cities. This includes, for example, Lausanne Polytechnic with the research and practice program “IGLUS; MIT Smart Cities Lab; URENIO; Smart Cities Academic Network. These programs bring together practitioners and scientists from different fields of knowledge: urbanists, architects, geographers, engineers, economists, management experts, political scientists and many others.

First, when analyzing the approaches to Smart Modeling of Cities, it is necessary to note the method of Image Modeling, a type of computer modeling that uses the methodology of systems analysis, the central procedure of which is to create a generalized model that reflects all the factors of the real system.

The assumption approach is nowadays actively used for modeling of territorial systems, especially regional ones.

Modern tendencies in modeling of processes of development and functioning of the city provide for research of social, economic, transport, cultural and other structures of the city territory; The main goal of the project is to provide the study of the city's social, economic, transport, cultural and other structures of the city; to provide the basis for city development decisions; development of the city's economic policy; integrated diagnostics of the city's territory; variant planning of space development, and others.

Modern models of cities built with the help of the imaginative modeling are models of the resource type. The state of the urban system in these models is described in a modified way. External influences and managerial decisions determine the dynamics of the modeled system. Based on the processing of expert knowledge, all the factors that operate in this system and the cause-and-effect relations between them are revealed. With the help of modern modeling systems, a model of the analyzed system is formed. In the decision-making blocks, controlling influences on various kinds of objects are made on the basis of this information. The main goal is to set the balance of resource use in the system.

Modelling of economic processes in the city can be demonstrated by the work of V. Stanislav “Computer Modeling of the Budget Process and Dynamics of the Housing Stock of the City”. In this work we have proposed a model of the municipal system, which allows predicting the dynamics of the main indicators of the city's development taking into account various factors, such as the evolution of the housing stock and planning of housing and communal services, budgetary processes and business activity in the city, the activities of construction organizations, financial relations, demographic and migratory processes [1].

Modeling of Socio-Economic Processes of the City

This involves developing interactive models of the city that analyze the link between the economic model and the model of social processes in the city; creating a tool for accomplishing the goal objectives; Creation of predictive models of municipal economy development; development of multidisciplinary interaction principles for different branches of knowledge and taking into account specialized data in the model [2].

The peculiarities of socio-economic models of the city include the absence of strong ties to the territory of the city. The model is bendy and overly “crumbly”. Human and financial flows give a general picture of the dynamics of the city's development, but are often abstracted from its material structure.

The basis for the creation of these models are social and financial parameters in the dynamics of their life and interaction, which allows us to describe the city as an open dynamic system. On the level of work with non-material aspects that form the processes of the city functioning, no unambiguous solutions have been proposed. It should be noted that practically all the existing models have this problem at the stage of development, because it is connected with the attempts to quantitatively assess non-material phenomena, for example, to find a link between the growth of spirituality of the population of the area and the growth of prices for real estate [3].

Modeling of Environmental Processes in the City

Each element of the city is a part of its general ecological system. On the basis of descriptions of the ecological state and place in the general ecosystem of each element, an interactive model of the city is created. Considering the number of scientific fields in ecology, the interactive model of the environmental status of the city completely reflects the processes of its life activity. The disadvantage of the ecological model of the city is that it is difficult to assess the processes that take place in it. [4].

Information Modeling of the City

There are models of informational and communicative relations that help to solve practical tasks rationally. The city as an object of modeling is seen as an open system of information relations, which is divided into economic, social, political, cultural and activity spheres. Each part of the analyzed territory is regarded as a self-sufficient model, linked to the main model by certain flows and relations. The economic sphere reflects the productive types of activity aimed at renewal and development of all parts of the environment. Peculiarities of the social sphere are shown through the indexes of the number of population, its qualitative composition. In the cultural sphere the indicators of preservation and development of historical and cultural and informational traditions are described. Information processes, as well as innovation, are organically included in all spheres of activity.

Big Data and New Tools in the Analysis of the City

The task that faces the developers of "Smart Cities" models is to use the digital advantages of strategic planning as efficiently as possible. For this purpose, at the present time are implemented programs for the management of large amounts of data (Big Data), facts and systems that react to any changes in any subsystems of the city.

The development of Big Data about the city is accompanied by a software package of new analytical tools developed for extracting input from very large, streaming datasets and includes four big categories: Data extraction and image recognition; data visualization; statistical analysis; prediction, modeling, and optimization [5-8].

Big data is fed into centralized systems such as the «Centro de Operações Prefeitura do Rio de Janeiro» - a functional center that operates the flows of data about the city, where data from 30 agencies are collected in real time by a staff of 180 employees, including traffic and public transportation system, municipal and municipal utilities, security and emergency services, weather information, administrative and statistical data, and many others.

The Big Data sphere is characterized by the following signs: Volume - accumulated data base; Velocity - Velocity, which indicates both the incremental speed of data accumulation and the speed of data processing; Variety - variability or possibility of simultaneous processing of structured and unstructured differently- formatted information; Veracity - reliability of data; Value - value of accumulated information [9-11].

Concepts and Implementations of Smart City Projects

"Smart cities" can be defined as systems that integrate the following areas of activity within a single urban space: 1) smart economy; 2) smart mobility; 3) smart environment; 4) smart people; 5) smart living; 6) smart management [12].

These six axes must be combined with traditional regional and neoclassical theories of urban development. In particular, the axes based on theories of regional competitiveness, efficient use of natural resources, transport mobility, urban economy, priority formation of human and social capital, increasing the quality of life, as well as the participation of citizens in the management of cities. In fact, it is possible to obtain knowledge about cities and control them in new dynamic ways using at the same time the data (Big Data) about them being collected [13-16].

Today enough knowledge has been accumulated to create methods and technologies for diagnosing such a complex system as the modern megapolis. The relevance of this topic is confirmed by the enormous effort and costs of many scientific schools of the world, including architectural ones, aimed at the development of systems for managing large amounts of data about the city.

Most of the world's leading cities are actively developing their own digital models for managing the parameters of their life. The implementation of innovative technologies allows significant resources to be withdrawn to solve the critical social problems of modern megapolises. The most important fact is that the "architectural" component in the developed digital tools is connected practically with all the processes of megapolis functioning.

Virtually all of the big cities in the world are now at this or that stage of construction of the Smart system of urban infrastructure management: Vienna, New York, Hong Kong, London, Paris, Berlin, Barcelona, Sidney and many others. All these are examples of "intellectualization" of old cities. Apart from them, "new intelligent cities" are developing: Khabar in Kuwait, Masdar City in the UAE, Dongtan in the PRC, Treasure Island in California, and others.

The study examined several programs for the implementation of the principles of Smart City. Among them:

CaaP is a strategic project involving 18 Swedish municipalities. It is implemented on open IoT platforms. The goal is to optimize the functioning of urban infrastructure. Tools - Internet of solutions and big data management systems (Big Data).

City as a platform – a system of implementation and management of digital services. The project provides the ability to connect, access and integrate data between components of the digital and physical levels of the city.

Umi is an urban modeling platform that evaluates the environmental performance of buildings and cities. It is managed by the Massachusetts Institute of Technology's Steel Design Laboratory.

City Performance – CyPT is a dynamic simulation tool that analyzes the economic, social and environmental performance of various technology clusters in more than 70 areas of construction, transportation, energy, etc. The product was developed to reduce the impact of everyday activities of the city on the environment [17].

However, smart systems are still quite amorphous idea of digital "management" of city life. That is why the concept of "smart" cities has been repeatedly criticized for its superior technocentrism and neoliberal ideology.

ISO standards and Smart Design.

Today, ISO-standards have been developed, which describe three levels of Smart projects: the infrastructure level, the level of facilities and the level of municipal services. The standards specify a list of target indicators, measurement and control of which allows cities to evaluate their development. Indicators of municipal services and quality of life regulate 46 mandatory and 56 additional indicators in 17 areas.

On the basis of ISO in Ukraine adopted a number of state standards related to steel development, namely: "DSTU ISO 37101:2019 (ISO 37101:2016, IDT). Steel development in communities. The system of management of steel development. Requirements and regulations on the use" [18]; "DSTU ISO 37120:2019 (ISO 37120:2018, IDT). Stable cities and communities. Indicators of urban services and quality of life" [19].

These standards use a comprehensive approach to the development of the requirements of the system of management of sustainable development in communities, including cities, and ensure the management to achieve the goals of sustainable development of territorial communities. These FTAs can be considered one of the grounds for the development of smart technologies in our country.

The indicators described in detail in ISO 37120 have quickly become a point of reference for the development of sustainable cities around the world. This document helps municipal governments to define indicators for the use of urban management systems, such as ISO 37101, and to implement policies, programs and designs for a Smart City:

- To respond effectively to such factors as: environmental, demographic, social, economic, agricultural and others;
- To optimize the work of various city systems;
- Use modern technology to provide better services and improve the quality of life of citizens, businessmen and guests of the city;
- Ensure the stable improvement of the city's living environment, in which intelligent policies, practices and technologies serve the interests of residents;
- In a more innovative way to achieve the goals set in the field of old development and environmental protection;
- Realize the benefits of intellectual infrastructure;
- To promote innovation and increase the quality of goods and services;
- To create a dynamic and innovative economy that is ready for tomorrow's challenges. [20]
- Since accelerated improvements in urban services and quality of life are fundamental to defining a Smart City, ISO 37120 is intended to provide a comprehensive set of indicators for measuring progress towards a Smart City.

Methodological basis for forming the technical task of creating the software product "complex model for the analysis of the city as a dynamic system".

In view of the uniqueness of the task, the study has developed methodological foundations for the formation of the technical task of creating a software product "complex model for the analysis of the city as a dynamic system". Analyzing interdisciplinary (economic, ecological, informational) models of city functioning and supporting their crazy practical usefulness, we should note that for the most part they are deprived of coordinate connection of information blocks to the fabric of the city. This disadvantage often prevents obtaining a comprehensive prognostic or diagnostic response, because they are specialized on individual "floating layers" of the city's informational model. The complex systematic complex model of a large city requires a new approach and development of new modeling principles.

Taking into account the above-mentioned positions the authors of this article have identified the professional specificity of Big Data management tools in architecture and urban development. The particularity of the presented requirements is the need to combine and manage large amounts of verbal and statistical data, which must be clearly linked to the geographical map of the city. That is why it seems natural that during the development of the mentioned complex, the architectural and construction model was used as an informational basis. This approach allows us to make an informational link between the processes of the city's functioning and its material structure. This assertion is based on the fact that the architecture is connected practically with all processes of the city's functioning, so it can be the universal basis for creating a model of the city in the entirety of its life. The proposed development is devoted to the problems of implementation of Smart-oriented software and analytical tools based on Big Data management in architecture and housing management. The goal of this toolkit is prognosis and monitoring of the architectural structure of the city as a dynamic system. Relevance of its implementation lies in optimizing the principles of functioning of the architectural structure of the city with the calculation of its impact on the processes of functioning of other urban subsystems.

This complex is based both on architectural and building standards, and takes into account the regulatory requirements of the totality of disciplines, which in their totality comprehensively describe the dynamic processes of functioning and development of the city. The methodological basis of the research is the methods of system dynamics. According to these methods, the totality and interplay of all dynamic processes in the city system determines the parameters of its existence. The strength of these changes, their speed and acceleration form certain requirements for the architectural structure of the city. This approach allows to identify cause-and-effect links between the main subsystems of the city and its architectural structure.

The developed complex is the core of the information and analytical system supporting the processes of preparation and adoption of management decisions at the level of regional and local administrations. Its use allows to analyze and give forecasts of systemic risks and potential threats to the functioning of the city. This approach meets the goals and objectives of ISO 37122: 2019 for creation and development of Smart City.

The model complex consists of two hierarchically connected but autonomously organized parts: verbal (descriptive) and mathematical models.

Verbal cognitive and investigative matrix allows to analyze the problems of functioning of the “architecture” subsystem as a component of the city system. This is a software product developed in the form of a template, which is based on the synthesis of methods of cognitive analysis, extensive matrices, agent-based modeling and specialized software products. Formally, the matrix is designed in the form of a table. Three columns denote groups of material artifacts of the city subsystems: Technosphere, Ecosphere and Population. The rows are the main consumers that ensure the functioning of the city as a system: social, energy, resource, food, nature, economy, technology.

Each of the needs or subsystems that became the basis for the name of a column or a matrix row is a complex morphological tree. At the intersection of the row and the column there is a “lump”, which contains information about one or another aspect of the city's functioning. The principle of her work is in the macro - drawing of these combinations and their transformation into new templates of matrixes. Each next opened matrix becomes the basis of a new matrix.

The work of the cognitive-investigative matrix is based on the deductive method of developing the study of the city and its elements as well as on the experimental construction of the “morphological tree” of the problem that is being investigated. This work actually consists in following the structures of morphological trees of columns and rows of the table. In this case the investigation of the place is carried out from the level of general understandings and abstractions to the level of the simplest elements (patterns).

The operating principle of this model-matrix can be interpreted as cycles of studies ordered by its structure, which are aimed at exploring the current problems of the city. The method of matrixes adapted for the needs of the model complex provides a template for quantitative and verbal description of each structural element of the morphological tree of the matrix. Each previous level of the investigated system becomes an informational source that forms structures of templates of the next level.

The main function of the mathematical information-storage model, storage and processing of information and the responsibility for identifying the occurring interconnections and patterns that affect the processes of development and functioning of the city as a dynamic system.

For this purpose, the principle of synthesis of innovative methods of analysis of the urban environment and software that allows to process large amounts of data and conduct their structural analysis was developed.

The nature of the tasks solved with the help of the information-storage model of the city, refers to the issues of modeling the dynamic processes of its life as a system and imitating the reactions of this system to changes in the architectural environment under the influence of a continuum of external and internal factors. In this case the architecture is considered as one of the basic subsystems of the city, on the basis of which the city's identity model is created.

The model is based on the inductive method of studying the city and its elements. It consists of a set of information commissions, each of which represents a set of statistical information about a single element of the urban environment (paternity). Information about paternity, which is accumulated in the informational compartment of the model, allows you to create a dynamic model of its life. The totality of dynamic processes of the city system functioning is the basis for creation of the dynamic model.

The novelty of the information-storage model of the city lies in the creation of two parallel systems of internal links between blocks of information: statistical and verbal. The statistical level of links quantitatively describes the dynamic characteristics of functioning of material and non-material components of the functioning of the architecture and related components of the city. The verbal one describes the peculiarities of functioning of the subdivisions, paternities and clusters of the city. The principles of working with the verbal information level include the possibility of connecting the content analysis software module. This module is able to sort text blocks into groups according to the contexts of the words in them according to the needs of the research.

As a result, we get an instrument capable of detecting and controlling complex information flows describing the functioning of elements and subsystems of the city, analyzing them and integrating data according to predetermined parameters. Due to the bell link built into the principles of functioning of the information and accumulation model, this tool is a means of forecasting the city's life cycle.

On the application of the district “Novi Budynki” Kharkiv conducted an experiment, the purpose of which was to test the efficiency of the software complex analysis and modeling of the city. The aim of the experiment: to identify “problem nodes” associated with changes in Ukrainian legislation requirements for energy efficiency and environmental friendliness of buildings and in accordance with these laws of modernization of architectural objects. For this purpose, on the basis of statistical data, a comparative analysis of the dynamics of functioning of the totality of architectural and planning elements of the area.

Formulated a group cohesive map of ideas about the peculiarities of functioning of the housing estate “Novi Budynki” in Kharkiv.

The managerial “problem body” was revealed. it consists of three main parts: legislative regulation, local self-government and community interests. The essence of the set of problems lies in the fact that the community's interests in comfort, safety and economic accessibility of housing interfere with the resource capacities of the region, the distribution of which is regulated by local self-government bodies, whose activity, in turn, is regulated by the legislation of the country. Aspects of the possibilities and consequences of compliance with the Law “On Energy Efficiency of Buildings” to the rehabilitation of the buildings of the housing estate “Novi Budynki” were investigated.

The main obstacles that make up the “managerial body of problems” are that at this stage of development of social and economic relations in the housing estate, the main provisions of the law “On Energy Efficiency of Buildings” will not be fulfilled. The city does not have enough funds for large-scale modernization of housing, and its owners have neither the desire nor the income to take steps to improve the situation.

The technogenic level of problems of modernization of the housing stock of the district “Novi Budynki” was revealed. In the process of studying the problems of modernization of the housing stock of the district and attempts to adapt international experience to it, a significant difference between domestic and European urbanistic approaches to the renovation of buildings was revealed. Unlike European urbanism, Ukrainian urbanism is forced to work under conditions when the crisis experienced by most cities in the country is dangerously close to a pre - catastrophic state.

This conclusion is obtained as a result of the imposition of dynamic indicators of technical and economic data on the reconstruction of residential areas of the Nordic countries, Spain and Moscow to the system of housing estate “Novi Budynki” in Kharkiv. The study used data on the architectural and structural and economic parameters of the measures taken to rehabilitate large - top buildings, which was given by European colleagues. This allowed to determine the quantitative parameters of the necessary improvements of the buildings of the housing stock.

But at the same time, it has been recognized that under the conditions of economic and social crisis it is impossible to copy the experience of countries that differ in their social and economic situation. It is necessary to carry out subtle, courageous and continuous measures to stabilize the critical dynamics of the studied system, which was first mentioned in the study.

A social problem of modernization of the housing stock of the district “Novi Budynki” was revealed. The formation of group perceptions of social problems of the district revealed a social crisis, obviously close to a pre -catastrophic state. The data obtained during the experiment allows us to assert the presence of depressive attitudes of the inhabitants of the district and the breakdown of social relations between them. Under such conditions, any attempts of state regulation, except for full financing of measures to rehabilitate the buildings do not lead to positive results. Identified nodes of the problems point to groups of systemic disadvantages that can potentially become a hindrance in the way of measures to improve the energy efficiency of the buildings of the analyzed territory. Further, in the development of strategies for the development of the housing estate, the above - mentioned problem nodes will help to identify the first priority tasks that need to be fulfilled to increase the comfort of the surveyed area.

It was found that each of the city's subsystems (Ecosphere, Technosphere or Social Sphere) actively reacts to changes in the functional dynamics of the other two subsystems. The analysis of the interaction of these subsystems creates an unique “map of problems” for each housing estate. This fact confirms the thesis that with such a complexity of the system, which modern cities have acquired, trying to solve problems locally can lead to incomplete negative results. Only a detailed analysis of the interplay of dynamic processes between elements of the system (Society, Technosphere, Ecosphere) can reveal the problems that contain this system. Quantitative and qualitative changes in any of the components inevitably affect the others.

The experiment revealed the practical value and feasibility of using the developed model complex to analyze the problems of the city as a dynamical system. It is proved that the view of the city as a structured totality of dynamic processes of life of all its elements allows us to identify the specificity of architectural and urbanistic approaches to the formation of ideas about its stable functioning as a dynamical system.

CONCLUSION

The developed program complex can be considered as a Big Data toolkit of Smart City. The implementation of the “Program Complex for Modeling the City as a Dynamic System” into the city management system will allow assessing the risks associated with the implementation of architectural and urban strategies into practice and breaking them down into tactical tasks. This will potentially allow

to solve a lot of problems associated with the adaptation of architecture of postindustrial cities to the conditions of modern global challenges.

Applying the method of morphological analysis to the city revealed a significant problem of data management. Already at the level of the analysis of the housing estate it became obvious that the description of each pattern (data packets about the elements of the studied object - ecological, technical and social, which define in the sum of their processes the dynamics of its activity) contains a lot of data including coordinate relation, statistical description, description of dynamics and coefficients of importance, parametric links with the system and other parameters, etc. п. There are hundreds of thousands of such patterns in the analyzed residential area. Thousands of clusters and cases are also added to the pattern data. In the model complex, the data production becomes seamless, provides complete coverage within a single system, and is highly disaggregated, interconnected, and reliable, integrating different subject areas.

The study confirmed the productivity of the concept of using prototype programs for the intellectual analysis of the processes of complex dynamical systems (Data Mining and Any Logic). The value of the Data Mining technology for the developed model complex lies in its ability to analyze the masses of available information and automatically identify clusters characteristic of any fragments of nonuniformly rich and rich data. Thus, the Data Mining technologies allow you to automatically and in an automated mode to identify the hidden dependencies and interrelationships in large amounts of information (Big Data).

Potential value of automatic analysis methods used in AnyLogic software as a prototype of an IMM tool was revealed. This prototype program is potentially able to carry out a variant analysis of the impact of change agents on the clusters of the model complex, determine the correlation between the resources necessary for the city to achieve sustainable development and the real possibilities of the region, identify the optimal strategies for the development of the region.

The experiment confirmed the necessity of using the GIS toolkit as a basis, which allows linking the patterns of the model complex to the coordinate grid of the city. The basic model ball in the complex is the city's architecture. The spacious model of the city's architecture modeled in GIS provides coordinate relations of elements of social, economic, ecological and morphological village of the city system. That said, modelling of the city development processes is carried out through a system of thematic layers, which have the dynamics of events and clusters by means of analytical procedures and methods that describe the interaction of the output data and express the result of their mutual influence. This requires the possibility of interoperability with “infrastructural” add-ons such as Civil3D and LandXML formats.

The analysis of the results of the experiment revealed an important advantage of the parametric modeling method as a tool for introducing the dependencies between the parameters of the city into the model. Parametric modeling provides direct access to these relationships and data sets, which quantitatively describe the parameters of the patterns and clusters based on them. An important positive feature of this is the automatic control of these dependencies with every change in the

model. When new components are added to the model, the intrinsic dependencies of these elements are preserved. If an element is changed, the program itself determines which elements related to it require modification.

Methods of system dynamics, which are used in the research, require specification and development. These tools allow to see the consequences of taken decisions, quickly master the methods and understand the structure of complex systems, design tactics and strategies for greater success.

It is important to understand the investigated process in the form of diagrams consisting of loops of positive and negative correlation, which practically correspond to cognitive maps. It can be said that cognitive maps serve as proto - models for the theory of system dynamics, the mathematical apparatus of which is the systems of differential equations.

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Variability of Modern Possibilities of Organization of Museum and Exhibition Space

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Abstract. The organization of museum spaces according to different principles, depending on the subject area is considered. An integrated approach with a combination of different types of spaces and exposition options is offered. The main purpose of the organization of the museum and exhibition space is to create an "exposition scenario", programmed movement and action, for all age groups and categories of the population. It is proposed to involve a system of sensory receptors that cause complex, combined perceptions of space. A modern person is accustomed to a large amount of information, the speed of its change and a bright visual range. Therefore, it is advisable to involve the latest technological solutions in the demonstration processes. This will allow to combine spatial, auditory, visual, tactile and other types of perception into a multilayer and multilevel system. According to the perception of different types of exposition, it is proposed to take into account the following peculiarities of the types of exhibition environment: exposition of an object or group of objects that need to be viewed from all angles, exposition of the room, exposition of three-dimensional objects that require a certain aspect angle, exposition of objects that require a close perception. Generalized principles of modern organization of museum and exhibition space as the interrelation of internal space with the external environment: visual penetration, isolation, transformativeness, mobility, virtuality. Methodical techniques that add new opportunities in modern museum and exhibition space based on the peculiarities of perception: complex and diverse structure of space, structure of space with continuous movement, structure of space with multivariate movement, creation of feeling of "infinity" of space, zone of visually variable environment, zone of physically variable environment.

PROBLEM

Exhibition spaces can be very diverse and have rather contrary concepts. It should be noted that modern exhibitions are different from the classic museum ones, they have new interactive features, new technical capabilities, new demands from society. Even the pace of perception and analysis of what has been seen began to require new methods of organizing museum and exhibition spaces. The problem of update of museums of different directions is very actual today, as there is an increase in the cultural level of people, the increased interest of most of the population in the historical heritage and creative heritage of today [1]. At the same time, there is a socio-psychological problem related to the perception of information, interest and memory. People have become more visual perceptive and need the change of exhibits and information at an accelerated pace. This should be taken into account in the modern planning or modernization of museum spaces.

RELEVANCE

Therefore, the topic is urgent and present in different information sources. It is no secret that an average Ukrainian enthusiastically visits museums and exhibitions abroad and very rarely visits such institutions at home. Of

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course, the psychological effect of travel is in place, but most of the museums are more interesting and modern. Temporary exhibitions and expositions using modern technologies and attracting curiosities that help increase the flow of people have already started to appear in Ukraine. Individual museums have also begun to attract various new technologies, or simply more interesting formats for viewing. But there is no systematic approach. That's why we usually see empty halls here, and in Europe we often queue at the entrance.

NOVELTY

The peculiarities of the types of exhibition environment according to the perception of different types of exposition are studied and generalized. The basic principles of organization of museum and exhibition space in the aspect of interrelation of internal space with external environment are formulated. Psychological features of exposition awareness when applying new experimental concepts of architectural environment are described. The concept of an integrated approach to the exhibition space, logical combination of different types and variants of exposition, variability of complementarity of activity and relaxation of the spectator's attention are considered. The organization of the museum and exhibition space is proposed by creating an "exposition scenario", programmed movement and action, for all age groups and categories of the population, including people with limited mobility and people with special needs.

THE MAIN SECTION

The organization of museum space can be created based on different principles, according to the theme of the exhibition. We propose to consider its formation by various features: the diversity of perception, the type of visual interrelation of spaces and the way the visitor moves through space.

Diversity of perception. The perception of the exhibited material depends on the type of exhibited objects, their subject matter, style and size (Figure 1, Figure 2).

1. An object or group of objects needs a full viewing from all angles. *For example: sculpture, installation (stationary or mobile), historical object, model or waxwork, stuffed animals, aquariums, etc.* In this case, there should be a suitable place for viewing, a certain distance, maybe even levels for descent and ascent. There can also be several options in this case: a) a moving visitor, b) a moving object. A full view from above and below is possible, viewing from different levels (floors), which also increases the psychological effect (Figure 1, a).

2. The subject of the exposition is the room itself where the visitor is located. *For example: historical authentic halls, separate rooms in museums of modern art, rooms created as an object of installation in the museum, etc* [2]. This requires free entry and movement inside and can be equipped with seats, if necessary. The number of visitors who can be inside simultaneously is regulated by the size of the room. Sound and visual effects, as well as the change of lighting for a short time in the room are very contemporary (Figure 1, b).

3. The exhibits are three-dimensional, but do not require a circular view. *For example, bas-reliefs, dioramas, some sculptures, objects of art and history*. They can be displayed in shop windows or in an open way so that there is a view of about 180°. As a rule, this is the most typical and common way of exhibiting objects along walls or in shallow niches or shop windows. For the more modern interpretation of the exposure, interactive inclusions accompanying the exposition are required (Figure 1, c).

4. Plane objects. *For example, paintings, graphics and text materials, etc.* They often require a single visual point of view or a small and slow movement past the object. In such premises places for sitting, contemplation, rest can be established. In such methods of exposition, it is very important to calculate the proportion between the object and the maximum and minimum distance to it. Often the pictures are not perceived properly in small halls because there is no distance for proper contemplation, no variability (Figure 2, d).

5. Small exposition. *For example: jewelry, coins, small engravings and other art objects.* As a rule, small items are grouped by periods, style, material, etc. The disadvantages of such exposition are inconvenient ways of identifying each object, the inconvenience of group viewing during tours. The effect of psychological fatigue from a large number of monotonous exhibits can also often occur. Such types of exposition also need conceptual changes (Figure 2, e).

As positive examples we can name active involvement of the visitor in the conceptual atmosphere of the museum, programmed escort along the exhibition, involvement, at some stages of the review, in the participation and compassion of history, reality, etc. This is facilitated by a modern visual range, which includes the architecture of the building for exhibitions, the solution of space with a certain algorithm of movement, with a certain speed, direction, visual and physical stops. The program of the modern exposition should be supplemented with interactive means to create some "game of complicity", greater immersion in the process, the possibility of tactile contact and participation in creativity, which will increase interest [3].

Let us consider what opportunities arise based on the development of visual interconnection of various internal spaces of the museum and exhibition building and their connection with the external environment.

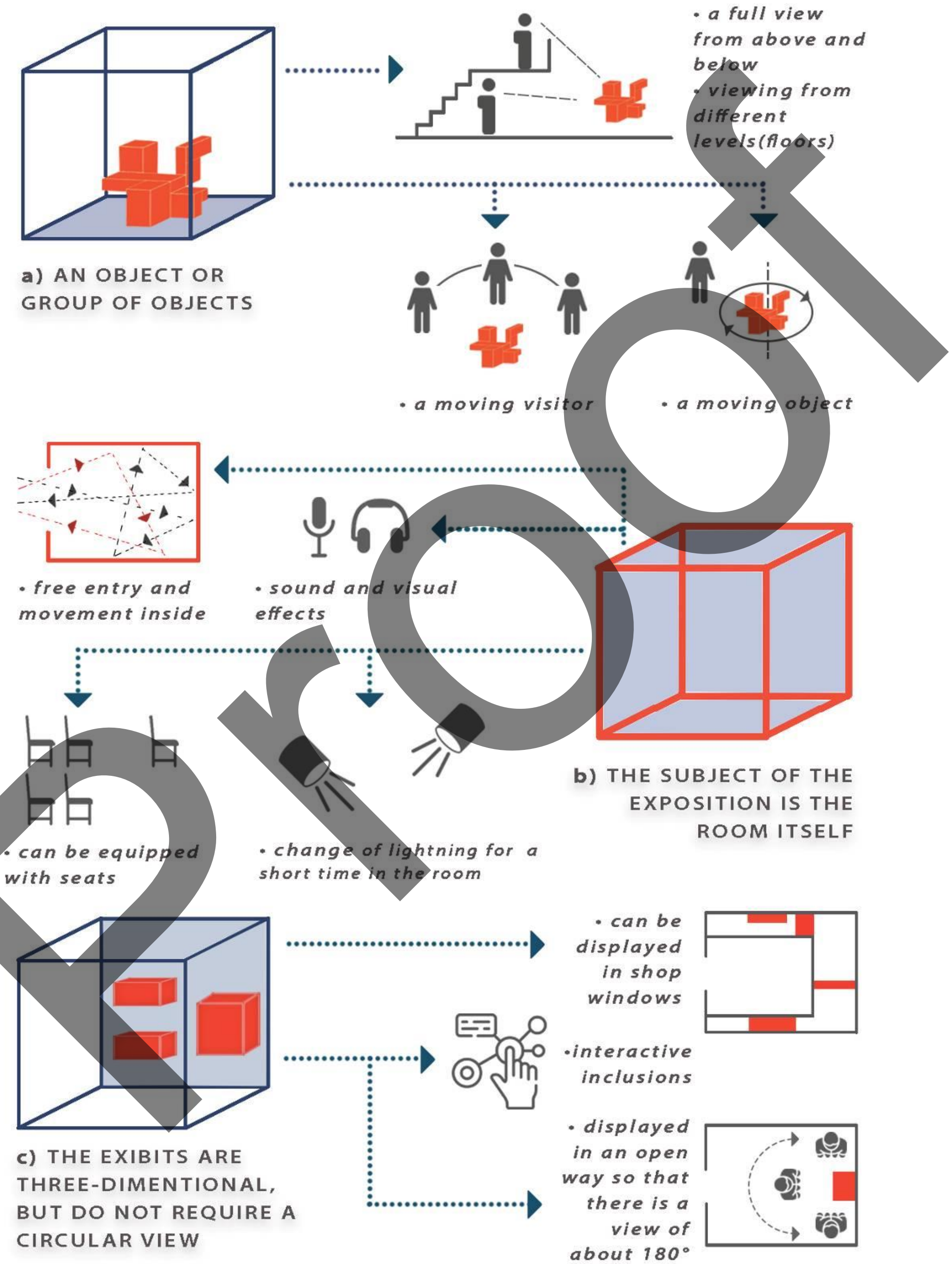


FIGURE 1. Diversity of perception of the exhibited materials depending on the type, their subject matter, style and size (a, b, c).

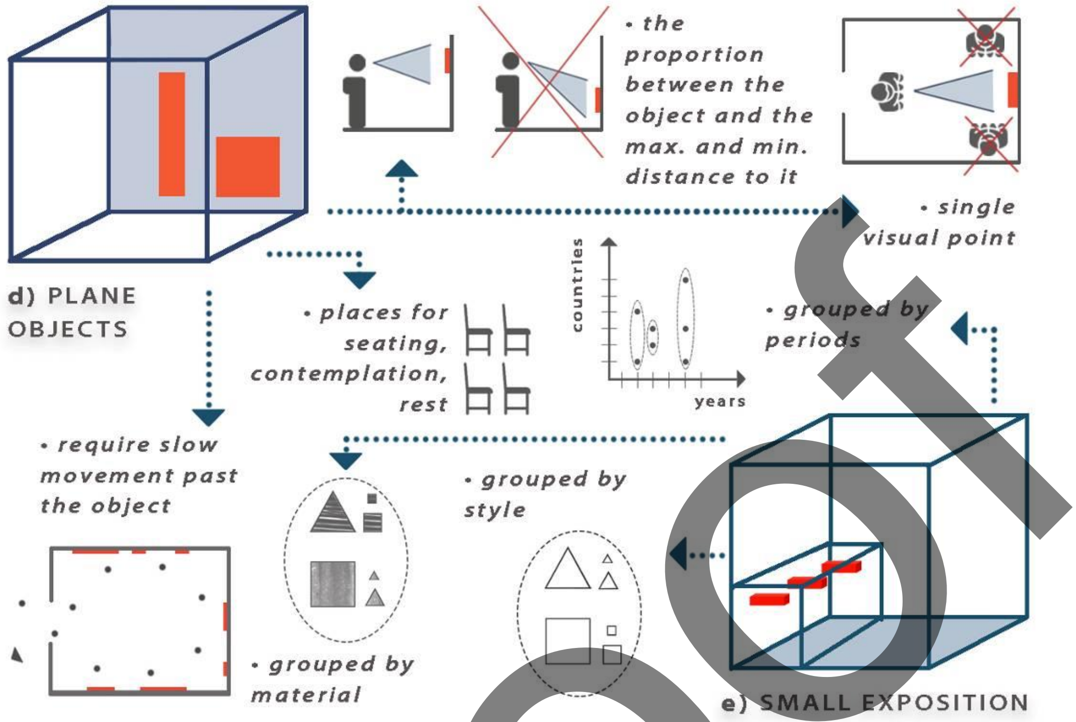


FIGURE 2. Diversity of perception of the exhibited materials depending on the type, their subject matter, style and size (d, e).

TYPES OF VISUAL INTERCONNECTION OF SPACES

When observing small and medium-sized exhibits, close spatial plans apply. When the gaze is transferred to the space of the outer opening, the eye is accommodated in the distant planes and at the same time rests. Not only the eyes get rest and break in the intense comprehension of the exhibition, but also the human mind [4].

The modern architecture of museum buildings demonstrates many techniques based on *the principle of visual penetration* between the internal and the external environment, used by L. Mies van der Rohe (Old National Gallery in Berlin, 1960). Not limiting the development of exposition to the external environment only at ground level, the architects offer artificial level terraces - a technique that develops *the principle of visual penetration* by multiple repetitions vertically.

In the solution of the volume-spatial organization of museum and exhibition buildings the opposite tendency can be applied as well – the isolation of internal space from the external environment by blind surfaces. *The principle of isolation* is used, for example, in the building of the museum in Caracas (O. Niemeyer, 1955), in "Pinakothek of Modernity" in Munich (S. Braunfels, 2002), in the Museum of Contemporary Art in New York (K. Sejima, R. Nishizawa, 2007). This increases the total surface area of the walls where exposition is possible; the visitor is not distracted; lighting can be adjusted according to various scenarios; the composition of the building without windows and large glazing looks monumental in volume and stands out from the surrounding buildings. According to the principle of complete isolation, separate rooms can be created in unlit areas of the total volume of the building.

The next principle of three-dimensional organization of museum and exhibition buildings is *the principle of transformativeness*, according to which a universal space is created, which changes and transforms over time. Exhibits in such space interact with each other and with the external environment, which is visually present in the interior. The internal supports are absent or minimized; light, freely located partitions may not reach a ceiling.

The principle of mobility involves the creation of adaptive exhibits that can be moved to different museum and exhibition buildings. These can be special systems for one exhibition, or universal systems that can be filled with different themes of the exhibits. Such system quickly deploys mobile complex subject-spatial environment and is able to transform compactly and modularly as needed. For example, traveling exhibitions, which were popular in the nineteenth century around the world. At present, various forms of mobile exhibitions are also popular, from mobile exhibitions, both outdoors and in existing spaces, to mobile exhibition complexes, appealing to kinetic and mobile architecture.

Considering *the principle of virtuality*, it should be noted that it is already being actively implemented in the world architecture. In virtual space steam, light, holograms are used; buildings smell, "talk" and maintain themselves. Among the means of virtuality: interactive surfaces, 3D images, holographic projections, external media facades and internal media areas, including interactive scripts. There is an option of a "passive visitor" who only observes the virtual exhibition, and an "active visitor" with full immersion in the process and interactive participation [3] (Figure 3).

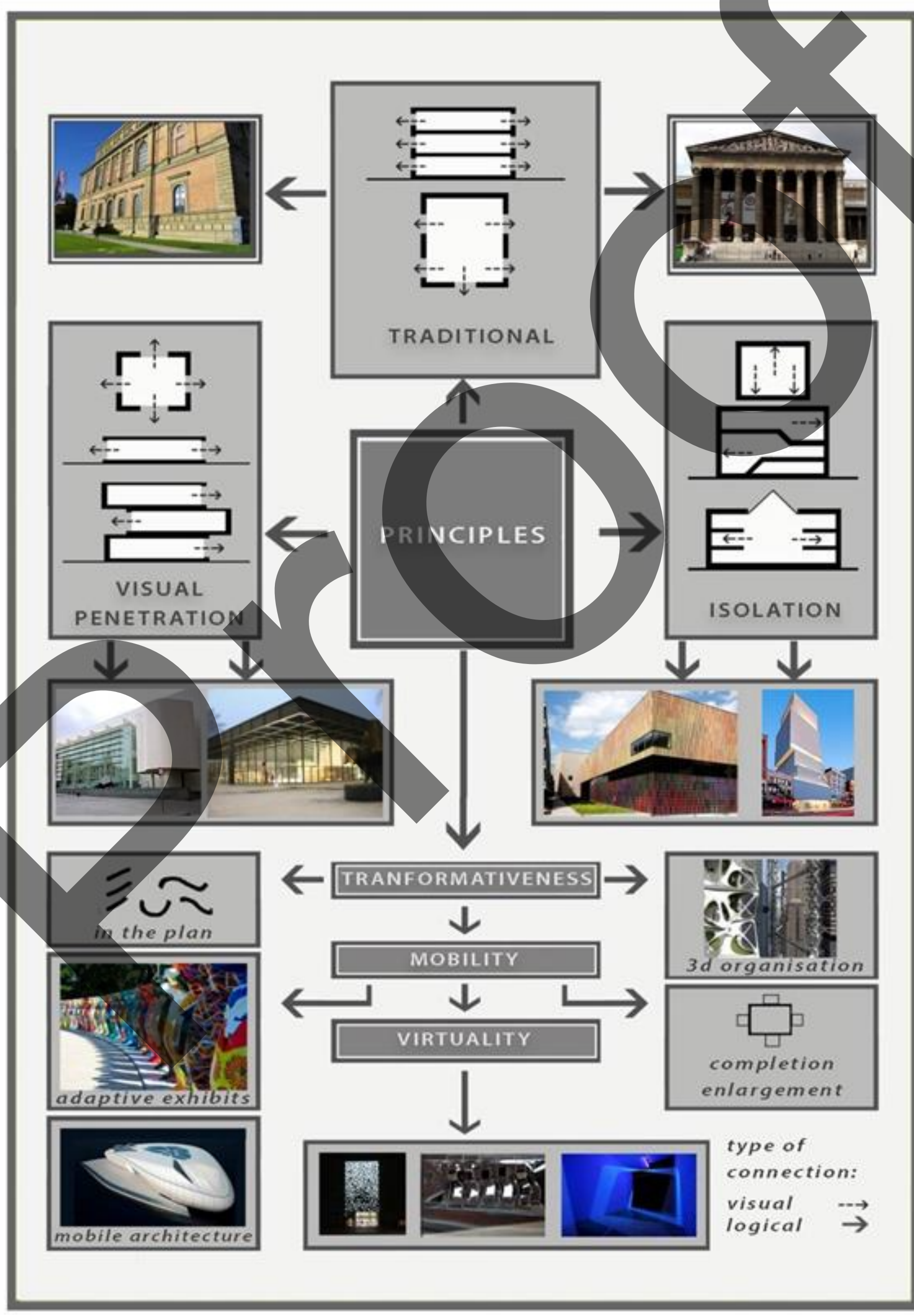


FIGURE 3. Types and principles of visual interconnection of museum's spaces.

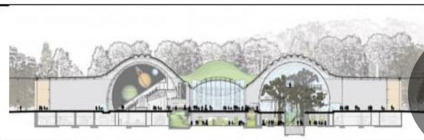
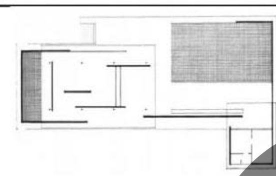
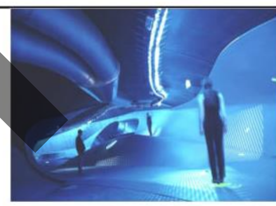
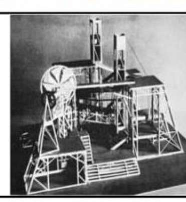
№	METHODOLOGICAL TECHNIQUES	EXAMPLES	
1	Complicated diverse structure of space, parts of which have contrasting properties		Renzo Piano. California Academy of Sciences in San Francisco, USA. 2008
2	Forming of the structure of space, which provides the possibility of continuous movement		Ludwig Mies van der Rohe. German Pavilion for the 1929 International Exposition in Barcelona, Spain. 1929
3	Forming of the structure of space, so that there is a possibility of multivariate moving for individual routes		Foster + Partners. Research Center: Hankook Technodome R+D Centre. Daejeon, South Korea. 2016
4	Creating a sense of "infinity" of exhibition areas, using either shading or lighting of enclosing surfaces		Herman Hertzberger. Chasse Theater. Breda. Netherlands. 1995
5	Transition from the distribution of interior surfaces on the floor, ceiling and walls - to the integrated surface		NOX ARCHITEKTEN. Fresh H20 eXPO - Water pavilion and interactive installation, Neeltje Jans, Netherlands. 1997
6	Organization of zones of visually changeable environment		Interactive media installation. EXPO 2008. Acciona pavilion Caparoca, Spain
7	Organization of zones of physically changeable environment		Alexander Vesnin. Stage construction for a sketch by Chesterton at the Moscow Chamber Theater. 1923

FIGURE 4. Methodological techniques of organization of museum and exhibition space based on the characteristics of perception.

Now we will consider the spaces ***for exhibitions based on the movement of the visitor*** (Figure 4). When applying new experimental concepts of the architectural environment to create a museum and exhibition space, a field of opportunities opens up to make the stay of visitors brighter, more diverse, with the effect of "immersion". This ensures the memorization of the image of the environment, to which it is easy to "return" mentally. It is expedient to transform the information flow into a logical and hierarchical structure in space. The parts of the content are divided into small portions, because the perception of new information causes psychological and physical stress. These structural parts are located in different conditions of perception and properties of the environment. Thus, separate integral portions of information are amplified in the mind and memory by associations with different simultaneous sensations of visual, sound, tactile, kinesthetic images. The space of a complex and interactive structure allows both for a quick generalized overview of the exposition, as if on the outer layer, as well as for a long in-depth study on the inner layers. Below are *the methods* that, based on the peculiarities of perception, add new opportunities to the modern museum and exhibition space [5]:

- Creating a complex diverse structure of the interior, parts of which contrast with each other by the properties of the environment: dimensions, shape and texture of the enclosing surfaces, the overall shape of the room, lighting, colors.
- The formation of the structure of space, which provides the possibility of continuous movement, in contrast to the linear-sequential scheme with a clear beginning and end. The visitor is motivated to revisit if desired and feels the continuity of the inner world of the exhibition.
- The formation of the structure of space, which provides the possibility of multivariate movement by individual routes, choosing the path through the exhibition areas according to own preferences.
- Creating a sense of "infinity" of exposition areas, using either shading of enclosing surfaces, or, conversely, their lighting. This effect is also provided by illusory means: mirror surfaces, projection images on interior surfaces, screens integrated in the interior surface.
- The transition from the traditional division of interior surfaces into floor and ceiling planes and vertical fences - to an integrated surface, where the floor, walls and ceiling are transformed into a solid surface (curved or faceted) and side partitions are not vertical but with a variable configuration. This creates unusual conditions for both movement and perception, which exacerbates feelings and impressions.
- Organization of visually variable environment zones (using the system of video projections on interior surfaces).
- Organization of zones of physically variable environment (the structure of space changes when viewing the exhibition).

The best result is achieved through a comprehensive approach, a logical combination of different types of spaces and options for exposition, complementing the activity and relaxing the viewer [5]. It should be noted that the main purpose of the museum and exhibition space is to create an "exposition scenario", programmed movement and action for all age groups and categories of the population, including people with limited mobility and people with special needs. The visitor has some freedom of movement and choice, but perceives the main direction of the logic of the exhibition, the zone of visual accentuation, the main benchmarks. Space perceptions are divided into visual, auditory, tactile, motor and other, according to the predominant role of one of the sensory receptors involved in the act of perception. When a system of sensory receptors participates in the perception, complex, combined perceptions (time, space, motion) are developed [6]. A modern person is already very accustomed to a large amount of information, the speed of its change and a bright visual range. Therefore, it is reasonable to involve the latest technological solutions into the demonstration processes. This will combine spatial, auditory, visual, tactile and other types of perception into a multilayered and multilevel system.

CONCLUSIONS

According to the perception of different types of exposition, it is proposed to take into account the following peculiarities of the types of exhibition environment: exposition of an object or group of objects that need to be viewed from all angles; exposition of the room, exposition of three-dimensional objects that require the viewing sector of no more than 180°, exposition of planar objects, small expositions that require a close distance of perception. The principles of modern organization of museum and exhibition space in the aspect of interrelation of internal space with external environment are generalized: the principle of visual penetration, the principle of isolation, the principle of transformativeness, the principle of mobility, the principle of virtuality. Methodical techniques that add new opportunities in modern museum and exhibition space based on the peculiarities of perception: complex and diverse structure of space, structure of space with continuous movement, structure of space with multivariate movement, creation of feeling of "infinity" of space, zone of visually variable environment, zone of physically variable environment.

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The Problems of the Visual Qualities of Lighting Managing in Public Spaces

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Abstract. The author analyzed the problems of managing the visual qualities of lighting in public spaces. It is concluded that it is necessary to introduce emotional-aesthetic and figurative-artistic levels of perception of the architectural environment into the methods of assessing the illumination of public spaces. Violation of the visual comfort of these levels negatively affects human health. The compilation of norms for the quantitative assessment of these levels will make it possible to create a toolkit for the analysis and control of the quality of illumination of the urban environment. The development of norms and regulations for the illumination of public spaces can have a noticeably beneficial effect on the economic and medical components of the life of settlements.

INTRODUCTION

Today, innovations in architecture, psychology, and light generation have reached a level where it became possible to develop methods for managing the aesthetic qualities of artificial lighting in public spaces. Taking into account the perception of it by target groups of consumers, innovations make it possible to create visually attractive, a certain group of resident's harmonious local spaces. They manage and distribute pedestrian traffic taking into account the morphological factor of the composition of the population, develop recommendations for increasing the visual comfort of light.

The main hypothesis of the study was stimulated by the report "Effects of light-emitting diodes (LEDs) on humans and the environment", made in 2016 by the Council on Science and Public Health of the American Medical Association (AMA). These studies point to laboratory-confirmed negative health effects of electric light, especially at night. The main problem is the violation of the "circadian rhythm". (Circadian rhythms are natural, internal cyclical fluctuations in the intensity of various biological processes of living organisms and repeats approximately every 24 hours) [1].

Long-term exposure to bright artificial light causes chronic sleep disturbance and increases the risk of cardiovascular disease, cancer, diabetes, and obesity. The report also highlighted that many innovations related to lighting public spaces have five times more impact on human circadian physiology than previously used high-pressure sodium lamps [2]. European standards (DIN EN No 12464-1) regulate illumination standards, depending on the psychophysiological aspects of visual perception. In this case, the circadian effect of artificial light on a person is also taken into account. Several legislative acts regulate artificial lighting in public spaces in Ukraine. For example, DBN V.2.5-28: 2018, State Standard of Ukraine ISO 9241-6: 2004, State Standard of Ukraine 8546: 2015, etc. The regulatory framework of our country includes the physiological aspect of the problem of illumination of public spaces.

The main disadvantage of modern investigations is that some of them relate only to the primary stages of perception and assessment of the architectural environment by a person (psychophysiological level). However, in addition to psychophysiological needs, a person has a need for beauty and harmony of the environment. Therefore, a promising area of work with the management of the visual qualities of the illumination of public spaces is the introduction into the methods of their assessment of the emotional-aesthetic and figurative-artistic levels of perception of the architectural environment. Each level has its own specifics and performs its specific function. For each of them, it is

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possible to develop and generalize the principles of information content and the conditions of visual and ecological comfort. The compilation of norms for the qualitative and quantitative assessment of these levels will make it possible to create a toolkit for analysis and control over the quality of illumination of the urban environment.

PRESENTING MAIN MATERIALS

The original purpose of lighting public spaces was a security function. In ancient civilization, oil lamps were used as the main source of light, which gave a long and moderate flame. Street lighting was first noted in the city of Antioch on Orontes around the 4th century BC. The Romans had special slaves who lit oil lamps in front of wealthy villas. This tradition continued until the Middle Ages [3]. According to research, regular lighting of public spaces first appeared in 1417. This innovation is associated with Sir Henry Burton, mayor of London, although there is no convincing evidence of this fact. Before the advent of gas lamps, candles were used to illuminate the streets in cities. The earliest examples of street lamps required a lamplighter to drive through the city at dusk, lighting each lamp. The development of this area accelerated after the invention of glass-walled lanterns, which significantly increased the amount of light produced. In 1667, King Louis XIV authorized radical reforms in Paris, which included the installation and maintenance of lanterns in streets and intersections, as well as punishment for tampering or theft of lamps. According to the decree of the French Parliament, the lantern must hang under the level of the first-floor window sills. It should have been placed in such a prominent place from November 1 to March 1, so that the street received enough light. These lamps gave structure and order to the city streets, focusing on the volumes and boundaries that form the space. Also, this system made it easy to find the desired houses at night [4].

In 1669, Jan war der Heyden developed an oil lantern for street lighting, which was first used in Amsterdam. By the end of the 17th century, there were over 2,700 streetlights in Paris, and double that number by 1730. The improved oil lantern, called the "reverb", was created in 1745. The light coming from the reverb was significantly brighter than that produced by older designs. So much so that some people have complained about glare [5].

In 1791, Philippe Le Bon discovered the principle of light based on the gasification of coal. In 1792, William Murdoch and J.P. Minkelers created gas lamps using the principle of distilling coal in a closed chamber [6]. However, it took over 20 years of various experiments to create a commercially viable type of gas lantern. The first gas street lighting was carried out by the German inventor Frederick Albert Winsor in London in 1807. In 1812, the British Parliament issued a charter to the London and Westminster Gas Light and Coke Company, and the world's first gas company was born. Less than two years later, on December 31, 1813, Westminster Bridge was gassed. The earliest lamps required a lamplighter who traveled around town at dusk and lit each lamp separately. Later designs used ignition devices that automatically ignited the flame when the gas was turned on [7].

With the development of power generation technologies, the first examples of electric street lamps began to appear. Initially, these were arc lamps - "Electric Candle" or "Yablochkov's Candle" (patent No. 112024), developed by the Russian inventor Pavel Yablochkov in 1875. Soon, experimental arc lamps were used to illuminate the Holburn Viaduct and the Thames Quay in London, the first electric lighting for public spaces in the UK [8].

In the late 19th century, cheap, reliable, and bright incandescent bulbs replaced obsolete arc lamps. Incandescent lamps were used for street lighting before the advent of higher intensity discharge lamps. After the First World War, electric street lamps became the most widespread in the world.

The first HID lamps appeared in the 1930s and quickly gained popularity in public space lighting. The lamps were in the form of a thin glass tube, coated from the inside with a fluorescent powder, filled with gaseous mercury, at the ends of which electrodes were located. They quickly became known as fluorescent lamps, and their widespread use began in 1945.

Luminaires using sodium lamps (HPS) were introduced in 1950. Sodium lamps were more energy-efficient than fluorescent lamps. Between 1950 and 1970, sodium lamps were installed exclusively on highways, major intersections, and industrial sites. In 1961, General Electric launched the first metal halide (MH) lamp in the United States. It used a mixture of mercury and negative sodium ions. In the 1990s, metal halide lamps gained the upper hand in public lighting.

Light-emitting diode (LED) lighting technologies are now taking an increasing share of the market. They offer promising benefits in terms of energy efficiency, higher light intensity, longer lamp life, and lower operating costs.

Until about 1970, the requirements for street lighting were practically reduced to safety goals. The customer's requirements were simple: to provide maximum illumination at the lowest possible price. In the late 1960s, new lighting needs arose, with an increasing emphasis on the lighting aesthetics of public spaces.

Research into the psychophysiological aspects of the effects of artificial lighting on humans has been actively developed since the 1960s. Earlier expert opinions have argued that bright night lighting virtually guarantees a positive impact on public safety at night. Cycles of experimentation have proven that excessive and uncontrolled street lighting can even hurt urban communities. Discomfort and sometimes disability glare from poorly designed street lighting can reduce the human eye's light perception at night, ultimately compromising safety and creating a hazard on the roadway [9].

The innovative development of street lighting technologies has made the problem of visual comfort and health safety more and more acute every year. As a result, in 2016, the American Medical Association's (AMA) Council on Science and Public Health concluded that the widespread use of night lighting poses potentially harmful effects to the health of citizens. AMA appealed to the US government to justify the urgent need for more extensive research on the effects of lighting on health and human safety, especially given the rapid adoption of lighting innovations [10].

Analysis of studies devoted to the psychophysiological aspects of the perception of artificial light made it possible to identify the following problems:

- Most studies misdiagnose the problem of increasing light levels as improving night lighting conditions. This simplistic interpretation meant that many other important lighting characteristics were left out. Improvements in night lighting conditions need to be calculated in terms of night visibility and visual comfort, rather than simply adding light sources.

- In the survey of residents (conducted by AMA), such important quantitative characteristics as illumination, duration of exposure, spatial distribution, brightness, uniformity, color temperature, and color rendering index, and so practically were ignore.

These examples convincingly indicate that a deeper and multidimensional analysis of the characteristics of lighting of an architectural environment is required, taking into account the information processes of visual perception of the architectural environment. Involvement of works from modern psychology of perception in the research carried out significant understanding of the complex hierarchical structure of the processes of the influence of the architectural environment on a person. Moreover, it is possible to determine the mechanisms of this influence, as well as to study the comfortable requirements for the visual-ecological state of modern architecture, the problems of illumination of public spaces.

The practice of recent decades has convincingly proved the harmfulness of an exclusively rational approach to lighting public spaces. The illusion of safety and efficiency, without taking into account the laws of human perception of the environment, threatens to result in losses that significantly exceed the expected preferences.

Visual culture today is one of the main means of human self-identification, and the architect must have the maximum means and capabilities to create the most effective and consumer-friendly visual solutions. The heterogeneity, oversaturation and diversity of the urban environment require that its inhabitants be able to quickly navigate in this diverse and rapidly changing environment, change their behavior depending on which information and communication field they enter.

Involvement of the works of modern psychology of perception in the ongoing research significantly deepens the understanding of the complex hierarchical structure of the processes of the impact of the architectural environment on a person. It also allows you to determine the mechanisms of this impact, as well as to investigate the comfortable requirements for the visual state of illumination of public spaces of the city.

Visual perception methods. The visual perception of the subject-spatial environment is the result of a two-sided, objective and subjective, process of information exchange between the viewer and his environment. This process is due to the properties of the object and subject of perception (architectural environment and human). Anthropometric and psychophysiological characteristics of a person are constant factors in the process of perception. The variable components include individual qualities, experience, knowledge, culture.

Methods of information theory. The visual perception of the architectural environment, as a particular case of epistemological processes, is an informational process. Architecture is one of the most informative systems. The strength of the emotional impact of an architectural work is proportional to the amount of new, unexpected information contained in it. This means that the more new solutions and techniques are in the environment, the more interest they cause in a person, the more information they contain. Moreover, information is considered a reflection of diversity. At the same time, information theory admits that in a minimum time the perceiving individual can perceive only the maximum number of information elements for a given channel. If the message contains more elements, then the person does not take them into account [11].

Methods of neuropsychology. Neuropsychology is a branch of psychology that studies how the brain affects human cognition and behavior. Understanding which parts of the brain are responsible for certain decisions made it possible to manipulate the recipient in order to develop certain behavioral patterns [12].

The relationship between architecture, medicine, light innovations and the requirements of visual comfort research by the work of Abraham Maslow "Motivation and personality" [13]. Maslow's investigation experimentally demonstrates the impact of environmental aesthetics on human health. Based on the data obtained, the question arose about the criteria for assessing the medical, cultural, aesthetic and regulatory parameters of lighting public spaces.

Also noteworthy are the methods of "videoecology" [14], gestalt psychology [15] and the theory of pattern recognition [16].

As a methodological approach to the consideration of the architectural component of public space artificial lighting, the choice was made in favor of the Kharkiv architectural scientific school [17], [18] of three basic levels of visual perception. The psychophysiological level of perception of the architectural environment with its inherent properties - mass, volume, size, location in space, texture, light, and color. They are the objective morphological characteristics of the architectural environment a person perceives. The study of this level allows analyzing the visual and ecological requirements for places where a person at the subconscious level feels comfortable. Here, the formation of an image takes place, which carries information about the simplest psychophysiological needs of a person: the need for orientation, recognition of forms and their relationships that are formed in space, and the possibility of movement in it.

The informativeness of the psychophysiological level consists in the statement that the more different visual elements are contained in the environment, the more dynamic and informative it is. At the same time, there are boundary parameters for this informative content.

The visual and ecological comfort of the psychophysiological level of perception of the architectural environment consists in its saturation with a variety of visible elements. The necessary, genetically determined stimulation of attention during perception is provided by the "redundancy" of visual information contained in the architectural environment. Along with this, when crossing certain thresholds of perception, the amount of redundant information can lead to negative assessments.

A homogeneous visible environment is such an environment in which there are no visible elements, or their number is sharply reduced. When meeting with homogeneous fields, the eyes begin to work in the same search mode, which leads to a feeling of discomfort. In this case, other mechanisms of vision are also disturbed, including the binocular apparatus. The visual system appears to be disoriented, which in turn gives rise to unpleasant sensations.

Sensory hunger. Prolonged exposure to a lack of information leads to sensory hunger. It has been established that life and work in an environment poor in visual elements will cause neurotic states in people - depression, hallucinations, sleep disorder. An aggressive visual environment is inherent in all multi-story buildings, where a large number of identical windows are located on a huge wall. This repetition leads to an overload of the brain with the same information. In the end, this is negatively reflected in the work of the central nervous system and a person's well-being.

At the psychophysiological level, the regulation of the illumination of public spaces is based on numerous field studies of physicians and therefore does not present any particular difficulty. There are already many standards and recommendations that regulate the simplest parameters of artificial light that negatively affect the human psyche. Among them: brightness, spectrum, rhythm, the contrast of light and shadow, aggressive and homogeneous fields, etc. In their totality, all of the above parameters of artificial light can have both a sharply negative effect on a person's well-being and have a pronounced positive therapeutic effect.

The emotional and aesthetic level of perception of the architectural environment is the expressiveness of lines, colors, shapes, planes, spaces that form the architectural environment as the basis for emotional influence on a person. The level of perception of the architectural environment provides that a person perceives information from the environment through emotional and aesthetic signs. At this level of perception, an image is formed, which is determined by the interaction of the conscious and unconscious levels of the process of perception. The main factors influencing the work of the semiotic mechanisms of such an image are the sensory and emotional sensibility of a person.

The visual comfort of the emotional-aesthetic level of perception of the architectural environment consists in its saturation with a variety of "emotionally colored" elements. The fullness of the architectural environment with information makes it a source of various emotions and a positive emotional state associated with the fundamental cognitive, informational need of a person.

The emotional and aesthetic level of perception of the illumination of public spaces is probably one of the most powerful in terms of impact on a person. Violation of the psychophysiological parameters of favorable lighting makes the recipient avoid unfavorable places, protest or fight against violators of human rights to a comfortable environment. There are many such precedents, and for research, they are of exclusively statistical interest. Unlike the first level of perception, the emotional and aesthetic level is so strong that it is actively used by directors and cameramen in thousands of films. Artificial light can actively project fear, threat, ecstasy, peace, comfort, and hundreds of not just emotions, but their subtlest shades. This level of perception is actively mastered in the synthesis of innovative arts, where architecture acts as a gigantic stage, on the field of which many scenarios of urban life unfold.

The figurative and artistic content of the architectural environment is a process of comprehending its artistic and stylistic features, and through them - figurative expressiveness. This is reflected in the styles and trends of architecture. At this level of perception, an artistic image is formed associated with filling the architectural object with content. The function of this image is cultural memory. The informativeness of this level is semantic, which is explored using concepts such as the informativeness of the new and the traditional, associated with an orientation towards certain canons and norms.

The figurative and artistic level refers to the highest intellectual form of perception of illuminated architectural spaces. At this level of perception, the language of architecture consists of signs, the form of which can vary, and the meaning allows for interpretations that depend on the perceiving person, the characteristics of his personality and attitude to perception, and the development of culture. All this, in turn, is reflected in the styles and trends of architecture and art.

This level is potentially a powerful factor in the development of cities as sustainable systems. At this level, such complex phenomena arise as, for example, the "Bilbao Effect", when an architectural object changes the life of the entire city for the better. At this level of perception, with skillful manipulation of the architectural expressiveness of public spaces, city branding develops, the socialization of residents grows, and economic indicators improve.

Here we can recall the book of the English architect K. Day "Places where the soul dwells: architecture and the environment as medicine", in which design processes are considered in the framework of architectural "complicity" [19].

According to Day, architecture has a strong influence on a person, on the atmosphere of a place. The negative impact of architecture can reach such proportions that it is prudent to consider whether it is possible to consciously achieve an equally strong positive impact. A place cannot speak in words, but we can listen carefully to what it asks, determine what it will perceive. Caring for the aesthetics of the visual is the main part of the work of most architects. To obtain healing properties, a place must bring harmony, absorb change as an organic development so that new buildings are not perceived as invading aliens [19].

CONCLUSION

The synthesis of the methods for analyzing the visual qualities of the architectural environment considered in the study makes it possible to assert that there is a fundamental possibility of developing recommendations for standardizing the qualities of the visual comfort of the illumination of public spaces.

Today it is considered proven that artificial lighting can have a noticeable negative impact on human health. Artificial lighting of public spaces is a factor that almost no city dweller can avoid. Thus, the development of principles for increasing the comfort of illumination of urban spaces should be attributed not only to the humanitarian and aesthetic factors of the functioning of the city. The development of norms and regulations for the illumination of public spaces can have a noticeably beneficial effect on the economic and medical components of the life of settlements. At the same time, quantitative methods should be developed in which the elements and connections of the architectural space interact to achieve the visual unity of the architectural form. The "ecological" aspect of this analysis is determined by the dynamics of the visual interaction of man and space.

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The Relevance of Mobile Architecture in the Formation of the Architectural Environment During the Pandemic

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Abstract. The article considers the role of mobile architecture in creating an architectural environment during the global pandemic crisis. The analysis of the world experience of using mobile architecture in the creation of temporary medical institutions for the treatment of patients with COVID-19 is carried out. The main stages and means of adaptation of architectural objects to the health care institution during 2020-21 have been identified. Mobile architecture, due to its main features, compared to stationary architectural objects, is able to meet the changing needs of creating an artificial environment for various purposes in a short time. The experience of formation of temporary medical institutions during a pandemic is considered. The most common type of mobile medical buildings used to create temporary hospitals are block container buildings. The most promising architectural and structural systems of mobile buildings for the organization of temporary hospitals are identified.

INTRODUCTION

Today, we are experiencing a global crisis related to the COVID-19 pandemic, which has affected all spheres of life, especially health. The new dangerous disease has dealt a devastating blow to the usual way of life, first in China, then in Europe, and then around the world. Quarantine, self-isolation, distancing have made radical changes to the everyday scenario of people's lives and made everyone to think about the role of the architectural environment in our lives, its safety, comfort in the new social conditions. The architects were faced with the question: what will be the future architecture and urban environment after overcoming the pandemic? How much will the architectural environment change after the realization of new post-pandemic changes in public life? Architects and urban planners have yet to answer these questions…

At the same time, having one-year experience in combating a pandemic, we see some special requirements that faced the architectural environment during the crisis. Architecture and the architectural environment, as well as society in general, had to respond extremely quickly to changes in society. And the architectural environment began to adapt to these changes actively, especially the environment of medical institutions.

The urgency of the work is related to the problem of using mobile architectural objects in the formation of the architectural environment in socio-pandemic conditions to ensure the adaptation processes, in particular medical institutions.

Analysis of theoretical research in the field of mobile architecture shows a significant potential of mobile objects in providing adaptation processes in architecture. In particular, the Russian researcher, Professor Saprykina N.O. in her research identifies the important role of mobile architecture in ensuring the dynamic adaptation of the architectural environment to the rapidly changing conditions of operation of architectural objects in emergencies of various kinds [1]. A group of Russian researchers led by Professors Asaul O.M. and Kazakov Y.M. identifies a number of advantages of mobile buildings and complexes and buildings of rapid erection, compared with stationary architectural objects, and the prospects of their use in crisis social phenomena for the organization of the architectural environment and the provision of certain types of public services [2].

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World practical experience in the construction and placement of mobile architectural objects for various purposes in complex socio-psychological conditions and crises, as well as in emergencies shows the significant potential of architectural objects of this area for use in pandemic conditions to provide medical care for population [3].

PRESENTING MAIN MATERIAL

The main means of adaptation processes in architecture during the coronavirus pandemic of 2020-21, which we could observe, were flexible planning organization, transformation, change of functional purpose and re-profiling, application of mobile architecture and temporary architectural objects. It was a response to the global medical crisis and the general shortage of medical facilities to treat infectious diseases.

Adaptation processes can be divided into two stages: the first stage - the actual conversion of various public buildings for medical functions, the second - the deployment of temporary mobile hospitals and hospitals on the basis of rapid deployment buildings for the treatment of coronavirus patients. The first stage was usually observed in most countries during the first wave of the COVID-19 epidemic, the second stage is more typical for the second and third waves of the pandemic.

Due to the rapid increase of the incidence rate and hospitalization of critically ill patients in need of specialized treatment, during the first wave of the epidemic COVID-19 (early 2020), there was a process of temporary adaptation of public buildings for medical purposes for patients with coronavirus: formation of temporary hospitals in shopping and exhibition centers, sports arenas, re-equipment of resorts and rehabilitation facilities, hotels, etc. [3].

Of course, China, which became the source of the virus, was the pioneer in the adaptation and conversion of public buildings into temporary medical hospitals. At the beginning of pandemic, in Wuhan, when it was impossible to place patients in overcrowded existing hospitals, the authorities placed patients in arenas and halls of sports buildings, in exhibition complexes with minimal amenities and minimal provision of medical equipment. The largest temporary medical center in Wuhan for the treatment of coronavirus disease was the Wuhan Living Room Temporary Hospital, which was converted from an exhibition center to a medical center with 1500-2000 beds. Two months after the beginning of the pandemic, the 1000-bed modular mobile hospital the Huoshenshan Hospital was built in Wuhan in less than 10 days. The hospital is a two-story building with an extensive planning structure that includes 30 intensive care units and isolation wards. It is a modular method of construction allowed to implement construction in the shortest possible time. The Leishenshan Hospital in Wuhan was built using a similar method on the place of an abandoned parking lot, which is designed for 1500 bed [4]. The basis of the medical planning structure of the Leishenshan Hospital is two ward blocks based on volume blocks with dimensions of 3 m × 6 m × 2.9 m and 2 m × 6 m × 2.9 m. The two wards are united by a gateway for medical personnel or buffer room and a sanitary block and make up the planning cell of the therapeutic block [5].

There are also some examples of European experience in adapting public architectural objects to the therapeutic function for patients with coronavirus infection as the first stage of adaptation. Thus, in Serbia, by the decision of the authorities, in March 2020, the Belgrade Fair complex was converted into a coronavirus hospital with 3,000 beds. Belgrade Fair complex consists of three main domed buildings and is considered the largest domed building in Europe. The temporary hospital is located under the largest dome of the Belgrade Fair complex. The Serbian military was involved in the deployment of the hospital, and the placement of beds was organized at the expense of minimal means and ensuring the necessary distance between patients. His task was to isolate patients whose illness was mild or asymptomatic.

At the same time, the Corona Treatment Center on the Berlin Trade Fair (Messe Berlin) was opened in Germany, which allowed the deployment of a 500-bed coronavirus hospital in the shortest possible time. The pavilion of the exhibition center was converted into a medical function according to the project of the architectural firm Heinle, Wischer und Partner.

The treatment department is designed on a modular basis with modular blocks for 16-24 beds and a common service area. The project envisages the placement of auxiliary medical units (offices and locker rooms for medical staff, technical premises) in mobile units of container type on the territory of the exhibition center near the main building and related passages. Engineering provision involves the connection of the latest medical equipment. The center combines the idea of a modern medical center and a temporary field hospital to ensure the most effective treatment of contagious patients [6].

Comparing the adaptation of the Berlin Trade Fair under the Corona Treatment Center in Berlin with the hospital in the Belgrade Fair complex, it should be noted that the former is equipped with a more developed medical infrastructure and much better conditions for the treatment of patients with COVID-19.

The second stage of adaptation of the architectural environment to the global health crisis is characterized by the active use of mobile architecture to create temporary medical institutions for the treatment of COVID-19. In order to meet the treatment needs of patients in 2020, such mobile architectural objects as temporary mobile hospitals and hospitals were also used.

Why is mobile architecture used in a pandemic? The main features of mobile architecture better meet the requirements of the extreme social environment that has formed in connection with the pandemic. After all, mobile architecture most dynamically responds to changes in the needs of people and society in the organization of the artificial environment. The main positive features of mobile architecture, due to which its use is appropriate in complex epidemiological conditions, are the ability to deploy a mobile facility in places where there is an urgent need, short installation time, the possibility of full factory readiness and provision of all necessary equipment at the manufacturing stage mobile building, the possibility of ensuring the autonomy of operation, etc.

Unlike stationary buildings, mobile architectural objects can change their position in space and time, i.e. move from place to place, thus often providing a shortage of stationary buildings of a particular function for a certain time, which we can observe during COVID-19 pandemic, when mobile hospitals increased the bed stock of inpatient hospitals during peak hours. Examples of such mobile facilities are the well-known modular hospitals in Wuhan, China, built in the shortest possible time on the basis of prefabricated modular structures in the first half of 2020. After overcoming the pandemic, these facilities will cease to function and may be dismantled and relocated, or stored in a warehouse until another urgent need arises. Also, mobile buildings can be repurposed for other functional purposes.

Architects have contributed to understanding the quality of treatment of coronavirus patients during the medical crisis and have developed many projects of temporary mobile hospitals. The most common idea of creating mobile hospitals of different capacities, during the period of maximum load on stationary objects, is to form them on the basis of light volumetric blocks, often on the basis of sea containers equipped with all necessary medical and engineering equipment.

One of the first examples of a mobile medical facility project is the CURA mobile intensive care unit, created by Italian architect Carlo Ratti in collaboration with scientists from the University of Massachusetts Institute of Technology. The intensive care unit is designed on the basis of a 20-foot sea freight container and can work completely autonomously due to the equipment of all necessary medical equipment. Each unit is equipped with a special exhaust ventilation, which creates a negative pressure inside the room, and thus protects against the spread of infection by air. The first CURA mobile medical unit was implemented in a temporary hospital in the former OGR industrial complex in Turin, northern Italy, the region most affected by the pandemic in Europe in the spring of 2020 [7,8,9].

The property of mobile architecture to develop, increase the volume and spatial parameters, is extremely important for the provision of public facilities during a pandemic. It can be implemented by connecting additional mobile functional and planning units depending on the needs. Based on this block method, the Emergency Modular Hospital was designed by Norwegian architects. It has a flexible architectural and planning organization. The basis of the architectural and structural system are modules from used transport containers and their combination with the help of inflatable awning structures for transitions. One block module consists of three interconnected containers and consists of two adjacent separate chambers, designed for one person each. In addition to the space for the patient, the ward also includes a private bathroom and a lock before entering each ward. Architects consider the most appropriate organization of a mobile hospital, by forming a plan in the form of a horseshoe, as this provides the possibility of ambulance access to each block and placing the patient directly in the ward. This spatial planning solution most fully meets the requirements for isolation of infectious patients and non-spread of COVID-19 virus [10].

Unconventional placement of a temporary hospital to overcome the coronavirus crisis is offered by the architectural firm Weston Williamson + Partners: the organization of a temporary hospital on the ship - Hospital ships. It is proposed to place a temporary hospital on a vessel for transporting cargo containers, where the containers will be used as medical modules to accommodate patients. According to the architects, the use of a container as a regular ward, or intensive care unit is ideal for the treatment of a single patient. Thus, a hospital on ships can be created on the basis of the block method, adding containers-wards, if necessary. If necessary, you can create a full-fledged hospital by creating a multi-level structure of block containers [11].

In the COVID-19 pandemic emergency, military field hospitals based on lightweight rapid deployment designs have been used in Latin America. Another example of mobile architecture usage is awning buildings for rapid deployment of military and emergency services, which are able to deploy buildings in a few hours for temporary stay of people and their treatment, based on the experience of many post-Soviet countries, as it is also the cheapest way to organize temporary medical institutions on the basis of existing rapid deployment awnings.

Ukraine has the experience of deploying mobile hospitals based on light awning structures during the third wave of the coronavirus pandemic in Ivano-Frankivsk region in early 2021. On the basis of awning buildings of the emergency service, additional rapid deployment modules were deployed to accommodate patients with COVID-19 at an inpatient hospital in Ivano-Frankivsk region (Figure 1). The rapid deployment mobile hospital in Bogorodchany, Ivano-Frankivsk region consists of 30 tents and is designed for 120 beds. Its structure includes a reception department, an intensive care unit and wards for patients. The hospital is equipped with autonomous life support systems and can function independently as a medical institution [13].

FIGURE 1. Mobile department of the hospital on the basis of rapid deployment structures, Ivano-Frankivsk region, Ukraine [13].

The most dynamic, or dynamically mobile, as they are called by Saprykina N.O. [1] are mobile self-moving objects. Dynamic facilities can also be used to organize temporary medical facilities during a pandemic. It is possible to consider the creation of separate treatment units from mobile transportable objects on the basis of trucks. Due to the combination of special transitions, or blocking of trailer blocks, it is possible to form small medical institutions and their components. Due to the presence of its own chassis, these modules can quickly change location and respond quickly to changes in the epidemiological situation [1, 12].

CONCLUSION

In this way, traditional architecture is quite inert in the context of the rapidly changing needs of society in reformatting the architectural environment in connection with the crisis social phenomena associated with the pandemic. The adaptation of the environment of public facilities to the new needs of society happens usually due to internal reserves and the processes of adaptation and transformation. Therefore, the use of mobile architecture is an important area, as mobile architecture is able to respond quickly to social needs during a pandemic.

Global experience shows the significant potential of mobile architecture to create a temporary treatment environment during a pandemic crisis. The most expedient types of mobile objects that are able to form elements of medical infrastructure efficiently and quickly are light three-dimensional blocks or block containers, collapsible mobile buildings, awning and pneumatic buildings, highly mobile buildings with their own chassis.

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Formation of the Architecture of Public Educational and Recreational Centers as Innovative Institutions of Non-formal Education

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Abstract. The article presents some results of theoretical and methodological research on the formation of the architecture of such an innovative type of non-formal education institutions as public educational and recreational centers. The definition of the term of non-formal education is given, the information on researches of the accompanying branches of its formation in Ukraine is briefly presented, the basic factors of influence are specified. Two main structural and functional trends are identified: "in-depth specialization" and "cooperation", which are given definitions and foundations. Some information on the formation of architectural adaptability of such institutions is given. It is determined that public educational and recreational centers belong to the trend of "cooperation", this type of institutions is defined, the main positions on the formation of their architecture in the modern world are outlined. Examples of world experience of formation of architecture of similar establishments are presented. Basic scheme and recommendations for their modern formation are also presented. .

INTRODUCTION

The concept of non-formal education in the world has several definitions and is related to the concepts of "lifelong learning" and additional education. The UNESCO Educational Glossary defines the following wording: non-formal education – education that is institutionalized, intentional and planned by an education provider. The defining characteristic of non-formal education is that it is an addition, alternative and/or a complement to formal education within the process of the lifelong learning of individuals. It is often provided to guarantee the right of access to education for all. It caters for people of all ages, but does not necessarily apply a continuous pathway-structure [1, 20]. Current events in the world in general and in Ukraine in particular dictate a radical change in approaches and qualitatively solve the problems of all social processes taking place in society. The main problem now is that the social demand for certain services far exceeds the current supply. Despite the fact that the main factor in the formation of social demand is, first of all, the most recent quality of certain services. One of the key issues of our time is the quality of education. The formation of a modern approach to the phenomenon of non-formal education, lifelong learning is associated with various fields: pedagogy, psychology, sociology, economics and more. Modern domestic teachers note that in Ukraine the existence of non-formal education covers the following areas: extracurricular education; postgraduate education and adult education; civic education (diverse activities of public organizations); school and student self-government (due to the possibility of acquiring managerial, organizational, communicative, and other skills); educational initiatives aimed at developing additional skills (computer and language courses, interest groups, etc.) Recently, several third-age universities have started working, providing educational services to the elderly [2, 9, 21, 22]. Foreign scientists from different industries also note the need of society for non-formal education and the

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introduction of non-formal educational scenarios [3,5,17]. Along with the pedagogical factor of such a public demand, the architectural reflection of new views on the processes and algorithms of work inherent in non-formal education, as a material manifestation of the formation of educational institutions of a new type that must meet modern requirements. The relevance of the topic of this study is determined by the need to reform the typological and regulatory support in the new socio-economic conditions prevailing in Ukraine, changes in the global educational space, increasing the role of human capital, increasing societal requirements for both new educational product and new educational and public space that will meet modern requirements, as well as changes in the field of civil engineering. In the architectural field, non-formal education institutions are represented by various architectural and typological structural units and elements. One of such progressive links, the authors of the article consider public educational and recreational centers, which during the genesis occupied certain typological niches and were created at the request of society. Types of such buildings also well known as cultural centers, community centers, community learning centers etc.

BRIEF HISTORICAL REVIEW AND MODERN EXAMPLES

Historical Part

The time limits of the study covered the period from the second half of the XIX century to the present - a period that covers not only and not so much the formation of non-formal education institutions as pedagogical institutions, but also the gradual formation of their architecture. Regarding the formation of the architecture of public educational and recreational centres, as innovative institutions of non-formal education, we can identify the following important positions, according to the authors:

– People's houses are a typological link that best corresponds to the scenario of functioning of public educational and recreational centers in the past. Examples are: the People's House in Belgium, in Brussels, designed by Victor Horta in 1896-1899 - a specific new type of buildings, which were built by workers' unions on a cooperative basis [12]. An example of the first people's houses on the territory of Ukraine is rightly considered to be the People's House in Kharkiv, beg. XX century, author - Odessa architect A. A. Vensan [23,25]. In the Ukrainian experience of the same period, the Prosvita society played an active role in the formation of people's houses. [13, 15, 16].

– Palaces of Labor, Palaces of Nations, etc. - a phenomenon typical of the Soviet period. Youth clubs, Houses of Youth and Culture, as well as Houses of Culture were also prototypes of modern public educational and recreational centers. They arose at the turn of epochs and changes in ideological principles. For example, paid leave for workers and employees - the result of the conquests of the Popular Front (1936) in France - led to the emergence of a new factor among workers: leisure. Thus, in the late 30's there were prerequisites for the construction of some types of buildings of a democratic nature, designed to serve the general population [7].

– Libraries, museums, schools and palaces of arts, Houses of creativity - that is, typological links aimed at the educational scenario. Each of these types once introduced non-formal education scenarios to a wide range of visitors.

The authors define such typological links as "shimmering" architectural-typological links, which, during genesis, appeared and formed, then progressively dynamically developed, then faded or branched, and after some time reproduced again in an updated form and under the influence of modern factors.

Modern Examples: Dominant Function – Sport

Among the modern architectural examples of public educational and recreational centers there is the presence in the functional composition of different components, which are combined according to a certain scenario and in a certain ratio. However, in almost every example there are dominant and secondary functions. What unites the different types of such institutions is that their functionality is focused on the specific needs of the community and implements a certain educational function. The difference is the presence of a dominant function. In some institutions it is a sports component, in others art and education. Next, it is proposed to consider relevant examples that illustrate public educational and recreational centers and correspond to modern buildings of mixed typology.

As an example of an innovative non-formal education institution with a dominant sports function, the authors of the article thought it appropriate to cite Mycal Cultural and Athletic centre by Emilio Ambasz which is shown on Fig. 1 [18, 19].

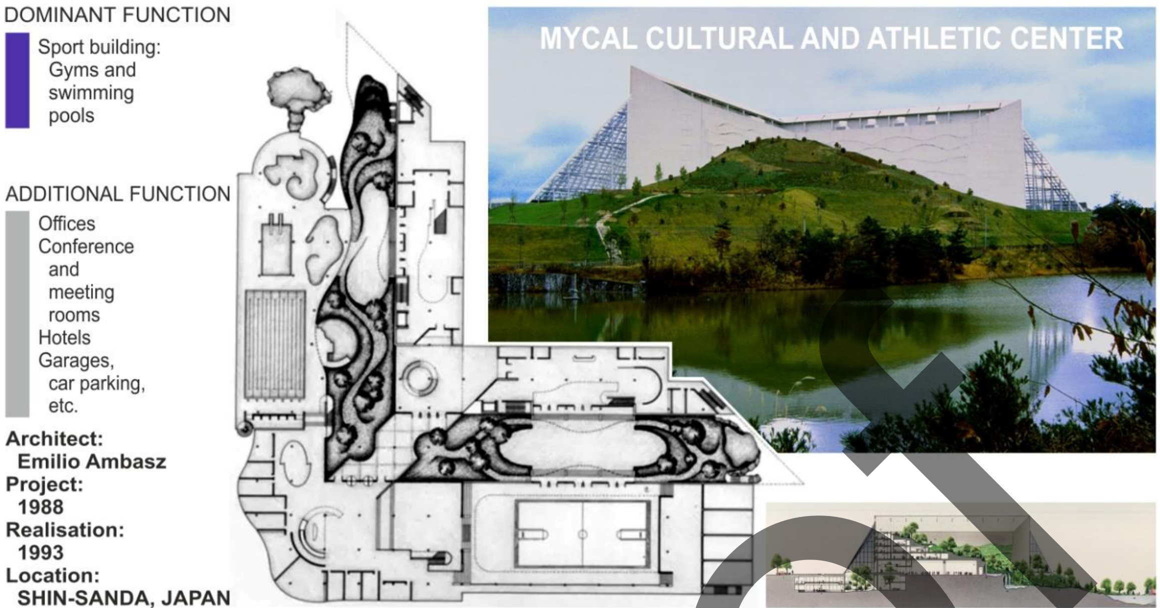

FIGURE 1. Mycal Cultural and Athletic Center by Emilio Ambasz [18,19]
Photo: EMILIO AMBASZ & Associates Inc. © 2022

A cultural and athletic centre erected by a department store chains in the new town of Shin-Sanda benefits not only its employees but also the growing local community. Ambasz was able to return to the new town of Shin-Sanda virtually all of the greenery that this enormous building footprint would normally have taken away [18]. Emilio Ambasz is well known for his approach to the preservation of greenery on the construction site. Here we see a tendency to combine architectural volume and landscape. There are gyms and swimming pools as dominant functions and offices, conference rooms, hotels as additional civil function present in the centre.

Modern Examples: Dominant function – art

According to the authors, a good example for illustration of prevalence of the art function is The You Art Centre by Atelier Global that is shown in Fig. 2. The building is built on rather a small city site and its function is inverted inside. There is a philosophy of architects that becomes materiality of the art centre. As architects say: “The project vision is to use urban art as medium and catalyst for city upgrade and redevelopment, promote aesthetic education for better public spaces, urban art and lifestyle. We envision an art space with more publicness, flexibility and public engagement. Unlike many other enclosed white boxes in the traditional art exhibition centre, the future of the art centre is not just a stage for the art pieces but more about promoting interaction between the public and artists. A vertical public atrium as an informal public space for exhibition, events, and circulation reflects the traditional social characters of the lanes and streetscape in a vertical manner to interface art with the public. The architectural design concept of the Art Centre takes “The Light of Changde” as the main theme, using architectural space as the medium, we aspire to create a stage/platform for the cultivation of art and spiritual lifestyle” [24]. The dominant functions of the building are the art centre and an exhibition gallery. As additional functions, a library, an education centre for kids, a studio theatre, a multi-media room and a cafe are present.

The main concept of the You Art Centre is dual in nature. From the one side, the whole building is permeated by an atrium space that flows and creates a sense of unity, as laid down in the architectural concept. From the other side, on each floor, there are green terraces designed to promote meditation and solitude.

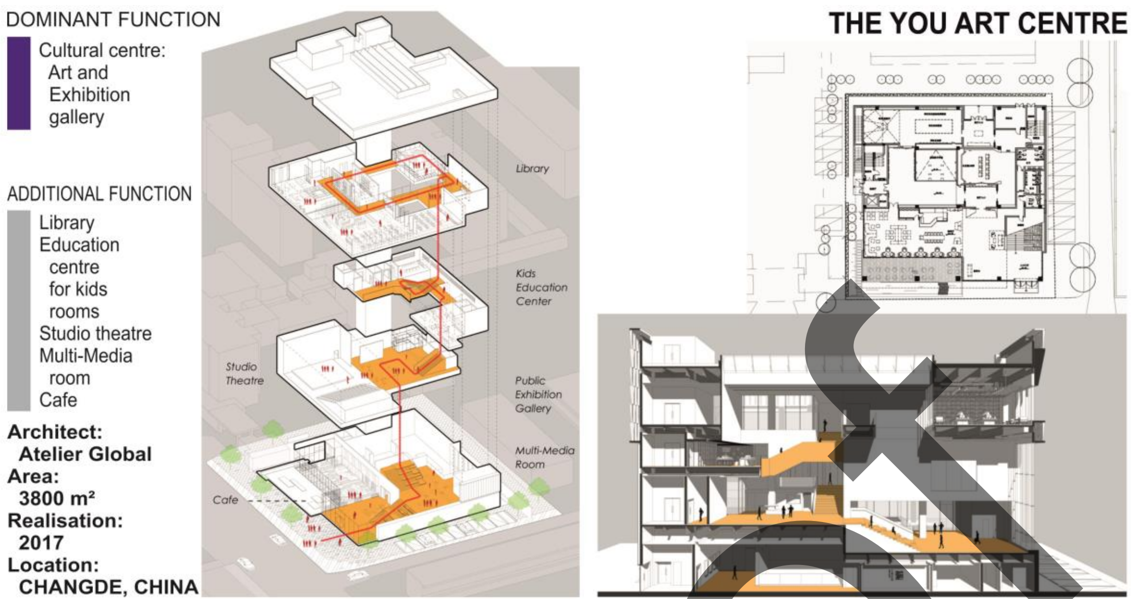

FIGURE 2. The You Art Centre by Atelier Global [24]

According to authors of the project, Ascend art gallery – a vertical museum without walls and boundaries. It is an informal public space for interaction, cultural and social exchange. The You Art Center also reflects the aspiration of an Utopia where people lead an ideal existence in harmony with nature. It becomes a place or venue open for public engagement and participation [24].

Modern Examples: Dominant function – learning

Oodi Helsinki Central Library by ALA Architects illustrates public educational and recreational centres with the dominant function of learning that provides for a wide range of visitors (Fig. 3) [4,14].

FIGURE 3. Oodi Helsinki Central Library by ALA Architects [4,14]
Photo: Tuomas Uusheimo © Helsinki Central Library Oodi.

Authors of the project say: "... The siting of Oodi opposite the Eduskuntatalo was chosen to be symbolic of the relationship between the government and the populace, and act as a reminder of the Finnish Library Act's mandate for libraries to promote lifelong learning, active citizenship, democracy and freedom of expression. Oodi has a peaceful open-plan reading room on the upper floor that has been nicknamed "book heaven", but books only fill one third of the space within the library. By reducing on-site storage and consulting library-users on how they access culture, the designers and librarians of Oodi have been able to introduce facilities including a café, restaurant, public balcony, movie theatre, audio-visual recording studios and a makerspace. This is representative of broader experimentation within Finnish libraries to offer new services in addition to loaning books. The design divides the functions of the library into three distinct levels: an active ground floor that extends the town square into an interior space; "book heaven" on the upper level; and an enclosed in-between volume containing rooms to accommodate additional services and facilities within the library. This spatial concept has been realised by building the library as an inhabited bridge, with two massive steel arches that span over 100 meters to create a fully enclosed, column-free public entrance space, clusters of rooms grouped around the structure, and the open-plan reading room carried above" [4, 14].

So, the building stands as a symbol of the main non-formal education principle - lifelong learning and its availability for everybody.

MATERIALS AND METHODS

The topic of this article is a part of the author's study of the theoretical foundations of the formation of non-formal education institutions architecture. The systematic approach in the context of this study was used in relation to the educational object itself, as a system unit, and the system of non-formal education in general, as a part of the education system. It is determined that the system of non-formal education institutions is an open, mixed, definite, complex system, structurally organized, and capable of systemic transformations under the influence of external factors [8-10]. The architecture of such buildings is a material aspect of that system. The main trends in the development of the architecture of non-formal education institutions are identified: the main structural and functional trends – "cooperation" and "in-depth specialization".

RESULTS AND DISCUSSION

Main trends of the development of non-formal education institutions architecture

Author's research of factors influencing the development of architecture of public educational and recreational centres has revealed a number of external factors that have a constant, dynamic and powerful influence: socio-economic, technical, political, environmental [8,9]. Against the background of modern changes, under the influence of a number of factors, given the modern examples of architecture, we can identify the main trends. First of all, it is necessary to identify two main structural and functional trends that are manifested at the level of the object and element in the formation of the architecture of innovative non-formal education institutions, at the stage of concept formation and, further, in project documentation development [10]. Specifically:

- "Cooperation" – functions, different age groups, architectural and planning techniques, architectural volume and landscape.
- "In-depth specialization", a trend that involves the enrichment of additional functional groups of educational and / or educational components together with the optimization of functional-planning schemes, the creation of not so much a building but rather a place of information and educational space.

Another group of trends that influence the formation of the architecture of innovative non-formal education institutions is adaptability, which is manifested on all levels of the formation of the architecture of non-formal education institutions: environment, object and element. This tendency is already widely considered by architects. Among the strong global trends to the architectural adaptability of non-formal education institutions, there are certain positions that should take into account the specifics of the functioning of such buildings: renovation (refunctionalization) of abandoned or abandoned architectural objects, buildings and areas - the level of the environment; optimization (functional, climatic, constructive) and integration, which provides full compliance of the non-formal education institutions building to the requirements of inclusiveness, integration of different capacity and purpose of non-formal education in the existing fund and city structure [10].

In accordance with the above trends, the direction of development of the architecture of public educational and recreational centers, the authors attributed to the trend of "cooperation". The adaptability of such institutions is manifested at all levels and can cover a wide range of issues. As a rule, such institutions are created at the request of a specific community, or under a specific program, so they can have quite different functional content.

Definition

Public educational and recreational centers - public institutions (complexes / centers) that combine groups (blocks) of premises of different public purposes in different combinations and provide the implementation of everyday (formal education centers, catering, retail space), periodic (non-formal education institutions, clubs, sports facilities, etc.) and episodic (entertainment facilities) services subject to cooperation of various public functions, clear zoning and the availability of appropriate groups of facilities for the implementation of non-formal education scenarios. As a structural-functional and architectural-typological link can be included in regional and interregional (large capacity), inter-district and centers of united territorial communities (medium capacity), and everyday (small capacity) community centers of the following categories: daily public services (for local residents); neighborhoods; residential areas; district centers; regional centers; centers of united territorial communities.

Basic functional scheme & recommendations

The structural and functional trend of "cooperation" involves a combination of different functions aimed at the needs of the community. Prognostically, it is recommended to include in the following centre: 1 (or maximum 2) group of preschool education institutions and / or 1 stream (class) of primary school - provided a separate block of such premises with its recreational area in accordance with regulatory requirements - is recommended for everyday services. local residents. Here, we should mention Jeffery A. Lackney (2007), who, having declared 33 principles of designing schools and public training centers, teaches in 4 principles «Plan for Learning to Take Place Directly in the Community». He says "...A variety of social and economic factors have created an environment in which many educators recognize that learning happens all the time and in many different places. The school building is just one place where learning takes place. While the school building is being seen more as a community centre, the idea of embracing the whole community as a learning environment has evolved in a complementary fashion. Educational programs can, and are taking advantage of educational resources in urban, suburban and rural settings alike. Formal educational program partnerships have been established with museums, zoos, libraries, other public institutions, as well as in local business workplace settings. In addition, increasing costs of public spending for education has encouraged the idea of sharing the school and community facilities to prevent cost duplication of similar facilities such as gymnasiums, auditoriums, performance spaces, and conferencing facilities. Sharing facilities can also realize long-term maintenance and operating cost savings over the life of the building. Sharing school facilities with a variety of community organizations may fostering meaningful inter-organizational partnerships that can strengthen educational opportunities for learners" [11]. And, although his recommendations relate more to the principles of designing modern schools, one cannot fail to note the architect's well-founded desire to make school buildings real community centres. In this regard, an interesting experience is the development of so-called "extended schools". Such establishments are widespread in the Netherlands, Germany, England and Finland. As Herman Hertzberger (2008) writes: "... The last stage in the process of eliminating the traditional school building is to integrate it in a socio-cultural complex, what we in the Netherlands call a Brede School, the "Extended school" or "Community school" [6].

Thus, we can recommend the following items: sports and wellness unit should be aimed at a wide range of visitors and can be represented in a wide variety of ways, including: universal gyms, public pools, gyms, rooms for wellness treatments (massage room, certain physiotherapy programs, rehabilitation programs), etc. centres of non-formal education institutions can have a variety of content, for example: universal classes; a block of workshops, training laboratories - in accordance with a certain theme inherent in the selected community and area - but should be accessible from the outside to visit all age groups; premises for drawing, painting, music; rooms for group classes and meetings, small lecture halls, etc (Fig. 4).

Club, entertainment and leisure facilities, a catering unit, must also work on the whole complex and be accessible to users from the outside. The group of premises in which administrative and social functions can be performed can also be diverse - depending on the design task. Recommendations for combining all such blocks:

– clear zoning of all groups of premises of the complex;

- arrangement of the general educational and communicative space of the building by combining and / or replacing traditional functions (the functions of the library and media library can be combined with general recreation, which will acquire information and educational content);
- such a combination can take place according to different schemes: atrium, courtyard with a public gallery, creation of blocks of rooms with their own recreations, combined with warm passages, etc.
- a combination of architectural volume and landscape is a prerequisite and a common method of organizing the educational space of an institution.

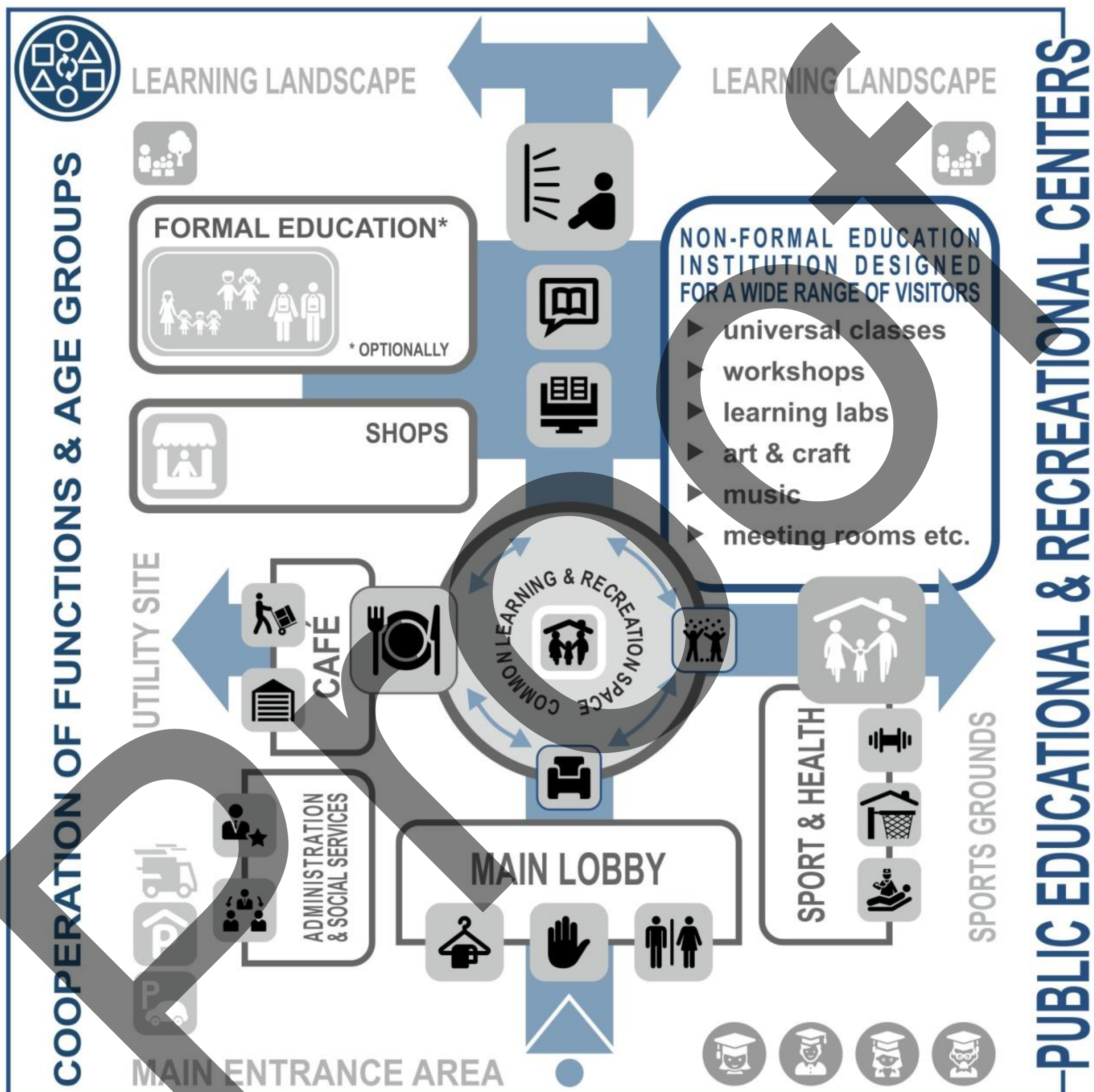

FIGURE 4. Basic functional scheme of public educational & recreational centers.

CONCLUSION

Public educational and recreational centers can have different functional content and are quite flexible in their functional composition. Much depends on the special design task, the peculiarities of accommodation and the wishes of residents - potential users of such complexes. However, it should be noted that this type of educational buildings is one of the most viable models of the "cooperation" trend. The formation of the architecture of such complexes is closely related to the requirements of a particular community, so all blocks of premises may have different composition and capacity. Summarizing the above information, it can be noted that in the formation of architectural and planning algorithms of public educational and recreational centers and complexes should be applied a balanced methodological approach, which will take into account:

– structural and functional changes in the social, political, technological, economic field, and their impact on the reform of educational requirements;
– social, psychological and pedagogical aspects, because both educational scenarios and algorithms for their implementation, and, ultimately, the ability of a person to perceive them, follow them and choose the best for themselves personally - all these are factors that affect the formation of society's requirements, both to the new educational product and to the corresponding modern architecture of the educational space;
– a combination of different types of learning spaces according to educational scenarios, including such components as internal public educational and communicative space, which now acquires subject information content, and educational landscape, which is created systematically together with the scenario of the building as a whole;
– requirements, characteristics, history and cultural traditions of a particular community in the formation of the task of design - a certain social interactivity between the architect and the potential consumer.

This scientific work is developed in line with the general direction of scientific work of the Department of Theory of Architecture at KNUCA "Theoretical foundations of the architecture of public buildings and complexes"

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Configuration of Urban Planning Spaces as a Subject of Protection. Innovative Approaches to Monuments Protection Works on the Mass Industrial Development of Kharkiv of the 1960s – 1980s

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Abstract. In all the large cities of Ukraine, significant spaces and, accordingly, a significant percentage of the housing stock are those of mass building of 1960–1980. The purpose of this research is to find an answer to a very specific question about the fundamental worldview and architectural attitude to the era of mass industrial development as to a huge cultural heritage, including architectural and urban planning one. Extension of the ideology of monument protection to the housing estates of the 1960s and 1980s contains a kind of "categorical imperative" to develop non-standard approaches to this special morphology, which is completely unknown to the current monuments protection practice. this analysis should be integrated from the beginning with the development of promising programs of architectural and spatial reconstruction and social rehabilitation of these housing estates, as well as with the formation of special, essentially innovative approaches to heritage protection work on such non-traditional objects of documentation and preservation. A structural basis of protection zones projects i.e. protected territories, where the such a regime of town-planning and economic activity is established, which provides physical security of cultural heritage object and its historical environment, should be town-planning framework, step of highways, configuration of their trajectories. Components of the subject of cultural heritage protection may be the structure of the spatial environment, which includes the planning module of microdistricts and plots, scale, altitude and division of the building.

INTRODUCTION

In all the large cities of Ukraine, without exception, significant spaces and, accordingly, a significant percentage of the housing stock are those of mass building of 1960–1980. Today the environment of such residential, "sleeping" areas is a place of partial optimization measures, including: filling reserve plots by sealing buildings, current reconstruction of residential buildings, public facilities and surrounding areas in accordance with modern requirements. But on the way, are the measures incomparably more radical and responsible, which should be carried out during mass decommissioning of all large-panel, in fact temporary buildings of the times of "developed socialism".

The purpose of this research is to find an answer to a very specific question about the fundamental worldview and architectural attitude to the era of mass industrial development as to a huge cultural heritage, including architectural and urban planning one. Extension of the ideology of monument protection to the housing estates of the 1960s and 1980s contains a kind of "categorical imperative" to develop non-standard approaches to this special morphology, which is completely unknown to the current monuments protection practice. Hitherto known methods of identification, documentation, protection, restoration and museification of architectural heritage, are obviously inapplicable to those building blocks that were created during the period of mass industrial development, so there is a need for methodological innovations.

Although tens and tens of millions of square meters of prefabricated buildings built during the period under study are still in operation and inhabited by millions of citizens, the period itself has ended definitively and long ago and

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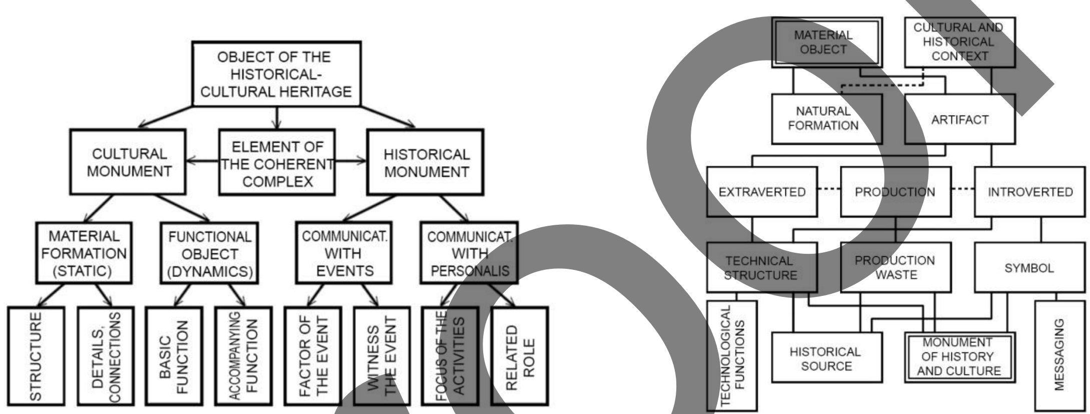
went down in history. Let not today and not tomorrow, but in the near future we will have to agree on a systematic, comprehensive strategy for the vast expanses of large-panel buildings, and therefore also for its monuments protection component.

METHODOLOGICAL APPROACH

The starting point for the formation of the methodological basis of this study were current developments of Ukrainian scientists engaged in the theory and methodology of cultural heritage protection and, in particular, the structure of architectural monuments which is a complex activity that affects a number of segments not only monument protection reconstruction of the urban environment, architectural and urban design, historical and architectural research, etc. As a typical example of a modern approach to this issue, the basic schemes of the functional structure of the cultural heritage object and the substantive structure of the material object as monuments of history and culture are given here - Fig. 1 (a) and (b). Both schemes belong to L.O. Griffin and included in his fundamental work "Theoretical Foundations of Monument Studies", published by the Center for Monument Studies of the National Academy of Sciences of Ukraine and the Ukrainian Society for the Protection of Historical and Cultural Monuments [1].



(a) (b)

FIGURE 1. (a) Functional structure of a cultural heritage monument; (b) Material object as a monument of history and culture (according to L. O. Griffen) [1]

But it should be noted that these approaches were formed in relation to the usual scheme of organization of conservation research, focusing on the material object, single or part of a complex. Accordingly, research and organization of protection measures ranged from "discovery" of the object as a monument and further, through analysis of its structure and features, correlation with the cultural-historical context and subject-spatial environment - to architectural attribution, definition of the subject of protection, planning and organization of the monument protection actions.

When we are faced with the task of building a conservation strategy for the heritage, which has a fundamentally different structure, in fact to the arrays of industrial housing, the above procedure does not work. Strategies for the protection of objects, the defining feature of which is mass, as cultural and historical heritage, should unfold in a significantly different order - namely from creating a general concept of cultural value of this period in history to gradually delving into the principles, methods and implementation of such urban formations. and only on this basis - to a specific morphological analysis.

When creating such a strategy, a non-trivial theoretical task is to determine the subject of protection in this unprecedented case. Our hypothesis is that the subject of protection should relate to the urban composition of the areas to be reconstructed. This view is based on the understanding of design methods used to create new areas. As A.V. Ikonnikov once noted, "to achieve a certain artistic impression of the architectural and spatial organization of the microdistrict one chooses and identifies a general method of building of the residential complex as a whole, reveals a compositional idea on the basis of which the building is solved and space is composed" [2].

Within a microdistrict concept framework, elaborating of a compositional idea of a microdistrict and a residential quarter was based on identification by means of architecture of microdistrict public life centres and of the ways of movement to them. Thus, a compositional centre was most often formed by a complex of public buildings (shopping malls, cultural institutions, schools, kindergartens, sometimes sports facilities), and a spatial "skeleton" – by a system of internal passages and pedestrian alleys. On this basis a specific architectural and spatial content was arranged, which largely depended on the available series of standard projects and corresponding technologies, materials and other building conditions, as well as on the general structure of the city, its master plan, natural conditions, etc. [3].

Theoretical bases for elaboration of the strategy of rehabilitation and reconstruction of the areas of mass housing development were laid by the works of several generations of domestic researchers. In particular, the works of M.V. Bevz [4], M.M. Dyomin, G.I. Lavrik [5], V.P. Myronenko, V.O. Timokhin, I.O. Fomin and others.

Search for ways to improve the environment of the historic city goes in different directions. The laws of functioning and cities development depending on the peculiarities of the city centre historical formation are studied in the works of N.N. Baranov [6], A.E. Gutnov [7], Z.N. Yargina [8]; the issues of including of modern objects into historical surrounding are considered in the works of MG Barkhin [9], Yu. G. Bobrov [10], A. Yu. Becker [11], and others.

One of the basic principles that these studies adhere to, is comprehensive preservation of heritage as a component of the city's economic and social development policy, as a part of long-term planning and urban planning projects, as a key element of urban renewal strategies.

RESULTS AND DISCUSSION

Conceptual Basis

The principle of integrated preservation includes initiation, controlling and coordinating functions of public administration bodies in the development of partnership with the public and the non-governmental sector. Interdisciplinary, interagency approaches to identification, protection and preservation of cultural heritage should be encouraged using all available resources. The task of cultural heritage preservation cannot be solved only by the efforts of monument protection bodies. Consideration of these tasks should constantly be in the focus of attention of the structures in charge of urban planning and architecture, economics and industrial development, ecology, transport, landscaping, property complex, housing and communal services, legal services, etc.

A three-dimensional planning framework, city-wide silhouette, configuration of the main water spaces, river panoramas, perspectives of the main streets have indisputable value. Kharkiv, like most large metropolises, has significantly changed its spatial structure throughout its existence. But it was during the period of industrial development that the city grew most dynamically, capturing large areas of agricultural landscapes [12].

In the West and in many post-Soviet countries the study of the architectural and urban heritage of the period of mass industrial development has been carried out for a couple of decades [13]; German works show a special interest in this issue. Formulation of the problems of modernization and further maintenance of large volumes of typical panel housing, which Germany had received after unification, was studied in [14–20].

Case studies of typical housing in the cities of Germany, Russia and Ukraine, which demonstrate a multifaceted nature of the tasks to be solved, despite of the important socio-cultural, legal and financial characteristics of each country, are presented, in particular, in the work of B. Engel [20]. For several years the author was the initiator and leader of the international research project "Socialist City – Unloved Heritage?", which considers the possibility of using German experience of rehabilitation of mass housing in post-Soviet countries.

During the Soviet period Ukrainian researchers paid much attention to the possibilities of reconstruction of mass housing, improving the efficiency of typical series of buildings and the problems of their further use [21-23]. A set of issues related to the development of Kharkiv planning structure and of long-term urban plans, the definition of planning indicators of the main areas of the city are discussed in the collective work "Kharkiv yesterday, today, tomorrow" [24].

The creation of significant urban areas, built on the basis of the microdistrict system, has become an urban experiment of unique scale. It combined in rather a complex way pan-European tendencies of post-war mass development with new discovery by the Soviet technocracy modernist ideology and aesthetics after a quarter of a century of Stalin's "heritage mastering". To this were added purely Soviet social issues, and after all – technical and economic aspects, including new planning and design solutions, types of buildings, technologies of mass industrial production of typical houses etc. Adopted architectural and urban planning principles of mass development often came into conflict with the care about natural and historic urban environment [25, 26].

Historical values related to the urban space structure superimposed for a long time, but their preservation directly depends on the volume and state of preservation of the material heritage, as well as on the relevance, systematicity and reliability of protection measures that ensure its protection. In the historical environment of different periods and with different types of city development the value hierarchy of the components of the subject-spatial environment can change significantly.

In particular, in the vast majority of successful examples of prefabricated housing estates, the subject of protection will most likely be not individual buildings or even their complexes, but the character of architectural spaces, formed by the mutual arrangement of building volumes. In the housing estates, where architects managed to form a clear urban composition of microdistricts, the reflection of the epoch is just the configuration of spaces in conjunction with their functional logic. In this case, the building morphology itself may not even contain elements worthy of preservation. Then the valuable cultural heritage and accordingly, the subject of protection is the character of the environment as such, primarily – the geometric configuration of urban spaces. Then it is necessary to structure carefully this notion and make it operationally flexible to be used, taking into account individual characteristics of different urban complexes. Possible components of the notion here are planning modules of quarters and sections, architectural scale, and hence the buildings altitude and division and so on.

Creating a methodology for identifying and evaluating these spatial complexes will require a specialized study of the evolution of planning techniques for the areas of mass housing. Empirical material for such a historical-comparative analysis should include the first German and Dutch examples of the 20's–30's, transitional building character of the 2nd part of the 1950s (for example, the Moscow Southwest, in comparison with Kharkiv TP settlement), and then the whole path of evolution of compositional techniques in the building of microdistricts from the 1950s to the middle 1970s, including the urban composition of Pavlovo Pole, New Houses and Saltivka districts.

Kharkiv Examples and Western Background

Analysing the best examples of the achievements of neomodernist urban thought in Ukraine, it should be noted a widespread use in the initial stages of closed or semi-closed composition of the microdistrict, associated with the compositional schemes of the 1950s, with their tendency to symmetry, balance and frontal buildings. Examples of this can be found in Pavlove Pole housing estate in Kharkiv (Fig. 2), in particular in the development along its structural axis – Nauki Avenue (formerly Lenin Avenue).

FIGURE 2. Planning scheme of Pavlovo Pole residential area [17]

FIGURE 3. August 23 Street. Kharkiv [18]

The most spectacular in this complex is the main composition of the second central street of the district – 23rd of August Street (Fig. 3). It belongs to the next stage in the evolution of compositional techniques. Its expressiveness is formed by a number of separate high-rise 14-storey residential buildings, connected by a common stylobate of a complex of large stores. It is this memorable accent that dominates the silhouette of the entire residential area [18]. Planning structure of the housing along the 23rd August Street, in the northern sector of Pavlovo Pole, demonstrate mastery of the principles of a new urban grammar, namely "line" development. Just in this sense Pavlovo Pole district may require to become a subject of protection as a monument of urban planning.

Comparing Ukrainian heritage with the European methods of housing formation, we can note the commonality only in the general structural logic, which depends on similar forms of the residential buildings of the industrial era. Instead, the compositional culture of the Soviet industrial urbanism, for a number of reasons a great while had little in common with contemporary Western experience [22]. This was dictated, in addition to the basic difference in socio-economic grounds, also by the special way of development of Soviet urban planning in the 1930s and 1950s, different strategies of the building industry development etc.

That is why, working out a methodological basis for identifying and documenting domestic monuments of mass urban planning of the industrial era, it is necessary to conduct – in parallel with historical and architectural analysis of the evolution of compositional techniques in Ukrainian cities – a similar analysis of Western experience. Only against this background it will be possible to form a theoretically based idea of the content, character and specific manifestations of national identity during this specific segment of our architectural and urban history.

The range of phenomena to be considered should first and foremost include the most striking examples of the use of new principles of mass building in the UK since the 1950s. At that time, the hostilities of World War II inflicted great material damage to the economy and infrastructure of the United Kingdom. Systematic German bombing of major cities in England turned many of their areas into ruins. In addition, by the 1940s, much of the working-class microdistricts that had been built up in the nineteenth century during the country's industrial revolution and industrialization, had evolved into real slums with the corresponding social and economic decline, unsanitary conditions and rising crime.

Against this background, the pre-war urban planning concepts of Le Corbusier, André Lurçat and the like, which gave hope for the rapid provision of the masses with modern and, most importantly, relatively affordable housing, gained new notoriety. The quarters destroyed by the Nazis could be painlessly demolished in order to build a new spatial structure on their ruins, which would correspond to the vision of the "progressive world" of a bright future.

Naturally, along with planning techniques, the first examples of high-rise housing in the UK should be considered, such as the 10-storey The Lawn (1951) in Harlow near London, which was probably Britain's first example of “the only appropriate type of housing” (Le Corbusier), after which individual residential towers, their groups and entire areas began to appear in large and medium-sized cities of England as reminiscent of the urban concept of Le Corbusier.

An example is Alton West area to the southeast of London (1958), which consisted of several 12-storey towers, five 11-storey "wall-houses" and a complex of low-rise townhouses. Large-panel housing was not as widespread in Britain as in the USSR or in the countries of "people's democracy", but still there were more than enough of examples.

Later, when numerous shortcomings of such development were revealed, new districts began to lose their popularity. But for our topic it is extremely important that today, with a significant change in functions and replacement of the original buildings by new ones, the British prefer to preserve the planning structure of the districts.

Examples to be analysed include also large housing projects in Paris, built in the 1950s and 1980s, marked by a search for the "architecture of the future" in sharpened modernist and later postmodernist styles. Among them is the project of the 1960s "Italy-XIII", the core of which was "Olympics" quarter with a wide internal esplanade with cafes and shops.

In Germany, as well, a significant percentage of mass building of the industrial period is still in use. It is significant that here, too, the successful free planning structure of the microdistrict becomes a reference point, the scheme of compositional solution, which can be used to meet today's needs.

Therefore, we can say that in determining the subject of protection of urban monuments, first of all, the general compositional scheme of residential education should be analysed. The microdistrict as a compositional structure has specific architectural and artistic features related to the nature of the use of planning and natural situations. When determining the subject of protection we must try to identify the main compositional idea of the spatial organization of microdistricts, taking into account the peculiarities of the area and functional requirements for the territory. All the most diverse methods of realization of the compositional idea should be revealed and recorded in the language of formal-compositional analysis. Typical is the concentration of buildings around the central core, which can be, for example, a compact microdistrict garden, or the territory of educational institution, public shopping centre and so on (Fig. 4).

This technique, in turn, may involve different options for the location of the service network, but often the main service complex tends to the geometric centre of the territory. In Kharkiv urban planning experience, this technique dates back to the first examples of modernist mass building, such as Pavlove Pole residential district №5 with a clear separation of housing groups, areas around two schools and the placement of service facilities along the highway.

FIGURE 4. «Radyansky» Shopping Center is the first shopping centre in Saltivka in Kharkiv against the backdrop of a panorama of the surrounding neighbourhoods. Located at Gvardiytsiv-Shironintsiv, 45. The department store was built in 1978 [19]

Among the post-war urban implementations in the USSR, the creation of specialized scientific and industrial complexes, the so-called "science cities" (naukograds), usually located at a certain distance from the main plots of urban development, – deserves special consideration. In Kharkiv, such examples are Pyatihatky and Zhukovsky districts. Naukograd Pyatihatky provides development of the territories of Kharkiv Institute of Physics and

Technology (KFTI, former UFTI) and the adjacent district for employees of this scientific institution. It is generally recognized that this area is one of the outstanding monuments of Ukrainian scientific culture. Here the specifics of the functional-spatial complex with the developed social, educational, sports and transport infrastructure deserves to be analysed and preserved. It should be noted that the architectural and town-planning composition and the monument protection potential of these complexes have never been the subject of a special study.

CONCLUSIONS

1. Determining of the subject of protection of cultural heritage of the studied period will be a central point of the monument protection strategy when planning a full-scale reconstruction of industrial buildings. For a long time the widespread practice of monuments protection was limited to working with individual architectural monuments, almost without taking into account their environment. Design of protected areas for certain monuments is, in essence, a confirmation of this statement. The specificity of the cultural heritage of the industrial period of building dictates rather a combination of environmental and urban protection practices. Objects of cultural heritage protection are key parameters and characteristics of the environment, as well as carefully selected individual elements that can be considered as carriers of historical and architectural value, historically marked type of organization of urban subject-spatial environment.
2. Particular attention is drawn to the method of development, when large spaces were filled with almost identical residential and public buildings, built after standard projects. Plot development envisaged mostly a combination of houses of two, sometimes three standard series, as well as several options for using one ready-made residential building. It would be desirable to preserve the first houses, as representatives of the series, as the monuments of the history of technology, possibly with functional purpose changing and partial museification of interior typical equipment. The subject of protection here is innovative for those times structure and architectural quality of finished building products – residential or public buildings.
3. A separate aspect of the study should be identification, analysis and systematization of theoretical models and methodological rules, which the designers guided by. These regulations are recorded in various documents, including guidelines for the projects of certain types of residential and public buildings and structures, projects documentation, analytical and critical publications, as well as fairly extensive methodological literature in the genre "To help an architect-designer".

During the reconstruction of residential formations, formed from typical buildings, metro-rhythmic relations, dynamics of spaces and large-scale correlations, variety of methods of building of a rhythmic system can be a subject of protection. Among the means of the microdistrict composition there is skilfully found scale of the whole and the elements. Successful urban composition of industrial buildings can be used as a stereometric scheme-matrix in the projects of reconstruction on the existing site with replacement of the buildings that have outlived their term.

4. In conclusion, we'll point out a typical example of urban development of the period under review, for which one can deploy a pilot technique. There is a potential of a town-planning monument in the implemented scheme of detailed planning of Saltovsky housing estate. The project of this largest modernist residential complex in Ukraine was developed in parallel with Kharkiv master plan (architects LM Tulpa and IT Demeshko). The plot was solved on the basis of the progressive for its time planning structure of inter-highway territories, with a step of highways of 800–1000 m and organization of a system of cultural and household services according to "focusing" principle [15]. Four inter-highway territories (enlarged microdistricts), creating intersections, consisted of a spatial "focus", in which public trade and consumer services were located. A good example of such a "trick" is an inter-district centre at the intersection of Jubilee Avenue (formerly the 50th anniversary of Komsomol one) and Traktorobudivnykiv Street.
5. The study of urban complexes of mass industrial development of the Soviet period as unique architectural and artistic monuments of the era is at an early stage. Obviously, this analysis should be integrated from the beginning with the development of promising programs of architectural and spatial reconstruction and social rehabilitation of these housing estates, as well as with the formation of special, essentially innovative approaches to heritage protection work on such non-traditional objects of documentation and preservation.
6. Analysis of mass industrial building in terms of isolation of the subject of protection is a fairly new area of work with regard to grandiose new Kharkiv building complexes, implemented in the 1960s–1980s. Architectural fabric of these complexes today is rapidly losing performance, its morphological units – factory-built residential

buildings – are mostly not of interest as the possible objects for assigning the status of an architectural monument. Instead, the transport framework created during their building, the spatial configuration of large urban formations – residential areas – and author's design findings, which were implemented in the composition of microdistricts, still remain important.

7. Looking ahead, we can already make some assumptions about the probable methodological foundations of promising research and development in this area. Firstly, when determining the subject of protection of urban monuments of the era of mass housing development, the general compositional scheme of urban development should be analysed. There are successful examples of placement of residential and social buildings, the formation of transport framework and pedestrian paths, which fit into a coherent stereometric scheme. Giving it the status of restrictive and guiding parameters for a new design can be extremely productive when carrying out reconstruction – both with the demolition of the buildings themselves and with a change in their functional use.

8. A structural basis of protection zones projects i.e. protected territories, where the such a regime of town-planning and economic activity is established, which provides physical security of cultural heritage object and its historical environment, should be town-planning framework, step of highways, configuration of their trajectories, etc. In addition, components of the subject of cultural heritage protection may be the structure of the spatial environment, which includes the planning module of microdistricts and plots, scale, altitude and division of the building. A separate aspect of the study should be theoretical models and compositional principles, which designers were guided by, while forming the complexes of unprecedented scale and social significance.

9. For the further existence and successful development of urban fabric, which was created by the efforts of architects of the 1960s–1980s, the most attractive are compositional achievements. And if technical condition of residential buildings, landscaping and quality of roads within the district need modernization and replacement, just the compositional moments of development of new inhabited spaces are the most valuable and stable, worthy of protection as a legacy of urban culture of our parents.

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The Impact of the Covid-19 Pandemic on the Architecture of Residential and Public Spaces

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Abstract. For the second year in a row, the fear of transmitting the virus changes the distance between people, occasionally closing offices, schools, restaurants, cultural events, office buildings and transportation centers, and restricting access to common areas. As the result of the rapid spreading of the virus, new spatial zoning rules that reduce the circumstances in which the disease can spread have been introduced. It is important for the architect to quickly, but consciously, make adjustments to the norms of zoning private and public spaces, adapting to the current situation so as not to disrupt the concentration on different processes and their interaction in one private space. Thus, the task of searching follows - what a person needs in his personal living space under quarantine conditions, at a time when access to familiar daily places is limited. The article reveals the question that a person's own housing should now replace offices, gyms, health procedures, places of communication and meeting people, as well as other places of earnings, leisure and the development of personal qualities. The article addresses the issues of changes in the daily routine of people due to restrictions that affect changes in the typology of housing today.

THE IMPACT OF GLOBAL PANDEMICS ON ARCHITECTURE

Outbreaks of pandemics, or disasters, as they are often called, have been thoroughly investigated in the field of history. History describes many pandemics that forced architecture to develop and form a new type of city. It is the bubonic plague that struck Europe in the 14th century, which contributed to the cleansing of cities and the involvement of various specialists for the transformation of urban spaces; 18th century yellow fever, 19th century cholera outbreaks and smallpox, which set a precedent for the development and implementation of innovative sewer systems and the emergence of plumbing inside buildings, the construction of wide streets and large public spaces; the Spanish flu of 1918 and the outbreak of other unpleasant diseases of the 20th century became a precedent for cleaning slums, zoning of premises, increasing the space of premises, sanitation; and the not-so-distant Ebola virus in West Africa in 2014 and the current COVID-19 pandemic will not leave architecture unchanged. Throughout human history, very few phenomena have shaped our society and culture like outbreaks of infectious diseases. For a long time in history, pandemic outbreaks have destroyed societies, determined the outcome of wars, destroyed entire populations, but, paradoxically, paved the way for innovation and advancement in science, economics, and political systems. [1].

Not so long ago, in the 40s of the 20th century in the industrial quarters of New York, the "loft" direction was born, which set a new vector in architecture and design and is still popular in some countries. It involved the re-equipment of abandoned industrial buildings that ceased to fulfill their functions into living rooms, spaces for creativity, exhibitions of artists and musicians who settled in huge open spaces with their inherent creative approach. Already by the 50s, these apartments had become very popular and increased in price due to their convenient location, spaciousness and special urban charm. Thus, abandoned factory and warehouse areas have turned into luxury loft-style apartments. Even in the 2010s, all millennials dreamed of living in a loft-style apartment. Theoretically, it can be assumed that the currently unused office and coworking spaces due to the COVID-19 pandemic will also change their function and become a new trend [2].

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In his book, Sharon Zukin writes that urban revitalization through the loft trend has been more sustainable than previous disaster-driven urban changes. The loft synthesizes arts, culture and industry in a single architectural space, at the core of which is diversity.

"In the grand scheme of things, loft living gave the coup de grace to the old manufacturing base of cities like New York and brought on the final stage of their transformation into service-sector capitals. The form itself sets up a matrix of accumulation and consumption, cultural expression and social control, that changes the nature of urban space," said Sharon Zukin [3].

Thus, we can expect new directions in architecture after the COVID-19 pandemic. The author of the article highlights the changes in the architectural space that are already in effect, based on the elaboration of theoretical material and personal observations. However, this issue requires further study, since the world is immediately under the influence of restrictions and is being transformed in real time. Where this will lead architecture - now we can only try to predict, but the fact that architectural spaces are waiting for change - becomes obvious.

The Pandemic is Changing the Lifestyle and, as a result, the Architecture

Today, millions of scientists around the world, in all fields of knowledge, are working on the task of solving the global problems of the world's population associated with a significant deterioration of the ecological situation on the planet. It is paradoxical, at first glance, but the more knowledge is accumulated by humanity, the more topics for new, original research opens before the scientist. The question of choice arises [4].

Are global catastrophes (such as pandemics and their restrictions on moving freely around the city) the only forces that can seriously change architecture? Based on millennia of history, the answer is yes. Tracing the global history of pandemics from the Stone Age to the present day, various sources of information show that it never went unnoticed. The Covid-19 pandemic has changed a lot for the city's residents. Its influence has forced people in all industries to change and develop in real time with long-term effects that will last in the long run. The very ways we live, work, learn, and even play have changed dramatically in the days of the crisis. In many ways, the change isn't going anywhere. These changes affected all spheres of life, from agriculture to the economy, from pharmaceuticals to aviation, from travel to office work, from technology to architecture.

Temporary Buildings and Structures During the COVID-19 Pandemic

Last year, the coronavirus made architects think about new problems that architecture and urban planning can solve. We find ourselves in a new scenario of life, which was not inherent in us before. And the question is what should be the architecture of the future for the comfortable life of human being in complete or partial isolation. On the other hand, what innovative technologies, methods and materials will help architecture to quickly address urgent issues, such as the need for temporary accommodation and protection of large number of people in critical periods?

The pandemic has changed the view of human life and its communication with society. Gradually adapting to the new demands of life, we can follow the situation with the virus on the site "worldometers", which clearly demonstrates the dynamics of the pandemic. There are graphics that show situation in real time such as active cases, closed cases, total cases, total deaths and cases by countries [5]. The diagram on website shows that humanity has already gone through two peaks of an outbreak of infection in the winter of 2020 and in May of 2021. At present, after mass vaccinations and other quarantine measures, the indicators are moving downwards, which gives hope for a return to a normal way of life, but with new norms, trends in the planning of public and residential spaces and a scenario of life.

Now the partial cessation of traffic and social interaction are crucial for the maintenance of the coronavirus, but also change people's habits. These spatial interventions have a longer line, architects have previously seen design as a panacea for the disease of crowded cities. During today's global pandemic, cities have been transformed: squares, hospitals, hotels, cruise liners, parking lots, and even the most unexpected spaces have been transformed into temporary means to combat the COVID-19 virus. They provided the population with urgent help and further treatment, information about the disease, heat, electricity, household services and hope to survive until the situation with the outbreak of the virus is over. Temporary hospitals are being built all over the world and existing buildings are being adapted for hospitals.

The first rapidly built hospital for patients was built in the Chinese city of Wuhan. The structure was build from separate blocks within 10 days, the hospital is designed for 1,000 people and began operating on February 3, 2020. It has become one of 16 temporary hospitals opened due to the virus. As Yanzhong Huang, a senior fellow for global health at the Council on Foreign Relations said, "China has a record of getting things done fast even for monumental projects like this" [6]. He said that the Beijing hospital in 2003 was built in seven days, so the construction team was probably trying to break that record. Like the hospital in Beijing, the center in Wuhan was built from prefabricated houses. This "race" demonstrates to us that this is the best moment for professionals in various fields of knowledge to demonstrate their best qualities to save humanity in the shortest possible time with maximum accuracy.

On March 11 last year, all the quickly constructed temporary hospitals closed due to the cessation of the spread of the virus in China. However, the virus did not recede and spread further. Later, European countries that encountered a similar outbreak turned to the experience of the East, studying the epidemic solutions of Wuhan, Hong Kong, Singapore and other Asian cities that overcame the crisis [7]. An interdisciplinary approach to overcoming the problems of the pandemic is the key to solving the question of human survival as soon as possible. It is the productive cooperation of specialists in various fields of knowledge - architects, pharmacists, physicians, economists, psychologists, historians, sociologists - that minimizes quarantine in the world at the same time by various means - raising immunity to the virus, reassessing lifestyle, changing distances between people, new planning of public spaces and so on.

Changes in the Architecture of Public Space During the COVID-19 Pandemic

Quarantine 2020 is a precedent for the formation of a new vector in architecture, the development of new scenarios of human behaviour in the city, respectively, and new futuristic architectural concepts. The process of designing innovative architecture includes more and more specialists in such specialties that were not previously involved in the system, and with each crisis, architecture reaches a new level of development. Coronavirus obviously has such a profound impact on today's world as previous crises. In just over one year of quarantine, we are already seeing certain changes in the architecture of urban spaces and the ways in which it is used.

A. Jasiński in his paper reveals the question of how the outbreak of the coronavirus COVID-19 has changed human habits and its direct impact on the way we use public space during forced measures of social isolation. Behaviour and interaction between people in public space has changed. In an effort to protect themselves from infection with the virus, people increasingly prefer walking, bicycles and private cars to city transport. Mr Jasiński draws attention to the fact that the use of private and public spaces has changed to the opposite: in public spaces, people are less and less likely to meet, while private space has become a luxury, accessible only to the richest [8].

Public spaces are changing according to new rules of life. On a global scale, this can only be a prediction of what all this will lead to, and on a local scale, humanity is obviously getting used to isolation, but it also needs communication, so there are such chamber spaces, for example, for eating. Social distancing involves avoiding large companies and keeping 6 feet between people when possible, wearing a cloth face mask, and other public health mandates. Indoors, the virus is transmitted more actively, which increases demand for more outdoor spaces and improved ventilation. Service industries and restaurants keep up with the times reorganizing the reception of visitors in open spaces where the risk of transmission of the virus is lower, placing tables further apart, arranging additional terraces and balconies, and in cold climates experimenting with free-standing structures for one dining table. Currently, public institutions, each in its own concept, are experimenting with isolated rooms for receiving visitors as the most effective solution with minimal contact and the ability to host guests in any climate (Fig. 1, 2).

FIGURE 1. Amsterdam, the Netherlands. Mediamatic Restaurant. Serving from a Distance. Anisa Xhomaqi (September 28, 2020). Source: The Website "Mediamatic" [9].

FIGURE 2. Amsterdam, the Netherlands. Mediamatic Restaurant Establishes Small Architectural Forms. Willem Velthoven (April 28, 2020). Source: The Website "Mediamatic" [9].

Quarantine has had a huge impact on all industries, including real estate. As people continue to vaccinate, there is even greater potential to contain in the pandemic. While public spaces remain deserted and private spaces expensive, the real estate industry has also reversed: new opportunities are opening up in the rental sector. The pandemic can limit the creation of new relationships, especially between strangers. In public spaces, we still have the opportunity for social interactions, but it can be more difficult for spontaneous and informal ones. These forms of exchange are often needed to build a community [10].

Many companies are moving to remote work partially or on a permanent basis. Due to this, a change is observed in the way of life of people - more and more people are exploring the nomadic way of life, some of whom will prefer to stay in shared living quarters, rather than in apartments or hotels, in order to communicate with like-minded people and not feel lonely in their free nomadic way of life. Many people are so used to working remotely that they do not want to return to their offices, and at the same time, it is profitable for companies to abandon the maintenance of offices for a large number of employees and move to smaller premises. The person becomes less and less attached to the place.

Thus, it might be that the nomadic lifestyle and remote working will continue to develop after the end of the Covid-19 pandemic, as the result of which more and more hostels will appear in the future, not only in tourist cities but also in rural areas and unique places.

Changes in the Architecture of Living Spaces due to Quarantine

Architecture plays a huge role in the integration of civilization into a wild environment. Under normal conditions, at least three quarters of all human activity takes place in an artificial environment, and in isolation - almost full time. Thus, applying the latest knowledge and technology, we are able to create cities and architecture that will be not only safe for people, but also comfortable for a variety of activities.

Health, safety, environment and comfort are the main aspects of residential buildings for human mental and physical well-being, which have been confirmed during the quarantine and are expected to be transformed because of new lifestyles and new safety requirements for most people. In view of the latest developments, we design our living spaces, providing their residents with certain health and safety measures, such as the use of new sensor technologies for opening doors, decontamination lamps, proper sanitation, washable surfaces, creating open balconies and terraces with greenery and additional spaces for changing the type of activity, which can help restore and improve mental health. [11].

History reminds us that the tuberculosis epidemic in the early 20th century also influenced architectural design - buildings became white, windows became large to allow maximum sunlight and fresh air to enter rooms, and terraces for sunbathing appeared. In the 1850s, a medical institution was created in the south-west of Finland – the famous Paimio Tuberculosis Sanatorium. Alvar Aalto's book describes in detail the functions of the sanatorium, its purpose and the innovations that have been introduced into architecture through color, shape and arrangement among themselves [12]. Despite the fact that over the years the building has lost its relevance as a medical facility, it influenced all subsequent modernist architecture. In its demanded time, the sanatorium was a model of hygienic architecture in a pandemic. At the same time, poor healing rates, a vague medical requirement and a lack of a promising alternative treatment approach created opportunities for innovation and the development of new architectural ideas [13].

With the development of technology and the emergence of a variety of gadgets, the lifestyle of residents has already changed and changes in the planning of living space have been needed. Over the past decade, there has already been a move away from open-plan home spaces. The Covid-19 pandemic has made its own adjustments and set a precedent for the reorganization of living spaces. The family with one TV is forever a thing of the past, now people need separate spaces, often soundproofed from each other, since there is no longer a rigid differentiation between work and leisure. Thus, the old norms for the design of living spaces have a number of certain disadvantages. Previously, that set of rooms and their sizes was enough for us, now housing should be structured in a different way to increase the resilience of living conditions to pandemics:

- It makes sense to divide open-plan spaces, united by an entrance hall, living room, dining room and kitchen into an independent entrance area and other isolated rooms. This separation would minimize the risk of infection. As a buffer zone between the street and clean rooms, the entrance area should include a dressing room for outerwear and a bathroom (or a sink, depending on the planning solution of the housing), and it is desirable to have a door or an interior partition to prevent the spread of dust from outdoor things. There, a resident leaves his shoes, clothes and things, returning from the street, washes his hands well and gets clean in other areas of the dwelling, which does not transfer dirt to the living room and other rooms.
- Arrangement of the isolated workplace at home is important due to change of work style to remote – it should be a completely separate, sound-insulated room with comfortable furniture, large windows, blackout curtains and technically equipped with everything a person needs to work. If several people need a workplace in a living space, then it should be several separate rooms or a room separated by designer partitions.
- For physical health for the period of strict quarantine, it is advisable to create a sports area for morning exercises, massages and individual needs, preferably with an open balcony, adequate ventilation and sanitation, which are provided in all rooms. If the living area does not allow for a separate room for a gym, then it can be a terrace or an area in the living room that does not perform its direct functions during the period of isolation.
- Given that a period of self-isolation is required for most people infected with the coronavirus - from 14 to 21 days, it is necessary to create a space suitable for comfortable self-isolation [14]. A separate dwelling or isolated space in family housing should have access to the garden, terrace or balcony directly from the room of the infected person. The room should be large enough to accommodate all the necessary areas of human activity for the period of isolation - a workstation, a place for morning exercises, a sleeping place, a bathroom, a place for eating and other areas to allow a person to live to the fullest life as far as their health allows (Fig. 3).

FIGURE 3. Space Suitable for Self-Isolation. Illustrated by Olga Smirnova.

- Windows in living quarters are important for the comfort and health of residents, perhaps even more so during a pandemic. When a person spends most of their time inside their home, looking out the window helps restore focus through the space of the environment. Natural views from the window make residents calmer, improve well-being, attention and the mood of people [15].
- The pandemic has been tough on families who have not been able to visit their relatives during the shutdown and a return of the tendency to live with relatives in the neighborhood or in a common house is expected.

Summing up the theoretical material considered, the study proposed its own vision of the optimal zoning of living space during the covid-19 quarantine period (Fig. 4), which will give a sense of security and protection from the virus from the outside. Following the scheme proposed by the author, placing a kitchen with a bathroom between the entrance area and living rooms, they are combined into a kind of block that works as an additional buffer between rooms clean from the virus and possibly infected things that enter the house from the outside. Thus, the chance of getting an infection is reduced even more than if we restrict ourselves from the outside by only the entrance zone. Besides, the location of the kitchen near the entrance allows residents to leave purchases in this area or start cooking. It is also convenient that the kitchen area is located at an equal distance from the self-isolation room and the main living space, which should not be connected by a direct passage. Thus, after passing through two buffer zones, residents have the opportunity to spend their leisure time, do hobbies, work, exercise or sleep in a safe space. Each living space should have large windows or glass doors to the balcony, because daylight has a beneficial effect on people, their well-being and comfort, as well as on the mental and physical health of people, and contributes to a speedy recovery [15]. The number of rooms in this area may vary, depending on the needs and capabilities of residents, but there must also be at least one bathroom. In addition, this zone can be divided into two more - sleeping and active. As for the self-isolation room, it is convenient to place it closer to the entrance in case of emergency hospitalization or the arrival of an ambulance. In this case, the medical staff will go directly to the patient without entering other areas of the housing.

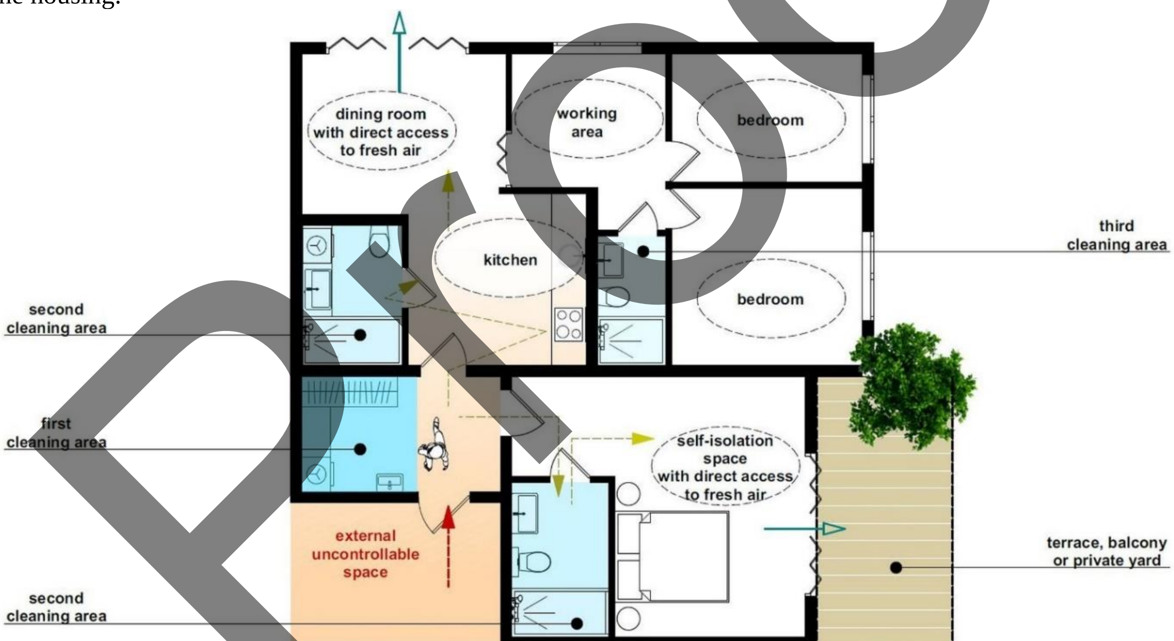

FIGURE 4. Space Suitable for Living During the Quarantine Period. Illustrated by Olga Smirnova.

Proposed living space model is general and may change depending on the needs of specific residents. In quarantine, everyone was locked up in their homes and each family has its own requirements for "comfortable housing", depending on the type of activity and the lifestyle that they lead. For some, the living room is a stadium, for others – a sewing workshop, for some people – an office for online meetings. The role of the interior is determined by the user. This living space layout diagram aims to protect residents from the outside world and give a sense of security in their own home, as well as spend the most comfortable days of isolation in case of infection of one of the family members. However, this requires further study and adjustments with the course of the situation in the world. The results of this study should therefore not be regarded as the definitive response of specific medical requirements for architectural planning.

CONCLUSION

Today's pandemic, as a typical satellite of globalization, changes the way of life, and at the same time the living conditions of people in cities in general and in their own living space in particular. We can already confidently predict that additional housing functions, such as home office, massage parlor, sports room, isolated "home medical center", open balconies and terraces for outdoor recreation and other important for the health and well-being of people become not a luxury, but a comfortable living space in case of infection of a family member or strict quarantine with restrictions on social life. People's behavior is also changing, with the appearance of hitherto unpopular design elements to improve the sanitary conditions of the premises.

Urban planning and design directly affect our physical and mental health. As the pandemics of previous years have shown, changes in the architecture of public and residential spaces are an integral part of human development and remain the "new norm" until humanity gets used to the new conditions until a new pandemic breaks out, making adjustments to architectural spaces. As Le Corbusier said: "To be modern is not a fashion, it is a state. It is necessary to understand history, and he who understands history knows how to find continuity between that which was, that which is, and that which will be" [16].

Architecture, in particular the layout of spaces and the design of the architectural environment, are the main tools for adapting society to the survival of the planet as a result of outbreaks of pandemics. It is important for an architect to react in time to changes in conditions and quickly, but deliberately, develop new solutions for architectural spaces for various purposes, which relies on the development and knowledge of specialists in other fields of knowledge - sociologists, doctors, economists, historians and others. Summing up the above, in an interdisciplinary connection, humanity is entering a new level of life, where the goal of architecture is to adapt people to new conditions not only for the survival of the species, but also in for creating comfort and safety under various additional circumstances of changes in life.

Thus, having not only knowledge from history, but also living the changes on our own experience, it can be argued that pandemics set a new vector for architecture.

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Strategy of Functional-Spatial Development of Slavske United Territorial Community

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Abstract. Results of functional-spatial development and the basin approach to the area of Slavske United Territorial Community (Lviv region, Ukraine) are presented. Recreational development of the Carpathians should be based on the even distribution of anthropogenic load throughout the territory, with reference to individual settlements, taking into account their unique attractiveness – "highlights". The arrangement of mountain settlements should preserve local ethnographic and architectural features.

PROBLEM

Main features of the geographical location, natural and climatic conditions contribute to the development of the Ukrainian Carpathians as a recreational region of national and international importance as well.

The main recreational resources of the Ukrainian Carpathians are natural mountain landscapes, climatic conditions, cultural and historical monuments and objects, the existing network of mountain resorts. The recreational network of the Carpathians is represented by a multifaceted combination of institutions of different profiles.

The authors' team began design and survey work in the mountainous regions of the Carpathians in 1977 and to date have prepared about 46 master plans with programs of strategy for the development of certain recreational areas.

ACTUALITY

The system of settlements in the Ukrainian Carpathians has historically been formed, as a rule, in the lowlands of river valleys. This system is explained by the possibility of running own farms.

Analysis of the current state of development of mountain areas of the Carpathians shows negative trends in overcrowding of mountain valleys, transport problems during peak seasons, reduction of forest land and land plots suitable for private farming, spontaneous "selective" construction of tourist and recreational facilities. The existing recreational complexes of the Ukrainian Carpathians are mainly located at an altitude of less than 1000 m above sea level that causes the inevitability of invasion of the tourist infrastructure in small settlements. Lack of water resources is a significant limitation at the current stage of functional and planning development of areas in the Carpathians. Problems with water supply impose limitations on the tourism development for local administrations, planners and investors.

The development of the recreational system requires both innovative forms of the recreational environment organization and traditional types of recreation in mountain areas and ethnic centers [1-3].

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NOVELTY

Analysis of the practical planning and operation of winter mountain resource (WMR) in the Alps and the Carpathians showed the general trends in formation of a spatial environment for recreation:

- the main profile of mountain resorts is skiing and tourism, and the main feature of their functional-planning structure is multi-functionality and versatility;
- in the process of forming of a recreational environment there are two the most usual types of spatial planning structure: the first type is represented by integrated resorts for 1000 and more persons, the second type is a territorial association of several local resorts each of medium and small capacity.

In the process of developing the "Strategy" [4, 6] the authors' methods of quantitative assessment of recreational resources by individual parameters and the principles of forming a multifunctional planning and spatial structure of recreational facilities of a new type were used. When planning the territory of the Slavske United Territorial Community (UTC) the principle of "spatial-basin development" of this recreational zone was tested. According to this method it is recommended to develop three recreational sub-resorts (Slavske, Grabovets, Pshonets) and a recreation center, to introduce various types of mountain tourism (hiking, riding, skiing, sledding) and to determine reference points of perception of visual spaces. The basis of the spatial framework of the recreational zone "Slavske", as a kind of agglomeration, are the valleys of the rivers Opir, Golovchanka, Slavka, Rozhanka. Forms of the valleys, steep slopes, watersheds cause a linear method of forming the planning structure of such a resort agglomeration and other settlements in the area of its influence [1, 5, 6] (Fig. 1, 2).

FIGURE 1. Panorama of mountains Orozovets, Trostyan, Menchil from Slavske village, Lviv region (author's photo)

FIGURE 2. Panorama of Menchil, Slavske village, Lviv region (author's photo)

Spatial-planning structure of the recreational zone "Slavske" provides the following alternation: open spaces - visual pools and structural elements "resort - recreational node - ski center - recreational village." Today Slavske is a well-known brand of winter recreation in the Carpathians. Namely here in Slavske were formed traditions of ski centers development in former USSR. Besides that the village is situated at the intersection of five transport crossings between the recreational structural elements of the resort.

MAIN SECTION

According to our analysis of the natural potential of Slavske village as well as Volosyanka, V. Rozhanka, Grabovets, Golovetske, Grebeniv, N. Rozhanka, Pshonets, Khashchovanya, Yalinkuvate villages (Fig. 3) it is possible to argue the possibility to develop resort Slavske [5] with a focus on winter sports and recreation with elements of local lore and cognitive tourism.

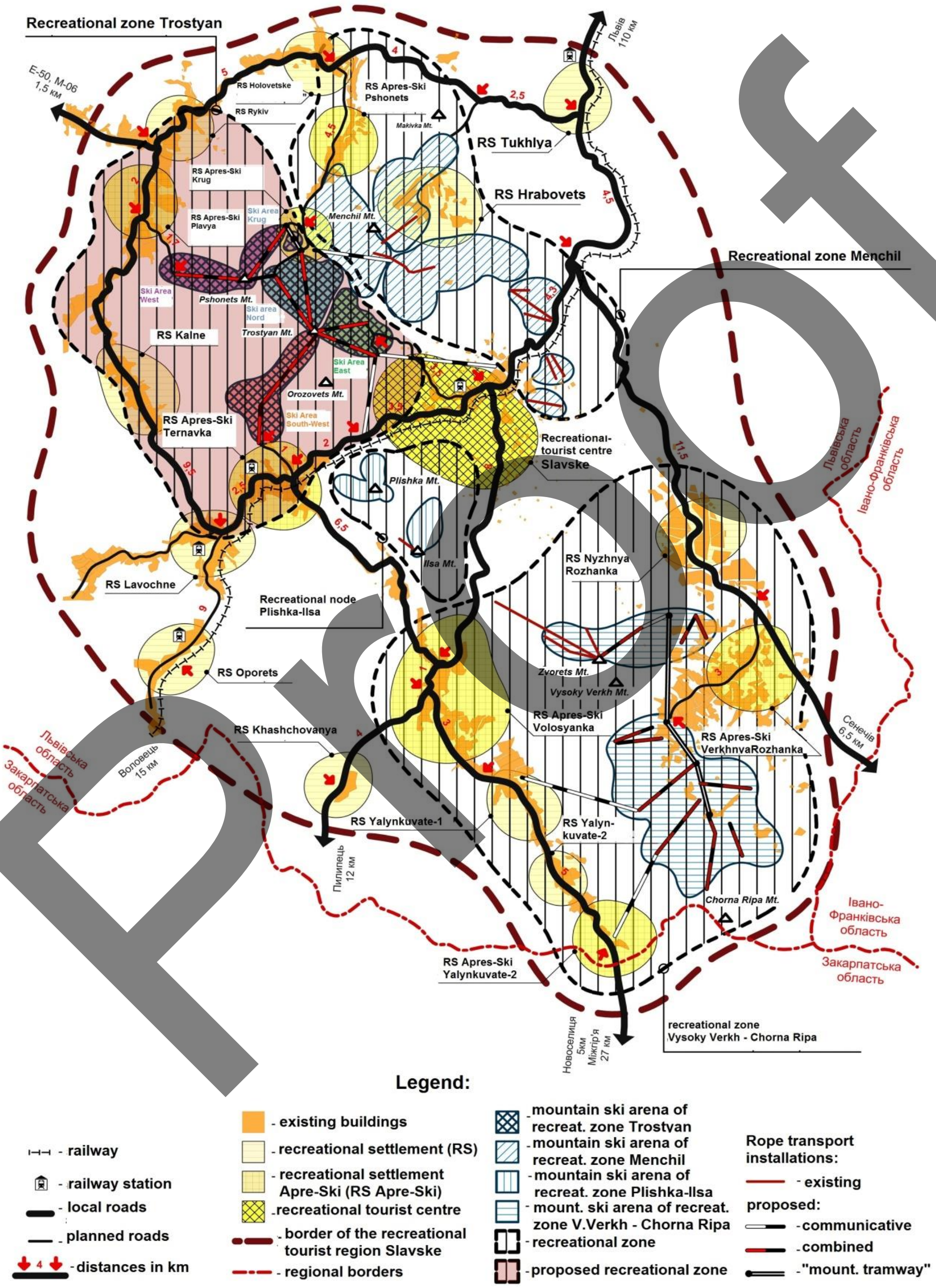

FIGURE 3. Recreational and tourist area "Slavske Arena-Ski" (based on materials of AKD Ltd. and Priv.Ent. Horizont AL)

From the north the border of the resort runs along the valley of the river Golovchanka including the village Golovetske. In the south it borders with the village Novoselytsia, Mizhhirya district, Zakarpattia region. The eastern border of the resort runs along the line of the Boelin ridge with the peaks Magic (1251 m) - Magay (1281 m) - Menchilin - area Pryslop - Magura (1362 m) and in the Ivano-Frankivsk region near the village Senechiv, Dolyna district. From the west the resort is limited by the slopes of Plishka - Gorby - Trostyan - Yalinka – Kichera mountains.

The resort is formed by mountain-recreational nodes (MRN): MRN Menchil-Warsaw, MRN Kremin-Pogar-Crocus, MRN Yalina-Gnilishche-Zholob-Tovsty, as well as mountain-recreational centers (MRC): MRC Trostyan, MRC Zvorets, MRC Plishka. The basis of the planning and spatial framework of the resort "Slavske" are the valleys of the rivers Opir, Golovchanka, Slavka, Rozhanka. The valleys are V-shaped with steep slopes; in combination with watersheds of the first, second and third order they form a linear radial multinuclear planning structure of the valley settlement system. Recreational settlements of Slavske, Volosyanka, Yalinkuvate, Verkhnya Rozhanka, Grabovets, Golovetsko, Grebeniv, Nyzhnia Rozhanka, Pshonets, Khashchovanya villages act as a planning core. Such a form of natural landscape requires structural reorganization of the territory – actually Slavske is a functional-spatial and administrative center of the resort.

An important factor in the center is the railway which provides external connections to the resort, including connection with Western Europe. The geographical location of Slavske has a great importance in accessibility to other recreational areas: Slavske is located at the intersection of mountain valleys Opir-Slavchanka-Rozhanka, almost in the geometric center and, therefore, another recreational areas are accessible within 30 minutes [5].

The landscape-spatial structure of the area is characterized as narrow V-shaped valleys with a linear alternation of open spaces - visual pools, i.e. areas suitable for housing. This nature of the environment determines the linear multi-core functional-planning structure with a hierarchical model which can be expressed by the following system: “resort – recreational node (RN) – mountain recreational centre/sub-centre (MRC) - mountain ski complex (MSC) – recreational settlement (RS)”.

Orography of the area and the nature of settlement of the territory both from Verkhnia Rozhanka and Yalinkuvate (significant length of the ridge, frequent partition of its slopes by deep valleys, deep V-shaped river valleys with settlements there, houses on slopes) requires the formation of few MRC with corresponding MSC. Preliminarily according our research these may be recreational multifunctional centers with a dispersed planning structure which are planned to be located according to the principle of a basin approach. In this case the system of cells should be built with a hierarchy: functional core - complexes such as "Carpathian farm", "Carpathian barton", "Carpathian grange". Functionally MRC Volosyanka combined with MRC Yalinkuvate is a zone of leisure and active recreation with Apres-ski facilities for vacationers. MRC Yalinkuvate is of accumulating type from the directions of Slavske (North) and Zakarpattia region (North and South). The main purpose is to filter and distribute the recreational flow in the ski area. MRC V. Rozhanka can perform a distribution function of flows from Skole (Slavske) and Ivano-Frankivsk region and form the basis of service for skiers in the MSC [4].

MRC V. Rozhanka is a recreational hub which makes connections (the basis of logistics) between the ski resorts MSC Zvorets, MSC Yalyna, MSC Gnylishche, MSC Zholob, MSC Tovsty, MSC Dykhtovets.

RESULTS OF THE STUDY

During developing the main provisions of the strategy the following ways to solve the protection problem of natural and territorial complexes have been found:

- sanitary protective zones have been established which envisage special regime zones, water-protection areas and catchment drains of sources when planning development territories;
- analysis of inclinations and orientation of mountain slopes suitable for recreation has been made;
- when calculating the capacity of the areas of mountain recreation center the permissible loads on natural and landscape complexes were taken into account.

When developing the functional-planning structure "Strategy" the following items were envisaged:

- compliance with the rules for water resources use in accordance with the Water Code of Ukraine;
- the need to install protective zones for gas pipelines on the territory of development in accordance with DBN (State Building Standards);
- interests of the owners of existing buildings, the legal status of land tenure and land use in settlements and beyond should be taken into account;
- distances between housing and noise sources should be taken into account.

A special attention is paid to formation of three-dimensional and compositional structure in the natural landscape. The principle of preserving the panorama and silhouette of the natural landscape is the main one in three-dimensional building solutions [7-9].

CONCLUSIONS

This article is based on authors' research and theoretical developments during last 40 years. These are master plans for the creation of recreational facilities of various capacity and purposes, proposals on transport networks, methods of calculating recreational flows, comprehensive assessment of resources, the concept of strategic development of mountain areas, including the national project "Olympic Hope 2022". The project "Strategy for the development of the recreational area Slavske Arena-Ski" was announced at a field meeting of the Cabinet of Ministers of Ukraine (Slavske, Skole district, Lviv region, sports camp "Dynamo", 2010) [10].

Recreational development of the Carpathians should be based on the even distribution of anthropogenic load throughout the territory with reference to individual settlements taking into account their unique attractiveness - "highlights". The arrangement of mountain settlements should preserve local ethnographic and architectural features [11].

Now the natural potential of mountain landscape is suitable for development of recreational complexes with ski areas. It is advisable to develop also the recreational network within the Carpathians - a multifunctional complex including mountain skiing, if possible.

Currently the local population is active in promotion of recreation in the Carpathians, namely, in green tourism which has significantly increased number of tourists in summer and winter. Finally, in our opinion creation of second powerful pole for active recreation - a competitor of "Bukovel" - will provide much more uniform loading on the natural environment of the Carpathians.

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Innovative and Traditional Methods of Non-Invasive Reconstruction of Architectural Monuments

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Abstract. Restoration of architectural monuments has a long historical tradition and today reconstructions perform not only a representative, touristic function, but are also significant method of scientific research. Invasive methods of architectural monuments reconstruction which have been predominant since the mid-19th century to the beginning of the 20th century, at present are considered to be controversial, non-compliant with modern principles of restoration and conservation of architectural monuments. Alternatively, non-invasive reconstructions are being commonly used. The article analyzes the traditional methods of reconstruction of architectural monuments (2D graphic reconstructions and physical 3D models), as well as the importance of modern innovative approaches: virtual 3D modeling and augmented reality. It has been established that all the above mentioned traditional methods of non-invasive reconstructions still remain relevant. They complement each other and remain important information carriers. The use of innovative methods, such as 3D modeling, provides new opportunities to promote and disseminate information about architectural monuments. At the same time, the use of virtual reconstructions opens up new prospects in the study of historical heritage sites.

INTRODUCTION

Reconstruction of historical monuments is not new. Conversely, it has been a common practice for centuries. The ICOMOS Burra Charter, which was adopted in 1979, defines "reconstruction" as "the returning of a damaged building to a known earlier state by the introduction of new materials". Additionally, Burra Charter highlights certain cases when reconstruction can be undertaken: "Reconstruction is appropriate only where a place is incomplete through damage or alteration, and only where there is sufficient evidence to reproduce an earlier state of the fabric. In some cases, reconstruction may also be appropriate as part of a use or practice that retains the cultural significance of the place" [1]. The document refers to a method of invasive reconstruction that modifies the authentic elements of an architectural monument. Currently, this debatable method is sometimes viewed as unscientific due to the fact that reconstruction process alters the object`s authenticity, preserving only its exterior [2].

Therefore, alternative methods of architectural monuments reconstruction are extensively developed nowadays, which can also be described as "non-invasive", i.e. those which do not tend to infiltrate and destroy the preserved remains of the architectural object.

The aim of this article is to analyze and systematize modern non-invasive methods of architectural monuments reconstruction. The study also aims at identifying the importance of non-invasive reconstruction methods for the modern practice of presentation and study of architectural monuments.

Our empirical research was based on expeditions, field observations, and recording of examples of non-invasive reconstructions on architectural monuments that are open to the public, as well as on Internet search.

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THE PRACTICE OF INVASIVE RECONSTRUCTION

It is difficult to say when the method of integral restoration of the authentic (or original) appearance of the monument was first established. Purportedly, the first practices are associated with the name of Alexander the Great, who after the conquest of Persia in 334 BC, saw that the tomb of Cyrus had been plundered. He ordered the perpetrators to be punished and the grave to be rebuilt [3, p. 5].

The first great idea of analogy-based restoration/conservation method is attributed to Raphael. In 1516, the famous artist became a custodian of all antiquities at the papal court. On behalf of Pope Leo X, he deeply explored ancient monuments of Rome. Raphael accurately depicted the most important ancient buildings of the city and gave recommendations for the restoration of monuments in their original style, i.e. proposed a method of analogy-based reconstruction [3, pp 32-34].

The reconstruction of architectural monument gained its popularity in the middle of the 19th century. It was also propagated by Eugene Emmanuel Violet-le-Duc, a French architect and a restorer, an expert in medieval architecture. Reconstruction of the fortified city of Carcassonne in the South of France is a typical reconstruction practice of the second half of the 19th century, time when the concepts of purity of style were developed by restorers, and when the conjecture or artistic imagination of the monument was more important than seeking for the archaeological evidences of its original appearance (Fig. 1) [4].

FIGURE 1. The fortified city of Carcassonne in the South of France, the example of Violet-le-Duc's reconstraction (1853- 1889), photo by S. Linda, 2016

Although such tendency sparked numerous protests, which by the end of the 19th century reached its climax, invasive reconstructions before the inter-war period of the 20th century were still common practice. It was due to weak rule of law and a lack of coherent international policy on restoration. A vivid example of this was the reconstruction of some fragments in the Palace of Knossos performed by Sir Arthur Evans in 1920s years (Fig. 2) [3, p 191]. Another example is the restoration of Sforza Castle in Milan. "Stylistic restoration", carried out by Luca Beltrami (1893-1905), forever hid from viewers eyes the preserved parts of the ancient castle, offering a life-size model, a "blended" fortified building of medieval Italy instead (Fig. 3) [3, pp 205-206]. A famous Italian architect and a restorer Camillo Boito (1836-1914) criticized the practice and the concepts of the "stylistic restoration" at the turn of the 19th-20th centuries. Over his extensive restoration work, he aligned the conflicting views of his contemporaries on restoration, and presented his findings at the 3rd Conference of Architects and Engineers held in Rome, in 1883. His studies were laid out in the pages of a document, known today as the "Prima Carta del Restauro" or Charter restorers. S. Boito recommended rejecting the "stylistic restoration", because he considered it to be a falsification of a monument [3, pp 201-203].

Ideological cohesion of different restoration schools was expressed in major principles of the International Charter of Restoration adopted in Athens, in 1931 [4], and later in the Venice Charter, in 1964 [5]. They proclaimed abandoning the completely physical restoration of monuments, maintaining respect for cultural peculiarities of different eras, and preserving authentic style of each of them. It had been replaced by an approach that focused only on preserving the authentic structure of the object. However, the idea of how the monument could hypothetically look like continued to be relevant.

It should be noted that invasive methods of reconstruction of completely destroyed objects were still applied in the postwar period (after the Second World War). Among typical examples were the reconstruction of the center of Warsaw and the Royal Castle (Fig. 4), both of which were reduced to ruins by the Nazis, the postwar reconstruction of Gdansk, Nuremberg, Dresden. The scientific validity of the restoration work has increased significantly due to the fact that restoration projects involved meticulous surveying of the remains, examining multiple pre-war photographs and measurements, processing eyewitness accounts and descriptions.

FIGURE 2. The Palace of Knossos, Creta, Greece (reconstruction of A. Evans, 1920s), photo by S. Linda, 2018

FIGURE 3. Sforza Castle in Milan, Italy (reconstruction of L. Beltrami, 1893-1905), photo by S. Linda, 2016

FIGURE 4. The reconstruction of the Royal Castle in Warsaw, Poland, 1970s, photo by R. Przewłocka-Sionek, 2017

NON-INVASIVE TRADITIONAL METHODS OF RECONSTRUCTION

Extensive criticism of invasive reconstructions has called for the improvement of alternative approaches to the representation of a hypothetically original appearance of an architectural monument. Additionally, the development of exhibition activities, which were spreading extensively during the postwar period, engendered a growing need for the presentation of reconstructions, museumification of architectural ruins, the creation of numerous archaeological sites. Reconstruction methods that do not intervene in the authentic fabric of the monument include 2D graphic reconstructions and 3D physical models presented “in situ” or in museums and scientific institutions.

The genre of graphic reconstruction originated in the Renaissance and even evolved into an individual style of architectural activity. The graphic reconstruction of the architectural monument became a newly formed trend at the end of the 18th and in the 19th centuries, when large-scale research of the monuments of Antiquity of Ancient Greece and Ancient Rome was launched. The study of these monuments was accompanied by attempts to perform architectural restoration, and the implementation of graphic reconstruction became an important stage in design work. For example, we see graphic reconstructions in the works of Leo von Klenze, which he created in 1834, commissioned by King Otto of Greece on the reconstruction of Athens and the restoration of the Acropolis of Athens [6]. The methodological foundations of such reconstructions were laid in the works of the English art critic John Ruskin in the 19th century, who strongly advocated against any attempts to interfere with the authentic structure of the monument (which differed him significantly from Eugène Emmanuel Viollet-le-Duc) and contended that the restoration of architectural monuments is not an object of art, and should rather be based on solid scientific foundations [3, pp 174- 176].

Graphic reconstructions required deep knowledge of the historical period to which the monument belonged, which in turn entailed in-depth study, conducting accurate archaeological and architectural measurements, and recording all the preserved elements. An important methodological prerequisite was iconographic research: the study of drawings, photographs, and any other images. The destroyed fragments were modeled by analogy - on the principle of similarity to such similar preserved monuments. The lack of scientific evidence is the cause of debate, as exemplified by the dozens of reconstructions of the Church of the Tithes in Kyiv, the first brick church in Kievan Rus, known since the 10th century. Almost all researchers of architecture and monumental art of Kievan Rus, among them were O. Povstenko, Y. Aseev, M. Kholostenko, P. Rappoport, G. Logvin, N. Logvin, A. Reutov, I. Krasovsky and others, were engaged in historical and architectural interpretation of the Church of the Tithes and elucidation of its architectural type. One of the reasons for the unresolved main issues in the architecture of the Church of the Tithes, its origin, and various reconstruction theories of its original form was a lack of extensive and rigorous research sources [7].

Currently, graphical representations of the hypothetical appearance of objects are an integral part of the process of exhibiting archeological monuments that have not survived to this day. Some vivid examples are the graphic 2D reconstructions of the Roman cities of Dougga in Tunisia (Fig. 5) or Ostia Antica near Rome (Fig. 6). Graphic reconstructions enable the display of almost all destroyed architectural objects.

FIGURE 5. The graphic 2D reconstructions of the Roman cities of Dougga in Tunisia, photo by S. Linda, 2017

FIGURE 6. The graphic 2D reconstructions of Ostia Antica near Rome, Italy, photo by S. Linda, 2019

Maquettes and physical models became another historical type of non-invasive restoration. The history of creating three-dimensional models dates back centuries. It is common knowledge that small scale models of houses, made of brick, were widely used in Italy. Moreover, since the mid-20th century even the models of cities were made. Probably one of the first such examples was the model of Florence, made in 1529, which unfortunately has been lost. Another example is the models of Bavarian cities that were created between 1568 and 1574 by Jakob Sandtner. These models were exhibited at the Münchner Kunstkammer of Albrecht V [8]. The practice of creating 3D models actively developed in the 20th century. Today, physical models of architectural monuments are made of various materials (wood, paper, metal, plastic) and for multiple purposes: representational and touristic (model of the complex nuraghe Su-Nuraxi di Barumini in Sardinia) or scientific (model of the temple in Zvartnonts). Models of hypothetical appearance of cities are the result of long-term research. For instance, it took Janusz Witwicki 15 years to complete the famous model of medieval Lviv (a 1:500 scale model is preserved in Wroclaw) (Fig. 7) [9]. The Model of Jerusalem in the Second Temple period, which was created in 1962 -1966 which was recognized by researchers. It become a very popular attraction in Jerusalem for both Israelis and international tourists (Fig. 8) [10].

FIGURE 7. The Model of medieval Lviv by J. Witwicki, 1930s (now in Wrocław, Poland), photo by R. Przewłocka-Sionek, 2017

FIGURE 8. The Model of Jerusalem in the Second Temple period, 1966 (Jerusalem, Israel), photo by S. Linda, 2018

At the same time, local solutions of non-invasive reconstructions started to appear: spatial "overlay" of a graphic image on a transparent screen on preserved ruins (The Temple of the Winged Lions in Petra, Jordan) (Fig. 9), or formation of spatial structures replicating the outlines of the former building (outlines of a Gothic chapel in a shopping center in Prague) (Fig. 10).

FIGURE 9. The spatial "overlay" the graphic image on a transparent screen on preserved ruins: the Temple of the Winged Lions in Petra, Jordan, photo by S. Linda, 2019

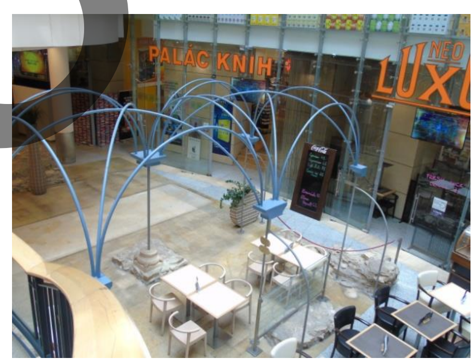

FIGURE 10. The spatial structure replicating the outlines of the former building: outlines of a Gothic chapel in a shopping center in Prague, Czech, photo by S. Linda, 2018

INNOVATIVE METHODS OF NON-INVASIVE RECONSTRUCTIONS

Digital reconstructions of architectural monuments have comparatively shorter history and are connected with the technological development of software and hardware. Assumingly, the foundations were laid in the USA in the 1960s, when MA Ivan Edward Sutherland devised the SKETCHPAD program at the Massachusetts Institute of Technology (MIT) in Cambridge. Contemporaneously, he was working on his doctoral dissertation, which was published in 1963. The program enabled the transformation of two-dimensional objects into three-dimensional, using the keyboard and so-called "Light pen" and "interactive light terminal" [8]. In 1973, archaeologist John D. Wilcock was the first to use new possibilities in the study of architectural monuments. But it was Werner Müller who pioneered computer visualization of architectural monuments. Together with Klaus Hänisch, he analyzed the possibilities of computer modeling in the article, published in 1976. "Die Möglichkeit einer computergesteuerten isometrischen Darstellung von figurierten Gewölben der deutschen Spätgotik" (The possibility of a computerized isometric representation of figured vaults from the German late Gothic period) [8].

The 1980s marked a turning point in the use of computer technology in archeology. In 1985, Bernhard Frischer made a presentation on the use of 3D technology at the Computer Applications in Archaeology (CAA) conference. The possibility of widespread use of digital technology to perform three-dimensional reconstructions was justified by the British archaeologist Paul Reilly, in particular, the term "virtual archeology" was introduced. The experience of his virtual reconstructions had a huge resonance, because he, as a scientist, was able to solve a scientific problem, besides computer programming specialists were involved in its visualization. The next stage in the development of 3D modeling was associated with two aspects: prospects and limitations of computer technology, and a specific period and type of building. The first approach was represented by P. Reilly, the second is widely used at present. Three-dimensional reconstructions of ancient Roman monuments [11], Byzantine heritage sites [12] , virtual reconstructions of Shikki and Sazadeo in Japan [13] and many others have appeared since the 2000s. Moreover, there are publications dedicated to the use of architectural heritage objects and virtual reconstructions in games [14].

In recent years, Augmented Reality (AR) technologies have been implemented in architectural reconstruction projects. Images created on a computer of a non-existent building are superimposed on the actual appearance of the saved remains of the object, virtually supplementing the information about it. The introduction of VITA system (Visual Interaction Tool for Archeology) allows viewers to immediately get a an image of the excavation sites [15].

The creation of virtual reconstructions in Ukraine has started relatively recently. Among the most important projects: hypothetical reconstructions of the rock fortress in Tustan, the settlement of the early Middle Ages Plisnesk and the princely city of Zvenyhorod.

State Historical and Cultural Reserve"Tustan" was established by a resolution of the Cabinet of Ministers of Ukraine in 1994 in order to preserve and rationally use the rock fortress city of Tustan near the village Urych in Lviv region (Ukraine) [16]. Research in Tustan began about 40 years ago by Mikhajlo Rozhko [20], where the researcher discovered an unknown rock fortifications, which had no analogues in the world. The study of the rock fortress in Tustan was continued by his son Vasyl Rozhko, who carried out architectural measurements, topographic and geodetic survey of rocks and created a series of 2D graphic reconstructions [18]. However, despite extensive investigative work, many issues remained unresolved: the location of vertical communications, the height of the floors, conflicting locations, a clear differentiation between the configuration of buildings belonging to different periods, etc.

Prospects of creating a virtual 3D reconstruction opened new perspectives for researchers in clarifying unresolved issues. The creation of the three-dimensional model was carried out in 2011–2012 by the joint efforts of the staff of the Department of Restoration of Architectural and Artistic Heritage and Department of Architectural Design at Lviv Polytechnic National University (M. Yasinskyy) and the historical and cultural reserve "Tustan" (V. Dmytruk). At the first stage, a three-dimensional model of rocks was created [19]. The next step was making three-dimensional models, using 3D visualization software and 3D rendering (Autodesk Softimage and Autodesk 3D Max). Thus, visualizations of all five stages of the fortress were created. The model made it possible to analyze the differences between the stages of the fortress development, to clarify graphic reconstructions (in particular, the places of fastening wooden structures to the stone base were specified), to identify the specifics of each stage [20]. Graphic reconstructions laid the foundations for the development of a virtual three-dimensional model, which elucidated on the previous graphic reconstructions of the fortress city of Tustan (Fig. 11-13).

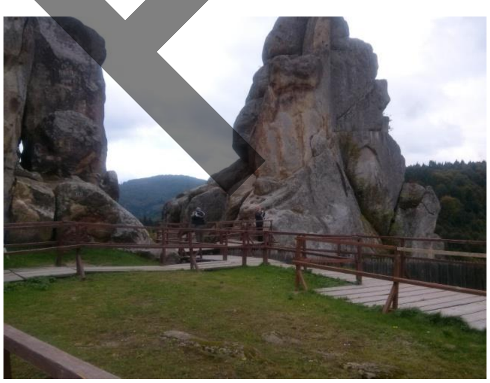

FIGURE 11. The rock fortress city of Tustan near the village Urych in Lviv region (Ukraine), photo by S.Linda, 2014

FIGURE 12. The graphic reconstruction of the rock fortress city of Tustan, photo by S. Linda, 2014

FIGURE 13. The virtual 3D reconstruction of the rock fortress city of Tustan (2011-2012), screenshot by S. Linda, 03.03.2021

Plisnesk Archaeological Complex is a unique collection of monuments belonging to different periods, primarily to the Middle Ages, which are now located in and around the village of Pidhirtsi, near Lviv (Ukraine). Ancient Plisnesk, covering an area of 250 hectares, was not only one of the centers of the Carpathian Croats but also one of the largest cities in Eastern Europe. After the 20th century, the city fell into disrepair and was rebuilt a little later, in the times of Kievan Rus. In 2019, with the support of the Ukrainian Cultural Foundation, a virtual reconstruction and development of 3D-visualization of the planning structure of the Plisnesk Archaeological Complex over the period of the 7-13th centuries began (project coordinator – V. Shelep, scientific support – A. Filipchuk, architects – M.Yasinskyy, V. Mishchenko). The 3D reconstruction was created by V. Mishchenko using 3D visualization software (SketchUp) and 3D rendering (Lumion). It were more than 80 reconstructed objects of defense, housing and sacred architecture presented (Fig. 14). The work lasted for five months. Assumingly, this project has laid significant foundations for more extensive undertaking, which should be enhanced with augmented reality and virtual tours [21].

Figure 14. The creation of 3D reconstraction of ancient Plisnesk (2019) screenshot by S. Linda, 03.03.2021

Since 2015, the results of research on the archeological monument of national significance “The settlement of the chronicle city of Zvenyhorod” (Resolution of the Cabinet of Ministers of Ukraine № 928 of 2009) have been actively introduced into scientific circulation [22]. The monument is located about 20 km southeast of Lviv (Ukraine). Large-scale archeological excavations on the territory of Zvenyhorod began only after the Second World War. In general, during

1953–1994, excavations were planned in all components of the monument (citadel, outer city, suburbs, and neighbourhood). A total of 10,709.6 km^2 was explored and more than a hundred residential, commercial, and industrial facilities were discovered, tens of thousands of artifacts were found, including unique ware. This huge source base has posed new challenges for archaeologists. The most urgent task of today is the correlation characteristic of the obtained material. The oldest materials date back to the second half of the 11th century. Today we can say that the city had the total area within the fortifications of 139.5 hectares and it was the most important city of the then principality [23].

The application of achievements in the field of virtual reality already allows to recreate the external image of the city, its visualization, which is one of the effective tools for preserving historical memory. In this regard, in 2019- 2020, large-scale work began on the creation of a 3D model of princely city of Zvenyhorod, which is based on the achievements of multi-year archaeological researches of several generations of scientists. A group of specialists, such as architects V. Petryk and A. Kharkhalis, computer graphics specialists R. Jack, V. Dmytruk, V. Flood worked on the visualization (Fig. 15). The works were performed within the framework of projects of the Ukrainian Cultural Foundation [24].

FIGURE 15. The virtual 3D reconstruction of princely city of Zvenyhorod (2019), screenshot by S. Linda, 05.03.2021 [26]

The project created a VR-exhibition for the historical and cultural park "Ancient Zvenyhorod", which allows you to visualize the pages of ancient history of Ukraine and demonstrate what the princely city, the capital of the principality of the same name, could look like almost a thousand years ago. 12 locations were created for the exposition to fully immerse a person in historical reality with the aid of the latest technologies. An interactive application "Ancient Zvenyhorod AR" was developed to help you travel through the interiors of princely buildings or see AR-postcards with archeological exhibits [25].

CONCLUSIONS

Non-invasive reconstructions fully comply with the modern doctrine of restoration of architectural monuments, as they do not interfere with the authentic fabric of the object. Reconstructions have a dual nature, so they can be interpreted both as a process and as a result. As a process, reconstructions are a system of methodological and organizational-technical procedures, the purpose of which is to obtain the most accurate data on the original appearance of the destroyed object. Thus, non-invasive reconstruction can be interpreted as a method of architectural research which operates with its own specific methods of collecting and analyzing primary source. As a result, the reconstruction is a reproduction of a hypothetical appearance of an architectural object which is based on the collection, processing of primary source and its interpretation. In this context, it is subjective and unverified.

All the above mentioned traditional methods of non-invasive reconstructions still remain relevant. They complement each other and remain important information carriers. The use of innovative methods, such as 3D modeling, provides new opportunities to promote and disseminate information about architectural monuments. At the same time, the use of virtual reconstructions opens up new opportunities for researchers to explore historical heritage sites.

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Aesthetic and Informational Principle of «Interesting» in the Architectural Environment

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Abstract. The urban environment at this stage is a complex multi-faceted formation. It is important to consider its significant characteristics not only from the point of view of functional comfort, but also as a synthesizing aesthetic principle determined by semantic content. The problem of the study is the decrease in the aesthetic and informational qualities of the modern urban environment because of the loss of the semantic factor of constantly changing architectural structures, which is the basis of the modern aesthetic category "interesting". The concept of "interesting" is considered as a complex evaluation category that enriches the aesthetic and informational criteria of architectural spaces. The aim of the work is to identify in the urban environment the structural features of "interesting" as an aesthetic and informational principle, analyzing the historical fragment of the city of Kharkiv as an example.

1. INTRODUCTION

The urban environment is a multi-faceted aesthetic object that emotionally affects a person in the process of daily activity. Therefore, it is important to consider significant characteristics of the urban environment not only from the point of view of functional comfort, but also as a synthesizing aesthetic principle. The aesthetic influence of a composition is the information of the environment, the influence of its physical parameters on our senses. What parameters have a decisive effect? What causes positive and negative reaction?

The question of "interesting" in art in general, and in the architectural environment in particular is not studied enough. Philosophers consider the category of interesting as a category of art along with the category of beautiful, since it carries an intellectual and aesthetic meaning, which, as Y. Golosovker writes, "does not exclude the participation of feelings and imagination in it." That is, in this case we are talking about intellectual sensuality, when the sence makin of imagination in art or architecture excites and interests our intellectual sensuality" [1, 226]. The question of sense making content of the modern architectural environment is a topical issue, that was considered by philosophers, cultural scientists, and architects [2-4].

The urban environment during the period of the XX - beginning of the XXI centuries under the influence of scientific and technological development and social factors has changed repeatedly and at this stage is a complex multifaceted formation. Very often, urban spaces appear monotonous and uninteresting to residents. On the other hand, they may not be interesting due to the complexity of perception because of the oversaturation of forms under the influence of new fashion trends.

Therefore, the problem of research is the decrease in the aesthetic and informational qualities of the modern urban environment caused by the loss of the sense making factor of constantly changing architectural structures, which is the basis of the modern aesthetic category of "interesting". The aim of the research is to identify the structural features of "interesting" as an aesthetic and informational principle in the urban environment. The study is based on the works of Y. Golosovker, Y. Lotman, U.Eko, M. Epstein and other experts who considered the topic of interesting in their works as a category of aesthetics, culture, philosophy and issues of information and visual communication [1, 5-12].

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The methodological basis of the work is the outlook at the aesthetic qualities of the architectural environment from the point of view of the criterion "interesting" as the most relevant aesthetic category in modern society. In accordance with the aim of the work, the following research methods were applied: full-scale (visual surveys), interdisciplinary, and the method of system-structural analysis. The full-scale method of studying the architectural environment provides direct contact of the subject with the object of perception, its sensory-emotional assessment and dynamism of perception in motion. The interdisciplinary method of research is determined by aesthetic perception, which is the subject of a wide range of scientific disciplines.

The novelty of the study lies in the application of the aesthetic principle of "interesting" as an evaluation category of the architectural environment. The content of the concept of "interesting" as enriching the aesthetic and informational criteria of architectural spaces of urban ensembles is determined. The structure of the aesthetic principle of "interesting" in the architecture of the urban environment is specified: functional, morphological, informational, stylistic, artistic-figurative, interpretive.

2. THE CONCEPT OF "INTERESTING"

The first stage of research is to reveal the architectural content of the concept of "interesting". The term "interesting" is a complex evaluation category that covers almost all cultural phenomena and determines the degree of the viewer's involvement in the perceived object. From a philosophical point of view," interesting " is defined as the ratio of reliability to probability. The more reliable and less likely a particular idea is, the more interesting it is [9]. An interesting course of events is one that is perceived, on the one hand, as inevitable, on the other - as unpredictable. As in scientific theory, the logic and consistency of an artistic plot is combined with its surprise and paradoxical nature.

The concept of "interesting" is often used in modern science to define a property of a theory that makes it intellectually attractive. So, interesting is not just the sphere of some superficial excitement, it is the basis of our culture [13]. The meaning of "interesting" as a term Ya. Golosovker sees in the following: "interesting - as unusual, extraordinary, unprecedented, - as something new, original, amazing, supernatural, wonderful, terrible, - as frightening, awe-inspiring (that is, interesting and causing horror), - "interesting" - as everything that is beyond the norm: Quasimodo, ancient Chimera, gins. Interesting - as mysterious, unknown, as something that we particularly care about - as our attraction to Mystery" [1, 228]. Freeman Dyson, a physicist, develops the principle of "maximum diversity", according to which "the laws of nature and initial conditions are such as to make the universe as interesting as possible" [14, 252]. The philosopher M. Epstein draws attention to the tension unfolded in time and the expectation of a favorable release, inherent in the concept of "interesting" [9]. In relation to the aesthetics of the urban environment, one can talk about a certain plot and its development over time with a consistent increase in tension (figuratively - the struggle of life and death). Y. Golosovker points out the pivotal − informative moments of the text as those that form sense making image responsible for the "interesting" in the plot.

The principle of "interesting" as the embodiment of sense making images can be traced in the historical structures of the city: the most meaningful and informative, interesting. It is determined by the functional-typological, stylistic, visual-spatial structure in which information, imagery and content-semantic aspects are revealed [15, 16, 17, 18, 19, 20, 21, 22]. These aspects of the study can be clearly traced on the example of Rizdvyana Street in Kharkiv, which is why the article considers compositional and imagery methods of forming the environment with a detailed description of the buildings of this street.

3. "INTERESTING" SPACES IN THE HISTORICAL STRUCTURES OF THE CITY. RIZDVYANA STREET

Rizdvyana Street is part of Kharkiv historical center. The multiplicity of semantic architectural and informational messages of Rizdvyana Street forms the structure of the environment as the one corresponding to the concept of "interesting".

The visual and spatial structure of the street is complicated by three spaces of squares and garden parks opening towards the river and the city center. The stylistic structure as a whole is represented by the predominance of art nouveau, which comprises constructive, decorative and romantic styles interspersed with eclecticism. In the functional and typological aspect, the historically established territory has retained mainly its commercial function.

3.1. Functional and Typological Structure

The architectural environment of the street is represented by two types of buildings. The first type consists of buildings with vertical dominance: manufactory buildings, a hotel, and the Blahovishchensk Cathedral. These are tall houses with complex finishes. The second type of buildings is represented by two- or three-storey residential buildings with a predominance of horizontal in shapes and volumes. The regularity of such a structure of different heights is achieved via the alternation of tall buildings (from one to eight floors) with low-rise ones, where a low building stands out against a high one. This alternation of houses is observed in the street structure four times, forming a kind of a regularity (system). This rhythmic pattern forms in the viewer an informational effect of predictability.

3.2. Stylistic Structure

The regularity of Rizdvyana Street forms its stylistic structure, which is expressed in the architectural-plastic and architectural-spatial nature of the mid-XIX-early XX centuries environment. The stylistic structure of the street consists of a number of art nouveau trends (constructive – Houses No. 6,11,19; decorative – No. 17; romantic – No. 9), which complicate perception and require attention, as well as two- or three-storey buildings of the period of eclecticism and historicism. Attention is drawn by the pattern of silhouettes, shapes, and details. The contrast of shapes focuses special attention.

Within the territory of Rizdvyana Street, the most significant are Houses No. 17 and No. 19, while other art nouveau objects are background in the historical development of Kharkiv [23]. The architectural environment of the art nouveau style is represented by manufactory shops (№ 13, 1/13,17,19) and hotel No. 14. The height of buildings is from three to six floors, all of them have a predominant vertical orientation. Three (No. 13, 14, 1/13) of the five buildings are located at street turns and have active volumes of towers that are clearly visible from long distances and have rhythmic vertical divisions. The other two neighbouring houses No. 17, 19 are completely different in the plastic of facades and configuration, their vertical divisions are not so active.

Another stylistic group is residential buildings from the period of historicism and eclecticism (№ 1,6, 7, 6/12, 8/10, 21,27); their height is from one to three floors. This type of building also forms its own system, the main code of which refers to the older time layer of the street. The high-rise contrast that forms the silhouette features of the street emphasizes the architectural and plastic contrast of the facades of these buildings. The architecture of two contrasting styles – horizontal in historicism and elongated vertically in art nouveau − creates a characteristic feature of the street, forming its main code. The system formed by art nouveau objects includes the building of the Central covered market (an architect I. Zahoskin, 1912-1914; restored and reconstructed, an architect B. Miroshnichenko, 50s) located at Rizdvyana Street, 33. Art nouveau facades made of plastered bricks, decorated with stucco details, are characterized by plasticity [24].

3.3. Visual-spatial Structure

The visual and spatial structure of the street is formed by the open spaces of the squares. There are three such spatial and light gaps along the entire length of the street. All spatial extensions are located on the western side of the street and face the Lopan river, towards the city center. When approaching Rizdvyana Street from Suzdal Ryady Street, just behind the first house on the western side of the street is the maidan space of the bus station, which offers a view of the eclectic development of the northern part of the buildings of Suzdal Ryady. This large open space of the square is replaced by a narrow street space. The second spatial and light gap is the Blahovishchenski Maidan. Together with the adjacent public garden, it is the largest open space on this territory. It should be noted that the Blahovishchenski Maidan with its space relieves visual tension that is created in the segment of streets from Kotsarska to Blahovishchenska street. This section of the street is perceived from a very sharp angle, in which buildings stretch out into strips that are not convenient for viewing, and only the exit to the square evens out the picture of this section of the street, allowing you to view each building freely. The third open space is located at the intersection of Rizdvyana Street and Kontorska Street, represented by the square where the Rizdvyana Church used to be located. The square is a chamber space in a quiet part of the street.

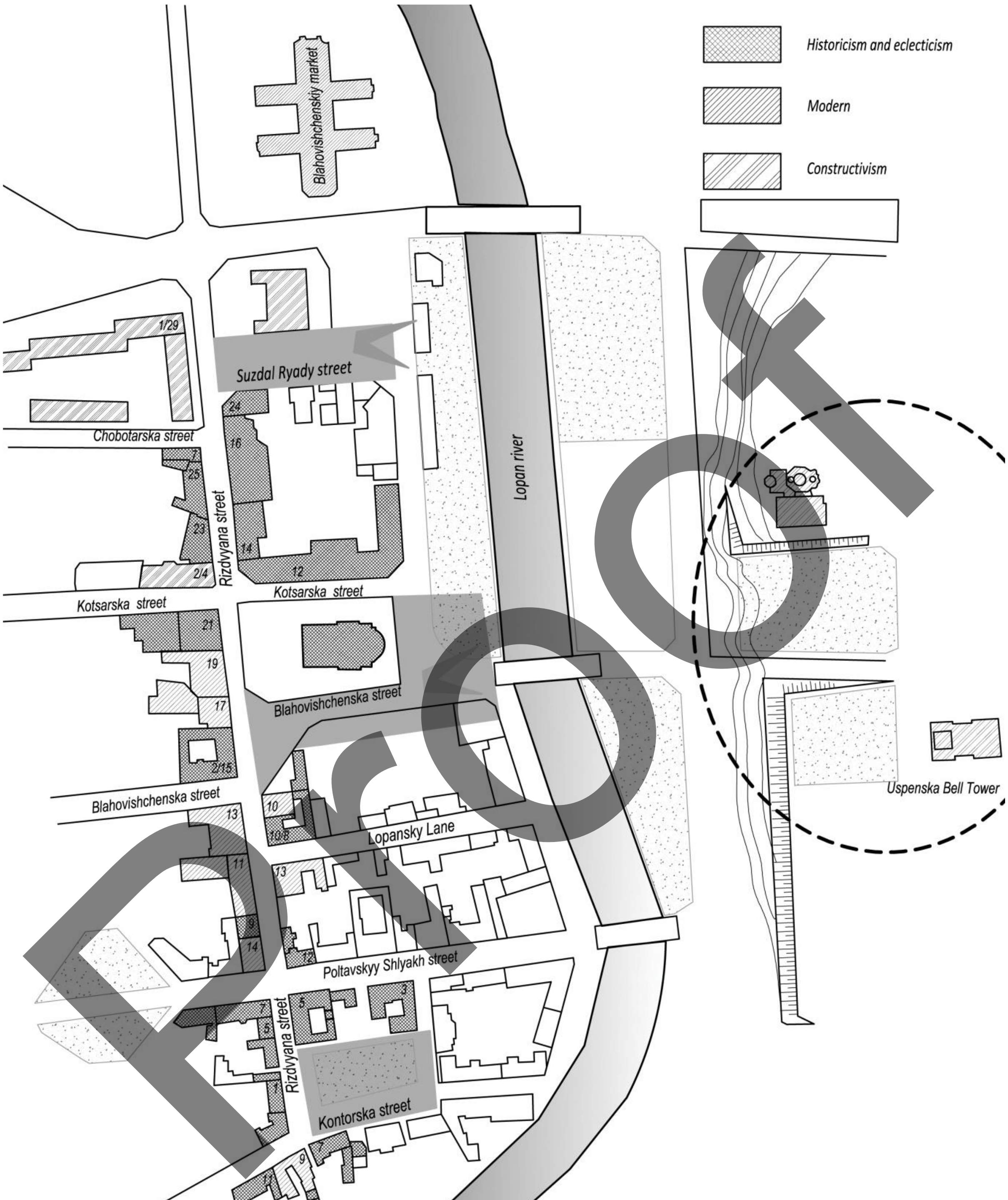

FIGURE 1. Scheme structure of Rizdvyana Street in Kharkiv. Sourse: Julia Zhmurko

Ordering patterns also include the alternation of linear sections of the street and static spatial fragments at intersections with cross streets. There are seven such fragments, including the intersection with Suzdalski Ryady

Street. Four of them differ in a general regularity. They are formed by a contrasting opposition: a high house with an active vertical and a low-rise building with horizontal plastic.

Another factor plays a role in the system of spatial organization of the street − the entrances to the courtyards of houses that are typical of the architecture of the XIX- early XX centuries. Open arches are an element of fixing attention and the desire to read the code to the end, passing through the threshold space in anticipation of something new. At the moment, many entrance arches to the courtyards are blocked, which interrupts communication with the architectural environment. Closed spaces of arches do not allow you to read this architectural code. That is, in the recipient's mind the inability to cross their spaces reduces their value qualities.

3.4. Structure of Information and Code Elements

The architectural and spatial environment of Rizdvyana Street contains the main structural code elements expressed in the geometry of buildings, architectural plastic, and silhouette. Each architectural situation is characterized by basic code elements, individual and variable.

One of the structural elements of the Rizdvyana street environment that forms code chains is buildings with active architectural plasticity. Such buildings are houses No. 9,1/13,13,14,17,19 in which vertical elements are clearly expressed.

Houses No. 1/13, 13, 14 have a number of general principles of architectural expressiveness. This is due to their location at the intersection somewhat protruding, which contributes to the perception of the object, strengthening the vertical of the building. Verticality is also enhanced by the angular shapes of towers protruding with hipped ends, as well as vertical divisions of facades. Houses 1/13, 13 are typologically similar, have an equal height, a semicircular shape with a dome; the structure of the protruding building is vertically divided by powerful protruding risalits. The height of these houses allows you to see the facades only from a strong vertical angle.

Houses No. 9 and No. 14 are located next to each other, they are different in style: house No. 14 is in the art nouveau style, and house No. 9 is in the historicism style. Being the same height, both buildings have very complex finishes, that makes them look solid. House No. 14 has vertical divisions of arcade risalits with large gables of a corner bay window and with a hipped finish, which give the building orientation, and stucco decor – solemnity. The neighbouring house No. 9 is made in the forms of Gothic architecture, the dominant element on the plane of the building is a pointed arch three floors high and a thin vertical draft. The building is completed by a shaped wall, located above the building itself and decorated with four towers. Houses No. 17 and 19 are located side by side, both are monuments of art nouveau architecture, but have a significant difference in the type of buildings. House No. 17 is a two-story building that stands out due to the extensive dismemberment, majolica inserts in the upper part and the unusual profile of the final part of the building. The frame of the building is accentuated by flat blades separating large window openings, enriching the thin stone imposts of the middle span. The building No. 19 differs from the neighbouring one in its large size and strict forms. The facade of the building has larger divisions in the lower two floors and smaller ones in the upper ones. On one side there is a risalit with a passage at the bottom and a bay window connecting the second and third floors, which sets the dynamics of the building.

3.5. Content Structure

All the abovementioned patterns of the environment form information elements that determine the structure of interesting and shape the information perception. The structural elements of the Rizdvyana Street environment are: a complex silhouette of the street, represented by alternating horizontally extended and vertically directed buildings, the dynamics of the street – open spaces of squares, the presence of two styles: art nouveau and eclecticism, rich architectural plastic and landscape features of the environment – exits of the street spaces to the water.

The structural elements of the environment form the main information principles that reflect the fullness of architectural messages.

The carrier of an architectural message is an architectural (spatial, plastic, etc.) form that serves the purpose of sense making formation – information codes. The process of conceptual ordering is determined by architectural and spatial patterns of the environment, which are clearly read by a person who perceives the architectural environment.

3.5.1. Semantic aspect

Semantic aspects of architectural messages are a prerequisite for the formation of artistic and figurative associations in humans, which are aesthetic information for them. The emergence of associations and images is influenced by stimuli and reactions of the environment that excite the human imagination and cause the emergence of various interpretations. The number and content of information codes formed by a stimulating architectural form, read by a person, is largely determined by the viewer's thesaurus.

3.5.2. Game aspect

The identification of information codes and the operation of the principle of "interesting" as the embodiment of sense making in the architectural environment is associated with the game situation and non-system elements. The game situation is caused by solving a riddle that space sets for a person. The answer at the highest level is the image of the sky-boon as a common task of architecture.

The game effect of the environment is recorded in the area of the street twice.They can be described as nodes with maximum information content. These places of localization have a high artistic value due to the picturesqueness and unpredictability of what is expected. Places with high imagery are two visual disclosures along Rizdvyana Street, they have the very surprise that I. Zholtovsky wrote about as a mandatory feature of an architectural composition [25].

The first one is located at the turn of Rizdvyana Street and Lopansky Lane, where from the street in a narrowed space the culminating opening of the peripheral district to the urban dominant unfolds. The distant opening to the urban dominance associatively connects the sacredness of the bell tower on the hill as the center of the city and the mundaneness of the shopping area. These associations endow the environment with attractiveness and an excess of information.

The visual frame is formed by buildings, bounded on both sides, and the plane of the ground, as if in a baguette frame you can enjoy a panoramic view of the Uspenska Bell Tower surrounded by dense park greenery. The aesthetics of this place is in the integrity of the frame, its versatility. The foreground is "held" by buildings with rich plastic, brick two- or three- storey buildings on the left side and a large reinforced concrete manufactory building on the right side, the background − the compositional center of the visual frame is represented by a view of the main urban dominant.

The next informative node is a structure that is located topographically outside Rizdvyana Street, but closes it. Building No. 9 on Kontorska Street, 9 closes the perspective of the street. In this building, the arched part that previously informed about the passage deep into the courtyard has been lost. Now this space is represented by a gap, a darkened corridor between buildings, noise. It opens up a spacious, cozy courtyard of the art nouveau period with a building that in the past was Tambovtsev’s commercial apartment building, which has a very expressive and bright image. In the structure of two oppositions: the darkness of the corridor and the light of the spacious courtyard, there is a playful effect of the environment of this place. This house is impossible to see without passing through the passage between the buildings. Since the information code in the form of an arch indicating a passage to the deep is lost, interest in the environment decreases and the artistic qualities of the environment remain "unread".

At the same time, system elements are highlighted in informational messages, which are carriers of values. Non-system ones are interpreted as not carrying information and are discarded. The category of non-system elements is an object that acts in informative opposition to the informative structure of the street. Such elements of the structure fall out of the environment, but express the diversity and temporary nature of the development of the environment. At the same time, Y. Lotman points out that the ratio of system and non-system text elements is the most important factor in the study of information in a literary text, and architecture belongs to such texts that carry messages [2]. An exception to the stylistic pattern is the eight-story house No. 29 on Rizdvyana Street . This building is an example of constructivism. It is devoid of decorative architectural plastic, looks solid and monumental, has bright red inserts on the facade. This building forms a block, being part of a group of buildings located on Chobotarska Street. The building is the tallest and largest in the street structure, exceeding the dimensions of neighbouring buildings by several times. In a two-story system, this large house looks out of the system and falls out of the street pattern. In the system of constructivist stylistics, the general historical context is supported by a number of buildings along adjacent streets: Chobotarska and Blahovishchenska.

Regarding Rizdvyana Street, it can be noted that a number of art nouveau trends (constructive, decorative, romantic) are recorded in this area, eclecticism and the building of the Church of Blahovishchensk, which complicate perception and require attention to stop. Attention is held by the pattern of silhouettes, shapes, and details. Special attention is paid to the contrast of forms, it is reflected in the character of the street. A lot of buildings united by a common commercial function, and which at the same time have a completely different appearance, indicates competition for the attention of buyers among merchants. With such a variety of shapes, many domed and spire-shaped endings, an associative image of freedom arises. It is also possible to note the recorded associations of the environment of Rizdvyana Street, namely archetypal oppositions: periphery – center, external – internal, general – individual [26].

It can be concluded that the aesthetic principle of "interesting" includes all the artistic components, contributing to obtaining images from the environment. A certain problem is the complexity of the street system over time, that is, the transition of an overcomplex system into information noise.

Elements that complicate perception are elements of information noise: angle, overlap of the view, inclusion of another component of the environment. Complicating forms produce new codes that evoke figurative and associative impressions, but make it difficult to read the semantic structure. It should be noted that maintaining the readability of the street system is important not only for the communication process, but also for the ability to be spiritually satisfied, receiving aesthetic pleasure from the environment.

Conclusion

The structures that form sense making images are present in the historical environment of the city, making it interesting, that is, orderly-reliable and probabilistic-mysterious at the same time. The tension of the climax nodes implements the stipulated by the culture attraction to the mystery and its solution, the informational principle of the curious. The culminating release after the experienced tension as a complicating component is the main factor of artistic interest that causes a complex historical environment. The sense making images formed in this way contribute to the emergence of a sense of the architectural environment as an intellectual environment that requires tension for its comprehension, that is, it increases interest in it and, thereby, can increase the humanitarian status of the environment in the viewer's perception of it.

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Investigation of Correlation Between Maximal Thickness of Ice and the Lowest Average Monthly Temperature by Methods of Multivariate Correlation on the Example of Dnieper Cascade of Hydroelectric Stations

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Abstract. The maximal ice thickness and the lowest average monthly temperature of ambient air are among the influential factors of influence on hydraulic structures. Hydraulic power systems that are formed by cascades of hydroelectric stations have considerable geographic extent. This leads to presence of correlations between natural climatic factors, that are observed when passing from one hydro scheme of cascade to another. For the first time the correlation between the maximal ice thickness and the lowest average monthly temperature of ambient air has been investigated from the data of direct measurements of hydrometric and meteorological stations at hydro schemes of the Dnieper cascade of hydroelectric stations with the use of methods of multivariate correlation. Application of approaches of multivariate correlation and regression turned out to be acceptable during modeling relationship between ice conditions of water storages of Dnieper cascade and temperature of ambient air. Confidence intervals of regression equations and accuracy of the obtained results have been estimated. From the viewpoint of better approximation of real data by predicted ones the results can be improved by using more complex nonlinear polynomial regression models of high orders. The procedure can be used in probabilistic calculations of reliability of cascades of hydroelectric stations.

INTRODUCTION

To date probabilistic methods are becoming widespread in calculating and designing hydraulic structures, estimating their reliability and safety. Such approaches are introduced in domestic and world practice and are regulated by modern codes [1-7]. Introduction of probabilistic methods of calculation makes it possible to carry out estimation of reliability of hydraulic structures taking into account probabilistic character of loads and influences, and also mechanical properties of building materials and soils of foundation that are described by various distribution laws over the whole possible range of their values. In particular, probabilistic methods of the system theory of reliability make it possible to perform an integral estimation of reliability and safety of complex engineering objects that have considerable geographic extent, to model loads and influences interrelated by correlation dependencies.

Ice conditions of water storages and temperature condition of ambient air are among important factors influencing hydraulic structures. When estimating reliability of such complex natural engineering objects as hydro systems, for example for cascade arrangement of hydro schemes, it is urgently necessary to model their ice and

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temperature conditions.

ANALYSIS OF THE LATEST INVESTIGATIONS AND PUBLICATIONS

Simulation of probabilistic distribution laws of statistical data of ice thickness at water storages and temperature influences over hydro schemes of Dnieper cascade was performed in investigations [8]. Existence of certain correlation interrelation between yearly maximal ice thickness at water storages, and also between the yearly lowest average monthly temperature of ambient air over hydro schemes of Dnieper cascade of hydroelectric stations was proved in investigations [8, 9]. Nonlinear one-factor and multivariate regression simulation of systems of random quantities is presented in work [10]. Linear and nonlinear regression, multiple and serial correlations are considered in works [11-17]. Examples of application of cluster analysis, logistic regression and models of analysis of statistical data connected with it, models for binary and multicategorical variables are presented in work [14]. Linear discriminant analysis for statistical groups, comparison of their covariance structures are presented in work [17]. Strategies of multidimensional simulation, general aspects of application of regression models, verification of their adequacy and simplification are presented in investigations [18-20].

One of the methods of simulation of ice and temperature condition for cascade arrangement of hydro schemes may be approaches of multivariate correlation and regression, which is the part of the problem that has not been solved earlier.

DEFINITION OF THE GOAL AND TASK OF THE INVESTIGATION

The task of the work is development of algorithm of determination of correlations between the yearly lowest average monthly temperatures of ambient air and the yearly maximal thickness of ice at water storages of hydro schemes of the Dnieper cascade of hydroelectric stations with the help of methods of multivariate correlation and regression.

The goal of the work is development and evaluation of the algorithm for temperature and ice conditions of water storages for cascade arrangement of hydro schemes of Dnieper cascade of hydroelectric stations.

THE MAIN PART OF THE INVESTIGATION

Statistical data on the yearly lowest average monthly temperatures and the yearly maximal amplitudes of average monthly temperatures of r. Dnieper basin from 1966 to 1983 yrs, from 2002 to 2008 yrs according to the data of “Agrometeorological yearbooks for territory of the Ukrainian SSR” are presented in [8].

Statistical data on the yearly maximal ice thickness at water storages of hydro schemes of the Dnieper cascade over the period of observations from 1956 to 1979 yrs according to data of “Hydrological yearbooks” are given in [8].

Investigations of correlation dependence of the yearly maximal ice thickness according to statistical data of observations at water storages of hydro schemes of Dnieper cascade were performed in work [8].

Correlation dependence between the yearly lowest average monthly temperatures, the yearly maximal amplitudes of average monthly temperatures according to statistical data over hydro schemes of Dnieper cascade when passing from one hydro scheme to another is investigated in work [8, 9]. Existence of close correlation between the mentioned natural factors was proved.

Procedure of investigation of correlation relation of the yearly lowest average monthly temperatures and the yearly maximal ice thickness at water storages of hydro schemes of Dnieper cascade is based on application of methods of correlation theory and mathematical statistics. Their application requires condition of correspondence of distribution laws of output quantities to normal distribtions.

Parameters of normal laws of distribution of probability of the yearly lowest average monthly temperature at places of location of hydro schemes of Dnieper cascade are presented in table 1.

To transform series of statistical data of the yearly maximal ice thickness, substitution in the form:

$$h_{\max,\,\mathrm{cond}} = d_1 \cdot mean(h_{\max}) \cdot \left(\frac{h_{\max}}{mean(h_{\max})} \right)^{d_2} \tag{1}$$

was used [19], where h_{max} – yearly maximal ice thickness, cm at water storages of Dnieper cascade; d_1, d_2 – empirical coefficients (see table 2); $mean(h_{max})$ – average value of yearly maximal ice thickness, cm at water storages of Dnieper cascade (see table 2).

TABLE 1. Parameters of normal law of distribution of probability of the yearly lowestaverage monthly temperature at the place of location of Kakhovka hydro scheme [8].

Region of observations	Expectation	Standard deviation
t. New Kakhovka	– 3.300	3.518

TABLE 2. Parameters of the expression for transformation of distribution law of yearly maximal ice thickness h_{max} (cm) at water storage of Kakhovka hydro scheme into the normal distribution law [8].

Water storage	d_1	d_2	$max(h_{max,\text{cond},i})$ (cm)	$\frac{max(h_{max,\text{cond},i})-min(h_{max,\text{cond},i})}{\sigma(h_{max,\text{cond},i})}$
Kakhovka	1.090	0.640	28.455	2.84 < **3.79** < 3.86

Conditional distribution law of the maximal ice thickness according to [20] corresponds to normal law if the value of expression (1) is within confidence interval:

$$\frac{max(h_{max,\text{cond},i})-min(h_{max,\text{cond},i})}{\sigma(h_{max,\text{cond},i})}, \tag{2}$$

where $max(h_{max,\text{cond},i})$ – the maximal value of ice thickness of the transformed normal distribution; $min(h_{max,\text{cond},i})$ – the minimal value of ice thickness of the transformed normal distribution; $\sigma(h_{max,\text{cond},i})$ – standard deviation of the value of ice thickness of the transformed normal distribution.

When the number of members of statistical series is n = 11 and the significance level is p = 10%, the lower boundary of the interval is 2.84, the higher boundary of the interval is 3.86 [20].

Numerical processing of the sample of yearly lowest average monthly temperatures and yearly maximal ice thickness, calculation of statistical characteristics of equations of linear regression, determination of correlation coefficients was performed by methods of regression and correlation analysis with the use of software package Math Cad.

Statistical characteristics of the equations of linear regression at points of observation (see table 1, 2) and results of correlation analysis – coefficients of equations of linear regression, coefficients of correlation of samples, covariations of samples, standard errors were obtained as results of processing of statistical data of yearly lowest average temperatures and yearly maximal ice thickness at water storages of hydro schemes of Dnieper cascade [8, 9].

Equations of linear regression were taken in the form of:

$$y(x) = b_0 + b_1 \cdot x, \tag{3}$$

where $y(x)$ – regression of statistical sample of yearly maximal ice thickness at dam sites of hydro schemes of Dnieper cascade along X axis to statistical sample of yearly maximal ice thickness along Y axis; x – statistical sample of yearly maximal ice thickness along X axis; b_0, b_1 – empirical coefficients [8, 9].

Results of correlation analysis of statistical samples of yearly lowest average monthly temperature of ambient air, °C at dam sites of hydro schemes of Dnieper cascade for the observation period from 1966 to 2008 yrs [9] made it possible to determine the values of correlation coefficients of two samples for pairs of dam sites of hydro schemes of Dnieper cascade, that indicate close correlation dependence. The values of correlation coefficients of two samples are within from 0.738 (dam site of Kyiv hydro scheme – dam site of Dnieper hydro scheme) to 0.987 (dam site of Middle Dnieper hydro scheme – dam site of Dnieper hydro scheme).

In this investigation, methods of the theory of multiple correlation were used, that, in their turn, require time synchronization of statistical series of data. Results of statistical processing of yearly maximal ice thickness h_{max} (cm) at Kakhovka water storage over observation period 1959-1966 yrs are presented in table 3. Parameters of equations of linear functions of regression of statistical samples of yearly maximal ice thickness, h_{max} (cm) to statistical samples of yearly lowest average monthly temperatures of ambient air t_{min} (ºC) at dam site of Kakhovka hydro scheme over observation period 1959-1966 are presented in table 4 and in figure 1.

TABLE 3. Results of statistical processing of yearly maximal ice thickness h_{max} (cm) at Kakhovka water storage over observation period 1959–1966 yrs.

Point of observation (water storage)	Sample mean (cm)	Sample median (cm)	Standard deviation	Sample variance
Kyiv	43.888	43.881	8.534	72.823
Kaniv	43.044	42.616	7.559	57.143
Kremenchuk	48.970	54.078	11.604	134.663
Middle Dnieper	37.670	36.005	7.690	59.141
Dnieper	24.155	24.271	11.529	132.914
Kakhovka	26.850	29.360	7.704	59.356

The values of partial correlation coefficients presented in Tab.4 are higher than boundary values of correlation coefficients (table 9.2, p. 162 [17]) $r(P=0.95;\ f=6)=0.71$, where P – boundaries of confidence interval, f – the number of degrees of freedom. This proves significance of the determined partial correlation coefficients, except Kyiv hydro scheme for which $r(P=0.95;\ f=6)=0.71>|-0.618|$.

TABLE 4. Parameters of equations of linear functions of regression of statistical samples of yearly maximal ice thickness, h_{max} (cm), to statistical samples of yearly lowest average monthly temperatures of ambient air t_{min} (ºC) for dam site of Kakhovka hydro scheme over observation period of 1959–1966 yrs.

Point of observation (dam site, water storage)	Free term b_0	Coefficient b_1	Correlation coefficient of two samples	Covariation of two samples	Standard error
Kyiv	33.017	– 1.660	– 0.6180	– 15.763	6.929
Kaniv	32.329	– 2.456	– 0.9066	– 16.733	3.445
Kremenchuk	19.805	– 4.009	– 0.9720	– 23.800	3.342
Middle Dnieper	28.537	– 2.609	– 0.9403	– 17.178	2.866
Dnieper	15.375	– 1.820	– 0.9079	– 45.151	5.92
Kakhovka	23.467	– 2.853	– 0.8427	– 12.663	4.544

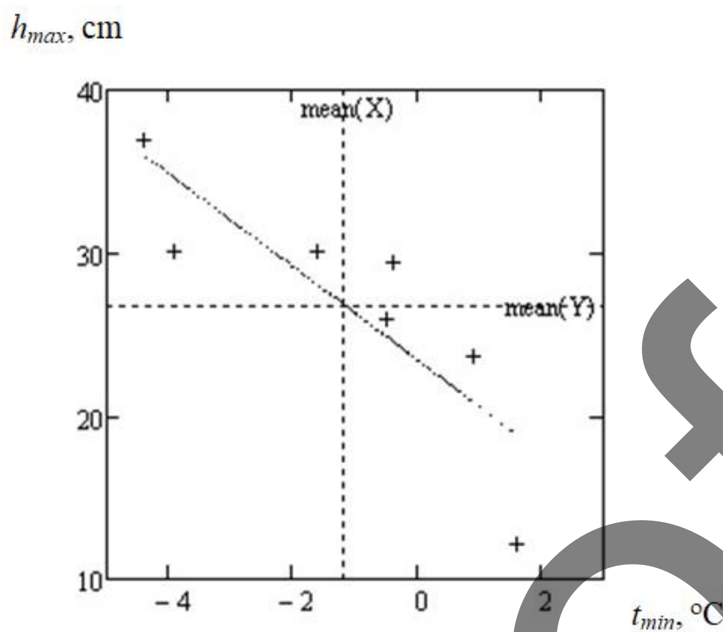

FIGURE 1. Plot of linear function of regression of statistical sample of yearly lowest average monthly temperatures of ambient air t_{min} (°C) that was observed at dam site of Kakhovka hydro scheme, to statistical sample of yearly maximal ice thickness, h_{max}, that was observed at dam site of Kakhovka hydro scheme: - - - – plot of function of linear regression; + + + – data of statistical samples over observation period of 1959–1966 yrs.

If $t_{min,\text{cond}}$ – yearly lowest average monthly temperatures of ambient air, °C y at the site of location of hydro scheme, and $h_{max,\text{cond}}$ – yearly maximal ice thickness at the water storage of the hydro scheme, that are given as random correlated quantities by normal distribution laws, then such correlated quantities obey the normal law [8], that is determined by five parameters: expectations $m_{t_{min,\text{cond}}}, m_{h_{max,\text{cond}}}$, standard deviations $\sigma_{t_{min,\text{cond}}}, \sigma_{h_{max,\text{cond}}}$, coefficient of correlation $r_{t_{min,\text{cond}} h_{max,\text{cond}}}$. Besides, covariance $K_{t_{min,\text{cond}} h_{max,\text{cond}}}$ and variation coefficient C_v, are to be determined. Random probability of yearly lowest average monthly temperature of ambient air $p(t_{min,\text{cond}})$, distributed from 0 to 1, is prescribed. By normal distribution law with the parameters given above $m_{t_{min,\text{cond}}}$, $\sigma_{t_{min,\text{cond}}}$, the quantile – the value of yearly lowest average monthly temperature of ambient air $t_{min,\text{cond}}$ - is determined. Parameters of conditional distribution law $m_{t_{min,\text{cond}} h_{max,\text{cond}}}$, $\sigma_{t_{min,\text{cond}} h_{max,\text{cond}}}$ are determined by formulas (4, 5):

$$m_{t_{min,\text{cond}}, h_{max,\text{cond}}} = m_{h_{max,\text{cond}}} + r_{t_{min,\text{cond}}, h_{max,\text{cond}}} \cdot \frac{\sigma_{h_{max,\text{cond}}}}{\sigma_{t_{min,\text{cond}}}} \cdot \left(t_{min,\text{cond}} - m_{t_{min,\text{cond}}} \right), \tag{4}$$

$$\sigma_{t_{min,\text{cond}}, h_{max,\text{cond}}} = \sigma_{h_{max,\text{cond}}} \cdot \left(1 - r^2_{t_{min,\text{cond}}, h_{max,\text{cond}}} \right)^{1/2}, \tag{5}$$

With known probability of the quantity of yearly maximal ice thickness $p(h_{max,\text{cond}})$ and using conditional distribution law, the quantile – the value of the quantity of yearly maximal ice thickness $h_{max,\text{cond}}$ - is determined. Recalculation of the value of yearly maximal ice thickness $h_{max,\text{cond}}$, presented by conditional distribution law with substitution by formula (1), into real maximal ice thickness h_{max} at water storage of the hydro scheme is performed.

By the algorithm presented above with the use of conditional normal law, that is determined by five parameters for system of random correlated quantities with known statistical series of yearly lowest average monthly temperature of ambient air t_{min} (°C) over observation period of 1966-1983, 2002-2008 yrs, yearly maximal ice thickness h_{max} (cm) was determined. The obtained results are presented in figure 2.

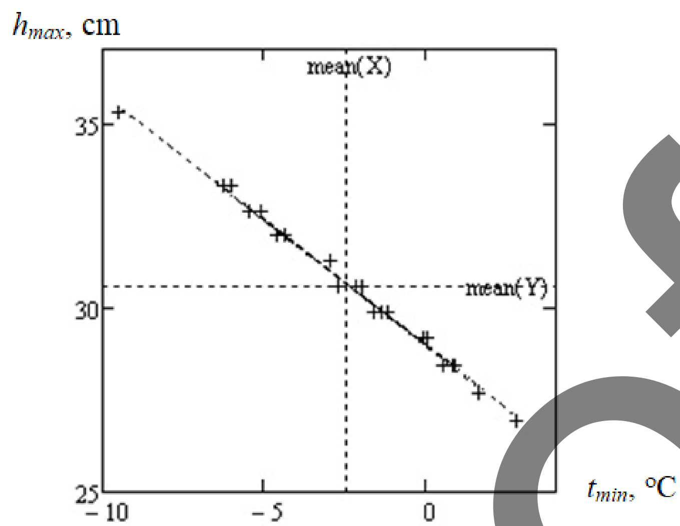

FIGURE 2. Plot of linear function of regression of statistical sample of yearly lowest average monthly temperatures of ambient air t_{min} (°C) that was observed at dam site of Kakhovka hydro scheme, to statistical sample of yearly maximal ice thickness h_{max} (cm) (transformed to normal law), that was observed at dam site of Kakhovka hydro scheme: - - - – plot of linear function of regression; + + + – data of statistical samples over observation period of 1966–1983, 2002–2008 yrs.

TABLE 5. Results of statistical processing of yearly maximal ice thickness h_{max} (cm) at water storage of Kakhovka hydro scheme over observation period 1966–1983, 2002–2008 yrs.

Point of observation (water storage)	Sample mean (cm)	Sample median (cm)	Standard deviation	Sample variance
Kakhovka	30.168	30.569	2.094	4.385

TABLE 6. Parameters of equations of linear functions of regression of statistical samples of yearly maximal ice thickness, h_{max} (cm) to statistical samples of yearly lowest average monthly temperatures of ambient air t_{min} (°C) at dam site of Kakhovka hydro scheme over observation period of 1966–1983, 2002–2008 yrs.

Point of observation (water storage)	Free term b_0	Coefficient b_1	Correlation coefficient of two samples	Covariance of two samples	Standard error
Kakhovka	28.964	– 0.681	– 0.9972	– 6.138	0.159

The value of partial correlation coefficient, presented in table 7, is higher than the boundary values of correlation coefficients r (P=0.95; f=22)=0.4, where P – boundaries of confidence interval, f – the number of degrees of freedom. This proves significance of the determined partial correlation coefficient for which r (P=0.95; f=22)=0.4> $|-0.9972|$.

With the help of regression calculations we obtain the system of normal equations for three independent variables $X_{1,i}$, $X_{2,i}$, $X_{3,i}$ [9, 18]:

$$a_0 \cdot (n+1) + a_1 \cdot \sum_{i=0}^{n} X_{1,i} + a_2 \cdot \sum_{i=0}^{n} X_{2,i} + a_3 \cdot \sum_{i=0}^{n} X_{3,i} + a_4 \cdot \sum_{i=0}^{n} X_{4,i} + a_5 \cdot \sum_{i=0}^{n} X_{5,i} = \sum_{i=0}^{n} Y_i \,, \tag{6}$$

$$a_0 \cdot \sum_{i=0}^{n} X_{1,i} + a_1 \cdot \sum_{i=0}^{n} \left(X_{1,i}\right)^2 + a_2 \cdot \sum_{i=0}^{n} \left(X_{1,i} \cdot X_{2,i}\right) + a_3 \cdot \sum_{i=0}^{n} \left(X_{1,i} \cdot X_{3,i}\right) + \\ + a_4 \cdot \sum_{i=0}^{n} \left(X_{1,i} \cdot X_{4,i}\right) + a_5 \cdot \sum_{i=0}^{n} \left(X_{1,i} \cdot X_{5,i}\right) = \sum_{i=0}^{n} \left(X_{1,i} \cdot Y_i\right), \tag{7}$$

$$a_0 \cdot \sum_{i=0}^{n} X_{2,i} + a_1 \cdot \sum_{i=0}^{n} \left(X_{2,i} \cdot X_{1,i}\right) + a_2 \cdot \sum_{i=0}^{n} \left(X_{2,i}\right)^2 + a_3 \cdot \sum_{i=0}^{n} \left(X_{2,i} \cdot X_{3,i}\right) + \\ + a_4 \cdot \sum_{i=0}^{n} \left(X_{2,i} \cdot X_{4,i}\right) + a_5 \cdot \sum_{i=0}^{n} \left(X_{2,i} \cdot X_{5,i}\right) = \sum_{i=0}^{n} \left(X_{2,i} \cdot Y_i\right), \tag{8}$$

$$a_0 \cdot \sum_{i=0}^{n} X_{3,i} + a_1 \cdot \sum_{i=0}^{n} \left(X_{3,i} \cdot X_{1,i}\right) + a_2 \cdot \sum_{i=0}^{n} \left(X_{3,i} \cdot X_{2,i}\right) + a_3 \cdot \sum_{i=0}^{n} \left(X_{3,i}\right)^2 + \\ + a_4 \cdot \sum_{i=0}^{n} \left(X_{3,i} \cdot X_{4,i}\right) + a_5 \cdot \sum_{i=0}^{n} \left(X_{3,i} \cdot X_{5,i}\right) = \sum_{i=0}^{n} \left(X_{3,i} \cdot Y_i\right), \tag{9}$$

$$a_0 \cdot \sum_{i=0}^{n} X_{4,i} + + a_1 \cdot \sum_{i=0}^{n} \left(X_{4,i} \cdot X_{1,i}\right) + a_2 \cdot \sum_{i=0}^{n} \left(X_{4,i} \cdot X_{2,i}\right) + a_3 \cdot \sum_{i=0}^{n} \left(X_{4,i} \cdot X_{3,i}\right) + \\ + a_4 \cdot \sum_{i=0}^{n} \left(X_{4,i}\right)^2 + a_5 \cdot \sum_{i=0}^{n} \left(X_{4,i} \cdot X_{5,i}\right) = \sum_{i=0}^{n} \left(X_{4,i} \cdot Y_i\right), \tag{10}$$

$$a_0 \cdot \sum_{i=0}^{n} X_{5,i} + + a_1 \cdot \sum_{i=0}^{n} \left(X_{5,i} \cdot X_{1,i}\right) + a_2 \cdot \sum_{i=0}^{n} \left(X_{5,i} \cdot X_{2,i}\right) + a_3 \cdot \sum_{i=0}^{n} \left(X_{5,i} \cdot X_{3,i}\right) + \\ + a_4 \cdot \sum_{i=0}^{n} \left(X_{5,i} \cdot X_{4,i}\right) + a_5 \cdot \sum_{i=0}^{n} \left(X_{5,i}\right)^2 = \sum_{i=0}^{n} \left(X_{5,i} \cdot Y_i\right), \tag{11}$$

where a_0, a_1, a_2, a_3, a_4, a_5 – empirical coefficients of the system of equations; Y_i – statistical series of dependent quantity – yearly maximal ice thickness, that was observed, h_{max} (cm) at water storage of Kakhovka hydro scheme; $i = 1, 2, \ldots n$.

System of equations (6-11) presents linear regression model from five independent variables $X_{1,i}$, $X_{2,i}$, $X_{3,i}$, $X_{3,i}$, $X_{4,i}$, $X_{5,i}$. Independent variables $X_{1,i}$, $X_{2,i}$, $X_{3,i}$, $X_{3,i}$, $X_{4,i}$, $X_{5,i}$ (n = 25) present series of statistical data of yearly lowest average monthly temperatures of ambient air t_{min} (ºC) at points of observation: Kyiv, Kaniv, Kremenchuk, Middle Dnieper, Dnieper water storages [8]. System response or predicted value Yr_i presents the expected quantity of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme, that is determined by the expression of linear polynomial [19, 20]:

$$Yr_i = a_0 + a_1 \cdot X_{1,i} + a_2 \cdot X_{2,i} + a_3 \cdot X_{3,i} + a_4 \cdot X_{4,i} + a_5 \cdot X_{5,i}, \ \left(i = 1,2,\ldots,n\right), \tag{12}$$

Solution of system of normal equations (6-11) made it possible to determine empirical coefficients a_0 = 23.876, a_1 = –0.132, a_2 = 0.462, a_3 = –0.42, a_4 = –0.641, a_5 = –0.139. The obtained results are presented in figures 3, 4.

Standard deviation of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme, obtained with the use of conditional normal law for system of random correlated quantities, from yearly maximal ice thickness obtained with expression of linear polynomial equals σ = 0.572.

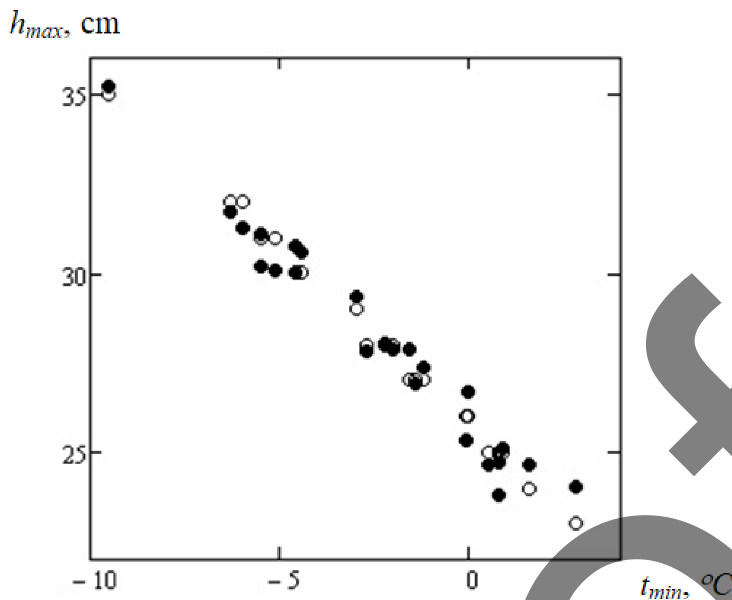

FIGURE 3. Plots of statistical series of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme versus yearly lowest average monthly temperatures of ambient air t_{min} (^{o}C) of Kakhovka hydro scheme: ○ – yearly maximal ice thickness, h_{max} (cm) obtained with the use of conditional normal law for system of random correlated quantities; • – yearly maximal ice thickness, h_{max} (cm) obtained by the expression of linear polynomial (12)

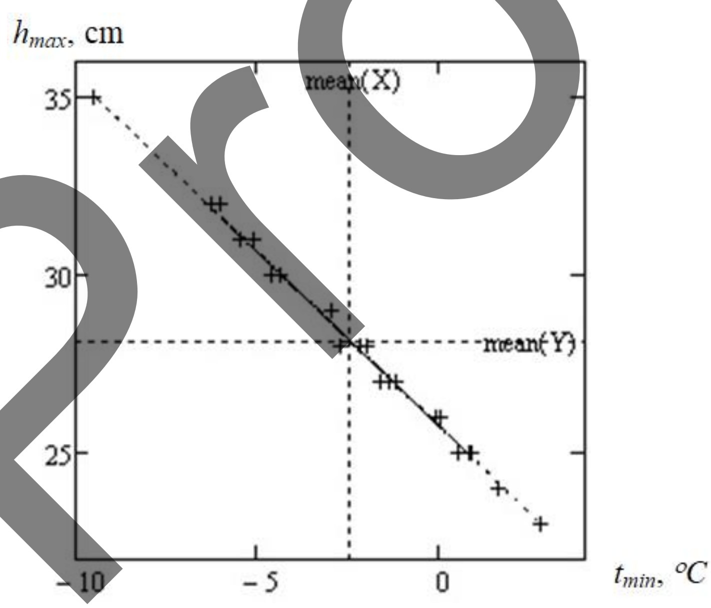

FIGURE 4. Plots of linear functions of regression of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme, obtained by methods of multiple correlation, versus yearly lowest average monthly temperatures of ambient air t_{min} (^{o}C) of Kakhovka hydro scheme

On condition of presence of linear correlation let us use the results of correlation analysis of statistical samples of yearly lowest average monthly temperature of ambient air t_{min} (°C) at dam sites of hydro schemes of Dnieper cascade over observation period 1966-1983, 2002-2008 yrs. According to data [8, 9] the values of pair correlation coefficients of pairs of series of statistical data equal: $r_{t_{min1}t_{min2}}$ = 0.826, $r_{t_{min1}t_{min3}}$ = 0.833, $r_{t_{min1}t_{min4}}$ = 0.804, $r_{t_{min1}t_{min5}}$ = 0.738, $r_{t_{min2}t_{min3}}$ = 0.979, $r_{t_{min2}t_{min4}}$ = 0.924, $r_{t_{min2}t_{min5}}$ = 0.889, $r_{t_{min3}t_{min4}}$ = 0.945, $r_{t_{min3}t_{min5}}$ = 0.916, $r_{t_{min4}t_{min5}}$ = 0.987, where t_{min} (ºC) – yearly lowest average monthly temperatures of ambient air at dam sites of hydro schemes: t_{min1} – Kyiv, t_{min2} – Kaniv, t_{min3} – Kremenchuk, t_{min4} – Middle Dnieper, t_{min5} – Dnieper hydro scheme.

The values of the presented partial correlation coefficients are higher than boundary values of correlation coefficients $r(P = 0.95; f = 22) = 0.4$, where P – boundaries of confidence interval, f – the number of degrees of freedom. This proves significance of the determined partial correlation coefficients.

In this investigation, correlation analysis of statistical samples of yearly lowest average monthly temperature of ambient air t_{min} (ºC) at dam sites of Dnieper cascade: t_{min1}, t_{min2}, t_{min3}, t_{min4}, t_{min5} and yearly maximal ice thickness, h_{max} (cm) at water storage Kakhovka hydro scheme was performed. As a result, the values of pair correlation coefficients of pairs of series of statistical data were obtained: $r_{t_{min1}h_{max}}$ = –0.8193, $r_{t_{min2}h_{max}}$ = –0.8945, $r_{t_{min3}h_{max}}$ = –0.9375, $r_{t_{min4}h_{max}}$ = –0.992, $r_{t_{min3}h_{max}}$ = –0.9815.

The values of the presented partial correlation coefficients are higher than boundary values of correlation coefficients $r(P = 0.95; f = 22) = 0.4$, where P – boundaries of confidence interval, f – the number of degrees of freedom. This proves significance of the determined partial correlation coefficients.

Partial correlation coefficients of the first order between two variables under constant value of the third variable were calculated by formula (13), and analogous formulas obtained from formula (13) by way of circular permutation of corresponding subscripts:

under $t_{min1} = const$:

$$r_{h_{max}\,t_{min3}\cdot\,t_{min1}} = r_{t_{min3}\,h_{max}\cdot\,t_{min1}} = \frac{r_{t_{min3}\,h_{max}} - r_{t_{min1}\,h_{max}} \cdot r_{t_{min1}\,t_{min3}}}{\left(1-\left(r_{t_{min1}\,h_{max}}\right)^2\right)^{1/2} \cdot \left(1-\left(r_{t_{min1}\,t_{min3}}\right)^2\right)^{1/2}} = 0.804\,, \tag{13}$$

$$r_{h_{max}\,t_{min5}\,t_{min1}} = -0.974\,,\; r_{h_{max}\,t_{min5}\,t_{min1}} = -0.978\,,\; r_{h_{max}\,t_{min2}\,t_{min1}} = -0.674\,;$$

with $t_{min2} = const$: $r_{h_{max}\,t_{min5}\,t_{min2}} = -0.910$, $r_{h_{max}\,t_{min4}\,t_{min2}} = -0.968$,
$r_{h_{max}\,t_{min3}\,t_{min2}} = -0.678$, $r_{h_{max}\,t_{min1}\,t_{min2}} = -0.618$,

with $t_{min3} = const$: $r_{h_{max}\,t_{min5}\,t_{min3}} = -0.879$, $r_{h_{max}\,t_{min4}\,t_{min3}} = 0.932$,
$r_{h_{max}\,t_{min2}\,t_{min3}} = -0.329$, $r_{h_{max}\,t_{min1}\,t_{min3}} = -0.199$,

with $t_{min4} = const$: $r_{h_{max}\,t_{min5}\,t_{min4}} = -0.118$, $r_{h_{max}\,t_{min3}\,t_{min4}} = 0.001$,
$r_{h_{max}\,t_{min2}\,t_{min4}} = -0.458$, $r_{h_{max}\,t_{min1}\,t_{min4}} = -0.290$,

with $t_{min5} = const$: $r_{h_{max}\,t_{min4}\,t_{min5}} = -0.962$, $r_{h_{max}\,t_{min3}\,t_{min5}} = -0.501$,
$r_{h_{max}\,t_{min2}\,t_{min5}} = -0.250$, $r_{h_{max}\,t_{min1}\,t_{min5}} = -0.245$.

It is evident that, besides $r_{h_{max}\,t_{min2}\,t_{min3}}$, $r_{h_{max}\,t_{min1}\,t_{min3}}$, $r_{h_{max}\,t_{min5}\,t_{min4}}$, $r_{h_{max}\,t_{min3}\,t_{min4}}$, $r_{h_{max}\,t_{min1}\,t_{min4}}$, $r_{h_{max}\,t_{min2}\,t_{min5}}$, $r_{h_{max}\,t_{min1}\,t_{min5}}$, the values of the other presented partial correlation coefficients of the first order are higher than boundary values of correlation coefficients $r(P{=}0.95; f{=}21){=}0.41$, where P – boundaries of confidence interval, f – the number of degrees of freedom.

The obtained data make it possible to understand mutual influence of yearly lowest average monthly temperature of ambient air t_{min} (ºC) at dam sites of hydro schemes of Dnieper cascade: t_{min1}, t_{min2}, t_{min3}, t_{min4}, t_{min5} on the value of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme. It becomes evident that correlation dependence of yearly maximal ice thickness at Kakhovka water storage on maximal lowest average monthly temperature of ambient air at dam sites of Kyiv and Kaniv hydro schemes decreases, which is evidenced by the values of correlation coefficients $r_{h_{max}\ t_{min1}\ t_{min3}} = -0.199$, $r_{h_{max}\ t_{min1}\ t_{min4}} = -0.290$, $r_{h_{max}\ t_{min2}\ t_{min5}} = -0.250$.

The values of correlation coefficients $r_{h_{max}\ t_{min2}\ t_{min1}} = -0.674$, $r_{h_{max}\ t_{min1}\ t_{min2}} = -0.618$ only corroborate substantial general interconnection between lowest amerage monthly temperatures of ambient air at dam sites of Kyiv and Kaniv hydro schemes.

The values of correlation coefficients $r_{h_{max}\ t_{min5}\ t_{min4}} = -0.118$, $r_{h_{max}\ t_{min3}\ t_{min4}} = -0.001$, $r_{h_{max}\ t_{min1}\ t_{min4}} = -0.290$ testify to insignificant interconnection between lowest average monthly temperature of ambient air at dam site of Middle Dnieper hydro scheme and yearly maximal ice thickness at Kakhovka water storage.

Calculation of partial correlation coefficients makes it possible to understand mutual influence of variables under their unsolved mutual dependence [18]. Partial correlation reveals dependent variables from the whole set of variables.

Partial correlation coefficients of the second order between two variables under two constant values of the third and fourth variables were calculated by formula (14) and analogous formulas obtained from formula (14) by circular permutation of corresponding subscripts:

under $t_{min1} = const$, $t_{min2} = const$:

$$r_{h_{max}\ t_{min3}\cdot\ t_{min1}\ t_{min2}} = r_{t_{min3}\ h_{max}\cdot\ t_{min2}\ t_{min1}} = r_{t_{min3}\ h_{max}\cdot\ t_{min1}\ t_{min2}} = r_{h_{max}\ t_{min3}\cdot\ t_{min2}\ t_{min1}} =$$
$$= \frac{r_{h_{max}\ t_{min3}\cdot\ t_{min2}} - r_{t_{min1}\ t_{min3}\cdot\ t_{min2}} \cdot r_{h_{max}\ t_{min1}\cdot\ t_{min2}}}{\left(1-\left(r_{t_{min1}\ t_{min3}\cdot\ t_{min2}}\right)^2\right)^{1/2} \cdot \left(1-\left(r_{h_{max}\ t_{min1}\cdot\ t_{min2}}\right)^2\right)^{1/2}} = 0.876, \tag{14}$$

$$r_{h_{max}\ t_{min4}\cdot\ t_{min1}\ t_{min2}} = -0.975,\ r_{h_{max}\ t_{min5}\cdot\ t_{min1}\ t_{min2}} = -0.983;$$

with $t_{min1} = const$, $t_{min3} = const$:

$$r_{h_{max}\ t_{min2}\cdot\ t_{min1}\ t_{min3}} = -0.672,\ r_{h_{max}\ t_{min4}\cdot\ t_{min1}\ t_{min3}} = -0.983,\ r_{h_{max}\ t_{min5}\cdot\ t_{min1}\ t_{min3}} = -0.977;$$

with $t_{min1} = const$, $t_{min4} = const$:

$$r_{h_{max}\ t_{min2}\cdot\ t_{min1}\ t_{min4}} = -0.637,\ r_{h_{max}\ t_{min3}\cdot\ t_{min1}\ t_{min4}} = -0.784,\ r_{h_{max}\ t_{min5}\cdot\ t_{min1}\ t_{min4}} = -0.986;$$

with $t_{min1} = const$, $t_{min5} = const$:

$$r_{h_{max}\ t_{min2}\cdot\ t_{min1}\ t_{min5}} = -0.665,\ r_{h_{max}\ t_{min3}\cdot\ t_{min1}\ t_{min5}} = -0.840,\ r_{h_{max}\ t_{min4}\cdot\ t_{min1}\ t_{min5}} = -0.155;$$

with $t_{min2} = const$, $t_{min3} = const$:

$$r_{h_{max}\ t_{min1}\cdot\ t_{min2}\ t_{min3}} = -0.624,\ r_{h_{max}\ t_{min4}\cdot\ t_{min2}\ t_{min3}} = -0.923,\ r_{h_{max}\ t_{min5}\cdot\ t_{min2}\ t_{min3}} = -0.935;$$

with $t_{min3} = const$, $t_{min4} = const$:

$$r_{h_{max}\ t_{min1}\cdot\ t_{min3}\ t_{min4}} = -0.214,\ r_{h_{max}\ t_{min2}\cdot\ t_{min3}\ t_{min4}} = -0.615,\ r_{h_{max}\ t_{min5}\cdot\ t_{min3}\ t_{min4}} = -0.927;$$

with $t_{min4} = const$, $t_{min5} = const$:

$$r_{h_{max}\ t_{min1}\cdot\ t_{min4}\ t_{min5}} = -0.219,\ r_{h_{max}\ t_{min2}\cdot\ t_{min4}\ t_{min5}} = -0.224,\ r_{h_{max}\ t_{min3}\cdot\ t_{min4}\ t_{min5}} = -0.492.$$

Besides $r_{h_{max}\,t_{min4}\cdot t_{min1}\,t_{min5}}$, $r_{h_{max}\,t_{min1}\cdot t_{min3}\,t_{min4}}$, $r_{h_{max}\,t_{min1}\cdot t_{min4}\,t_{min5}}$, $r_{h_{max}\,t_{min2}\cdot t_{min4}\,t_{min5}}$, the values of the other presented correlation coefficients of the second order are higher than boundary values of correlation coefficients $r(P = 0.95; f = 21) = 0.42$, where P – boundaries of confidence interval, f – the number of degrees of freedom. This proves significance of the determined correlation coefficients of the second order.

The values of partial correlation coefficients of the second order between the first and second variables were calculated under condition that influence of the third and fourth variables was excluded. The obtained results testify that the largest influence on the value of yearly maximal ice thickness at Kakhovka water storage is caused by the lowest average monthly temperature of ambient air at dam sites of Middle Dnieper ($r_{h_{max}\,t_{min4}\cdot t_{min1}\,t_{min2}} = -0.975$), Dnieper ($r_{h_{max}\,t_{min5}\cdot t_{min1}\,t_{min2}} = -0.983$) hydro schemes on condition of exclusion of influence of temperatures observed (or registered) at dam sites of Kyiv, Kaniv, and Kremenchuk hydro schemes.

Coefficient of multiple correlation under $t_{min1} = const$, $t_{min2} = const$:

$$R_{h_{max}\cdot t_{min1}\,t_{min2}} = R_{h_{max}\cdot t_{min2}\,t_{min1}} = \left(\frac{\left(r_{h_{max}\,t_{min1}}\right)^2 + \left(r_{h_{max}\,t_{min2}}\right)^2 - 2\cdot r_{h_{max}\,t_{min1}} \cdot r_{h_{max}\,t_{min2}} \cdot r_{t_{min1}\,t_{min2}}}{1-\left(r_{t_{min1}\,t_{min2}}\right)^2} \right)^{1/2} = 0.906 \tag{15}$$

and the corresponding values of coefficients of multiple correlation without indication of constant variables, the content of those is evident:

$$R_{h_{max}\cdot t_{min1}\,t_{min3}} = -0.940,\ R_{h_{max}\cdot t_{min1}\,t_{min4}} = -0.993,\ R_{h_{max}\cdot t_{min1}\,t_{min5}} = -0.992;$$
$$R_{h_{max}\cdot t_{min2}\,t_{min3}} = -0.944,\ R_{h_{max}\cdot t_{min2}\,t_{min4}} = -0.994,\ R_{h_{max}\cdot t_{min2}\,t_{min5}} = -0.983;$$
$$R_{h_{max}\cdot t_{min3}\,t_{min4}} = -0.992,\ R_{h_{max}\cdot t_{min3}\,t_{min5}} = -0.986,\ R_{h_{max}\cdot t_{min4}\,t_{min5}} = -0.992.$$

The values of coefficients of multiple correlation are higher than boundary values of correlation coefficients $r(P=0.95; f > 21)=0.42$, where P – boundaries of confidence interval, f – the number of degrees of freedom. This proves significance of the determined coefficients of multiple correlation.

Boundaries of 95% confidence intervals for equations of linear regression were estimated with satisfactory accuracy by expressions (16, 17) given at page 408 [20]:

$$\Delta_{h,\,l} = b_2 \pm t_{n-2;\ 0.05} \cdot D + b_3 \cdot t_{min,i}, \tag{16}$$

$$D = \left(\frac{\sum\left(Y - mean(Y)\right)^2 - \dfrac{\left(\sum\left(X - mean(X)\right)\cdot\left(Y - mean(Y)\right)\right)^2}{\sum\left(X - mean(X)\right)^2}}{n-2} \right)^{1/2} \tag{17}$$

where $\Delta_{h,\,l}$ – the higher and lower boundaries of 95% confidence intervals for equations of linear regression; b_2, b_3 – coefficients of equations of linear regression (see table 7); $t_{n-2;\ 0.05}$ – parameter of Student distribution, (see table 2, page 130 [18]); $mean(t_{min})$, $mean(h_{max})$ – average values of statistical series t_{min} (°C) and h_{max} (cm).

TABLE 7. Parameters of equations of linear functions of regression of statistical series of yearly lowest average monthly temperatures of ambient air t_{min} (°C) to statiatical samples of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme over observation period 1966–1983, 2002–2008 yrs.

Point of observation (water storage)	Free term b_2	Coefficient b_3	Correlation coefficient of two samples	Covariance of two samples	Standard error
Kakhovka	25.746	–0.979	–0.9975	–8.830	0.219

TABLE 8. Parameters for estimating confidence intervals of equations of linear regression.

Statistical series	$mean(t_{min})$ (°C)	$mean(h_{max})$ (cm)	$\pm t_{n-2;\ 0.05}$
t_{min} (°C) and h_{max} (cm)	28.125	–2.429	±2.074

At figure 5 presented are boundaries of confidence interval for the line of regression of yearly lowest average monthly temperatures of ambient air t_{min} (°C) to statistical samples of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme.

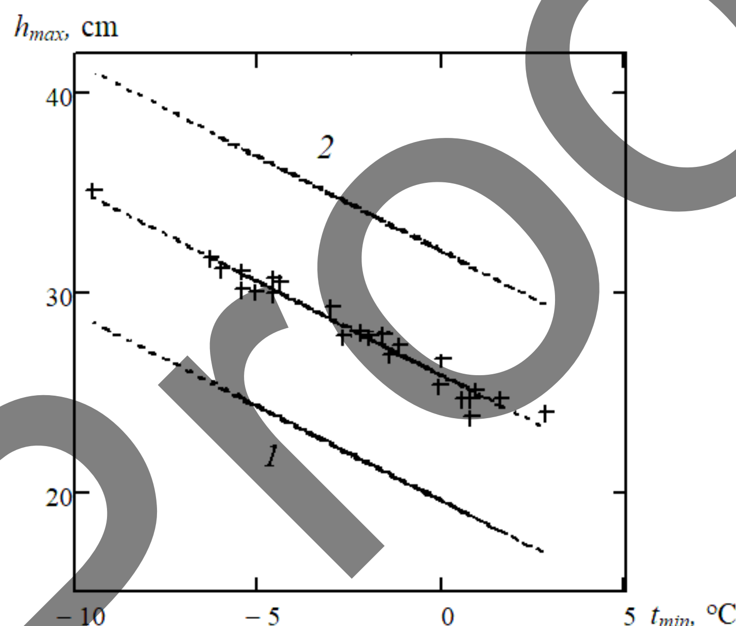

FIGURE 5. Plot of linear function of regression of statistical series of yearly lowest average monthly temperatures of ambient air t_{min} (°C) to statistical samples of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme; the higher boundary of confidence interval of regression function – line 1; the lower boundary of confidence interval of regression function – line 2

Parameters of normal distribution laws were selected for statistical series of yearly maximal ice thickness h_{max} (cm) at water storage of Kakhovka hydro scheme, obtained by expression of linear polynomial (12), and also by conditional normal law for two random correlated quantities. The results are presented in figure 6 and in table 9.

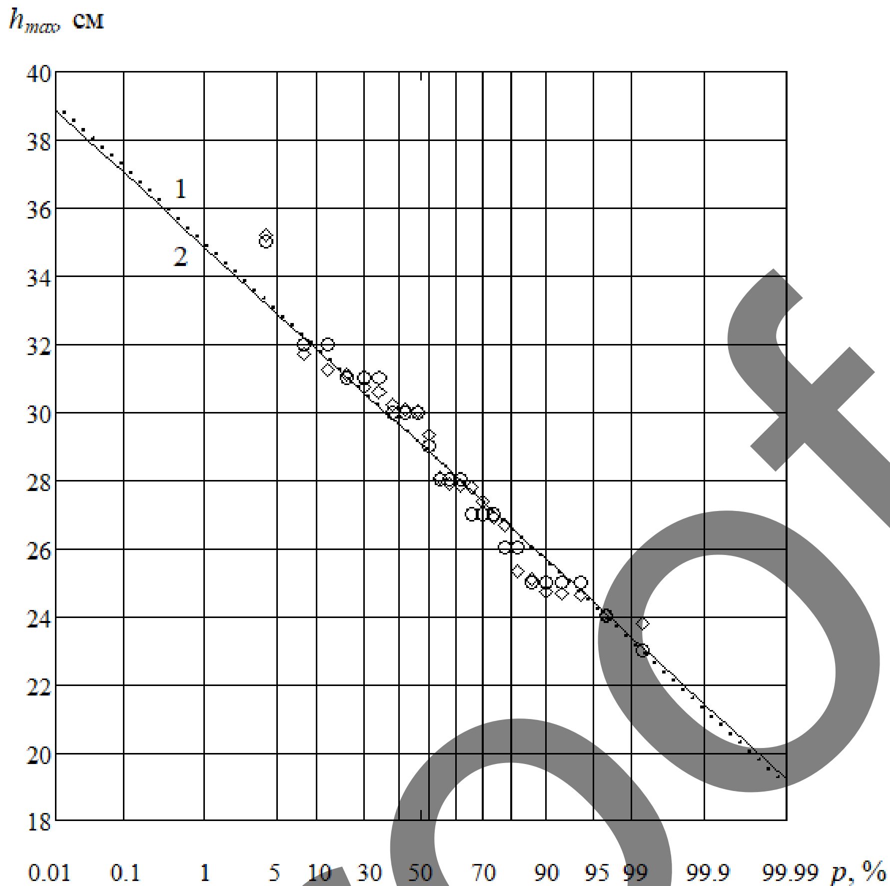

FIGURE 6. Comparison of results of calculation of probability of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme: ◊ – statistical series of yearly maximal ice thickness, obtained by expression of linear polynomial (12), to which normal distribution law corresponds – line 1; ○ – statistical series of yearly maximal ice thickness, obtained under conditional normal law for two random correlated quantities, to which the normal distribution law corresponds – line 2; *p*, % – probability

TABLE 9. Parameters of normal laws of distribution of probability of yearly maximal ice thickness, h_{max} (cm) at water storage of Kakhovka hydro scheme.

№	Water storage	Normal distribution law	Parameters of normal distribution law	
			Expectation	Standard deviation
1	Kakhovka	Line 1 in figure 6	28.123	2.889
2	Kakhovka	Line 2 in figure 6	28.125	2.948

Standard deviation of points of statistical series of yearly maximal ice thickness obtained by expression of linear polynomial (12) from points of statistical series of yearly maximal ice thickness obtained by conditional normal law for two random correlated quantities equals $\sigma = 0.39$ cm. Standard deviation of points by the plot of normal law of distribution presented by line 1 (see figure 6) from points of the plot of normal distribution law – line 2 is $\sigma = 0.139$ cm.

From the viewpoint of approximation of real data by the predicted ones, results can be improved by way of the use of more complex nonlinear polynomial regression models of higher orders [20].

CONCLUSIONS

Application of approaches of multiple correlation and regression turned out to be acceptable in modeling temperature and ice conditions of water storages under cascade arrangement of hydro schemes. Confidence intervals of regression equations and accuracy of the obtained results were estimated. The developed algorithm was tested for temperature and ice conditions of water storages of hydro schemes of Dnieper cascade of hydroelectric stations. The results of the investigation can be used in probabilistic calculations of reliability of hydraulic structures and cascades of hydro schemes.

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Analysis of the Duration of Operational Stage as a Part of Constructed Assets Life Cycle with Impact of Natural and Man-Made Factors

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Abstract. The purpose of this work is to formulate the general principles of a systematic approach to justify the duration of the components of operational stage as a part of constructed assets life cycle for further development of organizational and technological model of operational suitability of constructed assets during their operation. It is established that measuring works are an integral part of the process of operation and repair work in its composition, which are carried out according to a single schedule of operation of the building, and the frequency and volume of measuring work are correlated with the corresponding indicators of repair work. Increasing the life cycle of constructed assets can be ensured by timely repair work, preventing the decline in serviceability of buildings during their operation. Optimization of repair work is possible by taking into account a set of informational, technological and technical factors influencing the operational suitability of the constructed assets. Without taking into account timely information about the technical condition of the object, their labor costs increase; the use of information system of instrumental monitoring reduces the number of repairs and labor costs during their implementation by obtaining timely information about the technical condition of the object. Organizational, technological and technical indicators of the life cycle of buildings depend on the efficiency of information systems. Detection, prediction of development and correction of damage during operation is an urgent problem related to the need to improve the serviceability of constructed assets, which can be solved by systematically processing reliable information about its technical condition, which will be obtained by instrumental measurements.

INTRODUCTION

The problem of long-term operation of constructed assets, which is becoming increasingly important, is associated with the timely determination of their technical condition [1]. Some of them, due to physical wear and tear, became unusable and potentially dangerous for further operation [2]. The duration of building life cycle is the sum of the duration of all its stages, the longest of which is the stage of operation. Increasing the duration of the life cycle is possible through the timely maintance and repairs that prevent the reduction of building serviceability during operation period. Their timely execution is possible due to a systematic approach to a set of informational, technological and technical factors influencing the operational suitability of buildings. Detection, prediction of development and correction of damages during operation is an urgent problem.

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ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

A systematic approach to maintaining the reliability and durability of constructed assets is provided at all stages of the life cycle [3,4]. Physical wear and tear of the building is accelerated due to the impact of defects and damage resulting from unforeseen circumstances, errors in design or operational documentation, insufficient qualification of contractors. The threat is the uncertainty of the place and time of its appearance. The period of normal operation is characterized by the time during which the operational properties of buildings are maintained at the regulatory level. The period of end of normal operation begins when the intensity of failures leads to a decrease in the serviceability of buildings below the regulatory level [5, 6, 7, 8, 9, 10]. During operation, it is important to evaluate the nature and risk of damage, so the creation of models [13] and systematization of factors influencing the technical condition will increase the efficiency of constructed assets serviceability.

GENERAL RESEARCH METHODS

Systematic approach to the serviceability of buildings takes into account all the factors that affect the organization process, and focuses on the relationships between its elements. In the research of organizational and technological solutions to ensure the operational suitability of buildings should be analyzed and investigated the relationship and interaction between the elements of information, technical and technological systems.

PRESENTMENT OF THE MAIN MATERIAL

Ensuring the operational suitability of buildings is carried out by planned precautionary measures, including visual inspections, instrumental measurements and monitoring of buildings. Inspection of buildings is an element of the information system and is designed to obtain and analyze data on qualitative and quantitative indicators of their performance. For their long-term supervision, long-term monitoring is carried out using instrumental methods. Surveys are divided into scheduled and unscheduled: scheduled - assess the current technical condition of the building, establish the possibility of its further operation, or the need for restoration; unscheduled - carried out if necessary to restore operational properties, change the conditions of use or termination of operation.

To ensure the conditions of normal operation, it is necessary to take into account the negative impacts that lead to a decrease in the serviceability of buildings. Technical inspections and surveys of the object take into account: the impact of complicating conditions - subsidence, seismic, technological impacts, etc .; the current technical condition of drainage from the site area; technical condition of roofs and drainage systems from roofs; the condition of foundations waterproofing and paving around the object; technical condition of load-bearing structures; the condition of the protective layer in reinforced concrete structures; condition of anticorrosive and fire-retardant coatings of structures; technical condition of responsible wooden structures; technical condition of engineering systems, and their impact on the structural system; condition of internal fire water supply, smoke and heat release systems; compliance with the design temperature-humidity regime; the risk of injury to people on or near the facility, changes in spatial planning, technological and design solutions without design documentation, overloading structures.

The actual volume and frequency of all types of repairs in practice significantly different from those recommended by the regulatory documents in public utilities. The analysis of the project documentation on current, capital repairs and reconstruction, the survey of the specialists of the maintenance and technical supervision services allowed to make an approximate scheme of the periodicity and relative duration of the maintance works at the stage of constructed assets operation. In the general case, during the operation phase using elements of information and technological systems, including instrumental methods, perform the collection of initial data to justify the necessary and sufficient amount of repair work. Maintenance and repair work of various complexity are preceded by: development of design decisions, projects of selective or complex capital repairs, reconstruction, change of functional purpose, conservation or liquidation and preparatory works. When assessing the duration of repair work during operation period, it should be taking into account that instrumental measurements are part of them and are performed, depending on the type of such work in parallel with the operation of buildings (parts) without resettlement, consistent with operating periods and possible resettlement, or by flow line method. In any case, there is a period of social discomfort for participants in the process, with the need to compensate for material or moral damage, which affect the complexity and cost of repairs in general and instrumental measurements - in particular (Fig. 1).

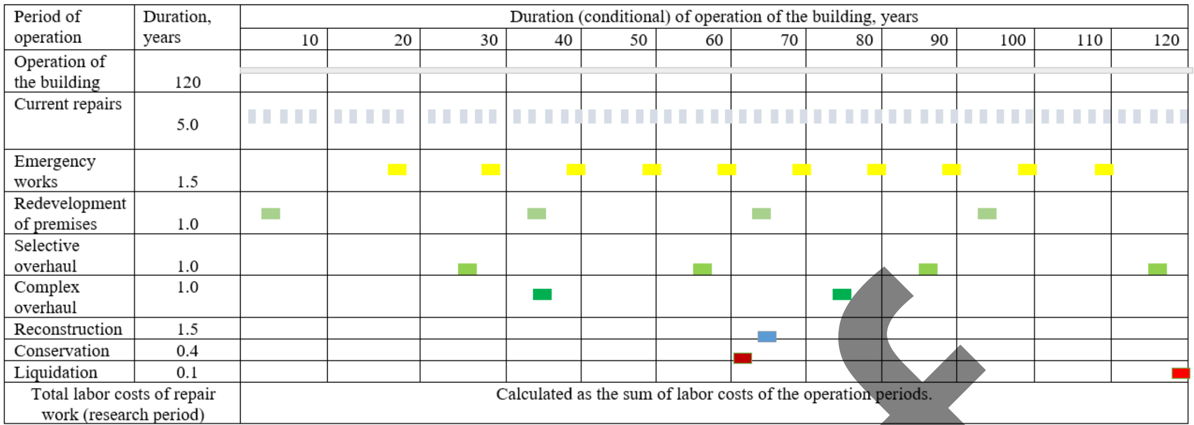

FIGURE 1. Scheme for estimating the duration of repair work at the stage of operation (period of social discomfort)

Current repairs, redevelopment, emergency repairs, selective overhaul, complex overhaul, reconstruction, conservation, liquidation, taking into account the social component, constitute the duration of the life cycle of the object. Building repair is a set of construction measures aimed at maintaining or restoring the original performance of the building as a whole and its individual elements.

Depending on the technical condition of load-bearing and enclosing structures, repair work is divided into current repairs and overhaul.

Current repairs include systematic and timely protection of building and engineering equipment parts from premature wear by carrying out precautions, repairing minor damage and breakdowns. Maintenance work is performed regularly throughout the year according to schedules, which is the service department based on the results of current and special inspections. Emergency building damage, creating danger or violating operating conditions, lead to building structures destruction, must be eliminated urgently. Overhaul is a set of construction works related to the restoration or improvement of building performance, with the replacement or restoration of load-bearing or enclosing structures, engineering equipment and fire protection equipment without changing the construction dimensions of the object and its technical and economic indicators. Overhaul includes the replacement or reinforcement of worn structures and building elements to improve their performance, with the exception of dismantling or complete replacement of the main structures. Overhaul can be complex (for the whole building) or selective (structures, equipment). Selective overhaul is carried out when the complex repair causes obstacles to the operation of the building as a whole, with a large wear of individual structures, or with the economic inexpediency of complex repairs. During selective overhaul it is necessary to provide repair of those structures on which the normal mode of operation depends, and also structures which influence reliability of other building parts. Redevelopment of premises is characterized by: moving and dismantling of partitions, doorways, extension and re-equipment of vestibules, extension of balconies, etc. Reconstruction of constructed assets involves a change in its geometric dimensions and / or functional purpose, resulting in an improvement of its technical and economic characteristics, operating conditions and quality of services. Reconstruction involves the complete or partial preservation of the elements of the load-bearing structures and whole or partial operation suspension for its duration. In case of impossibility, or inexpediency of object operational properties restoration, or in case of the termination of its operation there should be a conservation or liquidation of object. Liquidation of the object is carried out by its demolition with waste utilization, dismantling with use of the released products or the mixed method. The constituent elements of ensuring the operational suitability of constructed assets are characterized by the corresponding organizational-technological and technical-economic indicators, which depend on many factors of influence, which in relation to the constructed assets are divided into external and internal; natural, man-made and anthropogenic, etc. [11, 12] (Fig. 2)

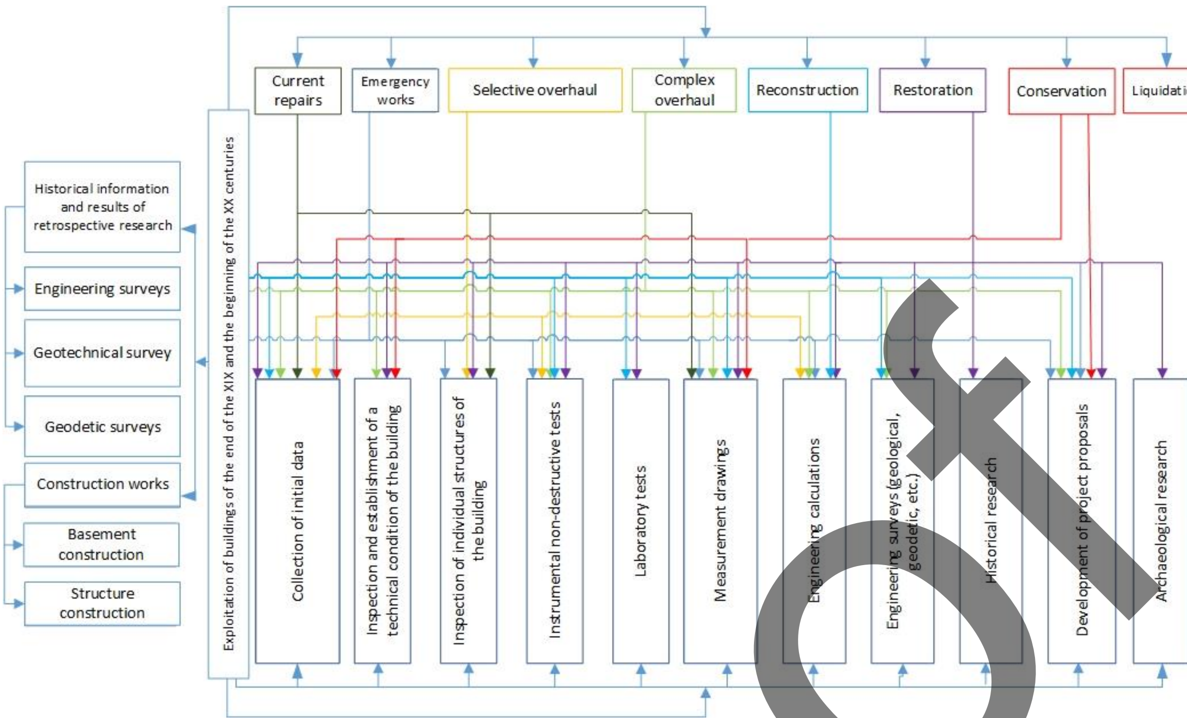

FIGURE 2. Block diagram of the relationship of information, technical and technological systems of real estate.

In accordance with the analysis of the relationship of information, technical and technological systems as part of the stage of constructed assets operation, it is shown general principles of dependence of technical and economic indicators of operational periods on the volume and type of measuring information. Naturally, the technical, economic and organizational and technological indicators of the technological construction cycle operation stage depend on the relevant organizational and technological indicators components of this stage construction processes, which are derived from their duration, namely: current repairs (Tcr), emergency works (Tew), selective overhaul (Tso), complex overhaul (Tco), reconstruction (Trc), restoration (Trs), conservation (Tcon), liquidation (Tliq). The duration of the technological construction cycle of the operation stage (Tcyop) is defined as the sum of the durations of all its components (1):

$$\begin{aligned} Tcyop &= (TTcrNc + TewNew + TsoNso + TcoNco + TrcNrc + \\ &+ TrsNrs + TconNcon + +TTliqNliq + \sum Toтj \end{aligned} \tag{2}$$

where, $\sum$ Tot j is the sum of organizational and technological breaks of the relevant components in the technological construction cycle, related to communal and social issues of the operation stage.

The composition, volume and frequency of all types of repair and restoration works, ie construction processes, as part of the operation phase are determined on the basis of data analysis on the technical condition of the constructed assets in general and its components in particular. The systematic nature of such data ensures the use of information systems for obtaining and processing information. The amount of information to ensure the operational suitability of the constructed assets during the technological construction cycle of the operation phase is correlated with the volume of work of technological processes that are part of it.

In accordance with the structural scheme of the relationship of information, technical and technological systems of constructed assets, the elements of the technological construction cycle of the operation stage have their organizational and technological components of a lower level (Fig. 3). Accordingly, the duration of current repairs (3) depends on the duration of the following elements of the information system - the collection of initial data (*tcr.id*), inspection of individual structures of the building (*tcr.is*), measurement drawings (*tcr.drw*). Similarly, emergency work (4) requires the availability of initial data (*tew.id*), the results of inspection and establishment of the technical condition of the building (*tew.itc*), inspection of individual structures of the building (*tew.is*), laboratory tests (*tew.lt*), measurement drawings (*tew.drw*), development of project proposals or emergency response project (*tew.pr*). Selective overhaul (5) - collection of initial data (*tso.id*), inspection of individual constructions of the building (*tso.is*), instrumental non-destructive tests (*tso.ndt*), engineering calculations (*tso.ec*), development of project proposals or project (*tso.pr*). Complex overhaul (6) - collection of initial data (*tco.id*), inspection and establishment of technical condition of the building (*tco.is*), instrumental non-destructive tests (*tco.ndt*), laboratory tests (*tco.lt*), measurement drawings (*tco.drw*), engineering calculations (*tco.ec*), engineering surveys (geological, geodetic, etc.) (*tco.es*), development of project proposals or project (*tco.pr*). Reconstruction (7) - collection of initial data (*trc.id*), inspection and establishment of technical condition of the building (*trc.is*), instrumental non-destructive tests (*trc.ndt*), laboratory tests (*trc.lt*), measurement drawings (*trc.drw*), engineering calculations (*trc.ec*), engineering surveys (geological, geodetic, etc.) (*trc.es*), development of project proposals or project (*trc.pr*). Restoration (8) - collection of initial data (*trs.id*), inspection and establishment of technical condition of the building (*trs.is*), inspection of individual constructions of the building (*trs.is*), instrumental non-destructive tests (*trs.ndt*), laboratory tests (*trs.lt*), measurement drawings (*trs.drw*), engineering calculations (*trs.ec*), engineering surveys (geological, geodetic, etc.) (*trs.es*), historical research (*trs.hr*), archaeological research (*trs.ar*), development of project proposals or project (*trs.pr*). Conservation (9) - collection of initial data (*tcon.id*), inspection and establishment of a technical condition of the building (*tcon.is*), measurement drawings (*tcon.drw*), development of project offers or the project (*tcon.pr*). Liquidation (10) - collection of initial data (tliq.id), measurement drawings (*tliq.drw*), development of project proposals or project (*tliq.pr*).

The duration of the process of obtaining information on the constructed assets technical condition at the stage of operation and design of varying complexity restoration work is calculated as the sum of the duration of its components, which are derived from the duration of construction processes in the technological construction cycle (Table 1).

It should be borne in mind that repair work at the stage of operation is performed, depending on their complexity in parallel with the operation of buildings (their parts) without resettlement of residents, sequentially with operational periods and possible resettlement of residents, or by flow line method. In fact, the duration of the technological construction cycle of the operation stage is equal to the period of social discomfort for participants in the complex organizational and technological process of operation of constructed assets (11):

$$Tsd = Tcyop = \sum T_i N_i + \sum Tot_j \tag{2}$$

where, *Ti* is the duration of the *i-th* component of the organizational and technological element of the construction cycle of the operation stage; *Ni* - the number of relevant components in the technological construction cycle of the operation phase; $\sum T_i N_i$ - the sum of the durations of all components of the construction cycle of the operation phase.

TABLE 1. Determining the duration of the elements of the information system of the construction cycle at the stage of operation of the constructed assets

	Construction cycle components	**The duration of the construction cycle components**	
1	Current repairs	$Tcr = tcr.id + tcr.is + tcr.drw$	(3)
2	Emergency works	$Tew = tew.id + tew.itc + tew.is + tew.lt + tew.drw + tew.pr$	(4)
3	Selective overhaul	$Tso = tso.id + tso.is + tso.ndt + tso.ec + tso.pr$	(5)
4	Complex overhaul	$Tco = tco.id + tco.is + tco.ndt + tco.lt + tco.drw + tco.ec + tco.es + tco.pr$	(6)
5	Reconstruction	$Trc = trc.id + trc.is + trc.ndt + trc.lt + trc.drw + trc.ec + trc.es + trc.pr$	(7)
6	Restoration	$Trs = trs.id + trs.is + trs.is + trs.ndt + trs.lt + trs.drw + trs.ec + trs.es + trs.hr + trs.ar + trs.pr$	(8)
7	Conservation	$Tcon = tcon.id + tcon.is + tcon.drw + tcon.pr$	(9)
8	Liquidation	$Tliq = tliq.id + tliq.drw + tliq.pr$	(10)

In general, the duration of the operation phase (*Top*) is defined as the sum of the duration of social discomfort (*Tsd*) during the technological construction cycle of the operation phase and the period of normal operation of the building (*Top*):

$$Top = Tsd + Tnorm \tag{11}$$

The duration of the period of social discomfort is equal to the total duration of repair and measurement work that accompanies them. To assess the impact of the period of social discomfort in the composition, it is necessary to determine the main technical and economic indicators, ie - duration, complexity and cost of work on current, emergency and selective overhaul with resettlement, without resettlement, or partial resettlement of residents.

The total duration of work without resettlement of residents (twor) is:

$$twor = trw\ (1+(Mi + 1) / M\ i) + tm \tag{12}$$

trw - duration of repair work; *Mi* - the number of conventional units of repair (plot, apartment, sq.m, etc.); tm - duration of measurements accompanying repair work.

The total duration of work with partial resettlement of residents (*tpr*) is:

$$tpr = trw\ (1 + krr\ (Mi + 1) / Mi) + tm \tag{13}$$

krr - coefficient that takes into account the volume of resident resettlement.

When performing repairs under the condition of complete resettlement of residents, repair works are transformed into construction and installation, ie performed without interaction with the operation. This is especially true for complex overhauls and reconstruction.

The total complexity of work without resettlement of residents (*twor*) is:

$$Qwor = [trw\ (1+(Mi +1)/ Mi)+tm]\ Nwr \tag{14}$$

Nwr - quantity of workers

The total complexity of work with partial resettlement of residents is:

$$Qpr = [trw\ (1+ krr\ (M\ i +1) / M\ i) + tm]\ Nwr \tag{15}$$

Determining the duration of work on current, emergency and selective overhaul with complete resettlement of residents (*tcr*):

$$tcr = trw + tm \tag{16}$$

The total complexity of work with the full resettlement of residents (*Tcr*) is:

$$Qcr= [trw+ tm]\ Nwr \tag{17}$$

Clarification of labor intensity taking into account additional indicators for different options of repairs and resettlement:

$$Qai\ i = Qi\ kai \tag{18}$$

kai - coefficient that takes into account the availability of additional indicators for different options for repairs and resettlement.

Determining the cost of work, taking into account the organization of their implementation, additional indicators for different options for repairs and resettlement (Ci):

$$Ci = Tai\ i\ [C\ rw\ i + Cm\ i] \tag{19}$$

Crw i - the cost of repair work, taking into account the organization of their implementation, additional indicators for the i-th option of repair and resettlement; *Cm i* - the cost of measuring works, taking into account the organization of their implementation, additional indicators for the *i-th* option of repair and resettlement.

We found [11, 12] that with the traditional approach to assessing the frequency of repairs, without taking into account timely information about the technical condition of constructed assets, their labor costs increase. At the same time, in the presence of an instrumental monitoring information system, the number of repairs and, accordingly, labor costs for their implementation and the period of social discomfort is reduced.

CONCLUSION

Increasing the life cycle of constructed assets can be provided by timely repair and restoration work, preventing the decline in serviceability of buildings during their operation.

Timely performance of repair and restoration works is possible due to a systematic approach to a set of informational, technological and technical factors influencing the operational suitability of constructed assets.

With a declarative approach to assessing the frequency of repair work, without taking into account timely information about the technical condition of constructed assets, their labor costs increase. The use of information system of instrumental monitoring reduces the number of repairs, labor costs and the period of social discomfort during their implementation by obtaining timely information about the technical condition of the object.

Organizational, technological and technical indicators of the life cycle of buildings depend on the efficiency of information systems, including their instrumental and measuring component. Information systems are the basis for determining the scope of work on repair, reconstruction, restoration, technical re-equipment.

Detection, prediction of development and correction of defects and damage during operation is an urgent problem related to the need to improve the serviceability of constructed assets, the solution of which is possible with the availability and systematic processing of reliable information about its technical condition, obtained by instrumental measurements.

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Methodology for Determining the Effectiveness of the Use of Earth-moving Machines and Their Parts in the Construction of Architectural Structures

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Abstract. Based on the results of the study of determining the criterion for the efficiency of earthmoving machines (EMM) in operating conditions, it is stated that an efficiency factor can be such a criterion. Justification of the efficiency of the proposed methodology is based on the use of reference data obtained with traction bulldozers from 30 to 350 kN, of which five known samples are presented for consideration. Reference data for these bulldozers and the calculation of output and input capacities for each of them as technical systems were used to determine their efficiency value. One of the bulldozers is taken according to the obtained highest value of efficiency. This approach allows you to determine the efficiency for other structures of the bulldozer, in particular, energy sources and energy consumers. For the first time, the total efficiency value for the EMM workflow is determined. According to this principle, based on the proposed methodology, the efficiency value for other EMM can be determined based on reference information, such as motor graders, excavators, scrapers, and the most effective EMM among similar ones can be chosen. The efficiency can also be used to determine the state of the components of the EMM under operating conditions.

INTRODUCTION

The construction of architectural structures requires significant amounts of earthworks at the initial stage of preparing the site for such construction. Bulldozers, excavators, motor graders and other EMM are commonly used for such work. The use of such energy-consuming machines in the construction of architectural structures requires material expenditures. They include fuel costs, driver's labor costs, depreciation costs for upgrade of EMM, and others. Currently, EMM manufacturers have introduced a fairly wide range of machines designed to perform earthworks. Choosing the machine which is most effective in the given operating conditions from a range of similar ones, at first glance, should not cause any problems, since such a choice of machine is based on the use of publicly available information, which can be found in the technical documentation and in the reference literature. It has been experimentally established that this approach to the choice of the most cost-effective EMM for specific operating conditions, does not guarantee making the right decision and therefore it needs its further improvement.

ANALYSIS OF RECENT STUDIES AND PUBLICATIONS

In the studies conducted to determine the performance indicators of EMM, according to [1, page 204] it is said verbatim that "performance indicators can be determined by processing data from a full-scale experiment, as well as by modeling methods, in particular, economic and mathematical." Further, in the same paper, it is stated that "it is advisable to form a system of indicators for evaluating the efficiency of earthmoving machines on the basis of such a generalized indicator as specific reduced costs, which, taking into account the relevant relationships and restrictions, most fully meet the requirements under consideration." This point of view is shared by other researchers, in

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particular [2, 3, 4 and 5]. In the work [6] according to the translation, it is stated that "the efficiency criterion should have the following characteristics; – measuring the actual effectiveness of the chosen option; – being expressed quantitatively; – only one criterion for the problem to be solved; – the criterion should be determined accurately and quickly within a short time; – ensuring that all the essential aspects of the problem to be solved are taken into account; – having a physical meaning that makes it understandable and tangible. Further, the work [6, p. 186-187] contains analysis on the search for a cost-effective bulldozer design between a range of bulldozers which includes three brands DZ-9, DZ-54 and DZ-34C. This analysis is based on determining the cost of production obtained by bulldozers, taking into account the following factors: – volume of work; – range of soil transportation. Even a brief overview of this problem shows that requires further solutions. So, the problem of determining an effective earthmoving machine from a range of similar machines and creating efficient detachments with extensive capabilities from them is still relevant today.

STATEMENT OF THE OBJECTIVE AND TASKS OF THE STUDY

The purpose of this work is to create a scientific methodology for a reasonable choice of appropriate criteria for determining one EMM from a range of similar ones, which is characterized by the highest level of effective functioning in operating conditions while ensuring maximum performance with minimal fuel consumption and capable of establishing the actual condition as a whole and their components in operating conditions based on diagnostics.

To achieve the above goal, the following problems should be solved:

- substantiation, using the example of a range of similar bulldozers, a methodology for determining the criterion appropriate for selecting an efficient machine for given operating conditions;

- application of a systematic approach to the consideration of EMM, taking into account the rank subordination and significance of all components, with the determination of the efficiency of each of them and the system as a whole and its application to establish the state of the components of EMM in the on-board diagnostic mode.

PROBLEM SOLVING

A range of bulldozers of with different traction classes (30-350 KN) is selected randomly with the increasing tractor engine power. According to well-known reference sources [7], which are characterized by a high level of reliability, the main technical and operational parameters for each bulldozer are accepted, the results of which are summarized in Table 1.

TABLE 1. Technical and operational parameters of traction class bulldozers (30–350 kN)

Reference parameters of bulldozers according to the source [2], page 8, 75-82, 94-99	**Brand of the bulldozer (traction class), T_j, kN**				
	1. DZ-42, (30 kN)	**2. DZ-19, (100 kN)**	**3. DZ-24C, (150 kN)**	**4. DZ-34C, (250 kN)**	**5. DZ-68, (350 kN)**
1. Rated power of the (ICE) internal combustion engine, N_j^{ice}, kW, (h.p.)	DT-75, 55 (75)	Г-100MGP, 80 (108)	T-180G, 129 (175)	DET-250, 238 (323)	T-500, 364 (500)
2. Specific fuel consumption of an ICE, q_j^{sfc}, g/h.p.hour	185	175	175	165	175
3. Bulldozer performance, (average), P_j^{b}, m^3/hr.	50-65 (57,5)	80-90 (85,0)	120-160 (140,0)	250-300 (275,0)	300-400 (350,0)
4. Resistance of cutting of the soil of the II category, R^{srsc}, kPa, (kgf/cm^2)			90, (0,9)		

According to Table 1, the main parameters are: rated engine power of the bulldozer; specific fuel consumption; productivity of the bulldozer; specific resistance to cutting soil of Category II. To create the same opportunities for the entire range of bulldozers, the same distance to which the soil is moved in the face and its category are adopted. A bulldozer, as an EMM, from the point of view of a systematic approach, is a complex branched system that can function if there is an operator in its structure.

The main function of the operator is to perform high-quality control of the bulldozer, provided that he is highly qualified and responsible for his duties. It is known that the operator's qualification affects the performance of the bulldozer and is determined by the coefficient: 1 – high level of training; 0,75 – average level of training; 0,5 – low level of training. In the study, the condition is assumed that the operator has a high level of training and responsibility for their duties. According to this assumption, he does not affect the performance of the bulldozer. Then the productivity of the EMM depends only on the technical capabilities, the actual condition of the machinery and the external environment (in particular, the category of soil).

The efficiency level of all structural components in the bulldozer system by efficiency value is determined by applying a systematic approach [8, 9 and 10], according to which all selected components are represented as structures with their own inputs, outputs and internal state, as shown in Fig. 1.

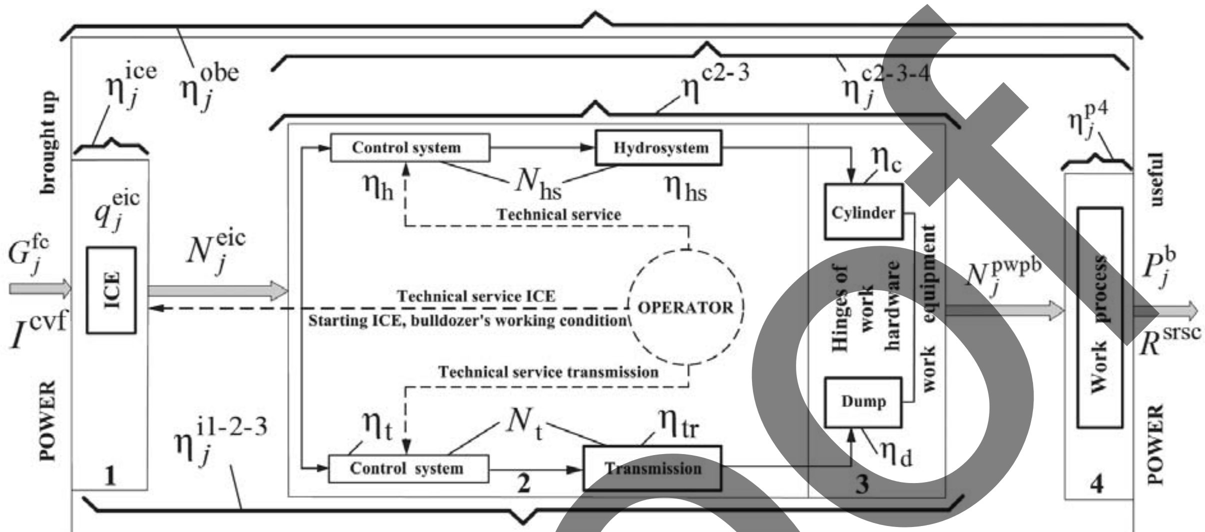


FIGURE 1. Block diagram of the bulldozer and its relationship between the main components in the mode of operation: 1 – energy source; 2, 3 and 4 – energy consumers

Analysis of all components of the bulldozer. The main components are: 1 – energy source with state η_j^{ice}; 2, 3 and 4 – energy consumers with state η^{c2-3} and η_j^{p4}. However, it should be noted that energy consumers 2 and 3 are part of the bulldozer structure and, together with Source 1, create components with a conditionally static mode, which is indicated η_j^{i1-2-3}. Dynamic mode is possible only during the operation of the bulldozer when another component 4 appears, which is called the workflow η_j^{p4} and together with the component η_j^{i1-2-3} is designated as η_j^{obe}.

The energy consumer of the 4 component structure η_j^{obe} is characterized by the energy consumption for cutting and moving the soil over a given distance when the working equipment interacts with the soil and when the bulldozer is controlled by the machine operator. The result of this interaction is the actual performance of the bulldozer.

Overall efficiency of the bulldozer during interaction with the external environment. In functional mode, the EMM is viewed in the aggregate of all four components in the form of an integral system, which is characterized by its inputs G_j^{fc} and I^{cvf} as well as outputs P_j^b and R^{srsc} is shown in Fig. 1. For a bulldozer as a system, the net power is N_j^{cp}, kW

$$N_j^{cp} = (P_j^b \cdot R^{srsc}) / 3600, \tag{1}$$

where P_j^e is hourly productivity of the bulldozer when moving soil at a distance of 40 m, m^3/hr.; R^{srsc} is specific cutting resistance of category II soil, kPa, (kN/m^2).

For the operation of the internal combustion engine during one time of operation of the EMM, for which the total engine power and its specific fuel consumption are known [11], the amount of fuel will be determined based on the dependence G_j^{fc}, kg/hr.

$$G_j^{\text{fc}} = 1{,}03 \cdot 10^{-3} \cdot N_j^{\text{eic}} \cdot q_j^{\text{sfc}} \cdot k_N \cdot k_{\text{ei}} \cdot k_{\text{rl}}, \tag{2}$$

where N_j^{eic} is engine power of the tractor on which the bulldozer is mounted, HP; q_j^{sfc} is specific fuel consumption of the internal combustion engine, G/HP H; k_N, k_{ei}, k_{rl} are coefficients, the first of which characterizes fuel consumption depending on the intensity of engine operation, the second and third take into account the use of the bulldozer engine in terms of operating time and relative load in terms of power, which are 1,18; 0,86 and 0,75, respectively.

The input (delivered, consumed, total) power consumed by the bulldozer during its operation is determined by the formula N_j^{tp}, kW

$$N_j^{\text{tp}} = (G_j^{\text{fc}} \cdot I^{\text{cvf}}) / 3600, \tag{3}$$

where I^{cvf} is calorific value of fuel, KJ/kg.

It is well known that each type of fuel is characterized by a corresponding calorific value, specific only for it. In particular, the calorific value of diesel fuel is 42700 KJ/kg. Based on the use of (1), (2) and (3), the average value of the total efficiency of the bulldozer during its operation is calculated by the formula, η_j^{obe}

$$\eta_j^{\text{obe}} = N_j^{\text{cp}} / N_j^{\text{tp}} = (P_j^{\text{b}} \cdot R^{\text{srsc}}) / (G_j^{\text{fc}} \cdot I^{\text{cvf}}) = (P_j^{\text{b}} / G_j^{\text{fc}}) \cdot k^{pm}, \tag{4}$$

where k^{pm} is the dimensional constant depending on (4) for determining the value of the overall efficiency, which, as in case of bulldozers that cut soil of Category II (cutting resistance 90 kPa) and using diesel fuel with a calorific value of 42700 KJ/kg, based on the ratio 90/42700, is 2,1077 x 10^{-3} kg/m^3.

Based on the use of dependencies (1) ... (4), taking into account the initial data given in Table 1, calculations are performed, the results of which are given in Table 2.

TABLE 2. Calculation of the total efficiency of traction class bulldozers (30–350 kN)

Calculation parameters	Brand of the bulldozer (traction class), T_j, kN				
	1. DZ-42, (30 kN)	**2. DZ-19, (100 kN)**	**3. DZ-24C, (150 kN)**	**4. DZ-34C, (250 kN)**	**5. DZ-68, (350 kN)**
1. Useful power, N_j^{cp}, kW, (1)	1,438	2,125	3,5	6,875	8,75
2. Fuel consumption ICE when cutting the soil, G_j^{fc}, kg/hr., (2)	10,876	14,814	24,005	41,774	68,585
3. Supplied (spent) power, N_j^{tp}, kW, (3)	129,001	175,711	284,726	495,486	813,494
4. The total efficiency of earth-moving machines, η_j^{obe}, f. (4)	0,011	0,012	0,012	0,0138	0,0107

Analysis of the obtained data according to the 4th line of Table 2 for a range of traction class bulldozers from 30 to 350 KN when comparing the overall efficiency values obtained for each of them allows us to identify the bulldozer that is the most effective in terms of this criterion. Such a machine is a traction bulldozer DZ-34C 250 kN, the efficiency of which is 0,0138, as the largest of the range of these bulldozers.

Overall efficiency of the energy source in the bulldozer structure. Component in the structure of the bulldozer (see Fig. 1), which is indicated by the number 1, is an internal combustion engine. For bulldozers, the internal combustion engine is an energy source with input parameters G_j^{fc} and I^{cvf}, and the output parameter is its power N_j^{eic}. Thus, for energy source 1, the input and output powers are known. Since these capacities are known, then the state of the energy source 1 in terms of the overall efficiency is calculated according to the dependence η_j^{ice}

$$\eta_j^{\mathrm{ice}} = N_j^{\mathrm{eic}} / N_j^{\mathrm{tp}} = (N_j^{\mathrm{eic}} \cdot 3600)/(G_j^{\mathrm{fc}} \cdot I^{\mathrm{cvf}}) . \tag{5}$$

The results of calculations according to (5) are summarized in Table 3. From the analysis of the results presented in Table 3, a conclusion can be drawn about the quality of internal combustion engines used to drive modern bulldozers and it can be determined which of the tractor engines is the most effective. The most efficient bulldozers are those with the DET-250 tractor engine, see Table 1.

Overall efficiency of the components of energy consumers 2 and 3. Components 2 and 3 function together and transmit energy in two streams: – through the transmission for moving the bulldozer; – through the hydraulic system for driving working equipment with their articulated connection to the body of the bulldozer. The input power of components 2 and 3 is a known value N_j^{eic}. The output power of the components, which is indicated N_j^{pwpb}, requires its further determination knowledge of the efficiency of these components [12], is determined by the formula $\eta^{\mathrm{c2\text{-}3}}$

$$\eta^{\tilde{\mathrm{n}}2\text{-}3} = (1 - k_{\mathrm{pr}}) / \Big((1 - k_{\mathrm{pr}} - k_{\mathrm{d}}) \big/ (\eta_{\mathrm{h}} \cdot \eta_{\mathrm{hs}} \cdot \eta_{\mathrm{c}}^{\mathrm{n}}) + k_{\mathrm{d}} \big/ (\eta_{\mathrm{t}} \cdot \eta_{\mathrm{tr}} \cdot \eta_{\mathrm{d}}^{\mathrm{m}}) \Big), \tag{6}$$

where k_{pr} is the power of the internal combustion engine, which is consumed for the operation of various devices, air conditioning lighting and other needs, are at the level of 6%; k_{d} is power consumption for the operation of the transmission, provided that the power distribution is equal for the operation of the hydraulic system and transmission, which is 0,47; η_{h}, η_{hs} are the value of the efficiency of the hydraulic system and its control system, respectively 0,7 and 0,75; η_{t}, η_{tr} are the value of the efficiency of the transmission and its control system, respectively 0,8 and 0,85; $\eta_{\mathrm{c}}^{\mathrm{n}}$ is the value of the total efficiency of the hinges of the power hydraulic cylinders, which is 0,95 and intended for connecting them to the working equipment and to the EMM housing with a number that is expressed as a number n and is 4; $\eta_{\mathrm{d}}^{\mathrm{m}}$ is the value of the total efficiency of the joints of the working equipment, which is 0,9 and is intended for connecting to the EMM housing with a number that is expressed as a number m and is 2. The results of calculations according to (6) are summarized in Table 3.

Given that for components 2 and 3 the input power N_j^{eic} and their internal state $\eta^{\mathrm{c2\text{-}3}}$ are known, the output power for these components will be determined by the formula N_j^{pwpb}

$$N_j^{\mathrm{pwpb}} = N_j^{\mathrm{ice}} \cdot \eta^{\mathrm{c2\text{-}3}} = (G_j^{\mathrm{fc}} \cdot I^{\mathrm{cvf}} \cdot \eta_j^{\mathrm{ice}} \cdot \eta^{\mathrm{c2\text{-}3}}) / 3600 . \tag{7}$$

The results of calculations according to (7) are summarized in Table 3. The use of this technique made it possible to determine the overall efficiency of component 4, i.e., the workflow that occurs as an energy consumer 4 during the operation of the bulldozer and when the input N_j^{pwpb} and N_j^{cp} output capacities are set, is determined by the formula η_j^{p4}

$$\eta_j^{\mathrm{p4}} = N_j^{\mathrm{cp}} / N_j^{\mathrm{pwpb}} = (P_j^{\mathrm{b}} \cdot R^{\mathrm{srsc}}) / (N_j^{\mathrm{ice}} \cdot \eta^{\mathrm{c2\text{-}3}} \cdot 3600) . \tag{8}$$

The results of calculations according to (8) are summarized in Table 3. The results obtained for determining the overall efficiency of the workflow, as a component of the bulldozer system, is a value in the range of 5–6 %.

At the same time, the overall efficiency of the bulldozer as a whole system, which is shown in Table 2 is 1,1 – 1,38 %. The reason for the rapid decrease in the overall efficiency of the bulldozer relative to their components largely depends on the method of their connection, in this case, a mixed compound is used in the bulldozer.

Overall efficiency of components 2, 3 and 4 as an integral structure of the bulldozer – energy consumer. Energy consumers in components 2, 3 and 4 create a complete structure of the bulldozer in the dynamic, i.e.

operating mode, as shown in Fig. 1. The input parameter for the energy consumer, according to Fig. 1, is power N_j^{ice}, and the output parameter is useful power N_j^{cp}, which is determined in terms of components P_j^{b} and R^{srsc}, according to Table 1. The efficiency of components 2, 3 and 4 as a complete structure of the bulldozer is calculated by the formula $\eta_j^{\text{c2-3-4}}$

$$\eta_j^{\text{c2-3-4}} = N_j^{\text{cp}} / N_j^{\text{ice}} = (P_j^{\text{b}} \cdot R^{\text{srsc}})/(N_j^{\text{ice}} \cdot 3600)\,. \tag{9}$$

The results of calculations according to (9) are summarized in Table 3.

The analysis of the obtained results according to (9), which are summarized in Table 3, suggests a conclusion on the efficiency of functioning in the operating conditions of one of the energy consumers, as an independent structural component of a range of bulldozers.

Overall efficiency of bulldozer components 1, 2 and 3. Components 1, 2 and 3 form the structure of the bulldozer, which can be represented conditionally in the static mode, i.e., as a bulldozer that does not perform useful work. Using this technique the value of their overall efficiency can be determined by the formula $\eta_j^{\text{i1-2-3}}$

$$\eta_j^{\text{i1-2-3}} = \eta_j^{\text{ice}} \cdot \eta^{\text{c2-3}}\,. \tag{10}$$

The results of calculations according to (10) are summarized in Table 3. Using all the components of the bulldozer efficiency in numerical values, according to Fig. 1, it is possible to determine in various interpretations the value of the overall efficiency of the bulldozer as a whole, according to the formula $\eta_j^{\text{obe}'}$

$$\eta_j^{\text{obe}'} = \eta_j^{\text{ice}} \cdot \eta^{\text{ñ2-3}} \cdot \eta_j^{\text{p4}} = \eta_j^{\text{ice}} \cdot \eta_j^{\text{c2-3-4}} = \eta_j^{\text{i1-2-3}} \cdot \eta_j^{\text{p4}}\,. \tag{11}$$

The results of calculations according to (11) are summarized in Table 3. Provided that equality is observed $\eta_j^{\text{obe}'} = \eta_j^{\text{obe}}$, then the calculations of all components of efficiency for bulldozers are performed correctly.

TABLE 3. Determination from the efficiency in the components in the structure of the energy consumer for the same type of traction bulldozers (30–350 kN)

Calculation parameters	**Brand of the bulldozer (traction class),** T_j, kN				
	1. DZ-42, (30 kN)	**2. DZ-19, (100 kN)**	**3. DZ-24C, (150 kN)**	**4. DZ-34C, (250 kN)**	**5. DZ-68, (350 kN)**
1. Efficiency energy source, η_j^{ice}, f. (5)	0,428	0,452	0,452	0,479	0,452
2. Efficiency components 2 and 3, $\eta^{\text{c2-3}}$, f. (6)			0,481		
3. Efficiency workflow, η_j^{p4}, f. (8)	0,054	0,056	0,057	0,06	0,049
4. Efficiency all energy consumer, $\eta_j^{\text{c2-3-4}}$, f. (9)	0,026	0,027	0,027	0,029	0,024
5. Efficiency components 1, 2, 3, $\eta_j^{\text{i1-2-3}}$, f. (10)	0,205	0,217	0,217	0,23	0,217
6. Efficiency bulldozer, $\eta_j^{\text{obe}'}$, f. (11)	0,011	0,012	0,012	0,0138	0,0107

The results of the calculations summarized in Table 3 allow us to determine the bulldozer that is most effective under operating conditions, in particular, such bulldozer is DZ-34C. According to the calculation for this bulldozer, the efficiency value is η_j^{obe} = 0,0138.

For the convenience of calculations, we will accept the condition that the volume of soil moved by each bulldozer will be 275 m³, i.e. V = 275 m³. This volume of soil was chosen because it is moved by a bulldozer with maximum efficiency in just one hour of operation, that is, P_4^{b} = 275 m³/hr. The fuel consumption for this bulldozer is G_4^{fc} = 41,774 kg/hr. The duration of performing a given amount of work by each bulldozer is determined by the formula, t_j, hour

$$t_j = V / P_j^{\mathrm{b}}, \tag{12}$$

where P_j^{b} is the performance of each of the bulldozers, according to Table 1 and Table 4.

The total fuel consumption of each of the bulldozers when they perform the same amount of work with the DZ-34C bulldozer, as the most efficient, can be determined as follows by the formula, Q_j^{b}, kg

$$Q_j^{\mathrm{b}} = t_j \cdot G_j^{\mathrm{fc}}, \tag{13}$$

where G_j^{fc} is fuel consumption of each bulldozer, according to Table 2 and Table 4.

For the DZ-34C bulldozer, the fuel consumption according to (13) is Q_4^{b} = 41.774 kg. Then, the excess fuel consumption of each bulldozer from the known range in comparison with the fuel consumption for the DZ-34C bulldozer will be determined according to the dependence Δq_j, kg

$$\Delta q_j = Q_j^{\mathrm{b}} - Q_4^{\mathrm{b}}. \tag{14}$$

The results of calculations according to formulas (12), (13) and (14) are summarized in Table 4. The value of the specific capacity of a bulldozer per unit of fuel consumption per hour of operation is determined by the formula, k_j, m^3/kg

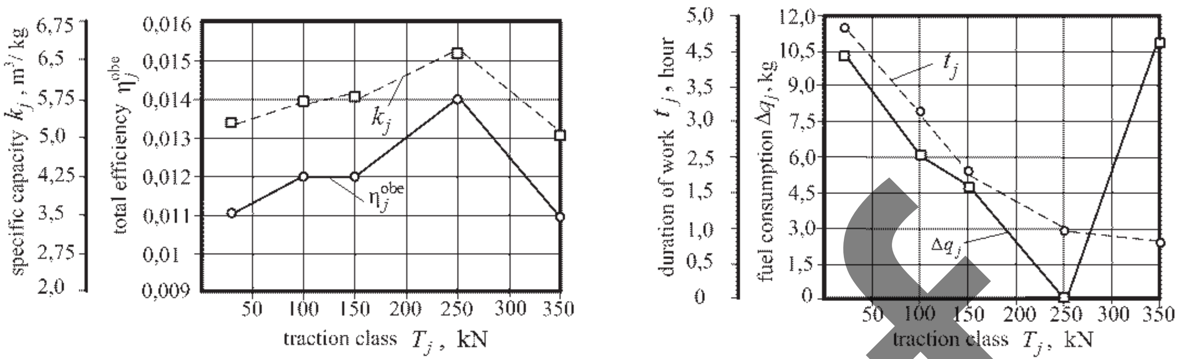
$$k_j = P_j^{\mathrm{b}} / G_j^{\mathrm{fc}}. \tag{15}$$

The results of calculations according to (15) are summarized in Table 4. A visual representation of the change in the overall efficiency η_j^{obe} of bulldozers (Table 2) and specific productivity per unit of fuel consumption k_j depending on the traction class of bulldozers (Table 4) is shown in Fig. 2 (a).

TABLE 4. The results of using the methodology for determining the effective design of earth-moving machines, on the example of bulldozers, from the array of traction class (30–350 kN)

Calculation parameters	**Brand of the bulldozer (traction class), T_j, kN**				
	1. DZ-42, (30 kN)	**2. DZ-19, (100 kN)**	**3. DZ-24C, (150 kN)**	**4. DZ-34C, (250 kN)**	**5. DZ-68, (350 kN)**
1. Bulldozer performance (average), P_j^{b}, m^3/hr,	50-65 (57,5)	80-90 (85,0)	120-160 (140,0)	250-300 (275.0)	300-400 (350.0)
2. Fuel consumption when cutting the soil, G_j^{fc}, kg/hr,	10,876	14,814	24,005	41,774	68,585
3. Time to perform work with a volume of 275 m^3 of soil, t_j, hour, (12)	4,78	3,23	1,96	1	0,78
4. Total fuel consumption of each bulldozer, Q_j^{b}, kg, (13)	52,096	47,928	47,153	41,774	53,888
5. Excess fuel consumption relative bulldozer DZ-34C, Δq_j, kg, (14)	10,242	6,154	5,379	0	12,114
6. Specific productivity per unit of fuel consumption, k_j m^3/kg, (15)	5,286	5,737	5,832	6,583	4,957

The results of time spent t_j and fuel overspending Δq_j compared with the operation of the DZ-34C bulldozer are shown in Fig. 2 (b).



(a) (b)

FIGURE 2. Results of researches of bulldozers of a traction class (30 – 350) kN

The results of the studies shown in Fig. 2, in comparison with the data from Table 4, clearly confirm that among the range of similar bulldozers there is one with the maximum value of overall efficiency η_j^{obe} and maximum productivity per unit of fuel consumption k_j, which is the DZ-34C bulldozer. Minimal fuel overruns, according to Fig. 2, are also typical for the DZ-34C bulldozer.

Knowledge of the efficiency of the components of a bulldozer in designing its individual structures based on the results of design and manufacturing, their values are taken, in particular, η_h, η_{hs}, η_c^n, η_t, η_{tr} and η_d^m. Studies at the systemic level allowed us to determine the efficiency of the main components of the bulldozer, in particular, such as η_j^{obe}, η_j^{ice}, $\eta^{c2\text{-}3}$, η_j^{p4}, $\eta_j^{i1\text{-}2\text{-}3}$ and $\eta_j^{c2\text{-}3\text{-}4}$. The obtained results of the study allow us to perform work not only to increase their overall efficiency, but also to determine on the basis of diagnostics and maintain their condition in the operating conditions of bulldozers on the basis of eliminating failures by monitoring the efficiency value [13, 14 and 15]. Summarizing the obtained data, we can state that detachments of various machines grouped can be formed to perform a given amount of work with minimal fuel consumption. This suggests that such a problem can be solved in the future.

THE RESULTS OF THE CALCULATION AND THEIR DISCUSSION

The essence of the developed methodology is determining the ratio between the output and input capacities for each EMM is characterized by the value of the overall efficiency and comparing the obtained values with each other and identifying the largest of them. Moreover, the higher the efficiency value, the greater the amount of products produced per unit of fuel consumption, according to the results given in Table 4 and Fig. 2 (a). The excess fuel consumption of each bulldozer when performing work with a volume of 275 m^3, in comparison with the DZ-34C bulldozer, is from 5,3 to 12,1 kg. At the same time, the time required to perform the specified amount of work by bulldozers is from 4,78 to 0,78 hours. For the DZ-34C bulldozer, this duration is 1 hour of operation. The results of such studies are presented in Table 4 and Fig. 2 (b). Based on the results of the study according to the results given on Fig. 2 (a), it can be concluded that the criterion for evaluating the effectiveness of bulldozers can be not only efficiency, but also a criterion k_j.

CONCLUSIONS

This methodology makes it possible to determine the efficiency for each of the structures of the bulldozer separately, in particular, for the energy source and all its energy consumers and the bulldozer as a whole. For the first time, the total efficiency value for the EMM workflow is determined. Comparing the product of the efficiency of individual structures with the value of the overall efficiency of the bulldozer allows us to draw conclusions about the validity of the calculations performed. Using this approach, based on the proposed methodology, it becomes possible, for example, for motor graders, excavators, scrapers and other machines to determine the value of their efficiency and select one of the most effective in terms of efficiency from the EMM range, using reference information.

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The Practice of Reconstruction, Modernization and Improvement of Five-story Residential Buildings

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Abstract. The article analyzes the issues of modernization, rebuilding, reconstruction and restoration of five-storied residential buildings in Ukraine and in European countries. The reason for four and five-storied buildings construction development was fast resident rehousing providing them with minimal detached apartments and improving their housing conditions.

The article considers large-scale residential development during the postwar period in Ukraine and in the foreign cities such as Vienna and Salzburg in Austria, Paris in France, Moscow in Russia, the city of Prague and Stodulki in Czechoslovakia, Frankfurt an der Oder and all of East Germany. But in the course of time, the five-storied residential buildings have become obsolete because the life quality of urban residents and the environment has improved, and attention has been given to recreation organization. In this regard, there is an urgent need to reconstruct and modernize five-storied residential buildings in all European countries, including Ukraine. Thus, based on the system of quality-of-life indicators developed by the UN, which is widely used in the modern world community and includes 12 main groups of indicators, it can be emphasized that the fourth place of these indicators is housing conditions.

The article reflects what changes in space- planning and design decisions have taken place in five-storied residential buildings abroad, strategies and methods, technological solutions for building reconstruction, rebuilding and modernization were considered and analyzed.

It was investigated the technology of a five-storied residential building attic floor arranging 21 Marshala Zhukova Ave Kharkiv , with the use of modern light, non-combustible materials that reduce the duration of construction and installation works, insulate the house, replace window openings with a new window blocks. This has led to increasing of living comfort of Kharkiv citizens.

INTRODUCTION

Experiments with typical neighborhood housing development began in many European countries before World War II. The process was started in France, and after the war it continued around the world. The reason for the development of construction was the same in all countries: it was necessary to rehouse residents fast. There was no money and resources for an individual approach in the postwar world, so the way out seemed logical – "the conveyor belt".

Vienna was also one of the first cities in Europe that developed large-scale construction. At the beginning of the 20th century, the population of Vienna was 2 million that is up 150,000 more from now. By European standards the huge capital needed large new buildings, so 4 to 6 storied residential buildings were constructed actively in Vienna. Initially, this was necessary to provide cheap housing for the working class. But during World War II, Vienna was heavy damaged. 20% of the housing was destroyed, 87,000 houses were uninhabitable, and neighborhood development was built on a large scale in the 1950s and lasted until the 1980s. There are still whole squares of 4- and 9-storied prefab flat blocks (Figure 1), which almost were all reconstructed.

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Reconstruction of a residential building includes rebuilding, which is associated with a change in its dimensions (superstructure) or position (movement, lifting of buildings), as well as a change of purpose.

Viennese four-storied buildings were built without elevators. Five-storied buildings are not built here because it is assumed that a person without an elevator can only go up for 4th floor, and an elevator is already needed for the fifth floor [1].

FIGURE 1. Four-storied building (prefab flat block) in Vienna. Photo by Yuri Gayevoy

At the same time, the entrance doors are transparent, house intercoms with the names of the residents, the entrance to the building is the entrance on the same level with the elevator at the entrance, which is a completely barrier-free environment (Figure 2).

However, from a modern standpoint, such housing does not meet modern requirements. As a result, there has been a lively debate in the European Economic Community recently and many practical steps have been taken to overcome this [2, 3].

a) b)

FIGURE 2. Example of doorway layout a) outside; b) elevator at the entrance. Photo by Yuri Gayevoy

In the 60s of the last century, this type of buildings looked innovative and promising. Nowadays, in the Josefiau district, near the center of Salzburg, many houses have been completed with elevators. Greenery very well masks the lack of architectural diversity, even without leaves - there are different types of plants and their combinations, diversity smooths over the appearance of houses. Green yards have been preserved here, lawns for parking or playgrounds have not been cut.

As for Prague, almost 500,000 people live in prefab flat blocks throughout the Czech capital. The territory where the five-storied buildings of the old housing are located is a historically known area - Stodulki (Prague 13 district). The South-Western city was originally designed by the architect Ivo Oberstein, but in the process of territory housing development his project was connected with the projects of other architects (Figure 3).

Significant changes took place with the “Khrushchevs” in the Czech Republic.

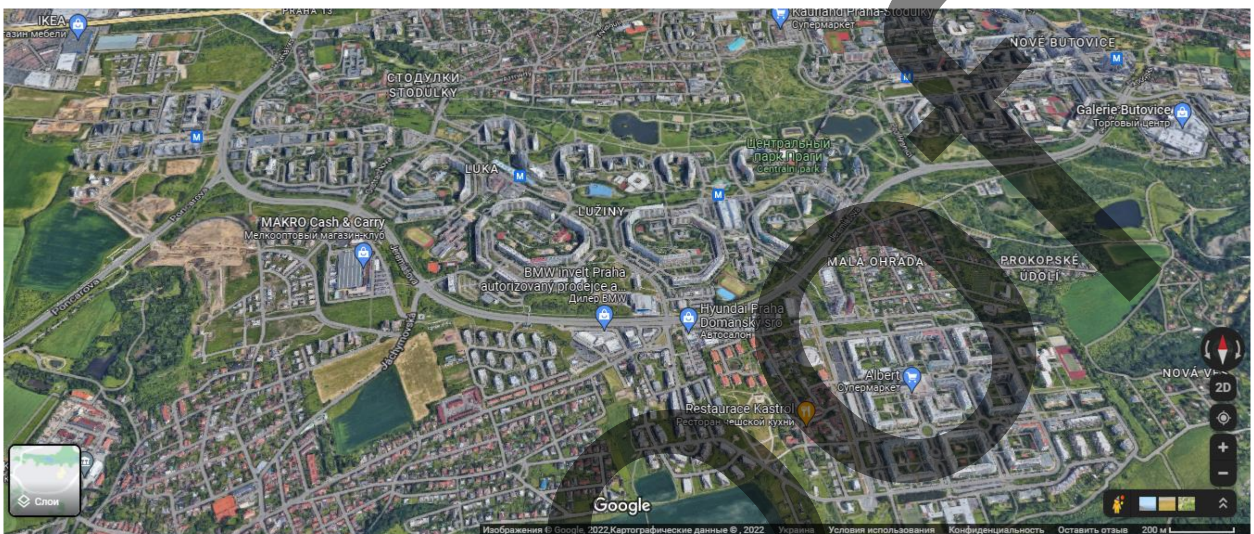

FIGURE 3. Stodulki in Prague [4]

There is also other experience of post-socialist reconstruction of housing and social sphere in Eastern Europe [5, 6]. The UN system of living standards, which includes 12 main groups of indicators, is widely used in the modern world community. At the same time in the fourth place of these indicators are living conditions. The Prague Local Authorities managed to accumulate money from regional budgets, the EU and apartment owners in these buildings, due to which a large-scale reconstruction of the housing stock began. In addition, in the late 90's the houses were bought by companies that completely transformed them into modern and comfortable housing.

As part of the reconstruction, the planning was changed, major repairs were carried out, windows were replaced, modern elevators were installed, and the facades of buildings were insulated with heat-insulating plates, followed by decorative and protective finishing.

As a result, the old five-storied residential buildings, in their classic form, in the country are almost gone. In the past gloomy areas have been painted in bright colors and have become much more attractive to buyers, and have become more comfortable and cozy for their residents. At the same time, after the end of the modernization program, not only the demand for such housing has grown, but also its prices. Former buildings are now part of the segment of medium and sometimes even luxury housing.

In Germany, about 43% of all residents live in rented housing, and in Berlin this figure is all 80%. However, the presence of efficient owners of multistoried buildings in the form of management companies led to the fact that in East Germany was reconstructed almost 2.2 million apartments in prefabricated houses, i.e. more than 20 thousand houses, and this was done without resettlement.

Thanks to numerous social support programs, all residents were provided with housing.

It turned out that the reconstruction is much cheaper than building new houses. In East Germany, according to average estimates, the cost of reconstruction of "Khrushchev" is up to 30% of the working cost of new housing.

During the reconstruction of residential buildings in Germany, were carried out such measures as replacement of the roof covering; technical floor insulation; facades warming with building decorative designing; windows replacement with problem solution of ventilation and recuperation; underground floor floorings insulation with their rehabilitation; balconies rehabilitation; rehabilitation of entrances; installation of an elevator in the outer part of the building (in the absence of an elevator); replacement of utilities in the building; replacement of radiators with installation of thermostats and heat meters; arrangement of a horizontal scheme of heat supply to the apartment; installation of apartment water consumption meters; arrangement of a heating unit in the underground floor of the building and collective meters of gas and water consumption; arrangement of the adjacent territory. You can get acquainted with the results of the reconstruction works carried out by viewing the photographs of Haus 07 [7].

In such a way, the Germans proved that there are no technical or economic harassments to ensuring compliance with the operation of prefab flat blocks houses such as "Khrushchev" even to such high requirements as energy efficiency in the European Union.

The comfort of living and architectural appearance, according to European experts, in these houses is provided at the level of modern requirements.

Reconstruction experience of housing according to German technology is in Moscow. Modernization works of five-storied buildings were carried out in 2004. The technical results achieved were similar to the results obtained in East Germany. And most important, that the cost value of rehabilitation was twice lower than the costs that would have to be incurred during rehousing of residents to newly built buildings.

After inefficient East German enterprises closing, many citizens lost their jobs and eventually moved to the West, often simply abandoning apartments in depressed cities. For example, in Frankfurt-on-Oder, a fifth of all apartments in the city were emptied.

Nowadays for financially backed citizens more interesting housing options have become available. Thus, the partial dismantling of the upper floors in five-storied buildings was a decision to create modern architecture and increase the comfort of living, and an additional factor was the involvement of leaseholders in the modernized "Khrushchev".

Currently, it is popular an extension of the external elevator shaft to existing buildings, the replanting of which does not imply the placement of the elevator inside the building. Graphic materials on this topic can be found in article "How the Germans in Germany modernize the panel "Khrushchev" of the 60-70s" [8].

Glazing opens the mechanism of lift shaft with all the features of the metal structure. It would be suitable for a modern high blocks, but in house front built in the Soviet period such an elevator fits with difficulty. However, apart from the simplest case where the lift shaft is outside the building, there are several other variants.

More radical changes in the modernization of many entrance five-storied buildings, was that they were reduced to 3 floors and dismantled the segment in the middle, making from one building two, repainted facades from gray to more optimistic colors. A striking example of such a solution is Haus 4 [9].

The first "Khrushchevs" were four-storied, which now can be found in many cities of the former Soviet republics. Less well known are examples of six-storied buildings that can be found in hilly cities.

With uneven urban ground, such houses were built on the slopes as a result there were five floors near the house on the higher side, and six on the lower side. In this case, the lower floor is called the basement, or semi-basement: often there were only two apartments, and the windows faced on one side. Thus, the obligatory norm about five ground levels remained - residents of the bottom floor of the six-storied building didn't rise but went downstairs to get to their platform. There were no elevators or sewers in the most common series of five-storied buildings. Elevator "glass» was developed and built in the sixties. Now elevators are added to the "Khrushchev" in a case of complete reconstruction of the building [10, 11].

German buildings modernization method is more acceptable "Khrushchev" problem has been studied there for a long time. Five-storied residential buildings are not demolished there, but modernized, reconstructed and made suitable for further living.

This way of reconstruction was tried in Kyiv: after residents resettle, the builders proceeded to "rehabilitate" the building [12]. Different approaches to the reconstruction process were considered [13].

The issue of "Khrushchev" modernization is more relevant from year to year. The main discussions revolve around two main approaches: demolition or reconstruction, but each approach causes a lot of controversy, especially in the Ukrainian reality: with fears for their homes, legal paradoxes and not the simplest relationship between the city, developers and citizens [2, 14].

This method was also chosen in Kharkiv, but the reconstruction was carried out without residents resettle. An experimental pilot project for the reconstruction of a five-storied residential building at 21 Marshala Zhukova Ave. in Kharkiv is the first such project in Ukraine. The functions of the customer for the design and execution of works were entrusted to the Department of Construction, Repair and Reconstruction of the city. The general contractor for the design is Wagner-System-Ukraine LLC. General contractor - JSC "Zhytlobud-1".

The installation of attic floors is the simplest and most effective solution for the mass series buildings reconstruction. Modern technologies allow performing this type of work with the use of methods of maximum safety of work, limiting the weight of structures, parts, reducing the complexity and duration of work (Figure 4) [15, 16].

FIGURE 4. Five-storied residential building at Marshala Zhukova Ave Kharkiv. Photo by Tatiana Karzhynerova

The reconstruction project provided partial replacement of water supply, sewerage, heat, electricity, telephone lines, all sanitary engineering systems with installation of heat meters, meters for hot and cold water supply, reconstruction of house entrances with extension of household premises, installation of loggias for first floor and existing loggias glassing , insulation of building external walls and reconstruction of the facade, superstructure of the sixth floor with 12 comfortable apartments: 2 one-rooms, 2 two-rooms and 8 three-rooms with two balconies - loggias and with total area of 1175 m^2 meters with installation of counters.

"Zhitlobud-1" made an interesting proposal during the installation of the attic: the superstructure of the floors should be made of light enclosing structures with a steel frame and floors of small reinforced concrete slabs on metal beams [14].

The walls were built of foam concrete blocks, interior partitions of plasterboard. The ceiling of the attic apartments is partially sloping and is a very interesting design element, which gives the attic a special personality and turns it into a full-fledged living room [10].

Weight of structures is the main issue for designers and builders during reconstruction a residential building with the construction of an attic floor. Currently, the buildings in operation are significantly worn out, so it is very important not to overload existing structures when adding floors. That is why only light and non-combustible materials that meet all sanitary norms are used in the reconstruction: frame made of ferrous metal, frame made of thin-walled galvanized profiles, wood frame and glued laminated timber frame (Figure 5) [14, 17].

FIGURE 5. Erection of a high-quality bar sections framework over an additional floor. Photo by Tatiana Karzhynerova

The superstructure of attic floors is a complex task that includes technical, economic and other issues, requires consideration of a set of organizational and technological solutions. Detail surveying, comparing alternative engineering methods of construction works, as well as taking into account all social aspects are necessary during building reconstruction.

Structural elements that assembled by hand, products of full or partial factory readiness were used for the construction of attics. As more environmentally friendly wood materials and structural timbers, metal structures suitable for installation works were used for roofing systems [18]. Mineral wool was used as insulation that must meet the third category of fire resistance and safety.

Roof trusses and load-bearing structures were assembled on site from prefabricated elements, which allow the frame to be delivered to the top with minimal use of lifting mechanisms (Figure 6).

FIGURE 6. Roof trusses and load-bearing structures of building attic erection. Photo by Tatiana Karzhynerova

During the modernization of a five-storied building in Kharkiv rise of building materials was carried out from a construction site adjacent to the end of the building with the help of a winch and a roof crane - Pioneer lift.

Canopies over each entrance, and fences around the building were provided as an additional security measure. The frame of the attic is a prefabricated load-bearing beams and racks, which was made of high-grade metal. The roof elements are cold-drawn galvanized profiles, and wooden structures. All of them are made in the factory and have undergone the necessary fire and antiseptic treatment.

A reinforced concrete belt with fasteners was installed around the perimeter of the building to reinforced and strengthen the existing supporting structures. For fastening of roofing materials battens were settled down on a roofing structure. Roofs, partitions, ceilings and gables were main attic elements, which were insulated (Figure 7).

FIGURE 7. Execution of the construction and assembly works during the modification of a five-storied residential building at 21 Marshala Zhukova Avenue. Photo by Tatiana Karzhynerova

Building architectural forms and design, appearance of the building have been changed and improved as a result of construction and installation works.

All works on reconstruction and modernization of the five-storied building were performed in accordance with the developed design documentation in order to ensure the load-bearing capacity of the erected structure, operational reliability, durability of the building as a whole and comfortable living (Figure 8).

FIGURE 8. Modernized five-storied residential building. Photo by Tatiana Karzhynerova

Following offers are offered as a result of the analysis of existing technological decisions:

1. Criteria of offered optimal solutions should be considered during designing;
2. to use innovative technology of narrow-focused buildings attic superstructure with a flat roof and with expansion of bulk by bay reinforcement and pulling devices;
3. to apply rational technology of a superstructure of an attic with a flat roof without expansion of the case which is made by means of the roof crane;
4. to use the latest technology of superstructure of an additional floor with a sloping roof by assembly designer and the cable crane;
5. to apply the expedient technology that allows execute the works without resettlement of inhabitants at superstructure of attic floors on the block - conveyor way.

Great financial attractiveness of such projects for investors, builders and benefits for residents shows the modernization and reconstruction practice analysis of a five-storied building in Kharkiv with the addition of an attic.

CONCLUSION

Reconstruction of old building is a more rational solution than buildings dismasting and new building construction because:

1. Requires much lower costs, using existing structures and utilities.
2. Lifting equipment shouldn't be used.
3. House service life is extended for 30 years.
4. Significant energy savings are achieved due to insulation.
5. There is a decrease in operating costs for roof repair and facades reconstruction.
6. Reconstruction of a building with a superstructure recoups the cost of insulation for 5 years.
7. The procedure for carrying out work on the superstructure of the attic allows to avoid leakage during operation.
8. The use of innovative technologies allows first mounting the attic and then dismantling the roofing without relocating residents.

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Experimental Laboratory Tests of Piles with a Polymer Casing under the Action of Additional Loading Friction Forces from Soil Subsidence

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Abstract. Using two variants of modeling the process of soil subsidence, the results of experimental laboratory studies of cylindrical and tapered piles have been obtained in the form of the graphs of dependences of deformations S and their intensities I on the values of relative subsidence ε and pressure P. The advisability of using tapered piles with a polymer casing to reduce the additional loading friction forces in structurally unstable soils has been substantiated.

INTRODUCTION

The geotechnical conditions of many construction sites under development, especially in dense urban areas, require the use of piles as the most economical design solution for the foundations of buildings and structures due to the presence of weak, noncompacted fill-up or subsidence soils. In this case, the bearing capacity of a pile is determined by the work of the soil under its lower end and on a limited portion of the lower part of the lateral surface, which is located within the reliable base soils.

The peculiarity of interaction between piles and soil masses consisting in the upper part of unreliable soils is associated with the emergence of negative friction forces due to the development of additional deformations of the soil cut through by the piles, which occur under the influence of various factors, the main of which, other than the force ones, is additional soil moistening [1, 2].

The development of technical solutions that increase the effectiveness of pile foundations by reducing additional loading friction forces, as well as the creation of appropriate calculation methods is an important area of scientific research. To substantiate the effectiveness of the proposed technical solutions and of the relevant technological features of pile designs, it is advisable to conduct experimental laboratory studies, which would allow identifying and evaluating the effect of reducing additional loading friction forces generated by structurally unstable soils cut through by the piles.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The problems of the influence of additional loading friction forces of soil on the lateral surface of piles are the subject of many works by domestic and foreign researchers, in particular, Dalmatov B., Polishchuk A., Gotman A., Sokolov L., Samorodov O., Snisarenko V., Tabachnikov S., Paik Kyu-Ho, Manandhar S., Yasufuku N., Jinqi Wei, Hesham El Naggar M. and others. Moreover, the results of their in-situ experiments indicate the need to take into account the negative friction forces when designing pile foundations [3–8].

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Making design decisions with regard to the foundations of buildings and structures in structurally unstable soils requires the use of special approaches to the selection of the optimal design most often represented by the pile option that takes into account additional loading friction forces, which are generated due to the subsidence of the soil surrounding the pile and act on its lateral surface within the cut-through soil layer [9].

Requirements for the effectiveness of design solutions of pile foundations in the presence of structurally unstable soils determine the necessity of introducing new pile designs and piling technologies, among which should be noted composite piles [10], bored piles in elastic casing or with enlarged base [11], the use of antifriction coatings [12], etc.

The research papers by Samorodov O.V., Tabachnikov S.V., Naydenova V.E. [11, 13] are devoted to the results of experimental laboratory studies on the development of a method for determining the resistance forces of sandy soil acting on the lateral surface of a model pile at rest and the reduction of the influence of additional loading friction forces of soil acting on the lateral surface of bored piles in unstable soils.

PURPOSE OF THE STUDY

Experimentally, by recording the settlement deformations occurring during the modeling of soil subsidence, to study the effect of the shape of the pile shaft with a polymer casing on the reduction of the value of additional loading forces.

PRESENTATION OF THE MAIN MATERIAL

The interaction of the piles under study with the soil medium (Fig. 1) involves cutting through the upper part of the soil mass (5) by the pile shaft (3) with a polymer casing (2) and plunging the lower part of the pile (1) into the reliable soil (4). The cut-through part of the soil base (h_2) is assumed to consist of structurally unstable subsidence soils [14]. During the development of subsidence deformations in cut-through soils, additional loading forces occur on the lateral surface of the pile, which are perceived by the shaft, depending on the conditions of interaction between the soils and the lateral surface. Since the bearing capacity and settlement value of the pile are only due to the interaction of the lower part of the pile with reliable base soils (on the lateral surface and under the lower end), the additional settlement of the pile during subsidence of the cut-through soils depends on the value of the additional loading forces. Thus, the reduction of additional loading forces manifests itself as a decrease in the subsidence deformation of the pile.

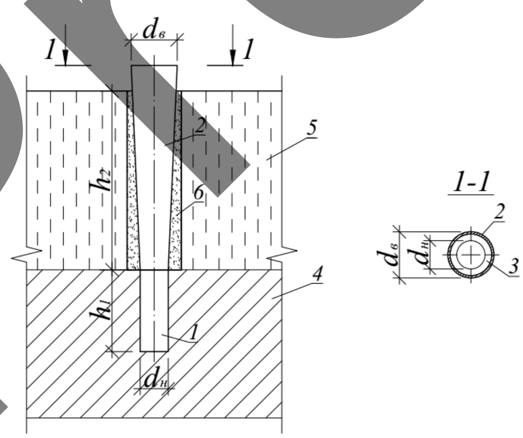

FIGURE 1. General view of a tapered pile with a shaft in a polymer casing: 1 – reinforced concrete pile; 2 – tapered polymer casing; 3 – pile shaft; 4 – bearing layer of soil; 5 – structurally unstable soil; 6 – sand

The study of the reduction of negative friction forces of the soil on the lateral surface of the pile by placing a part of the shaft in a tapered polymer casing was performed in two experimental setups (Fig. 2, 3), using scale models of a tapered pile (600 mm in length, with a diameter of 70 mm in the upper part and 40 mm in the lower part) and a cylindrical one (600 mm in length, 40 mm in diameter). Medium-coarse sand was used as a model soil medium.

A feature of the experimental setup shown in figure 2 is the possibility of applying vertical forces to the head of the model pile and the principle of modeling subsidence deformations due to the compression of the upper part of the soil mass with flange plates [15].

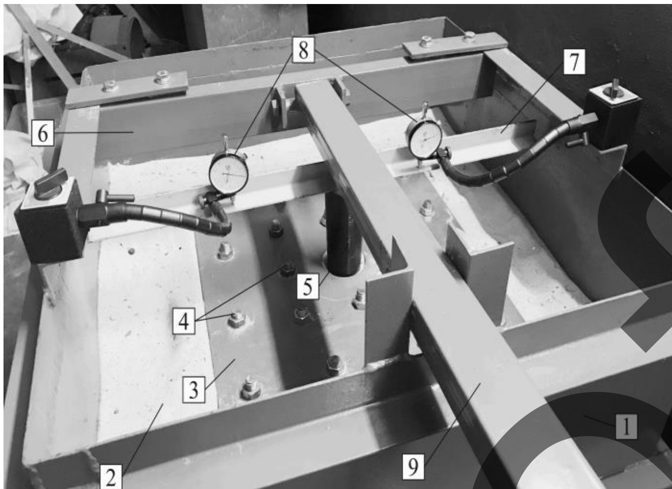

FIGURE 2. Photo of the laboratory setup during the first stage of the experiment: 1 – laboratory tray; 2 – soil medium; 3 – metal flange plate; 4 – studs; 5 – model pile with a polymer casing; 6 – support rail of the lever with a hinge; 7 – device for centering the pile load; 8 – indicators for measuring displacement; 9 – lever for loading the pile

The experimental setup shown in figure 3 provides for the application of a distributed load to the surface of the soil medium in the form of vertical pressure, the value of which at each stage of loading was monitored according to the readings of the oil station manometer. The upper part of the soil medium is represented by a mixture of sand and granulated polystyrene foam in a volume ratio of 6:1.

The vertical displacement of the model piles in the experiments was recorded using two dial indicators (Fig. 3, Fig. 4).

FIGURE 3. Photo of the laboratory setup during the second stage of the experiment: 1 – metal barrel; 2 – modeled soil medium; 3 – metal plate with a hole; 4 – metal beam attached to the pile; 5 – stands; 6 – rigid stamp; 7 – hydraulic jack; 8 – hinge; 9 – manual oil station with a manometer; 10 – displacement indicators

Based on the results of measurements of the pile settlement deformations depending on the magnitude of the soil medium subsidence deformations, after statistical processing of the data [16], characteristic graphs were obtained which are shown in Figures 4–7.

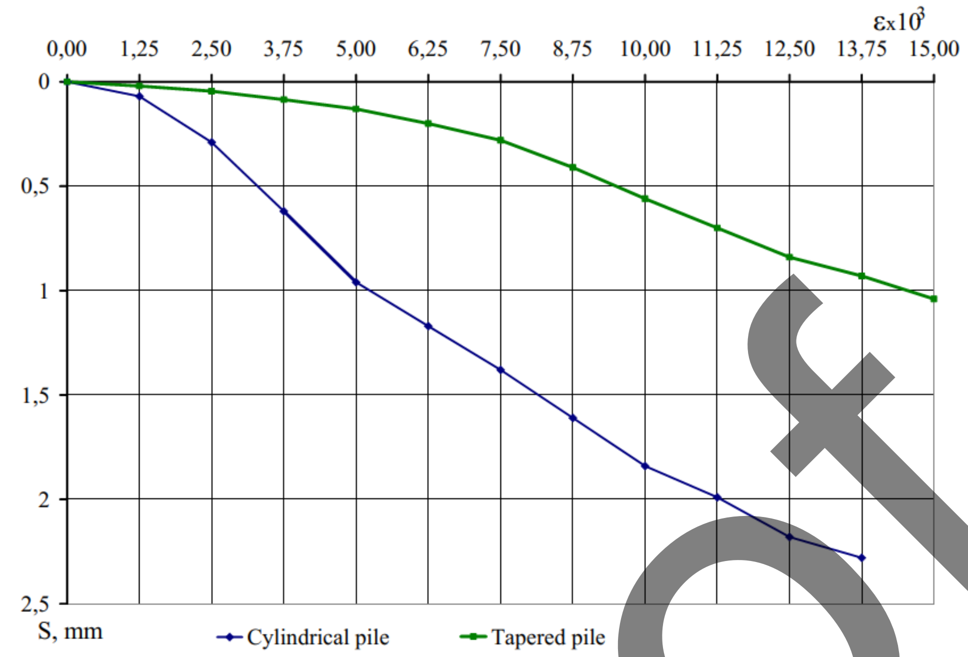

FIGURE 4. Graphs of the dependence of the development of deformations S on the value of relative subsidence ε when modeling subsidence of soil under its own weight

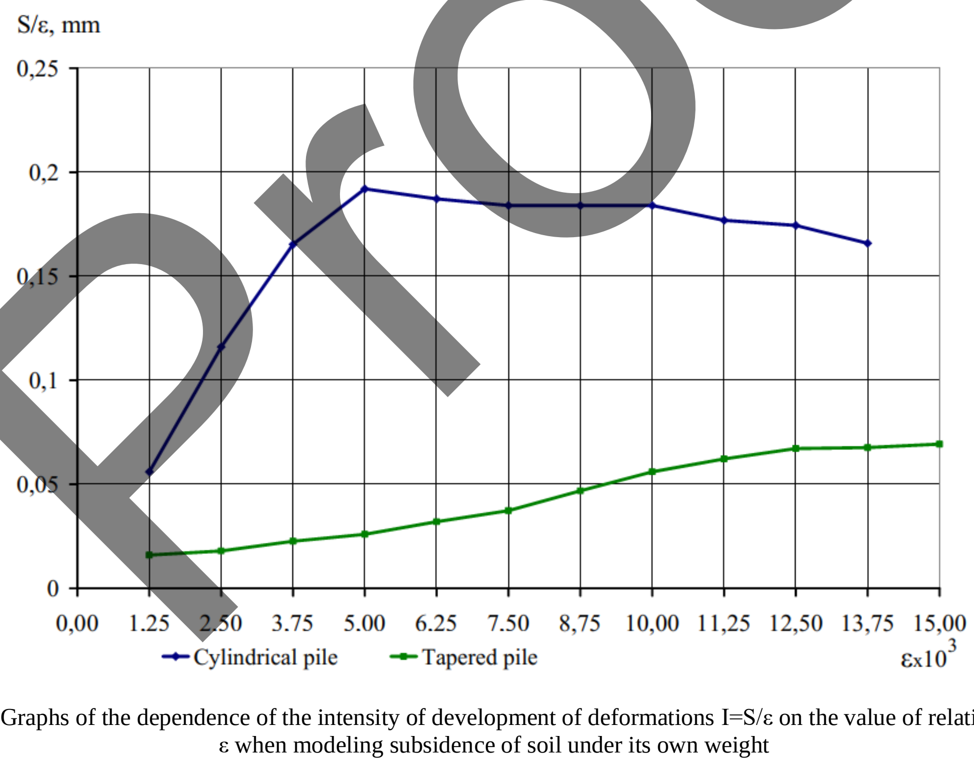

FIGURE 5. Graphs of the dependence of the intensity of development of deformations I=S/ε on the value of relative subsidence ε when modeling subsidence of soil under its own weight

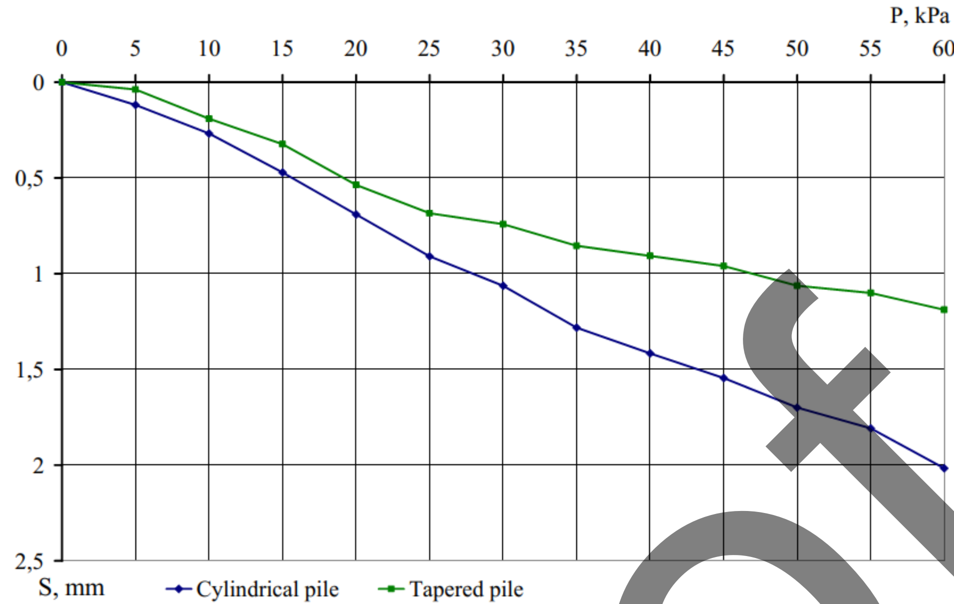

FIGURE 6. Graphs of the dependence of the development of deformations S on the value of pressure P when modeling subsidence of soil due to additional load on its surface

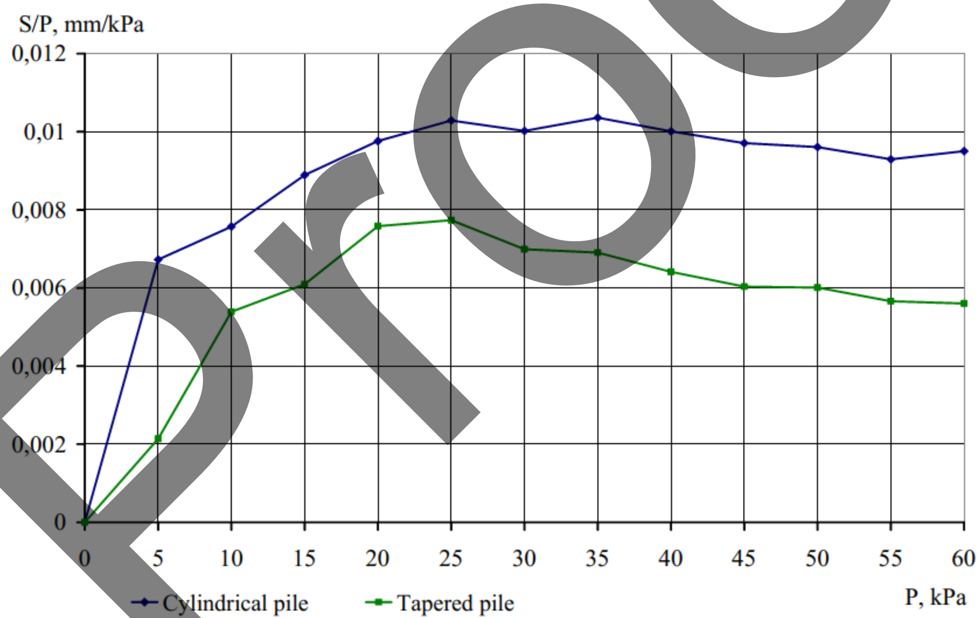

FIGURE 7. Graphs of the dependence of the intensity of development of deformations I=S/P on the value of pressure P when modeling subsidence of soil due to additional load on its surface

CONCLUSIONS

Analysis of the experimental data indicates a significant reduction of negative friction forces and the possibility of using the pile design solution under study when cutting through weak, structurally unstable soils.

Technological features of the pile design with the use of polymer casings, including tapered ones, allow not only reducing the coefficient of soil friction on the lateral surface of the pile due to polymer casings, but also managing the initial stress-strain state of the soil mass surrounding the pile, thereby achieving the greatest effectiveness in reducing the force effect of negative friction during the development of subsidence deformations.

One of the prospects for further research to be considered is the improvement of calculation methods that take into account the peculiarities of the pile installation technology with the use of polymer casings.

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Problems of Optimization of Innovative Solutions and Improvement of the Current Building Information System

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Abstract. Problems of strategy and tactics of European integration of innovative development of the construction complex of Ukraine have caused in modern conditions the need for structural adjustment with the transfer of crisis activities to a modern technical basis of development using BIM technology. Against the background of the achievements of European countries in the introduction of information technology in the construction industry, Ukraine has an urgent need to reform and modernize the construction industry, covering a huge range of tasks, ranging from creating a solid basis for decision-making in investment construction processes. In addition to that, cost analysis, improving the control of capital investments, improving the pricing system, ensuring the integration and interconnection of government services and information systems, etc. The new methodology of BIM provides for research to improve the analysis and evaluation of the effectiveness of production organization in design and construction from the standpoint of a system of models and methods of structural optimization in innovative development in the construction of Ukraine in difficult market conditions. For implementation in the construction industry of Ukraine, it is necessary to solve a number of problems of software and its regulatory framework at different stages of the life cycle.

INTRODUCTION

European and world experience in implementing the Building Information Modeling (BIM) involves combining national efforts in a common and coherent European approach to the development of the excellent digital construction sector. It should be noted that the adoption of EU Directive 2014/24 / EU has become an incentive for many European countries to put the issue of BIM technology on the agenda. As a result, EU member states have gradually embraced digital construction innovations, among which BIM technology has taken a leading position. The European BIM market was estimated at 1.8 billion euros in 2016, and the expected growth is 13%, reaching 2.1 billion euros in 2023. However, the ways and pace of implementation of BIM in European and other developed countries differ. Therefore, an important step is to study the successes and mistakes made by other states [6].

The information model of the building and the automated building management system in the complex are control, monitoring and optimization of functioning of engineering systems of the building for maintenance of optimum conditions with the minimum expenses. As a result, we receive:

- reducing the likelihood of emergencies;
- increase the level of comfort;
- saving energy and resources;
- increase of service life.

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In general, savings of up to 40% of operating costs, reducing the total cost of ownership of the building to 30% [2].

In Ukraine, the introduction of BIM-technologies at the state level was declared in 2019. Two sectoral conferences were held, a number of concepts were published, a “road map”. On February 17, 2021 the Cabinet of Ministers of Ukraine approved the Ministry of Regional Development of Ukraine (BIM-technologies) in Ukraine, as one of the key moments of digital transformation of the construction industry.

ANALYSIS OF BASIC RESEARCH AND PUBLICATIONS

Problems of strategy and tactics of European integration of innovative development of the construction complex of Ukraine have caused in modern conditions the need for structural adjustment with the transfer of crisis activities to a modern technical basis of development using BIM technology. The introduction of BIM technologies has caused some difficulties in many countries, whose construction industry is associated with many regulatory documents and requirements for technology and organization of work, but the success of the achievements lies in the thoughtful and purposeful implementation of public policy. Today in a number of developed countries (Great Britain, USA, Norway, Finland, etc.) technically complex state construction projects are carried out with the obligatory use of BIM technologies.

The Concept adopted in Ukraine identifies areas for further reform and modernization of the industry, covering a huge range of tasks, ranging from creating a solid basis for decision-making in investment and construction processes, the transition to life cycle management and cost analysis, improving capital investment control, improving pricing. , ensuring the integration and interconnection of public services and information systems, etc.

The main advantage and feature of design in programs that reflect BIM principles (for example, these programs include Autodesk Revit, All plan, Tekla Structures, Bentley Building Designer, MagiCad, Graph iSOFT Archicad and others), is that the structure it is necessary to virtually "build" specialists of different specialties. At the same time, it is necessary to adapt the management system, the effectiveness of which can be assessed by increasing the level of structuring of project documentation, quality while ensuring design deadlines and costs, assessing the final economic efficiency of construction options over the life cycle.

Analysis of the main problems that arose during the implementation of BIM-technologies in construction companies, the researchers identified the following: significant initial costs, expensive software and incorrect operation of software packages and lack of specialists in the field of VIM modeling. These problems are relevant today for Ukraine as well [6].

METHODS

Based on the achievements of European countries to conduct research on the problem of optimizing innovative solutions for the life cycle of the object in the current state of the information model of the building.

RESULTS

Building information modeling (BIM) is a technology for optimizing the processes of design, construction and operation of a building, which is based on the use of a single model and the exchange of information on any object between all participants, throughout the life cycle - from the owner and the architect's first sketches for the maintenance of the finished house.

BIM is a creative process of generating and using data about a building, its design, construction and operation during its full life cycle. The effects are due to: centralized data exchange, visual communication using three-dimensional objects, early analysis and recognition of options, the use of sustainable, interdisciplinary and interactive design, control during and on the construction site, regular updating of documentation (design changes during construction , as well as in the process of operation). In determining the economic efficiency at all stages of the project life cycle [1, 2].

The new methodology includes a study to improve the analysis and evaluation of the effectiveness of production organization in the design and construction from the standpoint of a system of models and methods of structural optimization in innovative development in the construction of Ukraine in difficult market conditions.

Dimensions of BIM–conditions for designating subsystems that characterize the degree of coverage of the model of different groups of control tasks:

- 2D-3D –visualization of the object;
- 4D –additional time parameters;
- 5D –additional cost;
- 6D – in addition to environmental friendliness (energy consumption, emissions, comfort);
- 7D – additional maintenance and operation management information prior to the occurrence of the reconstruction or liquidation project;
- 8D–additionally the final decision on the selection of the optimal option of a cost-effective version of the building project taking into account the life cycle of the object [3].

The main income and benefits to its owner the building brings during the period of operation, which stretches for many decades. The information model in this case allows for effective management, accounting of spent resources and payments, quality and timely maintenance, overhaul and emergency repairs, make the necessary adjustments to the configuration of the premises and do much more to ensure optimal use of the building.

The information model of the building and the automated building management system in the complex are control, monitoring and optimization of functioning of engineering systems of the building for maintenance of optimum conditions with the minimum expenses of energy and resources, increase of service life.

BIM 3D systems allow you to make a parametric description of geometric and material features that allow the use of the latest available technologies related to the production and processing of building elements. Systems "above" 4D–8D, include each 3D block, which allows you to include and take into account in the complex such parameters as time, cost, as well as other parameters aimed at sustainable development and management of the object. BIM 4D allows you to combine geometric and material information with time parameters, which help in planning and creating schedules that are related to the construction site.

In the case of BIM 5D, together with the parameters specific to BIM 4D, it is possible to determine the cost parameters from the estimated cost to the actual cost of the building at all stages of the life cycle. BIM 6D allows calculations of energy efficiency and energy consumption of the building, as well as complex calculations of the entire building (taking into account the location) and all its elements simultaneously. With the use of BIM 6D and 7D-8D, we additionally get the opportunity to collect and use a variety of information about the object in one central system, which allows you to assess the cost-effectiveness of innovative development in facility management [1, 2].

A building with low operating costs is cost effective. One of the ways to increase the economic efficiency of the building is the use of information modeling of buildings and automated building management system (BIM).

The Concept of BIM of Ukraine defines 13 principles, terms, problems that need to be solved, purpose and terms of implementation, methods of solving problems, impact forecast and key interests of stakeholders, expected results, cost items and sources of funding [1].

The concept provides for 4 phases of implementation of state policy regarding the implementation of BIM technology:

Phase one (2020-2022) - the beginning of the systematic use of BIM and providing legislative, regulatory, regulatory and technical justification.

Phase two (2023-2024) - development of BIM and mandatory use for individual facilities.

Phase three (2025-2030) - development of BIM and extension of mandatory use to "pilot projects" and operation of facilities.

Phase four (2030-2035) - full use of BIM in the implementation of construction projects.

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The information model of the building and the automated building management system in the complex are control, monitoring and optimization of functioning of engineering systems of the building for maintenance of optimum conditions with the minimum expenses of energy and resources, increase of service life [1].

Implementation of the requirements of EU Regulation 305/2019 in Ukraine, especially for buildings of impact class (responsibility) SS-3, based on the principles and mechanism of project life cycle management requires solving a number of problems and creating preconditions, according to the Concept of BIM implementation at public facilities. Design of the life cycle of objects, the management methodology of which in BIM must comply with the following principles [3, 7]:

- Focus on end-of-life cost indicators should be applied at all steps and levels of decision-making in the design process;
- The cost of the life cycle should include sufficiently complete losses in relation to the object;

- Analytical procedures and results should be compatible with the systems of accounting, reporting, financial planning and control, and these systems, if necessary, should be improved accordingly;

- Complete information support should be subordinated to the tasks of effective management.

These principles should be the basis for a combination of three models of the life cycle: design, construction, operation - from 1 stage of design to the appearance of the project of reconstruction or liquidation of the object.

• Improving cost rationing, pricing, object accounting and cost management, by eliminating shortcomings and reforming methodological approaches that are close to real time and cost indicators, to introduce the definition of cost and accounting along with the work on the structural elements and the object as a whole

• Management of maintenance and operation of facilities becomes a complex problem that must be solved for specific buildings and structures for the period of this period, the system of repairs of structural elements, methods of determining cost indicators and bringing them into a comparative form when evaluating efficiency over the life cycle.

• Information and software and hardware–creation and accumulation of databases of library elements and other information, as well as the creation of comprehensive software and hardware that covers all life cycle models is a guarantee of further successful operation of BIM.

• Organizational, financial, and personnel support is given special attention at the state level for the implementation of BIM [3, 7].

At the same time, the use of BIM software requires the improvement of the existing regulatory framework and the creation of a new one to predict its changes during the life cycle of the object (10-100 years):

- For the time from the appearance of the sketch project to the contractual term and cost at the beginning of construction.

- For the actual construction period and fixed assets at the time of delivery of the object to the customer.

- For the period of operation of the facility before the first overhaul, with an assessment of energy consumption and economic efficiency over the life cycle.

The use of BIM technology significantly increases the objectivity and reliability of design decisions, the probability of obtaining economic efficiency embedded in the project and get real design indicators during the construction and operation of the facility.

Analysis of short- and long-term dynamics indicates that the recovery in construction will be long, unstable and leads to new requirements for scientific research of economic problems in the industry. In overcoming the crisis, the leading role is given to state regulation, at the level of the construction organization to anti-crisis management, in order to timely diagnose, and find innovations for survival and development in the phases of recovery and prosperity.

In these conditions, the scientific problems of assessing the impact of organizational and economic risks in a crisis situation and possible innovations in the future on the quality, timing and cost of construction and operation of the building, to assess and select a cost-effective option.

The urgency of the problem became apparent in the analysis of the method and models of development of the project of construction organization (POB) and the project of operation of the future building (PFB), which is urgently needed by the subsystem D8 BIM. This is especially urgent for buildings of class (responsibility) CC-3, for which the time of scientific support and design in stage 3 reaches 2-3 years, examination, approval and construction up to 5 years, operation before reconstruction or liquidation up to 50-100 years. With such time parameters of the life cycle components, there is a problem of reaching the real market investor value at the time of delivery of the building and then the real operating costs over the years with access to funding sources and assessing the impact of these costs on choosing the best building in the early stages of design.

The general principle in the methodology of evaluating the effectiveness of any economic system is to compare the MAXIMUM EFFECT (benefits, results) and COSTS with the excess of the results over costs.

ECONOMIC OPTIMUM - the trajectory of development (in dynamics) or state (in statics) of the economic system, the best for its specific purposes in these conditions and at a specific time, under certain objective constraints.

Optimization - modification of the system to improve its EFFICIENCY under certain objective limitations.

In today's market conditions, most researchers in assessing cost-effectiveness and optimization, prefer the principle and indicator of the minimum payback period of PP investments and related indicators NPV, IRR:

NPV - maximum net discounted cash inflows for the investment cycle (T), UAH - cash flow model + CFt (Cash Flow), UAH;

RR - minimum payback period of capital investments (- CFt) - average or discounted, years;

IRR - internal rate of return on fixed assets for the investment cycle (T).

In a market economy, in determining these indicators, BIM technologies require taking into account the impact of features of architectural, construction, design, environmental solutions of the building over time, and changes in external market environment: cyclical development, pricing and inflation.

The methodology of strategic management of innovative projects in construction, for the future, the study is based on a systematic approach and the main characteristics inherent in the operation of the economic system - as a set of elements and relationships between them that form a certain integrity. Creating an information model can be divided into two stages:

• Development of primary design elements (building materials, finishing elements, etc.) that are directly related to the construction site, but are produced outside the construction site;

• Modeling of what is created on the construction site (foundation, columns, floors, walls, facades, roof and more).

BIM building information technology allows you to create a virtual model of a 3D building, but the important point is that the visualization of the object is closely related to the engineering calculations about it. Any changes are instantly displayed in 4D-8D views, drawings and sections.

The implementation of the BIM system in the design and construction process has undeniable advantages, as it allows instant access to any information about the object, control the quality of work at all stages, avoid collisions in the project, and significantly reduce construction costs. However, the main advantage of the introduction of BIM technology in construction is the ability to achieve almost complete compliance with the characteristics of the future object to customer requirements [3].

The formation of the BIM–3D project model today is associated with the software of the architectural part of the project–Autodesk (Revit), All Plan Deutschland GmbH., Graph iSOFT (Archi CAD), Tekla Corporation, AutoCAD and others; structural part - LIRA-CAD, Monomakh, plumbing and electrical parts–Magi CAD for AutoCAD. These software packages are stand-alone products that are not connected to each other, have different owners, which greatly complicates the implementation of independent developers. A number of measures are proposed for exporting data and establishing feedback between these programs.

A number of software products operating in Ukraine remain detached from the 3D design model; this applies to the organization and management of construction (4D) - Microsoft Project, Primavera P6, Spider Project and others; estimated and contractual pricing (5D) - "Construction technology. Estimate (Computer Logic Group), ABK-15, AC-4; a number of new programs on environmental protection, energy efficiency (6D), maintenance and operation of buildings (7D) and especially the lack of software to determine the economic option of the building for the life cycle (8D) [3].

Against the background of achievements in the EU on the introduction of BIM, technology in the construction industry of Ukraine should solve a number of problems of software and its regulatory framework at different stages of the life cycle.

1 Designing

Problem № 1: After completing the Revit 3D architectural model and structural calculations for the object, it is possible to obtain specifications of the need for work, material resources and their cost at the accepted prices for exporting data to the following programs to build a construction plan (POB) and calendar schedule (PVR). Where some of the researchers suggest on the basis of determining only the material consumption of the object to take the best option for future design, which covers up to 30% of life cycle costs and cannot be the final criterion for optimization [9].

Lack of software (templates, families) of construction technology of the object in accordance with the DBN - the choice of organizational and technological scheme of construction causes the problem of regulatory support. DBN A.3.1-5 regulates general requirements for the organization of construction production in Ukraine: 2016 "Organization of construction production" for all participants in construction, regardless of ownership and departmental affiliation.

In the context of Ukraine's transition to a market economy and the creation of an investment market, the circumstances and requirements for the implementation of investment projects related to new construction, expansion, reconstruction, technical re-equipment of facilities, enterprises, as well as completion and diversification of unfinished construction sites have changed.

The life cycle of investments is the basis for assessing their economic efficiency and covers the time from the emergence of the idea or plan of the project to its implementation and operation - the emergence of conditions for new investment.

The choice of organizational and technological schemes is made based on a variant choice of rational sequence of construction object construction with indication of sequence of works, substantiation of methods of performance of works, possibility of application of flow method of construction organization and models for optimum decisions in section "Project of construction organization" designing "PROJECT".

Comparative analysis shows that when constructing calendar schedules in the Project package to determine the duration of work, it is advisable to use data from maps of labor processes, taking into account the volume and front of work or process maps. In the absence of such data, you can use data on labor intensity with Resource element estimates with the entrance to the average expected labor intensity and the share of major and related works in full labor intensity. Based on the data on the duration of work, the number of crews, the start date of the project in Gantt mode in the Project package develops a calendar schedule of project implementation with the location of capital investment in accordance with the requirements of the POB.

Problem № 2: The need to improve budget rationing, pricing, object accounting and cost management, by eliminating shortcomings and reforming methodological approaches that are close to real time and cost indicators, to introduce the definition of cost and accounting along with the work on the structural elements and object as a whole.

Problem № 3: Management of maintenance and operation of facilities becomes the most difficult problem for designers, which should be solved for specific buildings and structures for the period of this period, the system of repairs of structural elements, methods of determining cost indicators and bringing them into a comparative form cycle [15].

Problem № 4: Information and software and hardware– creation and accumulation of databases of library elements and other information, as well as the creation of comprehensive software and hardware that covers all life cycle models is a guarantee of further successful operation of BIM.

2 Construction

At the stage of "Construction" before the BIM building developed by the designers there are problems that require changes and especially in Block 2 when conducting a tender for the selection of the general contractor, subcontractors, suppliers; concluding contracts and supply contracts, which include new calendar schedules (4D), contract prices (5D) and as a consequence of changes in determining the economic option of the building for the life cycle (8D).

The use of BIM software at the construction stage requires the improvement of the existing regulatory framework and the creation of a new one to predict its change during the life cycle of the object (10-100 years):

- for the time from the appearance of the sketch project to the contractual term and cost at the beginning of construction;
- for the actual term of construction and fixed assets at the time of delivery of the object to the customer;
- for the period of operation of the facility before the first overhaul, with an assessment of energy consumption and economic efficiency over the life cycle.

The project of performance of works (PVR) is developed by the general contracting construction and assembly organizations or the organizations which are carrying out these works. PVR can also be developed by specialized design organizations at the request of the developer or contractors. It is recommended to provide for the transfer of PVR to the construction site no later than two months before the construction of the relevant parts of the object or the performance of relevant works.

Analysis of the composition and content of design documents for the organization of construction allows us to summarize several common requirements for the design of the organization of production in market conditions.

1. The leading role in these projects is given to the development of calendar schedules justifying the duration of construction to within one month.
2. Development of complex consolidated network schedules is offered only for complex objects.
3. Projects must provide for rational methods of organizing BIS, ensuring compliance with the terms of construction contracts. To correspond to production possibilities and interests of executors, that is to be optimized according to interests of the customer at the level of the project of the organization of construction. At the level of the project performance of works in accordance with the interests of contractors.
4. In market conditions, the circumstances of the formation of the order book of construction companies have changed, when the demand for construction of facilities has decreased several times, and the number of construction companies of all forms of ownership has increased due to small and medium construction companies.

Problem № 5: Competition in the construction market has led to changes in the standards of organizational preparation of construction, and the standards of construction duration, which operated in the former USSR, have lost their significance and require new justification in new market conditions based on new labor standards.

To build the final calendar schedule of construction, taking into account innovative measures, the following justification is given:

- formation of the structure of the construction flow,

- variants of the topology of the network model,
- determination of labor intensity,
- intensity of resource consumption,
- formation of options for the composition of teams and their mode of operation over time,
- calculations of network and calendar schedule options, their optimization with justification of the base and design construction period [9, 10].

Enlarged network models should be built on the type of "robot-vertex", in which each work corresponds to a specific vertex, and the arcs reflect the sequence and relationship between the works. For calculations and design of the organization of construction in this subdivision, it is necessary to use the package "Project" [8].

Problem 6: Analysis of the methodology for constructing all calendar schedules in the project of production of works showed that the key problem is to determine the duration of work. In today's market conditions with the existing regulatory framework and the lack of software for the development of technological maps with the minimum allowable risks depending on the planning horizon. These circumstances necessitate the search for new methods of developing projects to perform work in the conditions of BIM. New technical means coordinated with the current technological maps at the enterprise.

The technological map is a document for the executor of works and an integral part of the project of production of works that defines a set of instructive instructions on rational technology and the organization of works. Technological maps are developed for construction processes, the result of which are finished structural elements, as well as parts of buildings or structures.

Problem № 7: Lack of software to justify possible options for mechanization of work. Based on the volume of construction and installation work, building dimensions, weight and size of structures, construction conditions with the analysis of the impact on the technical and economic indicators of construction according to the method for assessing the effectiveness of organizational and technical measures.

Problem № 8: Lack of software streaming method. The flow method is a continuous and uniform execution of homogeneous technological processes by crews of workers of a constant structure in technological sequence on captures. At parallel execution with combination of the following processes similarly formed crews of workers after the termination of previous works on the first capture. At the same time, the work of different teams is combined as much as possible in time.

3 Exploitation

Problem № 9: There is no methodological, methodological, organizational, software maintenance, current repair, overhaul of the building and its structural elements, terms of all types of repairs, costs and sources of funding before the reconstruction or liquidation project. Without specifying the solution to these problems, the implementation of BIM will have declarative wishes [14].

Problem № 10: For the implementation of BIM IRD in modern conditions there is no software that could combine the results of the implementation of the two BIM Blocks. Provide export of source data from the first Block, subsystems 4D-7D to subsystem 8D of the second Block. The software that should answer the above questions and choose the best option for the structure during the design.

CONCLUSION

Building information modeling (BIM) is a technology for optimizing design and construction processes, which is based on the use of a single building model and the exchange of information on any object between all participants, throughout the life cycle - from the owner's plan and the first sketches of the architect to the maintenance of the finished house. The use of BIM technology significantly increases the objectivity, reliability of design decisions, the probability of obtaining the designed efficiency and get real design indicators during the construction and operation of the facility.

The basis of the optimization methodology in BIM is a systematic approach - a set of cognitive rules, compliance with which allows a certain way to orient specific research. The problem in modeling the economic component of BIM and assessing economic efficiency is the planning horizon - the term of calculations and especially at the stage of operation of the building, due to the contradiction between service life, depreciation and overhaul.

The risk-oriented approach adopted in the research in the implementation of BIM technology involves the development of a modern regulatory framework using methods and models that create methodological support and real indicators at levels 4D - 8D in accordance with the scheme showing the leading participants in the project.

The system research revealed 10 problems in the normative-reference and software, without the solution of which in BIM‒optimization of innovative solutions becomes impossible.

Further research of the scenario approach and modeling of forecast estimations of economic efficiency of projects on BIM-technology, in the future periods, will allow working out of several variants to choose the optimum variant on the basic technical and economic indicators, considering their changes for a life cycle of the building project. Of particular relevance is the improvement of BIM technology, evaluation and implementation of development projects through foreign investment, which have certain features of construction project management, and their implementation will determine the effectiveness and reliability of the project in today's market conditions in Ukraine.

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The Impact of the COVID-19 Pandemic on the Development of the City and Major Lessons for Urban Planning, Design, and Management

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Abstract. The purpose of the study is to identify the features of urban development after the coronavirus pandemic. The authors believe that with the many advantages of living in cities, they have a number of serious dangers. The ecological situation in cities is far from normal. But if the environmental problems of the city can be solved with the help of modern technologies, there are dangers that are practically uncontrolled or poorly controlled by humans. Among them, the main problem is endemicity, pandemics, the foci of which are primarily cities. It is argued that with a high population density and development, the risk of a large number of sources of infections and various bacteria and viruses is significantly increased. The mechanisms of their transmission are significantly simplified, since the interaction of a large number of people occurs constantly. As the COVID-19 pandemic continues to transform lives and ways of living across the globe, it is becoming increasingly clear that adaptations involving both physical and institutional infrastructure are warranted. Cities are at the forefront of these adaptive changes as dense urban environments are particularly vulnerable to the spread of contagious airborne diseases such as the novel coronavirus. This paper considers how COVID-19 might influence where and how these changing patterns might in turn shape future development trajectories. We also discuss how cities are currently responding to the public health threat posed by COVID-19, and how they might use planning and design strategies to improve resilience in the face of future pandemics.

INTRODUCTION

From the devastating cholera outbreaks in mid-19th century London to the infamous Typhoid Mary epidemic just over a century ago in New York, the disease has had a significant impact on modern urban planning, design and development. For at least the last two hundred years, our response to outbreaks of such diseases has largely led to a healthy and safe urban environment. The construction of modern sewage systems, water treatment facilities, hospitals, as well as the establishment of zonal codes, medical commissions and many regulations designed to improve sanitation and limit the spread of the disease, have significantly contributed to public health. However, COVID-19 has

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demonstrated that cities (as well as suburbs and rural communities) are still very vulnerable to airborne infectious diseases. How can this latest pandemic shape the way we build our homes, communities and cities over the coming years and decades? How can we build and manage our way out of infectious diseases, and can densely populated cities be healthy cities even during a pandemic? In this paper, we try to consider these issues while identifying key areas for future research [1].

The aim of the study is to identify features of urban development after the coronavirus pandemic. The authors believe that, having the many benefits of living in cities, they have a number of serious dangers. The ecological situation in cities is far from safe. But if the city's environmental problems can be solved with modern technology, there are dangers that are virtually uncontrolled or poorly controlled by humans. Among them, the main problem is the pandemic, the centers of which are primarily cities. It is claimed that a high population density significantly increases the risk of a large number of sources of infections and various bacteria and viruses. The mechanisms of their transmission are greatly simplified, as the interaction of a large number of people is constant. As the COVID-19 pandemic continues to transform lives and lifestyles around the globe, it is becoming increasingly clear that adaptations involving both physical and institutional structures are justified. Cities are at the forefront of these adaptive changes as dense urban environments are particularly vulnerable to the spread of infectious airborne diseases such as the new coronavirus. This paper examines how cities are currently responding to the public health threat posed by COVID-19 and how they can use planning and design strategies to improve resilience to future pandemics.

The main objectives of the study are to understand the impact of the pandemic on cities and to highlight the main lessons that can be learned for urban planning, design and management after COVID-19. The results show that in terms of topics, early studies of the impact of COVID-19 on cities are mainly related to four main themes, namely: environmental quality, socio-economic impacts, management and transport. This indicates a diverse research agenda. The study contains other recommendations related to socio-economic factors, urban management, transport and urban design that can be used for urban planning and urban management after COVID.

FORMULATION OF THE PROBLEM

From the first days of the COVID-19 crisis, the scientific community has been constantly trying to shed light on the various issues and mechanisms that affect the spread of the virus, its environmental and socio-economic consequences, and the necessary actions and policies for recovery and adaptation. Due to the high concentration of population and economic activity in cities, they are often hotspots of COVID-19. Accordingly, after the first confirmed cases of the disease were reported in Wuhan, China, many researchers are trying to study the dynamics of the pandemic in urban areas to understand the impact of COVID-19 on cities.

The lack of effective urban governance mechanisms in the context of the COVID-19 pandemic demonstrates the need for comprehensive measures to address the challenges of inefficient urban governance in the face of forced transformation and current threats. Lockdown is a precedent for the formation of a new vector in architecture, the development of new scenarios of human behavior in the city. Despite significant advances in medicine over the past year, the COVID-19 pandemic has shown that many countries and cities around the world have been largely ill-prepared to address these issues. The pandemic highlighted weaknesses in the institutional infrastructure that need to be addressed by the next pandemic. For city managers, designers, and other local actors, the pandemic provided a rare opportunity to make cities more resilient and prepared by increasing the importance of public health in a variety of land use, transportation, and public space decisions [1].

In general, the available knowledge shows that the COVID-19 crisis provides an excellent opportunity for urban planners and politicians to take transformational measures to create cities that are more resilient to threats. The COVID-19 pandemic has proven to be a major challenge for cities and urban lifestyles. Cities that are ready to make quick decisions, apply best urban policy practices, have the best chance of remaining resilient and thriving in these times of global change on a global scale.

METHODS

We employed a narrative approach to explore how the built environment modulates crowding and the risk of SARS-CoV-2 transmission. The objects of this study are relevant papers indexed in Scopus, a widely used database for archiving scientific articles. Another commonly used database is the Web of Science. However, Scopus was used for its broader coverage. Also, the search string was intentionally designed broad to provide reasonable coverage of the diverse research that exists on cities and their planning, design, and management.

RESULTS

The main aims are to understand impacts of the pandemic on cities and to highlight major lessons that can be learned for post-COVID urban planning and design. Results show that, in terms of thematic focus, early research on the impacts ofCOVID-19 on cities is mainly related to four major themes, namely, environmental quality, socio-economic impacts, management and governance, and transportation and urban design. While this indicates a diverse research agenda, the first theme that covers issues related to air quality, meteorological parameters, and water quality is dominant, and the others are still relatively underexplored. Improvements in air and water quality in cities during lockdown periods highlight the significant environmental impacts of anthropogenic activities and provide a wake-up call to adopt environmentally friendly development pathways. The paper also provides other recommendations related to the socio-economic factors, urban management and governance, and transportation and urban design that can be used for post-COVID urban planning and design. Overall, existing knowledge shows that the COVID-19 crisis entails an excellent opportunity for planners and policy makers to take transformative actions towards creating cities that are more just, resilient, and sustainable (Figure 1).

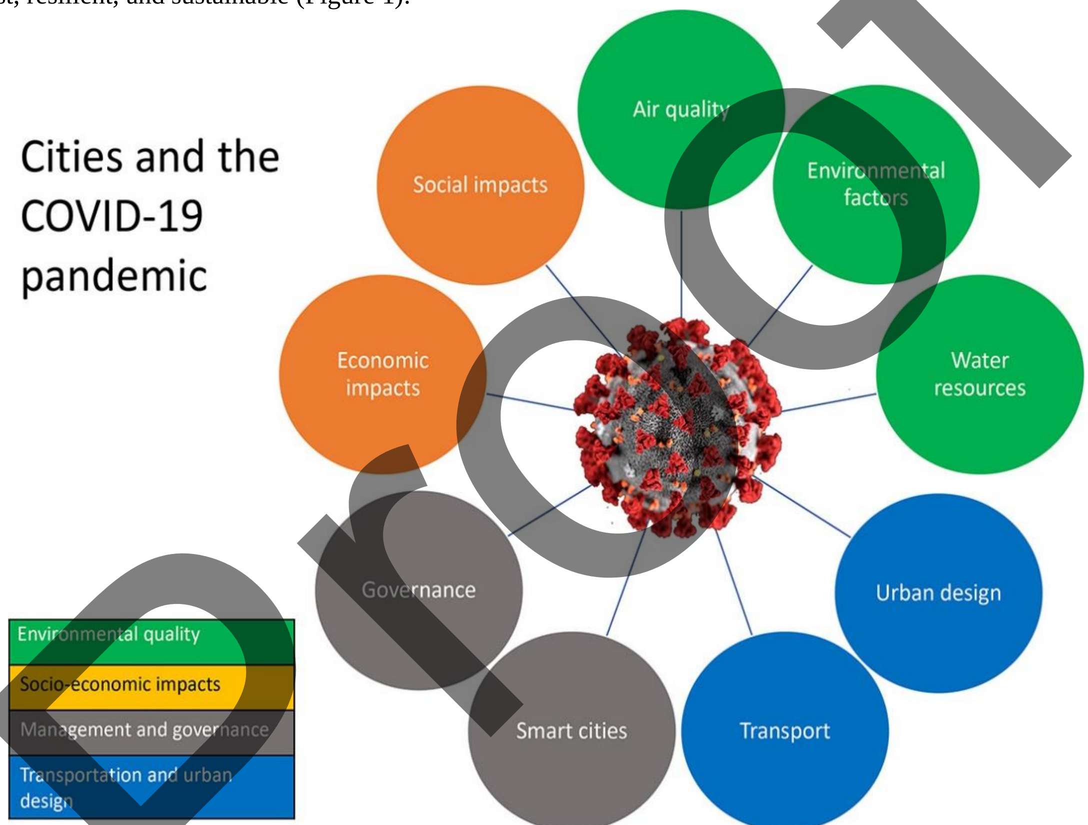

FIGURE 1. Cities and the COVID-19 pandemic [6]

Cities are home to most of the world population and are centres of economic growth and innovation. However, the high concentration of people and activities in cities make them vulnerable to various stressors such as natural and man-made disasters. Understanding this, over the past few decades, a vast body of research has been published on the impacts of a wide range of disasters on cities, and necessary planning, recovery, and adaptation measures that need to be taken to deal with those disasters [2]. However, while this is not the first time in the human history that pandemics affect cities, limited literature related to cities and pandemics existed before the emergence of the COVID-19 pandemic [3]. Urban research related to previous pandemics is mainly focused on issues such as in-equalities that make poor and marginalized groups more vulnerable to pandemics [4]. The recent pandemic has brought to the fore the issue of urban vulnerability to pandemics and has resurrected interest in this topic. As various forces such as climate change and human encroachment into natural wildlife habitats may increase the frequency of pandemics in the future, better knowledge of the underlying patterns and dynamics of pandemics, their effects on cities, and necessary preparation, response, and adaptation measures is needed [5]. In this regard, the recent pandemic offers an unprecedented opportunity to understand how cities might be affected by pandemic sand what actions are needed to minimize the impacts and enhance urban pandemic resilience.

Yet, COVID-19 has demonstrated that cities (and indeed suburbs and rural communities as well) are still very much vulnerable to airborne contagious diseases. How might this most recent pandemic shape the way we build our homes, communities, and cities over the coming years and decades? To what extent can we "build and manage our way out of infectious diseases" [7], and can dense cities be healthy cities, even during a pandemic? In this paper, we attempt to address these questions, while also identifying key areas for future research. We also highlight global cities on the forefront of COVID-19 mitigation strategies to stem the spread of the disease. Table 1depicts the major cities and notable mitigation strategies they have implemented (Table 1).

TABLE 1. COVID-19 mitigation strategies [15-20]

City	Notable Mitigation Strategies
Auckland, New Zealand	•Business closings and lockdowns as part of central government strategy. [1]
Berlin, Germany	•Subsidized bike sharing program.
Chicago, USA	•Enhanced sanitation of public transportation vehicles (electrostatic sprayers, increased cleanings, ridership demand app).
Guangzhou, China	•Passenger temperature check screenings and thermal imaging. •Outdoor socially distanced queuing for public transit. •Contact tracing. •Lockdowns as part of central government strategy.
Houston, USA	•Slow Street program.
Jakarta, Indonesia	•Deployment of low-cost water containers and soap dispensers.
Kigali, Rwanda	•Sinks and handwashing stations at public locations.
Melbourne, Australia	•Permitting of restaurant seating expansion into laneways and sidewalks to de-densify patrons.
Milan, Italy	•Conversion of some streets into bicycle and pedestrian paths.
New York City, USA	•Enhanced sanitation of public transportation vehicles (electrostatic sprayers, research into antimicrobial materials and cleaning strategies).
Oakland, USA	•Repurposing/closing streets into recreational areas (Slow Street program). •Making streets more pedestrian friendly (Slow Streets: Essential Places program).
Oslo, Norway	•Closing of schools and businesses as part of central government strategy. [2] •Restrictions on indoor recreation activities.
San Francisco, USA	•Slow Street program. •Shared Spaces program.
Seattle, USA	•Stay Healthy Streets program.
Seoul, South Korea	•Advanced contact tracing, surveillance, and notification system. [3] •Mobilization of rapid testing kit production as part of strategic plans of national strategy. •Strict patient isolation as part of national strategy.
Shenzhen, China	•Mobility restrictions. [4] •Contact tracing and isolation.
Tokyo, Japan	•Increased teleworking. •Staggered work hours.
Vienna, Austria	•Lockdowns as part of central government strategy. [5] •Building of temporary hospital facilities.

One of the most profound and decisive questions that needs to be addressed is how COVID-19 will impact where people live. Over the last two to three decades, there has been a clear shift in support and demand for more dense urban environments [8-10]. While suburbanization has not subsided on the outskirts of most cities, there has nonetheless been a rise in population, as well as an increase in investment within older, more walkable neighborhoods and urban centers [11, 12]. The desire to live and work in close proximity to urban amenities such as shopping, entertainment, and transit is often reflected in residential and commercial land values [13, 14].

Had we been investing – MDGs and SDGs – we would have a better foundation for withstanding shocks. A hard truth is that we could have been better prepared for this crisis. The MDGs and the SDGs could have put us on track towards a world with access to universal health coverage and quality health care and more inclusive and sustainable economies. Instead, most countries have underinvested in health systems; facilities are insufficient for the level of the unexpected demand and rely heavily on imports. Most countries are characterized by weak, fragmented health systems that do not ensure the universal access and capacity needed to face the COVID-19 health crisis [21] (Figure 2).

Given the rate of infection expected, the final death toll of COVID-19 could take on dramatic proportions. The economic and social effects of the pandemic are likely to be well in excess of those of the latest global crisis in 2008. Only international coordination can prevent a worst-case scenario. Overarching principles Keeping all people, households and businesses afloat is the main objective. We need to focus on people – families, women, children, youth, persons with disabilities and the elderly, low-wage workers, small and medium enterprises and the informal sector. Important steps have already been taken in this direction. This must be scaled up. Extraordinary times require extraordinary measures. Economic policy should meet peoples most immediate health, food and other basic needs, protect social cohesion and maintain political and economic stability. Since the crisis is evolving rapidly, careful monitoring of the direct and indirect effects of all interventions are crucial to ensure policy responses are, and stay, relevant. A sense of urgency must prevail. Specific measures are needed at different levels. International organizations, international financial institutions and leadership groups such as the G20 all have levers that must be activated to full effect and in a coordinated manner. A coordinated regional approach will enable collective examination of impacts, coordination of fiscal, monetary, and social measures and sharing best practices and the lessons learned. National actions are perhaps the most crucial, but they are dependent on context, including geographic context, type of government and level of development. Developed and developing countries do not have the same resources to respond quickly to the pandemic and, among developing countries, there are significant differences between different categories of countries, such as Small Island Developing States (SIDS), Least Developed Countries (LDCs) and Land Locked countries. Local governments are at the frontline of the epidemic but their capacity to respond rapidly depends heavily on the governance context and the financial health of the local government and its budgetary authority. A whole-of-society approach is needed. COVID-19 is menacing all of humanity and all of humanity must fight back. An effective response needs to be multidimensional, coordinated, swift and decisive. It needs to be result of strong political leadership and buy-in of the population. It needs to foster public trust; be focused on human values; and supported by solid institutions, technical skills and financial resources. Everyone needs to play their part in the response. No individual country can do this alone [21].

There is an urgent need to rethink and transform cities to respond to the reality of COVID-19 and potential future pandemics, and to recover better, by building more resilient, inclusive and sustainable cities. We know that this is possible. The rapid shifts in society due to COVID-19 present a powerful lesson that society is capable of near-overnight transformation that is needed to confront our most urgent threats, such as the climate and pollution crises that threaten the very viability of cities. Indeed, previous disease outbreaks – such as the flu pandemic (1918) and localized epidemics of tuberculosis and cholera – have driven several positive urban transformations – such as the introduction of sewage systems, public parks, and housing regulations to improve sanitation and reduce overcrowding. Today, local and regional governments are already demonstrating an impressive array of innovative solutions that can address structural weaknesses exposed by the pandemic [22].

Addressing COVID-19 in an increasingly urbanized world requires a focus on how urbanization shapes impacts, responses and longer-term recovery. Responses that are siloed or shortsighted, focusing on quick fixes, could worsen and entrench impacts laid bare by the COVID-19 pandemic. Meanwhile, many of the short-term response measures will need to be maintained for some time, even when the initial outbreak appears to have been contained, given the risk of secondary waves of infections. Long-term policy choices by national, regional and local governments are needed to build our resilience against future pandemics, including climatic and economic hazards and shocks, while safeguarding human rights, sustaining peace and strengthening our ability to achieve the SDGs [22]. Realizing these potential gains will require intensified commitments and action in three key areas: 1) tackling inequalities and development deficits; 2) strengthening the capacities of local actors, particularly local governments; 3) pursuing a resilient, inclusive, gender equal and green economic recovery.

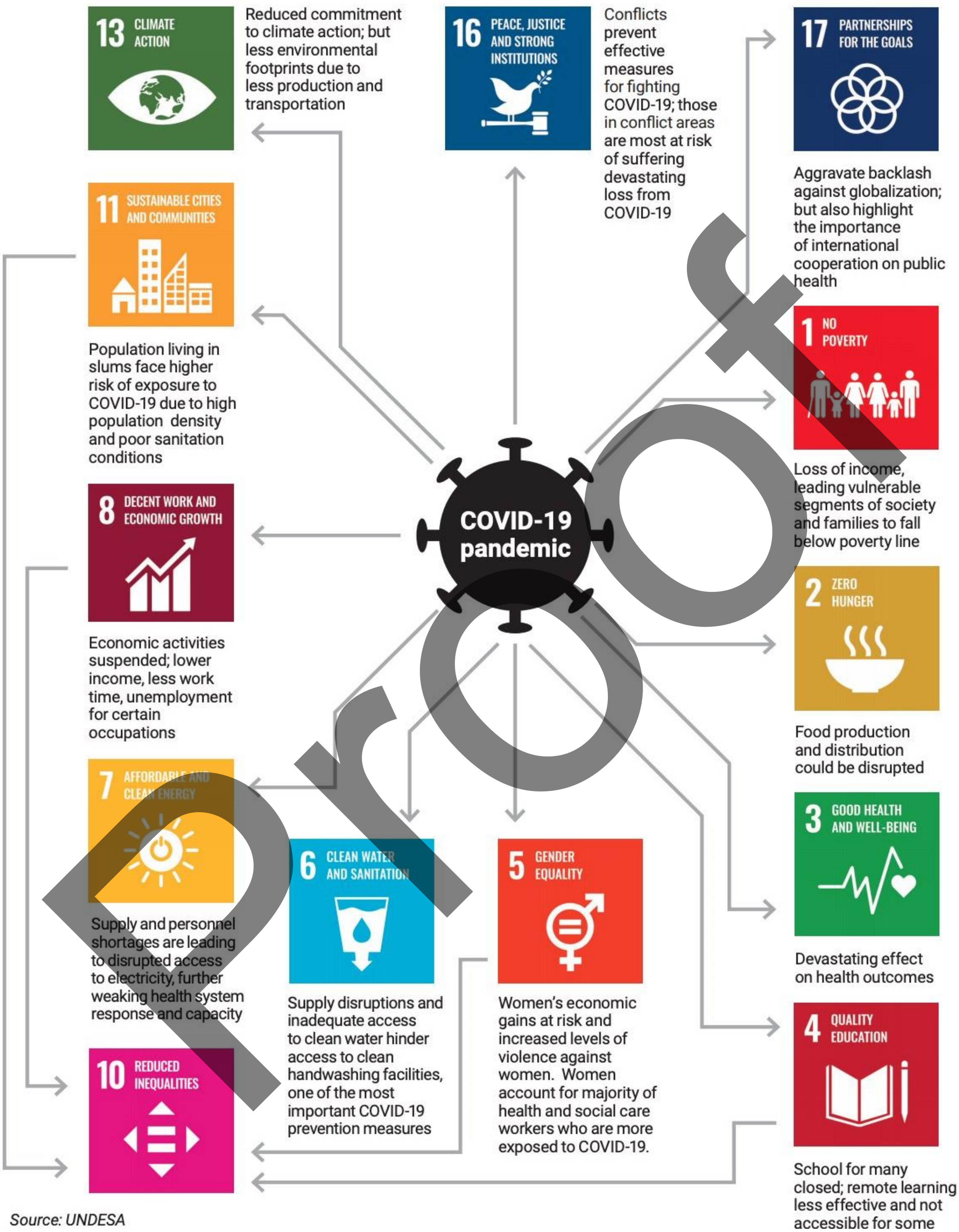

FIGURE 2. COVID-19 affecting all SDGS [21]

DISCUSSION

Many cities around the world, including those in wealthy countries, appeared ill-prepared for the COVID-19 pandemic. Of the fifteen largest cities in the U.S., only San Diego makes publicly available its pandemic plan, and many of these other cities' plans are unavailable and/or have not been recently updated. County and municipal governments and departments have been instrumental in public health legislation and implementation such as mask mandates, school operations, public gathering sizes, and events planning in response to COVID-19 rates with in their jurisdictions. Emergency and disaster planning cities often appear to take on a reactionary or after-the-fact approach [23]. COVID-19 represents the largest health emergency in recent history for the world., especially for urban areas. Therefore, contingency planning and resilience strategies using new decision-making approaches based upon simulations and uncertainty models may become key tools for designing pandemic plans for a future outbreak. Transportation planners sometimes use simulations to engage in exploratory scenarios [24] and robust decision-making (RDM) planning [25]. to model challenges to the urban transportation infrastructure. Similar approaches involving scenario planning, worst-case scenarios, and simulated urban health system stress-tests using data and computer simulations will likely become more important for urban health planning and for emergency managers developing pandemic plans and resilience strategies.

CONCLUSIONS

Despite significant advances in medicine over the past year, the COVID-19 pandemic has shown that many countries and cities around the world have been largely ill-prepared to address these issues. The pandemic highlighted weaknesses in the institutional infrastructure that need to be addressed by the next pandemic. For city managers, designers and other local actors, the pandemic provided a rare opportunity to make cities more resilient and prepared by increasing the importance of public health in a variety of land use, transport and public space decisions. As noted, we recommend that cities thoroughly consider prioritizing pedestrian infrastructure to ensure proper social distance in the event of a pandemic and to improve the capacity for active transit in the long run [26]. The consequences of the demographic shift can be serious and long-lasting, and future research should examine the extent and consequences of such changes. Additional normative recommendations for cities to successfully combat the COVID-19 and/or future pandemics include:

•Expansion of outdoor sidewalks/walk spaces near businesses and the easing of permitting processes during pandemics to allow businesses (especially restaurants) to use these spaces for de-densified business activities.

•Planning, promoting, funding, constructing, and maintaining public green spaces and corridors near residences to allow individuals to exercise and maintain a healthy lifestyle during times of lockdowns and restricted mobility.

•Designing municipal and intergovernmental strategic plans for future pandemics that focus on contact tracing, mitigation strategies, patient housing, resource allocation, information provision, and intergovernmental cooperation.

•Implementation of increased and innovative public transportation sanitation practices to not only mitigate the spread of pandemic diseases, but to also prevent more common viruses and bacteria such as the common cold, influenza, staphylococcus, etc.

The COVID-19 pandemic has proven to be a major challenge for cities and urban lifestyles. Cities that are ready to make quick decisions, promote best practices in urban policy, have the best chance of remaining resilient and thriving in this global age.

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Biotechnologies Introduction in the System of Natural and Wastewater Treatment at Dairy Enterprises and Settlements

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Abstract. Dairy industry is one of the key branches of food industry in Ukraine. Water supply of most milk processing enterprises is based on using uderground waters of their quality are not always agree with technologic norms: ions of heavy metal (Fe^{2+}, Mn^{2+}), ammonium nitrogen, dissolved organic matter, phenols. As a result of many year experiences, authors established that the main role in providing for necessary quality of water for technology needs and also for treating wastewater in milk processing enterprises belongs to biological treatment methods. The work presents the results of researches in technology including bio-reactors and filters for comprehensive treatment of uderground water under conditions of irregular changes in specific loading, filtration rate, seasonal fluctuation of their quality and air temperature. It has been determined that the usage of modern technologies of milk processing results in reduction of drinking quality water waste along with increase in concentrations of wastewater pollutions. Possibility of effective usage of big hydraulic height metal aeration tanks with surface jet aeration for highly concentrated wastewaters treatment under conditions of change of pollutants concentration, pH values and temperature was confirmed. The paper considered one of the variants to comprehensively solve issues of water supply-water disposal for small settlements where enterprises of milk processing industry are located by way of introducing power and resources saving biotechnologies for treating natural and waste waters developed at NUWEE.

1. INTRODUCTION

In recent decades in Ukraine a problem is acute of water aupply and water disposal in small settlements particularly if they have enterprises of milk processing industry: cheese factories, town milk factories, butter producing factories, milk preserving combines which are known to be one of the most spread sources contaminating natural water reserves.

The total number of enterprises of milk processing industry in Ukraine in 2020 amounted to 192, in large cities being 35%; in small town settlements 41%; in settlements 18%; in villages — 6%. As is known [1], the system of water supply for main shops in milk processing factories is chiefly of current flow. Recirculating water supply is used for freezing installations, vacuum apparatuses and other equipment where there is no its contact with produce. Normative demands for recirculating water quality are: temperature — 20 ºC, suspended substances — 40 mg/dm^3; colour — 20 grad; pH 6.5-8.5; carbonate hardness — 2.8 mmol/dm^3; dry precipitate — 500 mg/dm^3; Fe — 0.1 mg/dm^3; permanganate oxidizability — 5 mg O_2/dm^3; BOD_{20} — 5 mg O_2/dm^3 [1]. The main part of clean water (up to 90%) which is spent for production demands of cooling milk and milk products, cheese washing, washing of technological equipment must meet demands of State sanitary norms and regulations "Hygienic requirements for drinking water for human consumption" (SSNR 2.2.4-171-10).

As a result of conducted monitoring studies parameters of undereground waters quality in a number of settlements in Rivne and Volyn regions (Table 1) it was established that by some indices they do not meet demands of SSNR 2.2.4-171-10 and demands for technological waters which are used in systems of water supply for milk processing enterprises. Before supplying such waters into the system of water supply it is necessary to carry out their treatment

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and stabilization processing with the aim of preventing corrosion process. The existing practice shows the expediency of conducting comprehensive treatment of water both for milk processing enterprises and for settlements where they are situated.

TABLE 1. Parameters of underground waters quality in settlements where milk factories are located

№	Town settlements	Water quality indicators						
		pH	**Carbonate hardness mmol/dm^3**	**Fe^{2+}, mg/dm^3**	**PO, mg O_2/дм^3**	**Mn^{2+}, mg/dm^3**	**NH^+_4 mg/dm^3 / H_2S mg/dm^3**	**Langelier Index I_L**
1	Volodymerets	6.7-7.0	1.5-2.0	1.65-2.6	2.4-3.5	0.05	2.5 / 1.5	-1.3
2	Berezno	7.3	2.0 -3.8	1.6 -2.73	< 3.5	0.05	0.5-0.8 / 0.8	-0.48
3	Rivne	7.3	5.9 – 6.4	1.4-2.0	1.7-2.0	< 0.1	1.5-1.75 / 1.5	-0.09
4	Dubno	6.8-7.5	7.0	< 0,3	2,72	-	0,15 / -	0.2
5	Bugrin	7.45	7.0	4.5	8.0	0.46	0.18 / -	-0.12
7	Kovel	7.2-7.4	6.0	6.5-7.3	4.8	0.15	1,8 / -	-0.08
8	Lutsk	7.1	6.4 – 7.2	0.5-1.8	1.4-2.8	-	0,4-1,9 / -	0.2
9	Torchin	7.4	6.7	>0.5	1.76	0.12	0.7 / -	0.34

Results of the process audits of developed technologies, as well as monitoring of more than 100 factories of dairy industry of Ukraine conducted on base of applied research laboratory of agroindustrial complex wastewaters treatment, which is functining at NUWEE since 1981, allowed to acknowledge changes in structure and characteristics of wastewaters (Table 2) and reclassifying of wastewaters as highly concentrated [2].

TABLE 2. Wastewater characteristics of butter factory, city milk plants and milk condensed plant [5]

Parameter	The values of wastewater pollutants concentrations for enterprises				
	Butter factory	**City dairy plants**	**Hard cheeses**	**Processed cheeses**	**Milk condensed plant**
pH	5.9	6.13–11.9 / 9.0	4.18–6.37 / 5.56	6.8–7.2 / 7.0	-
TSS [mg/dm^3]	2860	30–1204 / 366	248–867 / 493	255–1884 / 634	448–602
COD [mg/dm^3]	5304	164–10547 / 2569	910–6664 / 4116	720–3480 / 1528	1100–2210
BOD_{20} [mg/dm^3]	-	-	760–4508 / 354	418–1960 / 982	920–1870
BOD_5 [mg/dm^3]	3126	115–6245 / 1723	590–3925 / 3335	390–1330 / 699	890–1440
Fats [mg/dm^3]	-	18–131 / 82	32–146 / 66	-	-
Ammonia nitrogen [mg/dm^3]	9.11	0.8–50 / 12.5	5.8–8.8 / 7.2	9.2–15.7 / 12.4	25–39
Nitrite (N) [mg/dm^3]	2.23	-	-	-	-
Nitrate (N) [mg/dm^3]	56.3	-	29.4–37 / 33.2	-	-
Phosphate [mg/dm^3]	-	2.2–39 / 13	49–295 / 210	-	-

Wastewaters from dairy factories are mainly discharged to municipal sewage. According to monitoring results, based on integrating indicators which characterize composition of organic substance (BOD and COD), and allowed concentrations of suspended substances the level of incomplete biological treatment is acceptable for discharge of factory wastewaters to municipal sewage.

At the same time low concentrations of ammonium nitrogen (less than 2.5 mg/dm^3), nitrites (less than 1 mg/dm^3) and nitrates (less than 1 mg/dm^3) indicate need for additional nitrification-denitrification processes to be performed. Normalized concentrations of fats in treated wastewaters vary from 50 to 4.4 mg/dm^3.

Considering that finely emulsified fats left in wastewaters after primary treatment will be oxidized biochemically, the remaining fact concentrations, in addition to another indicators, can determine the required level of biological wastewaters treatment.

Therefore the pressing task of today is the comprehensive solution of the issue of water supply-water disposal in small settlements where are situated enterprises of milk processing industry by way of introducing up-to-date power and resources saving technologies of treating natural, waste and recirculating waters [2-7, 14, 18-20]. The solution of this problem renders the possibility to simultaneously keep up normal technological processes at enterprises, supply drinking water of high quality to population and workers, to provide for the proper level of ecological safety for surrounding environment.

MATERIALS AND METHODS

As a result of many years of our own studies it is established that main pollutants of underground waters are cations Fe^{2+}, Mn^{2+}, NH^{+}_{4}, H_2S, dissolved organic phenols, and also corrosion degrees. The existing non-reagent technologies based on mehods of simplified or deep aeration with the subsequent filtering are not aimed at the comprehensive treatment of water from said components [6]. One of present non-reagent methods of treating underground waters is the method of biological deferrization-demanganation [8-11].

In the paper are presented the results of the research of the efficiency of modernized technology operation (Fig. 1) for the comprehensive treatment of underground waters under conditions of irregular change of the specific loading, filtration rate, seasonal fluctuations of underground waters quality and air temperature.

The basic technological equipment: a bioreactor of 2.8 diameter, with 8 m height is equipped with a cavitation block; three open polystyrene foam filters of 2.0x2.0x4.3m size equipped with the system of hydroautomatic washout; an electrolysis device «Polumya-2»; a pump-weigher of sodium; hipochlorite; a reservoir of clean water (RCW); pumps of second lifting; a block of stabilizing water treatment.

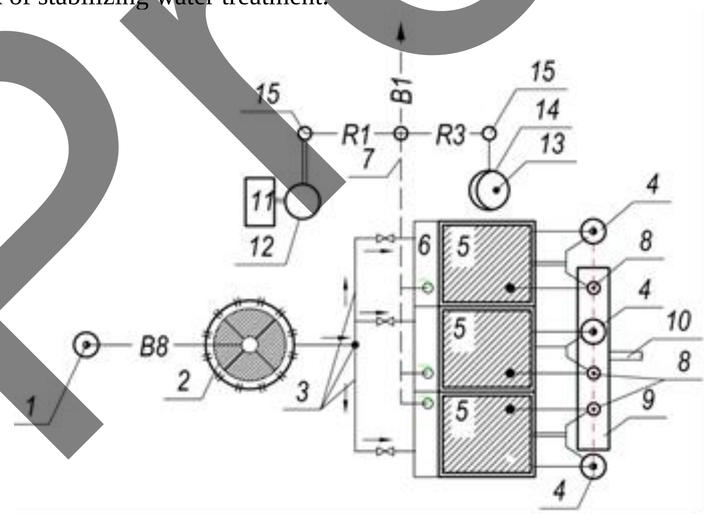


FIGURE 1. Technological scheme of treating agressive, near neutral waters: 1 – groundwater bore; 2 – bioreactor, 4 – air separators; 5 – filters; 6 – pocket of filtrate collection; 8 – hydrorobot; 9 – canal for collecting washout waters; 10 – pipeline for disposal of worked out washout waters; 11 – elerctrolyser; 12, 14 – tanks for solutions of sodium hipochlorite and $Ca(OH)_2$; 13 – mixer; 15 – pumps-weighers; 3,7 – technological pipelines

The overall view of water treatment station developed jointly with professor M.G.Zhurba is presented in (Fig. 2, 3). Parameters of the quality of initial water: NH_4^+ – 0.55-0.65 mg/dm^3, C_5H_5OH – 0.025-0.028 mg/dm^3, Fe^{2+} – 1.7-1.9 mg/dm^3, values of permanganate oxidizability – 3.6-4.0 mg O_2/dm^3, hydrocarbonate alkalinity – 3.96 mmol/dm^3, pH 7,2. The treated and stabilized water was used in the system of water supply in the town of Berezno and at milk processing enterprise PE «Duvar» which is a producer of such products as yogyrt, kefir, milk, milk produce, pasterized milk.

It is a known fact that biological treatment is a main method of wastewaters treatment at dairy factories and it involves usage of aeration tanks and biological filters [12-14]. Primary wastewaters treatment is conducted by means of screens, sand traps, grease traps and Imhoff tanks. In foreign countries [15-17] primary treatment of wastewaters is performed using sand traps, greet arresters, balancing reservoirs and flotators with usage of reagents: coagulates and flocculants.

In [18] the technological parameters (the size of particles and air bubbles, water rise rate and air concentration in water) which can significantly affect the quality of suspension clarification by flotation, are considered. An improved mathematical model for studying the influence of technological parameters on the flotation process is presented.

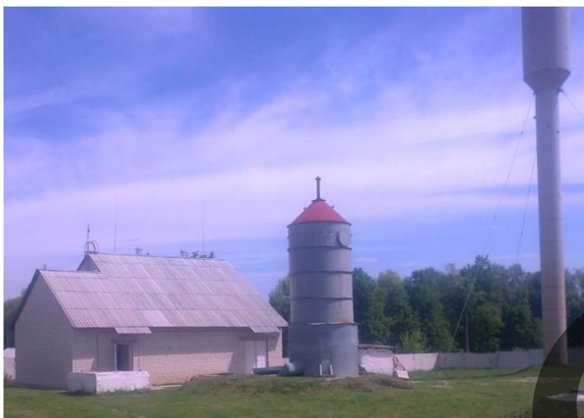


FIGURE 2. General view of the water treatment plant with a capacity of 2000 m^3/day in the water supply system of Berezne town (Photo by O. Kvartenko)

FIGURE 3. Filter hall (Photo by O. Kvartenko)

Discharge of treated wastewaters to municipal sewage is limited to anaerobic treatment, whereas discharge to surface waters involves anaerobic-aerobic treatment. Determination of techological scheme of wastewaters treatment for each specific dairy plant is a complicated technological and techno-economic task.

FIGURE 4. Wastewater treatment plant of Shostka city dairy plant (Photo by V. Kovalchuk)

FIGURE 5. A grate and a horizontal sand trap in Shostka city dairy plant (Photo by V. Kovalchuk)

This article contains effectiveness studies of proposed structures and technological schemes using the example of treatement facilities at Shostka city fairy plant, which facitilies were built using developed technology [19]. Wastewaters treatment facilities at Shostka city fairy plant (Fig. 4) contain of non-treated wastewaters pumping station, sand trap and horizontal greet arrester (Fig. 5), located within pumping station, and two aeropacks with sludge reactivation and jet aeration. Treated wastewaters are discharged to municipal sewage.

3. RESULTS AND DISCUSSION

As a result of studying the operation of the modernized technology of treating underground waters the efficiency was established of its operation under conditions of irregular change of specific loading, of filtration rates (Fig. 6, 7), of seazonal fluctuations of underground waters quality and of air temperature [20]. It should be noted that notwithstanding rather substantial fluctuations of values of the specific loading and filtration rates during the researched period at the water treatment stationthe stabilized effect was observed (Fig. 6). Figure 7 presents the results of a filtration cycle in the period from 12.11.16 to 13.11.16. The water treatment station in the said period worked under changing water expenses, from 13 to 40 m^3/hour. Filtration rates were correspondingly: in a bioreactor – from 2.5 m/hour to 8 m/hour; in clarifying filters – from 1.5 m/hour to 3.5 m/hour. Under such a scheme filters were transferred into a regime of a washout once per two days. The efficiency of treating water from easily oxidized organic compounds and iron amounted correspondingly from 62 to 79% and from 87 to 98% (Fig. 7).

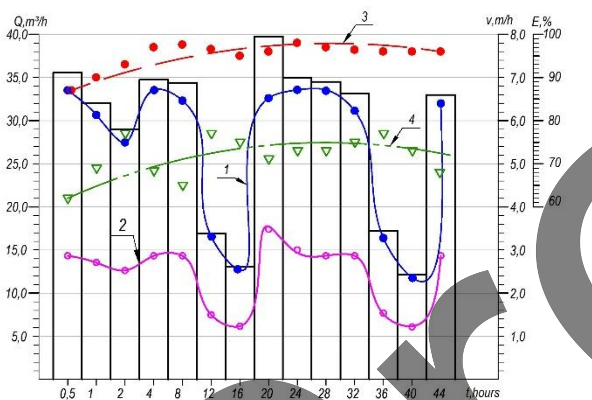


FIGURE 6. Change of filtration rates and efficiency of water treatment depending on hourly water expenditures: 1 – rate in a bioreactor; 2 – rate at filters; 3 – efficiency of deferrization after filters; 4 – efficiency of removing organic substances by PO after filters

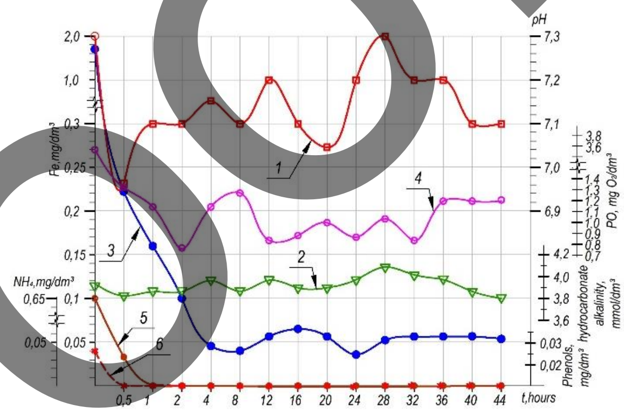


FIGURE 7. Change of quality parameters of treated water after filters during filter cycle: 1 – pH values; 2 – hydrocarbonate alkalinity; 3 – ferrum compounds; 4– permanganate oxidization; 5 – ammonia nitrogen; 6 – phenols

Compounds of ammonia nitrogen and phenols had been completely from water during the first hour of filter cycle (Fig. 7). Throughout the whole filter cycle values of Langelier Index (LI) of initial water fluctuated from -0.39 to -0.27. Such waters are classified as waters with the slight level of corrosion in relation to metal and concrete. After the bioreactor and filters values of Langelier Index increased correspondingly to -0.33...-0.14 and -0.18...-0.1. Water became less agressive and was classified by a very slight level of corrosion. As a result of introducing to the filtrate the calculated quantity of clarified solution of lime values of Langelier Index stabilized within 0.1...0.15.

The developed technology is calculated for carrying out the comprehensive treatment and conditioning agressive, near-neutral waters with normal alkaline reserve from ammonia nitrogen (up to 1.5 mg/dm^3), dissolved organic matter (by PO up to 6.0 mg O_2/dm^3), ferrum (up to 5.0 mg/dm^3), phenols (up to 0.05 mg/dm^3). The use of two-level scheme permits the use of the equipment under conditions of the irregularity of hydraulic loadings. The increased duration of a filter cycle to 48 hours had become possible as a result of the use of the biochemical treatment method. The operational filtration rates were for a bioreactor 7-11 m/hour, for filters 3.5-6.0 m/hour.

Efectiveness studies of developed technology of high-strength wastewaters treatement at milk processing industry plants were performed at wastewater treatment plants of Shostka city dairy plant which are functioning since 2003. These wastewater treatment plants serve as an example of successful implementation of technological method that combines processes of equalization and biological treatment of high-strength wastewaters and thus allows its effective cleansing under conditions of changing pollutants concentration, pH values and environment temperature. As it is shown on Fig. 4, aeration tanks-settlers of Shostka city dairy plant are made of metal and therefore fall under influence of environment temperature, especially in winter. However, aerobic processes that involve heat release in aeration zone during biological treatment of high-strenth wastewaters in milk products processing (including hard chesses) result in increase of mixed liquor temperature.

The measurement of wastewaters temperature for one year of wastewater treatment plants operating has shown that mean temperature of non-treated wastewaters entering pumping station of dairy plant equaled to 25.4 °C (range of changes 20.5-37 °C). Mean temperature of mixed liquor in one of aeration tanks-settlers was equal to 26,8 °C (20-32 °C), and in generator of the same aeration tanks-settlers – 26.6 ° C (20-32.5 °C). Mean temperature of mixed liquor in one of aeration tanks-settlers equaled to 25.2 °C (18-32.5 °C), and in generator of the same aeration tanks-settlers – 25.1 °C (18-32.5 °C). Therefore, a conclusion can be made that the temperature of mixed liquor does not change to significant extent while using metal aeration tanks-settlers with surface jet aearation, and these packs can be freely used in winter.

Two-years observation of aeropacks performance has shown that during the first year pH indicator of treated wastewaters measured within pumping station, varied in quite wide ranges – from 2.24 to 12.46. First aeration tanks-settlers exit value of pH was in range of 6.8-8.06 (mean value 7.47), second aeration tanks-settlers exit value – 6.94-7.94 (mean value 7.50). Next year pH indicater of treated wastewaters varied in a slightly narrower range from 4.80 to 11.55. First aeropack exit value of pH was in range of 7.30-8.06 (mean value 7.77), second aeration tanks-settlers exit value – 7.35-7.61 (mean value 7.47). Despite flactuations of pollutant concentrations, temperature and pH of treated wastewaters, operation of aeropacks at Shostka city dairy plant remained stable and provided required pollutant concentrations in treated wastewaters (Table 3).

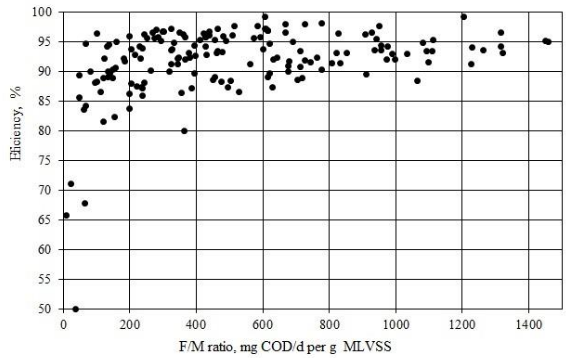
TABLE 3. Results of Shostka city dairy plant wastewater treatment

Parameter	**The values of wastewater pollutants concentrations**		**Purification efficiency [%]**
	before biological treatment	**after biological treatment**	
TSS [mg/dm^3]	248–867 493	8.6–367 234	52.5
COD [mg/dm^3]	910–6664 4116	45–739 231	94.4
BOD_{20} [mg/dm^3]	760–4508 3547	12.5–613 58	98.4
BOD_5 [mg/dm^3]	590–3925 3335	5.8–581 44	98.6
Ammonia nitrogen [mg/dm^3]	5.8–8.8 7.2	0–0.87 0.48	93.3
Nitrite (N) [mg/dm^3]	-	-	-
Nitrate (N) [mg/dm^3]	0–37	-	-
Phosphate [mg/dm^3]	49–295 210	0–61.3 21.9	89.6
Fats [mg/dm^3]	66	13	80.3

Relationship between aeration tanks-settlers effectivity and F/M ratio (Fig. 8) shows that in the range from 80 to 1450 mg COD/day to g MLVSS the effectiveness of biological treatment at city dairy plant falls within range of 90-98% per COD.

During observations concentration of activated sludge in aeration zone remained within range of 2.85-5.7 g/dm^3, and in regenerator – 2.6-7.4 g/dm^3. Mean value of sludge index was slightly increased and equaled to 150 – 243 cm^3/g, however, with increased sludge zone height it did not cause over-limit concentrations of suspended substances during discharge of treated wastewaters to municipal sewage.

Oxygenating capacity of aeration tanks per BOD_{20} fell within the range 407-2276 g/(m^3·day). Sludge growth during biological treatment of wastewaters was equal to 0.88-1.63 g per 1 g of taken BOD_{20}. During processing of results of biological oxidation of wastewater at Shostka city dairy plant it was determined that these results can be fully described by Ekkenfelder equation. As it was identified, value of constant *K* depends on effectiveness of biological oxidation E, and provided values are > 50-60% this value can be calculated via empiric equation:



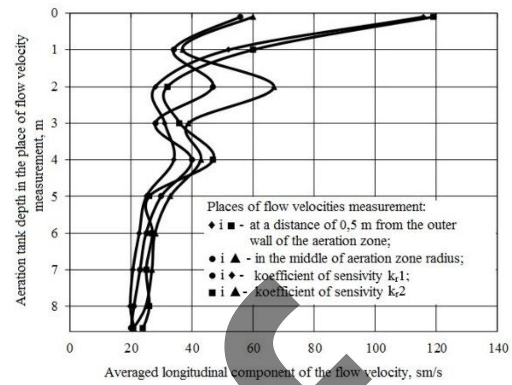


FIGURE 8. Effect of F/M ratio on COD removal efficiency

FIGURE 9. Dependence of the horizontal component of the average flow velocity on the depth of the aeration tank

$$K = 0.126(1-E)^{-0.89}, dm^3/(g.hr).$$

When using aeration tanks-settlers of big hydraulic height with surface jet aeration, the effective stirring of mixed liquor must be ensured in order to avoid sedimentation of activated sludge on the bottom. As a result of theoretical researches based on energy dissipation it was identified that sedimentation of activated sludge is not feasible with power-weight ratio of jet aeration of > 8 W/m^3 [2]. This conclusion was experimentally verified at Shostka city dairy plant via measurement of flow velocity in aeration tanks-settlers. Mean direct-axis component of flow velocity was measured by non-contact current meters connected to milliamperemeter – at a distance of 0.5 m from the outer wall of aeration zone and in the middle of aeration zone radius. Reduction of flow velocity through aeration tank height from 120 to 20 cm/sec (Fig. 9) was identified as a result of this measurement, which reduction is sufficient for maintenance of activated sludge suspended.

As it was said before, water supply system of most milk processing enterprises is based on underground waters [1]. Water quality parameters in most of them do not correspond to technological standards. Besides, not all enterprises have their own groundwater bore and therefore depend on the operation of municipal water treatment installations, performing with uneven hydraulic loadings during the date. Therefore, in our opinion, finding a comprehensive solution to technical, environmental and social problems of small settlements in which the dairy industry is located is a matter of great importance in the nowadays environment.

CONCLUSIONS

1. On the basis of conducting the monitoring of parameters of the quality of underground waters on which systems are based of water supply in small settlements and at enterprises of milk processing industry it is determined that in most cases they are polluted by compounds of Fe^{2+}, Mn^{2+}, NH_4^+, NO_2^-, NO_3^-; phenols, humine complexes, require purification and stabilization treatment.

2.The developed technology is designed for carrying out the comprehensive treatment and conditioning of agressive, near-neutral waters with normal alkaline reserve from ammonia nitrogen (up to 1.5 mg/dm), dissolved organic matter (by PO up to 6.0 mgO$_2$/dm^3), ferrum (up to 5.0 mg/dm^3), phenols (up to 0.05 mg/dm^3) on the basis of using biochemical mehods with productivity from 1000 to 200000 m^3/day.

3. Factors that affect increase in concentration of wastewater pollutions at new type plants in milk processing industry have been analyzed.

4. It has been identified that wastewater pollutants concentrations vary to a significant extent throughout the day, and wastewaters are soured rapidly. To avoid this, it is recommended to direct wastewaters specifically to aeration tanks-settlers, which process will provide blending and neutralization of wastewaters with simultaneous biological oxidation of organic pollutants.

5. When using aeration tanks-settlers of increased hydraulic height with surface jet aeration, the moving speed of mixed liquor is 0.2 to 1.2 m/sec, which allows maintenance of activated sludge suspended. With F/M 50 ratio of 80

to 1450 mg COD/day to g MLVSS the effectiveness of biological treatment at city dairy plant falls within range of 90-98 % per COD.

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The Impact of Modern Technology on Shaping Objects Design Architectural Environment

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Abstract. The article discusses modern technologies in the development of new materials, the use of which improves the quality of products, influences the search for new forms in the design of the architectural environment: landscaping, small architectural forms, bicycle equipment and special accessories for citizens with disabilities. Authors are analyses the results of research on the use of the latest materials of modern scientists in various fields of science: ecology, materials science, economics, mathematics, architecture, building physics, medicine. The concept of development of use of technologies of 3D printing with a combination of recycling are presented. The use of new technologies as the only possible in the conditions of the development of the Moon and Mars and in places of catastrophes, also in social orders for inclusive design, comfortable ergonomic furniture for interiors and urban public spaces. Futuristic possibilities in the formation of architectural objects of architectural environment based on parametric design, bio tectonic and fractal regularities. Review of organoid technologies from nature innovations: banana waste, bamboo fibre in sandwich composites, solar paper, honeycomb paper, bio based architecture was conducted. We noted about the need to address the disposal of products made of modern materials to ensure sustainable environmental development.

INTRODUCTION

Requirements for the scientific approach in the design of architectural environment today characterize by the complexity of technical, industrial, ecological and hygienic, socio-cultural characteristics. With the expansion of opportunities and the rapid development of modern technologies, designers do not have time to adapt to new changes. The regulatory framework, the concept of convenience and aesthetics of design objects in connection with changing social needs is becoming obsolete. The precarious situation in society arises due to epidemic situations, economic decline, environmental degradation, urban sprawl. As a result, social orders appear for inclusive design, ergonomic furniture, convenient for use and recycling. The person locked in his apartment; the boundaries between living and office space are blurred. Accelerating the pace of life, facilitating, and automating the processes of mass production leads to a reduction in the moral life of things. At the same time, the form of production becomes complicated to way of digital technology at decrease in material consumption. Practical implementation requires cooperation with specialists in various fields of science.

The purpose of this article is to analyze the state of modern trends in materials science and determine the prospects for the introduction of additive technologies for 3D printing, recycling, to find new forms of architectural design objects. The scientific material bases on the integration of knowledge from different branches of science: the formation and implementation of innovative building technologies, the psychology of environmental thinking, the concept of sustainable development and the ideas of modern aesthetics.

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FORMULATION OF THE PROBLEM

The problem of application of modern technologies of production of materials for subject-spatial design of interiors and design-objects of urban environment due to economic necessity of updating of qualitative characteristics of objects of design of architectural environment. Using innovative approaches to the use of rapid globalization of the world market, reducing life-cycle placement of the transition to full automation.

One of the sections of the European Strategy for Smart, Sustainable and Integrating Growth from 2020 is devoted to the problems of forming and implementing a new industrial policy in Europe in the context of globalization. It envisaged solving a number of tasks aimed at diversifying the industry, creating the competitiveness of the industrial base with the active use of energy-saving technologies, taking into account environmental feasibility. An important environmental problem in this point is the processing of raw materials and the possibility of its secondary use.

Requirements for a balanced human environment are gaining new meaning in favour of sustainable development, environmental sustainability, structural and functional integrity of components in the new environmental, socio-economic conditions. The use of high-tech technologies opens up today's and futuristic possibilities in the design of the architectural environment associated with the digital design algorithm and computer modelling methods. Thus, the bio design of subject-based based on a comprehensive analysis of the principles of shaping living systems in order to use them to create new appropriate design solutions [1]. The search for new opportunities for the design of design objects in Ukraine is associated with the problem of lack of style in the improvement of urban areas, widespread uniform unified objects of street design. The need for a highly ergonomic design makes it possible to set precise anthropometric parameters for people with disabilities.

APPLICATION OF MODERN TECHNOLOGIES IN THE DESIGN OF THE ARCHITECTURAL ENVIRONMENT

The principles of optimal use of modern technologies illustrate the theoretical achievements of scientists on the functioning and application of innovative technologies for the manufacture and operation of materials, the practical basis for the manufacture and testing of new materials, the benefits of additive technologies, and quality assessment in different conditions. An important aesthetic aspect is the influence of digital technologies on the design of surfaces, shaping objects. Recommendations and examples of application in the design of the architectural environment as fragments of facades, pavilions, small architectural forms, street furniture and special equipment.

Theoretical and Practical Basis for the Development and Use of New Technologies in Manufactured Materials

The relevance and benefits of the use of additive technologies in the production of modern materials for use in the design of the architectural environment are evidenced by recent studies of such Ukrainian scientists in architecture and engineering as: Myhal S, Dyda I, Kazantseva T, Abyzov V, Androshchuk H, Grechko O, Zgalat-Lozynska L, Lebedyeva O, and others. It should be noted that the scientific work of these scientists is based on the results of developments and tests of Japan, the United States, the European Union, England, the Netherlands and China. German scientist Dr. Peters S travels around the world lecturing on new materials made to environmental biological materials.

3D printing technology has given rise to many legal discussions about the new legal relationship, copyright protection and its consideration as a possible locomotive of the innovative economy [2].

Among the main trends in the development of additive technologies in construction should be highlighted: appropriate investment for economic efficiency, reduction of human effort and mistakes; combination of functional, aesthetic qualities and strength of interior load-bearing partitions, furniture and exhibition structures with the help of “C-Fab” and “Mesh Mold” technology; adaptation of the use of robots for the manufacture of structures in places of global catastrophes [3]. This new direction is experimental for space exploration. NASA has begun experiments with 3D printing in space and, first of all, these technologies are planned to be used in the project of exploration of the Moon and Mars. In experimental and competitive design, such technologies of construction production are put [4].

3D printing laboratories are also becoming recycling centres, such as the Zero Waste Lab in Thessaloniki, which recycles plastic waste that will later become municipal furniture. Founded in 2015 in Rotterdam, the Netherlands, New Raw Studios is exploring ways to close the cycle of plastic use. The beginning of the Print Your City initiative marked by the creation of the XXX shop; the concept envisages the production of functional elements of the city infrastructure from plastic waste using 3D printing. Designers Jiang Zeng and Honghai Deng, graduates of the Massachusetts Institute of Technology and Harvard, recently developed the "Illusory Material", a new method of 3D printing that allows you to create products with incredibly unique optical and physical properties. Industrial designers and product designers can control the colour, texture, and refractive power of individual three-dimensional pixels in a material. The Dutch architectural firm DUS Architects uses bioplastics based on linseed oil for printing objects. Karlsruhe Institute of Technology has developed a polymeric material with a "bone" structure. This is the first development that has experimentally proven that materials can be created with a density less than water and strength as steel. The invention became possible after the German company Nano-scribe created a system that allows you to "print" three-dimensional materials with specified characteristics. The technology of creating objects by sequentially applying layers of material can be used both at the stage of manufacturing a prototype and the final version of the finished product. The advantages are material savings, as opposed to the method of "removal of excess material".

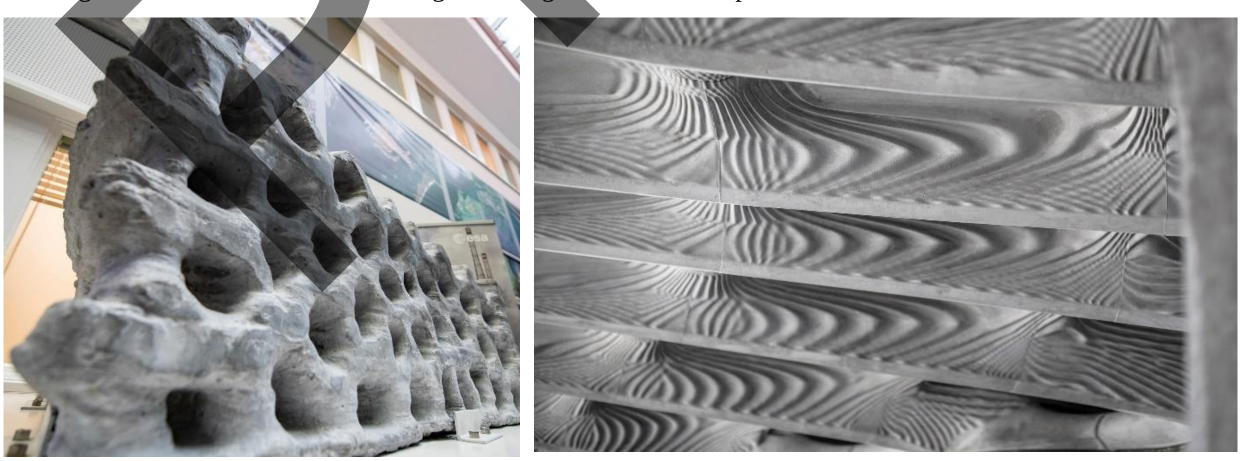
Some methods are based on melting or softening of materials to create layers: these include selective laser sintering (SLS), selective laser melting (SLM), direct laser sintering of metals (DMLS), printing by layer surfacing (FDM or FFF); production of solid models due to polymerization of liquid materials (SLA); lamination of sheet materials (LOM) using paper, polymers and metals. Each of these methods has its advantages and disadvantages [5].

The use of 3D technologies is related to the environmental aspects of forming design objects from recycled and reused resources. A variety of materials from metals to stem cells are used as "inks", but plastic remains the most popular. Currently, a wide range of additive production methods is available. The main differences are in the method of applying layers and consumables.

The problem of waste disposal is extremely relevant today. It is complicated by the fact that everyday goods have a short service life. Global brands are actively involved in this task and develop programs for the disposal of plastic, old things, garbage and even furniture. The method of recycling is used by both Ukrainian and European designers, which allows the use of available raw materials, its processing and the creation of eco-design elements.

Characteristics of Modern Materials that Influence the Formation of Architectural Design Objects

New products, application technologies and prospects for the development of 3D printing technology in the design of the architectural environment achieve not only the idea of full automation of production using flexible technologies to produce high quality mathematical precision products but also the complexity of bionic forms of design objects. The design tools used in parametric architecture are still far ahead of the means of production, and the constant practice of using 3D printers and industrial robots on construction sites is not enough to reveal complete freedom of design. If in the design of 3D, printers are already beginning actively used, then in architecture these are only isolated cases. New materials have a high level of ability to imitate, as well as high-quality functional capabilities (Figure 1). Undoubtedly, most of the profession is not able to join the new trend due to its technical unpreparedness and unwillingness to restructure to a new design thinking "nonlinear" and parametric architecture.



(a) (b)

FIGURE 1. Construction and aesthetics elements made by 3D printing technology**: (**a) – Lunar building block [6]; (b) – "Digital Concrete" by Andrei Jipa [7].

The fractal approach in shaping can significantly enrich the language of architectural and design practice. The transition to a new paradigm in architecture under the influence of the science of complex systems, including fractal geometry and nonlinear dynamics is possible using additive technologies. It should be note that the architecture uses simplified fractal rules of construction using a limited number of repetitions, changing the algorithms of their construction, violation of strict similarity by introducing different variations, to wit using quasi-fractals multifractal structures [8]. Architect and theorist Charles Jenks in his article "A New Paradigm in Architecture" described the emergence of a trend in architecture that includes fractal geometry and nonlinear dynamics. Based on an analysis of several key contemporary buildings, he noted that new bio tectonic and fractal architectural forms are more interesting and more relevant to our perception of the world than the endless colonnades or modernist hinged glass facades we inherited from the past [9]. Basic design techniques in subject bio design: stylization of a certain aspect of a natural prototype, sculptural interpretation of form, parametric design, use of natural raw materials and industrial waste [1].

Among the invented raw materials for 3D printers, should be note the properties of illusory material for creating sensory products that enrich the interaction between people and objects, which is important in the design of the architectural environment. Accurate calculation of street equipment parameters should meet the needs of inclusive urban environment. Exclusive requirements for the design of interior items, taking into account the ergonomic requirements of a particular customer will make them more organic and easy to use. The variability of computer-generated replicants will ensure compliance with the norms and special needs: garden and street furniture for children, the elderly and the disabled. Sanitary requirements in an unsettled epidemic situation require not only easy treatment and remediation of surfaces, but also new shaping of park equipment to ensure the least contact between groups of people. Along with new materials for additive production such common materials as glass, metal, wood, stone acquire a new manifestation. Modern approaches in the modification and addition of these materials significantly extending their service life expand the possibilities of molding. Durable and static-dynamic qualities of "improved" glass, cellular polycarbonate products, imitation of some materials by others, the development of nanotechnology will lead to the ability to use controlled plastic deformations over time [10].

Features of application of new technologies at development of elements of design of the subject environment

Numerous examples of the application of new technologies in the development of design items and small buildings and pavilions replenished every year. The range of products that can be produce is also expanding. We will look at examples of different objects of architectural environment design and formulate recommendations for approaches to their manufacture, operation and disposal.

Among the largest "printed" currently monolithic objects is a plastic bridge in China, work on which completed in 2019. The project implemented by the construction company Shanghai Construction Group with the support of the developer of industrial additive systems Coin Robotics Technology and the manufacturer of consumables for 3D printing Polymaker. Structure printed on a 3D printer installed in the Taopu Smart City techno park in Shanghai's Puto district. In the construction of the bridge was used engineering plastic with the addition of fiberglass to strengthen the structure. The modern 3D Stoofbrug bridge was "printed" from steel and opened in July 2021 in the center of Amsterdam (Figure 2).

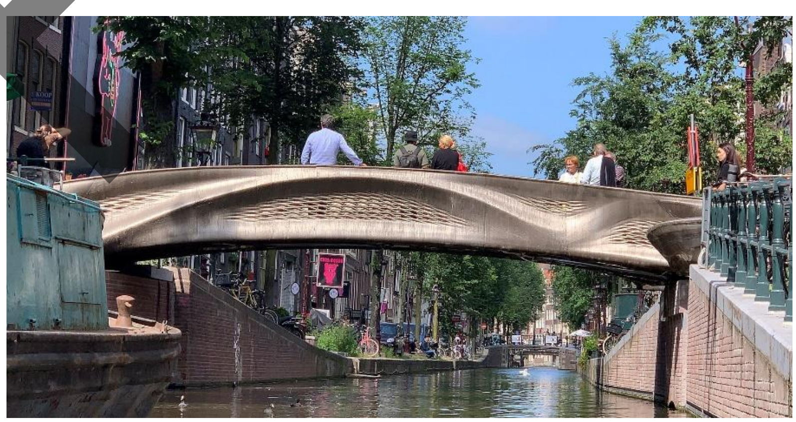


FIGURE 2. Stoofbrug Bridge made on a 3-d printer, Amsterdam [11].

Of the buildings completely printed on a 3D printer, the famous office in Dubai. Architects Yingchuang Technology Co. Limited. Parts of houses, concrete blocks, tiles and decor for facades printed more often. Concrete for 3D printing by CyBe Mortar is a specially designed quick-drying mixture. Components of buildings such as frames and walls printed separately from each other on huge 3D printers longer than 30 m, 10 m wide and 6.6 m high. As for environmentally friendly materials – they are successfully use in 3D printers and "ink" consists of soil, clay, silt, sand taken at the construction site, crushed straw, husks and hydraulic lime [12]. The Dutch architectural firm DUS Architects has decided to demonstrate how it is possible to build shelters for people in areas affected by natural disasters with the help of 3D printing. The volume of the house is 25 m^3. To create the walls, an unusual geometric structure resembling honeycombs used, which allows strengthening the building without the use of frames. Another example is a full-scale residential building built using 3D technologies (Figure 3).

FIGURE 3. House Wallenhausen built using 3D technologies [13].

Elements of urban design must also change over time as exhibits in modern exhibition complexes. It is increasingly believe that in the future, resource shortages will force communities to grow their own products. Conventional building materials, such as brick and concrete, replaced by bioplastics, a renewable material derived from agricultural products. The components of this material should be prepared from organic matter: sunflower, potatoes and apples, which grown on site by visitors to the buildings [14]. New efficient materials, including recycled materials, reduce the cost, speed up the construction process, reduce operating costs and improve the environmental condition of cities. This is a variety of products made of polymer composite materials or recycled plastic as a decoration of facades, urban furniture [15].

Among the objects of architectural environment design in this article, we highlight pavilions, small architectural forms, equipment in the urban environment, landscape and recreational areas, as well as interior elements. "Random elements" by the German designers Shapes in Play design studio Johanna Spath and Johannes Tsopanides create based on the use of the physical manifestation of sound or noise. The idea of "living" design, when the surface texture of the vase reacts to sound with horizontal shifts (Figure 4).

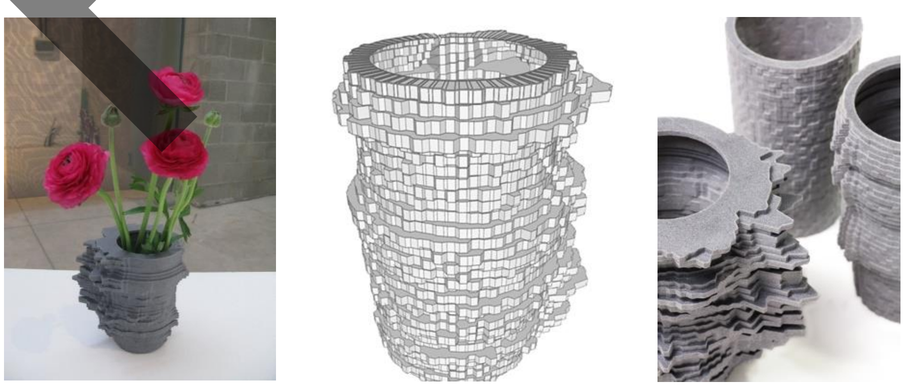


FIGURE 4. Sound Plotter project "Random elements" by Johanna Spath and Johannes Tsopanides, Germany [16].

In addition, relevant and promising direction is organoid technologies from nature innovations: waste and bamboo fibre in sandwich composites, solar paper, thermosensitive wallpaper, Honeycomb paper and bio based architecture, air purifying surfaces nanotitandioxide [17]. Modern construction materials companies are implementing a new approach aimed at developing biological foundations for the coating. The use of resins, which contain up to 52% plant-based carbon, used as 3D printing ink and facade paint. This expands the horizons of sustainable development in the field of decorative materials (Figure 5).

FIGURE 5. Eco-sustainable 3D printed house "Tecla" [18].

Recycling "garbage" is the process of transforming waste into new materials and objects. The use of recycled materials to create urban design elements is a visual message to city residents and visitors that this is an important issue today. Recycling of a material involves its ability to regain the properties it had in its original product. This approach used in 3D printing. Uniseafish made from recycled aluminum beer cans. Installation aimed at reminding about the need to follow the postulates of sustainable development. Clothing made from recycled plant biomaterials is already flooding the market. Exhibits-installations of extravagant specimens from garbage are also a kind of protest and a reminder of the need to save resources. A dress by Adrienne Duck from recycled materials discarded coffee filters (Figure 6).

(a) (b)

FIGURE 6. Installations made of recycled materials (a) – Uniseafish at the Pest bridgehead of Lánchíd, Budapest [19]; (b) – Dress for less by Adrienne Duck – Dress made out of recycled materials [20].

It takes into account current topics that have been developing in Ukraine in recent years regarding the development of cycling infrastructure, the formation of a barrier-free environment and the reconstruction of parks [21]. With the development of cycling infrastructure in different countries, the installation of single units for long-term and short-term storage of a small number of bicycles, street boxes, covered parking lots and rental points and open equipment at public places deserves considerable attention. The project, called “Plastic Road”, involves the pipeline company Wavin, the energy company Total and the engineering company KWS. The first recycled plastic bike path is being tested in Zwolle, the Netherlands. It consists of modular sections, contains sensors to measure the length of the path, the number of cyclists riding on it, and temperature, resistant to weathering and wearproof [22].

Equipment and special devices to create a barrier-free environment: handrails, pavement form and shape, equipment of pedestrian crossings, exclusive parts for special equipment, touch devices, etc. - it is advisable to make using modern technologies and materials that have smart properties. Mathematical calculations and accuracy of anthropometric parameters will help to eliminate errors and damage during operation, which justifies the cost of design and construction.

CONCLUSION

The revolution in shaping caused by the production of polymer materials has led to the emergence of new styles in design. Complications of forms based on the principles laid down in bionics and technologies of artificial morphogenesis of fractality have become possible with the development of digital technologies. Three-dimensional printing technologies undoubtedly have the advantage of saving time and money in the production of objects of varying complexity compared to traditional, improving the technology, quality and properties of materials. The accuracy of the ergonomic characteristics of architectural design objects makes it possible to create a safe life and health of city dwellers. New qualities of composite materials require research on safe disposal of products. The properties of the combination of different components require further research at the intersection of environmental, materials, economic, mathematical, architectural, medical, biological sciences.

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Study of The Properties of Arbolite Based on Hemp Shives and Ferroalloy Industry Wastes

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Abstract. The article discusses the possibilities of using agricultural and industrial production wastes in the composition of arbolite. To improve its performance characteristics, hemp shives were used as an aggregate and ferroalloy industry waste in the form of wet gas cleaning sludge of ferrosilicon production was used as an additive. Compositions of mixtures of heat-insulating and structural-thermal insulating materials for energy-efficient wall cladding with improved physical and mechanical characteristics that meet modern regulatory requirements have been developed. The effect of the mixture of wet gas purification sludge from ferrosilicon production on increasing the compressive and transverse bending strength of arbolite is considered. The use of hemp shives and wet gas cleaning sludge from ferrosilicon production contributes to solving the environmental problem, namely, the utilization of agricultural and industrial production wastes.

INTRODUCTION

The practice of modern construction of energy efficient comfortable houses is represented by various construction materials on Ukrainian market. The main examples are bricks, aerated concrete, coquina, ceramic blocks, wood. But in order to meet the requirements of the regulations on the energy efficiency of buildings, to save energy resources for heating, the thickness of single layer walls made of traditional materials will have an impressive size and, accordingly, becomes economically unprofitable [1]. Therefore, to reduce the thickness of the wall of these materials should be performed with an outer layer of insulation. This leads to another technological process, which is performed in a separate flow by separate staff, increases the duration of construction of the house and affects its cost.

Due to the reduction of non-renewable natural resources used in the production of various building materials, there is a question of finding new sources of raw materials. In this regard, cellulose-containing organic waste generated after harvesting agricultural crops can be a promising source of raw materials. One of the ways of sustainable use of agricultural waste is its utilization as a filler for thermal insulation and structural-thermal insulating walling.

An effective building material consisting of organic agricultural waste is called arbolite [2-4, 7]. It is made from a mixture of organic aggregates: hemp shives, flax, shredded wood waste, reeds, husks (up to 90%), a binding component (usually Portland cement) and water. To accelerate the hardening of concrete, hardening accelerators (chemical additives) are used.

Arbolite is a unique material that combines the best properties of natural materials of wood and stone. It was invented in the Netherlands in the 1930s. It has gained great popularity on all continents. The greatest development of construction using arbolite can be seen in Europe, Canada, USA and Australia. This is due to the ease of production, exceptional environmental friendliness and low thermal conductivity of arbolite.

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In Ukraine today there is an interest in this type of building material and, accordingly, an increase in the number of areas of its application [8-11, 16]. This is due to a number of properties of arbolite: strength, fire resistance, biostability and low density, thermal conductivity, ease of processing with cutting tools.

The use of arbolite as a wall material also solves the environmental problem, namely, the disposal of agricultural waste.

A variety of arbolite is kostrobeton. Kostrobeton with the use of hemp shives as an organic aggregate is used for the construction of exterior and interior walls of buildings. The authors are convinced that kostrobeton is the most successful type of arbolite, which is ideal for the role of modern, environmentally friendly and energy efficient wall material in construction.

To select the composition of arbolite mixture it is necessary to know how certain technological factors (type and cost of binder, aggregate, as well as the method of formation and hardening conditions) influence the basic properties of arbolite - strength and density. Various additives are used to increase the strength of such materials. Industrial waste can be used as an additive. In order to increase the strength of hemp shives-based arbolite, the authors used a waste product from the ferroalloy industry - wet gas cleaning sludge from ferrosilicon production. A complex of research and experimental work on the basis of various combinations of shives, cement and additives was carried out.

Despite the existence of numerous studies in the field of improvement of arbolite technology, further search for ways to effectively use industrial and agricultural wastes and thereby improve the quality of the product is very relevant [5-6, 8-11, 12-15].

MATERIALS AND METHODS

Hemp shives is a complete filler for arbolite. However, it contains a lot of sugars, which requires the mandatory use of chemical additives. Hemp shiv is a part of a stem, which is formed as a waste product during the mechanical processing of raw materials. Hemp shives consist of cellulose (42-55%), lignin (19-27%), and pentosans (22-25%).

Hemp shives from the rope plant in Kharkiv was used for the research. Experience shows that arbolite is of higher quality when the filler is needle-shaped and elongated, with an average particle size: length 5–25 mm, width and thickness of 1–5 mm. For the appearance of hemp shives, see Fig.1.

FIGURE 1. Appearance of a hemp shives

Portland cement ПЦ-500 Н I from Balakleya cement plant of Kharkov region was used as a binder in the experimental studies.

The following additives were used:

- liquid glass of JSC "Ukrainian Silicate" Kherson with silicate module 2.6 and density of 1.36 g / cm3, which meets the requirements of TU U 24.1-32725542-001: 2010;

- calcium chloride CJSC "Kharkovrekhim" anhydrous.

Chemical additives made it possible to use hemp shive without prior conditioning, because the sugars are neutralized and the quality of products and structures is improved.

To increase the strength characteristics of arbolite we used a waste product of the ferroalloy industry - sludge from the wet gas treatment of ferrosilicon production, which had lain in the sludge basin for more than 25 years after production. The chemical composition of the sludge is shown in Table 1.

TABLE 1. Chemical composition of wet gas purification sludge from ferrosilicon production.

Sludge name	**Component Content, %**										
	SiO_2	Fe_20_3	$A1_2O$	CaO	MgO	K_2O	Na_2O	TiO	P_2O_5	MпO	Other material from smelting
More than 25 years after production	81,3	3,6	3,5	1,2	1,0	0,9	0,65	0,1	0,03	0,01	7,71

The process of formation and compaction of the mixture occurred without applying load, i.e. with the usual vibration on the vibrating table.

RESULTS AND DISCUSSION

The high content of fiber particles in arbolite gives the products and structures made of this material improved mechanical properties, which are confirmed by the results of bending tension tests. According to these mechanical indicators arbolite confidently outperforms many well-known building materials, among which is such a popular material as aerated concrete. Hemp shives perform a reinforcing function, which explains the increased strength characteristics of the material.

Different types of arbolite vary in density and, consequently, strength. The main characteristic of hemp shives arbrolite is its compressive and bending strength, which is taken into account when choosing the floor structure and type of interfloor ceilings.

By changing the content of wet gas purification sludge of ferrosilicon production and binder, wall heat insulating and structural-thermal insulating material with certain strength and density indices are obtained. The results of the studies are given in Tables 2 and 3.

TABLE 2. Compositions of arbolite mixtures base on hemp shives

№	**Composition name**	**Amount, kg/m^3 of arbolite**				
		shives,	**cement**	**chemical additives**	**sludge**	**water**
1	Composition (test) of thermal insulation on cement of the PC-500 grade	150-180	290	Na_2nSiO_2 19	-	380
2				$CaCl_2$ 9	-	380
3				Na_2nSiO_2 19	58	390
4				$CaCl_2$ 9	58	390
5	Composition (test) Structural and heat-insulating on cement of PC-500 grade		445	Na_2nSiO_2 19	-	514
6				$CaCl_2$ 9	-	514
7				Na_2nSiO_2 19	90	535
8			450	$CaCl_2$ 9	90	535

TABLE 3. Indicators of arbolite samples based on hemp shives

№	Composition name	Average density, ρ_o, kg/m^3	Compressive strength, R, MPa	Flexural strength, Rd, MPa	Water absorption, %	Coefficient of thermal conductivity, λ W/m^2 K
1	Composition (test) of heat insulation with cement of PC-500 grade	494	1,9	1,3	61	0,097
2		497	2,0	1,3	66	0,099
3		511	3,1	1,9	54	0.11
4		513	3,0	1,8	56	0,12
5	Composition (test) Structural and heat-insulating on cement of PC-500 grade	724	3,4	2,1	53	0,134
6		731	3,5	2,2	55	0,135
7		740	6,1	4,1	49	0,134
8		752	6,0	4,0	51	0,135

High activity of wet gas purification sludge of ferrosilicon production, which affects the processes of hydration, structure formation and, ultimately, the structure of hardened cement stone and arbolite, is due to the presence of silicon dioxide of amorphous modification and the nature of ultradispersed particles (spherical shape).

The main factor in the mechanism of action of the slurry is the reaction between silica and calcium hydroxide with the formation of low-base hydrosilicates such as $Ca(OH)_2 + SiO_2 + mH_2O = CaO{\cdot}SiO_2nH_2O$; CSH (I) and the ratio CaO/SiO_2 from 0.9 to 1.3, which ultimately contributes to improving the strength of hemp concrete.

Using the developed thermal insulation compositions of hemp concrete on the basis of hemp shives, a one-storey apartment house was built in Kharkiv see Fig. 2.

FIGURE 2. Hemp concrete wall, made using monolithic technology

CONCLUSIONS

Introduction of wet gas purification sludge from ferrosilicon production into arbolite mixtures makes it possible to improve compressive strength indicators by more than 1.7 times, and transverse bending strength indicators by more than 1.8 times.

As a result of laboratory research and tests of compositions, it has been established that hemp shives can be used for production of heat insulating and structural insulation material (arbolite) with improved physical and mechanical properties for residential and industrial buildings and structures that meet the requirements of DSTU. Buildings constructed of arbolite on the basis of hemp shives can reduce the overall cost of construction by reducing the cost of additional insulation.

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Conceptual Issues of Abandoned Construction Projects' Revival Based on Building and Information Modeling (BIM Technologies)

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Abstract. The article concerns scientific approaches to solving the problem of revival of abandoned (desolate) construction projects, a significant number of which exists in our country and abroad. The presence of abandoned (unused) facilities leads to both inefficient use of land resources and environmental damage, damage to the state and the owners of such facilities. The urgency of the problem also lies in the insufficient state policy on the issues of abandoned projects' revival and in the practical absence of a scientific and methodological base that solves (or approaches to solving) the problem. An attempt has been made to develop a general concept and an enlarged algorithm for revival of abandoned construction projects, considering the entire life cycle of the revival with possible alternatives: from liquidation to the selection and implementation of the most effective use based on the idea of construction information modeling (BIM technologies).

INTRODUCTION

Formulation of the problem. One of the problems is the large number of abandoned construction projects (hereinafter referred to as ACPs) and the very low number of those being revived. Moreover, the rate of occurrence of ACPs increases much faster than the process of their revival. In addition, an important problem is the lack of state policy on the revival of such facilities, which is manifested in the lack of effective government incentives for revival of the facilities, as well as the lack of regulations, and scientific and methodological developments on this topic. This also applies to using of a relatively new approach to the management of construction in the form of information modeling (BIM). While this approach is increasingly used for new construction and renovation, BIM technology has not been developed for abandoned buildings.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Analysis of research as to the revival of abandoned buildings has shown that there are no regulatory requirements directly related to abandoned buildings. Some aspects of ACPs are given in [6, 7, 11-15]. The works of domestic and foreign scientists Afanasyev A.A., Goncharenko D.F., Kirnos V.M., Kravchunovskaya T.S., Radkevich A.V., Savyovsky V.V. and others are connected with the issues related to the revival of ACPs. The use of BIM-technologies is considered in the works of Trach R.V., Barabash M., Kozlov I. and others. In general, it should be noted the lack of research to address the problem under consideration.

Isolation of previously unsolved parts of the overall problem. Unsolved parts of the revival problem are still issues of substantiation of decisions on construction project revival in the conditions of multifaceted task related to involving a large number of experts in various specializations, development of management and technological models, and

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economic justification of ACPs revival. In terms of possible using the idea of BIM technologies for revival of ACPs unresolved issues remain software information models.

DEFINITION OF THE GOAL AND TASK OF THE INVESTIGATION

The purpose of the study is to develop a general concept of the ACPs revival, focused on creating scientific, methodological and administrative conditions of the block diagram algorithm, on planning and optimizing the management and investment model of the process. To achieve this goal, the following issues should be considered:

- analysis of definitions related to ACPs revival;
- analysis of the reasons for spreading ACPs in our country and abroad;
- justification of the need to create a system of state incentives (regulation) for ACPs revival;
- systematization of possible ways of ACPs revival;
- development of methodological foundations for the revival of ACPs, which are of cultural and historical value;
- development of methodological foundations of ACPs cost estimation;
- definition and substantiation of using methodical approaches and estimation procedures for different types of ACPs and types of estimation;
- development of the general block diagram for ACPs revival process algorithm in the frame of construction and information modeling (BIM).

PRESENTING THE MAIN ISSUES

Within the framework of the set goal, it is necessary to consider the definition of basic concepts before presenting the main issues. Such concepts should include the revival of ACPs, reproduction, organizational and technological modeling of the processes of revival and reproduction. The revival of ACPs should be understood as a set of actions aimed at transforming an abandoned project into an object that functions according to the accepted purpose. Such an object can be an existing building restored for the old or new purpose, or a land plot free of development for further use. Reproduction of ACPs should be understood as renovation of the object according to the old or new purpose. The management and technological modeling (MTM) should be understood as a complex consolidated or detailed process of revival or reproduction of ACPs.

To find ways to revive ACPs, it is necessary to analyse the causes of this phenomenon. By analogy with a living organism, ACPs is the result of a disease for the treatment of which it is necessary to determine its cause. Systematization of the causes of ACPs indicates the following possible options: financial and economic (the emergence of significant initial and current costs for further operation); socio-psychological (further operation is not prestigious, because of the emergence of more convenient for its intended purpose analogues); urban (architectural solutions are outdated and do not meet modern urban planning requirements); technical condition (presence of defects and damages that prevent further normal and safe operation); production (obsolescence of technical solutions that exclude the possibility of performing existing technological processes to create competitive products); environmental (emissions from the ACPs production processes into the environment are unacceptable for normal life); natural (exhaustion of natural resources used in the operation of ACPs); political; anthropogenic impact on the environment; construction errors, etc.

Determining the causes of ACPs occurrence is necessary both to find ways to reconstruct the projects, and to address issues of stimulating administrative measures to revive the projects. An important reason for the large number of ACPs is the lack of effective incentives from the state, which should promote their revival and find ways to revive.

Based on the presented analysis (Table 1) for possible uses of ACPs, the following uses are considered: dismantling the building; maintaining the original purpose; changing the purpose to the needs of the user; and finding the most efficient use.

It is known that a large number of ACPs are buildings and structures that have the status of cultural and historical monuments. The decision on their optimal use should be determined not only taking into account the economic feasibility of conventional preservation, but also the possibility of using them as museum and other exhibits.

To make decisions as to the further use of ACPs, it is important to determine its market or other appraisal at various subsequent stages of the ACPs life cycle. The peculiarity of establishing the appraisal of ACPs in comparison with the common estimates for nowadays is the need to determine the appraisal for the forecast period, which is associated with complex predicting calculations.

TABLE 1. Systematization of options for the use of ACPs

Options for using the software							
Elimination options			**With maintaining the intended purpose**			**With the change of purpose**	
Option to use land rights	Option to dismantle structures	Option to sell the extracted materials	Technical condition	Spatial planning solutions (SPS)	Design solutions (DS)	In the interests of a particular user	With MEU for the typical user
Without preserving the land rights, which are passed to the local authorities	Preservation of materials, and correspondding costs for dismantling	Use for own purposes	Complex of repair works on reproduction in the initial condition	Without changed layout of premises	Without changing design solutions	Changes tailored to the interests of particular users	Choice of option based on verbal analysis of advantages and disadvantages
Preservation of the intended purpose, with preservation in the original form	With partial preservation of materials and corresponding costs for dismantling	Selling them on the secondary market in its original form	A set of repair works to reproduce the optimal technical condition	With changed layout of premises without the need for permits	With the strengthening of load-bearing and enclosing constructions with the development of the project	Changes tailored to a particular user	Choice of option based on qualimetric model
Change of purpose, the right to land is determined based on the MEU	No storage of materials and minimal dismantling costs.	Implementation on the secondary market taking into account MEU	A set of works on modernization and reproduction of the original state taking into account the MEU	With changes in SPS on the basis of the project taking into account MEU	With reconstruction taking into account MEU	Changes tailored to the interests of a particular user	Choice of option based on economic and mathematical model

Given the above, we propose a block diagram of an enlarged algorithm for the implementation of BIM technology for the revival of abandoned construction projects for various purposes taking into account the whole life cycle, which includes different stages of the model in the form of blocks. Each unit needs software. The sequence of blocks reproduces the concept of information modeling in construction. The blocks have different degrees of development. Thus, if the blocks that reproduce the 3D design process in many cases have sufficient software, the blocks designed for the long-term perspective require complex predictive research, the results of which are of probabilistic nature. This also applies to the estimation of the market appraisal of ACPs at each stage of the life cycle.

TABLE 2. Block diagram of the enlarged algorithm BIM for ACPs revival

Links between blocks	**Block**	**Block number and description**	**Notes and explanations, the main tasks of the block**
		1 Collect source information about the object	Historical data about the object, source documents
		2 Legal identification of the building	Legal affiliation
no (on block 5)		3 Is the object ownerless?	
		4 Owner identification procedure	
no (on block.8)		5 Is the site a cultural and historical heritage site?	
		6 Determining the level of cultural and historical value	
yes (on block 9)		7 Is the cultural and historical value of software sufficient for revival?	
		8 Obtaining a certificate of ownership for further use	
		9 Technical (comprehensive) inspection of the building	Report on the results of the survey, recommendations
no (on block 12)		10 Is there an economic feasibility of reviving the object?	
		11 Formation of organizational and technological models of liquidation of the object	
		12 Determining the most efficient use of land and its value	The liquidation option is final.
		13 Formation of criteria and limitations of BIM	
		14 Choosing the best option for further use of software, determining the cost	Type of cost depending on the purpose of the ACP
		15 Formation of BIM recovery of the ACP according to the optimal variant of use	Including all stages of the full cycle
Is there a contradiction? (to block 10)		16 Development of design documentation for CAD 3D program for object reproduction	The contradiction here and hereafter means imperfection or errors in the stage
Is there a contradiction? (to block 10)		17 Development of a computer program for 4D project implementation over time (Fragments of PCMD and WPP)	
Is there a contradiction? (to block 10)		18 Development of a 5D computer program with cost control (with the development of a fragment of budget documentation	
Is there a contradiction? (to block 10)		19 Development of a 6D computer program in terms of control over efficient operation	
Is there a contradiction? (to block 10)		20 Development of a 7D computer program in terms of control at all stages of the cycle	
		21 Finding a sponsor to carry out work on the revival of the object	
		22 Monitoring the development and implementation of BIM	
		23 Analysis of BIM results	

CONCLUSIONS

1. Abandoned facilities in Ukraine and abroad have a high prevalence and a significant negative impact on the normal functioning of the population, causing great damage to the public and private economy.

2. The process of revival of abandoned objects is a complex multifaceted task, the solution of which requires a large amount of financial, human, material and information resources.

3. The use of BIM technologies for the revival of abandoned facilities will allow qualitative solving this problem from a long-term perspective.

4. Further research should be conducted to identify promising solutions at each stage of the life cycle and software development.

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"Green" Roofs as a Crucial Element for Energy Efficiency. Cases of Library Buildings

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Abstract. The paper studied 6 public buildings with the roof gardens of various sizes and arranged at different heights. It provides arguments for the relevance of the research and its topicality in the current context. Modern methods and technologies for arranging "green" roofs, with their key characteristics, have been provided. The analysis focused on the green roofs of libraries as public buildings since they have long been centers of ethical and aesthetic education for various social groups.

INTRODUCTION

Presently, energy efficiency of buildings has been critical on a global scale, the same as compensation of vegetation, reduction of volume and flow rate of rainwater from the roofs, and their heating temperatures decrease. Modern buildings roofing materials may overheat during heat waves and radiate the heat and hazardous substances, which strongly affects the condition of the air basin in the city and its climate.

One such most innovative and interesting solution to address these issues is the "green" rooftops systems. Environmental concerns and the issues of drastic decrease of green areas in big cities re-inspired the interest to "green" rooftops for big cities back in the 1960s. The large-scale feasibility studies have been undertaken. A key motivation for the research was about the benefits stemming from the reduced volumes of urban sewage and the improved air and water quality. As a result, the entire sector developed in the construction industry, and the "green" rooftop became an integral part of cityscapes.

TOPICALITY

A rooftop is an important element of a building's architecture. The roof's dimension and decorative appearance define the silhouette and attractiveness of the site. The "green" roof is particularly relevant for big cities with their high-rise buildings, and arrays of concrete and asphalt, whereas the sites of wildlife fade away. Since rooftops have large empty spaces that are usually not used for anything, they can be transformed into gardens and parks.

On the basis of theoretical and practical international experience, the paper suggests energy efficiency measures to improve the environmental situation through the roof greening technology for such public buildings as libraries. The prospects for further research and development of the issues will help identify public sites which rooftops could be reconstructed and planted.

Description of "green" roofs

A "green" roof is a multi-layered cover with the top layer either fully or partially planted with vegetation. The most important is the waterproofing layer as it protects the roof against moisture and prevents root penetration into the roof.

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To prevent moisture accumulation in the soil, a good drainage system shall be engineered. On top of drainage, a geonet is added, to avoid soil sliding. The soil layer is then spread into the geonet (Figure 1).

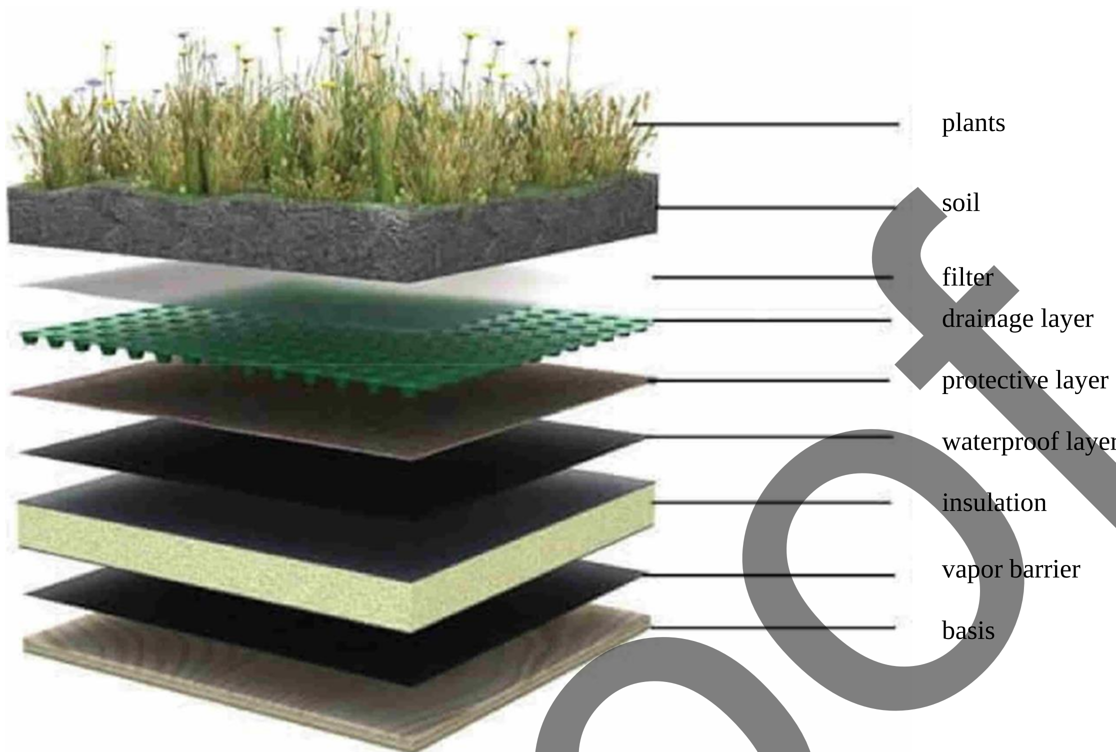

FIGURE 1. “Green” roof structure [1]

Due to water evaporation, to the soil thermal insulating property, and to the reflection of sunrays, the "green" rooftop can significantly cool the air in summertime – from 80° C to 25° C. The flat roof helps re-enter into the atmosphere at least 1 % of moisture. On the other hand, a thin layer of planting soil (10 cm deep), covered with grass, can retain up to 20 % of atmospheric precipitation. In summertime, the “green” roofs can retain up to 60–80 % of the rainfall. In wintertime, they retain 25–40 % [2].

Advantages and Disadvantages

The "green" roofs have a series of advantages. By way of example, the eco-benefits may include better air quality (urban air filtration and dust and dirt absorption at a rate of 0.2 gsm/day); improved water quality (rainwater filtration through the substrate); urban air cooling by 1-2°C; balancing the humidity of urban environment; additional photosynthesis process; accumulation of 30-90 % of the rainwater in the bedding; gradual re-entering of some moisture accumulated in the substrate into the atmosphere, after some time ("green" roof returns ab. 60 %); reducing the "peak" load on the building’s water sewage system and urban sewage system; extinguishing noise fluctuations from traffic down to 8 dB and reflecting up to 3 dB; and absorption of the electromagnetic "smog" by plants.

The economic benefits of the "green" roof may be described as protecting the waterproof membrane from solar radiation (UF); protecting the waterproof membrane from rapid change of temperatures (additional thermal protection in summer and winter time); reduced cost for heating and cooling of the building’s top floors; the rooftop useful life may last up to 50 years. The commercial advantages of the "green" roof lie in the creation of various landscapes and sceneries on the roof; additional space for retreat for people (sports ground, café, etc.); increased top floors price, and of the entire building (up to 30%).

Major disadvantages of "green" roofs include a rather big additional weight load. Therefore, the building structure shall have the high strength reserve pre-designed; and it requires labour-intensive repair works in case of leaking [3].

Types of "green" roofs

There are two types of "green" roofs, extensive and intensive. The extensive roof includes a thin soil layer planted with the turf grass or low-growing perennials, and an easy care (they need to be mown and cleared from the weeds). The soil mix consists of the gravel, organic substances, keramzit concrete, turf, and sand, and is from 5 to 15 cm thick on the rooftop. This type of greening is usually arranged on the unused and sloped roofs.

The intensive "green" roofs present a complex eco-system that requires a fully-featured care and irrigation. The roof soil layer thickness is from 20 to 60 cm, which largely complicates its structure. The roof weight may vary from 250 to 950 kg/sq.m. A major advantage of intensive roofs is the capacity to create a uniquely designed garden.

Cases of Arranging the "Green" Roofs

For better understanding of "green roof" as a concept, what it could and shall be, we shall consider the rooftops of certain library buildings and describe their composition solutions and implementation technologies (Figure 2).

FIGURE 2. "Green" roof of the Warsaw University Library [4]

The Warsaw University Library has a unique composition of a botanical garden integrating the building into its green environment. The garden starts from the ground level and rises 15 m high to cover some part of the library roof. The flat "green" rooftop has three functions: it provides heat insulation for the internal part of the building and protects it from the rainfall; it is the area for drainage extraction systems, air funnels, and smoke ducts, air conditioning units, and water sewage elements; it is part of the garden planning for the library building.

The roof structure is made of the 26 cm thick reinforced concrete slab with the pre-designed inverted cover. Heat insulation is arranged on the water-proofing layer that is a part of bitumen sheets with the PVC foil, on a polystyrol foam and polystyrol coating, with spacings for cable ducts and installation channels. The design is based on the flat roof. Polystyrol that shapes the slopes is covered with the waterproof foil, with green roofing layers on top. The rainwater drainage is ensured through the vacuum system [5].

"Green" Roof of the National Audio-Visual Conservation Center (Virginia, USA)

The most recent building of the Library of Congress in Culpeper, Virginia, the National Audio-Visual Conservation Center, may boast of the largest "green" roofs east of the Mississippi river. About 75% of that area is covered with the vast "green" roof of sedum and grasses (soil depths is up to 25 cm). The remaining roof has over 120 cm deep soil and can support all kinds of plants, including shrubs and trees. The project is huge; it includes 9,000 trees and almost 200,000 individual plants.

The building's below-ground part is efficient in maintaining climate control required for the archive storage facility. The massive "green" roof contributes to it as it can maintain the temperature levels constant for two weeks, even in case of a long power failure.

To ensure proper drainage, J-DRain 300, a pre-fabricated drainage composite was laid between the multiple layers of insulation board – a geonet. It is a unique product enabling the elevation of the insulation board, a two-way drainage and high compressive strength that might come from the vehicles. The latter feature was of high relevance since the roof needed to carry heavy machinery used to install and relocate the engineered soil. The project also used a J-DRain GRS system. It consists of a root-resistant top fabric layer, followed by a thin waterproof membrane draining the excess water from the substrate but retaining the amount critical for plants.

To ensure the integrity of the waterproofing membrane, an electric system was installed to detect the leaking. It uses the low-voltage power to identify the exact location of leaking spots, also through several feet of soil and plants [6].

"Green" Roof of the Delft University of Technology Library (Netherlands)

The Delft University of Technology Library is the biggest research and technical library in the Netherlands. It is more than a building, but rather a piece of scenery. The library building has been designed as an extension of the surrounding landscape. It resembles a wedge cut into the lawn often used by students to rest and sunbathe in summertime (Figure 3).

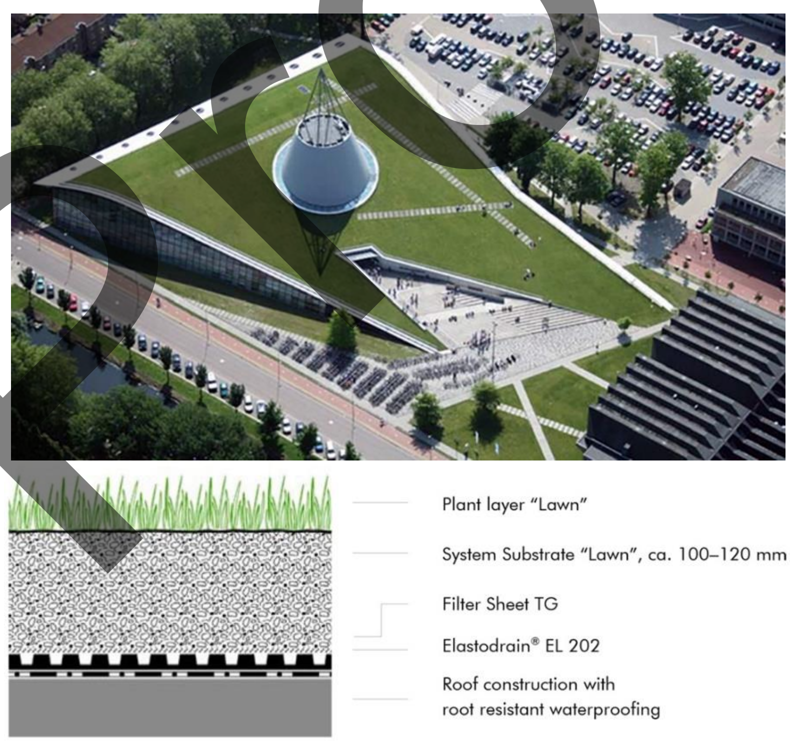

FIGURE 3. "Green" roof of the Delft University of Technology Library [9]

The library building is energy-efficient: the grassy roof offers an insulating effect and minimizes the huge temperature swings; the plantings retain rainwater, the slow condensation of the retained water produces natural cooling in summertime. It also provides for brilliant noise insulation.

During the capital repairs, a pressure-resistant foam glass heat insulation was installed on the roof, and a new bitumen waterproofing with the root-resistant EPDM top layer. Furthermore, the growing of the “green" roof was designed to withstand even some of the heaviest mechanical impact. That is why a strong drainage had been installed in the base, and the Elastodrain® EL 202 protective cover [7].

In addition, in the process of roof reconstruction, a thick Styrofoam insulant was replaced by a 10 cm thick foam glass consolidated by the hot bitumen. A rubber foil was added beneath and above the foam glass, covered with the spiked drainage plates sealed with felt.

The weight of the grass roof was decreased from 400 kg/m^2 down to 280 kg/m^2. It was made possible due to mixing the recycled soil with a mineral product with higher water retention capacity (up to 8 days in dry weather). As a result, the layer depths have dropped from 20 cm to 10 cm [8].

"Green" Roof of a Public Library in Milwaukee (Wisconsin, USA)

A Milwaukee public library is covered with over 9,000 m^2 of the "green" roof extending above the Business and Periodicals Room. The "green" roof is engineered with moisture barriers and insulating features to reduce the heating and cooling costs, to minimize the urban heat island effect, and to protect the library facilities inside. A key advantage of the "green" roof is the rainwater retention capacity. It helps reducing the rainwater sewage load on the MMSD sewage system, mitigates the risk of flooding the basements, and reduces the combined sewage overflows to the Michigan Lake. The roof is sown with the chives, Karl Forester Feather Reed Grass, and 12 varieties of sedum. The "green" roof is fitted with the waterproofing membrane, protective layers, an insulant, a filter, soil and plantings to create the roof ecosystem.

The roof offers both short-term and long-term benefits for Milwaukee citizens. The short-term prospect implies that replacement of 9 000 m^2 of the traditional non-porous roof with the vegetative system would reduce the wastewater volume, decrease the heat re-entering the atmosphere, and improve the air quality. The long-term prospects imply that the Milwaukee city would benefit from reduced costs on water treatment facilities and their operation. Furthermore, the "green" roof must serve at least twice as long as the usual roof [10].

"Green" Roof of the National Campus for the Archeology in Jerusalem (Israel)

National Campus for the Archeology in Jerusalem is located under the public park of 1,600 m² arranged on the rooftop. The Campus includes the archives, galleries, laboratories, an education center for students, and the Mandel National Archeology Library of Israel.

The basis for any "green" roof is a professionally fabricated waterproofing membrane that had already been installed on the new building of the National campus. The ZinCo system build-up “Roof Garden” was installed on top of this membrane, beginning with a protection mat that enables mechanical protection, retains water and nutrients, and improves the impact noise insulation capacity. The loose rolls of mat are laid with the 10 cm overlap, and they also protect the waterproof membrane from tensile and slide that may occur during the works.

The next layer includes the Floradrain® drainage and water retention elements. It is a basis for the "Roof Garden" system by ZinCo. The 1×2 m big elements of Floradrain® have chambers to retain water in the surface section, diffuse openings and an underlying system of channels to safely drain the water to the roof outlets. The drainage is installed on the entire territory: both under the green area, and beneath the paths. Moreover, Floradrain® has high pressure resistance that is relevant for all types of loads during the execution of works, and for the arranged paths and the weight of the intensive "green" roof. The drainage layer in the “green” roof structure is covered with system filter to sieve small particles from the topsoil. Thus, a filtrating drainage layer is achieved.

Another advantage of the “Roof Garden” by ZinCo that enables any "green" fantasy is the possibility to use different substrate bed depths, from 25 to 80 cm. This project uses a perlite substrate. It is a volcanic glass that expands to a loose porous structure when heated to a high temperature (+1000° C). It can help improve the water storage capacity and soil aeration [11].

"Green" Roof of the Stavros Niarchos Foundation Cultural Center (SNFCC) in Greece

A new Stavros Niarchos Foundation Cultural Center is composed of the buildings of the Greek National Opera (GNO) and the National Library of Greece (NLG). It is literally built into the open-air park extending around the area of 17 hectares. The roof area is about 25,550 m² and is fully planted with the ZinCo systems. It has an added value of sun radiation proofing for the building. It helps save the energy needed for air conditioning.

The roofs are engineered with the root-resistant bitumen waterproof membrane, typical for concrete roofs with the slope up to 5°. On top of the membrane, there are various "green" systems by ZinCo, depending on the building: the National Library of Greece and the Greek National Opera have the reverse roofs that need diffuse penetrating system. For the Opera House, they used the Stabilodrain® SD 30 system as it has a terrace on the roof that requires the drainage and compressive strength. The first layer installed on top of the heat insulant is the air and steam proof dividing membrane TGV 21; the second layer includes the 1×2 m Stabilodrain® sections acting as the casing within the accessible area; and eventually, the light seamless layer of concrete.

For vegetation, mostly the grain varieties, the reverse "green" roofs of the Opera and the National Library a Floradrain® system was used due to high water capacity, classic for the semi-intensive “green” roof. The SF filter layer was installed on the Floradrain® sections, with ab. 15–18 cm of substrate on top that was pre-fabricated by the Egreen company. Stabilodrain® and Floradrain® provide for the drainage in heavy rainfall on the entire area, even beneath the paths [12].

RESEARCH FINDINGS

The paper analyzed the “green” roof concept, its advantages and disadvantages, types and versions for arrangement. On the basis of the analyzed international experience for green roofing, it was proven that the consequences of large-scale urbanization may be partially tackled with the help of greening the rooftops on public buildings within cities.

A “green” roof construct offers some compelling advantages: the greening systems reduce a building’s heat waste; create a microclimate for the inside; the vegetation layer covering the roof protect it from the rainfall, temperature gradients, ultraviolet, and mechanical damage, thus ensuring its longer useful life; and create additional green areas, which has a positive impact on environment.

CONCLUSIONS

Green roof arrangement is a most promising area in the roofing evolution. It can be evidenced by the experience of developed countries.

Landscape organization of the roof garden open space shall be implemented with account for its perception from the top and bottom levels of buildings and comply with the environment requirements, whether the natural landscape, the residential area type, or the historical downtown.

To enable proper conditions for the roof vegetation, and for the building and its interiors to stay unaffected, the following peculiarities and criteria shall be ensured:

1) the “green” roof project design shall be provided on the stage of building design, to ensure correct calculation for additional loading on the load-bearing structures and the foundations;

2) the "green" rooftop is most appropriate for roofs with a small angle of pitch – up to 12 degrees; while projects with the 30° sloped rooftops are more complicated;

3) the layered roof structure must be engineered according to all the rules and using high quality materials, to prevent leaking, and enable favorable rooting conditions;

4) it is important to consider that the grass shall not be overwatered as it would turn “lazy.” The grass may enroot to ab. 8 cm deep in search for water which adds density to the turf. Excessive water prevents the grass from deep rooting.

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Determination of Destruction Probability of Brick Structures Caused by the Exhaustion of Brickwork Capacity Under Flexure

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Abstract. Using the statistical method by Monte Carlo, the procedure for determining the probability of brick constructions' destruction due to the capacity exhaustion under flexure is developed. Based on the proposed methodology, an algorithm is elaborated; and a computer program designed to solve such probabilistic tasks is written. Calculations to determine the probability of brickwork destruction are performed. It is elucidated that the value of the probability of destruction of brick structures for the basic service life corresponds to the minimum values of the reliability, recommended by current regulations and Eurocodes.

INTRODUCTION

The need in new scientific models of estimating the reliability of building structures both on the design and maintenance levels as well as on the level of standardization regulation is obvious nowadays. The structures designed according to the existing standards are considered to have sufficient safety level. Therefore, quantitative indices of safety parameters are not determined. Reliability estimation remains on the designer's intuitive level. Just since 2009 when UNCR (Ukrainian National Construction Regulation) B.1.2-14 [1] was introduced, reliability estimation of building structures as the main criterion of the safety level has become obligatory at the designing level. However, implementation of the items of the mentioned regulatory document is hindered because of the lack of the corresponding apparatus in designing regulations – Ukrainian regulations in construction do not provide (with few exceptions) either the algorithms of estimating reliability at the designing stage or instructions on the choice of statistic models of materials and loads, which are considered to be very important.

The construction of residential brick buildings in Ukraine is a considerable part of the total housing stock. The number of brick buildings, which are in critical conditions and require capital repairing and structures strengthening increases. The analysis of causes of brick structures destructions demonstrates the necessity of reliability and maintenance suitability control at all stages of a building life cycle. The investigation, devoted to the scientific search of estimation models of reliability and safety of brick structures, is considered to be urgent and meeting modern requirements. It gives the opportunity of realistic estimation of technical state of residential and industrial buildings and it is expected to have a considerable social and economic effect.

DISCUSSION

To estimate the probability of any boundary state, the task of the reliability theory using the apparatus of the theory of probability is to be solved. The basic data for this task are the parameters of distribution of random values. The sequence of solving the task may be the following:

1) the conditions of a brick element (structure) capacity are considered;

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2) the parameters of distribution of random values, considered as the basic data, are determined;

3) the task on the estimation of the probability of brick structures destruction is solved.

Probable estimation of the brick structures capacity is carried out on the basis of calculations for determining the destruction probability in conditions of exhaustion of brickwork capacity. In this case, the solution for determining the probability of brick structures destruction caused by the exhaustion of brickwork capacity under flexure using the Monte Carlo method is provided.

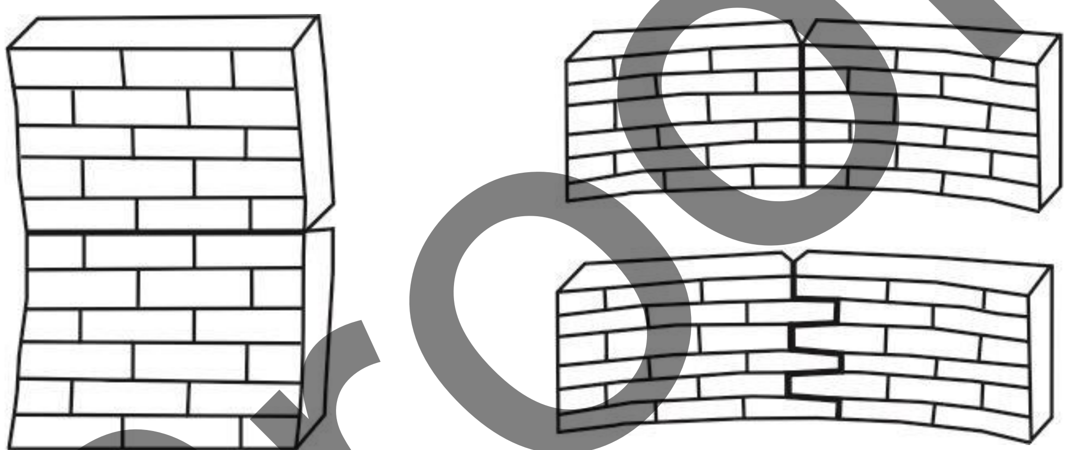
In a boundary condition of bearing strength losses, the calculation value of the moment applied to a brick wall M_{Ed}, is to be smaller or equal to the calculation value of the resistance moment of the wall M_{Rd} in such a way that:

$$M_{Ed} \le M_{Rd}\,. \tag{1}$$

The calculation value of the flexing moment of a brick wall M_{Rd} per unit of its height or length is:

$$M_{Rd} = f_{xd} \cdot Z\,, \tag{2}$$

where f_{xd} is calculation value of a capacity limit under flexure in the corresponding area of flexure; in this case, the capacity under flexure on the destruction area parallel to horizontal joints f_{xk1} and the capacity under flexure on the destruction area perpendicular to horizontal joints f_{xk2} are observed to differ (fig. 1); Z is the elastic resistance moment to the section per unit of a height or a length of a wall.



a) b)

FIGURE 1. Destruction areas of a brickwork under flexure: a – destruction area is parallel; b – destruction area is perpendicular to horizontal joints of a brickwork

In the case of vertical loading, the favorable effect of vertical stress may be taken into account by increasing the capacity value under flexure $f_{xd1,app}$, which can be found from the equation:

$$f_{xd1,app} = f_{xd1} + \sigma_d, \tag{3}$$

where σ_d – calculation value of a pressure stress affecting the wall, the value of which can not overpass 0,2 f_d.

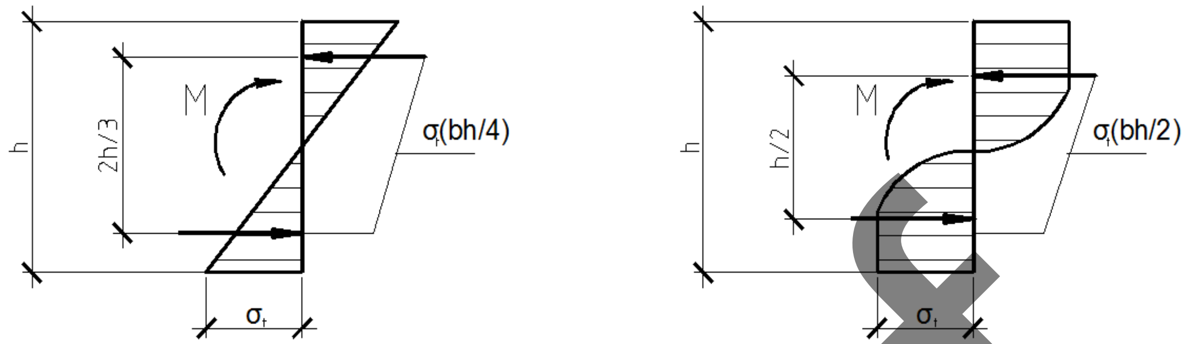
The flexure in a brickwork causes tension, with the help of which the brickwork capacity in the tension area is determined. The moment of internal forces is determined using triangular stress distribution diagrams like for an elastic body:

$$M_{el} = \sigma_t \frac{bt}{4} \cdot \frac{2}{3} t = \sigma_t \frac{bt^2}{6}\,. \tag{4}$$

However, besides elastic deformations in a brickwork the plastic ones can be observed. That is why the stress diagram is curvilinear (fig. 2), if it is taken as rectangular we will get:

$$M_{pl} = \sigma_t \frac{bh}{2} \cdot \frac{h}{2} = \sigma_t \frac{bh^2}{4}\,. \tag{5}$$

In the formulas (4) and (5) the following designations are employed for b, t, h – width, depth and height of the section accordingly.



a) b)

FIGURE 2. Epures of normal stress distribution in the section of the element:
a) rectangular epure; b) curvilinear epure

In this case, the condition for ensuring of the brickwork capacity under flexure can be defined by the following inequation:

$$M_{Ed} \leq M_{Rd}(f_{xd}, b, t,, e). \tag{6}$$

The equation for the ties balancing under flexure can be written as follows:

$$Y = M_{Rd}(f_{xd}, b, t, e) - M_{Ed} \geq 0. \tag{7}$$

The algorithm for determining the probability of destruction of brickwork structures under flexure using the Monte Carlo method is proposed as follows.

1. N number of statistical tests are performed.
2. Random probabilities of the intended load are assigned depending on the own weight of P_G, structures, the snow P_S, the payload P_Q and the load of non-uniform settlement of P_D.
3. According to the known values of P_G, P_S, P_Q, P_D, the quantiles of load G, S, Q, D are determined.
4. The value of the effective moment M_{Ed} is determined.
5. Random probabilities of capability of the brickwork under flexure $P_{f_{xd}}$ are assigned.
6. Using the value $P_{f_{xd}}$, the quantile f_{xd} and the capacity under flexure for the corresponding bending area M_{Rd} are determined.
7. The value of the limit state function Y is calculated using the formula (7).
8. The fulfillment of the condition Y ≥ 0 is checked.

RESULTS

Example of calculation.

The probability of a structural failure for a brickwall section is calculated. In Table 1 the determined values are given, in Table 2 obvious characteristics of the functions of normal distribution of random variables are presented. The calculations are performed using the Mathcad program. The number of tests was $N = 1x10^5$.

TABLE 1. Determined values

Parameter	Symbol	Measuring unit	Value
A section length	b	m	1.0
A wall thickness	t	m	0.64
Moment of resistance to the wall section	Z	m^3	0.068
The area of a wall section	A	m^2	0.64

TABLE 2. Probability characteristics of normal distribution functions

Parameter	Symbol	Measuring unit	Expectation value μ	Root-mean-square deviation σ
Calculation resistance of a brickwork tension under flexure in untied section	f_{xk2}	kPa	104	15.6
Calculation value of a moment, applied to a wall	M_{Ed}	kN·m	2.25	0.79
Calculation value of a resistance moment against a brick wall	M_{Rd}	kN·m	7.101	1.0608

Figure 3 shows the distribution of functions of the influencing moment M_{Ed} and the moment of resistance of the brick wall M_{Rd} as well as the probability density of the moment distribution M_{Ed} and the moment of resistance of the brick wall M_{Rd}.

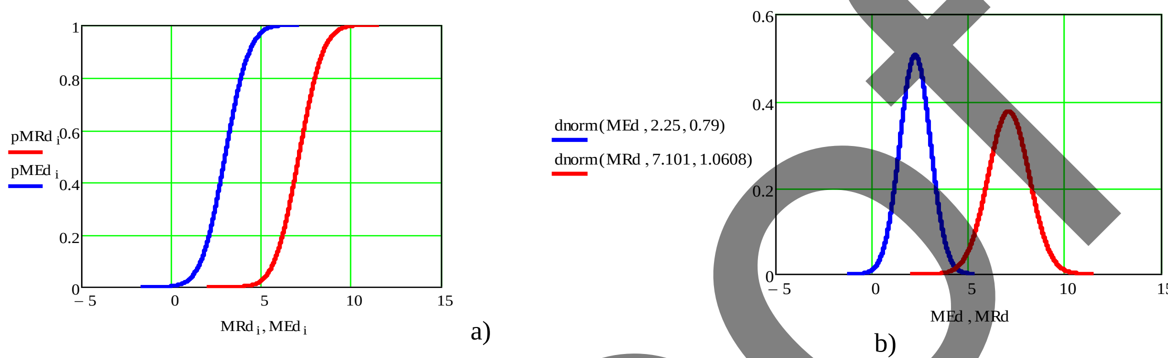


FIGURE 3. Distribution functions: a) the influencing moment M_{Ed} and the moment of resistance of the brickwall M_{Rd}; b) the probability density of the distribution of the moment M_{Ed} and the moment of resistance of the brick wall M_{Rd}

The research results are presented in Table 3.

TABLE 3. The results of calculations of the probability of destruction of a brick structure under flexure

Values	Probability p	Safety characteristic β
The probability of a brickwork destruction	1.1×10^{-4}	3.7
Recommended minimum values according to DSTU-N B V.1.2-13:2008 (EN 1990:2002, IDN) [2], ISO 2394-1998 [3]	1×10^{-4}	3.8

CONCLUSIONS

Using the statistical method by Monte Carlo, the procedure for determining the probability of brick constructions' destruction due to the capacity exhaustion under flexure is developed. Based on the proposed methodology, an algorithm is elaborated; and a computer program designed to solve such probabilistic tasks is written.

Calculations to determine the probability of brickwork destruction are performed.

It is elucidated that the value of the probability of destruction of brick structures for the basic service life corresponds to the minimum values of the reliability, recommended by current regulations and Eurocodes (Table 3).

The difference between the results of the calculation between the suggested approach and regulatory methodology is 2.3%.

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Organizational and Technological Design of Construction Objects in the Conditions of Innovative Development of Design and Construction Firms

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Abstract. Innovative organizational and technological solutions in construction are main ways of reforming the construction industry while Ukraine is integrating its economy with the economy of European countries. The design stage is where relevance of construction objects to modern requirements, national and worldwide standards should be taken care of. Organization and technology of construction are playing a significant role in it. Ability of a construction firm to carry out an innovative activity is what a level of organizational and technological solutions development depends on.

INTRODUCTION

Mandatory requirements for construction projects are: ensuring life and health support services and protecting the environment; ensuring mechanical resistance and stability; safety of operation; fire safety; noise protection; energy savings.

Besides requirements of safety, engineer during the development of design documents is responsible for an accordance of construction objects with these requirements:

- functional, implementation of which provides the best conditions to organize an object operation;
- technical – provides sufficient characteristics of strength, stability, insulating ability, durability, fire resistance of the building as a whole and its individual elements;
- economic, ensures cost optimizations at all stages of investment cycle, improvement of social conditions for participants, planed profits for an investor;
- architectural and artistic, implementation of which provides harmonic join of a building with the environment, attractive appearance of a building and its premises, comfortable conditions for residents and their high productivity;
- ecological – rational usage of natural resources, preservation of the natural landscape, reduction of air and water pollution to a minimum.

Fulfillment of these requirements is achieved, on the one hand, by using optimal layout and constructive solutions, and on the other hand – by technology and organization of processes, which allows for design solutions to be fully implemented.

METHODS

The research is based on methods of system analysis and generalization of legislative, regulatory, information sources, and experience of practical work in the industry.

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RESULTS

With the development of society, understanding of the global way the world works, cities of the future, Smart City, neuroarchitecture, digitization of cities, robotization, artificial intelligence in the field of design and construction, the requirements for objects of life change and evolve.

The desire of customers to sign contracts with contractors to perform a full range of work and get a ready-to-operate facility forced construction firms to include research and design departments in their organizational structures. The experience of the article's authors in the industry shows that the combination of scientists, designers and builders in one organizational structure contributes to the parallel research and design work, and to the combination of design and construction processes (when the design documentation is 30-40% ready all buildings' zero-cycle works begin). Thus, the duration of a construction project is reduced by reducing the stages of design and construction, reducing the cost, increasing the profit of a firm. Clearly, with parallel work the intensity and tension of work increases, and changes in the construction process become more likely, but decreasing the costs by shortening the design and construction cycle, as a rule, covers the risks of rising prices associated with the possible changes.

Innovative development of a design and construction firm should be focused on achieving a high level of competitiveness, and should be based on a thorough analysis of technological, informational, financial, logistic, marketing and other capabilities of a firm. The leading role in ensuring the competitive advantages of a firm in a market belongs to the technological potential, its innovative development.

Innovative development of a firm should be promoted by: state support, normative and legislative regulation of innovative activity; availability of a strategy for innovative development; financial, material and technical resources, technological infrastructure, necessary scientific potential and qualified personnel; flexibility of organizational structure; progressive marketing; accumulation and constant updating of the information base; appropriate socio-psychological conditions; etc.

There are many innovations that can potentially be implemented in the design and construction cycle. These include new automated design systems, materials, machines, and technologies for the construction of both construction objects and individual elements of buildings and structures. Digitalization now is part of almost all the spheres of the design and construction cycle. Technological innovations associated with glass began to be widely used – these are not only façade systems, but also load-bearing structures; efficient formwork systems that ensure the quality, speed and reliability of buildings' construction. A significant number of innovative technologies is aimed at energy saving. This is facilitated by state policy and the implementation of norms harmonized to European policies. In many developed countries, 3D-printing, unmanned aerial vehicles, and intelligent technologies have long been used in the construction of buildings. The goal of each innovation is to achieve high competitive advantages of a construction firm and high-quality final results of a building according to the parameters of functionality, environmental friendliness and economy.

Innovative activity can be ensured by introducing scientific and technical support of construction objects, as well as developing standards of organizations in Ukraine [2].

One of the tasks of support is to ensure the resolution of construction and technological problems with a minimum risk of errors in conditions not regulated by current norms and standards, and in the absence of sufficient experience or direct analogues in national and world practice.

At the stage of object's design, the support includes the analysis of the world experience in the design of such objects and the choice of technological solutions, and at the construction stage the support includes information assistance in solving the problems of construction production in terms of its preparation, the development of design and technological documentation, planning and management, providing all types of resources, accounting, etc. [2, 3].

A progressive direction in construction is the introduction of BIM technologies. BIM is an information modeling that involves the collection and complex processing in the process of designing all the architectural, construction, technological, economic and other information about object with all its interrelation and dependencies.

With information modeling technology you can evaluate project options in accordance with regulatory documents, make informed decisions at the early stages of the project, but the information base for modeling must be developed and accumulated first.

Information support of management activities contributes to the timely development and actualization of work schedules, the formation of realistic current tasks for performers, the operational tracking of their implementation in objectively planned terms.

The use of BIM makes the process of drawing up calendar plans (graphs) more accurate, fast and, most importantly, responds more effectively to changes that inevitably arise during the building's construction [3].

The practice of analyzing construction's project documentation shows that the quality of development of design solutions and innovation of design methods contribute to increasing organizational, technical and technological levels of construction production, reducing the duration, reducing the cost of construction and increasing the efficiency of construction projects on this basis.

In Ukraine, in accordance with organizational and methodological norms [4], decisions on the organization and technology of construction of a facility are provided by design and technological documentation, which consists of the Plan of Construction Organization (PCO) and the Plan of Production of Work (PPW). PCO contains decisions on the organization of construction of the facility as a whole and is used by participants in the investment process in solving financing issues, logistical support and organization of their activities for the construction of the facility. The PPW defines and details the technology, organization and conditions of construction work, and is a guiding document for the contractor in the construction of the facility.

The authors of the article developed a flowchart of the methodology of organizational and technological design in the conditions of innovative development of design and construction firms (Fig. 1).

Unit 1

The design task contains reasonable requirements of the customer to the planning, architectural, engineering and technological solutions of the construction object, its main parameters, cost and organization of its construction [5].

Unit 2

To ensure the reliability and constructive safety of buildings, building structures and foundations, a class of consequences (liability) is used. Characteristics of possible consequences are the basis for the classification of construction objects by three classes of consequences (liability) – CC1 (minor), CC2 (medium) and CC3 (significant) [6].

The class of consequences (liability) is also used to determine the composition (stage) of project documentation for the construction of objects [6, 7].

Unit 3

For non-production objects, the composition of the project documentation (the number of design stages) is:

- for objects belonging to the class of consequences to significant consequences (CC3) – three stages: sketch project (SP) or by the decision of a customer – feasibility study of investments (FSI), project (P), working documentation (W);
- for objects belonging to the class of consequences to medium consequences (CC2) – two stages (P, W) or three (SP, P, W), according to the justified decision of a customer, the stage of FSI can be developed instead of SP;
- for objects belonging to the class of consequences to minor consequences (CC1) – one stage of the working project (WP) or two stages (SP, WP).

Design stages for industrial facilities:

- for objects belonging to the class of consequences to significant consequences (CC3) – three stages (FSI, P, W);
- for objects belonging to the class of consequences to medium consequences (CC2) – two stages (P, W) or three (FSI, P, W);
- for objects belonging to the class of consequences to minor consequences (CC1) – one stage of the working project (WP) or two stages: technical and economic calculations (TEC), WP [5, 7].

The correctness of determining the class of consequences is checked during the examination of projects, if the implementation of such is mandatory.

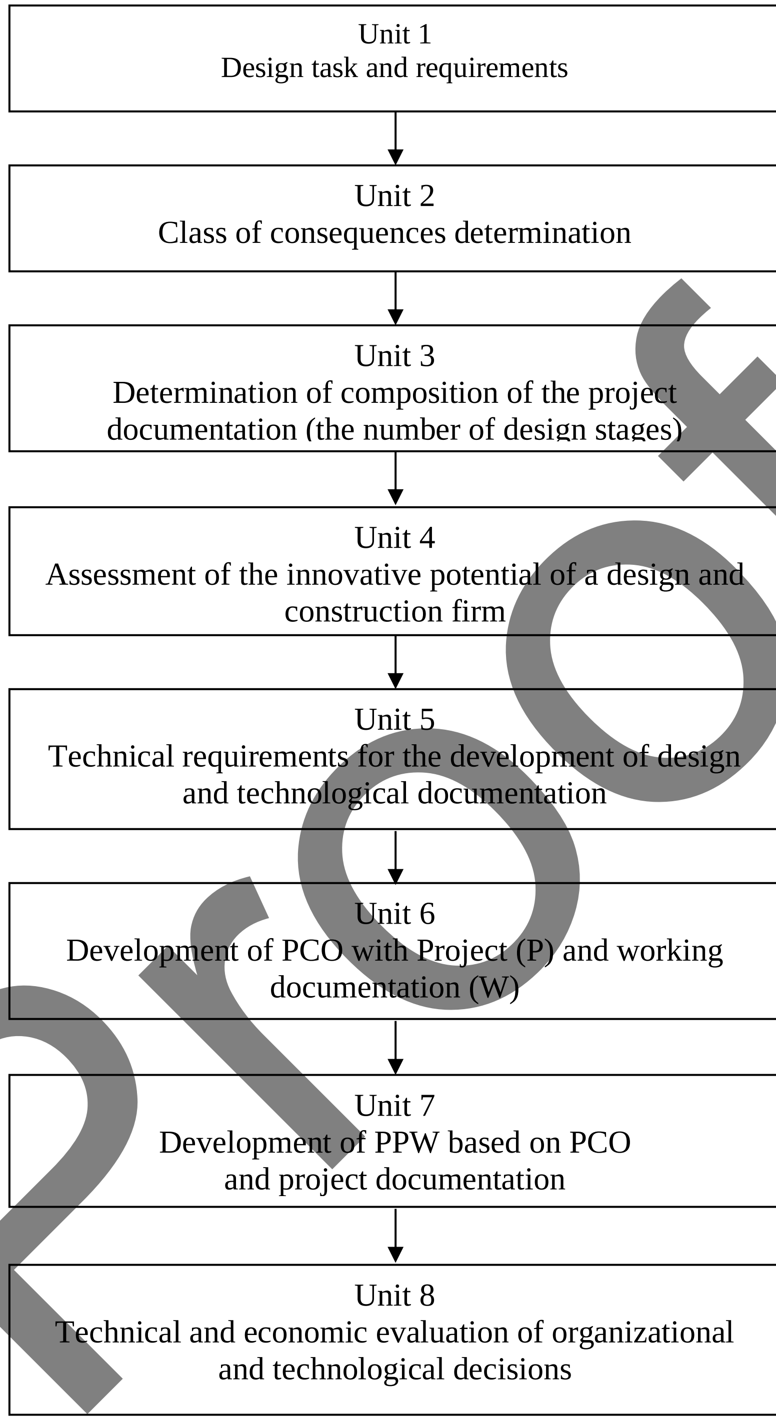

FIGURE 1. Block diagram of the methodology of organizational and technological design in the conditions of innovative development of design and construction firms.

Unit 4

To assess the innovative potential of the design and construction firm, both cost and resource natural indicators can be used. They should determine the achieved level and strategy for the development of innovative potential of a design and construction firm on the basis of improving the management of innovative potential.

Unit 5

Technical requirements for the development of design and technological documentation are setting main technical, economical and special requirements for technology and construction organization, taking into account the level of innovative potential of the design and construction firm.

The main task of design and technological documentation is the introduction of progressive methods and methods of organization of construction production, the use of modern effective construction technologies that should contribute to saving resources, reducing the duration at high productivity, high level of quality of work, economic efficiency.

Unit 6

The main documents in the PCO are calendar plans, organizational and technological schemes of construction, construction master plans, information on the volume of construction work, needs for construction structures, materials, machines and mechanisms, personnel builders. Calendar plans are used to distribute capital investments and the volume of construction work over time, in accordance with the normative period of construction of the facility, to justify the investor's cost of construction. Organizational and technological scheme establishes the sequence of work on the construction of the object, taking into account the accepted methods of organization of construction; construction master plan determines the organization of the construction site for the period of construction.

Unit 7

The content of the PPW, as well as the PCO, is regulated by the norms [4], but it is based on calendar charts and technological maps.

Calendar schedules as part of the PPW are developed on the basis of the volume of construction work, labor costs, material and technical resources and construction conditions based on the analysis of the use of progressive building materials and organizational and technological solutions, productive machines and equipment, positive experience and practice of construction of analogue objects [8].

The graph determines the total duration of the project, the duration and interrelation of individual works, their performers, the transfer of fronts of work, the provision of resources. The formation of graphs requires time-consuming collection, analysis and processing of large amounts of information.

Technological maps determine organizational and technical schemes of work execution, schemes of operational quality control, methods and schedules of work, needs for material, technical and labor resources.

One of the principles of designing a PCO and PPW is optionality, the purpose of which is to choose the best option of the organizational and technological solution from several possible ones.

The method of variant design involves: collection and analysis of initial data, construction conditions and innovative potential of the design and construction firm with the justification of possible options for organizational and technological solutions for comparison; selection and evaluation of economic efficiency of technically feasible alternatives; adoption of the best option, taking into account the innovative potential and economic possibility of its implementation by the design and construction firm.

Unit 8

For technical and economic evaluation of organizational and technological decisions, the most often choices are:
- indicators of the duration and cost of construction;
- cost of material, technical and labour resources for construction and installation work;
- maximization of profits.

Organizational and technological solutions in the PCO should satisfy the interests of investors-customers, and in the PPW – the interests of contractors. And for the economic assessment of innovative technological solutions, taking into account the investment cycle, methods generally used in world practice are: Net Present Value (NPV), Accounting Rate of Return (ARR), Internal Rate of Return (IRR), Payback Period (PP), Benefit Cost Ration (BCR).

The practical implementation of the improved methodology ensures accounting and consistency of design processes and solutions between units, allows effective management of the innovative potential of the design and construction firm, and coordinate the activities of construction participants, systematize the planning and control processes for the implementation of plans, reduce project risks, increase the efficiency of construction projects.

CONCLUSION

Analysis and generalization of legislative, regulatory, information sources, and experience of practical work in the industry allowed the article authors to improve methodology of organizational and technological design and ascertain that implementation of innovation organizational and technological solutions at a design stage affects quality indicators of final construction products, its compliance with international standards, provides significant economic, energetic and environmental impact. Ability of a construction firm to develop such solutions depends on a firm's innovative and competitive potential.

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Digital Technologies as an Innovative Tool for the Preservation of the Palace Complexes of Podillya in the Late 19th – early 20th Century

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Abstract. The use of innovative approaches to the preservation of the architectural heritage of Ukraine is an effective action that expands the possibilities of preservation and promotion of monuments and valuable objects. Digital technology is one of the modern tools to capture the state of the monument, to create a model of its reproduction both for exhibition and for further restoration or reconstruction. Such opportunities are especially relevant for the preservation of the palaces of Podillya (historical region of Ukraine) of the late 19th - early 20th century - objects large in scale and valuable in the aspect of architectural style. The article considers the advantages of using modern digital technologies in the sphere of architecture and suggests ways to apply them to palace buildings, depending on the degree of preservation of volume and architectural decoration: "3D-mapping" technology, creating a virtual reconstruction at the location, virtual reconstruction of a building with remote access. The paper presents the results of testing the method of reproduction of the original object appearance on the example of Bakhmetyev-Protasov Palace in Tymanivka, Vinnytsia region, with online access to the created model.

INTRODUCTION

One of the core problems of development of the socio-cultural space in Ukraine is the preservation of historical and architectural heritage. It is possible to state the unsatisfactory condition of a significant number of valuable objects, in particular samples of palace architecture of Podillya (as a historical region of Ukraine) of the late 19th – early 20th century. A large number of buildings were partially or completely destroyed during the First and Second World Wars, due to reconstructions and unprofessional repairs in the last century, as well as exclusion from active use. Some of the palaces have survived to this day, but have lost their original architectural image. Given the urgency of the problem of preserving numerous palace buildings as parts of palace and park ensembles, one of the first stages of restoration of such facilities may be their virtual reconstruction.

The use of modern digital technologies is one of the effective tools for the preservation and reproduction of architectural objects that have been actively used in conservation and, especially, restoration activities during the previous decade. A relatively simple step is the three-dimensional computer modeling of the object and subsequent printing of the model using a 3D printer. A more complicated method is to create a mixed reality - supplementing the physical reality with certain digital data. Augmented reality is part of virtual reality, the creation of which is another, more complex, way of digital reconstruction. Virtual reality allows to fully immerse oneself into the atmosphere of the historical era when the reconstructed object was built (Fig. 1).

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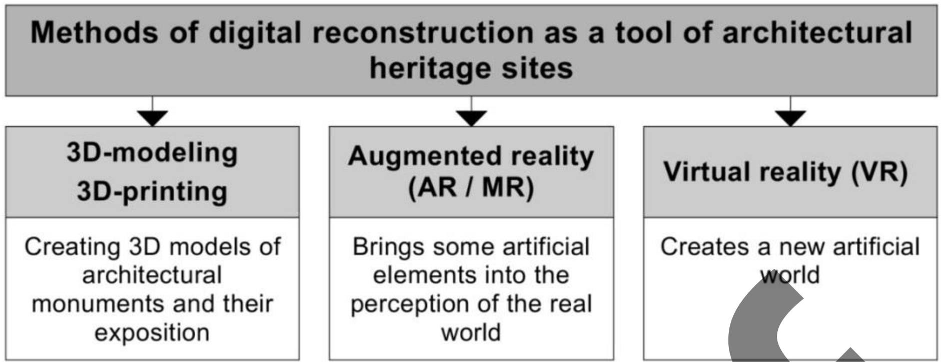

FIGURE 1. Methods of digital reconstruction of architectural heritage sites

THE GOAL OF THE RECEARCH

The goal of the article is to consider the advantages of using modern digital technologies in the field of architecture and to suggest ways of their applications to palace buildings, depending on the degree of preservation of volume and architectural decoration.

RESULTS AND DISCUSSION

The problem of the technique of virtual reconstruction and the effectiveness of its use for practical application is considered by foreign and domestic scientists K. Kosenkova [1], L. Borodkin, W. Terlikowski and others. Ukrainian scientists O. Kysil, R. Kosarevska, O. Levchenko analyzed the possibility of using information modeling technology (BIM) and historical building information modeling (HBIM), and proposed an algorithm for building a BIM-model using the software Allplan 2019 [2]. Information modeling of historic buildings is the topic of an article by G. Zakharova [3] ("Information modeling of historical buildings").

A. Semochkina's article "The technology of video mapping using the example of outdoor building video projection" considers the typology of video mapping and describes in detail the process of creating its architectural variant [4]. The same topic applies to the publication of J. Derwisz ("Modern multimedia technologies in virtual reconstruction and presentation of historic architecture").

Russian researchers I. Gorelov and Y. Nemtinov on the example of Tambov consider the importance of creating a virtual model of urban development to solve problems and work out strategies of its development [5].

The possibility of using digital technologies for the reproduction of lost urban buildings is considered in the monograph "Technologies of virtual and augmented reality (VR / AR) in the reconstruction of historic urban buildings (on the example of the Moscow Strastnyi Monastery)" [6].

P. Reyliv's monograph "Archeology and the information era: global perspectives" (1992) is devoted to the problems of conceptual and terminological characteristics of the processes of computer modeling of historical architectural objects, where the term "virtual archeology" was used for the first time [1, p. 219].

One of the most remarkable Ukrainian achievements in the field of digital preservation of architectural heritage sites is the project of Skeiron and Gwara Media - "Pocket City", the main purpose of which is to preserve historic architecture by its digitalization. Thus, four sets of AR-postcards represent the most outstanding architectural monuments of Ukraine, Kyiv, Kharkiv and Odesa. Virtual reconstructions of objects can be found with the help of the Pocket City AR smartphone app in augmented reality mode [7].

The approbation of the augmented reality method in the new edition of S. Taranushenko's book "Destroyed Masterpieces of Ukrainian Wooden Sacred Architecture. The Augmented Reality Book" (2020), which contains descriptions and drawings of the five most prominent lost churches in Central and Left Bank Ukraine. In addition to iconographic materials, the book contains QR-codes, which can be used to view 3D models of these objects.

The use of modern digital technologies has affected not only the preservation and restoration of lost architectural ensembles, but also other arts, closely related to architecture, e.g. sculpture. Here we should mention the project "Pinzel. AR", which aims to preserve the creative heritage of a famous sculptor of the mid-18th century J.G.Pinzel through the use of augmented reality tools. Digitalization of sculptures allows to use the created models for virtual reconstruction of an authentic condition of temple interiors or creation of an exposition in a virtual museum [8].

There are a number of advantages of using modern digital technologies in the sphere of architecture and urban planning:

- the ability to reproduce (create a digital model of) completely or partially lost historic cities, blocks and individual architectural objects;
- the possibility of visual demonstration of the original appearance of the object, which has undergone changes in the architectural image during the period of its existence;
- the possibility of reproducing the architectural ensemble in the context of the environment that has undergone irreversible changes;
- economic advantages of virtual reconstruction;
- 3D-modeling of architectural monuments creates the possibility to view the object from anywhere in the world (when such a model is placed on different Internet platforms) (Fig. 2).

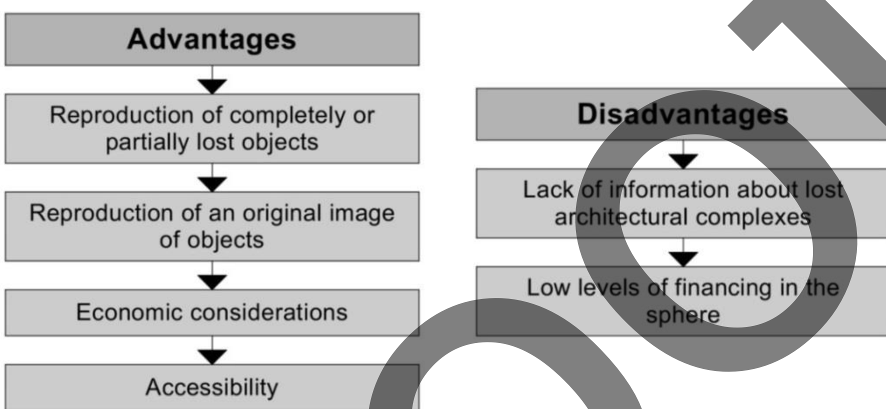

FIGURE 2. Advantages and disadvantages of using augmented reality technology for the preservation and reproduction of architectural heritage sites

Four ways of using augmented reality technology are envisaged to preserve and reproduce the objects of palace construction in the historic Podillya, each of which has its own implementation stages. In addition, regardless of the choice of method for creating a virtual model, the first stage is preceded by a preparatory stage (Fig. 3).

The first way is to use 3D-mapping technology.

3D-mapping (video-mapping) is an approach in audiovisual art, which resides in projecting images on any physical objects of the environment, taking into account their configuration and location in space [4, p. 12]. In the vast majority of cases of architectural video mapping, elements of a light show are projected on the facade of the building, while the content of this light show can be anything. In particular, with the help of "3D-mapping" technology one can project historical photographs of the building onto its existing facade, thus reproducing the original appearance and elements of the lost architectural and sculptural decoration. However, if several photos are available, it is possible to trace the history of changes in the architectural image of the object as a whole. The "3D-mapping" technology should be applied to palaces where the architectural decor is partially lost or the color scheme was changed (Zabotin Palace in the village of Mala Rostivka, Vinnytsia region, Mordvinov Palace in the village of Tarnoruda, Khmelnytsky region).

The second way to use augmented reality is to create a virtual reconstruction on site if physical renovation (restoration) is impossible (for example: the territory where the object was located in the past is now built up). This method is also the most acceptable for virtual reproduction of destroyed palaces. Based on the information about the location of the object and the available iconographic, fixation materials, the creation of augmented reality takes place in two stages. With the help of a computer application (AchiCAD, SketchUP, 3D-Max, etc.) a graphic 3D-reconstruction of the complex is carried out. The next step is creating augmented reality - "linking" the 3D model to the real environment. The created model ("reconstruction") - can be seen in real time using the respective application on the smartphone. This method is suggested for the Melenevsky palace in the village of Narayivka (Vinnytsia region) (Fig. 4).

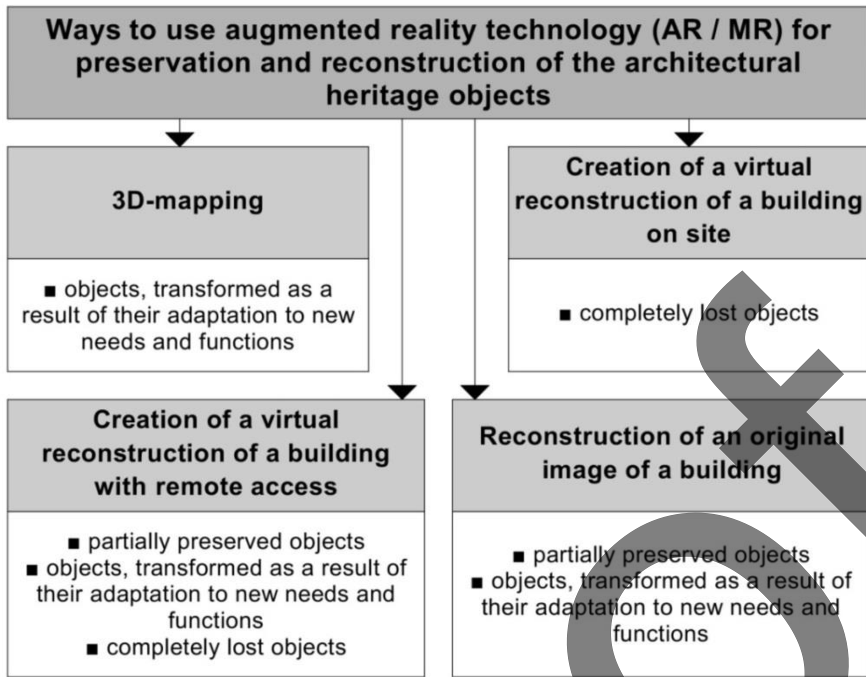

FIGURE 3. Ways to use augmented reality technology for preservation and reconstruction of the architectural heritage objects

FIGURE 4. Stages of virtual reconstruction in the second way

The third way is to recreate the original appearance of the building in cases of loss of individual elements of the architectural ensemble, building, architectural decor and to recreate the structure of the internal composition and interiors of the palace. A significant advantage of using this method is cost-effectiveness compared to the actual renovation of the object. This method is suggested for the renovation of the architectural and stylistic solution of the palaces of Bakhmetyev-Protasov (Tymanivka, Vinnytsia region), Shchenovsky (Kapustyany village, Vinnytsia region [9, p. 106]) and Vitoslavsky-Lvov (Chernyatyn village, Vinnytsia region), as well as interior reconstruction of the Dakhovsky Palace (Leskove village, Cherkasy region).

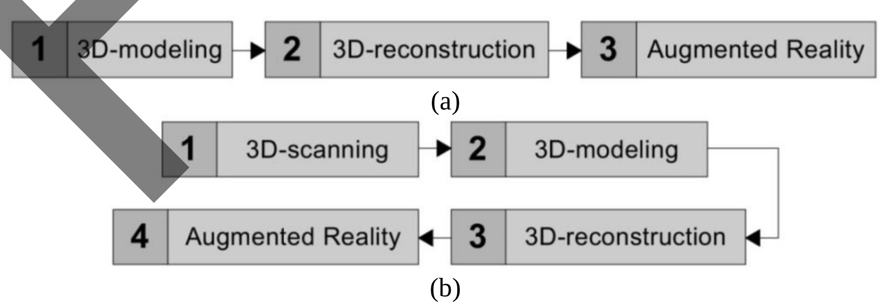

FIGURE 5. Stages of virtual reconstruction by reproducing the original appearance of the building: (a) in three stages; (b) in four stages

The implementation of virtual reconstruction takes place in three or four stages. At the first and second stages (3D scanning and 3D modeling) a three-dimensional image of the preserved part of the building is formed (the wing of the palace in Kapustyany, the palace buildings in Chernyatyn and Tymanivka without lost architectural decor and structural elements); on the third stage the object is reproduced in full (3D model of the whole palace building). The last stage is creating augmented reality. When performing a reconstruction in four stages, 3D scans are carried out using a 3D scanner. Also common is the method of photogrammetry - the process of creating 3D models from images of an object (or its surviving part), photographed from different angles and distances.

In the case of a three-stage reconstruction, the 3D scanning stage is omitted, the volume of the preserved part of the building is modeled immediately in the program on the basis of existing drawings (Fig. 5).

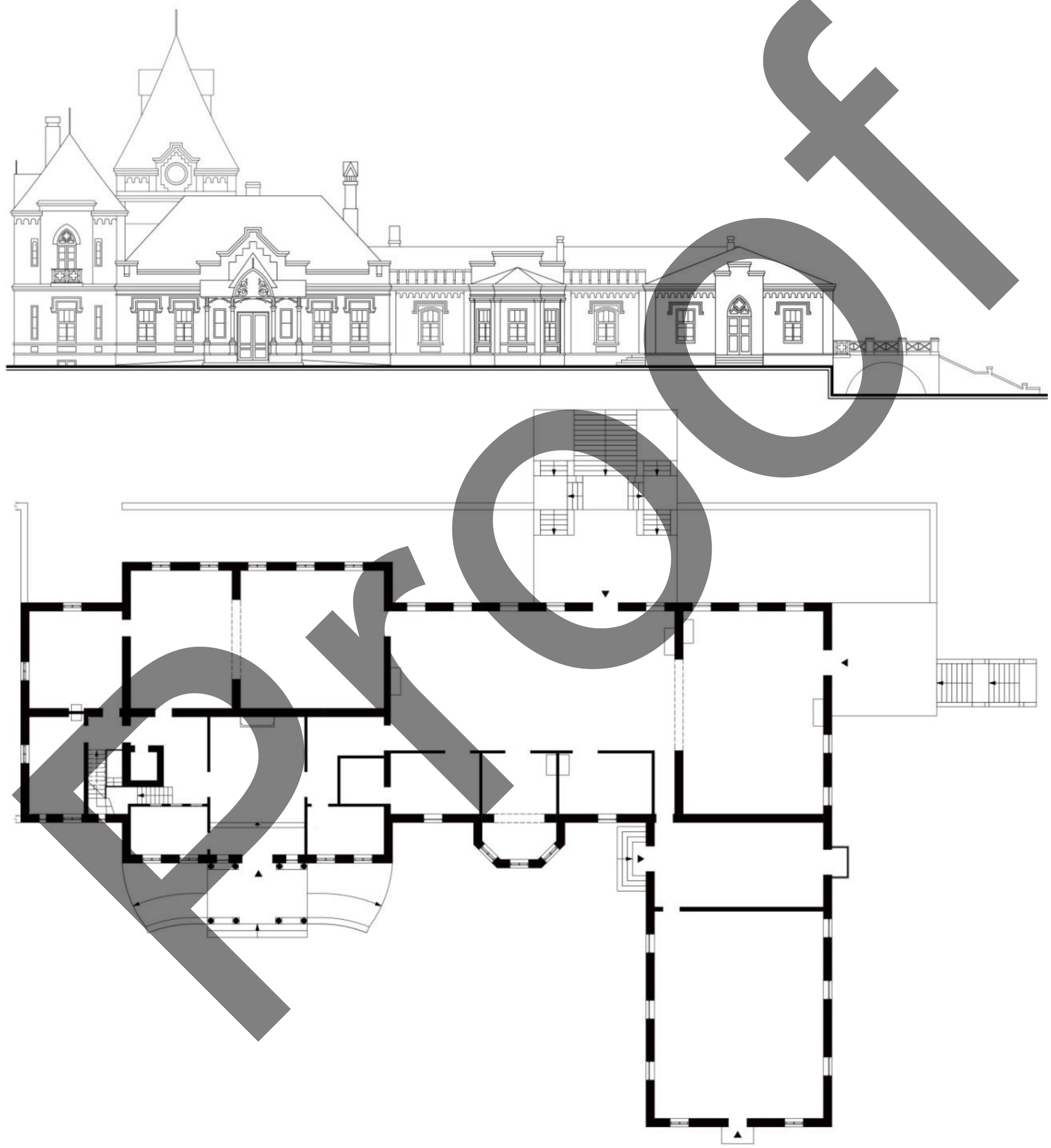

FIGURE 6. Reconstruction of the palace plan and the southern facade of the Bakhmetyev-Protasov palace in Tymanivka, Vinnytsia region (stages of 3D-modeling and 3D-reconstruction) [10]

The use of the fourth method - the creation of a virtual reconstruction of a building with remote access - is relevant for partially and completely lost objects, as well as those rebuilt or transformed in the course of exploitation. The essence of the method is to develop special cards with the image of palace buildings and QR-code, which enable to view a 3D model of the object anywhere in the world.

To clearly demonstrate the use of augmented reality technology, this study suggests to use the third method - reconstruction of the original appearance of the building in three stages. With the help of this method the virtual reconstruction of the palace of the Bakhmetyev-Protasov in Tymanivka (Vinnytsia region) is carried out.

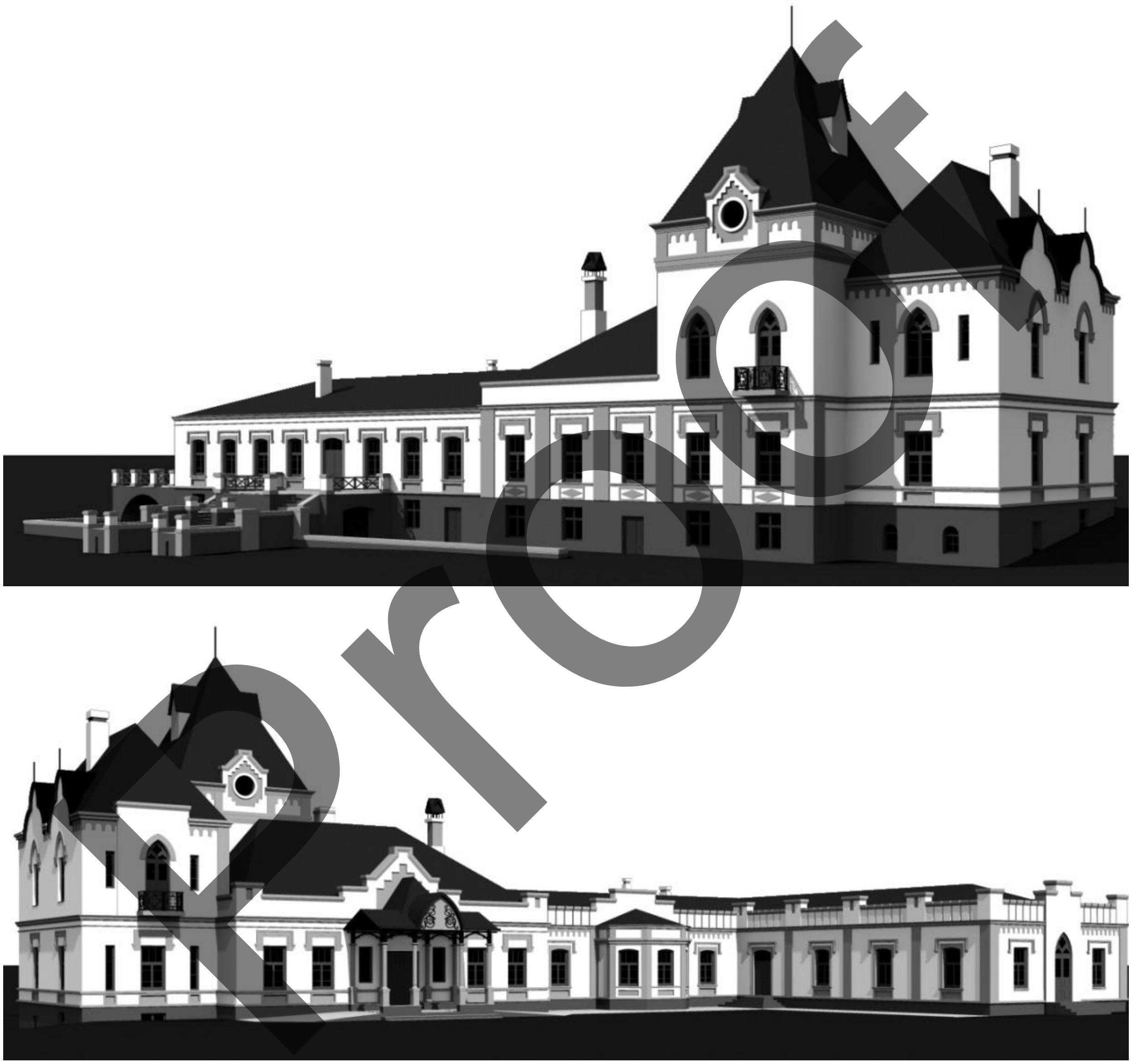

FIGURE 7. 3D-render of a palace in Tymanivka, Vinnytsia region. Drawing by A. Mahey.

At the preparation stage, the iconographic and factual materials related to this object are gathered, which allow for the most accurate reproduction of the original architectural image of the building and its layout (historical references, drawings, photos of the original condition, measurement findings, etc.).

At the first stage (3D modeling), the plan of the building, preserved parts of the palace, architectural details and decoration elements were reproduced in the software environment ArchiCAD 21 on the basis of field measurements carried out by the authors. At the stage of 3D reconstruction, a 3D model of the whole palace building was created, including the roof of the building, modified in the 20th century, and lost decorative elements (Fig. 6).

At the last stage, the reconstructed object is visualized with the help of 3D-Max software (Fig. 7). With the help of BIMx Viewer as part of ArchiCAD 21, the newly created 3D model of the palace building was saved and is available for viewing in real time. To do this, you need to install the BIMx Desktop Viewer application on a personal computer or mobile device.

CONCLUSION

With the development of modern digital technologies, the reconstruction of the original appearance of completely or partially lost architectural objects and / or complex ensembles has become possible not only in the real world, but also in the virtual space. The use of augmented and virtual reality technology is an innovative tool for working with architectural heritage, which expands the potential of the results. Firstly, a nationwide database of architectural monuments can be formed in this way – creating reference models, on the basis of which, secondly, their most accurate physical restoration can be carried out. Thirdly, the reproduction of the internal structure of the palace and the architectural decoration of the premises on the basis of available fixation materials will create an environment for a virtual tour and acquaint the widest range of recipients with the peculiarities of interior design and style, making a time travel based on innovative methodologies. Fourthly, the models can be used for thematic educational or entertaining computer games, which will generally help to expand the information outreach of the palace heritage of Podillya and Ukraine in general in the European and global cultural space.

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Modifying of Portland Cement for Modern Foam Concrete Technologies

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Abstract. The increasing of residential construction against the background of rising energy costs is making the problem of ensuring energy efficiency of housing more urgent. Exist steady trend of increased demand for structural and thermal insulation products and local energy efficient wall materials for low-rise construction. One such material is non-autoclaved foam concrete. The results of investigation of the effect of foaming agents on the setting time and strength of Portland cement are presented. It was established that the foaming agents increases the setting time of Portland cement and reduces the strength of cement paste at early age of hardening by 50-62%. The least negative effect on cement performance is observed when Centripor foaming agent is used. The hardening accelerator was used to compensate negative effect of the foaming agent on the properties of Portland cement. The accelerator provides high strength development of the Portland cement and increase the strength of the cement paste with the foaming agent by 14-27%. The modifying of Portland cement with hardening accelerator and foaming agent provides increasing of the degree of hydration by 1.2 time compered to Portland cement with foaming agent.

INTRODUCTION

Minimization of energy consumption and material resources in the process of construction and operation of building structures with reduction of negative impact on the environment in accordance with the provisions of the Paris Agreement become a priority in new construction, reconstruction and modernization of existing buildings. Problems of energy saving and environmental safety pose a number of urgent tasks for the construction industry, among which the development of new heat-insulating and structural insulation materials plays a crucial role [1, 2]. The increasing of cost of energy resources, requirements to energy characteristics of enclosing structures of buildings, enough simple technology, technical and economic parameters of producing confirm the high efficiency of foam concrete as wall material (precast blocks, precast wall elements or panels, cast-in-situ walls) or insulation floor screeds [3]. Foam concrete is widely used in modern construction due to the specifics of its porous structure and wide range of its functional possibilities. In particular, strength of foam concrete and low density is sufficient for build of walls, floor elements and other elements for low-rise construction. Fire resistance, high parameters of heat insulation, heat capacity determine the unique combination of performance characteristics of material [4]. The advantages of foam concrete compared to other wall and insulation materials are low thermal conductivity and density, high quality construction and reduced loads on the building [5]. Non-autoclaved foam concrete which obtained by hardening of

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mixture of sand, cement, water and foaming agent is the effective building material in civil engineering which can be used as environmental friendly material for heat-insulation [6].

The most important factor in the formation of the structure of non-autoclaved foam concrete is the composition and percentage of components that make up their formulation, as well as the type of the foaming agent. Foaming agent is an indispensable component in preparation of foam concrete with using prefabricated foams [7]. Foams are coarse colloidal systems containing gas phase as dispersed phase and liquid as dispersion medium, which usually forming thin films between gas bubbles. Foams are formed by mixing several substances with different surface tension [8]. The quality and quantity of foaming agent significantly effect on the Portland cement structure formation and on the density, strength, thermal conductivity, and other operational properties of the foam concrete [3, 9]. Such characteristics of foaming agents, which are used in the manufacture of foam concrete, as the ability of foam to hold on its surface finely dispersed mineral particles at long time (bearing capacity); compatibility of the active substance of foaming agent with the main clinker minerals (the ability of surfactant molecules of the foaming agent does not adsorb on the surface of mineral binders); compatibility of foam with technological additives introduced into foam concrete mixture are important. The effects of the foaming agent on structure formation of foam concrete are flow characteristics (conditional viscosity), setting time and strength characteristics of the hardened matrix when foaming agent is used [10].

The interaction between the foaming agent and cement plays an important role in the process of forming of structure of non-autoclave foam concrete. The foaming agents contain surfactants, which adsorb on cement grains. Degree of adsorbed surfactant depends both on its chemical formula and cement composition [11, 12]. Consequences of surfactant adsorption are change of cement grains zeta potential, hydrophobization of cement grains and bridging between cement grains [13, 14]. The morphology of the hardened cement depends on the bubble size distribution of the precursor foam and on the evolution of the bubbles during mixing and until cement hardening. As a rule, the use of foaming agents causes slowdown of hydration of cement at all hardening period.

The solving of problem of development of non-autoclaved foam concrete with necessary performance is very important. In order to increase the strength of the cellular concrete without changing its density the strength of the cement matrix should be increased. The structure formation control can be provided by improving of mixture composition and the processes of production of foam concrete, which may be achieved by increasing the amount of binding materials, use of full cement potential due to mechanical activation [15]. The disadvantage of ultrafine cements is increase of water demand, which can lead to a decrease of early strength. The effective way to control the structure formation processes of non-autoclaved foam concrete, especially at early period is use of modifiers, in particular hardening accelerators (chemical activation) [5, 7]. The accelerator serves to rapidly increase the viscosity of the mixture, thereby entrapping the foam or air within the matrix of the mixture before air can escape.

MATERIALS AND METHODS

The Portland cement CEM II/A-S 42.5 R (PC) produced at PJSC “Ivano-Frankivskcement” was used for the experiments. The initial setting time of Portland cement is 190 min, the final setting time – 370 min. The compressive strength of CEM II/A-S 42.5 R after 2 days according to EN 196 1 is 25.9 MPa (57 % of minimum standard strength for strength class 42.5); the standard strength of PC is 45.6 MPa. The admixtures Centripor, K-1, S-45 were used as synthetic foaming agent. The accelerator of hardening Mortebeschleniges was used to accelerate the hardening processes of Portland cement.

Setting period and compressive strength tests was carried out for evaluation of the influence of admixtures on the Portland cement properties. Vicat needle tests were used to measure setting time of cement. Cube-shaped samples (20×20×20 mm) were prepared to research of strength development of cement paste with foaming agents and accelerator. The specimens were de-moulded 24 hours after casting and were subjected to normal curing condition (relative humidity 95±5 %) in the room temperature. Samples are tested after 1, 2, 7 and 28 days.

Peculiarity of foaming agent and accelerator of hardening influence on hydration processes of Portland cement were examined by means of X-ray diffractometry (XRD).

The degree of Portland cement hydration was determined by the formula:

$$DH = \left(1 - \frac{I}{I_0}\right) \cdot 100\%$$

where I i I_0 - the intensity of the lines of hydrated and non-hydrated Portland cement, respectively.

The analytical line of alite C_3S with d/n = 0.218 nm use to determine the degree of hydration of Portland cement in the presence of admixture.

RESULTS AND DISCUSSION

The choice of foaming agent determines both the technology of foam concrete production and the technical and operational characteristics of foam concrete. The properties of foam impact on the structure and hardening of the foam concrete in different ways and designate performance of buildings and structures constructed from foam concrete [2]. One of main directions of action of foaming agents as surface-active substances is influence on hydration and hardening processes of Portland cement.

As result of composition design of foam concrete density class D600 it was establish, that optimal consumption of foaming agent is 0.6% by mass of cement. Therefore the effect of foaming agents Centripor, K-1, S-45 0.6 mass.% on the setting time and compressive strength of Portland cement was studied. The adding of foam agents causes increasing of initial setting time of Portland cement CEM II/A-S 42.5 R from 190 min to 270 min when Centripor foaming agent is used (Fig. 1). The initial setting time significant increase when foaming agents K-1 and S-45 were used. It was observed that PC with the K-1 increases the setting time to the greatest measured value (530 min). It should be noted that the final setting time of Portland cement also increases when foaming agents are used. Thus, final setting time increases from 370 min for Portland cement without admixtures to 400, 620 and 520 min for Portland cement with foaming agent Centripor, K-1, S-45 respectively.

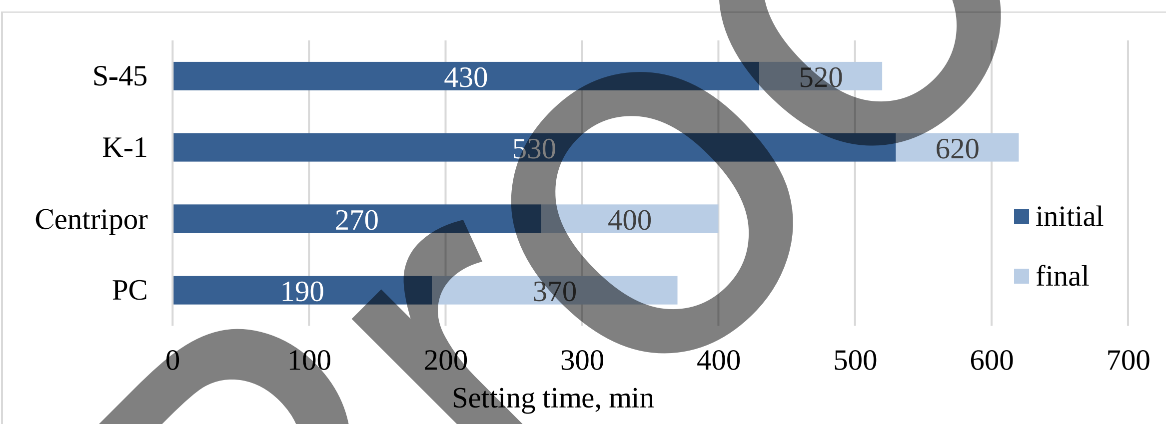


FIGURE 1. The effect of foaming agents on the setting time of Portland cement (W/C = 0.3)

The results of the compressive strength test of cement paste with foaming agents show that the adding of foaming agents (0.6 mass. %) causes decreasing of strength of cement paste in all hardening period (Fig. 2). Thus, adding of foaming agent Centripor causes decreasing of compressive strength of cement paste after 2 days by 50% (ΔR_2 =50%). Compressive strength after 2 days decreases by 62% and 59% for cement paste containing foaming agent K-1 and S-45 respectively. The smallest decreasing of compressive strength of cement paste after 28 days of hardening observes when foaming agent Centripor is used (ΔR_{28} = 50%). The using of foaming agent S-45 causes the largest decreasing of compressive strength of cement paste ΔR_{28} = 57% and corresponds to the value 39.4 MPa. The use of admixture Centripor causes the least negative impact on the properties of Portland cement among the investigated foaming agents.

The hardening accelerator Mortebeschleniges in the amount of 1.0 mass.% was used for accelerate of hardening of Portland cement containing foaming agent. Investigation of the effect of the hardening accelerator on the setting time of Portland cement shows that the adding of 1.0 mass.% Mortebeschleniges reduces the setting time of Portland cement. The initial setting time decreases by 40 min and the final – by 110 min compared to CEM II/A-S 42.5 R without admixture (Fig. 3). Reduction of period from initial and final setting time is revealed when the hardening accelerator used. Thus, duration of this period for Portland cement paste without admixture is 180 min and Portland cement paste containing hardening accelerator – 110 min, which indicates the acceleration of structure formation of cement in the presence of the accelerator. Portland cement modified with complex admixture 0.6 mass.% Centripor foaming agent and 1.0 mass.% Mortebeschleniges hardening accelerator characterizes by initial and final setting time of 170 and 270 min respectively, which is less by 100 and 130 min than the initial and final setting time of Portland cement with the Centripor foaming agent.

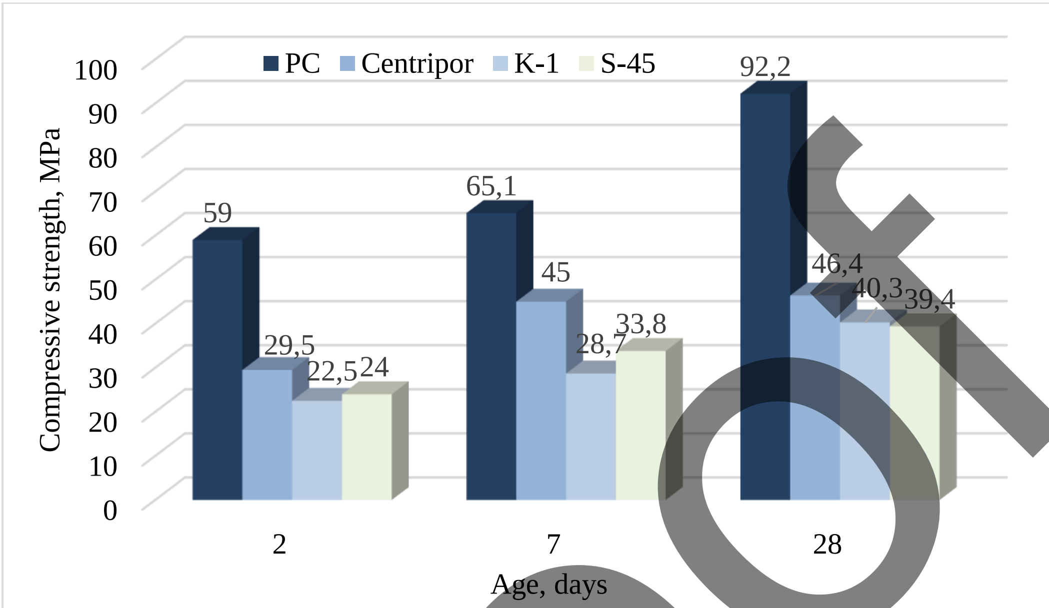


FIGURE 2. The effect of foaming agents on the compressive strength of Portland cement paste (W/C = 0.3)

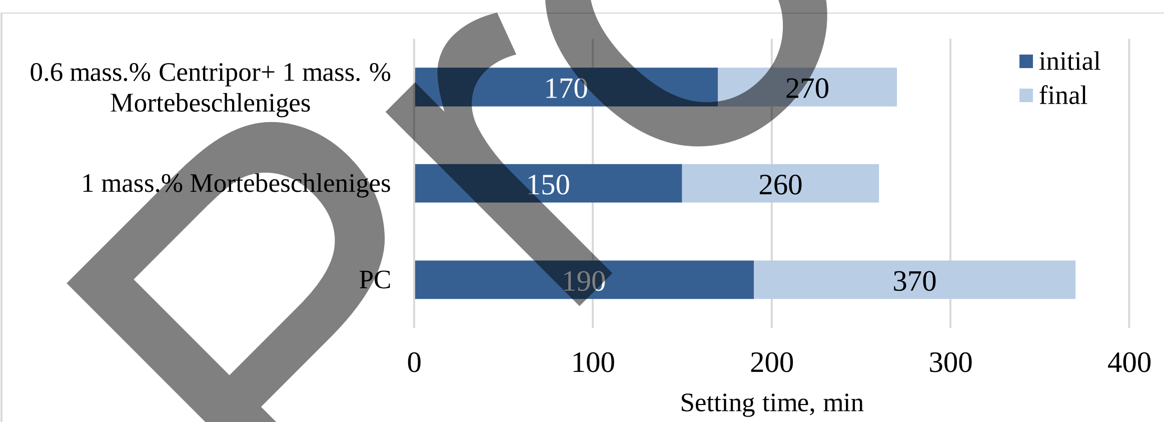


FIGURE 3. The effect of hardening accelerator on the setting time of Portland cement (W/C = 0.3)

The results of compressive strength development of Portland cement paste modified with the admixture of hardening accelerator and complex admixture are given in Fig. 4. The adding of 1.0 mass. % Mortebeschleniges provides increasing of cement paste strength by 26-30% at early period of hardening (1-2 days).

The relative strength index (R_{c2}/R_{c28}) for Portland cement CEM II/A-S 42.5 R is 0.64 and for Portland cement modified with hardening accelerator – 0.80. The use of complex admixture containing foaming agent and hardening accelerator can compensate the negative impact of the foaming agent on the strength of Portland cement at all period of hardening. Thus, the compressive strength of cement paste with foaming agent and accelerator after 24 h increases by 27%, after 2 days – by 24%, after 7 days – by 14%, after 28 days – by 27% compared to Portland cement with a foaming agent. However, compressive strength of Portland cement with complex admixture decrease by 1.3– 1.6 time compared to Portland cement CEM II/A-S 42.5 R.

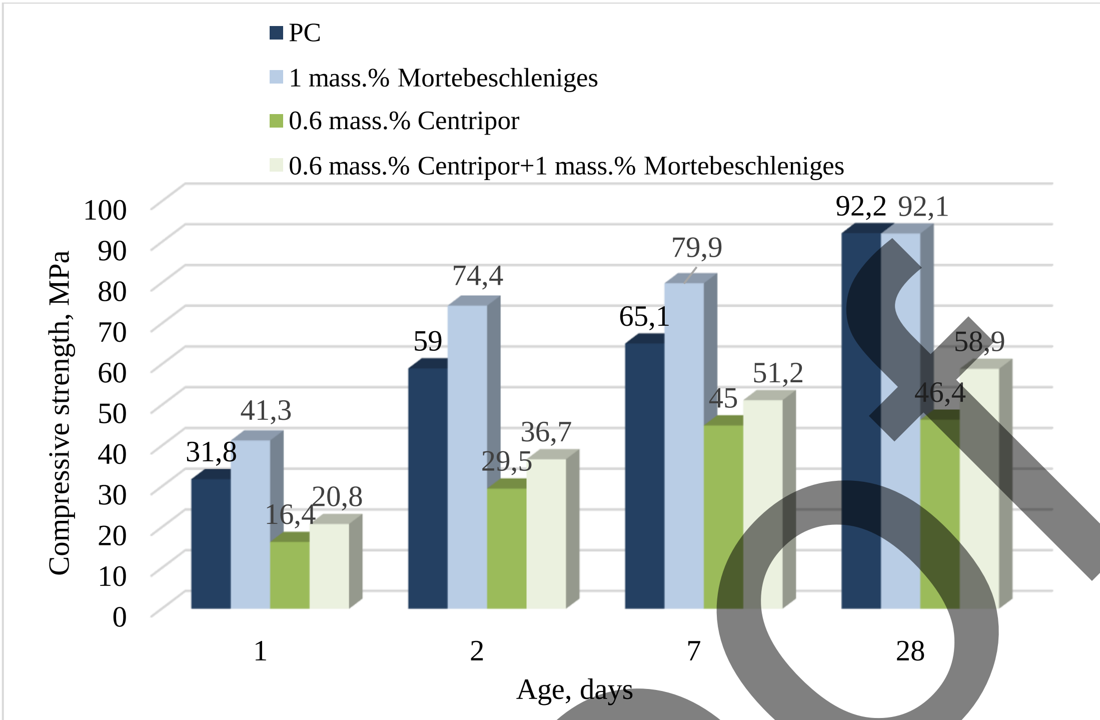


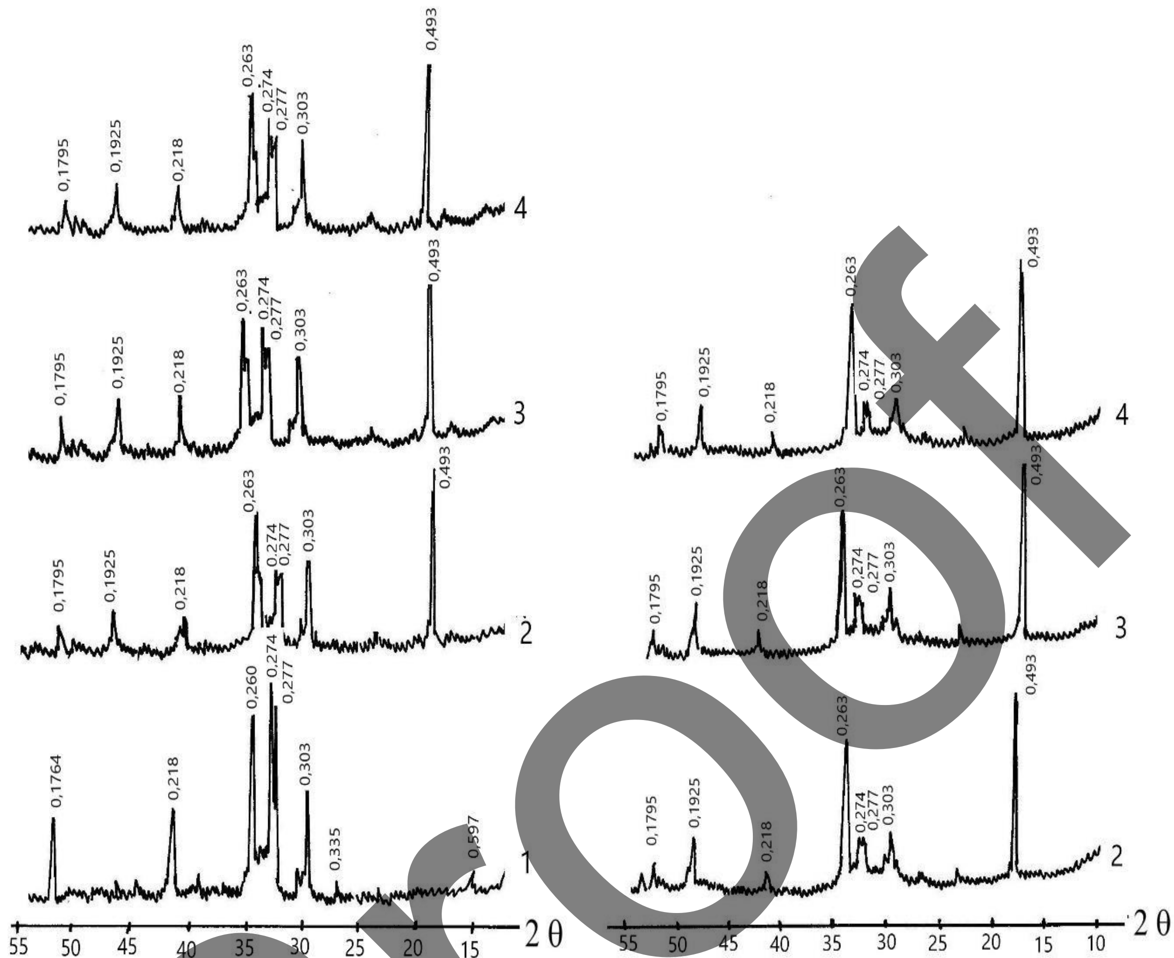
FIGURE 4. Strength test results of Portland cement paste modified with foaming agent and hardening accelerator (W/C = 0.3)

Investigation of hydration process is important to link the strength parameters with liquid/solid state reaction of cement phases in present of foaming agent and accelerator for achieve efficiency of foamed cementitious composites.

The XRD of the hardened pastes after 24 h and 28 days is shown in Fig. 5. It can be noticed that the main crystal phases for all specimens are attributed to ettringite (d/n=0.973; 0.561 nm) and $Ca(OH)_2$ (d/n=0.493; 0.263; 0.192 nm). However, the XRD patterns of the Portland cement paste with 0.6 mass.% foaming agent displays lower intensity of portlandite $Ca(OH)_2$ lines and higher intensity of nonhydrated clinker mineral lines (d/n=0.279; 0.218 nm), that indicates slowdown of the hydration processes at early age in presence of foaming agent. Likewise, no phase changes take place after 28 days of hardening of Portland cement with foaming agent.

The degree of hydration of Portland cement with 0.6 mass.% foaming agent after 24 h is 31%, while for Portland cement without admixtures – 42%. The degree of hydration of Portland cement with foaming agent after 28 days is 62%. At the same time hydration degree of CEM II/A-S 42.5 R is 78%.

The hydrate phases of Portland cement with foaming agent and hardening accelerator doesn’t change. However, XRD patterns of Portland cement modified with foaming agent and accelerator shows that intensity of the lines $Ca(OH)_2$ (d/n = 0.493; 0.262 nm) is higher and the intensity of lines of nonhydrated clinker minerals (d/n=0.279; 0.218 nm) is weaker compared to Portland cement without admixtures. Using of accelerator significantly intensifies the hydration processes of Portland cement system, which is reflected in the increase of degree of hydration of alite phase. Thus, degree of hydration of Portland cement modified with foaming agent and accelerator after 24 h of hardening is 62%, which is by 5% higher than Portland cement with foaming agent. At that time, the degree of hydration of Portland cement with foaming agent and accelerator after 28 days is 75%.



(a) (b)

FIGURE 5. XRD patterns of Portland cement paste hydrated 24 h (a) and 28 days (b): 1 – nonhydrated Portland cement; 2 – Portland cement without admixtures; 3 – Portland cement with foaming agent; 4 – Portland cement with foaming agent and hardening accelerator

CONCLUSIONS

Foaming agents are main component of cellular concrete. Their role is to create a porous structure of material. At other hand, foaming agents slowdown setting time of Portland cement and decrease of strength of cement paste in all terms of hardening. The compressive strength of cement with foaming agents at the early period decreases by 50-62%. The using of hardening accelerator compensates negative impact of the foaming agent on setting time, compressive strength and hydration processes of Portland cement. The strength and degree of hydration of Portland cement paste, modified with complex admixture increase by 1.2 time compared to Portland cement paste with foaming agent. The complex modification of Portland cement systems creates possibility of technologies of non-autoclaved foam concrete as effective thermal and structural insulation material for solve the problem of energy saving of residential and public building according to concept of sustainable development.

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Physical-Chemical Studies of Fiber-Reinforced Foam Concrete for Effective Thermal Insulation of Motorway Road Surfaces

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Abstract. For the first time, the authors developed the design principles of working compounds for motorway road surfaces using cast-in-situ structural and heat-insulating foam concrete reinforced with polypropylene fibers as a thermal insulation layer, thus creating effective conditions for frost heaving prevention of the base in multi-layer structures of non-rigid road surfaces. In the publication, the authors studied the mechanism of the structure formation of a cement stone matrix of foamed concrete grades of D600-1000 density reinforced with polypropylene fibers with a length of 8 mm to 20 mm and identified the main factors affecting the physical and mechanical properties of non-autoclaved fiber-reinforced foam concrete. As a result of the studies, factors that provide increased operational characteristics of road surfaces with a thermal insulation layer of fiber-reinforced foam concrete in non-rigid motorways are identified and the possibility of increasing the operational life in the process of compliance with the regulatory inter-repair cycle during the operation of the street and roadway network in Ukraine is determined.

INTRODUCTION (ISSUES RAISED IN THE ARTICLE)

The ways to reduce the cost of road transport infrastructure represent the introduction of new road surface design solutions into the design and construction practice, which would ensure high quality of the road surface during the guaranteed operational period [1–3]. This can be achieved most effectively if the process of frosty heaving of the roadway is prevented by using foam concrete reinforced with polypropylene fibers.

In terms of physical and chemical research in Ukraine, when using fiber-reinforced foamed concrete, sufficient attention was not paid to the issues of the thermal insulation layers of the non-rigid motorway road surface until the next moment.

Taking into account the increased requirements for the quality of road construction works and the practical experience of European countries, the use of fiber-reinforced foam concrete can create a significant technological, constructive, and economic effect [4–6]. This fact is the basis for conducting thorough theoretical and practical research for further using the structural and heat-insulating foam concrete in road construction.

URGENCY OF THE PUBLICATION

The issues of the inter-repair cycle increase in the operation of non-rigid motorways and the study of physical and chemical properties in the structure formation process of fiber-reinforced foam concrete layers of the road surface of modern street and road infrastructure in Ukraine are quite an urgent problem.

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NOVELTY OF THE ARTICLE MATERIALS

For the first time, the authors developed the design principles of working compositions for motorway road surfaces using cast-in-situ structural and heat-insulating foam concrete reinforced with polypropylene fibers as a thermal insulation layer, thus creating effective conditions for frost heaving prevention of the base in multi-layer structures of non-rigid road surfaces.

The structure formation specifics of the matrix of fiber-reinforced foamed concrete grades with D600 to D1000 density are studied using the latest methods of physical and chemical studies of structural and heat-insulating foam concrete reinforced with polypropylene fibers.

RESULTS AND DISCUSSION

From 2012 to 2019, the authoring team of the Department of Building Production of the Institute of Civil Engineering and Building Systems of the Lviv Polytechnic National University conducted comprehensive scientific research to identify the problem of using structural and heat-insulating foam concrete reinforced with polypropylene fibers as an antifreeze layer of the non-rigid motorway road surface [7, 8]. The main role in the process of these multi-method scientific studies of new road construction material was devoted to the study of the structure formation mechanism of the fiber-reinforced foam concrete matrix using physical and chemical methods with the involvement of specialist laboratory equipment. As a result of physical and chemical studies of the studied series of fiber-reinforced foam concrete samples of grades ranging from D600 to D1000, the authors of the publication established the sequence of the cementing matrix structure formation mechanism of the structural-thermal insulation layer, which was previously reinforced with polypropylene fibers.

It was found that the main connecting link of the cementing matrix inter-granular space of interporeal partitions is the hydrosilicate phase of the material (Figure 1). The presence of dispersed fibers in the studied composite material formed a base on which a strong and dense layer of newgrowths was formed mainly due to hydrated calcium silicates in the contact area of the components.

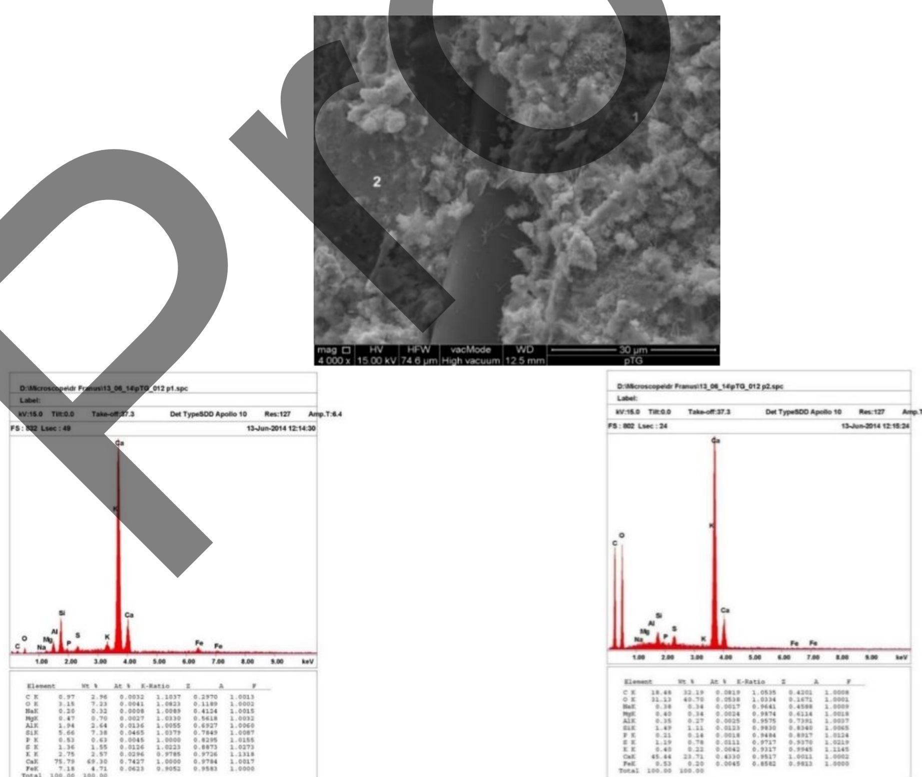


FIGURE 1. Microstructure and results of the microprobe analysis of cement paste of the foam concrete matrix with polypropylene fibers hydrated for 28 days

The contact area formation in the fiber-reinforced foamed concrete matrix increases the adhesion of fiber to the cement matrix, the joint work of the dispersed reinforced matrix components, and largely determines the future physical and mechanical properties of the stone based on it.

The relatively high compressive and flexural strength of dispersed reinforced foam concrete obtained further was provided due to the directed micropatterning of the cementing matrix with the formation of hydrated newgrowths and the cement stone compacting process due to pore mudding with hydrosilicates and hydrated calcium aluminates, as well as the joint effective operation of polypropylene fiber and cement matrix.

Figure 2 shows the results of physical-chemical studies of the construction heat-insulating foam concrete without fiber reinforcement.

As a result of the microstructure analysis of the foam concrete cement matrix, one can conclude that it is characterized by a wide variety of crystal forms – from low-crystalline AFm phases and AFt phases, which are structurally active components of cement stone and, together with dispersed polypropylene fibers, provide more stable construction and technical properties of foam concrete. According to microprobe analysis, rounded crystal blocks belong to calcium hydroxide, and this shape of the crystals is apparently stemming from the presence of a foaming agent.

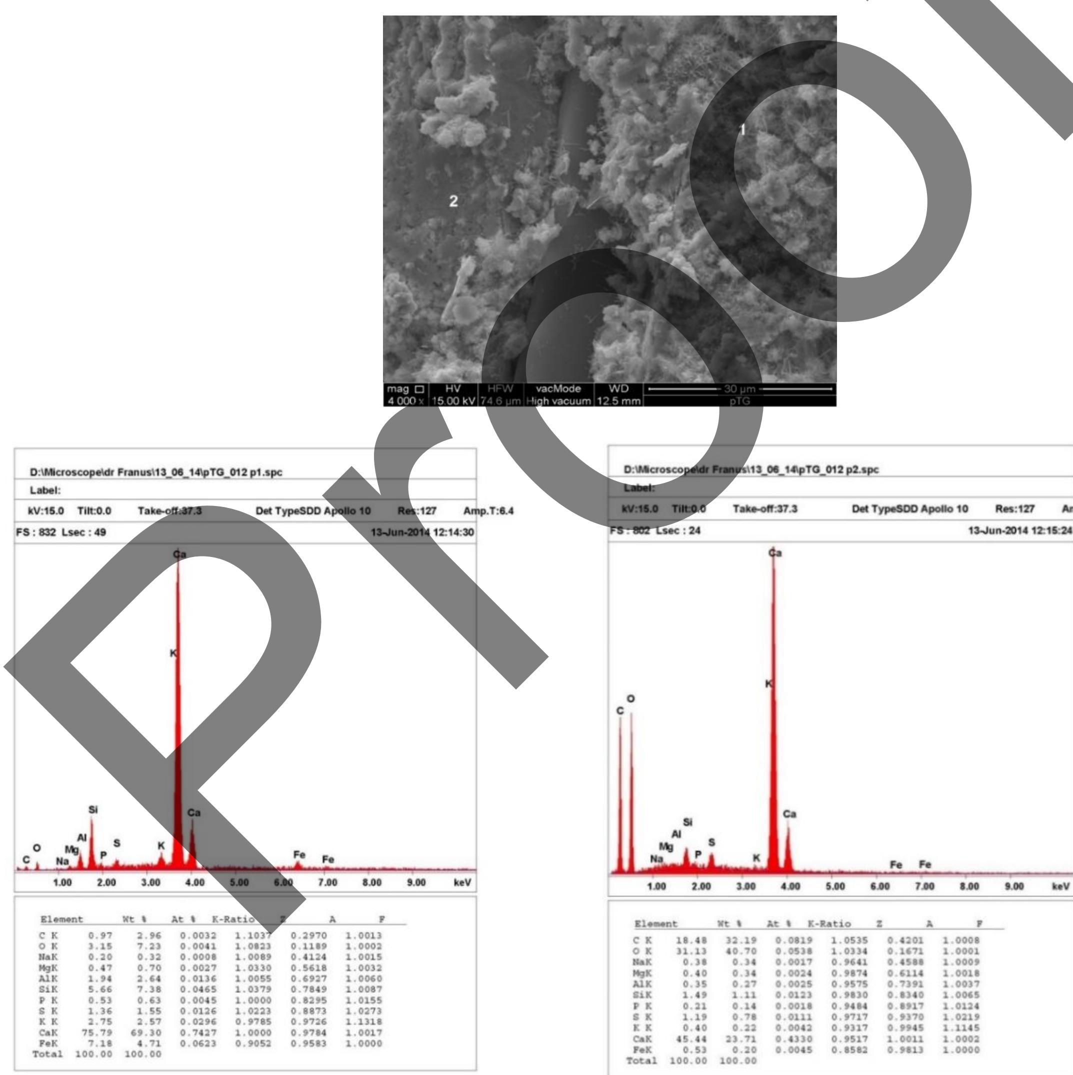


FIGURE 2. Microstructure and results of the microprobe analysis of Portland cement paste of the foam concrete matrix without fiber reinforcement hydrated for 28 days

The use of dispersed reinforcing elements causes changes in the processes of early structure formation, phase composition, microstructure compaction, and an increase in the strength of the foam concrete cement matrix. According to X-ray phase analysis, during hydration of cement stone based on PC I-500 after 28 days, the main lines of hydrate phases are recorded on diffractograms, in particular, ettringite (d/n=0.973; 0.561 nm, etc.) and Ca(OH)2 (d/n=0.493; 0.263 nm, etc.), while the line intensity of non-hydrated cement decreases (d/n= 0.302; 0.277; 0.275; 0.218 nm), as shown in Figure 3.

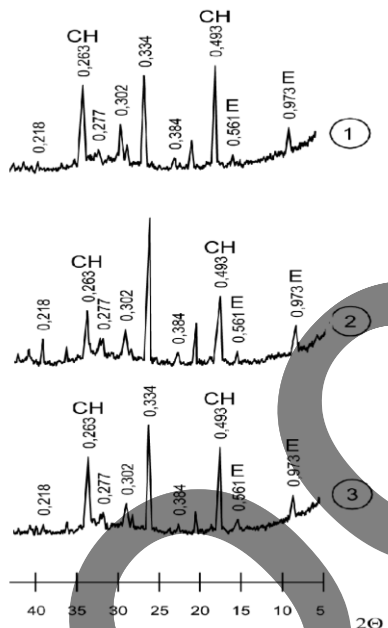


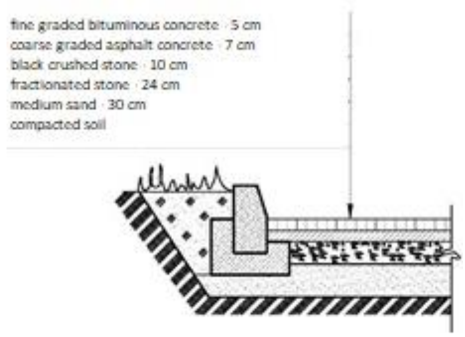
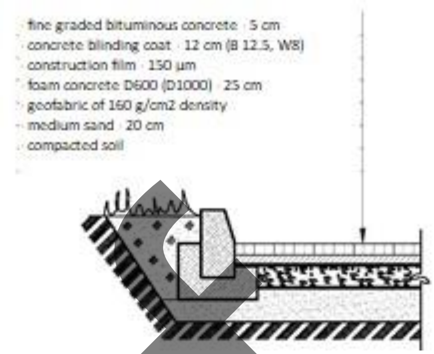
FIGURE 3. XRD patterns of the cement matrix based on: 1 – PC I-500; 2 – foam concrete cementing matrix; 3 – foam concrete dispersed-reinforced cementing matrix hydrated for 28 days under normal conditions

The study of the cement stone microstructure genesis of the fiber-reinforced foam concrete matrix is essential and allows assessing the influence of hydrated phases on the formation of a stable crystal frame and the strength of the interporeal cement stone. An important condition for obtaining fiber-reinforced foam concrete with specified structural and mechanical properties is controlling the process of structure formation at the initial stage. The peculiarity of the fiber-reinforced foam concrete matrix hydration processes is that the formation of the main hydrated phases occurs under conditions of the high-value physical and mechanical properties of the material (compressive strength, flexural tensile strength), where small fibers strengthen the cement stone in all directions and, as a result, increase the tensile strength of fiber-reinforced foam concrete under bending. To be noticed is that the incorporation of polypropylene fibers does not significantly affect the hydration process mechanism, since the diffractogram of the dispersed-reinforced stone shows lines of the main hydrate phases, in particular, ettringite (d/n=0.973; 0.561 nm), $Ca(OH)_2$ (d/n=0.493; 0.263 nm). However, the growth of the phase contact area with the polypropylene fiber incorporation, on which hydrated phases can crystallize, provides a noticeable increase in the hydration degree of Portland cement.

The authors' physical-chemical and construction-technical studies of fiber-reinforced foam concrete grades with densities ranging from D600 to D1000 allowed determining the algorithm for selecting working compositions of fiber-reinforced foam concrete mixtures for applying a high-quality antifreeze layer of the road surface and provided an opportunity to justify the formation mechanism of the interporeal space in the heat-insulating layer in non-rigid motorway road surfaces.

In the process of analyzing the technical and economic efficiency of the thermal insulation layer application, the authors took into account the service life of the road surface, the frequency of inter-repair periods, and the cost of repairs. The economic effect of using the thermal insulation layer of cast-in-situ fiber-reinforced foam concrete proposed by the authors makes it possible to provide an economic effect of 7.3% compared to the traditional road surface, where sand is used as a thermal insulation layer (Table 1).

TABLE 1. Comparison of the actual cost of applying a thermal insulation layer in road surface

Indicator name	Application of a sand thermal insulation layer	Application of a fiber-reinforced foam concrete thermal insulation monolithic layer
Road surface construction		
Technological operations necessary for applying a thermal insulation layer	1) transportation of sand and its stockpiling; 2) distribution and planning of sand by autograder or bulldozer on the prepared roadbed according to the project; 3) compaction and watering of the sand layer; 4) filling the sandy underlying layer with water, allowing to identify and correct areas that require additional upfilling; 5) final planning and detailed geodetic verification of the marks of the sand underlying layer profiles	1) laying of protective polyethylene film; 2) form setting; 3) transportation of fiber-reinforced foam concrete mixture; 4)applying the fiber-reinforced foam concrete mixture; 5) profiling and smoothing out the layer surface
Set of necessary machines	dump trucks, bulldozers, autograders, sprayers, pneumatic tire rollers	dump trucks, concrete trucks (or concrete pumps)
Durability (inter-repair period), years	2-7	15-20
Cost of repair for 25 years, UAH	8,000,000×4 = 32,000,000	8,000,000
Total cost for 25 years of operation, UAH	54,512,860	50,531,040
Economic effect of construction of 1 km of non-rigid motorway	-	7.3%

At the same time, the expediency of using cast-in-situ non-autoclaved fiber-reinforced foam concrete as a thermal insulation layer of the road base is economically justified and apparent due to the fact that the frequency of repairs (capital and current) on defective sections is reduced by 4 times and ranges from 25 to 30 years compared to a standard 7-year inter-repair period for non-rigid motorways.

A distinguishing characteristic of the anti-freezing layer technology in the non-rigid road surface using in-situ foam concrete from 600 to 1000 kg/m^3, reinforced with polypropylene fibers from 10 to 20 mm in length, is the ability to prevent heaving of surface structural layers of the road network in winter operating conditions in the relevant climatic regions of modern Ukraine due to the thermophysical properties of the above-mentioned layer of effective thickness.

The heat-insulating layer application technology using fiber-reinforced foam concrete of grades from D600 to D1000 for non-rigid road surfaces enables a significant increase in the standard inter-repair cycle in the operation of motor-road areas of this category and impacts the operational efficiency of the street and road network in Ukraine of the XXI century.

Thus, even if the direct economic effect of using a heat-insulating fiber-reinforced foam concrete monolithic layer of calculated thickness for the corresponding natural and climatic region of Ukraine and the base soils instead of the traditional antifreeze layer of sand in a road surface will not be very significant, the use of this material can reduce the cost of operating defective sections of non-rigid motorways by three times.

Besides, the use of non-autoclaved foam concrete of grades D600, D800, D1000, dispersed-reinforced with polypropylene fibers, due to its manufacturability, strength characteristics, and relative simplicity of the construction, underpins effective prerequisites for saving financial resources when applying the proposed design and technologic solution of the antifreeze layer in non-rigid motorway road surfaces in Ukraine.

CONCLUSION

Physical and chemical studies of structural and heat-insulating foam concrete of D600, D8000, and D1000 density grades reinforced with polypropylene fibers have created the basis for choosing the optimal algorithm for calculating the required thickness of the road surface antifreeze layer in the design of modern non-rigid motorways.

A significant economic effect from the introduction of the developed foam fiber concrete compositions in the process of constructing non-rigid motorways is proved due to a significant increase in the inter-repair cycle during the operation of the street and road network in the conditions of modern Ukraine.

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Study of the Properties of Epoxy Resin to Increase the Durability of Composite Materials

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Abstract. The article is a continuation of the research started earlier with the aim to create a technology for modification of composite materials to give them increased strength and durability by filling the porous space of the matrix with a permeable compound based on epoxy resin, which hardens in the pores of the matrix. The article analyzes the existing methods of decreasing the viscosity of the compound and investigates the decrease of viscosity under the influence of ultrasonic vibrations. A physicochemical model of the process of filling the porous space of the body, which leaks out, has been developed and grounded. The physical and chemical processes of solidifying surface during formation of the polymerizing structure are considered. Also, the physical and mechanical indicators of the quality of concrete soaked with epoxy compound under the influence of ultrasonic vibrations and overpressure are presented.

INTRODUCTION

One of the most widespread building materials is concrete (reinforced concrete) and its products. When building diverse objects there is a need to use building materials with increased expectations for quality, in particular durability and density, which can withstand high operational stress. Increased indicators of strength and durability ensure that such materials are widely used - in construction of skyscrapers, buildings in seismic areas, chemical plants, objects of storage for radiation sources, certain underground facilities such as canalization, water utilities and so on. Therefore, the development of composite materials with increased physical and mechanical properties is certainly relevant.

The main way to improve the properties of the materials is the addition of composite polymers to traditional mineral compounds in the form of additives or in the form of processing agents. Due to the complex of positive operational properties one of the organic substances is epoxy resin, which is used in polymers, adhesives, protective coatings, etc.

Comparatively high cost of epoxy resins interferes and reduces their widespread use in construction. Promising way to reduce the cost of concrete using epoxy resins is to develop ways of using resin-based products as a soaking composition. This will reduce the consumption of resin, significantly reduce the cost of high-quality concrete and provide the necessary physical, mechanical and physical-chemical indicators.

ANALYSIS OF THE LATEST STUDIES AND PUBLICATIONS

The works of the authors [1, 2] have revealed that the main reason for the loss of strength of CM is cracks and cavities which can increase over time under the influence of external stresses. This leads to the conclusion that the main method of increasing the durability of materials is the removal of porosity through filling the voids with hardening liquids.

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The soaking of concrete, asbestos cement and other capillary porous materials with bitumen, resins and other special reagents in order to increase their durability and resistance under special conditions is a well-known method of improving the properties of porous materials. However, due to the small depth of percolation and partially insufficient strength of the percolation composition it was not possible to significantly increase the strength of the concrete.

The research theoretically calculated the possibility of increasing the properties of concrete by using saturating concrete with polymers, which allows to achieve a decrease in porosity and increase the impermeability of a new composite material – concrete-polymer (CP). The properties of CP depend both on the properties of the concrete and the polymer, as well as on the technology of treatment. The stronger is the polymer that is used for the impregnation, the greater is the amount of it in the concrete, the stronger is the concrete stone skeleton and the higher is its strength. During concrete impregnation, the configuration of its pores and capillaries determines the speed of percolation. The height of the fluid is proportional to the radius of the capillary, and the velocity of the fluid is directly proportional to the square of the radius and is proportional to the velocity of the fluid. The work has shown that only in thin capillaries with rigid walls the monomer is retained quite intact and the polymer is reinforcing the matrix.

In terms of strength cement stone is the weakest element due to the presence of pores and voids. The dependence of concrete strength on the pore radius of cement stone is considered in the works of L.M. Reshetnik [3]. Pore appearance is inevitable, since the mixing water is introduced into the cement in the amount of 35-50%, only 13% strongly linked with the solid phase, and the space that is released (22-37%) forms cavities. The dependencies obtained by the authors allow us to reach the conclusion that the most disadvantageous, most significantly reducing the physical and mechanical properties of concrete, are capillary pores with a radius of 50 nm or more, as well as macrocapillaries with a radius of 0.01 mc or more. Theoretically it has been established that not all pores reduce the strength of concrete to the same extent, so it is possible to increase its strength by filling the large (capillary) pores in the first place.

DEFINITION OF THE GOAL AND TASK OF THE STUDY

Such a conclusion allows for the possibility of using more viscous liquids than ethers. However, the high viscosity of epoxy resin (ED-20) in its pure form requires quite a long time for the release process and since the beginning of polymerization, for example, ED-20 starts after 40 hr, this period is the limiting value for the time of release. The aim of the research is to select formulations and process solutions that will ensure a sufficient soaking depth over a period of time without increasing the compounds' viscosity due to the polymerization of the resin.

THE MAIN PART OF THE RESEARCH

In order to solve this problem, it is necessary to develop:

1) a composition of compounds with reduced viscosity on the basis of epoxy resin;

2) technological methods that would accelerate the permeation of fluid through the capillaries.

Separate stages of permeation of porous composite materials are distinguished by the way of creation of pressure Ppc on a liquid polymer which accelerates the process of pore filling. During capillary permeation the pressure Ppc is created without adding external forces, only at the expense of capillary forces Pc. During vacuum seepage (vacuum absorbtion) pores are filled with liquid due to the difference between the atmospheric pressure and the pressure created in the pores during vacuumization of the material. This difference corresponds to the value of the atmospheric pressure. Pouring under excessive pressure is possible only with the help of compressed gas or mechanical equipment. The percolation process can also be accelerated by applying ultrasonic vibrations (ultrasonic percolation) [4-9].

Due to the rapid polymerization of the epoxy compound, it is necessary to develop technological solutions for accelerating the filling of the capillaries with permeation compounds so that the permeation process is completed before the beginning of polymerization.

The correlation between the leaking fluid and the kinetics of the processes can be regulated through the use of different combinations of fills, but an excess of fills leads to a decrease in the solidity of the polymer.

Solid surface influences the structure and properties of adjoining polymers, which is caused by the processes that take place on the molecular level "polimer - solid surface". The surface of concrete influences the structure of cross-linked polymers. The surface energy influences the morphology of the cross-linked polymers.

The basis for the identification of the compound components is the influence of the solid phase surface and the active centers. The role of the solid surface, which structures the compound, is shown in the scheme (Fig. 1).

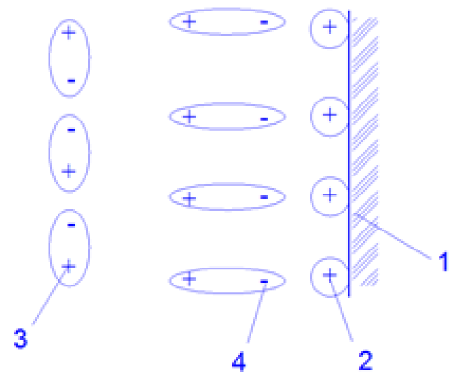


FIGURE 1. Schematic diagram of the appearance of high-density liquid layer near the solid surface of the capillary walls.
1 - solid surface of the capillary walls; 2 - surface charge; 3 - unstructured monomer molecules in mass; 4 - extracted monomer molecules under the influence of solid surface.

According to Y.S. Lipatov [9], the structural layer of monomer near the solid surface is 0.5-5 microns. Monomer molecules 3 (Fig. 1) are slightly dislocated in the mass (weak dipoles). Monomers near the solid surface 1 are deformed by the charge 2 into the reduced dipoles 4. Since they became thinner than the molecules in the mass, the layer of extracted dipoles appears to be packed more tightly, and in the process of polymerization in this ball the epoxy resin becomes thinner and stronger. On the basis of looking at the interaction between the solidifying liquid, and the solid surface, the hypothesis was made about the fact that during the filling of capillary compounds with resins (monomers) of ρ_{mon} density, dispersed with ρ_p, the separation of the compound happens in such a way, that substances with higher ρ_{mol} density are concentrated near the solid surface and in this layer the monomer is polymerized by covering the capillary walls with a layer of solid polymer (Fig. 2).

Based on the hypothesis presented, a physical and chemical model of interaction between the compound and the surface of the capillary walls was created based on the composition of the compound (Fig. 2).

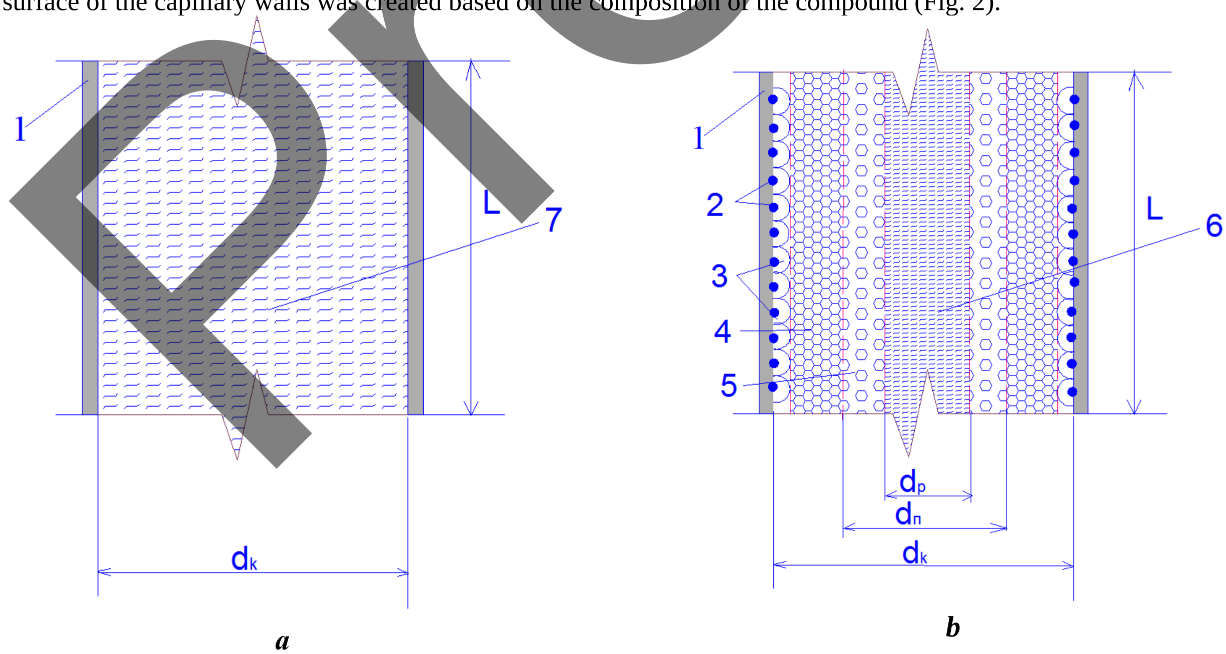


FIGURE 2. Physical and chemical model of interaction of epoxy resin-based compound with the surface of the capillary walls:
a) immediately after percolation; b) in an hour τ after filling of the capillary. 1 - solid surface; 2 - active centers of the solid surface with the potency ψ; 3 - adsorption interaction zone; 4 - layer of local concentration of

polymer from compound; 5 - zone of medium concentration of compound; 6 - zone of solvent release; 7 - epoxy compound.

Formation of polymer in the adhesion zone consists of several stages:

1) dispersion of the adhesive on the surface of the solid, its soaking;

2) equilibrium establishment of adhesive contact, depending on the macromolecular properties of the adhesive and the processes of adsorption and diffusion;

3) formation of chemical and physical structures of the adhesive in the hardening process, which is accompanied by the appearance of a near-surface layer, which is marked by the appearance of new properties that bring the adhesive to the indicators of the solid phase.

The development of a compound on the basis of ED-20 epoxy resin with a reduced viscosity indicator close to the water viscosity level allows the compound to be used as a permeation material and at the same time provides the basis for determining the kinetics of the water stress. The recommended compound is based on epoxy resin ED-20 in the composition: n (ED-20) + t (filler #647) + c (hardener PEPA), herewith the coefficients "c" and "t" are significant, similar to the coefficient "p".

On the basis of analysis of the physicochemical model (Fig. 2) it was found that the properties of the adsorption and surface layer change with the distance from the surface.

Increase of packing density in the near-surface layer is a result of forming of the surface layer and makes it possible to make a conclusion that the compound based on ED-20 epoxy resin with the withdrawal of the compound under the influence of the solid surface provides for release of resin molecules from the compound, their subsidence, and that compact packaging allows to obtain a solid mass in thin layers, for its strength is in line with the epoxy resin ED-20 without the filler.

On the basis of the developed models, it was found that the solid phase surface (on the inner surface of the capillaries) is affected by the ψ potential to solidify the oligomers in thin layers, which makes the packing of molecules in the adsorption layer more compact than in the mass. Such physical and chemical phenomenon allows to consider that the coating layer on the surface of the capillary walls due to the separation of the compound will be composed of ED-20 molecules, and the lYER strength corresponds to the strength of epoxy resin without a filler.

On the basis of the analysis of forces acting on the fluid during its movement along the capillary, it was theoretically established that the acceleration of the process of passing the compound through the capillary can be achieved in two ways:

1) by the effect of ultrasonic vibrations on the liquid compound by applying an ultrasonic field;

2) creation of vacuum at one end of the capillary and excessive pressure at the other end of the capillary, which combined accelerates the propulsion of the fluid through the capillary.

It was experimentally established [10-14] that application of ultrasonic field with a frequency of 22 kHz accelerates penetration of compound in the middle of the sample (concrete) in comparison with the usual (capillary) percolation by 1.8 times.

To verify the obtained theoretical solutions, the laboratory equipment was developed and comstructed, which allowed to specify the composition of the compound, the duration of permeation, its completeness under different forcing modes.

The regulation of the viscosity of ED-20 resin was carried out on a complex basis:

- for the addition of the compound;
- under the influence of ultrasonic vibrations.

The conditional strength of the compound was determined in seconds of time of uninterrupted circulation of 100 ml of fluid through the nozzle of the viscosimeter VZ-246.

Graphically, the variation of the viscosity of the compound on the basis of ED-20 with a varying volume of fluid in the time of ultrasound exposure is shown in Figure 3.

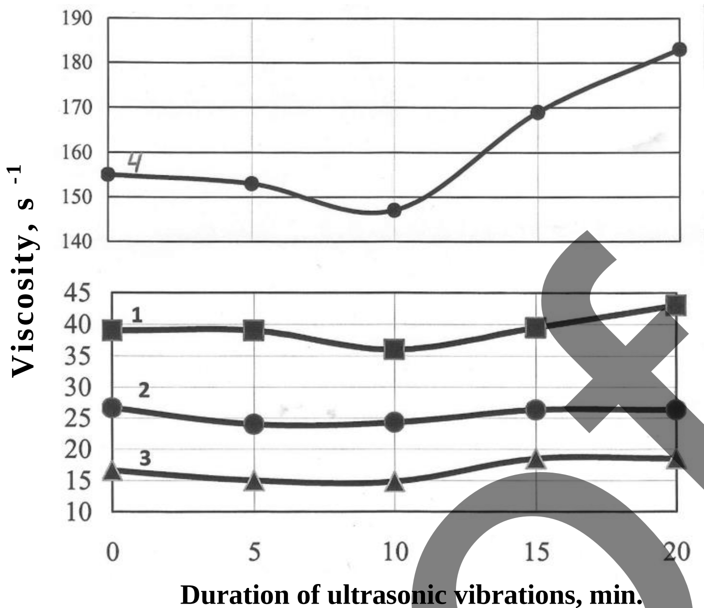


FIGURE 3. Changes in the viscosity of epoxy resin under the influence of ultrasonic vibrations in the viscosity of the compound: 1 - 80% of epoxy resin : 20% of solvent; 2 - 75% of epoxy resin : 25% of solvent; 3 - 70% of epoxy resin : 30% of solvent; 4 - 90% of epoxy resin : 10% of solvent.

The research showed that the decrease in the viscosity of epoxy resin under the influence of ultrasonic vibrations and the increase in the liquidity of the compound occurs in the first 10-12 minutes from the beginning of the ultrasonic vibrations. The composition of the compound based on epoxy resin is selected according to the indicator of the minimum of its viscosity. Under the condition of using 30% of the solvent, the viscosity of the compound is close to the viscosity of water.

The layer of polymer near the solid surface (boundary layer) differs in its structure from the main mass of the polymer. The thickness of this layer is one of the most important indicators, because this layer receives mechanical stress, which determines the strength of the composite material.

It was theoretically established that as the thickness of the film, which encapsulates the surface of cement stone (concrete), decreases under the influence of the potential ψ of the solid surface, the packing of polymer molecules becomes stronger, resulting in an increase in the solidity and hardness of the solidifying compound.

The hardness of the film, which covers the surface of the concrete was determined by pressing a steel ball into the surface of the film; after that the sample with a footprint was transferred to a microscope MPB-2 (with a scale in the field of view) where the diameter of the footprint was measured.

The hardness of the surface was determined on a Brinel press TSH-2M. Diameter D of steel ball - 10 mm, the pressure on the ball P - 250 kgf/mm^2. Footprint diameters were determined with an accuracy of 0,5 mm.

The dependence of the hardness of the compound on the surface of the concrete on the amount of solvent is shown in Fig. 4.

Analysis of the data (Fig. 4) shows that the compound in thin films on the hard concrete surface has greater strength than in the mass.

Optical microscopy (Fig. 5) confirms the presence of the film on the concrete surface.

Soaking of the concrete with the compound was carried out on the laboratory equipment with the following modes of pressure: capillary; under the influence of ultrasonic vibrations; under excessive pressure with the use of vacuumization of the middle of the sample in order to remove the gas component.

The samples - cubes (3 cm edge) and cylinders (4×4×16 cm) were subjected to soaking. The main indicator of percolation efficiency is the change in the mass of the sample during the given time. Control of the percolation process was carried out by measuring the mass of the sample "m" and calculating the increment Δm in time.

Comparison of capillary percolation with percolation under the influence of ultrasonic vibrations is shown in Fig. 6.

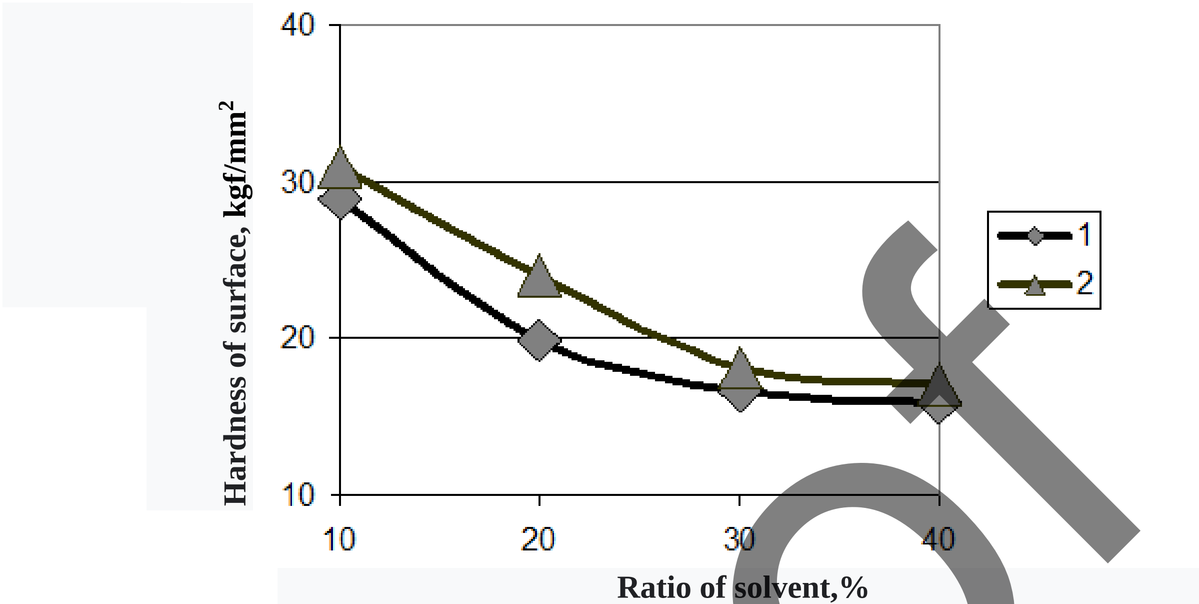
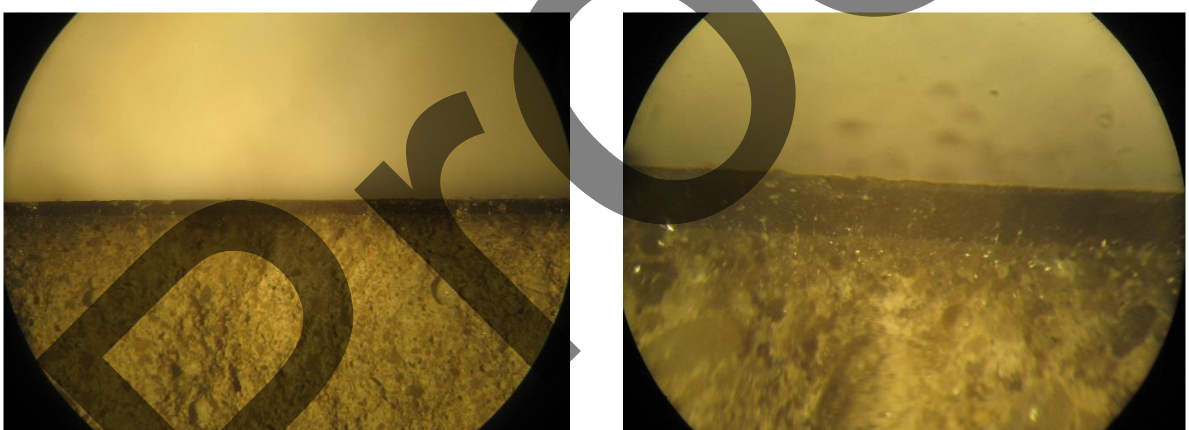


FIGURE 4. Hardness indices of the compound film on the surface of concrete:
1 - hardness of the compound in the mass; 2 - hardness of the compound film with thickness h=0.3·10^{-3} m at the concrete surface.



a *b*

FIGURE 5. Optical microscopy of the epoxy resin film on the concrete surface:
(a) 12.5 times increased; (b) 50 times increased.

Analysis of the data shows that the speed and completeness of percolation during the ultrasonic treatment provides greater completeness of saturation, which is indicated by the doubling of the mass of the bricks.

Investigations of physical and mechanical characteristics of the soaked concrete samples were carried out in the following modes:

1) for percolation under the influence of ultrasonic vibrations;

2) in the intensive mode with advance vacuumization of the sample on the laboratory complex LPU-1.

Technical efficiency of the technology of forced treatment is determined by an indicator - coefficient of performance improvement Kp.

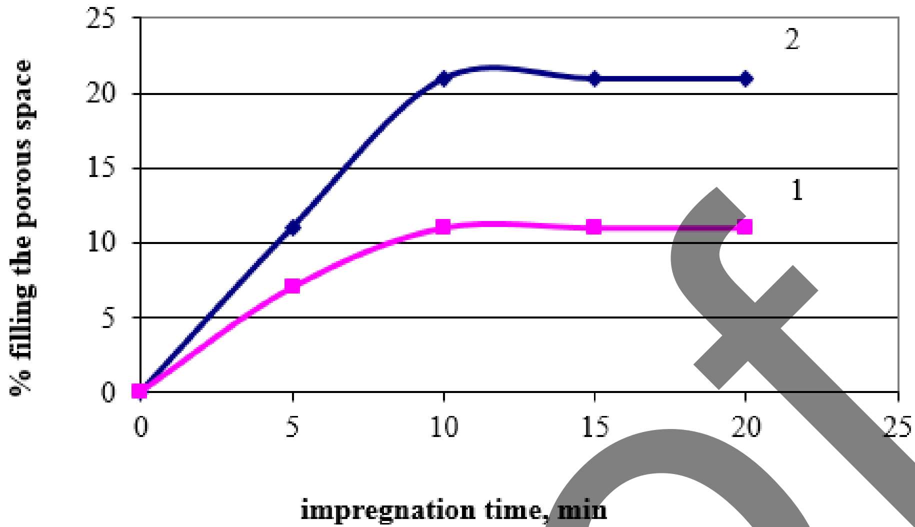


FIGURE 6. Stages of porous body filling:
1 - during capillary percolation; 2 - percolation with intensification of the process by ultrasonic vibrations.

TABLE 1. Physical-mechanical indicators of the quality of concrete impregnated with epoxy compound

Number of the sample	**Density of the sample, g/cm^3**	**The quantity of the solvent, %**	**Fill rate of the capillaries, %**	**Flexural tensile strength R_{btf}, MPa**	**Stress strength R_b, MPa**	**The infiltration method**	**Kp**	
							$R_{bt}f$	**R_b**
1-control	2,00	-	-	11,2	17,2	-	1	1
2	2,09	20%	16,7	13,25	18,4	ultrasonic.	1,18	1,06
3	2,12	30%	17,6	15,0	19,6	– // –	1,34	1,14
4	2,09	40 %	18,75	14,25	19,2		1,27	1,11
5	2,09	20%	43,5	15,0	23,6	vacuum	1,34	1,37
6	2,10	30%	43,7	15,75	24,8	– // –	1,4	1,44
7	2,09	40%	44,5	15,0	24,2	– // –	1,34	1,40

CONCLUSIONS

Due to the fact that polymerization of ED-20 (thickening) begins in 10 - 12 min after preparation of the percolation compound, with the aim of accelerating the percolation the technology was developed which includes vacuuming of the sample before the percolation of the sample. Efficiency of the percolation is set by coefficient of capacity increase (Kp), stress strength is Kp = 1,44; flexural tensile strength - Kp = 1,4.

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Variable Work Areas in the Course of Combined Performance of Reconstructive Processes

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Abstract. The development of rational combination of construction processes in the course of the reconstruction of buildings shall ensure the work-schedule reduction. It is proposed to apply a method of combining works in the course of the reconstruction of buildings with the use of variable work areas whose spatial parameters change dynamically in the course of work, at that with the need for horizontal delivery of the building materials and constructions to the work area, a zone of transportation and storage of constructions shall also be considered as a separate work area. Also, it is provided that for the period of implementing any interim process a transportation-and-storage zone free from main construction works should be organized in the work area adjacent to the beginning of materials conveyance area (a freight elevator location) in which the required amount of materials should be piled up to ensure further combined works performance without stops during the determined timeframe. This method allows enhancing the efficiency and safety of construction works, shortening the timeframe, and reducing the cost of reconstruction.

INTRODUCTION

Reconstruction of buildings is one of the important components of the construction industry. The efficiency of reconstruction in comparison with new construction is conditioned by the need to improve the operation properties of buildings, change generations of technological equipment and enhance economic efficiency, in particular, by eliminating the expansion of building areas, reducing communication costs, partial reproduction of fixed assets, and reducing timeframe [1, 2].

In general, the reconstruction of buildings is characterized by more complicated conditions for construction works due to which the efficiency of construction and installation works is reduced by 1.2-2.3 times, their unit cost increases by more than 15% compared to a new construction [3, 4].

Enhancement of the efficiency of reconstruction of buildings largely depends on reducing the timeframe, which shrinks the downtime of fixed assets involved in the reconstruction, increases the efficiency of use of cash funds. The main direction to reduce the timeframe of construction and installation work should be the increase of intensity of use of construction resources, as well as the number of used machines and workers, and application of combined construction processes [5, 6, 7].

The performance of construction works in the course of reconstruction of buildings is significantly complicated by the effect of various specific conditions - spatial constringency of work areas, ways of conveyance of materials and their storage, limited use of possible technologies, machines and mechanisms, environmental specifics, increasing impact of hazardous factors, etc. [8, 9].

In this regard, it is important to study the conditions of resources concentration and develop methods to ensure the rational combination of construction processes in the course of reconstruction.

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GOAL AND OBJECTIVES

Identification of reconstruction factors that have effect on combined execution of reconstructive processes. Determination of the need for forming separate transportation zones with horizontal conveyance of materials. Presentation of the possibility of modeling the combined performance of works in the course of reconstruction of buildings using variable work areas the spatial parameters of which change dynamically in the process of work, at that a zone of transportation and storage of structures is also taken as a separate work area.

MODELING OF PROCESS COMBINATION

Combined performance of construction works during reconstruction of buildings demands their high quality and full-fledged technological preparation. The existing developments in this field solve mainly local tasks related to the choice of organizational and technological solutions of certain types of construction and installation processes, taking into account a limited number of specific conditions [10, 7], as a result, in practice, the effectiveness of combining the reconstruction works remains quite low.

Traditionally the combination of construction works is ensured by applying the flow method of their performance, in which grips are allocated on project site as spread of activities for separately performed processes. At that, defined individual construction processes are performed by moving from grip to grip, combining their co-execution in a given technological sequence in a maximum scope equal to the number of grips. Graphic modeling of the flow method of construction work is reproduced in the form of cyclograms - schedules of work flow [11].

The use of traditional modeling of combined execution of works with the division of the building into a certain number of permanent grips that have the same spatial parameters for all processes performed thereon, under certain conditions of reconstruction may lead to significant complications in the process of work. Thus, if it is necessary to horizontally convey building materials and structures to a work area, their transportation will be performed within the grips on which other related processes are executed. This increases the risks with regard to processes safety, leads to interruptions in their execution, and even precludes combined execution of works (Fig. 1).

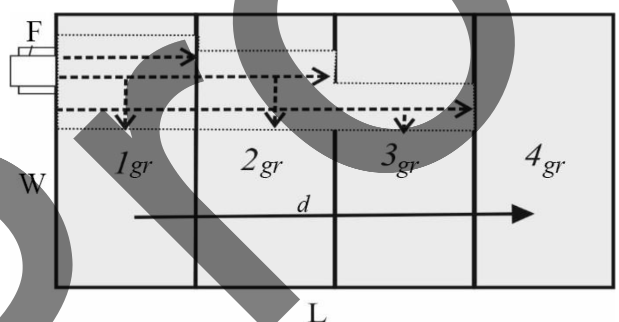

FIGURE 1. Horizontal transportation of materials in the course of traditional combination of works, where: W, L - width and length of the object; F - freight elevator; 1gr ... 4gr - grips; - directions of supply of construction materials; d - direction of construction processes; - zones of combined execution of separate construction processes.

For combining more works - more grips are required, the minimum sizes of which are limited when performing certain processes also by the parameters of structures being built. With the same sizes of grips this sets limits for increase in the quantity of co-executed processes, and the maximum saturation of their resources. To eliminate the above shortcomings, it is proposed to combine work in the process of reconstruction of buildings with the use of variable work areas, the spatial parameters of which change dynamically in the process of work, at that a zone of transportation and storage of structures is also taken as a separate work area (Fig. 2).

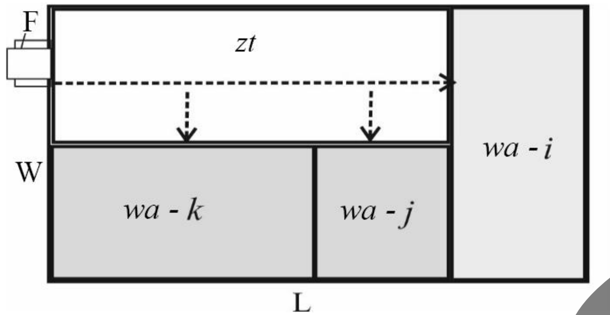

FIGURE 2. Formation of variable work areas, where: wa-i, wa-j, wa-k - work areas, respectively, and i, j, k - the processes; zt - zone of transportation of construction materials.

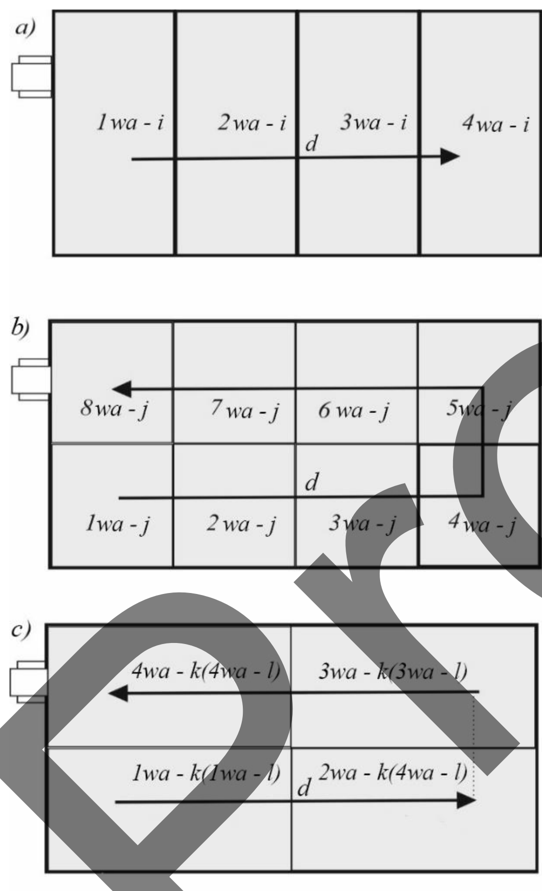

FIGURE 3. Formation of work areas of processes, a, b, c – respectively, and i, j, k - the processes; where: 1wa-i…8wa-j - work areas of the respective processes.

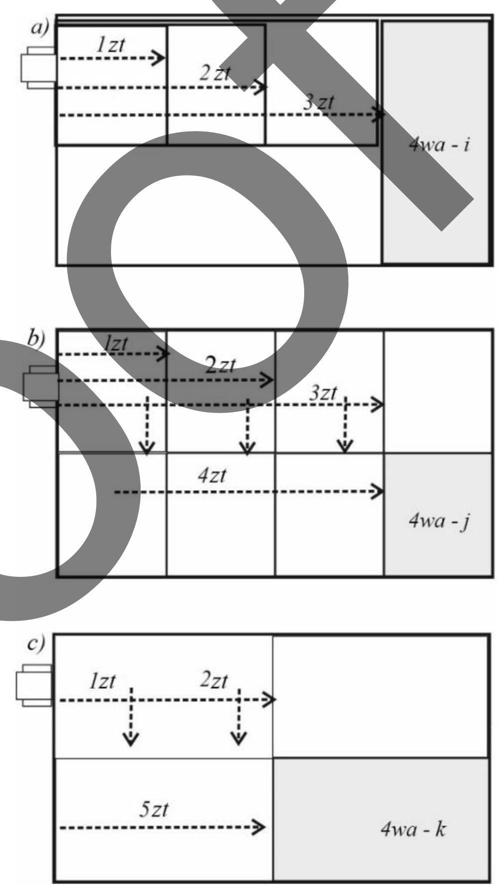

FIGURE 4. Formation of transportation zones of processes, a, b, c - respectively, and i, j, k – the processes.

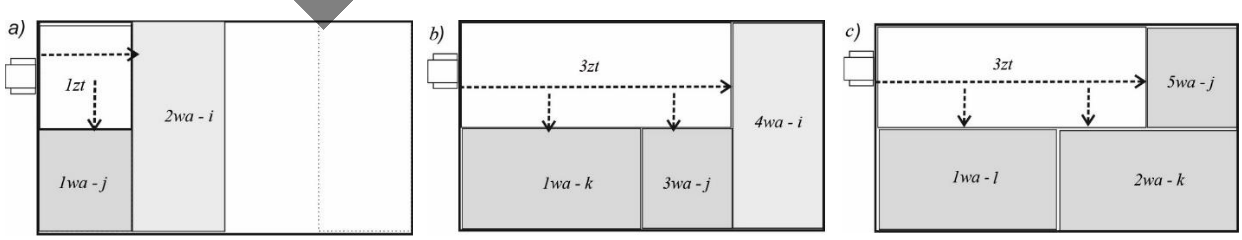

FIGURE 5. Combination of works: a) - combination of two work processes i and j; b) - combination of execution of three work processes, respectively i, j and k; c) - combination of execution of three work processes, respectively j, k and l.

The provision of modeling of workflow of combined works during reconstruction of buildings with the use of variable work areas is based on the following stipulations:

- Construction processes that will be performed by separate streams, and the general technological sequence of their implementation are established;
- Sizes of zones of performance of works for each of processes are defined on the basis of volume of planned spatial parameters and the sizes of constructions (Fig. 3a, 3b, 3c);
- Sizes of zones of transportation and storage are defined (Fig. 4a, 4b, 4c);
- Necessary equipment is defined for each construction processes, as well as mechanical aids and number of workers based on determined spatial parameters of the work area;
- Directions of execution of separate construction processes are defined taking into account positioning of materials conveyance points;
- Timeframes for performance of works in individual work areas for each process are defined taking into account the cumulative effect of specific factors influencing the performance of reconstructive works;
- time parameters of the endings and beginnings of works on specific work areas should be reconciled under each of combined processes, at that ensuring the allocation of material transportation zones ever-present and free from basic construction processes thereon. In this case, zones of material transportation should be adjacent to all work areas where combined processes are executed (Fig. 5a, b, c).

It is also assumed that for the period of any intermediate process in the work area adjacent to the beginning of the material conveyance zone (freight elevator location), a transport and storage zone free from the main works should be pre-organized and the required amount of materials should be accumulated thereon to ensure further uninterrupted combined work during defined timeframe (Fig. 4c).

CONCLUSION

The determination of reasonable limits of maximum combination of construction processes and their saturation with adequate resources on condition of ensuring safety and rational organization of technological solutions of their performance allows reducing timeframe of reconstruction, enhancing efficiency of the construction and installation works, and decreasing the cost of reconstruction.

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Mathematical Model of Fast Filters Drainage Work with Floating Load

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Abstract. This article is devoted to the most resource-intensive structures in water supply systems such as fast filters. Replacing traditional sand filters with floating ones with a layer of suspended polystyrene foam can significantly intensify the filtering process. As it turned out, their main drawback is drainage distribution systems. Replacing traditional drainage systems with polymer concrete drainage avoids these disadvantages. However, in polymer-concrete drainage of a tray type, an uneven distribution of flow along the length of the tray may occur. To prevent this phenomenon, it was proposed that the bottom of the drainage is performed with an uneven cross section with a slope towards the collection channel, by means of the device of a prototype. The mathematical description of this process is carried out using three equations: the equation of the influx of water into the tray; the equation of motion of water flow in the tray and the equation of balance. Based on this mathematical model, a program was developed in Microsoft Excel. A numerical study of this model was also carried out on a real-size filter. As research results showed that an increase in the coefficient of hydraulic resistance and the slope of the tray bottom contribute to a uniform flow distribution, and a change in intensity slightly affects the uniformity of distribution.

INTRODUCTION

Issues of resource conservation and rational use of water resources today are relevant and most important throughout the world.

In technological schemes for water purification, the most resource-intensive structures are fast filters, which in many respects affect the economic indicators and useful productivity of the entire treatment plant as a whole. This is due, first of all, to significant volumes of water for their washing, the need for equipment for supplying and storing washing water [1].

In recent years, floating filters have been widely used, the design of which eliminates the need for washing pumps and towers for storing washing water.

As floating loads, granular fiberglass, crushed polyurethane and polypropylene foam, fluoroplastic, nylon, polyethylene and other lightweight polymeric materials can be used. However, expanded polystyrene of the PSV and PSV-S brands has received the greatest distribution.

Currently, more than 100 designs of filters with a floating polystyrene foam loading have been developed, which differ in the scope, technological capabilities, a variety of structural elements, as well as the conditions for placing the load in the filter housing. Among them, filters with an upward flow of the FPZ – 1 design became widespread. An important element affecting their normal operation is drainage distribution systems [2].

The lower drainage of such filters is in the form of a central or side collector with perforated branches from asbestos-cement or plastic pipes. The upper drainage system is made in the form of a framework of a grid with a fine-mesh mesh mounted on it.

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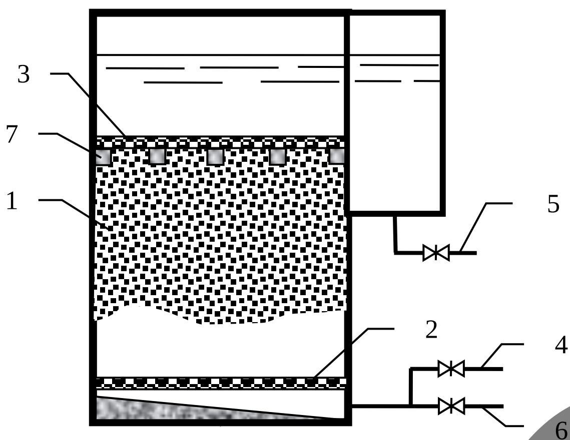
Designs have a number of significant drawbacks: corrosion of metal elements and deterioration of the quality of the filtrate during operation; colmatation of nets by loading grains and increase of their hydraulic resistance, loading ablation during washing and filtering, fragility [3-5].

To address these shortcomings, devices have been developed for collecting and discharging washing water based on a porous material - polymer concrete made of crushed granite and epoxy resin of the ED – 16 or ED – 20 grade, approved by the Ministry of Health of Ukraine for use in drinking water supply systems [6].

In filters with a floating load, the upper drainage system is proposed to be made of polymer concrete slabs laid on supporting reinforced concrete structures. The lower drainage system is in the form of a polymer-concrete drainage of a tray type (the most common option) [7].

The general scheme of such a filter is shown in (Fig. 1).



1 - floating load;
2 - lower drainage system made of porous polymer concrete of a tray type;
3 - upper drainage system made of porous polymer concrete;
4 - supply of source water;
5 - drainage of the filtrate;
6 - drain wash water;
7 - supports.

FIGURE 1. Flow chart of an upstream floating-load filter

When filtering, the source water is supplied to the lower drainage distribution system from a porous polymer concrete 2, where it is evenly distributed over the filter area, passes through polystyrene foam loading 1 and is collected in the loading space, from where it is discharged through pipe 5 outside the filter.To prevent the emergence of the load, arrange drainage system of porous polymer concrete slabs 3, laid on the supports 7.

When washing, the purified water from the overload layer moves down, rinses the polystyrene foam loading 1, and then is evenly collected by the lower drainage 2.

This design of drainage and distribution systems completely prevents the probability of entrainment of the filter load and, accordingly, the deterioration of the quality of the filtrate, because it consists of non-metallic elements, ensures uniform collection of washing water and the supply of raw water for filtration, which reduces the washing time and, accordingly, the flow of washing water [7].

During the operation of polystyrene foam filters of constructions FPZ– 1 with drainage and distribution systems based on porous polymer concrete, they can be clogged by a suspension contained in raw water and loading grains. However, as shown by studies performed in [8], colmatation is not irreversible, because the movement of water through porous structures occurs with the reversal of the flow - when filtering - from bottom to top, when washing – from top to bottom. As a result, contaminants and loading grains accidentally delayed in the thickness of the porous polymer concrete are washed out.

MATHEMATICAL MODEL OF WATER MOVEMENT IN POROUS POLYMERBETON DRAINAGE

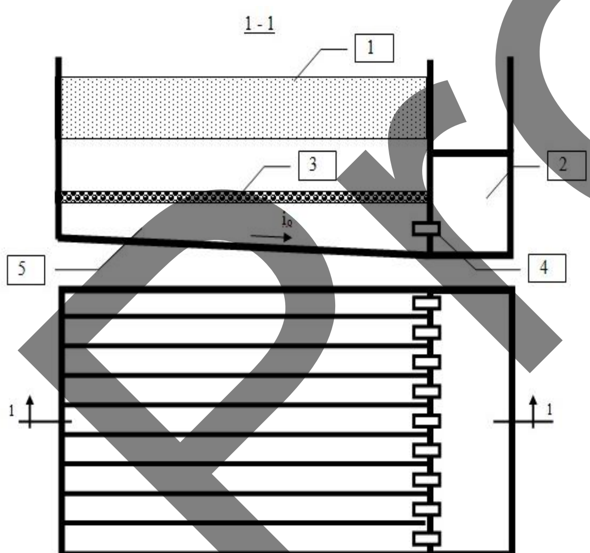
The requirements for the upper and lower drains of fast-moving water-treatment filters with a floating load are set, the main of which is to ensure a uniform velocity field during washing and filtering.If this condition is not met, the distribution of wash water flows by the upper drainage will occur unevenly over the filter area.As a result, part of the filter load will be washed poorly, which will lead to a gradual accumulation of contaminants in the non-washed part of the filter, further deterioration of the quality of the filtrate, decrease in the dirt capacity of the load and increase the duration of the filter cycle.Particularly dangerous is the fact that the process of uneven washing can progress over time.

The collection of wash water by lower drainage also has a significant effect on the normal operation of the filter.If the water collection during washing is uneven, there will be zones of increased and reduced speeds along the filter area, which will lead to an uneven discharge of the contaminants washed from the load.As a result, contaminants will accumulate in the pre-loading layer and, accordingly, during filtration, the quality of the filtrate will deteriorate.It will be necessary to increase the duration or intensity of washing, which leads to an increase in production costs (electricity, reagents) for supplying an additional volume of washing water.

If the filter is washed evenly, then, as a rule, the filtrate is also uniform in up flow filters.This is explained by the fact that the collection of water by drainage during filtration is determined by the total resistance of the granular load and drainage.And the pressure loss in the load during filtering is much larger than in the drainage.Therefore, the calculation of the upper drainage is carried out precisely in case of flushing, and if the degree of distribution uniformity during flushing is satisfactory, then there are no problems with the distribution when filtering.As for the lower drainage of the filters, as noted earlier, in up flow filters, it is designed to collect wash water and supply raw water for filtration.Accordingly, the flushing mode will also be the design case.

The scheme of the quick filter with the lower porous drainage of the tray type [6] is shown in (Fig. 2). Drainage consists of supporting walls forming trays overlapped by polymer concrete slabs.At the entrance to the trays there are nozzles, the resistance of which provides the necessary flow rate for each tray.

One of the drawbacks in the operation of the polymer-concrete drainage of the tray type is the possible insufficient uniformity of the distribution of washing water along the length of the distribution tray. If in the collection channel the uniformity of water drainage from the trays is ensured by nozzles of high resistance with diaphragms, then in the trays themselves, due to the difference in pressure at the beginning and end and the relatively small resistance of the drainage plates (10 - 20 cm), some unevenness may occur.To eliminate this drawback, it is proposed that the porous distribution tray in the filters with floating loading perform a variable cross-section with a slope of the bottom towards the collecting channel.



1 - filter loading;
2 - prefabricated channel;
3 - porous polymer concrete;
4 - pipe with a diaphragm;
5 - distribution tray.

FIGURE 2. Scheme of polymer-concrete drainage of a tray type

It should be noted that the wash water along the tray moves with a continuous change in flow along the length, and in the side channel with a discrete change in flow from pipe to pipe.

The mathematical description of the drainage is made using three basic equations:

- inflow equations;
- flow movement in the tray (channel);
- balance equations.

To describe the influx of water into the tray, you can use the power equation of the fluid through the porous wall [9]:

$$\Delta h = C\delta_n \upsilon^{2-n} V_f^n, \tag{1}$$

where Δh is the pressure loss in the porous septum, cm; δ_n is wall thickness, cm; υ is the kinematic viscosity of water, cm^2/s; V_f is the filtration rate, cm/s; C is a coefficient depending on the size distribution of the aggregate of the polymer concrete and the degree of density of its laying (in the case of filtering contaminated water, the coefficient C also takes into account the pore colmatation with suspended particles); n is an exponent that varies in the range $1 \leq n \leq 2$;with a linear law of resistance $n = 1$, and with a quadratic law $n = 2$, (with Reynolds numbers Re = 15-200).

The relationship between V and the magnitude of the inflow per unit length of the flow q_{fl} is carried out according to the formula:

$$q_{fl} = V_f F_n \tag{2}$$

where F_n is the area of the porous part of the tray through which water moves.

Then the water flow flowing to the main stream in an elementary section of length Δx will be:

$$q = q_{fl} \Delta x \tag{3}$$

For the case of discrete collection, when water flows through the nozzles, the flow rate is determined from the standard formula:

$$h_n = S_n q^2 \tag{4}$$

where S_n is the resistance of the nozzle.

To describe the motion of the flow, it is advisable to use the equation of the piezometric line obtained by V.V. Dilman et al., based on the energy equation [10], since when deriving it, a minimum of assumptions was used and the results were verified experimentally:

$$\frac{dH}{dx} + \frac{3-\theta^2}{2g} V \frac{dV}{dx} + \frac{V_r}{g}\frac{dV_r}{dx} + \frac{\lambda V^2}{2gD} = 0 \tag{5}$$

where V is the speed of the main stream; V_r – is the radial velocity of the separated stream; λ is the Darcy coefficient; θ is the ratio of the projection of the velocity of the attached (detachable) stream onto the direction of the main stream to the speed of the main stream.

This equation in finite-difference form has the form:

$$\Delta h = \frac{0.75\alpha}{g} \Delta V^2 + i_f \Delta x \tag{6}$$

where Δh the pressure drop within a section of length Δx; α is the Boussinesk coefficient; ΔV^2 is the difference of the squares of velocities at the beginning and end of the section; i_f – hydraulic slope (friction slope).

The hydraulic slope can be determined using the Darcy coefficient calculated by the formula A.D. Altshul, in which a coefficient is introduced taking into account the cross-sectional shape of the flow.

The balance equation closes the system:

$$\Delta Q = q \tag{7}$$

The obtained equations are solved under boundary conditions:

$$x = 0, Q = Q_л$$
$$x = x_k, Q = Q_0 \quad (8)$$

where x_k is the length of the tray.

The system of equations (1) - (7) with boundary conditions (8) is a mathematical model of the operation of porous polymer-concrete drainage. This model was implemented using a specially developed application program Microsoft Excel. The calculation was made from the beginning of the tray (at the entrance to the channel). At the beginning of the flow, we set the approximate pressure value, which was corrected if the boundary condition at the end of the flow was not fulfilled ($Q = Q_0$). This procedure was automated using Microsoft Excel applications ("parameter selection" or "search for solutions"). The calculations were performed by the iterative method. The calculation for the channel was carried out in the same way, however, the counting started here from the end of the channel, and since the distribution is discrete, a step-by-step calculation method was used.

NUMERICAL RESEARCH MATHEMATICAL MODEL

A numerical study of the mathematical model was carried out for a filter of real size: cell area $-F_f$= 40 m^2; tray length L_{tr}= 4,5 m; its cross section is 0.25×0.3m; channel length L_{ch}– 9 m; rectangular section – 0.7×1.0 m; the thickness of the polymer concrete slab is 0.05 m; the roughness of the walls of the tray and channel n_k– 2 mm; coefficient C = 1.0, exponent n = 1.67 (obtained from experimental data). The calculations were performed at a relative counting step of 0.01 (Δx = 4.5 cm).

The influence of the following parameters was studied: coefficient C=0.5-3.0; washing intensity V_{wsh}=12–18 l/(s·m^2); the slope of the bottom i = 0 - 0.06 for the uneven flow rate β along the length of the tray when collecting water.

In (Fig. 3) shows the influence of coefficient C, washing intensity V_{wsh} and bottom slope.

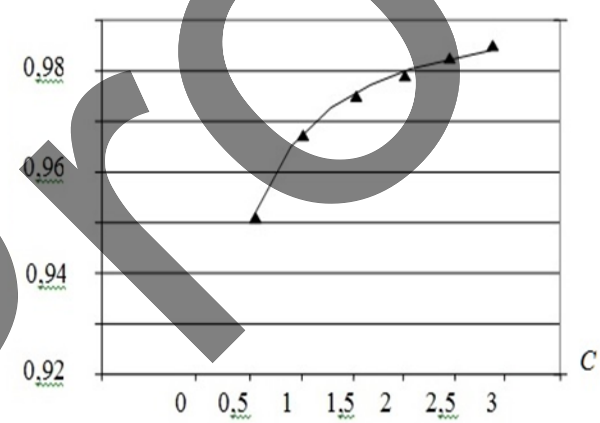


FIGURE 3. A graph of the study of the influence of coefficient C on the unevenness of expenses along the length of the tray when collecting water

As can be seen from (Fig. 3) with an increase in the coefficient C, corresponding to an increase in the resistance of the drainage porous plates, β tends to 1.0 (the collection becomes more uniform), which is consistent with the physical ideas about the process. A change in the washing intensity slightly affects the uneven collection (Fig. 4), and an increase in the slope of the bottom of the tray leads to equalization of velocities along the length of the flow, which contributes to a more uniform collection (Fig. 5).

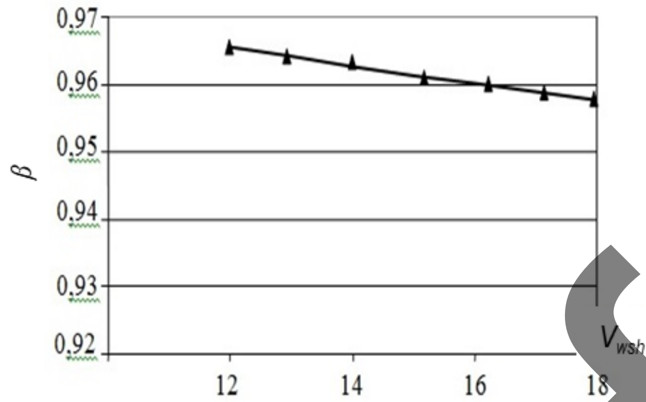


FIGURE 4.A graph of the study of the effect of flushing intensity on the unevenness of expenses along the length of the tray when collecting water

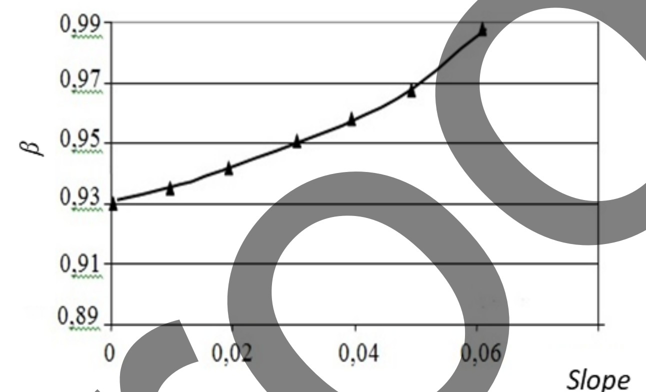


FIGURE 5. The graph of the study of the influence of the slope of the bottom on the uneven flow rate along the length of the tray when collecting water

Thus, the calculation results showed the adequacy of the developed mathematical model that describes the collection of wash water by trays of the lower porous drainage and channel.

The developed program allows you to calculate the drainage of any size for quick filters with one or two cells, with a rectangular cross-section channel.

CONCLUSION

Designs of porous polymer-concrete drainage-distribution systems in fast-moving filters with floating loading, working with an upward flow of water, which increase the reliability of their work, are proposed.

An improved mathematical model of porous drainage based on the use of equations of motion derived from energy equations has been developed.

Numerical studies of the operation of porous polymer concrete drainage on a real-sized filter have been performed, which have shown the adequacy of the mathematical model and its calculation methodology.

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Research of the Formation Process of High-basic Calcium Hydrosulfoferrite Based on Iron Oxides in Hardening Portland cement

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Abstract. Using physicochemical research methods, has been established that the ability of the developed composites to retain a significant amount of chemically bound water at a temperature of about 300°C is explained by the synthesis of highly basic calcium hydrosulfoferrites and mixed calcium hydrosulfoaluminoferrites based on mechanically activated 3-valent iron oxide. Such new formations are able to hold chemically bound water at higher temperatures than their counterpart, ettringite. On model systems, using physicochemical methods of analysis (X-ray phase, chemical and differential thermal), it was found that mechanical activation (grinding and temperature exposure) in the presence of atmospheric oxygen accelerates the process of spontaneous transition of the ferrous form of iron (which is contained in metal corrosion products and in rocks) into the ferric oxide by about 1000 times. The obtained oxide of 3-valent iron is characterized by an amorphous structure, which accelerates the formation of highly basic iron-containing compounds by three times, compared to their synthesis based on iron oxide, which is in a stable state. It is shown that the optimal parameters of mechanical thermal activation are achieved at a fineness of grinding 3000…3500 cm2/g and a treatment temperature of 200…300°C in atmospheric oxygen.

INTRODUCTION

The operational characteristics of concretes in radiation fields and their durability under these conditions are largely determined by the phase composition of the hardening binders. Studies [1, 2] proposed to regulate the special properties of concretes for absorbing neutrons by changing the content of chemically bound water by using different types of cement. So, for Portland cement, the content of such water at the age of 28 days, according to [1, 2], is 15…20%, alumina cement 25…30%, and expanding cement – 28…32%. Since radiation-shielding concretes during operation can be heated up to 300°C, the problem arises of the synthesis of binders containing a significant amount of chemically bound water at such temperatures. It is also known that concretes based on Portland cement and slag-alkaline cement with prolonged exposure to gamma radiation have a sufficiently high radiation resistance in comparison with control samples [3-5].

As shown by numerous studies [6-9], aluminate and ferrite compounds are relatively easy to synthesize from a wide range of raw materials.

The works [7, 8] showed that the hydration products of C_4AF, C_2F, and и C_3A in water and lime solution are represented mainly by new formations of hexagonal and cubic forms, in the presence of gypsum, phases $C_3(A, F)Cs_3H_{32}$ and $C_3(A, F)(Cs, CH)H_{12}$, represented by needle and plate-shaped crystals. It is known [10] that the formation of such needle-like or plate-shaped crystals contributes to the improvement of the physical and mechanical properties of cement stone.

Ferrite and aluminate calcium hydrates have a similar composition and identification parameters. These hydrates are characterized by isomorphism of Al^{3+}, Fe^{3+} ions. The synthesis of iron-containing hydrates, according to studies

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[11-13], is possible not only due to the aluminoferritic phase of cement clinker, but also due to the addition of chemical additives containing iron.

Directed synthesis of such compounds, according to [12, 13], is possible due to the introduction of iron oxides and water-soluble iron salts into cement. The possibility of chemical reactions between iron-containing compounds and components of hardening cement has been experimentally established and thermodynamically substantiated. The analysis of the literature data suggests the possibility of obtaining durable heat-resistant radiation-shielding compositions with an application temperature of up to 300°C and an insignificant removal of chemically bound water due to the development of a technology that will provide an intensive synthesis of highly basic calcium hydrosulfoferrite on a mixture of mechanically activated oxides FeO, Fe_2O_3.

The aim of the study is to synthesize iron-containing hydrates that hold chemically bound water at higher temperatures than their analogue ettringite by adding mechanically activated iron oxides to Portland cement.

MATERIALS AND RESEARCH METHODS

In studies related to the study of the processes of structure formation of binders, chemically pure FeO, Fe_2O_3, CaO, with a specific surface area of 3000…3200 cm^2/g, were used. In the same studies, chemically pure iron of various fractions was used.

X-ray phase analysis was carried out by the method of ionization registration of X-ray intensities on a DRON-3 installation equipped with a rotation angle counter from $2\theta=10°$ до $2\theta=60°$. X-ray diffraction patterns were deciphered by comparison with natural and artificial minerals described in the literature [14-16]. Differential thermal analysis was carried out on derivatograph Q1500D at a heating rate of 10°C. The new formations were identified by comparison with natural minerals or artificial formations known in the literature [14-16].

In order to study the effect of iron oxides on the physical and mechanical properties of the binder, samples of cubes 2x2x2 cm and samples-beams with dimensions of 4x4x16 cm of the corresponding compositions were made. The initial components were: Portland cement class 32.5 N, chemically pure FeO, as well as FeO after complex mechanothermal action, portlandite and natural gypsum stone.

RESULTS AND DISCUSSIONS

Formation of highly basic calcium hydrosulfoferrite is possible on the basis of 3-valent iron oxide, which is most often present along with 2-valence iron oxide in the corrosion products of this metal and water-soluble iron salts. The intensity of the synthesis of these new formations depends on the conditions in which it proceeds; therefore, the technological effect on the $Fe^{2+}\rightarrow Fe^{3+}$ transition process and the formation of highly basic calcium hydrosulfoferrite was studied. Thus, with an increase in the surface of FeO in contact with atmospheric oxygen, the process of the $Fe^{2+}\rightarrow Fe^{3+}$ transition should accelerate. This can be done as a result of mechanical grinding, in which mechanochemical processes will also take place. Their intensity depends on the method of milling, therefore, the most effective grinding method was chosen – the splitting method, which, as established in [17, 18], promotes the appearance of “fresh” highly active surfaces.

To carry out these studies, chemically pure bivalent iron oxide was used as a starting material, which was ground in an impact mill. Grinding was carried out for 1, 2, 3, 6 minutes. At the end of the grinding process, samples of the material were taken, and sieve and chemical analyzes of the substance were carried out.

As a result of sieve analysis, it was found that with an increase in the time of powder grinding, the process of an intensive increase in its specific surface occurs up to a certain limit. A further increase in the duration of grinding has less effect on the increase in the specific surface area of iron oxide powders. Chemical analysis of samples (Fig. 1) showed the presence of oxides FeO and Fe_2O_3 in the crushed substance. The intensity of the increase in the amount of Fe^{3+} in the mixture agrees with the data shown in Fig.1. So, from 1 to 3 minutes of grinding, the amount of Fe^{3+} increases intensively, and from 3 to 6 minutes, the intensity of Fe^{3+} formation stabilizes. Based on this, it can be concluded that the intensity of iron oxidation depends on an increase in the fineness of grinding in the presence of ambient air oxygen. To accelerate the transition of Fe^{2+} to Fe^{3+} in a mixture of oxides and create a more defective, disordered structure, it was additionally influenced by another method – temperature treatment. The temperature exposure parameters were adopted based on the following considerations. As is known [14, 15], at a temperature of 294°C in the air, an intense spontaneous $Fe^{2+}\rightarrow Fe^{3+}$ transition begins to occur. Therefore, in the presence of mechanochemical phenomena, the process of oxidation of ferrous iron (bivalent form) to ferric iron (trivalent form) can occur at lower temperatures. This caused the processing temperature of the mixture to be 200°C for 120 minutes.

It has been established that the complex effect of the temperature factor and the dispersing effect upon contact with air oxygen significantly intensifies the process of the transition of Fe^{2+} to Fe^{3+}. Thus, the number of chemically active Fe^{3+} in the mixture after 120 minutes of activation is equal to 50…70%.

The products of mechanochemical treatment, a mixture of $FeO+Fe_2O_3$, were studied using X-ray phase and differential thermogravimetric analyzes. So, according to X-ray phase analysis (Fig. 2, curve 1), the initial raw material has reflections d = 0.152; 0.215; 0.248 nm, which, according to [14-16], can be attributed to FeO. After the complex mechanochemical treatment of the mixture, the character of the X-ray diffraction pattern changed (Fig. 2, curve 2). Thus, the intensity of the peaks related to FeO (d=0.152; 0.215; 0.248 nm) slightly decreased. This indicates a decrease in the FeO content in the mixture. At the same time, peaks appear (d= 0.209; 0.254; 0.270 and 0.161; 0.258; 0.299 nm) related to Fe_2O_3 and Fe_3O_4.

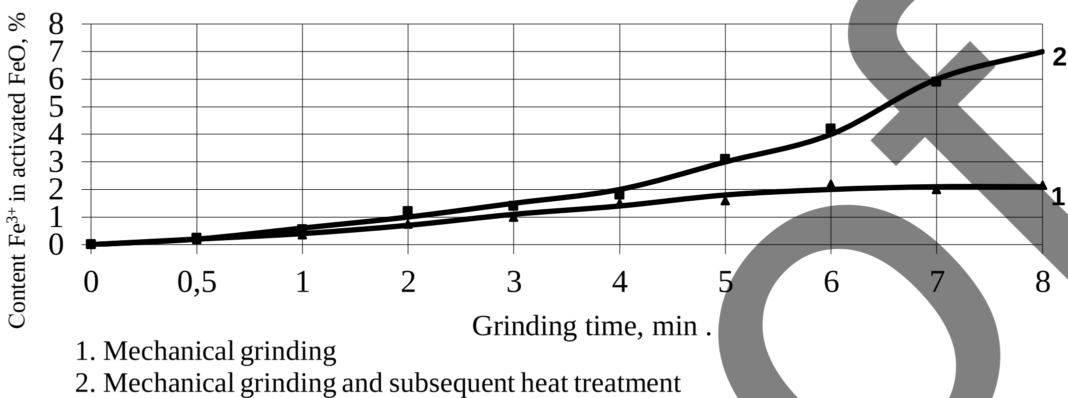

FIGURE 1. Dependence of the rate of transition of ferrous oxide to ferric oxide on the processing method

This indicates the presence of hematite and magnetite in the mixture. In addition, it should be noted that these peaks are characterized by significant width. This indicates the formation of poorly crystallized, amorphous oxides, which should promote the intensification of the synthesis of iron-containing ettringite. According to the data of differential thermal analysis (Fig. 3, curve 1), a number of endothermic and exothermic effects identifies the presence of non-activated ferrous oxide. Thus, the exothermic effect with a maximum at a temperature of 450°C can be attributed, according to [14-16], to the oxidation of FeO to hematite α-Fe_2O_3. The nature of endothermic effects in the temperature range 150…270°C, as indicated in [7], has not been established. After complex mechanothermal treatment of bivalent iron oxide, the character of the curve DTG changed (Fig. 3, curve 2). Analysis of this curve shows that the endothermic and exothermic effects have lost their shape, they became indistinct in comparison with the effects on curve 1 (Fig. 3). This indicates that the mixture under study is mainly represented by poorly crystallized substance.

When modeling the system of formation of ettringite-like iron-containing compounds, components in a finely dispersed state were used. The substances were mixed in the required molar ratio corresponding to the highly basic calcium hydrosulfoferrite [14-16]. The resulting mixture was placed in a test tube and stored for 28 days, ensuring the tightness of the package. After 28 days, the mixture was removed from the test tube and X-ray phase, differential thermal, and microscopic analyzes of the mixture were performed. Thus, according to the X-ray phase analysis data (Fig. 4, curve 1), the hydration products of the mixture based on non-activated ferrous oxide have reflections (d = 0.186; 0.228; 0.303 nm) and (d = 0.191; 0.262; 0.492 nm), which can be attributed, according to [4, 13, 20], to a mixture of calcite and portlandite. There are also peaks with interplanar spacings (d=0.189; 0.305; 0.756 nm), which can be attributed to gypsum stone; in addition, there are peaks with (d=0.161; 0.215; 0.248 nm), which, according to [7], can be attributed to a mixture of oxides $FeO + Fe_2O_3$. The formation of Fe_2O_3 is possible due to the oxidation of FeO with atmospheric oxygen. Reflexes related to the formation of highly basic calcium hydrosulfoferrite (Fig. 4, curve 1) were not detected.

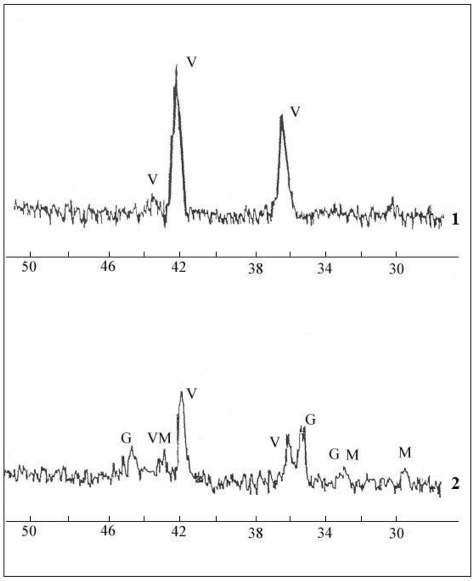

FIGURE 2. X-ray diffraction patterns of bivalent iron oxide (ferrous iron): 1 - before mechanothermal treatment; 2 - after mechanothermal treatment; V - wustite (FeO); G - hematite (Fe_2O_3), M - magnetite (Fe_3O_4)

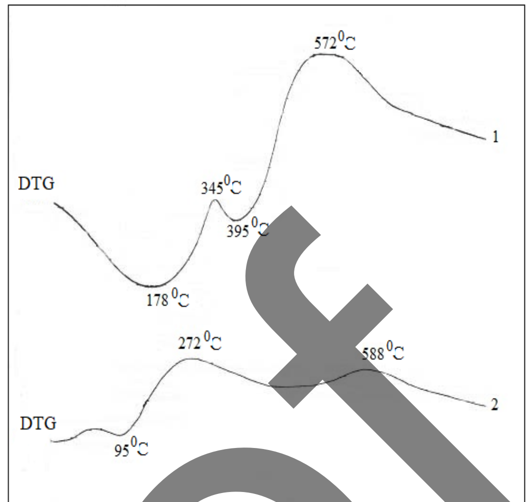

FIGURE 3. Thermograms of bivalent iron oxide (ferrous iron): 1 - before mechanothermal treatment; 2 - after mechanothermal treatment

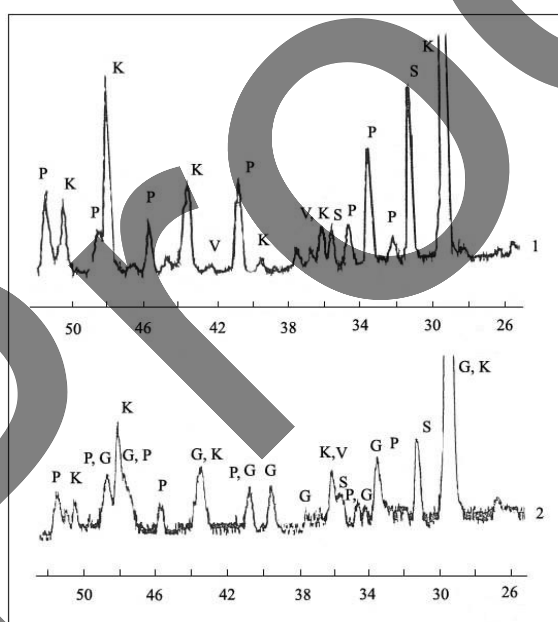

FIGURE 4. X-ray diffraction patterns of model compositions of highly basic calcium hydrosulfoferrite based on:1- non-activated iron oxide; 2 - complex mechanothermal activated iron oxide; G - highly basic calcium hydrosulfoferrite, P - portlandite, K- calcite, S - gypsum, V-wustite

When using bivalent iron oxide as an iron-containing component after complex mechanothermal exposure (Fig. 4, curve 1) on 28 days of storage under normal conditions, the model of highly basic calcium hydrosulfoferrite has peaks with (d = 0.221; 0.228; 0.262; 0.263; 0.300; 0.380 nm), corresponding, according to [14-16], to the formation of highly basic calcium hydrosulfoferrite. Reflexes related to the residues of the starting substances were also found. Thus, peaks with (d = 0.186; 0.191; 0.262; 0.303; 0.492 nm) can be attributed to a mixture of calcium and portlandite, peaks with interplanar distances (d = 0.189; 0.305; 0.756 nm) – to gypsum stone [14-16], and peaks with (d = 0.161; 0.215; 0.248 nm), which can be attributed to oxides FeO and Fe_2O_3. Thus, the complex mechanothermal activation of FeO leads not only to the formation of Fe_2O_3, which forms a highly basic calcium hydrosulfoferrite, but also to the amorphization of the FeO structure, which creates the prerequisites for the intensification of the oxidation of Fe^{2+} to Fe^{3+} and the subsequent synthesis of ettringite-like iron-containing new formations. The X-ray phase analysis data, confirming the formation of highly basic calcium hydrosulfoferrite, correspond with the data of differential thermal analysis (Fig. 5, 6).

When studying a model of highly basic calcium hydrosulfoferrite on unactivated FeO (Fig. 5), the DTG curve shows endothermic effects with a maximum at 165°C and 193°C. The presence of this double endothermic effect can be attributed to the dehydration of the gypsum stone to semi-aqueous gypsum, which ends with complete dehydration at a temperature of 220°C. The exothermic effect at a temperature of 322°C indicates a rearrangement of the crystal lattice with the transformation of insoluble anhydrite into soluble. The endothermic effect at a temperature of 815 ° C, according to [14-16], can be attributed to the dissociation of $CaCO_3$ into CaO and CO_2. After complex mechanothermal treatment of iron oxides, which are part of the model of highly basic calcium hydrosulfoferrite, the character of the differential thermal curve (Fig. 6) has changed, endothermic effects are shifted to a higher temperature level. Therefore, the endothermic effects at temperatures of 166°C and 200°C can be attributed not only to the dehydration of gypsum stone to semi-aqueous gypsum, but also to the beginning of the stepwise dehydration of highly basic calcium hydrosulfoferrite, in which about 20 water molecules remain at a temperature of 170…200°C. The emergence of a new endothermic effect at a temperature of 369°C (Fig. 6), according to [14-16], confirms the hypothesis of synthesis in a mechanically activated mixture of highly basic calcium hydrosulfoferrite, which dehydrates at this temperature, losing 10 water molecules.

The presence of an endothermic effect at a temperature of 502°C corresponds to both the third stage of dehydration of highly basic calcium hydrosulfoferrite and the decomposition of calcite. Analysis of the curves of weight loss upon heating (Fig. 5) of the models of highly basic calcium hydrosulfoferrite showed that when the mixture is heated on activated FeO (Fig. 6), the weight loss at a temperature of 300°C is about 25% of the sample mass, and at 900°C – 42%. In the case of using unactivated FeO (Fig. 5), as a result of heating at a temperature of 300°C, the weight loss is 15%, and at a temperature of 900°C – 25%.

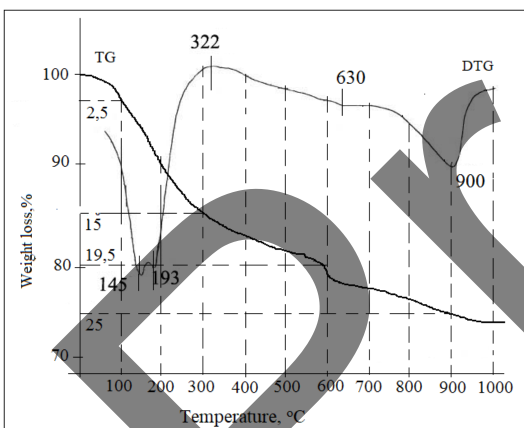

FIGURE 5. Thermogram of a model of highly basic calcium hydrosulfoferrite based on non-activated ferrous oxide

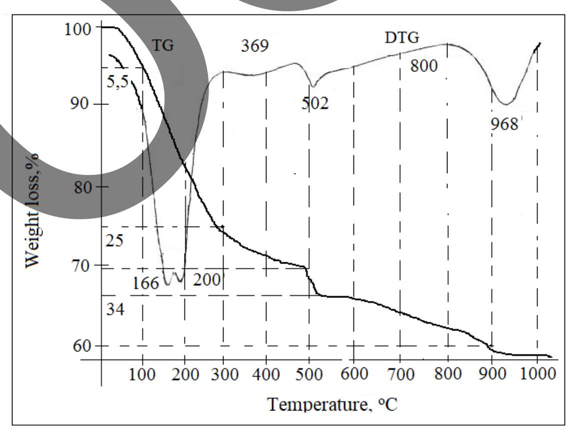

FIGURE 6. Thermogram of a model of highly basic calcium hydrosulfoferrite based on activated iron oxide

Thus, an increase in the mass loss of the mixture on activated iron oxide may indicate the formation of a highly basic deeply watered calcium hydrosulfoferrite. The content of chemically bound water in such a mixture is 17% higher than that of the initial components, which is consistent with the data [14-16]. In addition, the obtained highly basic hydrosulfoferrite has an increased temperature for removing chemically bound water in comparison with its analog, highly basic calcium hydrosulfoaluminate.

Thus, the possibility of intensifying the formation of highly basic calcium hydrosulfoferrite due to mechanothermal transformations of the system components has been established. In order to study the effect of iron oxides on the physical and mechanical properties of the binder, samples of cubes 2x2x2 cm and beams 4x4x16 cm of the corresponding compositions were made. The initial components were: Portland cement class 32.5N, produced by Zdolbuniv Cement Plant, chemically pure FeO and FeO after complex mechanothermal action, portlandite and natural gypsum stone. The content of the used additive in the cement, simulating the highly basic calcium hydrosulfoferrite, was taken in the amount of 20% by weight of the binder. For 7 days, the samples were stored in a humid environment (humidity 100%). After 7 days, thermogravimetric and X-ray phase analyzes of these samples were carried out, as well as tests to determine the physical and mechanical properties of the material.

A binder based on Portland cement is taken as a reference standard for comparison. The compositions of the binders, as well as the results of thermogravimetric studies and their physical and mechanical tests are shown in Tables 1-3.

According to the data of X-ray phase analysis (Fig. 7), after 7 days of hardening, the composition of the hydration products of such a binder contains portlandite, as evidenced by the peaks with interplanar spacings (d = 0.493; 0.310; 0.263; 0.193; 0.179; 0.169 nm). Reflexes are also present, which, according to [14-16], can be attributed to CSH (B) (d = 0.334; 0.301; 0.275; 0.262 nm) and to ettringite (d = 0.388; 0.301; 0.277; 0.262; 0.218; 0.180 nm (Fig. 7, curve 1). The formation of these compounds is also confirmed by the results of differential thermal analysis (Fig. 8, curve 1). In particular, the presence of the endothermic effect at t = 500°C can be attributed to the dehydration of $Ca(OH)_2$. Its shift to the area of slightly lower temperatures, in comparison with the data [14-16], indicates a low degree of crystallization of $Ca(OH)_2$.

The formation of CSH (B) hydrosilicates is confirmed by the presence of an endothermic effect in the temperature range (540…680°C). The formation of ettringite is confirmed by the presence of an endothermic effect on the DTG curve in the temperature range of 100…300°C, which is consistent with the data [14-16].

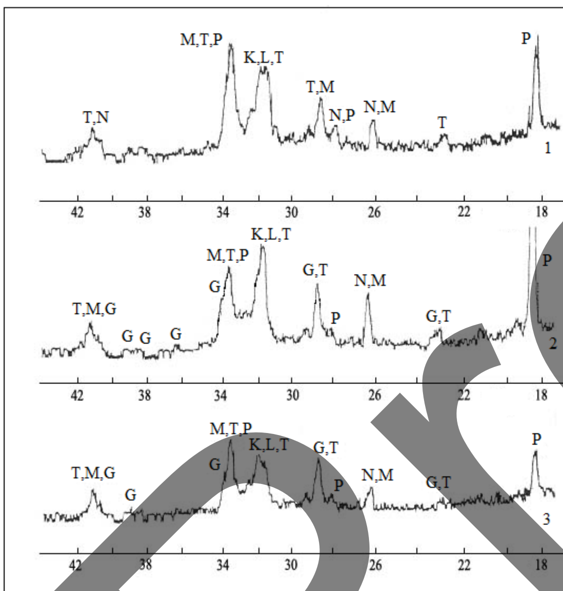

FIGURE 7. X-ray diffraction patterns of the studied binders: 1. Portland cement; 2. Portland cement + additive on non-activated ferrous oxide; 3. Portland cement + additive on activated ferrous oxide; P - $Ca(OH)_2$; T - $C_3AC_3H_{32}$; K - C_3S; L - β-C_2S; M - $C_2SH(B)$; N - C_3AH_6; G - $C_3A,FCsH_{32}$

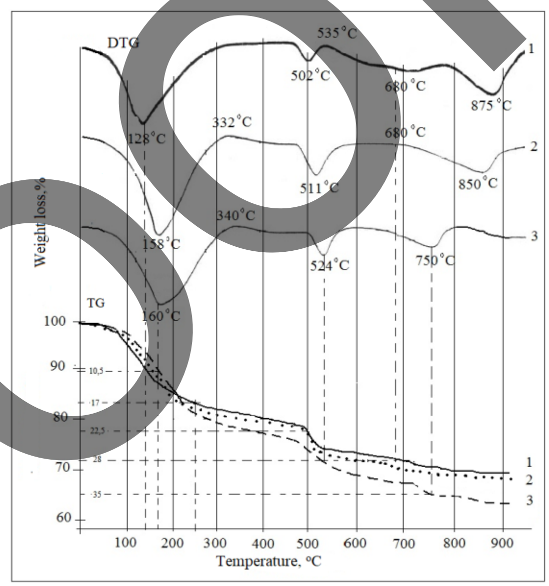

FIGURE 8. Thermograms of the of the studied binders: 1. Portland cement; 2. Portland cement + additive on non-activated ferrous oxide; 3. Portland cement + additive on activated ferrous oxide

The features of the phase composition of the hardening products of Portland cement stone make it possible to explain the increase in the strength of the samples when heated in the temperature range of 20…105°C. An increase in strength occurs due to the compaction of the structure due to the removal of water adsorbed by the hydrosilicate gel, as well as enhanced crystallization of $Ca(OH)_2$. In the temperature range 100…300°C, according to the data of differential thermal analysis, ettringite dehydrates, which, according to [14-16], is destroyed at these temperatures (Fig. 7, curve 1). This causes a decrease in the strength of the material and an increased shrinkage of the cement stone (tables 2, 3, composition 1).

Expansion and shrinkage deformations are presented in Table 2, the kinetics of changes in the strength characteristics of the cement stone at t=20…300°C – Table 3. The mode of heat treatment up to 300°C is adopted in accordance with applicable regulations.

TABLE 1. Thermal characteristics of Portland cement with an iron-containing additive

№	Composition of the binder, wt.%	Weight loss in the temperature range, °C, wt.%			
		20…300	300…500	500…800	30…1000
1	Portland cement - 100	18,0	4,5	7,5	30,5
2	Portland cement - 80 Additive based on non-activated FeO - 20	19,5	3,5	8,5	31,5
3	Portland cement - 80 Additive based on mechanically activated FeO - 20	20,5	5,5	9,0	36,5

With the introduction of 20% additives on non-activated iron oxide into the composition of Portland cement, despite the presence of the effect of reducing shrinkage during hardening of the composition in air-humidity conditions, significant changes in the volume of the samples are observed under the influence of the temperature factor (table 2, composition 2). This is apparently due to the dehydration of $Ca(OH)_2$, which formed during hardening of Portland cement. In this case, the residual strength of the samples after drying is higher than that of the standard (table 3, composition 2). This is due to the compaction of the structure due to the removal of water adsorbed by the hydrosilicate gel.

The composition based on Portland cement has significant shrinkage deformations in time and after drying (table 2, composition 1), but at the same time it has rather high strength characteristics (table 3, composition 1), which is due to the peculiarities of the composition of hydrated new formations.

TABLE 2. The results of determining the shrinkage deformation and expansion of binders during hardening in air-humidity conditions

№	Binder composition*, wt.%	Expansion (shrinkage) deformation, mm / m,				
		normal hardening, days			drying at temperature, °C (after 7th day hardening)	
		1	3	7	105	300
1	Portland cement - 100	0.031	0.00	-0.187	-4.68	-8.25
2	Portland cement – 80 Additive based on non-activated FeO - 20	0.0	0.0	-0.06	-6.2	-12.5
3	Portland cement – 80 Additive based on mechanically activated FeO - 20	0.062	0.218	0.28	-5.06	-10.75

***Note:** The water-cement ratio of the compositions corresponds to the test of normal density and is equal to 0.25.

TABLE 3. The results of determining the strength of binders

№	Binder composition*, wt.%	Compressive strength of material after 7 days of storage and drying at temperature, %		
		20°C	105°C	300°C
1	Portland cement - 100	100	84.4	68.75
2	Portland cement - 80 Additive based on non-activated FeO - 20	100	114.4	85.5
3	Portland cement - 80 Additive based on mechanically activated FeO - 20	100	130.4	91.3

***Note:** The strength of the material at 20°C is taken as 100%

When using the additive on mechanically activated oxide of bivalent iron (table 2, composition 3), the effect of expansion of the composition during the air-humidity method of hardening was noted. This is due to the additional formation of highly basic calcium hydrosulfoferrites in the hardening system, which is confirmed by the data of X-ray phase analysis of the composition. The character of the curve (Fig. 7, curve 2) has changed. The appearance of peaks with interplanar spacings (d = 0.388; 0.301; 0.277; 0.262; 0.218; 0.228; 0.221; 0.180 nm), which, according to [14-16], are attributed to a mixture of hydrosulfoferrites and calcium alumoferrites is noted. The intensity of the peaks increased, which is apparently associated with the formation of mixed highly basic hydrosulfoaluminates and calcium hydrosulfoferrites. These compounds perform a structure-forming role in the hardening cement stone, as a result of which the residual strength of the stone (table 3, composition 3) is higher than that of the standard after drying at temperatures of 105 and 300°C. Indeed, as is known [14-16], hydrosulfoferrites and hydrosulfoaluminoferrites of calcium have an increased temperature for removing chemically bound water.

The effect of an iron-containing additive on the nature of the crystalline phase and the features of crack formation in cement stone of various composition was studied on its cleavage using an electron microscopic research method. The data of electronic microscopic studies confirm and supplement the results of X-ray phase and thermogravimetric analyzes. The results of electron microscopic studies are shown in Figures 9, 10.

Therefore, in the images of Portland cement stone (Fig. 9), you can see fibers and plates, which can be respectively attributed to the hydrosilicates of the tobermorite group and portlandite. In the images of a stone based on a modified binder (Fig. 10), prismatic, needle-like crystals are visible along with fibers. Analyzing the data obtained, it can be noted that the samples of Portland cement (Fig. 9) have significant cracks, while in the samples based on the modified binder (Fig.10) such cracks were not found. Thus, the width of the cracks in the samples based on the source of Portland cement is 0.3…0.6 μm and length of 40…70 μm, while the cement paste samples on the basis of modified binder width of 0.15…0.3 μm, and length – 10…20 μm. This is due to the shrinkage of the Portland cement stone. Cracks in samples based on Portland cement have a through character (Fig. 9), while cracks based on modified binder are grouped around metal inclusions that are part of the additive (Fig.10).

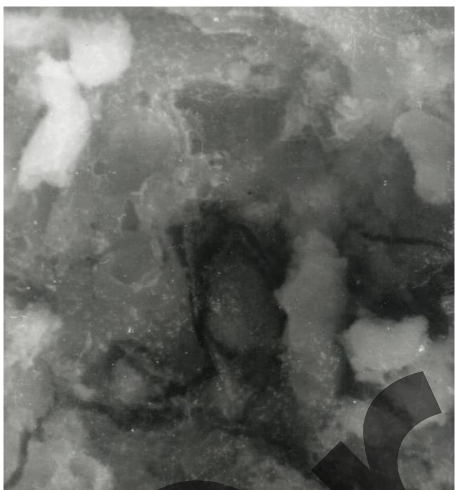

FIGURE 9. Micrographs of a reference Portland cement stone

FIGURE 10. Micrographs of a cement stone based on a modified binder

CONCLUSIONS

Thus, the proposed technological methods to activate the synthesis of highly basic calcium hydrosulfoferrite, which loses chemically bound water at higher temperatures than its analogue, ettringite.

At the same time, it should be noted that when operating a material at temperatures above 200°C, it is important not only to preserve chemically bound water in its composition, but also to control the processes of cracking in temperature fields. These processes are associated not only with shrinkage deformations during dehydration and expansion upon heating, but also with deformations associated with the decomposition of portlandite and the rehydration of CaO into it. Therefore, it is necessary to introduce a complex additive into the composition of the binder, capable of controlling cracking, dampening the propagation of cracks and binding calcium hydroxide formed during long-term hardening of cement. As the results have shown, it is advisable to use a mixture of dispersed iron particles and amorphous microsilica as such a complex additive to increase the thermal and crack resistance of concretes based on modified binding systems [19].

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Evaluation of the Influence of Micro- and Nanocarbonate Additives on the Strength and Rheological Characteristics of Portland Cement Compositions

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Abstract. A study of the features of regulation of strength and rheological characteristics of Portland cement compositions modified with micro- and nanocarbonate additives and the feasibility of their introduction in the form of nanocarbonate dispersion in cement compositions. The use of such additives provides a directed effect on the processes of structure formation and causes the formation of a dense, strong and minimally stressed microstructure of cement stone. The effectiveness of the use of additives in this particular form is due to the manifestation of the nucleation effect, which accelerates the hydration of alite and causes chemical binding of the carbonate component into more stable compounds than hydrocarboaluminates, what provides high mechanical properties and durability of formed artificial stone.

INTRODUCTION

Carbonate additives are now widely used for the production of Portland cements with additives (EN197-1, DSTU B EN 197-1: 2015), and the higher the C_3A content in the clinker, the greater the effect of the use of such additives. Such additives are also often used to produce high-performance concretes, including self-compacting concretes (SCC) and fine-grained concretes that can be used for a construction 3-D printers. According to the results of research [1–3], concrete made with the addition of fine limestone powder (average particle size <20 μm can have high workability and resistance to segregation). At the same time, the dependence of the obtained results on the mineralogical and chemical composition of carbonate additives, as well as on the technology of their preparation and addition.

It is known that fine-ground mineral components of different origin in the compositions of Portland cements with different mineral additives allows to provide a targeted effect on the processes of structure formation to form a dense, strong and minimally stressed microstructure of cement stone by binding portlandite to hydrosilicates and hydroaluminates, regulation of the formation of topochemical ettringite and acceleration of the pozzolanic reaction in the non-clinker part of the system for obtaining mortars, mixtures and concretes with improved technical properties [4].

According to V.V. Timashov and others. [5] the addition of microcarbonate additives has a positive effect on the construction and technical properties of Portland cement, due to the chemical interaction of carbonate additives with the aluminate phases of Portland cement clinker. Carbonate additives in cements, in addition to participating in the processes of structure formation, are a substrate for the crystallization of hydrate formations, accelerate hydration

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processes and provide good adhesion between the components of the stone. Namely, the addition of finely ground limestone to the composition of Portland cement promotes better activity of other components of the system.

It has also been proved that the use of a mineral additive with a specific surface area higher than that of Portland cement leads to an increase in the specific surface area of the whole system with a corresponding increase in the volume of physically bound water in the mixture. In the presence of a fine carbonate additive, the actual water-cement ratio in the system increases, the dissolution products are removed from the reaction zone to the surface of the microfiller particles with the formation of calcium carboaluminates $3CaO \cdot Al_2O_3 \cdot CaCO_3 \cdot 12H_2O$ [6].

Fine carbonate particles due to the effect of "fine powders" and chemical interaction with the products of hydration of aluminate phases with the formation of structurally active hexagonal AFm-phases contribute to the synthesis of strength of cement stone [7].

It should be noted that in the presence of finely ground calcium carbonate, hexagonal calcium hydroaluminates (C_2AH_8 and C_4AH_{13}) are replaced by more stable hydrocarboaluminates $3CaO \cdot Al_2O_3 \cdot CaCO_3 \cdot 12H_2O$, the structure-forming role of which increases over time. The $[CO_3]^{2-}$ groups in the structure of carboaluminates are packed in parallel to the $[Ca_2Al(OH)_6]^+$ layers and stabilize them [8].

Carbonate additives react not only with C_3A, but also with C_4AF, with additionally binding up to 2.5% of $CaCO_3$ [9]:

$$4\,CaO \cdot Al_2O_3 \cdot Fe_2O_3 + CaCO_3 + 12\,H_2O = 3CaO \cdot (Al_2O_3 \cdot Fe_2O_3) \cdot CaCO_3 \cdot 12\,H_2O$$

As noted by J. Stark and W. Burnt [6], the efficiency of the introduction of finely ground limestone increases with increasing size of its specific surface area. This provides a wider range of grain distribution by fraction, which allows to enrich the system with smaller particles and thus reduce the volume of voids between the clinker grains.

Thus, the effectiveness of carbonate additives of different degrees of dispersion, which can be classified as microadditives, is well studied by scientists from different countries and it is shown that their addition increases both the strength of artificial stone and improving the rheological properties of cement mixtures. At the same time, there are already nanocarbonate additives on the construction market, which have not been studied enough, but as the theory of this issue shows, they should give a much greater effect when used, and in much smaller quantities than in the case of microcarbonate additives. Today it is believed that the density of the cement matrix can be increased by introducing calcium carbonate, when it acts as a filler, i.e. its particle size is comparable to the particle size of cement, or even smaller, and it can be a chemical reagent that participates in the hydration process, and this process can be accelerated due to the nucleation effect [10].

When the particle size of calcium carbonate is comparable to the size of cement grains, the plasticizing effect will effectively influence on the rheology of cement paste and the process of cement hydration [11]. However, these effects are not independent and are often determined by the amount of carbonate additive, grain size and morphology.

Consequently, the specific result of the addition of finely ground carbonate additives (micro- and nanoadditives) always depends on the mineralogy and activity of cement, and the type of plasticizer component and mineralogical and chemical composition of the carbonate additive, as well as the technology of its preparation and addition [12].

MATERIALS AND RESEARCH METHODS

The aim of this work is to study the features of regulating the strength and rheological characteristics of Portland cement compositions modified with micro- and nanocarbonate additives, which has a decisive influence on the selection and use of such binders to obtain high-performance concrete for special purposes.

The experiments were made using Portland cement CEM I-42.5 R-N (according to DSTU B B.2.7-46: 2010) by CRH (PJSC "Podilsky Cement"), with a specific surface area of 390 m^2/kg according to Blaine. Mineralogical and chemical compositions of cement clinker are given in tables 1,2.

TABLE 1. Mineralogical composition of Portland cement clinker.

Name	The content of basic minerals, mas. %			
	C_3S	**C_2S**	**C_3A**	**C_4AF**
Portland Cement clinker PJSC "Podilsky Cement"	62,46 (Bogue) (69 XRD)	10,07 (Bogue) (5.5 XRD)	7,4(Bogue) (5,2 XRD)	11,3(Bogue) (10,4 XRD)

TABLE 2. Chemical composition of Portland cement clinker.

The content of oxides, mas. %									
SiO_2	**Al_2O_3**	**Fe_2O_3**	**TiO_2**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**SO_3**	**free lime**
21,06	5,1	3,16	0,31	1,55	65,28	0,11	0,58	0,58	0,93

In order of directed formation of artificial stone structure and improve its physical and mechanical characteristics superplasticizer based on polycarboxylates (MC PowerFlow 3100) with PEG molecular weight from about 3000 was used.

As nanocarbonate additives technical products of the Norwegian company "Nordcalk" in the form of a dispersion "Enrich C 50" was used, the main characteristics of which are presented in table 3. Additive and admixture were added into the composition in terms of dry matter by the weight of cement.

TABLE 3. General characteristics of nanocarbonate additive by "Nordkalk" company.

Technical characteristics		**Units of measure**	**«Enrich C 50»**
Dry matter content		%	50
Average density		g / cm^3	1,45
pH of the dispersion			7…9
Appearance (at T = 25^{0}C)			White dispersion
Particle size distribution			
	d50%	nm	130
	d90%	nm	300

As a microcarbonate additive, finely ground limestone of Humentsi quarry of Khmelnytsky region was used, the chemical and mineralogical composition of which is given in Table 4.

RESEARCH RESULTS

Considering the effect of polycarboxylate superplasticizers and nanocarbonate additives on the rheological properties of cement paste and on the processes of structure formation of cement compositions, it was rational to first study the physical and mechanical properties of cement stone samples to eliminate the effect of fine aggregate on strength and reduce test error.

TABLE 4. Chemical and mineralogical properties of finely ground limestone (microcarbonate additive).

The content of oxides by mas. %						
SiO_2	**Al_2O_3**	**Fe_2O_3**	**MgO**	**CaO**	**L.O.I.**	**$SiO_{2+}R_2O_3$**
1,59	0,49	0,44	0,51	53,89	42,94	2,16
Mineral content, mas. %						
$CaCO_3$ - 96,16; $MgCO_3$ - 1,26; clays (SiO_2+R_2O_3) – 2,27						

Studies of the strength of cement stone were performed using cube samples 2 × 2 × 2 cm, which were tested after curing under standard conditions on a hydraulic press. The kinetics of compressive strength of the investigated samples obtained on the basis of compositions modified with microcarbonate additives (finely ground limestone) at the same density of cement paste are shown in table 5.

TABLE 5. Kinetics of the strength gain of cement stone modified with polycarboxylate additives and finely ground limestone.

Composition	**Strength gain of paste samples, MPa, after curing for, days**			
	3	**7**	**28**	**365**
Portland Cement + water	43	61	74	79
Portland Cement + water + 1% MCPF 3100	64	82	94	96
Portland Cement + water + 1% MCPF 3100 + microcarbonate filler				
10%	79	85	90	92
12,5%	85	89	95	97
15%	75	76	78	79

The analysis of the given data allows to note that the compositions with 12,5% of $CaCO_3$ have the best strength gain kinetics both in early, and late terms of hardening. The effect of the carbonate additive in the presence of a plasticizer is higher than when using it in conventional cement compositions.

The comparable strength gain of cement compositions with the introduction of the optimal amount of finely ground carbonate additive (in the presence of polycarboxylate plasticizer) is 3 days -32%; on the 7th day - 8% and on the 28th - only 1%. Taking into account the results of our previous studies [12] and the dependence of the effectiveness of the nanocarbonate additive on the amount of added plasticizer, the determination of the optimal composition of the organocarbonate additive was performed using a mathematical two-factor experimental planning method. The content of polycarboxylate plasticizer and nanocarbonate additive in the form of dispersion was used as variable factors (Table 6).

The nanocarbonate additive dosage was calculated on the dry matter of dispersion. The kinetics of the strength gain of cement compositions modified with nanocarbonate additives was determined using cement pastes prepared at standard consistency of cement paste. The matrix of the experimental design, which reflects the change in the strength of nanomodified compositions over time, is given in Table 7.

According to the results of experimental studies, quadratic equations of regression of compressive strength of samples tested after 3, 7, 28, 180 days and isoparametric diagrams of changes in strength over time were obtained (Fig. 1).

The following are the regression equations for estimating the compressive strength of the samples after 3, 7, 28 and 365 days of hardening modified with superplasticizer MC "PowerFlow 3100" and nanocarbonate additive, which taking into account the regression coefficients are as follows:

$$f_{ck}\,(3\text{ days}) = 77{,}333+3{,}167\cdot x_2-5\cdot x_1^2-0{,}5\cdot x_2^2-1{,}25\cdot x_1\cdot x_2;$$

$$f_{ck}\,(7\text{ days}) = 96{,}778+2{,}5\cdot x_1+2{,}5\cdot x_2-0{,}167\cdot x_1^2-6{,}167\cdot x_2^2-1{,}5\cdot x_1\cdot x_2;$$

$$f_{ck}\,(28\text{ days}) = 127{,}778+0{,}833\cdot x_1+1{,}5\cdot x_2-3{,}167\cdot x_1^2-0{,}167\cdot x_2^2;$$

$$f_{ck}\,(365\text{ days}) = 131{,}33+1\cdot x_1+2{,}5\cdot x_2-4\cdot x_1^2-0{,}5\cdot x_2^2-0{,}75\cdot x_1\cdot x_2.$$

Analyzing the regression equation, it can be noted that in the early stages of hardening (3 days) the dominant factor is the consumption of superplasticizer, which at a consumption of more than 0.88% provides increasing the strength of artificial stone samples with the introduction of nanomodifying additives within 2.5…4.5% , while the strength of the specimens varies from 67 to 78 MPa.

TABLE 6. Intervals of variation and values of variables.

Factors, type: natural	coded	Levels of variation: upper	middle	low	Interval of variation
Plasticizer dosage (PCE), %	X_1	1,25	1,0	0,75	0,25
Nano-$CaCO_3$ additive, %	X_2	4,5	3, 5	2, 5	1,0

TABLE 7. Matrix of experimental planning and the results of strength gain over time of modified cement pastes.

№	Variable factors, type: coded		natural		Change in the strength of cement stone samples, MPa, after curing, days			
	X_1	**X_2**	**PCE dosage, % by mass**	**Nano-additive dosage, % by mass**	**3**	**7**	**28**	**365**
1	1	1	1.25	4,5	74	94	127	130
2	1	0	1.25	3,5	78	95	129	132
3	1	-1	1.25	2,5	78	90	125	130
4	0	1	1,0	4,5	74	96	125	128
5	0	0	1,0	3,5	77	99	128	133
6	0	-1	1,0	2,5	71	95	124	125
7	-1	1	0,75	4,5	68	95	124	126
8	-1	0	0,75	3,5	76	84	126	128
9	-1	-1	0,75	2,5	67	85	122	123

On the 7th day, the second variable factor becomes more important, namely the consumption of nanomodifying additives, and the higher the consumption of plasticizer, the greater the effect of the introduction of nanocarbonate additives. This is reflected in the strength of the studied compositions, which reach 95… 99 MPa.

On the 28th day, the nature of the isolines changes and the optimal dosing range of the nanoadditive is clearly distinguished, which is 3.1… 4.25% with a plasticizer consumption of about 1% or more, while the strength of artificial stone reaches 129 MPa, which is 37% higher than the strength of control samples modified only with polycarboxylate additive and 74% higher than the strength of unmodified compositions (Table 5).

After 1 year of curing, the range of optimal compositions that provide artificial stone with a strength in the range of 130… 135 MPa, significantly expands and the optimal consumption of nanoadditive is (2.6… 4.4)% at the same time using a polycarboxylate plasticizer in an amount greater than 0.88 %.

The effectiveness of the nanocarbonate additive compared to the analogue containing only a plasticizing additive is particularly noticeable at 28 and 365 days, due to the formation of a more stable composition of new formations, dominated by low-basic hydrosilicates of calcium and gillebrandite (Table 5.7) (Fig. 2).

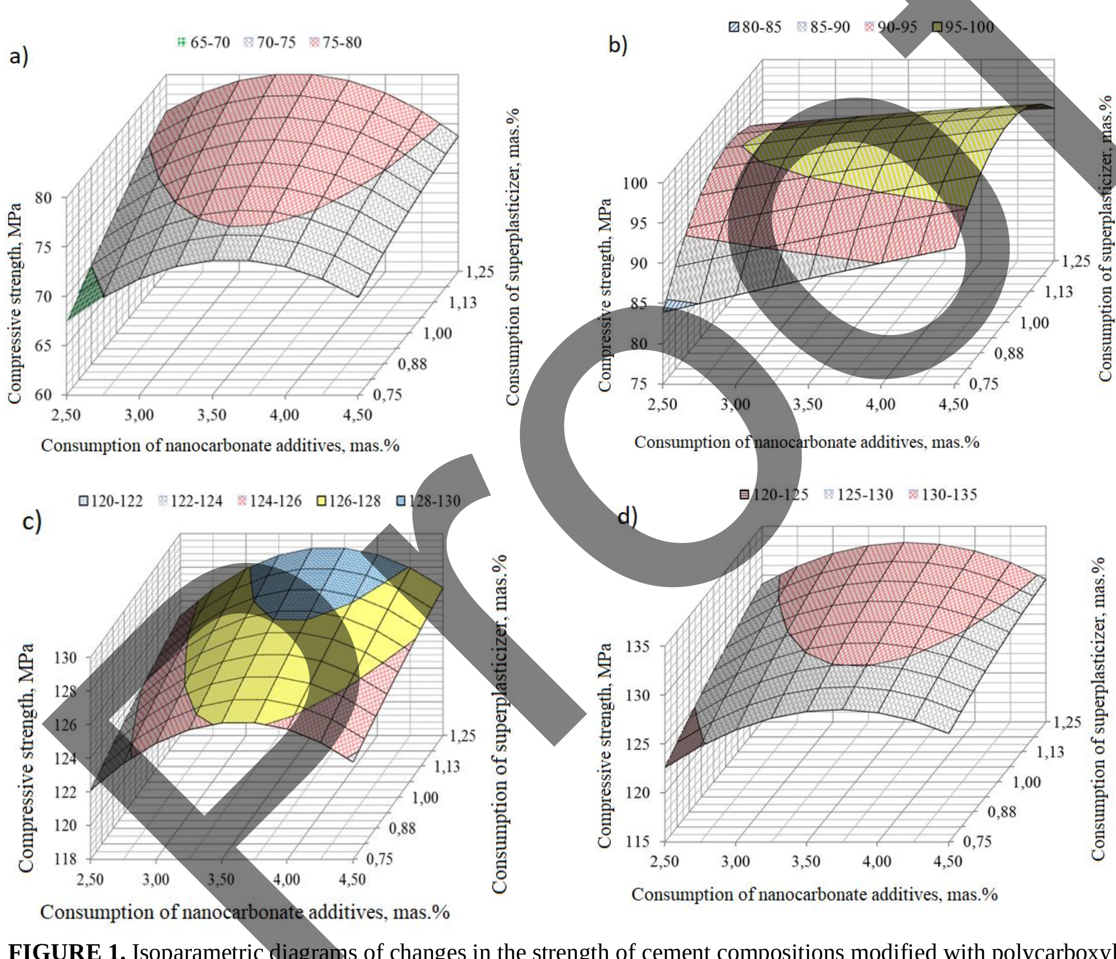
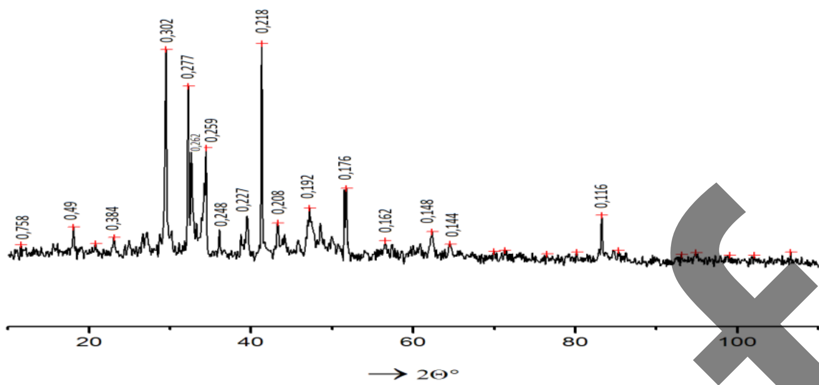


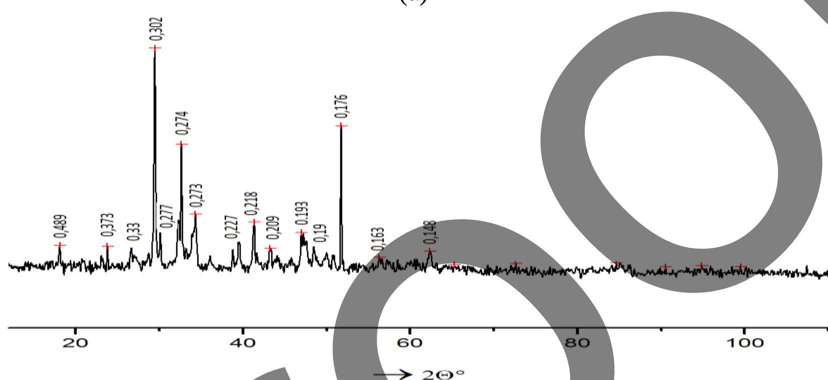
FIGURE 1. Isoparametric diagrams of changes in the strength of cement compositions modified with polycarboxylate plasticizer and nanocarbonate dispersion after curing for 3 (a), 7 (b), 28 (c) and 365 days (d)

According to X-ray phase analysis after 1 year of curing in the composition of hydration products of Portland cement, modified only with polycarboxylate additive (Fig. 2, a), recorded residues of Portlandite (d = 0.493; 0.236; 0.193; 0.179 nm) and the formation of tobermorite 11.3A (d = 0.328; 0.307; 0.297; 0.248; 0.228; 0.215; 0.207; 0.193; 0.176 nm) and dicalcium hydrosilicate similar to gillebrandite (d = 0.334; 0.301; 0.292; 0.275; 0.196; 0.175 nm).

With addition into the composition of Portland cement a nanocarbonate additive together with a polycarboxylate admixture (Fig. 2, b), in the composition of new formations in addition to gillebrandite and tobermorite 11.3 A (d = 0.307; 0.297; 0.228; 0.215; 0.193; 0.176 nm) probably recorded scoutite $6CaO \cdot 6SiO_2 \cdot CaCO_3 \cdot H_2O$ (d = 0.303; 0.301; 0.277; 0.227; 0.207; 0.193; 0.176; 0.163; 0.148 nm). The above compounds have similar parameters of the crystal lattice and according to the Ruye-Friedel rule can grow together, which contributes to the synthesis of the strength of artificial stone over time.



(a)



(b)

FIGURE 2. X-ray phase composition of artificial stone formations after 365 days of hardening of Portland cement modified with 1% PCE admixture (a) and an additionally nanocarbonate additive (b)

Nanocarbonate additive in comparison with finely ground limestone also has a significant effect on the rheological properties of cement paste, including changes in plastic strength.

Plastic strength was determined by the kinetics of changes in plastic strength over time or by plastometry [13]. The method is based on determining the immersion parameters of the cone under constant load F, which gives a conditional rheological characteristic, which shows the dependence of the velocity dh / dt on the tangential stress Pm at shear and decreases during immersion due to increasing contact area of the cone with the mixture.

The Pm value was determined by the maximum depth of the cone under the action of load F. It was assumed that when the cone is immersed, the movement of the mixture along the side surface of the cone. This condition is achieved when tested in sufficiently plastic systems, so the shear stress Pm, which causes this flow, is determined by the projection of the force F acting on the cone, on the slant height l of the cone, relative to the unit area S of the cone contacted with the paste (Fig. 3) . The shear stress was determined by the formula:

$$P_m = K_\alpha \left(\frac{F}{h^2}\right), \qquad (1)$$

Where Kα is the constant of the cone, which depends on the angle α at its vertex; F is the load on the cone, g; h is the depth of immersion of the cone, cm.

To determine Pm used a cone with an angle ϕ = α/2 = 30°. To exclude the edge effects, the test mixture was placed in a sufficiently large vessel. The results of comparative tests to assess the effect of micro- and nanocarbonate additives on the rheological characteristics of cement paste are shown in Fig.4.

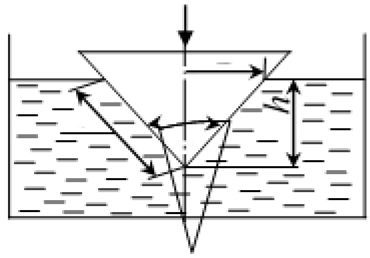
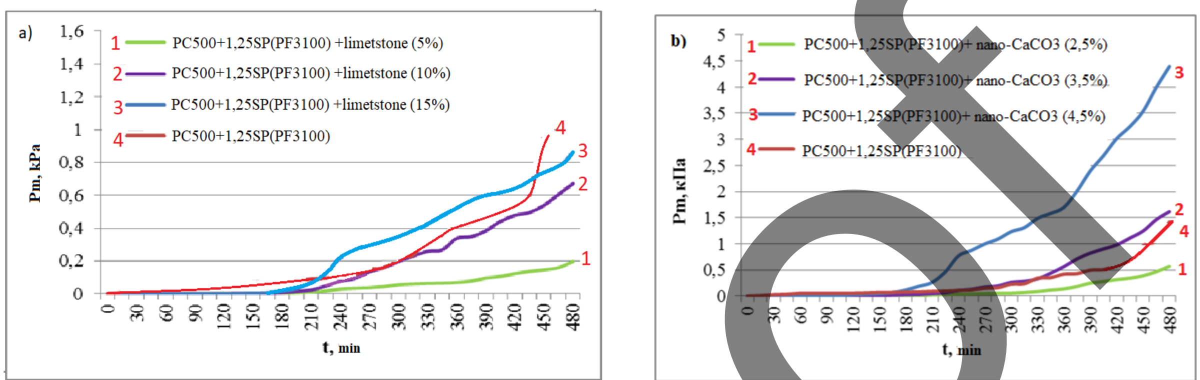


FIGURE 3. Schematic representation of the cone immersion under the load to determine the plastic strength



a) b)

FIGURE 4. Change in plastic strength of cement compositions modified with organo-carbonate additives of different degrees of dispersion: a) microadditive represented by finely ground limestone and b) nanoadditive in the form of nanocarbonate dispersion

The analysis of the given data allows to note various tendencies of influence of carbonate additives of various degree of dispersion on speed of structure formation processes of a cement stone. Thus, with the introduction of finely ground limestone in the amount of (5… 15 wt.%) there is some reduction in the plastic strength of cement paste compared to the paste without modifying additives (after 4 hours the plastic strength does not exceed 0.07 kPa, and for the control sample is about 1 kPa) . With increasing the amount of microcarbonate additive to 15%, there is a 4 hour increase in plastic strength to 0.2 kPa, which is less than the same figure for the Portland cement composition with a plasticizing admixture (0.25… 0.3 kPa).

According to the results of experimental data (Fig. 4) finely ground limestone contributes to some reduction in the plasticity of cement paste, increases the duration of the induction period compared to similar indicators for samples of control cement pastes (Fig. 4a), and this trend persists in the study of concrete mixtures, including SCC mixtures [14].

At the same time, in the presence of nanocarbonate additives there is an acceleration of the structure formation of cement paste, primarily affecting the acceleration of the hydration process of the mineral C_3S [15-17], and the higher the content of nanocarbonate additives, the faster the increase in plastic strength (Fig. 4, b), what is essential for concrete mixtures used in 3D printers, where, according to [18-20], to obtain the optimal number of layers, the plastic strength of cement compositions should be within 0.3… 0.6 kPa.

Thus, when choosing the type of modifying carbonate admixture, it is necessary to take into account not only its influence on the kinetics of strength gain over time, but also on the change of rheological properties of cement compositions, which are decisive given the latest technologies for high-performance concrete.

CONCLUSIONS

The addition of both micro- and nanocarbonate additives makes possible to increase the strength of Portland cement compositions, but the efficiency of nanoadditives is 35% higher than the efficiency of microadditives, and the optimal amount of nanoadditives is almost 2.5… 5 times less than the optimal dosage of microadditives. According to the results of physicochemical studies, the effectiveness of the addition of nanocarbonate dispersion in cement compositions is associated with the manifestation of the nucleation effect, which accelerates the hydration of alite and causes chemical binding of the carbonate component to more stable compounds than hydrocarboaluminates, but also durability of the formed artificial stone.

The use of polycarboxylate admixtures in combination with carbonates increases the workability retention of cement compositions up to 3… 4 hours, but with the addition of finely ground limestone in the amount of 12.5… 15% after 3 hours plastic strength begins to increase, and the more additive, the higher the speed of this process.

The addition of a microcarbonate additive improves the plasticity of the cement mortar, stretches the induction period and makes such compositions more suitable for the production of concretes capable to self-compaction.

With the addition of nanocarbonate additives (due to the manifestation of the nucleation effect) there is a change in the rheological properties of Portland cement paste: by using 2.5% additive, the duration of the induction period reaches 5 hours, 3.5% - 4 hours, and 4.5% - 3 hours, and in the latter case there is a sharp increase in plastic strength, which can be positively used in the development of concrete compositions for 3D printers.

By using a smaller amount of nanoadditive, i.e. 2.5… 3.5%, the increase in plastic strength is smoother, only after 4 hours the value of plastic strength reaches 0.1 kPa, which may explain the formation of a better structure and a stable rate of strength gain of artificial stone in time.

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Bio-Receptive Concrete for vertical Greening of Facades

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Abstract. It is known that most building materials are incompatible with microorganisms as a result of biocorrosive processes that lead to their destruction. The functional capabilities of modern concretes are constantly being improved and expanded due to the development of technologies for controlling their structure formation at the micro- and nanolevels. Expanding the range of raw materials used for their production made it possible to obtain biopositive concrete, the surface of which is a nutrient medium for the growth of bryophytes. In recent years, vertical landscaping of facades has become very popular, which has taken the form of street art, combining architectural aesthetics with environmental principles. The paper discusses a method for creating vertical bryophyte gardens in the form of architectural shells for the facades of existing buildings. Examples of possible implementations of the design of the facades of residential buildings with architectural shells made of bio-receptive concrete are given.

INTRODUCTION

Landscape design is an integral part of the architectural environment of a modern city. Analyzing the factors of its influence on the formation of the image of the environment, they are often limited to environmental and emotional aspects. However, a closer study of the role of landscape design reveals the possibility of using it as a tool to increase the economic attractiveness of objects by increasing the flow of tourists and the value of real estate. The search for ways to create an environmentally safe and aesthetically pleasing architectural environment is a problem that is solved at various levels of design practice – planning, volumetric, constructive and technological [1].

One of the directions in the development of landscape design has become the development of methods for vertical gardening of facades [2-5]. The popularity of this type of landscape design is now so high that it has taken on a form of street art. Although decorating the facades of residential buildings with green spaces (flowerpots, ivy, wild grapes, climbing rose) is a very common approach in all countries of the world (Fig. 1), the use of vertical landscaping methods for multi-storey buildings has also become widespread in recent decades.

Decorating building facades is the main purpose of using vertical landscaping. In addition to improving the aesthetic appearance, highlighting the features and hiding facade imperfections, the most important, from our point of view, is the environmental aspect today. The green facade is not just a decorative element, it is part of the building's life support system aimed at improving the quality of human life, improving the microclimate and environmental qualities of the environment. In vertical gardening of multi-storey residential and public buildings and structures, three main methods are used, which differ in the principle of usage: stationary, constructive and mobile [2].

The first of them, stationary, is based on the creation of structural systems that are attached to the outer wall of the building facade. Mobile vertical landscaping systems are based on the use of removable structures that are attached to the surface of the walls of the building facade. Structural systems are architectural envelopes in the form of panels, which are either attached to the wall or are themselves an element of the building structure. There are two types of such systems: rigid and flexible.

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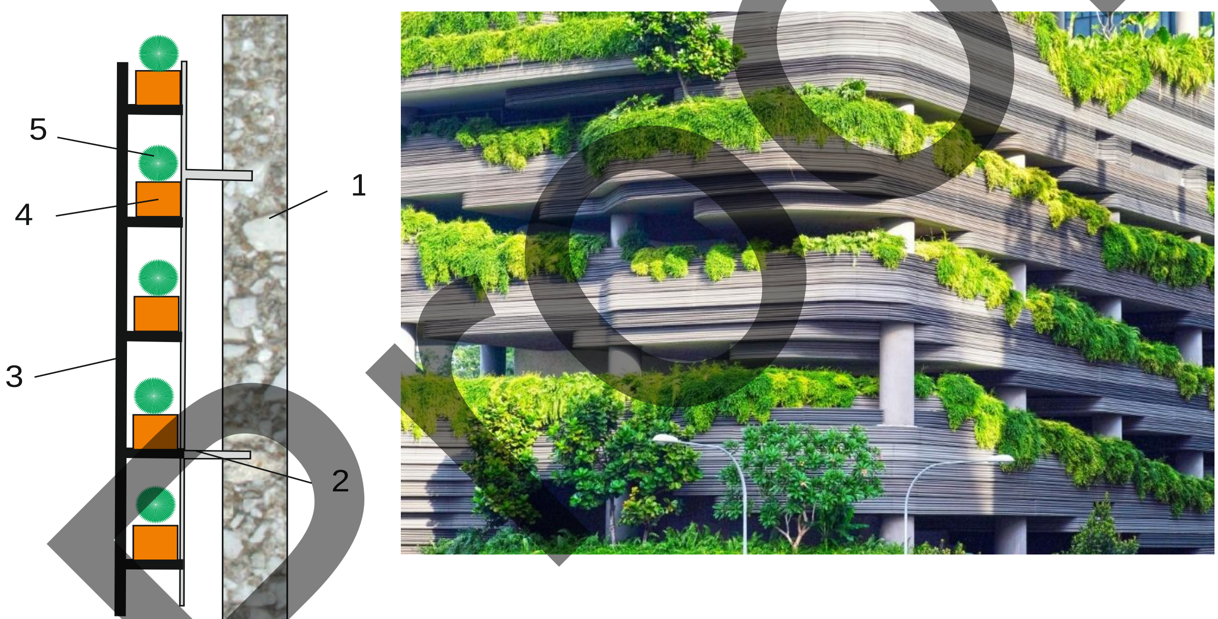
(a) (b)

FIGURE 1. Facades overgrown with vegetation (a) ivy [6], (b) roses

Rigid stationary systems are lightweight frame-type structures 3, on which containers 4 for plants 5 are placed, and are attached to the outer surface of the wall 1 (Fig. 2).



(a) (b)

FIGURE 2. Rigid stationary systems: (a) construction, (b) ACROS Fukuoka Prefectural International Hall [3].

The advantages of these systems include: durability of the structure, quick decorative effect, the ability to easily change landscape compositions, the ability to use large-sized plants, providing a sun-protection effect in buildings with a large glazing surface area.

The main disadvantage is the need for constant care of plants and for the climate of Ukraine, the seasonality of the use of plants.

Flexible mobile (felt) systems are a cellular coating made of polymer felt with cavities for planting plants (Fig. 3, a). A moisture-resistant plastic frame 3 is attached to the outer surface of the structure, covered with a polymer felt with holes for planting 4. A nutrient substrate is placed in the cavity-pockets and the corresponding plants are planted. An example of using this method is the Musee du Quai Branly Vertical Garden, decorated by Patrick Blanc in Paris (Fig. 3, b). The method proposed by Blank is based on the achievements of hydroponics - the technology of growing plants without soil on aqueous nutrient solutions [7].

(a) (b)

FIGURE 3. Flexible mobile modular systems (a) construction, (b) vertical garden Musee du Quai Branly in Paris [8]

The advantages of this method include the rapid achievement of a given decorative effect and an increase in heat saving rates.

The main disadvantages are the need for constant control over the operation of the hydroponic system, seasonal decorativeness, limitation of the possibilities for design changes, since the felt covering is one-piece.

As the experience of using vertical gardening of facades shows, in such buildings a special microclimate of internal premises with high humidity, oxygen-enriched air, containing less harmful gases and dust, improves the sound insulation properties of external walls. All this, together with the changed design of the facade, has a positive emotional effect on a person [8].

Constructive vertical gardening systems are architectural shells made of special concrete or other material, the surface of which is a favorable environment for the growth of plants (most often bryophytes) (Fig. 4).

The principle of functioning of the modules of decorative slabs by the Spanish architect Emilio Llobat, called the "living wall", is based on the use of hydroponics. These boards consist of a plant substrate or polyamide felt with pressed-in seeds.

(a) (b)

FIGURE 4. Stationary vertical landscaping systems (a) construction, (b) decorative modular slabs [9, 10]

The advantages of this method include the possibility of planning a decorative effect and increasing heat conservation rates.

Disadvantages are the need for constant monitoring of the hydroponic system and seasonal decorativeness. It is also necessary to take into account that any plant needs careful and professional care.

Another option for using a constructive vertical gardening system is the development of scientists from the Polytechnic University of Catalonia (Universitat Politècnica de Catalunya) Antonio Aguado and his colleagues [11]. The basis of this system is "biological concrete" based on magnesium phosphate cement, which differs from ordinary concrete by its pH value: in ordinary concrete, pH = 12...13, in bioconcrete pH = 6...9. The change of an alkaline medium to an acidic medium makes the surface of such concrete suitable for colonization of mosses and lichens with spores.

The advantages of this method include the longevity of the vegetation cover, improved thermal efficiency, no need for maintenance.

The main disadvantages are the impossibility of planning a decorative effect and a long period of spore germination.

APPLICATION OF BIO-RECEPTIVE CONCRETE

Magnesium phosphate cements are produced by an acid-base reaction between MgO and soluble acid phosphate (usually ammonium or potassium phosphate) to form an astringent magnesium phosphate salt

$MgO+NH_4H_2PO_4+5H_2O \rightarrow NH_4MgPO_4{\cdot}6\ H_2O$.

Preliminary studies have shown that the use of potassium dihydrogen phosphate KH_2PO_4 instead of ammonium phosphate leads to an increase in water resistance, a decrease in the shrinkage of the resulting concretes, and a slight increase in compressive strength [12, 13]. In addition, since KH_2PO_4 is used as a phosphorus-potassium fertilizer, an improvement in bryophyte survival on the surface of such concretes should be expected.

Since there is no root system in bryophytes, it was customary to use as a basis two-layer architectural shells 2 cm thick and 20 × 20 cm in size. Two types of concretes were used for their manufacture: the upper (outer) layer of concrete based on phosphate-magnesium cement and the lower made of glass fiber concrete on ordinary Portland cement (Fig. 5). The thickness of the bio-receptive concrete layer is 1 cm, which is sufficient for the growth of bryophytes. A layer of glass fiber reinforced concrete with a thickness of 1 cm also serves as a structural basis for the architectural envelope. Fastening of the shells is carried out using plastic dowels directly to the surface of the building facade.

An important aspect for Ukraine is the selection of appropriate bryophytes that can adapt to climatic conditions. The most acceptable, in our opinion, are mosses of the anthocerotaceous class – Tortula muralis. This species grows in nature on stones, on walls and is quite widespread in Ukraine. They obtain water and nutrients directly from humid air or precipitation. In the tissues of mosses there is a special type of cells that retain moisture for a long time. With prolonged drought, plants fall into a dormant state. They change color and reduce the metabolic rate to almost zero. At the same time, only a few drops of moisture are enough for them to get out of the state of suspended animation.

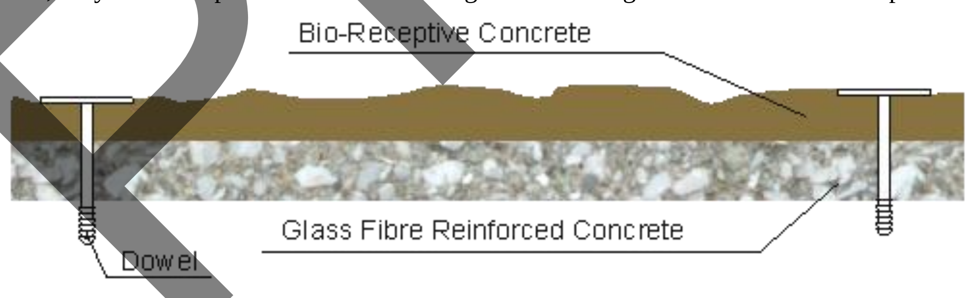


FIGURE 5. Schematic of the construction of bio-receptive concrete architectural envelopes

Unfortunately, this promising, actively developing direction in modern world architecture practically does not receive implementation in Ukraine. In addition to environmental and aesthetic qualities, the use of the method of vertical gardening and architectural shells made of biopositive concrete will increase the heat-insulating and noise-absorbing properties of the building walls, improve the microclimate, while not being costly [9, 10]. The possibility of using vertical gardening of facades in our climatic zone has been confirmed by the successful application of this method in Germany, France, Austria, Canada, Holland and Great Britain.

As an object for the use of architectural shells made of bio-receptive concrete were taken 5-storey residential buildings of the 1-447C series in Kharkov on the Sokolov str. (Fig. 6). Houses of this series are widely represented in

Kharkov. The outer walls are made of ceramic bricks with subsequent plastering with cement-sand mortar. The buildings are located in the industrial area of the city. As a result, unfavorable environmental conditions and air pollution, affect not only the well-being of people, but also the condition of buildings. The need to re-paint the facades arises every 2 years. It seems economically more profitable to decorate facades with panels made of bio-receptive concrete and glass fiber reinforced concrete. In addition to the advantages mentioned above, this will lead to the humanization of the architectural environment and the leveling of unfavorable environmental conditions.

The buildings are located along the street, perpendicular to its direction. The ends of the buildings are oriented to the north, which is favorable for the growth of bryophytes. It is supposed to decorate the side facades of buildings with panels.

FIGURE 6. Modern state of the residential buildings. Photo by Mariya Gavrilovskaya.

The proposed solutions for the decoration of facades involve the use of architectural shells made of bio-receptive concrete in combination with their glass fiber reinforced concrete slabs. The nature of the pattern in the form of simple linear compositions or more complex ones is limited only by the desired degree of saturation of the compositions (Fig. 7).

FIGURE 7. Decorating options for architectural shells made of bio-receptive concrete. The work by Mariya Gavrilovskaya

CONCLUSIONS

The main methods of vertical gardening are considered, their main characteristics are indicated, advantages and disadvantages are revealed.

A composition of bio-receptive concrete based on phosphate-magnesium cement obtained as a result of acid-base reaction between MgO and soluble potassium dihydrogen phosphate KH_2PO_4 is proposed. This makes it possible to increase the water resistance of bio-receptive concrete and, as a result, its durability. The surface environment of the resulting bio-receptive concrete is favorable for the growth of bryophytes.

Variants of decorating the facades of 5-storey residential buildings of the 1-447C series in Kharkov using two-layer panels made of bio-receptive concrete and glass fiber reinforced concrete are proposed.

The current level of development of building technologies has significantly expanded the range of opportunities for architects and designers in the formation of a strategy for the development of the urban environment. The block of environmental issues seems to be one of the most urgent. The solution involves transformations at all stages of design, and at each of them it is necessary to remember that the means of landscape architecture allow to neutralize the negative influence of both natural factors and the urban environment.

The competent use of various methods of landscaping will help to improve the sanitary and hygienic state of soils and the water basin, to ensure the cleanliness of the air basin, to harmonize the psycho-emotional state of a person, thereby increasing the comfort of the urban environment. And in the end, this is precisely the main task of the architect, since even Aristotle said that the city should make the life of people safe, and the people themselves happy.

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Problems of Choice of building Systems for penitentiary Complexes

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Abstract. The article is devoted to the problem of choosing the construction system of modern correctional buildings and complexes, as well as other traditionally "closed" institutions: hospitals, boarding schools, military camps, shift camps. The study covers a wide range of issues related not only to building materials, building structures, methods of their construction, but also includes an initial analysis of the prospects for creating a new architectural-spatial model of buildings and complexes that were traditionally considered outcasts in society and urban development. The study of traditional and modern building systems, which are the most important component of architecture, will make it possible to realize the mistakes of the past, as well as create and apply new approaches and methods of forming an open, full-fledged environment of "closed" institutions. The most important criteria influencing the choice of a building system for correctional buildings are the level of security of building structures, as well as for prisoners and staff; reliability and ease of maintenance, repair, operation of the facility; economic efficiency of buildings at all stages of the life cycle from design to material disposal; environmental friendliness and hygiene; flexibility and dynamics of spatial organization. The study of theoretical, methodological, design materials in this area led to the identification of some building systems used in the design and construction of correctional institutions in Ukraine and foreign countries, namely: a building system with load-bearing walls made of small-sized elements (brick, stone, block) using manual and mechanized technologies; panel and frame-panel construction system; monolithic and prefabricated-monolithic construction system and, finally, an additive system using innovative digital printing technologies on a 3D printer. All of the above building systems take their place in the modern construction of penitentiary complexes and other "closed" institutions, have their disadvantages and advantages, and require additional research by modern social, psychological, functional-regime, aesthetic requirements.

INTRODUCTION

The study of the experience of design, construction, operation of penitentiary buildings and complexes, which include prisons, remand prisons, correctional colonies, centers, made it possible to identify the features of the use of various structures and materials at various stages of the development of the correctional system. The penitentiary system as a whole and its elements have been and remain a fairly closed industry, therefore, the study of construction and structural systems used in the construction of buildings of penitentiary institutions was not carried out separately. On the other hand, modern correctional buildings and complexes certainly act as a typological unit in the general typology of buildings and structures, so it makes sense to study their building systems as one of the main starting points of the design, construction, monitoring process. Despite the well-known and proven need to introduce qualitatively new positive changes in the environment of the penal system, not a single new correctional building has been built in Ukraine during the years of independence, although such intentions were regularly declared. The current Ukrainian standards governing the design and construction of penitentiary institutions and pre-trial detention centers lack recommendations on the choice of building structures, materials, equipment. The main reason for this situation can be called the fact that most of the existing correctional institutions in Ukraine were built in the 50-the 60s of the last century as resource appendages of various enterprises, which explains their dense placement in the middle,

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northern and eastern regions. A small part of correctional colonies are located in former ancient monasteries (Zamkova Correctional Colony in Izyaslav, Sokal Correctional Colony, Shostka Correctional Colony), and pre-trial detention centers are mainly located in historical buildings - prison castles, which were built 150-200 years ago in large cities of Ukraine: Kyiv, Lviv, Odesa, Chernivtsi, Chernihiv, Izmail [1, 2].

Based on the above, we can conclude that an architect, engineer, and a correctional institution employee - everyone who takes part in the design of the penitentiary complex, in their work are forced to rely on the data of non-standard, not previously tested test methods, as well as on the recommendations of manufacturers and their own experience. It should be noted that for the architect-designer, the technical aspects of the choice of the building system act as secondary ones, which are taken into account after the general patterns of designing structures and determining their relationship with the spatial concept and shape of the building. The study of the historical process of the evolution of the embodiment of space-time concepts in the material environment allows us to assert that the analysis of the current trends in the development of structures and building materials allows predicting the future architectural solution, thereby helping to create a new harmonious spatial concept of the environment for keeping people in isolation.

FORMULATION OF THE PROBLEM

The purpose of the article is to review existing traditional and innovative building systems (structures, materials, construction technologies) in terms of the possibility of their use for the architectural and construction design of modern penitentiary complexes in Ukraine. Another important point of the research is the definition of a system of criteria and requirements for the choice of structural and construction system of buildings of penitentiary institutions, the use of which at the initial stages of design can become the basis for the formation of a new spatial concept of "closed" institutions.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The purpose of creating an architectural and construction project for any object is a complex combination and harmonization of function, structure, aesthetic form. The structural system is an interconnected set of vertical and horizontal supporting structures of a building, which together provide its strength, rigidity, stability. The building system acts as a more complex character of the constructive solution of buildings by the materials and technology of their construction. In specialized professional literature, the above terms are often used interchangeably, which is not correct. Analysis of a wide range of foreign and domestic literary sources made it possible to state that the construction method does not always act as a classification feature in the distribution of structural systems (schemes) by type.

This article is more about a building system than about a system of supporting structures, which acts as a means of harmonizing the architectural form and technological content of the object, in our, case this is demonstrated by the example of the buildings of a correctional institution. The classification of modern building systems adopted in Ukraine presupposes their distribution into several groups according to characteristic features, including the method of construction and the material of the main structures, namely: building systems with load-bearing walls made of bricks, small ceramic blocks, lightweight concrete or natural stone; construction systems where concrete is the main material of the supporting structures; building systems in which the main material of the supporting structures is wood. Each of these main groups is divided into several subgroups following the technology of manufacturing the elements and the method of building the building, for example, a panel system or monolithic and precast-monolithic structural systems.

The classification of structural systems (or schemes) of civil buildings in Ukraine is determined by the characteristics of their supporting structures and includes two main groups: horizontal and vertical. The horizontal supporting structures of capital civil buildings of mass construction are usually of the same type and usually represent a reinforced concrete disc-prefabricated, monolithic or precast-monolithic. Vertical bearing structures are more diverse and include the following main groups: rod load-bearing structures, which are created by the frame struts; planar (walls, diaphragms) internal volumetric and spatial elements of hollow section, forming stiffening trunks for the entire height of the building; volumetric-spatial external structures in the form of a thin-walled shell of a closed section, used for the entire height of the building.

According to the type of vertical supporting structures used, four main structural systems of civil buildings are distinguished - frame, wall (frameless), trunk, shell. Along with the main groups, combined structural systems are widely used, in which vertical load-bearing structures combine various types of load-bearing elements. These include many systems, namely: frame-wall elements connected employing stiffening diaphragms ("frame-diaphragm"); with an incomplete frame, combining load-bearing external walls and an internal frame; systems "frame-trunk", "box-trunk" and the like. The issue of choosing a structural system and building materials in architectural design was widely studied in Soviet times and the last thirty years in Ukraine and abroad [3]. Research into building technology over the past few years have pointed to the emergence of a new building system that is based on the so-called additive building technology using a building printer that builds up and synthesizes an object in layers. Due to the significant reduction in time and labor costs for the construction of walls, the construction 3D printer can produce high-quality structures with high protective and thermal insulation properties and durability, which takes on a special role in the construction and operation of correctional buildings [4].

MAIN MATERIAL

The review, analysis, selection of existing and prospective construction systems for penitentiary institutions, of course, should be based on the requirements that apply to them. The main criteria, in this case, are reliability and protection, efficiency, and innovation. So, the important characteristics that influence the choice of the construction system of correctional institutions are the level of security for the facility, for the convicts and staff, in other words, the structures must withstand acts of vandalism; reliability and ease of maintenance, repair, and operation of buildings, for example, to help prevent an emergency in the event of failure of electronic safety devices; economic efficiency with sustainable use of the facility, taking into account the possibility of recycling and disposal of materials; environmental friendliness and hygiene; ensuring flexibility and increasing the adaptability of spatial organization.

In this work, it is hardly possible to thoroughly and deeply present all aspects of the problem of choosing building materials and structures for correctional buildings and complexes, but the study and analysis of foreign sources show that American specialists carried out similar studies several decades ago. The methodology of such studies has several stages, the first of which concerns the survey of the existing condition and experience of operating the buildings of correctional facilities as part of the overall system. Looking at the current situation in Ukraine, it can be argued that such a survey of the material environment of existing penal institutions (correctional colonies) can be considered not only difficult to implement but also inappropriate due to the material and moral aging of buildings, their inconsistency with current international standards [5, 6].

The next step in researching prison buildings and other systems that make them work efficiently is to review the available guidelines, standards, and rules that can be used by architects and correctional staff when planning and designing new correctional facilities. It should be noted that the design standards for pre-trial detention centers and correctional colonies, an attempt to improve which was carried out several years ago, are closed to a wide range of architects and civil engineers, and this creates additional difficulties in solving the problem of modernization and humanization of the correctional system in Ukraine as a whole. Many foreign authors, in particular, an Italian Luigi Vessella, point out the need to involve architects, engineers, and builders in the activities of the correctional system of their states, as opposed to continuing the traditionally accepted path of "opacity" and isolation, which hinders the positive development of the industry [7].

The experience of cooperation with the penitentiary service of Ukraine, as well as the study of documents and electronic sources, suggests that the vast majority of 183 (information as of 05/10/2017) penal institutions in Ukraine are in an unsatisfactory material condition, therefore, the design and construction of new institutions, corresponding to international norms, as well as the development and adjustment of domestic building codes and standards can be considered a relevant and important task. As mentioned earlier, new penitentiary institutions in Ukraine are not yet designed or built, and the existing ones, excluding the historical buildings of prison castles and former monasteries, are low-rise barrack-type buildings with a corridor-type layout, built in the middle of the last century. The building systems that were used for the construction of correctional colonies during the period from the 50s to the 80s of the twentieth century can certainly be called outdated, those that do not meet modern world standards and progressive technologies. Another important aspect of the problem is the fact that even experts from economically developed countries of the world still have no answer to the question of what a correctional institution of the future should be and whether there is a need to build prisons “for centuries”.

The study and analysis of the experience of theoretical, methodological, and design materials of Western countries made it possible to identify some building systems used in the design, construction, and operation of correctional institutions. The most common type is a building system with load-bearing walls made of bricks, natural stone, ceramic and concrete blocks. It includes both a traditional system based on the construction of walls using the technique of hand masonry and a fully prefabricated system of mechanized installation of walls from large blocks and panels, made in the factory. Ukrainian correctional buildings, both historical and modern, are traditionally built of bricks and natural stone, with subsequent plaster and paint finish. Considering foreign correctional buildings and complexes, it can be noted that among them there are also quite a few buildings built in this way, and these are also quite old buildings. Despite the large-scale architecture of brick buildings corresponding to the size of a person, most of them were built in the 19th and 20th centuries, when this structural and construction system was considered, if not progressive, then cheap and familiar. By the way, the most "humane" prison today is Halden in Norway, designed for 250 prisoners and built from natural materials: brick, ceramic tiles, wood, and steel (Figure 1). Such a construction of small institutions is difficult to imagine in America, where the highest crime rate in the world and the prison industry are considered one of the most profitable industries. American experts believe that the main problem with traditional enclosing structures, made, for example, from hollow concrete blocks, is the ability to easily penetrate walls with hand tools. If the central part of the "core" of the block is filled with mortar or reinforced, the penetration time is significantly increased and the building becomes more efficient [9]. Although in Ukraine there is a national standard for determining the strength of walls prone to various loads - compression, lateral, impact, methods for measuring and calculating penetration resistance for walls have not been developed.

The next type, which includes panel and frame-panel construction systems, was widespread in the practice of building correctional complexes mainly in 70 - 90 years of the twentieth century in America and European countries, but even today some countries of the world, in particular Brazil, in cooperation with Germany, are designing and building thousands of square meters of modern panel correctional facilities. It is noteworthy that the construction time of each institution using Sistema Construtivo Penitenciário is 6 months instead of 4 - 5 years, in comparison with the traditional system [10].

The next and most common type of building system for penitentiary complexes in recent decades, in particular in America and Australia, is a monolithic and prefabricated monolithic system, which is especially effectively used for the construction of modular buildings. Prefabricated penitentiary buildings provide much greater security than brick, concrete, and stone blocks, as well as protect the premises for holding prisoners from unauthorized access and the prisoners themselves from physical harm. All precast concrete modules are manufactured at the manufacturing plant, where the quality of the product is easily controlled. Also, the introduction of such a construction system requires less time for construction, saves on the amount of equipment and labor.

The main elements of precast-monolithic concrete modules made of high-strength concrete are closed cells of cells (rooms) for prisoners, balcony slabs, and volumetric elements of attic rooms, provide placement of utilities (air, plumbing, and electrical wires). Modules of residential cells are interconnected by 2 and 4 cells, respectively, and consist of insulated external and internal walls and a roofing slab, cast in a monolithic method. Between adjacent modules, triangular cross-section channels are built to accommodate communications, and furniture and sanitary ware are bolted to the walls. A shower cabin is supposed only in the cells of institutions with a high-security level; in institutions with a minimum and medium security level, shared shower rooms are located on the floors. Between the lower and upper modules of residential cells, balcony slabs are built-in, serving as corridors (galleries) and places for placing lighting (Figure 2).

The modules for the formation of the attic are the C-shaped structures located on the upper levels of the living quarters for the prisoners and, in addition to the function of placing the engineering channels, they also help withstand the lateral wind load and carry the weight of the roof made of steel roof structures. The tops of the attic chambers are notched to support the trusses. Other components of prefabricated modular correctional buildings, such as wall panels, flat slabs, and columns, are non-specific and are used to form the corner spaces of common areas or interior middle walls that support steel trusses. Steel building components such as stairs, balcony railings, and roof trusses are installed after the prefabricated structures are completed [11].

The study of the experience of American builders in the field of the correctional system makes it possible to assert that in prefabricated reinforced concrete buildings, the details of the connection between the elements are very important details that ensure the overall structural stability of the structure. An insufficient number or quality of connections can significantly reduce the strength and durability of structures. Such key connections for the elements of penitentiary buildings are the connection between the detention modules (living quarters), the connection of the balcony slabs and the living modules, the connection of the upper floor cell modules and the attic modules, and between the lower floor cell modules and the foundation. Most connections are compressed and made by conventional means, but some specific connections require detailed design and protective measures [12, 13].

Therefore, it can be argued that prefabricated monolithic-concrete building systems have achieved sufficient popularity in the design and construction of penitentiary institutions in many countries of the world due to their safety, strength of structures, and materials, relatively short construction period, and the possibility of long-term operation. It is also important that with some modification, this manufacturing and construction technology can be used for the rapid construction of cheap residential units in various fields of their application, from hotels and holiday homes to hospitals and boarding schools for the disabled and the elderly. For our country, this technology is still new, modular structures are not used in sufficient volume for the construction of administrative, office, and logistics facilities, mainly for financial reasons, as well as because of the problems of organizing production, personnel training, and transportation. In the penitentiary system, the advantages of using a prefabricated monolithic building system for the construction and operation of correctional complexes may be the aspect that, if necessary, individual blocks of buildings can be replaced, as well as use the finished blocks for other purposes after the closure or relocation of the institution (Figure 1**)**. Although the system of prefabricated modular buildings cannot be called very cheap, in our time, when the pace of life is accelerating and circumstances are changing, this ability to transform and adapt to various functions may be appropriate and effective not only for buildings of correctional institutions but also for others that for functional and social reasons, they are relatively isolated from society and urban development, namely: military camps, hospitals, and other similar types.

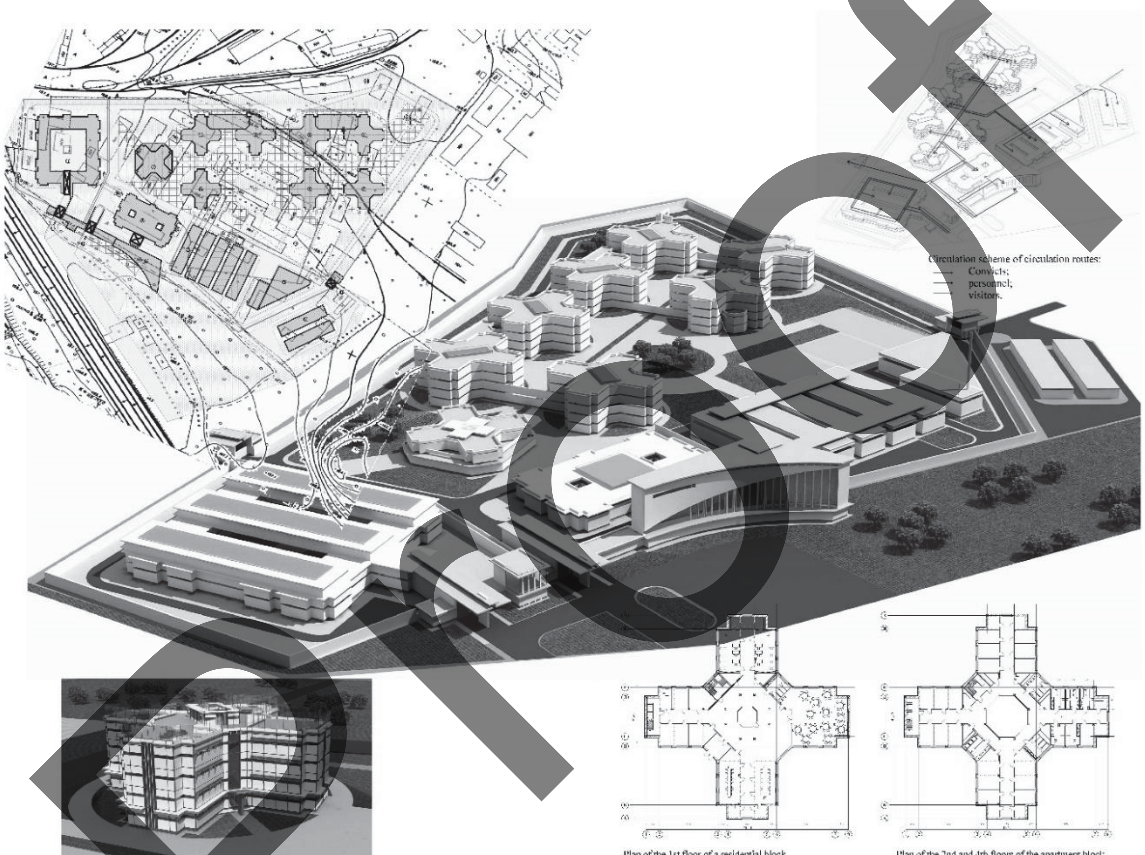

FIGURE 1. Conceptual design of a modular penitentiary complex for 1000 places, arch. Yuliia Tretiak, Maxim Tretiak, 2015

The last in chronology and the most modern of the above, but less proven experience, is the additive building system, according to the digital design and technologies of which, buildings and their parts are "printed" on a 3D printer. Acquaintance with some research in this area reveals that the structure of the walls in the plan of such a building resembles a multi-layer spatial truss, consisting of an inner load-bearing and outer layers, which are printed on a printer. An inner layer in the form of hollow triangles is built in between them, acting as stiffeners, and the cavities are filled with reinforcement, insulation, or used for laying communications. This design, together with the use of composite high-strength materials, provides some advantages for the possible implementation of this technology in the construction of modern penitentiary complexes. The technology of "printing" buildings and their parts on a 3D printer is certainly at the research and testing stage but promises to be a replacement for many traditional building systems due to its environmental friendliness, low cost in the future, short construction time, flexibility and adaptability, which are important qualities for the progressive development of the construction and operation of penitentiary institutions [14].

CONCLUSION

Within the framework of the concept of perspective development of architectural and construction and related industries, based on the interpenetration and synthesis of innovative knowledge and technologies to improve the design and construction practices of various types of institutions, there is a long-awaited opportunity to create a fundamentally new spatial scheme of buildings and complexes that were traditionally considered closed to society such as penitentiary institutions. The world is already showing the first signs of revolutionary changes in the penal system aimed at humanizing the environment for keeping prisoners, ensuring their education, labor, social adaptation, and relevance after release, but without losing the severity and fairness of punishment. The traditional fine-mesh closed spatial organization and high "perimeter" of correctional buildings do not correspond to the tasks of the new rehabilitation and aesthetic doctrine, which is designed to ensure the "transparency" of the system through the integration and cooperation of the functions of the penitentiary institution and the city, which will undoubtedly affect the improvement of the aesthetic properties of the penitentiary architecture. For this reason, it can be assumed that the involvement of architects and builders in the correctional industry, who will be able to bring into it new ideas regarding the correct choice and implementation of modern building systems described in this work, will open up new opportunities for harmonizing the environment for the detention and re-socialization of arrested and convicted persons.

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Method for Determining the Mineral Composition of Rocks as Components of Asphalt Concrete

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Abstract. The method and results of determining the mineral composition of rocks as components of asphalt concrete are presented by the method developed at the Department of Technology of Road-Building Materials and Chemistry of KhNADU. The features of the adhesion of bitumen to the mineral surface depending on the mineral composition various rocks are shown. The indicators of adhesion of bitumen to the mineral surfaces were determined by photometric method on various rocks. Thus, on the basis of determining the adhesion of bitumen to various mineral surfaces, it is possible to predict the service life of asphalt concrete pavements of highways.

INTRODUCTION

One of the urgent issues in road construction is to determine the guaranteed service life of asphalt pavements. To predict the durability of asphalt pavements, it is necessary to know the intensity of adhesion of bitumen to the surface of mineral materials. In turn, this indicator of adhesion depends on the chemical compounds that are part of the rocks in the form of rock-forming minerals. Previous studies in this direction have shown that the adhesion of bitumen to rocks that contain minerals of the carbonate class is much better compared to the adhesion of the same bitumen to rocks that contain minerals of the silicate class. A significant range of diversity of crystalline rocks of deposits in Ukraine, as components of asphalt mixtures, allows a large number of options for the selection and use of mineral materials, which include various minerals. Therefore, research to determine the rock-forming minerals that are part of the rocks in terms of their impact on the durability of asphalt concrete is becoming more urgent every year. Determination of minerals in rocks allows to determine the intensity of adhesion of bitumen to the surface of these rocks, which in turn can reduce the financial costs for the production of asphalt mixtures and arrangement of road surfaces by increasing their durability and not lose regulatory quality this coating in which these mineral components can be used. Regulatory requirements for asphalt concrete, ie DSTU B V.2.7-119:2011 [1], in these studies in the first place should be the main support platform.

The mineral composition of rocks as components of asphalt mixtures in different territorial regions of Ukraine may be different, as well as chemical compounds that are part of minerals, but the main task of manufacturers of these mixtures is that the mineral composition of rocks provides maximum adhesion to bitumen, and, accordingly, good bitumen coating of stone material and after its arrangement in the asphalt pavement of roads in which they are used, they did not reduce the service life. Based on the generally known information [2-6] that rocks containing minerals of the carbonate class, due to their good adhesion to bitumen, can provide greater durability of asphalt concrete pavements in which they will be used than in asphalt concrete with rocks, which contain silicate class minerals, which affects the durability of asphalt concrete. But in addition to this, it was hypothesized that dark feldspar minerals interact better with bitumen compared to quartz and other light minerals of the silicate class. And these rocks are present throughout the massif of the Ukrainian Crystal Shield, the Carpathians and the Crimea.

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A wide range of rocks by origin causes a significant amount of rock-forming minerals. But in turn, the adhesion of bitumen to minerals depends on the chemical composition, structure of the crystal lattice and many of their physical properties. Depending on these properties the density and structure of asphalt concrete which structure includes the chosen mineral components and further on which durability of a covering of highways depends is formed.

To solve this research problem at the Department of Technology of Road Construction Materials and Chemistry of Kharkiv National Automobile and Road University was created a device and software for measuring the area of bitumen stain remaining on the mineral surface after the regulatory test according to DSTU B V.2.7-81-98 [7] due to the stable adhesion to this surface. In addition to this device and software, this method also used the software of the raster graphic editor "GIMP", which allows to determine the quantitative color ratio of the areas of various minerals, which determines the intensity of adhesion of bitumen to the surface of rocks containing these mineral aggregates. This definition is mainly based on counting pixels of the same color that corresponds to a specific mineral. This calculation, using the functionality of the software, by changing the color and contrast parameters, allows you to determine the content of all the minerals that make up a certain rock. Having the ability to determine the percentage of minerals that make up the rock and knowing their chemical composition, it is possible to predict with which minerals the best adhesion of bitumen will be, and in general with the rocks that they are part of. In turn, the prediction of the adhesion indicators of bitumen is the basis for predicting the durability, as the main operational indicator of asphalt concrete, that is, the material that is most used in road construction.

ANALYSIS OF THE CHEMICAL COMPOSITION OF ROCK-FORMING MINERALS AND THEIR INTERACTION WITH BITUMEN

The most common road building material is granite. Its popularity among road builders is based on a sufficiently high strength, and as a result, low abrasion, which guarantees the durability of the asphalt concrete pavement. But the main indicator when choosing the initial mineral components of asphalt concrete mixtures is their adhesion to bitumen, and this indicator depends on the chemical composition of these rocks. In turn, the chemical composition of rocks depends on their mineral composition, and each mineral has its own individual chemical formula, by which it is identified.

For the analysis of the chemical composition of the granite rock were used the literature data [8-19], which indicate the average percentage of the mineral composition, presented in table 1, and the chemical composition of rock-forming minerals, presented in table 2.

TABLE 1. Mineral composition of granite rocks

Name of minerals	Content, %
Quartz	25÷35
Feldspars (orthoclase, microcline, albite, anorthite, augite, labrador, hornblende)	60÷65
Micas (biotite, muscovite)	5÷10

TABLE 2. Chemical composition of rock-forming minerals of granite rocks

Name of minerals	Content of chemical compounds, %							
	SiO_2	Na_2O	K_2O	MgO	CaO	Al_2O_3	Fe_2O_3	FeO
Quartz	100	-	-	-	-	-	-	-
Orthoclase	64,7	-	16,9	-	-	18,4	-	-
Microcline	64,7	-	16,9	-	-	18,4	-	-
Albite	68,4	11,7	-	-	-	19,4	-	-
Anorthite	43,2	-	-	-	20,1	36,7	-	-
Augite	21÷26	-	-	30÷60	-	4÷9	10÷40	-
Labrador	55,5	4,0	0,4	0,2	10,9	26,8	1,6	-
Hornblende	42÷48	1,5	-	11÷14	10÷13	6÷13	3÷9	9,5÷11,5
Biotite	33÷45	-	4,5÷8,5	0,3÷28	-	9,5÷31,5	0,3÷20,5	2,8÷27,5
Muscovite	45,2	-	11,8	-	-	38,8	-	-

The mineral composition of granite rocks (Table 1) varies in a fairly wide range, which makes it possible to choose rocks that have the best adhesion to bitumen without reducing the standard strength indicators. But a more significant indicator is the chemical composition of rock-forming minerals of granite rocks, which is presented in Table 2.

Based on the well-known provisions [2-6] that the adhesion of bitumen to the mineral surface is enhanced as a result of chemisorption processes on the surface of mineral materials containing oxides of alkaline earth and heavy metals and the data in Table 2, it was assumed that on the surface of granite rocks containing dark feldspar minerals (augite, labrador, hornblende) adhere to bitumen better than on the same surface containing light feldspar minerals (orthoclase, microcline, albite, anorthite), and even more so quartz. It was assumed that oxides of alkaline earth metals of the second group (MgO and CaO) would have the greatest positive effect on enhancing adhesion to bitumen. Such chemical compounds are found in dark feldspar minerals such as augite, labrador and hornblende. This assumption was based on the previously obtained results of cohesion of bitumen with alkaline (limestone, marble) and acidic (quartz, granite) mineral surfaces [20, 21].

MATERIALS

To determine the influence of the mineral composition of granite rocks on the adhesion of bitumen to them, plates were prepared from these rocks and marble-like limestone in accordance with regulatory requirements [7]. When choosing test objects, the types of mineral surfaces were preliminarily determined by exposing them to a 5 % aqueous solution of hydrochloric acid. The reaction in the form of boiling of a 5 % aqueous solution of hydrochloric acid on the mineral surface with the formation of foam with a large number of bubbles indicated that these surfaces were of the alkaline type, and the absence of boiling was characteristic of acidic surfaces.

Four samples of mineral surfaces were accepted for testing, one of which is alkaline (marbled limestone), and three are acidic (granite). Before applying a standard bitumen spot, the size of which was 76×25 mm, to the test surfaces, those parts of the area of mineral surfaces that were subsequently hidden under these bitumen spots, which are shown in Figure 1 under the index "a", were preliminarily photographed. After applying the normative bitumen spot on each plate before testing, they were also photographed and these photos are presented in Figure 1 under the index "b". After regulatory testing, the samples were photographed and these photographs are shown in Figure 1 under the index "c".

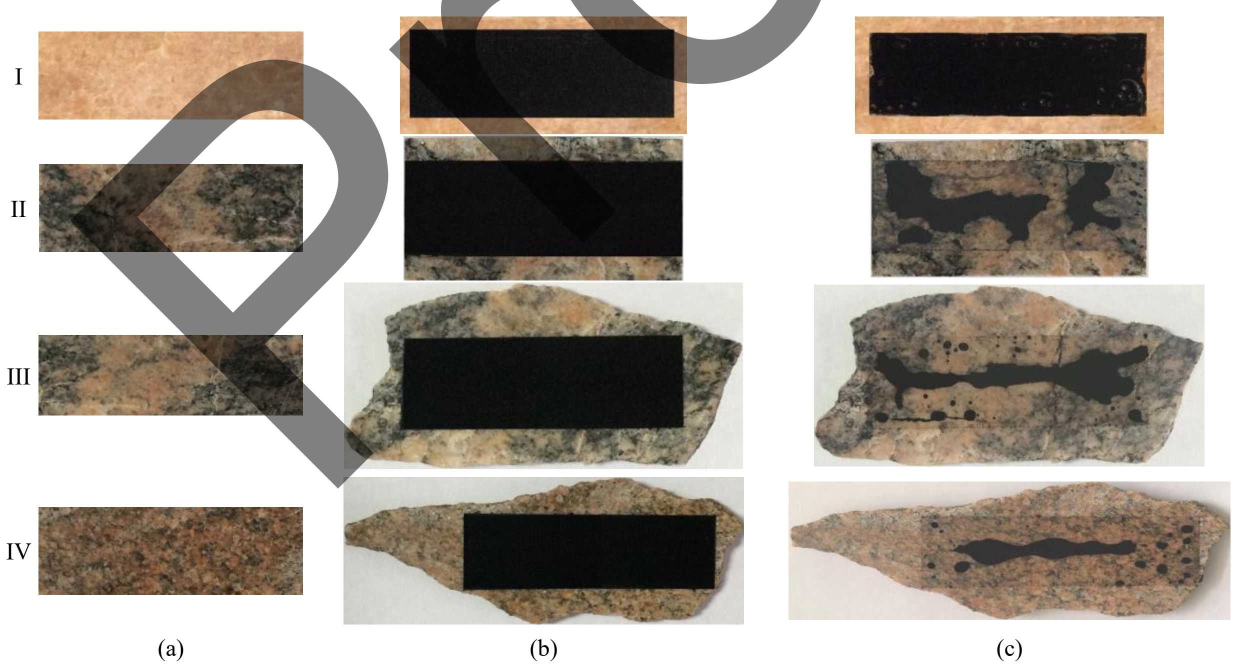

FIGURE 1. Mineral plates before and after testing: I – marbled limestone; II÷IV – granite rocks; (a) – areas of mineral surfaces before applying a bituminous spot; (b) – before the test; (c) – after the test

During the tests, BND 70/100 bitumen was used with a needle penetration depth at a temperature of 25 °C 78 • 0.1 mm and a softening temperature of 50.2 °C, which meets the requirements of DSTU 4044: 2019 [22]. Tests of samples of mineral surfaces with bitumen stains applied to them were carried out in accordance with the regulatory requirements [7] in distilled water.

METHODOLOGY, TEST PROCEDURE AND RESULTS

All images of all test objects were photometrically processed using specialized software. At the first stage, using the software of the raster graphic editor "GIMP", which allows to determine the quantitative color ratio of the areas of various minerals on the mineral surface of the tested samples, the total number of pixels of the area was determined (Figure 1a), which was subsequently covered with a regulatory bitumen spot (Figure 1b). Then, using the same software, the number of pixels in the color range, which was characteristic for each specific mineral, was determined. Based on the results obtained, the percentage of minerals in each granite sample was determined, which is displayed in Table 3.

TABLE 3. Mineral composition of granite samples

Name of minerals	Number of pixels /% ratio in granite samples		
	II	III	IV
Quartz	59244/31,1	66587/35,0	95242/49,8
Light feldspars (orthoclase, microcline, albite, anorthite)	29641/15,5	46041/24,2	73058/38,2
Dark feldspar (augite, labrador, hornblende)	101865/53,4	77622/40,8	22950/12,0
Total area under the bituminous spot	190750/100	190250/100	191250/100

At the second stage, after applying a standard bitumen spot on each sample and carrying out tests in accordance with the requirements of the standard [7], the indicators of adhesion of bitumen to mineral surfaces were determined using specialized software [23, 24]. The tests consisted in keeping in distilled water for 30 minutes at a temperature of 95 °C mineral samples with bitumen stains applied to them [7].

After the end of the normative test, the image files of the samples before and after the test were used to calculate the adhesion index of bitumen to the substrate using specialized software in the following sequence. The object image file before testing was loaded into the calculation program, as shown in Figure 2, and the functions of contrasting and highlighting the reference object were performed.

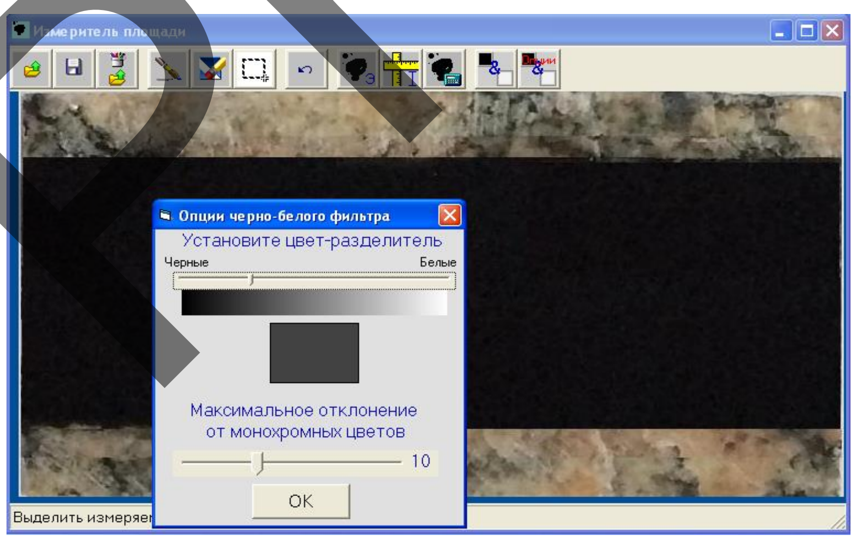

FIGURE 2. Loading a reference object

After selecting the reference bitumen spot, the area occupied by this spot was entered (Figure 3) and the program offered to load the next image of the object after testing.

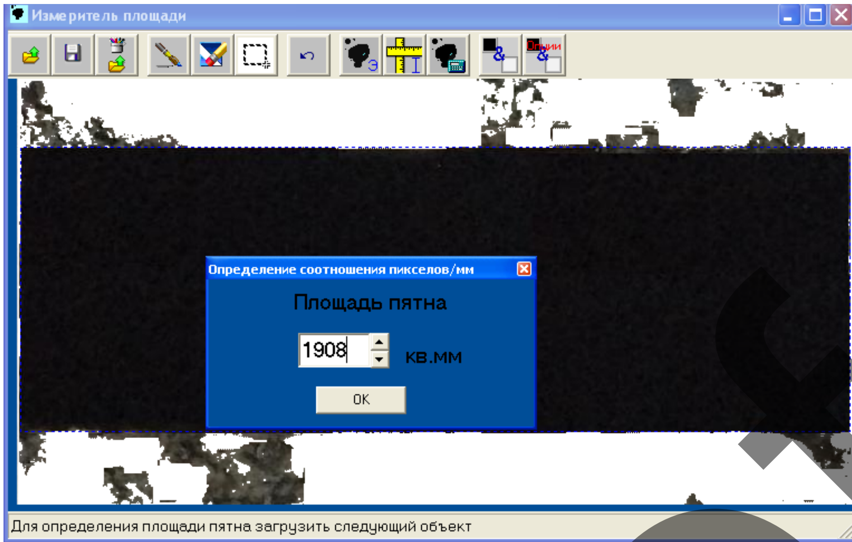

FIGURE 3. Introduction of the area of the reference bitumen spot

The next step in obtaining the adhesion index calculation was to image the same object after testing, as shown in Figure 4.

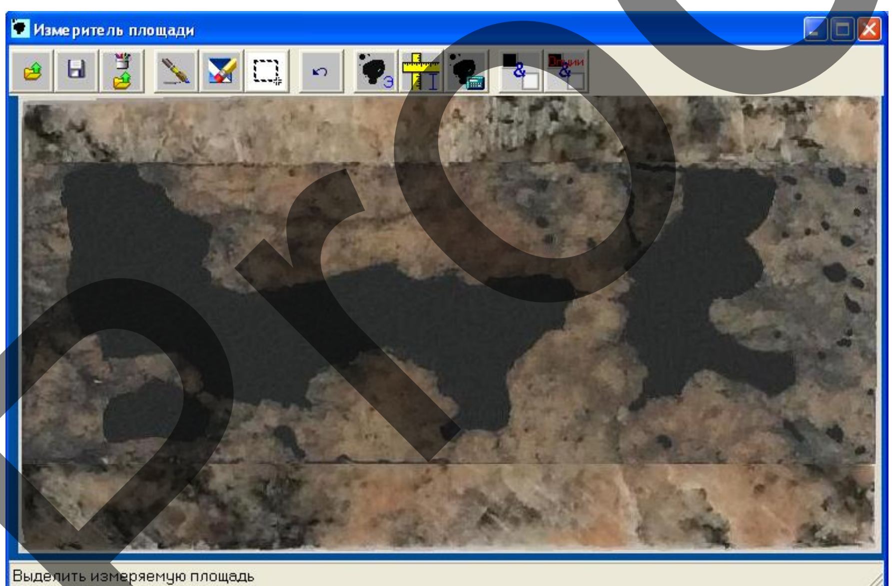

FIGURE 4. Entering an image of an object after testing

To highlight the area of the bituminous spot after the test, the input image was also edited by contrast and monochromatization, which is shown in Figure 5.

Based on the presence of information about the area of the reference object recorded by the program and the edited image of the object after the test, the program calculated the area occupied by bitumen after the test and the standard adhesion index in %, as shown in Figure 6.

The obtained results of calculating the areas and standard indicators of adhesion of bitumen with various mineral surfaces are presented in Table 4.

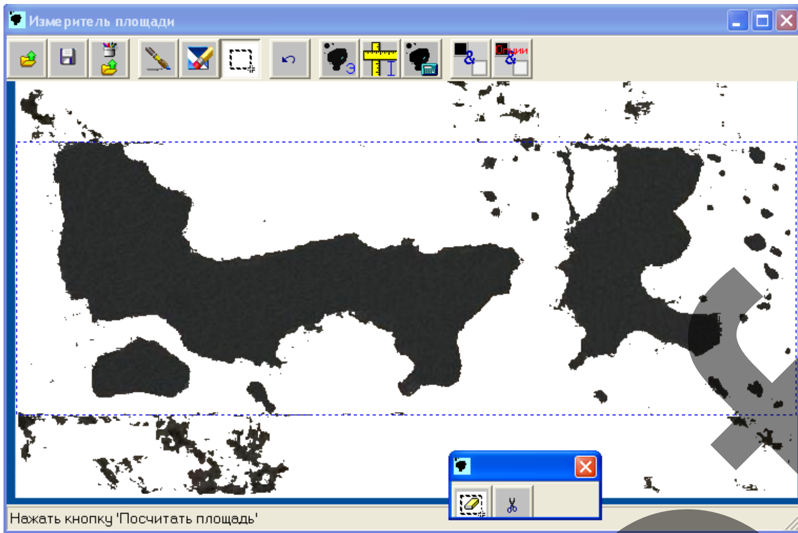

FIGURE 5. The result of contrasting and monochromatization

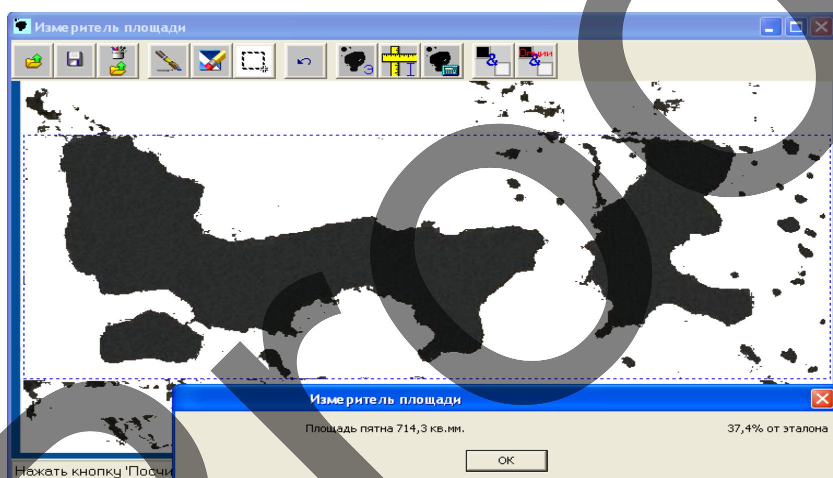

FIGURE 6. The result of calculating the area and adhesion of bitumen

Table 4. Area and coefficient of adhesion of bitumen to mineral surfaces

Sample no.	Surface name	Bitumen area before testing, mm^2	Bitumen area after testing, mm^2	Adhesion index,%
I	Limestone	1900	1693,51	89,1
II	Dark granite	1908	714,30	37,4
III	Dark pink granite	1903	553,20	29,1
IV	Pink granite	1913	357,73	18,7

The obtained test results confirm the generally known concepts [2-6] about the better interaction of alkaline mineral surfaces with bitumen in comparison with acidic mineral surfaces. Even the highest adhesion of bitumen to a granite surface is 2.38 times lower than that of a carbonate surface. But if we consider the trend among indicators only for granite surfaces, then the highest cohesion rate is 37.4 % (table 4) for a granite surface with the highest content of dark feldspars 53.4 % (table 3). And on the granite samples themselves, an increase in the contact area of bitumen with areas where dark feldspars are located is visually noticeable. This is due to an increase in the intensity of adhesion with oxides of alkaline earth metals of the second group. And areas of granite mineral surfaces with a high quartz content have the lowest adhesion rates, both quantitatively and visually.

CONCLUSIONS

Analyzing the test results, it can be considered that all mineral surfaces accepted for testing in general showed sufficiently high values of bitumen adhesion to them, which are more than 18 % and meet the regulatory requirements. But the adhesion index for sample IV "Pink Granite" is the lowest and is in the closest proximity to the regulatory requirements. In general, this gives reason to believe that asphalt concrete using mineral materials of various rocks can provide high indicators of durability. But it is necessary to focus on the fact that surfaces with minerals of the carbonate class, as well as minerals containing oxides of alkaline earth metals, adhere better to bitumen and can provide greater durability of asphalt concrete, in which they can be used, and such asphalt concrete can have the longest service life of road surfaces. This is explained and corresponds to the well-known regularities of the better interaction of alkaline mineral surfaces with bitumen in comparison with acidic ones. The superior surface interaction in alkaline mineral surfaces allows for a better enveloping of the bitumen on the carbonate grains, which in turn allows for nearly the highest durability values. Therefore, when choosing stone materials as components of asphalt concrete mixtures, it is necessary to strive to obtain granite rocks of the darkest possible color.

Based on the results obtained, it can be argued that such a method for determining the mineral compositions of rocks makes it possible to improve the qualitative selection of the mineral components of asphalt concrete mixtures by increasing the intensity of the interaction of bitumen with these rocks and to increase the durability of asphalt concrete pavements of highways.

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Ecological Feasibility of Pyrolysis in Comparison with the Incineration of Municipal Solid Waste

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Abstract. A comparative analysis of the mass of municipal solid waste before processing and the mass of products of their processing after incineration and after pyrolysis is carried out. The amount of gases formed during incineration and pyrolysis of solid household waste is determined. Calculations have shown that the incineration of waste does not decrease, but increases by approximately six times. Pyrolysis of household waste has advantages over their incineration, the main of which is the following: the amount of atmospheric emissions during their processing is much smaller - when burning one ton of waste, 5.65 tons of polluting gases are emitted into the atmosphere, and when pyrolysis - 1.36 tons.

Humanity uses to directly meet their needs only a few percent of the mass and energy contained in the natural resources of various species [1]. Municipal solid waste (MSW) is generated by the consumption of final products of human processing. Their number increases over time exponentially. This problem is especially acute in large cities. In the largest cities of the world the amount of Municipal solid waste reaches 10 m3 per person. According to forecasts, the total amount of household waste in the world by 2025 will reach 2.2 billion tons / year [2].Thus, humanity is drowning in its own garbage. Any settlement is surrounded by one or more landfills. These are sources of danger of many species - environmental pollution (soil, air, water), the habitat of parasitic organisms (insects, birds, mammals, many of which are carriers of dangerous diseases).Different types of resources with a certain value are also concentrated in landfills for an indefinite period of time. These resources are not used by humans, but are excluded from the cycles of circulation of materials, energy and money. The return of resources to the appropriate cycles of circulation is a necessary condition not only for the development of human civilization, but also simply to maintain a certain level of quality of life. The understanding of this is gradually spreading to almost all levels of organization of human society as a self-reproducing hierarchical system. Considerable attention is paid to further waste recycling around the world [3, 4]. Summarizing the ways in which humanity now gets rid of garbage, we can outline four groups of modern ways:

- burial in landfills;
- sorting of garbage with processing of separate components, burial of unprocessed part and composting of organic part;
- sorting of garbage with processing of separate components, burial of unprocessed part and pyrolysis of organic part;
- waste sorting with recycling of individual components, burial of unprocessed part and incineration of organic part.

The first of these methods does not meet modern requirements, because in fact the disposal of garbage does not occur, instead, this garbage pollutes the environment (soil, water, air).

General features of the other methods:

- waste sorting is a problem that, unfortunately, is still not completely solved;
- processing of individual components (paper, metals, polymers), for which it is now economically feasible;

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- disposal of organic matter by composting, incineration or pyrolysis.

The last two methods (incineration and pyrolysis) are thermal disposal of waste. They are the most common in modern conditions. And the most common is the incineration of organic waste.

Within this direction the following advantages are declared:

- reduction of waste mass [5] by 70-80 %;
- additional production of secondary thermal energy resources.

The essence of the method is the exothermic chemical interaction of the main chemical elements of waste with oxygen.

THEORETICAL PART

The amount of heat released during the combustion of a unit mass of material is characterized by the heat of combustion [6].

Higher heat of combustion does not take into account the heat consumption for the evaporation of all moisture - both the own moisture of the fuel and that formed from the elemental hydrogen contained in the fuel:

$$4H+O_2 \rightarrow 2H_2O$$

Here in the chemical equations, the chemical elements that are part of the waste compounds are conventionally written as atoms.

This value is calculated from experimental data adjusted for exothermic acid formation processes:

$$S+O_2 \rightarrow SO_2;$$

$$SO_2+H_2O \rightarrow H_2SO_3;$$

$$Q_s^{daf} = (0.9985Q_б^a - 0,0943S_t^a) * \frac{100}{100 - W^a} * \frac{100}{100 - A^d}.$$

Here $Q^{daf}{}_s$ – higher heat of combustion of combustible mass of fuel, MJ/kg; $Q^a{}_б$ – the heat of combustion of the analytical mass of fuel, determined in the calorimetric bomb, MJ/kg; $S^a{}_t$ – the total sulfur content of the analytical fuel sample, %; W^a – humidity of the analytical sample, %; A^d – ash content of the dry sample, %.

By calculation, the higher heat of combustion can be determined by the formula:

$$Q^{daf}{}_s=0,339C^{daf}+1,257H^{daf}-0,109(O^{daf}-S^{daf}).$$

Here C^{daf}, H^{daf}, O^{daf}, S^{daf} – the content of the corresponding elements in the combustible mass of fuel, %.

As you can see, the higher heat of combustion mainly depends on the elemental composition of the fuel.

In practice, the indicator of lower heat of combustion is more often used. It differs from the higher value by the amount of heat of vaporization of water contained in the source fuel and formed during its combustion. The indicator is usually expressed as the working mass of the fuel, MJ/kg:

$$Q_i^r = 0.9985Qб - 0.0943S_t^a - 0.0251(W_t^r + 9H^{daf} * \frac{100 - A^d}{100} * \frac{100 - W^a}{100}).$$

Here 9 – the ratio of molar masses of water and hydrogen (18/2).

Maximum enthalpy (heat content) of combustion products $I_г$ - lower heat of combustion, attributed to 1 m^3 of complete combustion products obtained by burning fuel in a stoichiometrically required volume of air and containing water vapor:

$$I_г = \frac{Q_i^r}{V_г}\ [kJ/m^3].$$

When calculating the amount of air required for the combustion of solid and liquid fuels, use the following chemical equations:

$$C+O_2 \rightarrow CO_2;$$

$$12 + 32 \qquad 44$$

$$S+O_2 \rightarrow SO_2;$$

$$\begin{array}{cc} 32+32 & 64 \end{array}$$

$$2H_2+O_2 \rightarrow 2H_2O.$$

$$\begin{array}{cc} 2+16 & 18 \end{array}$$

The mass of oxygen in the air, stoichiometrically required for complete combustion of 1 kg of fuel, is calculated by the formula:

$$G^c_{O2}=0{,}01(2{,}67C^r+S^r_n+8H^r-O^r)\ [kg/kg].$$

Here S^r_n – the content of combustible sulfur in the fuel,%, the coefficients before the content of the elements correspond to the stoichiometric ratio of the combustion reactions.
The mass of dry air required for the combustion of 1 kg of fuel is:

$$G_n^c = \frac{100G_{O_2}^c}{23}.$$

Here 23 – mass oxygen content in the air, %.
The volume of air stoichiometrically required for the combustion of 1 kg of fuel will be:

$$V_n^c = \frac{G_n^c}{1{,}293} = \frac{100G_{O_2}^c}{1{,}293 \times 23} = \frac{10}{3} G_{O_2}^c [m^3 kg].$$

The total volume of combustion products formed during the complete combustion of fuel in the stoichiometric volume of air is:

$$V^c_2=V^c_{CO2}+V^c_{SO2}+V^c_{H2O}+V^c_{N2}\ [m^3/kg].$$

Here:

$$V_{CO_2}^c = 0{,}01 \times 3{,}67C^r \frac{22{,}4}{44} = 0{,}0187C^r;$$

$$V_{SO_2}^c = 0{,}01 \times 2S_n^r \frac{22{,}4}{64} = 0{,}007S_n^r;$$

$$V_{H_2O}^c = 0{,}01(9H^r + W^r) \times \frac{22{,}4}{18} = 0.0124(9H^r + W^r);$$

$$V^{c_{N_2}} = 0{,}79V_n^c + 0{,}01N^r \frac{22{,}4}{28} = 0{,}79V_n^c + 0{,}008N^r.$$

In these formulas, the coefficients for different elements are stoichiometric ratios for the oxides of these elements in the reactions of their formation, 22.4 - the volume of 1 mole of ideal gas at 0°C and 101.3 kPa; numbers in denominators - molecular weights of the corresponding oxides; 0.79 - volume (molar) nitrogen content in the air.
The lower heat of combustion of gaseous fuel is calculated based on the heat of combustion of the components:

$$Q_i=126{,}4CO+107{,}6H_2+358CH_4+590{,}3C_2H_4+636{,}4C_2H_6+912{,}7C_3H_8+$$

$$+1184{,}9C_4H_{10}+1461{,}2C_5H_{12}+234{,}4H_2S\ [kJ/m^3].$$

Here, the chemical formulas denote the volume (molar) content of the corresponding component in the gas, and the coefficients before them - 1% of the heat of combustion of the corresponding component. The amount of oxygen required to burn 1 m^3 of gas is determined by the formula:

$$V^c_{O2}=0{,}01(0{,}5CO+0{,}5H_2+2CH_4+3{,}5C_2H_6+5C_3H_8+6{,}5C_4H_{10}+8C_5H_{12}+3C_2H_4+$$

$$+4{,}5C_3H_6+1{,}5H_2S-O_2).$$

Here, the chemical formulas also correspond to the content of a certain component in the gas, and the coefficients before them - the stoichiometric coefficient for oxygen in the equation of the combustion reaction of this component.
The stoichiometric volume of air required for gas combustion is determined taking into account the air content of 21% oxygen by volume:

$$V_n^c = \frac{100}{21} V_{O_2}^c = 4{,}76 V_{O_2}^c.$$

The total volume of wet products of complete combustion during the combustion of 1 m^3 of gaseous fuel will be:

$$V_г = V_{CO2} + V_{SO2} + V_{H2O} + V_{O2}.$$

Here:

$$V_{CO2} = 0{,}01(CO_2 + CO + CH_4 + 2C_2H_6 + 3C_3H_6 + 4C_4H_{10} + 5C_5H_{12} + 2C_2H_4 + 3C_3H_6);$$

$$V_{H2O} = 0{,}01(H_2 + 2CH_4 + 3C_2H_6 + 4C_3H_8 + 5C_4H_{10} + 2C_2H_4 + 3C_3H_6 + H_2S + 0{,}125x + 1{,}6\alpha V^c{}_n;$$

$$V_{N2} = 3{,}76\alpha V^c{}_n + 0{,}01N_2;$$

$$V_{O2} = (\alpha - 1)V^c{}_{O2}.$$

In these equations, the coefficients before the chemical formulas are the stoichiometric coefficients of formation of the corresponding oxide in the reactions by burning 1 mole of a certain gas component, 0.125 - 10% of the air density; x - moisture content (absolute humidity) of the gas; α is the coefficient of excess practical air flow in comparison with the stoichiometric need; 1.6 - coefficient that takes into account the presence in the air of an average of 1% moisture (0.016 m^3 per 1 m^3 of dry air).

Calculations [5] found that the mass stoichiometric ratio of air / waste is 4,811: 1. The stoichiometric demand for air can be higher and reach 8 t / t. The total number of combustion products will be:

$$(4\ldots8)+1=5\ldots9 \text{ t/t}.$$

As a practical example, consider the possible ways of processing waste composition, given in table 1.

Table 1. The composition of the working mass of waste, %

C^r	H^r	$S^r{}_t$	$O^r{}_d$	N^r	A^r	$W^r{}_t$	V^r
31,4	2,4	2,7	1,6	1,6	54,3	6,0	14,1

THE RESULTS OF CALCULATIONS

The theoretical air flow rate for waste incineration is 3.47 m^3 / kg (here in after the volumes of gases are given at 0 ^{o}C and 101.3 kPa). Practical consumption by the ratio of excess air α=1,15 – 3,99 м^3/кg. This produces 4.27 m^3 / kg of combustion products of the following composition (% vol.): N_2 – 75,4; CO_2 – 13,7; H_2O – 8,0; O_2 – 2,5; SO_2 – 0,4.

The density of combustion products with this composition is 1,323 kg / m^3. That is, the mass of the formed combustion products is 5.65 kg / kg.

Thus, in fact, during waste incineration, their number does not decrease, but increases. One ton of waste is converted into 0.25 tons of slag and 5.65 tons of gases. The total mass of combustion products is (for this case) 0.25 + 5.65 = 5.9 tons. That is, the mass of waste during incineration does not decrease, but increases by approximately six times.

Nitrogen oxides are formed during combustion and are very toxic. At high temperatures in the furnace part of the nitrogen air has time to react with oxygen to form nitrogen oxides:

$$N_2 + O_2 \rightarrow 2NO;$$

$$N_2 + 2O_2 \rightarrow 2NO_2;$$

$$2NO + O_2 \leftrightarrow 2NO_2.$$

The equilibrium of the latter reaction depends on a number of factors that characterize the combustion process, so the total equation of formation of nitrogen oxides is conventionally written as the equation of formation of compounds of variable composition:

$$N_2 + xO_2 \rightarrow 2NO_x.$$

Nitrogen oxides, like sulfur oxides, interact in an atmosphere with water vapor to form nitric acid:

$$NO + NO_2 + H_2O \rightarrow 2HNO_2.$$

It also causes acid rain.

Pyrolysis - the process of transformation of chemical (primarily organic) compounds under the action of high temperature.

Unlike combustion, pyrolysis is carried out without access of air. The results of a study of similar processes that occur during the pyrolysis of other types of waste (from coal enrichment) [6-9] showed that oxygen waste is spent on the formation of pyrogenetic water (50%), carbon dioxide (10%) and carbon monoxide:

$$O + 2H \rightarrow H_2O;$$

$$C + 2O \rightarrow CO_2;$$

$$C + O \rightarrow CO.$$

Nitrogen is converted to ammonia:

$$N + 3H \rightarrow NH_3.$$

The remaining nitrogen is released in free form:

$$N + N \rightarrow N_2.$$

Hydrogen is consumed, in addition to the formation of water, methane (30%), unsaturated hydrocarbons - ethylene and its homologues (4%), ammonia, and the rest is released in free form:

$$C + 4H \rightarrow CH_4;$$

$$nC + 2nH \rightarrow C_nH_{2n};$$

$$H + H \rightarrow H_2.$$

The rest of the carbon remains in the solid phase. The resulting high-carbon solid residue can be used as a household smokeless fuel for fireplaces, stoves, grills, etc., or as an adsorbent after opening the pores by activation by interaction with gaseous reagents:

$$C + O_2 \rightarrow CO_2;$$

$$C + CO_2 \rightarrow 2CO;$$

$$2C + O_2 \rightarrow 2CO;$$

$$C + H_2O \rightarrow CO + H_2.$$

Gaseous pyrolysis products have a heat of combustion at the level of 1216 MJ/m^3, which determines their certain consumer value as an alternative energy fuel.

Pyrolysis of waste with the composition, given in table 1, forms 23.8 m^3/100 kg of gas of the following composition (vol.%): H_2 – 65,5; CH_4 – 16,9; H_2O – 4,7; CO – 4,1; N_2 – 4,0; C_mH_n – 2,3; NH_3- 2,0; CO_2 – 0,5. The density of this gas is 0.373 kg/m^3. That is, the mass yield of gas is about 8.8 kg / 100 kg of waste, which, taking into account the moisture content of waste 6.0% is quite consistent with the output of the working mass of waste volatile substances (14.1%) - the relative error is 4.7% .

The lower heat of combustion of the obtained gas is 14.8 MJ / m3 (more than 3500 kcal/m^3). More than 65% of the volume of gas produced is hydrogen, the combustion of which does not produce greenhouse gases, ie it is the most environmentally friendly type of fuel. The total amount of combustion products formed is 4.81 m^3/m^3 of gas, their composition (% vol.): N_2 – 68,4; H_2O – 23,5; CO_2 – 5,4; O_2 – 2,4. The density of combustion products is 1,187 kg/m3. Thus, the total yield of pyrolysis gas combustion products is 1.36 kg/kg of waste.

CONCLUSIONS

A comparative analysis of the mass of municipal solid waste before processing and the mass of products of their processing after incineration and after pyrolysis is carried out.

The amount of gases formed during incineration and pyrolysis of solid household waste is determined.

Calculations have shown that the incineration of waste does not decrease but increases by approximately six times.

Pyrolysis of household waste has advantages over their incineration, the main of which is the following: the amount of atmospheric emissions during their processing is much smaller - when burning one ton of waste, 5.65 tons of polluting gases are emitted into the atmosphere, and when pyrolysis - 1.36 tons.

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Composition Design and Properties Forecasting Architectural Reactive Powder Concrete with Blast Furnace Granulated Slag

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Abstract. The article is devoted to the study of the possibility of obtaining reactive powder concrete for the construction of difficult configuration and increased architectural expressiveness structures by completely replacing silica fume and other active mineral admixture with blast-furnace granular slag. On the basis of experimental data showing the influence of technological factors on the waterdemand of the concrete mixture and the strength characteristics of the concrete under study at different ages, mathematical models of the main parameters were obtained. Using a set of models, a method is proposed for determining the composition of such concrete, which makes it possible to predict the properties of the concrete mixture and the strength of the reactive powder concrete at different ages. A numerical example of the design of the reactive powder concrete composition by the proposed method is given.

INTRODUCTION

Reactive Powder Concrete (RPC) [1] is a new generation of concrete, the use of which is quite interesting in the construction of responsible structures, as well as structural elements with increased architectural expressiveness [2, 3]. Distinctive features of RPC are high physical and mechanical properties, including the increased ratio of tensile strength and flexural strength, which indicates high crack resistance [4-14]. The concrete mix for RPC is characterized by the increased fluidity that allows receiving products of the most difficult configuration at the most dense reinforcement [15, 16]. Studies show that RPC allows expanding the possibilities of using concrete in the manufacture of new thin-walled structures, the production of which was previously impossible [17]. RPC is also used for thermal protection of building structures, as it provides better fire and heat resistance than ordinary high-strength concrete [18]. Despite the fact that the production costs of RPC are generally higher than for conventional concrete, there are still some economic advantages to using RPC. Due to the use of dispersed reinforcement with short steel fibers, complete or partial removal of reinforcing bars is possible [19]. At the same time achievement of ultrahigh mechanical characteristics of RPC allows to reduce section of concrete elements that leads to economy of materials and expenses for production of a design as a whole [11].

The complex of properties of RPC along with the low water-cement ratio is influenced by the high consumption of binder, which includes in addition to Portland cement a significant (up to 80% by weight of cement) number of active mineral components, the leading place among which is usually silica fume [20]. Despite many advantages over conventional and high-strength concrete, RPC has not been used in Ukraine even during the construction of critical structures. This is facilitated by insufficient study of the technological parameters of its production, as well as the shortage of silica fume, which is one of the main raw materials, which provides the properties of RPC. Silica

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fume as a stable technical product, is produced in limited quantities, its transportation, storage and dosing are associated with a certain complexity due to low bulk density and ultra-high dispersion [21]. In this regard, RPC with the use of such common dispersed technical products as ground granular slag, fly ash and other mineral components characterized by pozzolanic activity are of practical interest. The work of many researchers is devoted to the issue of silica fume replacement in RPC. Practically in all such works it is offered to replace with various active mineral additives from 25 to 75% of silica fume, thus keeping 75 ... 50% of initial durability RPC [22-27]. In addition, as our studies [3] show, RPC with a strength at normal hardening of 100...130 MPa can be obtained by complete replacement of silica fume with dispersed additives of lower activity, such as metakaolin, fly ash or blast furnace granulated slag.

AIM AND SCOPE OF THE RESEARCH

The aim of the research was to obtain experimental and statistical dependences to predict the main technological and mechanical properties of RPC on granular blast furnace slag and to develop a methodology for designing the composition of such concrete depending on a set of properties including water consumption of concrete mix and strength at different ages.

MATERIALS AND METHODS

Portland cement CEM I 42.5 “Volyn-Cement Dickerhoff-Ukraine” (Zdolbuniv, Ukraine) and blast furnace granulated slag (specific surface area of 2700 cm^2/g) (Kryvyi Rih, Ukraine) were used as the main starting materials for experimental research. As a aggregate in the manufacture of RPC was used quartz sand fraction of 0.16 ... 1.25 mm. To maximize water consumption and increase the strength of the RPC, the additive of polyacrylate superplasticizer type Dynamon SP-3 (Mapei, Italy) was used, the content of which varied in the range of 1 ... 2% by weight of binder. Fluidity of concrete mixture was monitored by measuring the flow with a Sutard viscometer (25… 30 cm).

The main studies were performed using mathematical planning of the experiment [28-30]. To do this, a three-level three-factor plan was implemented (Table 1).

Cube specimens of 10×10×10 cm and beams of 4×4×16 cm were made of concrete mix. Compressive (f_{cm}, MPa**)** and flexural ($f_{c.tf}$, MPa) strength at the age of 1, 7, 28 days of hardening under normal conditions was determined (Table 2). After processing and statistical analysis of experimental data, mathematical models of water-cement ratio (W/C) of the concrete mixture (provided the necessary fluidity) and compressive and flexural strength at different ages in the form of polynomial regression equations [28].

TABLE 1. Experimental planning conditions

#	Factors		Variation levels			interval
	Coded	**Natural**	**-1**	**0**	**+1**	
1	X_1	Cement consumption (C), kg/m^3	720	840	960	120
2	X_2	Mineral admixture (BGS) to cement ratio (ma/C) by weight	0.2	0.3	0.4	0.1
3	X_3	Consumption of superplasticizer (SP), %	1	1.5	2	0.5

Mathematical models of RPC properties:

Waterdemand, l/m^3 $W=246,3+23,3X_1+10,4X_2-10,5X_3+0,6X_1^2+2,1X_2^2-8,4X_3^2+1,5X_1X_2-2X_1X_3-0,8X_2X_3$ (1)

Water – cement ratio $W/C=0,29-0,016X_1+0,013X_2-0,011X_3+0,006X_1^2+0,001X_2^2-0,009X_3^2$ (2)

Flexural strength at 1 days, MPa

$$f_{c.tf}^1=7,21+0,56X_1-0,2X_2+0,48X_3+0,095X_1^2-0,375X_2^2-0,105X_3^2-0,15X_1X_3-0,2X_2X_3 \quad (3)$$

Compressive strength at 1 days, MPa

$$f_{cm}^1=27,16+4,2X_1-3,4X_2+2,1X_3+0,181X_1^2-5,02X_2^2-0,82X_3^2+0,05X_1X_2-0,1X_1X_3-0,03X_2X_3 \quad (4)$$

Flexural strength at 7 days, MPa

$$f_{c.tf}^7=12,33+0,42X_1+0,45X_2+0,51X_3+0,3X_1^2-0,91X_2^2-0,3X_3^2+0,02X_1X_2-0,2X_1X_3+0,1X_2X_3 \quad (5)$$

Compressive strength at 7 days, MPa

$$f_{cm}^{7}=75,37+5,7X_1-4,1X_2+3,1X_3+0,84X_1^2-4,96X_2^2-0,96X_3^2-+0,35X_1X_3+0,95X_2X_3 \quad (6)$$

Flexural strength at 28 days, MPa

$$f_{c.tf}^{28}=23,0+0,651X_1+0,35X_2+0,2X_3+0,457X_1^2-0,698X_2^2+0,123X_3^2+0,3X_2X_3 \quad (7)$$

Compressive strength at 28 days, MPa

$$f_{cm}^{28}=109,5+6,9X_1-5,2X_2+3,25X_3-3,5X_1^2-6,6X_2^2-2,25X_3^2-0,1X_1X_2+0,25X_1X_3+0,3X_2X_3 \quad (8)$$

TABLE 2. Experiment planning matrix and concrete composition

#	Planning matrix			Concrete composition, kg/m^3			
	X_1	**X_2**	**X_3**	**C**	**Blast furnace granulated slag**	**Sand**	**Superplasticizer**
1	1	1	1	960	384	926	26,9
2	1	1	-1	960	384	898	26,9
3	1	-1	1	960	192	1138	23,0
4	1	-1	-1	960	192	1118	23,0
5	-1	1	1	720	288	1303	20,2
6	-1	1	-1	720	288	1289	20,2
7	-1	-1	1	720	144	1469	17,3
8	-1	-1	-1	720	144	1447	17,3
9	1	0	0	960	288	1013	25,0
10	-1	0	0	720	216	1375	18,7
11	0	1	0	840	336	1100	23,5
12	0	-1	0	840	168	1285	20,2
13	0	0	1	840	252	1210	21,8
14	0	0	-1	840	252	1193	21,8
15	0	0	0	840	252	1193	21,8
16	0	0	0	840	252	1193	21,8
17	0	0	0	840	252	1193	21,8

TABLE 3. Experimental results

#[a]	Concrete mixes waterdemand			Strength (days), MPa					
	W, *l*/m^3	**W/B[b]**	**W/C**	**$f_{c.tf}^{1}$**	**f_{cm}^{1}**	**$f_{c.tf}^{7}$**	**f_{cm}^{7}**	**$f_{c.tf}^{28}$**	**f_{cm}^{28}**
1	250	0,19	0,26	7,3	24,3	12,7	76,3	24,1	102,5
2	278	0,21	0,29	7,0	20,4	11,9	67,5	23,1	94,9
3	230	0,20	0,24	8,1	31,1	11,5	82,6	22,8	112,5
4	250	0,22	0,26	7,1	27,0	11,1	77,6	23,0	106,1
5	209	0,21	0,29	6,5	16,0	12,2	64,2	22,8	88,4
6	223	0,22	0,31	5,6	11,7	10,6	56,8	21,8	81,8
7	187	0,22	0,26	7,3	23,0	11,2	70,5	21,5	98,0
8	209	0,24	0,29	5,6	18,5	9,9	66,9	21,7	92,6
9	259	0,21	0,27	7,8	31,5	13,0	81,8	24,1	112,7
10	209	0,22	0,29	6,7	23,1	12,1	70,4	22,8	98,9
11	244	0,21	0,29	6,6	18,7	11,8	66,2	22,6	97,5
12	227	0,23	0,27	7,0	25,5	10,9	74,4	21,9	107,9
13	218	0,20	0,26	7,6	28,4	12,5	77,4	23,1	110,3
14	235	0,22	0,28	6,6	24,2	11,5	71,2	22,6	103,8
15	235	0,22	0,28	7,2	27,1	12,30	75,2	22,9	109,2
16	235	0,22	0,28	7,1	27,1	12,2	75,1	23,0	109,1
17	235	0,22	0,28	7,2	27,1	12,2	75,2	22,9	109,2

[a] - concrete composition is given in Table 2;
[b] - W/B – water-binder ratio

RESULTS AND DISCUSSION

Studies have shown that increasing the consumption of cement and the consumption of plasticizing admixture leads to a decrease in the water-cement ratio of RPC made using blast furnace granulated slag. With an increase in the content of these substances in the composition of the RPC, the decrease in W/C averages 10… 12%. An increase in the content of active mineral admixture leads to some increase in W/C and, which is associated with a decrease in the total amount of cement in the binder.

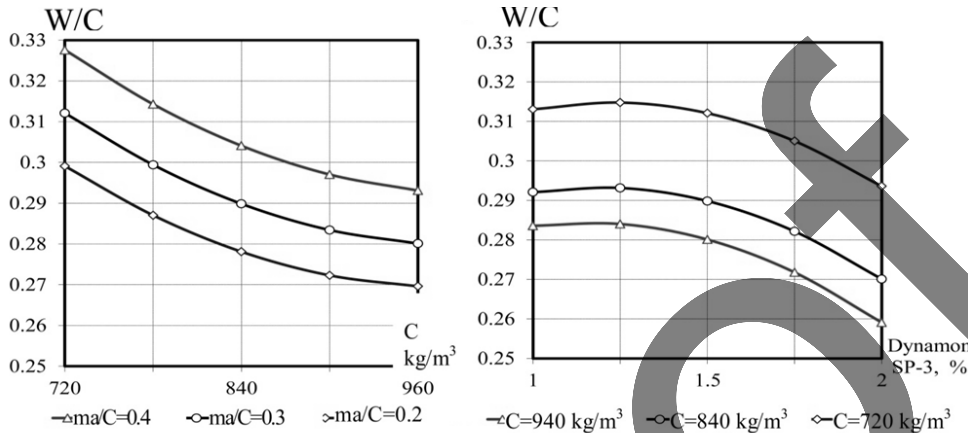

FIGURE 1. Effect of technological factors on RPC water-cement ratio

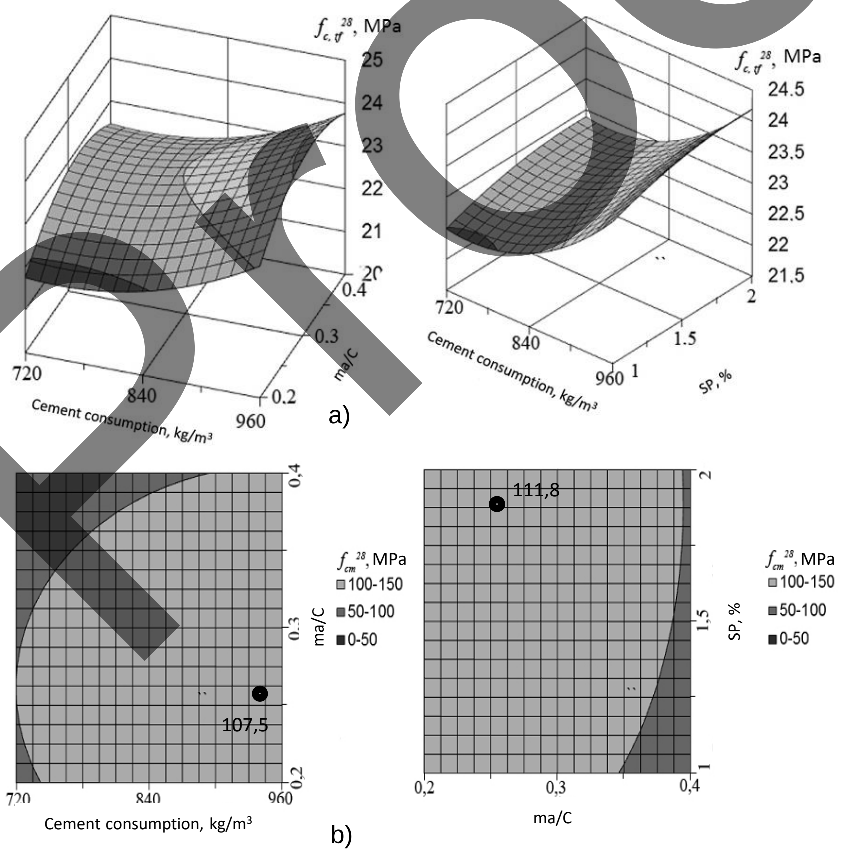

FIGURE 2. Effect of technological factors on RPC flexural (a) and compressive (b) strength at 28 days. Other factors in the diagrams are fixed at the average level (Table 1)

The nature of the influence of varied factors on the strength characteristics of RPC, as follows from the analysis of a complex of experimental and statistical models and graphical dependences based on them, does not change significantly with increasing duration of concrete curing. A significant increase in the compressive and tensile strength of concrete in bending causes an increase in cement consumption and the addition of superplasticizer Dynamon SP-3, which is mainly due to a sharp decrease in water-cement ratio and a corresponding increase in the density of cement stone [31]. An increase in the amount of active mineral admixture in the range from 20 to 30% by weight of the binder leads to a certain increase in strength both in compression and bending. A further increase in the amount of slag leads to a sharp decrease in strength, which is caused by a decrease in the amount of active clinker component in the total weight of the binder and an increase in water consumption.

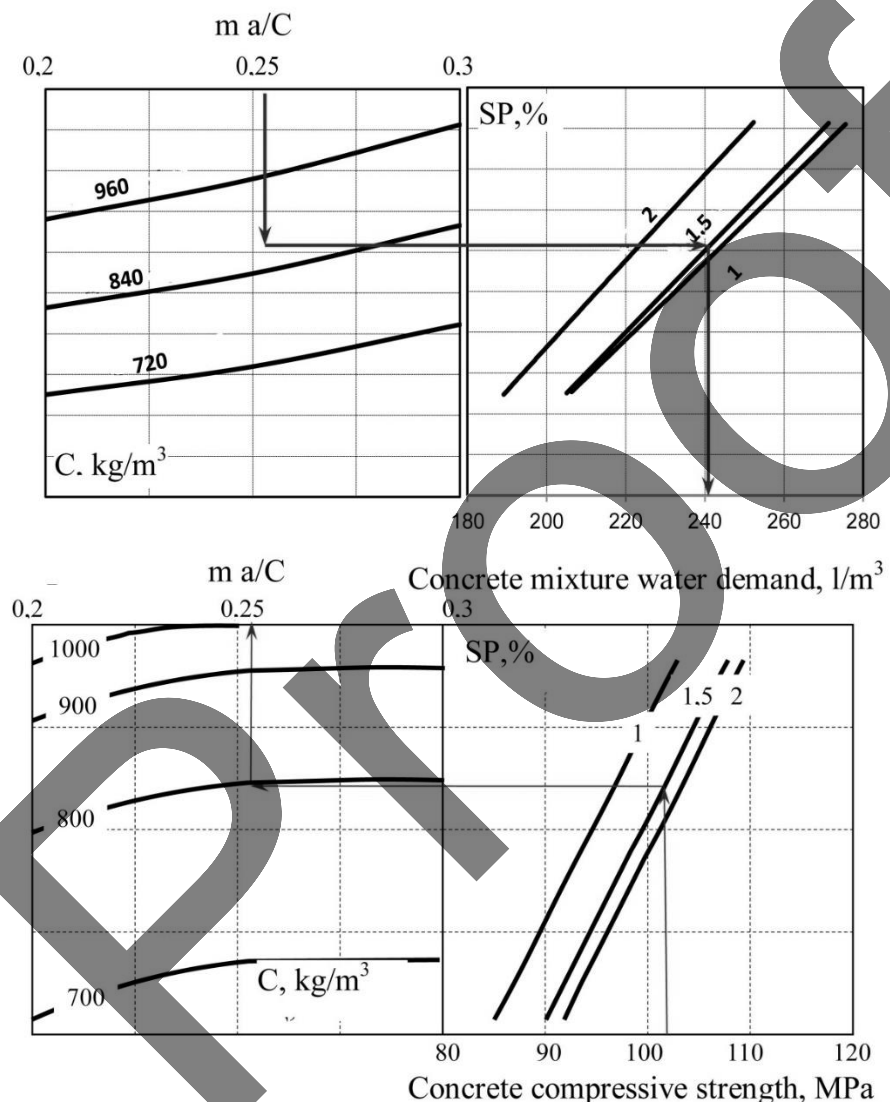

FIGURE 3. Nomograms of waterdemand and 28-day compressive strength of RPC produced using blast furnace slag

The maximum compressive strength (112.5 MPa) and flexural (24.1 MPa) of RPC on blast furnace slag is achieved at the following values of the studied factors: cement consumption at the maximum level - 960 kg/m^3, the ratio between slag and cement consumption at the average level - 0.3; consumption of superplasticizer Mapei Dynamon SP-3 at the maximum level - 2% by weight of binder. As a result of analysis of the complex of obtained experimental data, it was found that blast furnace slag ground to a specific surface area of 2700 cm^2/g is an effective active mineral additive, which makes it possible to obtain reaction-powder concrete with compressive strength up to 105…110 MPa.

On the basis of the received experimental and statistical models the nomograms of water demand and strength of the reaction-powder concrete made with use of blast furnace slag as active mineral admixture are constructed. These nomograms in combination with a complex of obtained models can be used to design the compositions of such concretes with a given strength and fluidity.

The calculation method is as follows:

1. Using the nomogram determine the cost of superplasticizer Dynamon SP-3, cement, as well as the content of active mineral admixture, which will provide a given strength of the RPC at a given age.
2. Using the nomogram of waterdemand and at predetermined consumption of superplasticizer, cement and active mineral admixture, set the consumption of water, which will provide a concrete mixture with a fluidity of 25 ... 30 cm (on the Sutard viscometer).
3. Knowing the volume of cement paste, we determine the consumption of aggregate.

The cement paste volume, l/m^3 is

$$V_{c.p} = \frac{C}{\rho_c} + \frac{m.a}{\rho_{m.a}} + W \tag{9}$$

The volume of sand, l/m^3 is

$$V_S = 1000 - V_{c.p.} \tag{10}$$

The sand weight S, kg/m^3 is

$$S = \rho_s V_s \tag{11}$$

In the above equations ρ_c, $\rho_{m.a}$, ρ_s are the real densities of cement ($\rho_c \approx 3.1$ kg/l), mineral admixture and sand, respectively.

Calculation example

Calculate the composition of RPC, produced using blast furnace slag as active mineral admixture. The target compressive strength at 28-days is 102 MPa, the required concrete mix fluidity by Suttard viscometer is 25 - 30 cm. As plasticizing admixture is used Dynamon SP-3 superplasticizer. The real densities are as follows:

- cement ρ_c = 3.1 g/cm^3,
- slag $\rho_{m.a}$ = 2.8 g/cm^3,
- sand ρ_s = 2.65 g/cm^3.

1. Following the nomogram for compressive strength shown in Figure 3, to achieve the specified compressive strength of 102 MPa, the minimum possible cement consumption is 780 kg/m^3, admixture content - 27.5% by cement weight, content of Dynamon SP -3 superplasticizer - 2% by binder weight.
2. Using the nomogram for water demand shown in Figure 3, for the calculated concrete composition of minimum possible water demand providing the required concrete mix fluidity of 25 - 30 cm by Suttard viscometer is 208 l/m^3.
3. The aggregates consumption is calculated for the known cement paste volume ($V_{c.p}$) in the concrete mixture.
4. The cement paste volume, l/m^3 is

$$V_{c.p} = \frac{C}{\rho_c} + \frac{m.a}{\rho_{m.a}} + W = \frac{780}{3.1} + \frac{215}{2.8} + 208 = 536.4 \text{ l/m}^3$$

The volume of sand, l/m^3 is

$$V_s = 1000 - V_{c.p} = 1000 - 536.4 = 463.6$$

The sand weight S, kg/m^3 is

$$S = \rho_s V_s = 2.65 \cdot 463.6 = 1228 \text{ kg/m}^3$$

The concrete mix composition is: cement - 780 kg/m^3, blast furnace slag - 215 kg/m^3, water - 208 l/m^3, sand fraction 0.16… 1.25 - 1228 kg/m^3. The content of Dynamon SP-3 superplasticizer is 2% by binder weight.

CONCLUSIONS

Studies have shown the possibility of manufacturing reaction-powder concrete, in which blast-furnace granulated slag is used as an active mineral additive, the cost of which is significantly lower than silica fume or metakaolin, which is usually used for concretes of this type. The obtained RPC is characterized by high fluidity and strength after curing under normal conditions from 80 to 110 MPa. According to the research results, a set of mathematical models was obtained, on the basis of which a methodology for designing concrete compositions was proposed, which allows to predict the strength of such concrete at different ages.

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Study of the Efficiency of the Adhesive Layer for Production from Thermomodified Wood

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Abstract. An analysis of the bonding process of thermally modified wood and found that the manufacture of glued products causes some difficulties in ensuring adhesion. One of the promising areas of use of thermally modified wood is the manufacture of glued products. Therefore, knowledge of the physical and mechanical properties of thermally modified wood, indicators of its quality, adhesion to organic adhesives, allows you to make a choice based on economic indicators, duration and safety. In addition, during the modification of wood, the process of polymerization and redistribution through the volume of the cell and give the cell walls greater density, hardness, increase hydrophobicity (water repellency), thereby reducing their ability to absorb moisture and edema. As a result of experimental studies, it was found that the nature of the destruction for the whole group of samples, which were based on glue, is the same. The additional effect of temperature or humidity did not show a significant difference in comparison with the control samples. It was found that in samples of untreated ash wood and modified at a temperature of 160, 220 °C, the destruction occurs on the glued layer. The results of the research will allow to solve further problems on the creation of new composites from thermally modified wood and the conditions of their operation at various sites.

INTRODUCTION

As a product of biological origin, wood has a number of properties that limit the scope of its practical use. These are anisotropy, vulnerability to temperature changes, fungal infections and insects, the ability to water and moisture absorption, shrinkage and swelling. Therefore, today the most effective method of improving the complex of negative properties of wood is its modification, the essence of which is to give wood the ability to resist moisture, biodamage [1, 2].

One of the promising areas of use of thermally modified wood is the manufacture of glued products. Therefore, knowledge of the physical and mechanical properties of thermally modified wood, its quality indicators, adhesion to organic adhesives, allows you to make a choice taking into account economic indicators, duration and safety, environmental aspects, etc. [3, 4].

Therefore, the development of technological measures for the manufacture of glued products from thermally modified wood, the study of the impact on the bond strength of various adhesive compositions is an unresolved component of ensuring the stability of composite wood products and necessitate research.

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ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

When using thermodified wood, it is assumed that the characteristics of the adhesive connection between the wooden elements is significantly affected by the degree of penetration of the adhesive into the porous network of interconnected cells [5]. In this regard, the study of adhesive penetration and the effective use of adhesives in terms of cost and productivity, especially in relation to the production of wood-based composites. The main attention was paid to methods of estimation, influence on gluing characteristics. But it is not specified how the differences between wood species, the great variety of methods of applying glue and curing processes, as well as many types of chemical composition and compositions of glue.

The influence of heat treatment and holding time on the surface roughness, wettability, shear strength and hardness of the samples were widely studied in [6] and found that the thermal effect negatively affected the shear strength and hardness, without establishing how the wettability of the surface changes it is treated with polar and non-polar liquids.

Despite the increased biological stability and dimensional stability, in some cases it may be necessary to treat the surface of thermally modified wood with coating systems. This study [7] evaluated the characteristics of the material of European spruce and Scots pine, subjected to thermal modification, as well as the process and their impact on the characteristics of commercially available coating systems: solvent-based oil, water-based acrylate paint, alkyd-reinforced, and acrylate water-based paints. However, it is not specified what methods are needed to characterize the change in quality in terms of improved target properties of the coating.

Changes caused by heat treatment that can affect the quality of the surface were measured and compared with control samples, such as water absorption, wettability and acidity [8]. After wood treatment, surface properties and aesthetic changes were evaluated; as well as the performance characteristics of the coatings. UV-cured coatings retain the hydrophobic effect of thermally modified wood, while water-based coatings increase the wettability of the surface. But there are no methods for assessing the wettability of the surface.

The test results showed [9] that heat treatment affects the shear strength and peeling of multilayer wood depending on the adhesive system used for bonding. The shear strength of glued wood bonded with water-based adhesive decreased for samples made of wood subjected to hydrothermolysis, and further decreased for samples made of fully heat-treated wood, but not specified by which technological indicators.

The difference in adhesion properties due to different chemical composition of the fiber surface was evaluated and it was found that it is replaced by the penetration of glue into the bulk fiber of thermally modified wood [10]. These results show more lignin or hydrophobic extractives on the thermally modified fiber surface. As for the adhesion characteristics, these results indicate the formation of a less polar surface of thermally modified fibers. However, the method of surface evaluation after wood treatment is not specified.

To improve the interfacial adhesion between wood veneer and high density polyethylene film, the veneer was thermally modified in the oven and chemically modified vinyltrimethoxysilane was used [11]. The results showed that both modifications reduced the hydrophilicity of the veneer and led to increased shear strength, wood destruction and water resistance. However, the established strength of silane-treated heat-treated wood was much lower than when using thermosetting resin composites at higher temperatures due to the melting of the thermoplastic polymer, excluding its use in certain programs.

In [12-14] it was found that the preliminary heat treatment was carried out in a humid environment using hot water or steam at temperatures up to 180 and 230 °C and led to a significant reduction in water absorption and swelling of wood composites in thickness. due mainly to the removal of hemicelluloses. The mechanical properties have been increased or sometimes decreased, depending on the product and the pre-treatment conditions. Pre-heat treatment also improves the resistance of composites to rot. But the role of adhesive compositions on the properties of wood composites is not disclosed.

It is known that heat treatment improves the stability and durability of different types of wood [15]. However, in the process, some surface properties change, namely, color, gloss, pendulum hardness and surface adhesion, heat-treated and untreated beech wood with a coating. The results showed that the hardness and adhesion decreased with increasing degree of processing of beech covered with single and double layers, but did not indicate the degree of phase transformations of thermally modified wood.

In [16] it was found that wood modification is a set of processes that give the treated material a greater ability to cope with damage caused by the external environment by increasing the duration of treatment. The process is also performed to enhance the physical, mechanical or aesthetic properties of wood and derived products with the advantage that they are not as harmful to users and the environment as natural wood.

Thus, from the literature it is established that the thermal modification of wood can give it the opportunity to resist destruction. All this gives grounds to say that it is advisable to conduct a study to determine the parameters that ensure its strength for bonding. Therefore, research in this direction is an unresolved component of ensuring the stability of building structures, which necessitated research.

THE PURPOSE OF THIS WORK

The purpose of this work is to study the effectiveness of the adhesive layer for the product of thermodified wood and substantiation of strength during chipping.

MATERIALS AND METHODS OF RESEARCH

To establish the efficiency of operation of the facades of furniture products at different temperature and humidity conditions, we used samples of oak veneer, which had previously undergone a heat treatment process. Thermal modification was performed in a convective chamber, for the reliability of the result, the veneer was fixed between the plates of porcelain. In general, the material was kept at a temperature of 250 ºC for 10, 20 and 30 minutes (Fig. 1). Samples of thermodified oak veneer with a tangential cross-sectional surface 0.7 mm thick and 155x150 mm in size were used for the study.


(a) (b) (c)

FIGURE 1. Samples of oak veneer after thermal modification at a temperature of 250 °C for: (a) – 600 s; (b) – 1200 s; (c) – 1800 s

In the production of samples, such bases as furniture board, MDF board and chipboard were used. They were glued in the form of a sandwich, ie between two bases glued thermomodified veneer at a temperature of 250 ºC for 10, 20 and 30 minutes. Two types of glue were used as a binder – PVA "Lux" D3 and PUR "Kleiberit" 507.0 D4.

Tests were also performed to determine the tensile strength for glued samples of thermodified ash wood. Glue of the KLEIBERIT 501.0 brand was used for gluing.

The principle of studying the strength of the adhesive joint is based on the applied force to a single joint under longitudinal compression. During the test, the device with the installed sample was placed on the platform of the rupture machine so that the axis of the punch coincided with the axis of the force.

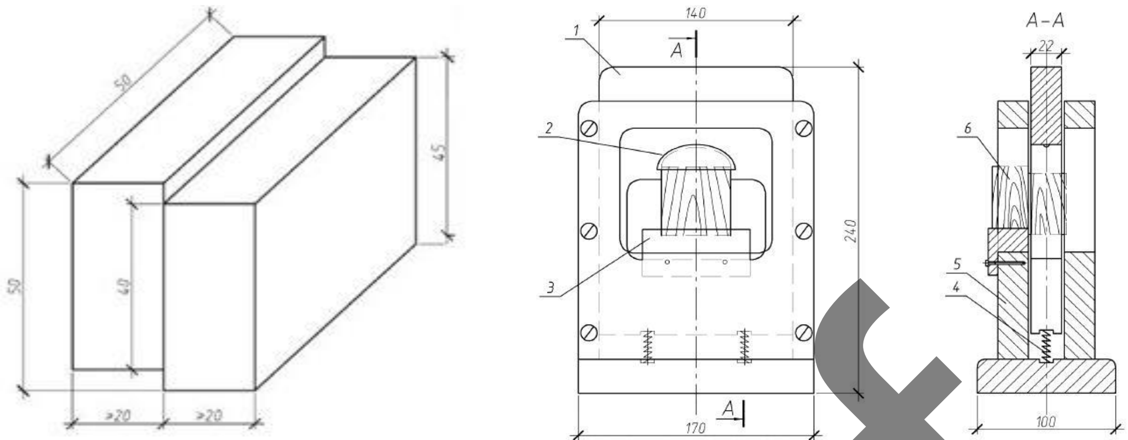
The essence of the research method was to continuously load the sample at a rate of 0.60±0.15 mm/min before failure. The yield strength of the adhesive joint was determined by the formula:

$$\sigma = \frac{P}{F} \tag{1}$$

where is the P – the destructive load, H; F – the area of the adhesive joint, m^2.

Studies of the strength of the adhesive joint were performed on samples (Fig. 2).

Indicators for unmodified material (control samples) were also determined for all types of studies.



(a) (b)

FIGURE 2. Determination of the strength of the adhesive joint for chipping: (a) – shape and dimensions of the sample; (b) – adaptation; 1 – punch; 2 – self-centering support; 3 – tab; 4 – spring; 5 – support rack; 6 – sample

RESULTS AND DISCUSSIONS

The tensile strength of the adhesive joint was determined on the samples described above, with a preliminary holding of 1/3 of the part in a humid environment, a third was exposed to a temperature of 80 °C (Table 1).

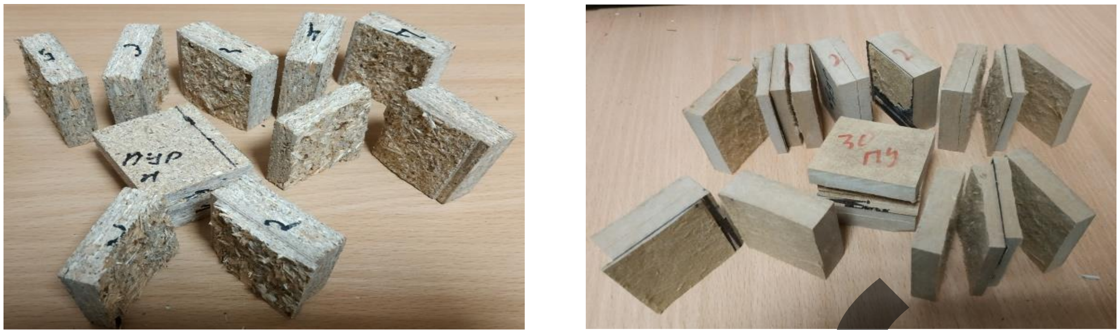
TABLE 1. The results of determining the strength of the adhesive joint*

Sample / glue*	Strength limit, MPa			Sample / glue*	Strength limit, MPa		
	counter	temperature	moisture		counter	temperature	moisture
Shield PU N	3.00	3.94	2.84	Shield PVA N	2.96	2.27	2.61
PU shield 10	3.24	3.20	2.70	PVA shield 10	3.05	3.01	3.55
PU shield 20	3.11	3.09	2.64	PVA shield 20	3.11	3.03	2.75
Shield PU 30	2.47	3.05	2.58	PVA shield 30	2.47	2.91	3.24
MDF PU N	3.67	3.27	2.37	MDF PVA N	3.19	3.50	3.46
MDF PU 10	2.98	2.92	3.00	MDF PVA 10	2.96	2.74	3.18
MDF PU 20	3.52	3.14	2.87	MDF PVA 20	2.26	3.05	3.23
MDF PU 30	3.00	3.37	2.73	MDF PVA 30	2.00	2.49	3.13
DSP PU N	2.77	3.88	4.28	DSP PVA N	2.62	2.38	2.76
Particleboard PU 10	4.00	3.70	4.80	Particleboard PVA 10	2.83	3.34	3.32
Particleboard PU 20	4.57	4.45	4.23	Particleboard PVA 20	2.79	3.63	4.26
Particleboard PU 30	4.20	4.20	3.61	Particleboard PVA 30	2.60	2.60	3.94

*Note. Shield, MDF, chipboard – base; PU, PVA – type of glue; 10, 20, 30 – duration of thermal modification of veneer at a temperature of 250 °C, min; H – unmodified veneer.

Immediately noticeable positive effect of moisture on the strength of the adhesive joint PVA "Luxury" D3, samples with a base of the furniture board, which was glued untreated and modified for 20 minutes veneer. The increase in the tensile strength is insignificant. In some cases it reaches 50%, for example, for samples with MDF and particleboard bases, the veneer is modified within 20 and 30 minutes. This can be explained by the increase in the ductility of the adhesive under such temperature conditions. For the group of samples that were glued PUR "Kleiberit" 507.0 D4 moisture had a negative effect and the results were slightly worse. The exception is a group of samples, the base of which is made of chipboard in addition to the veneer modified for 20 and 30 minutes.

In Fig. 3, 4 show the results of the destruction of the samples.



(a) (b)

FIGURE 3. The destruction of the samples during the study of the strength of the adhesive seam: (a) – the basis of particleboard; (b) – MDF base.

The fracture occurred on the base (Figure 3), namely the detached upper fine-grained layer, visible surfaces of the veneer and adhesive seam were not detected.

In the samples exposed to additional temperature, glued PU "Kleiberit" 507.0 D4, veneer which was modified for 30 min, and PVA "Lux" D3, 20 min, in several samples was noticeable about 10% of the area of destruction of the adhesive joint (Fig. 4 a).

The nature of the destruction for the whole group of samples, which were based on a furniture board, is the same. The additional effect of temperature or humidity did not show a significant difference in comparison with the control samples. On each sample peeling on an adhesive layer with the area about 50% (Fig. 4 b) with insignificant separations of a basis is found out.

(a) (b)

FIGURE 4. Destruction of samples during the study of the strength of the adhesive seam: (a) – MDF base; (b) – the basis of a furniture board.

In Fig. 5 shows a test to determine the tensile strength for glued samples of thermodified ash wood. Table 2 shows the results of the test for chipping along the fibers.

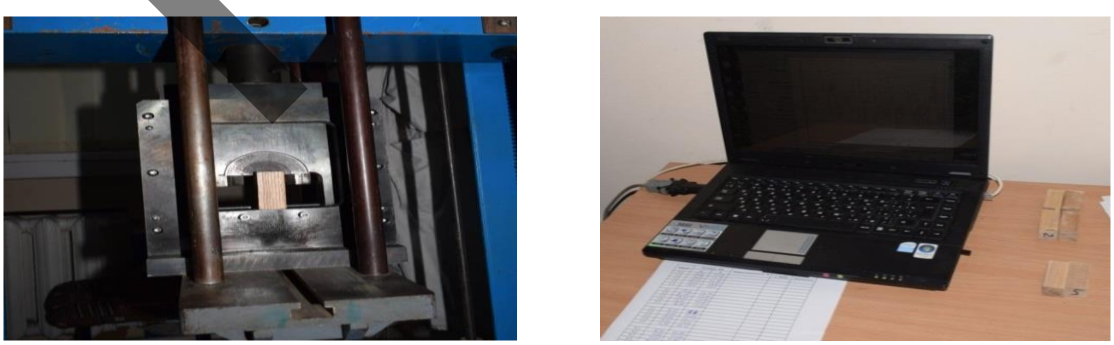
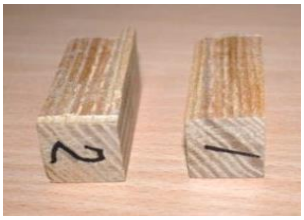
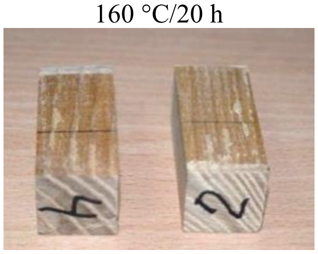
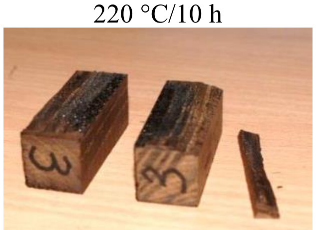


FIGURE 5. Testing.

TABLE 2. The results of the test for chipping along the fibers

Regime temperature / duration	No.	Dimensions, mm		Load P, H	Voltage, σ, MPa
		width	width		
160 °C/10 h	1	18,20	44,90	12187,45	14,9
	2	18,70	44,80	11777,36	14,1
	3	18,65	44,75	11293,55	13,5
	4	18,40	43,90	10553,84	13,1
	5	19,00	43,00	10354,70	12,7
The result of the determination					
			Average	11233,38	13,65
160 °C/20 h	1	18,25	44,70	12517,64	15,3
	2	18,25	45,25	10021,59	12,1
	3	18,45	45,20	9393,06	11,3
	4	18,40	44,05	11166,34	13,8
	5	18,70	44,60	14092,65	16,9
The result of the determination					
			Average	11438,26	13,88
220 °C/10 h	1	16,75	43,85	8278,58	11,3
	2	17,40	45,75	6601,38	8,3
	3	17,20	45,10	9856,41	12,7
	4	17,45	43,25	11924,21	15,8
	5	17,75	44,45	6317,24	8,0
The result of the determination					
			Average	8595,56	11,22
220 °C/20 h	1	16,75	44,20	5935,78	6,2
	2	17,20	44,05	4580,42	10,6
	3	17,40	41,65	8063,33	13,7
	4	17,65	45,80	9956,64	12,8
	5	17,70	43,25	10336,17	13,5
The result of the determination					
			Average	8234,14	11,37
not modified	1	19,00	43,00	12784,03	15,6
	2	19,20	42,10	10376,19	12,8
	3	19,20	44,90	8594,96	10,0
	4	19,00	44,15	12780,51	15,2
	5	19,15	45,30	7899,13	9,1
The result of the determination					
			Average	10486,96	12,56

As you can see from Table 2 the tensile strength for all samples is almost the same and ranges from 11.22 to 13.88 MPa. However, the nature of the destruction differs according to the visual assessment. Thus, in samples of untreated ash wood and modified at a temperature of 160 °C, the destruction occurs on the glued layer. But the samples modified at a temperature of 220 °C for 10 hours there is a destruction of bonding by 50% for 20 hours – separation of wood on 100% of the gluing area.

CONCLUSION

Thus, as a result of experimental studies, it was found that the nature of the destruction for the whole group of samples, which were based on glue, is the same. The additional effect of temperature or humidity did not show a significant difference in comparison with the control samples. It was found that in samples of untreated ash wood and modified at a temperature of 160, 220 °C, the destruction occurs on the glued layer. The results of the research will allow to solve further problems in the creation of new composites from thermally modified wood and the conditions of their operation at various sites.

ACKNOWLEDGMENTS

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Research of Certain Aspects of Improving the Color Resistance of Thermomodified Wood

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Abstract. It is proved that the color of wood tends to darken due to changes in the chemical components of wood, such as the degradation of amorphous carbohydrates during heat treatment at high temperatures. The application of heat treatment significantly changed the values of color parameters L*, a*, b* in samples of thermomodified wood. The parameter L* on the end and formation surfaces was significantly higher (72 for the end surface and 80 for the formation) in the control samples. As a result of heat treatment, the value of L* decreased significantly at a temperature of 160 °C, the duration of treatment was 10 hours to 44 and 47 respectively. The influence of different types of protective substances on the surface color of heat-treated wood is determined. The application of oil-wax and azure on the surface of the samples also affected the darkening of their color. We can say that heat-treated samples, the structure of which has changed compared to ordinary wood, show different interactions with the applied materials. The influence of the protective substance on the value of ΔL* depending on the treated surface is revealed.

INTRODUCTION

Increasing the level of information about the existence and practicality of wood products that do not contain any toxic preservatives has increased the popularity of heat-treated wood. Therefore, the use of this industrial material is gradually increasing. It is used both for premises, and for external furnish of buildings. Scope includes furniture, parquet, cladding elements, joinery, blinds, etc. [1].

The effect of high temperatures for some time on the wood not only improves its dimensional stability, durability, but also provides an attractive dark color. Heat-treated wood is often valued for its color spectrum from light brown to dark brown. Therefore, heat-treated wood is sometimes offered as a substitute for some tropical hardwoods. Both the processing time and the temperature of the modification process can be varied in order to obtain the desired color. Prolonged processing times and elevated temperatures usually give the wood a darker color. However, the achieved color is not resistant to light and needs protection [2, 3].

Therefore, the purpose of this study was to be able to justify protective coatings for color fastness of thermodified hornbeam wood to UV radiation. These results will provide a reliable indicator of the efficiency of heat-treated wood in the environment and develop measures for longer preservation of product color.

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ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

In recent years, wood protection has paid more attention to environmentally friendly analogues to traditional procedures [4-6]. One of the existing methods is thermal modification of wood. Modified wood in this way does not require impregnation with any harmful or chemical substances, and therefore the finished material does not create environmental pollution. It is known that in the process of heat treatment wood is heated to high temperatures, ranging from 160 to 260 °C, and maintained depending on the desired properties of the material for different times [7, 8]. As a result, the equilibrium moisture content decreases, hydrophobicity improves, dimensional stability increases, and protection against biological damage improves. Although there are losses of mechanical characteristics [9, 10].

Nevertheless, thermally modified wood has many uses for exterior decoration and interior design [7, 11] because it acquires a uniform color from light to dark brown. After all, the color of wood is important for consumers in terms of aesthetics. Thermal modification can be considered an inexpensive alternative method of changing the color of wood to mimic more expensive exotic species.

It is known that wood changes its color as a result of complex chemical degradation of hemicellulose and extractives under the influence of heat [12]. Changing the color of the wood surface, along with other surface characteristics have been studied in many studies [13]. The CIE L*a*b* system was effectively used to assess the color change of samples under the influence of temperature over a period of time [14].

Weathering is the process of slow degradation of materials under the influence of environmental conditions, including sunlight, moisture, temperature, wind and biological agents. Weathering of wood surfaces can cause color, chemical, physical, mechanical and microscopic changes. The study of natural weathering always takes many years. Therefore, many studies of the resistance of thermomodified wood to environmental influences are conducted in artificial conditions [15-17]. Tests for artificial weathering are generally considered to be simulations of external conditions and include only cycles of UV light and moisture.

The authors [3] tested the color fastness of spruce, beech, coastal pine and poplar core. The samples were pre-heat treated at 240 C for 2 hours in nitrogen. After irradiation with UVA-340 fluorescent lamps for 835 h, the results show that the color fastness for heat-treated wood is better. This is probably due to modification of lignin and monomers of phenolic compounds.

Heat-treated (at 160 and 200 °C) wood samples were irradiated with a strong mercury lamp. The results of color evaluation showed that the extractive content of wood plays an important role in color change not only during heat treatment, but also during light irradiation. Heat treatment at 200 °C was found to reduce the red change caused by photodegradation. The change in yellow photodegradation was less affected by heat treatment, which indicates the impossibility of lignin degradation under the action of light. In general, the effect of temperature slightly reduced the effect of color change due to irradiation. In this case, heat treatment at 160 °C was more efficient than treatment at 200 °C [18].

The authors [19] found that after heat treatment at 190 and 220 °C, the color change of the surface of Chinese fir during aging in natural conditions was slower. An increase in the degree of decay of the wood structure was revealed. Therefore, the surface of thermomodified wood requires the use of additional means of protection.

The effects of accelerated weathering by alternating irradiation with UV light and water spraying on the color change of pine, beech and spruce samples have been studied [20]. The surfaces were painted with 1, 2 or 3 layers of brown acrylic coating Superwax. The lowest color fastness, which was evaluated in the CIE L*a*b* color system, was the surface of beech wood samples painted with only 1 layer of Superwax. The highest resistance to discoloration was spruce, painted with 3 layers of this coating.

Thus, from the literature it is established that the thermal modification of wood is able to resist the change of color under the action of UV radiation. Additional surface treatment with protective substances contributes to a slower burnout of paint, so such products made of thermomodified wood require less care during operation. This indicates the feasibility of this study to determine the level of light protection of the surface of heat-treated wood, which will provide a longer period of application of building structures in the sun.

THE PURPOSE OF THIS WORK

The purpose of this work is to evaluate the color stability of the surface of thermomodified hornbeam wood treated with oil-wax and azure under the influence of direct sunlight and temperature-humidity fields.

MATERIALS AND METHODS OF RESEARCH

Hornbeam samples were used in the study. This wood is not widely used in the furniture and woodworking industries, but today Ukraine has a large number of stocks. In this study, we studied the stability of hornbeam wood measuring 10×20×10 mm (Fig. 1).

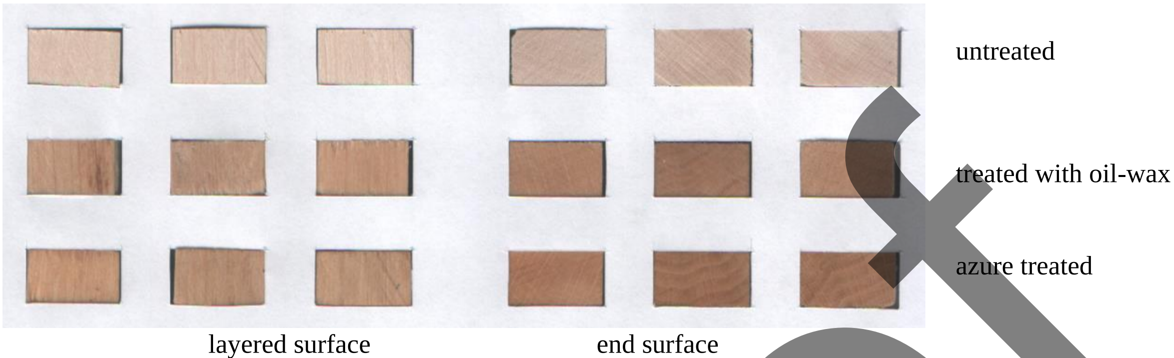


FIGURE 1. Samples of unmodified hornbeam wood treated with oil-wax and azure

After drying in a conventional oven to a humidity of 8%, the lumber was cut into samples measuring 300×85×10 mm. Heat treatment of the samples was performed using ThermoWood® technology in three stages. First, the wood was dried to a humidity of 0% at 105 °C for 1 hour. The second stage – thermal modification – was performed at three different (160, 190 and 220 °C), duration 1, 10 and 20 hours. The conditioning step was performed without spraying water with an unauthorized decrease in temperature in the chamber (Fig. 2).

After a week of acclimatization, test specimens measuring 10×20×10 mm with a total of 180 pcs. After grinding the surface, protective substances were applied by immersion in two stages with intermediate drying for 24 hours. External wax oil based on linseed oil and natural wax, as well as azure, were used as experimental paints and varnishes.

The color was determined on the end and layer surfaces of hornbeam wood samples after heat treatment and after application of paints and varnishes in three-dimensional color space CIEL *a*b*. In this system, L* (luminosity) characterizes the color from black to white (L* = 0 for black, L* = 100 for white), a* – from red (positive values) to green (negative values) and b* – from yellow to blue (Fig. 3).

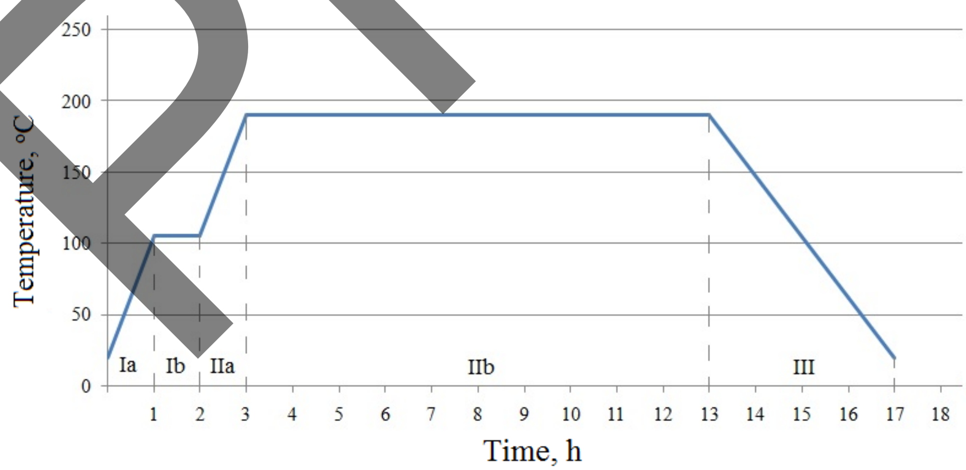


FIGURE 2. Scheme of the thermal modification process on the example of the temperature 190 °C, duration 10 hours

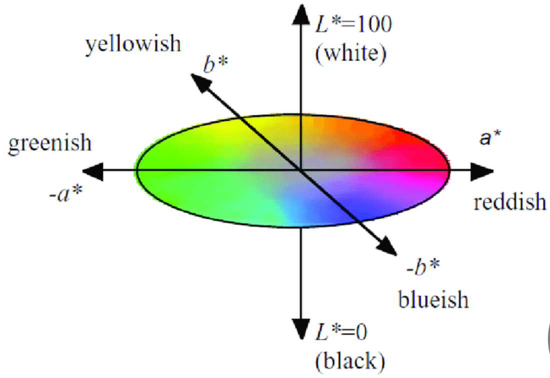


FIGURE 3. Three-dimensional color system CIELAB

The L* axis characterizes the luminosity of the color, a* and b* are the chromatic coordinates of the color. In the CIELAB system, the coordinates +a* and -a* represent red and green, respectively. The parameter +b* denotes yellow, -b* – blue. L* can vary from 100 (white) to 0 (black). The change in the corresponding color parameter ΔL*, Δa* and Δb* was calculated relative to the control raw wood samples from the equations:

$$\Delta L^* = L^* \text{ treated} - L^* \text{control}, \tag{1}$$

$$\Delta b^* = b^* \text{ treated} - b^* \text{control}, \tag{2}$$

$$\Delta a^* = a^* \text{ treated} - a^* \text{control}. \tag{3}$$

RESULTS AND DISCUSSIONS

The color of the wood tends to darken due to changes in the chemical components of the wood, such as the degradation of amorphous carbohydrates during heat treatment at high temperatures.

In Fig. 4-6 show the appearance of the samples after thermal modification at a temperature of 160 °C for different times and treatment with oil-wax and azure.

The results of many studies confirm that color changes as a result of heat treatment are associated with modification of polysaccharide structures, evaporation of dye extracts and rapid oxidation of lignin and some chemical elements at high temperatures.

In Fig. 7-9 show the appearance of hornbeam wood samples after thermal modification at a temperature of 190 °C for different times and treatment with oil-wax and azure.

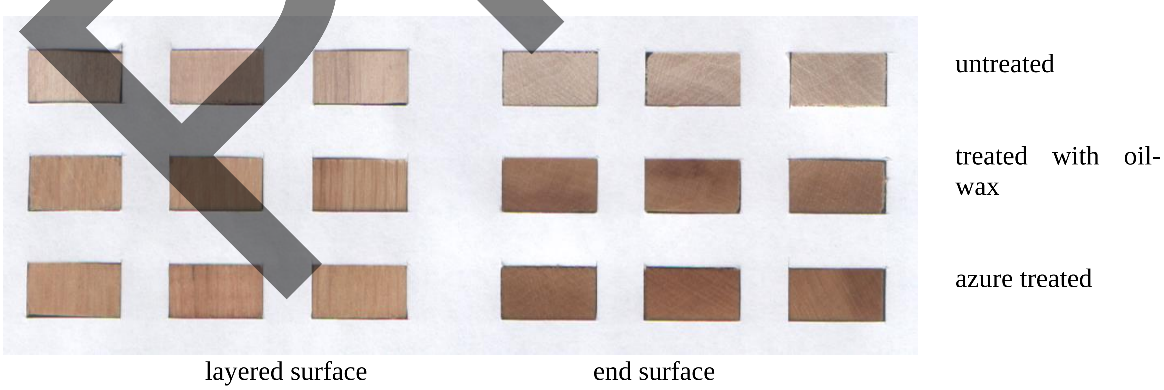


FIGURE 4. Hornbeam wood samples modified at 160 °C for 1 h, treated with oil-wax and azure

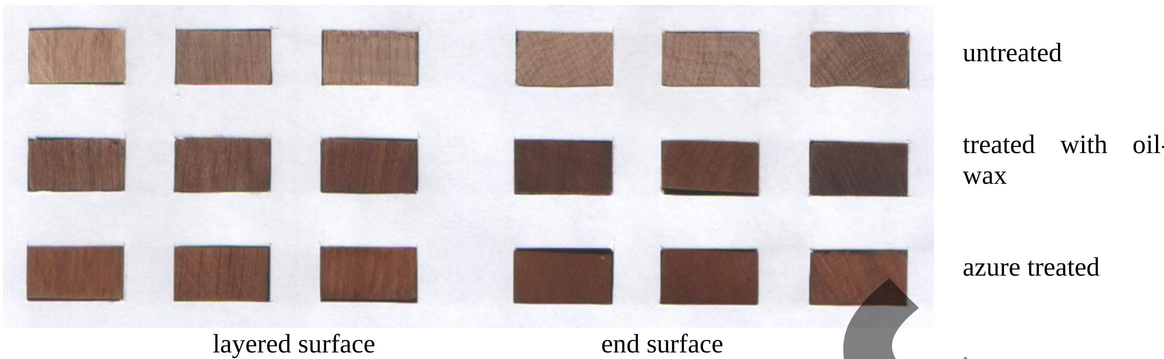


FIGURE 5. Hornbeam wood samples modified at 160 °C for 10 h, treated with oil-wax and azure

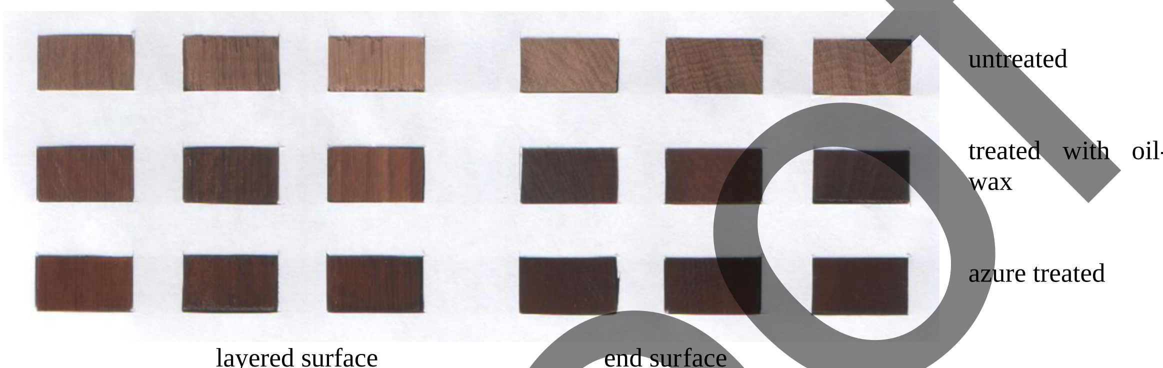


FIGURE 6. Hornbeam wood samples modified at 160 °C for 20 h, treated with oil-wax and azure

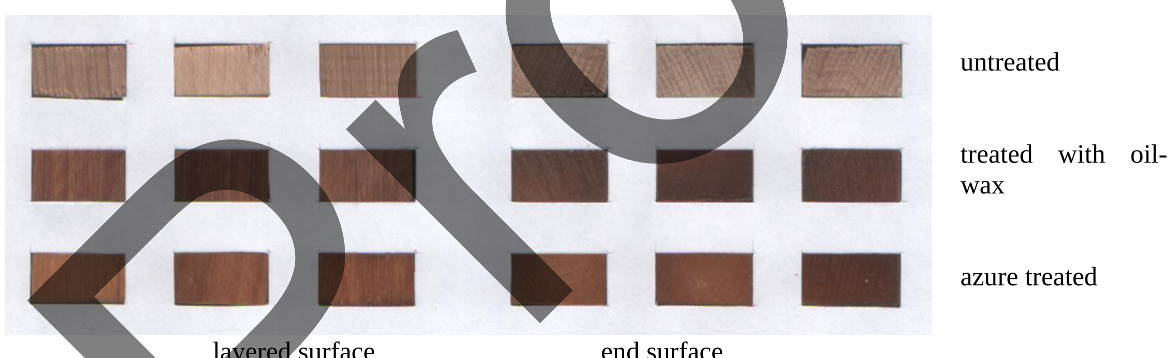


FIGURE 7. Hornbeam wood samples modified at 190 °C for 1 h, treated with oil-wax and azure

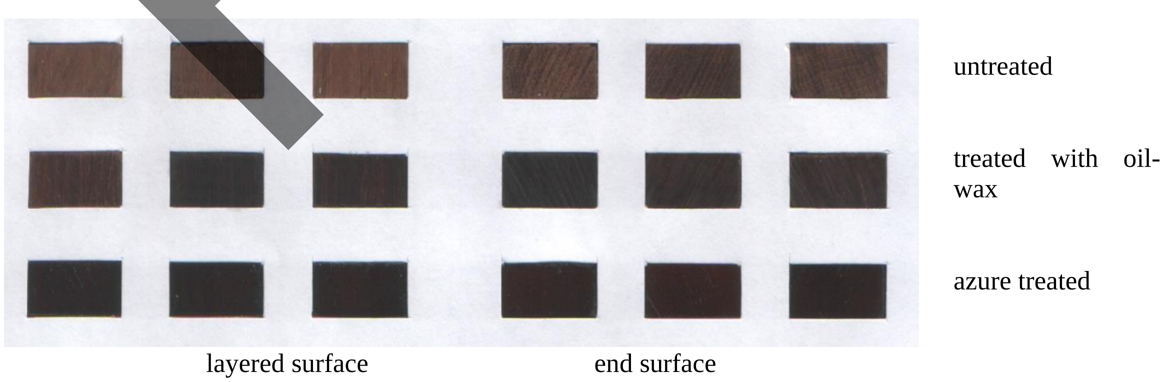
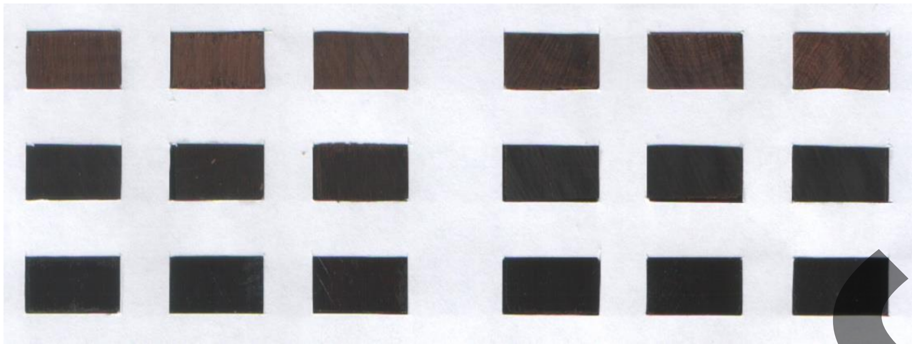


FIGURE 8. Samples of hornbeam wood modified at 190 °C for 10 h, treated with oil-wax and azure



untreated

treated with oil-wax

azure treated

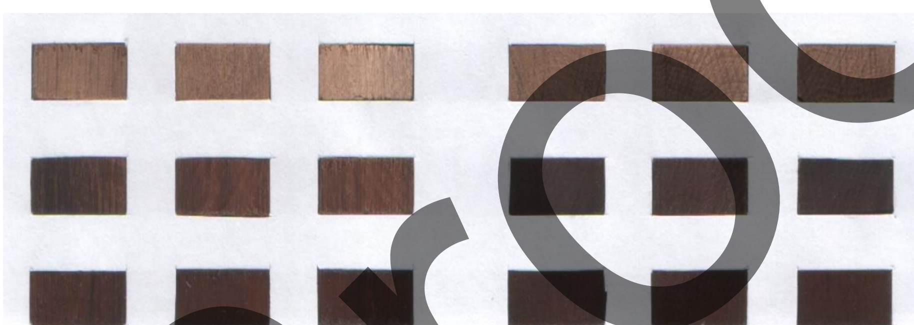
layered surface end surface

FIGURE 9. Hornbeam wood samples modified at 190 °C for 20 h, treated with oil-wax and azure

It is established that the degree of darkening of the color of wood is directly related to the degree of thermal degradation of wood material.

In Fig. 10-12 show the change in the appearance of hornbeam wood samples after thermal modification at a temperature of 220 °C for different times and treatment with oil-wax and azure.

The application of heat treatment significantly changed the values of color parameters L*, a*, b* in samples of thermodified hornbeam wood.



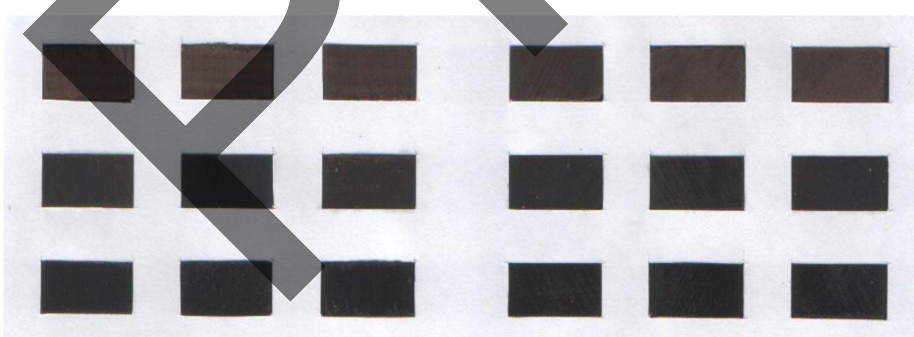
untreated

treated with oil-wax

azure treated azure treated

layered surface end surface

Figure 10. Hornbeam wood samples modified at 220 °C for 1 h, treated with oil-wax and azure



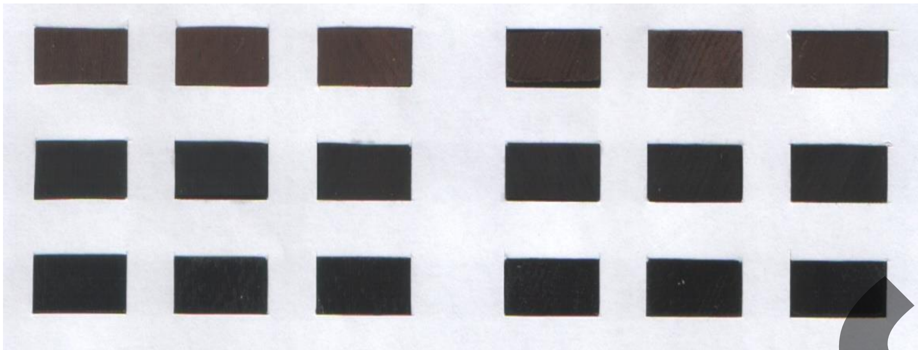
untreated

treated with oil-wax

azure treated

layered surface end surface

FIGURE 11. Hornbeam wood samples modified at 220 °C for 10 h, treated with oil-wax and azure



untreated

treated with oil-wax

azure treated

layered surface end surface

FIGURE 12. Hornbeam wood samples modified at 220 °C for 20 h, treated with oil-wax and azure

In the Table 1 shows the results of the influence of the parameters of the thermal modification mode on the color of the wood.

TABLE 1. Changing the color parameters of the end and formation surface of the samples after thermal modification

Mode parameters of wood modification		**Wood color options**					
		end surface			**layered surface**		
T, °C	τ, hours	L*	a*	b*	L*	a*	b*
control		72	7	11	80	7	11
160	1	69	6	10	72	7	11
	10	51	9	12	55	9	13
	20	44	9	12	47	10	12
190	1	54	8	12	57	10	14
	10	29	7	6	34	9	9
	20	27	5	4	32	7	6
220	1	43	10	12	52	10	13
	10	27	4	3	29	5	4
	20	25	4	3	29	5	4

The parameter L* on both surfaces was significantly higher (72 for the end surface and 80 for the formation) in the control samples. As a result of heat treatment, the value of L* decreased significantly at a temperature of 160 °C, the duration of treatment was 10 hours. to 44 and 47 respectively. At a maximum modification temperature of 220 °C for 20 h, the color brightness parameter decreased by 2.88 and 2.75 times for the end and formation surfaces of the samples. Chromatic parameters a* and b* increase slightly when modified at temperatures of 160 and 190 °C. There is a sharp decrease in their values during heat treatment at 220 °C for more than 10 hours.

In the Table 2 shows the change in color of the samples after application of oil-wax on the surface of thermally modified wood.

In the Table 3 shows the change in color of the samples after applying azure to the surface of thermally modified wood.

Comparing the chromatic parameters, a* and b*, it is seen that their values increase slightly when applying oil-wax and azure on unmodified and modified at 160 °C samples. On thermodified wood samples at 190 °C for more than 10 hours and at 220 °C there is a sharp decrease in these indicators.

The application of oil-wax and azure on the surface of the samples also affected the darkening of their color. We can say that heat-treated samples, the structure of which has changed compared to ordinary wood, show different interactions with the applied materials. The difference is especially noticeable on samples thermodified at 160 °C and 190 and 220 °C for 1 hour. The influence of the protective substance on the value of ΔL* depending on the treated surface is revealed. Thus, for samples thermally modified at 160 °C and 190 °C for 1 h, the end surface darkened even more. And in the samples modified at 190 °C for more than 10 h and at 220 °C, the formation surface became darker, although the effect is much smaller.

TABLE 2. Change in the color parameters of the end and formation surface of thermomodified wood samples after application of oil-wax

Mode parameters of wood modification		Wood color options					
		end surface			layered surface		
T, °C	**τ, hours**	**L***	**a***	**b***	**L***	**a***	**b***
control		56	12	18	63	11	18
160	1	48	12	16	62	10	18
	10	30	10	7	37	13	11
	20	26	7	4	34	11	9
190	1	33	10	8	37	14	13
	10	23	2	1	24	3	2
	20	22	0	0	23	1	0
220	1	26	5	3	31	9	7
	10	22	0	-1	23	0	-1
	20	21	0	-1	23	0	-1

"TABLE 3". Changing the color parameters of the end and formation surface of thermodified wood samples after applying azure

Mode parameters of wood modification		Wood color options					
		end surface			layered surface		
T, °C	**τ, hours**	**L***	**a***	**b***	**L***	**a***	**b***
control		52	14	20	63	11	20
160	1	46	13	18	62	11	20
	10	33	14	14	38	15	16
	20	22	7	5	28	12	9
190	1	34	15	15	42	17	20
	10	19	5	2	20	2	1
	20	17	0	0	20	1	-1
220	1	22	8	5	25	9	6
	10	18	0	-1	19	0	-1
	20	17	0	-1	19	0	-2

CONCLUSION

It is established that the color characteristics of wood have changed significantly after heat treatment. The largest difference is observed for the luminosity parameter L*. The duration of thermal modification has a significant effect on color darkening. The influence of different types of paints and varnishes applied on the surface of samples, to which heat treatment was applied at different temperatures, on the color state was also investigated. There was a significant darkening of the end surface of the samples thermodified at 160 °C and 190 °C for 1 hour during finishing with oil-wax and azure. That is, the color of the wood obtained at low processing temperatures, can be increased by applying these protective substances and make the material more attractive. Subsequent studies should evaluate the color fastness of thermodified wood additionally treated with oil-wax and azure, as well as the adhesion of these protective substances to the surface under the influence of environmental factors.

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Corrosion of Basalt Fiber with Titanium Dioxide Coating in NaOH and $Ca(OH)_2$ Solutions

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Abstract. Several different methods are used to determine the effect of an alkaline environment on glass materials. The main difference is the characteristic under observation. One common way to determine the alkalinity of a substance is to measure the relative weight loss after the object interacts with the alkaline environment. The study of the morphology of the basalt fiber surface and elemental and phase composition before and after interaction with alkali allows determining the details of the fiber etching in an aggressive environment and the impact of coatings on this process.

INTRODUCTION

One of the most common ways to determine the stability of raw materials in solutions of NaOH and $Ca(OH)_2$ is to measure the relative weight loss after their interaction. This method has a number of advantages over measuring the relative weight loss, as it takes into account the surface of the sample. However, in the case of sufficiently fine raw materials (powder) or fibers of small diameter (less than 100 μm), it is impossible not to take into account the change in surface area as the raw materials are etched.

Intensive development of these fibers and materials produced based on them in the world determines the formulation of sufficient scientific and technical problems, improvement of their component composition, production technologies to ensure a given set of properties and high quality, optimization of processing, and rational use. The number of scientific papers on this problem so far is quite large and growing. This is due not only to the significant application aspect but also to the fundamental tasks that need to be solved. Scientists such as Mokhort, Aslanova, Dzhigiris devoted a large number of works to the study of alkalinity resistance of basalt fibers [1,2,3].

The purpose and objectives of this work are to identify patterns of influence of titanium oxide additives on the physicochemical characteristics of basalt rocks, fiber formation processes, and structural characteristics of the obtained fibers to increase the level of basic physicochemical properties during operation under aggressive factors, the effect of NaOH and $Ca(OH)_2$ solutions.

RESEARCH MATERIALS AND METHODS

The studies of the surface of the basalt fiber with TiO_2 coating after immersion in 2H NaOH solution for 16 days using an electron microscope showed that the alkali damages the surface morphology (Fig. 1. a, b). The microphotographs analysis demonstrated that $Fe_6(OH)12CO_3$ neoplasms in the form of lamellar hexagonal crystals and spherical $CaCO_3$ aggregates appear on the surface of the etched fiber with the TiO_2 coating [4,5]. The analysis also showed microcracks in some parts of the surface, especially near the spherical formations and peeling of the

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corrosion shell (TiO_2 coating together with the corrosion layer). The thickness of the peeling corrosion shell according to SEM was 0.7-1 μm.

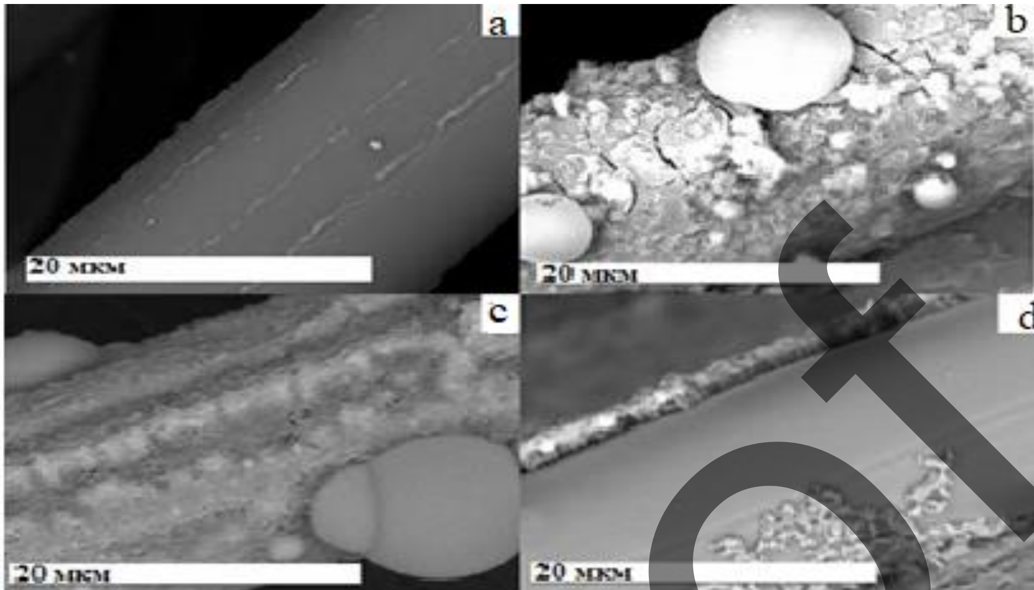


FIGURE 1. SEM photos of basalt fibers with TiO_2 coating before (a) and after immersion in a 2H NaOH solution for 16 (b) and 64 (c and d) days

According to SEM analysis, it can be stated and concluded that the content of iron and calcium is lower than those determined for etched uncoated fiber, while the content of silicon and aluminum in etched coated fiber is higher than in uncoated fibers (Fig. 2). This fact means that the etching of TiO_2 coated fiber occurs to a lesser extent than the original fiber under the same conditions. It should be noted that the elemental compositions determined on the surface under the corrosion shell for TiO_2 coated basalt fiber and uncoated fibers coincide, which indicates that after detachment of the corrosion shell a juvenile surface is formed [6,7,8].

Long-term 64-day etching of TiO_2 coated basalt fiber in NaOH solution leads to significant surface morphology changes (Fig. 1 c, d). These changes are similar to the changes for uncoated fibers after immersion in a NaOH solution for 64 days.

Notably, the lamellar crystals adhere to an almost continuous layer. Calcite collects in large compounds. The thickness of the corrosion shell reaches up to 2 μm. Based on the SEM results, it can be concluded that the basalt fiber with TiO_2 coating is more resistant to the interaction of aggressive alkaline media than the fiber without coating. However, the positive effect of the coating becomes quite insignificant after the long-term etching of TiO_2 coated basalt fiber in such an aggressive environment (Fig. 2).

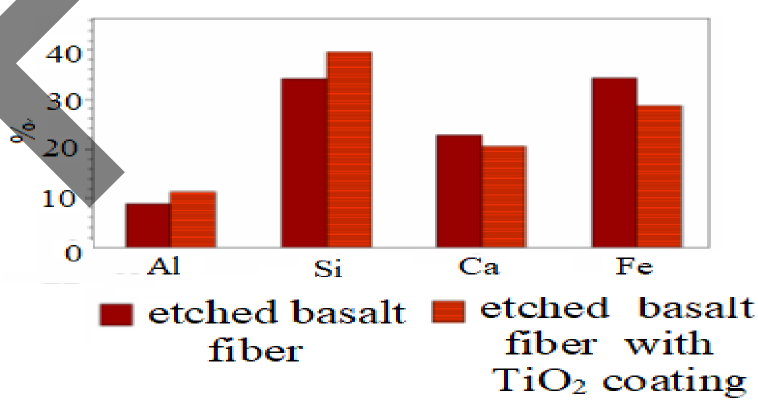


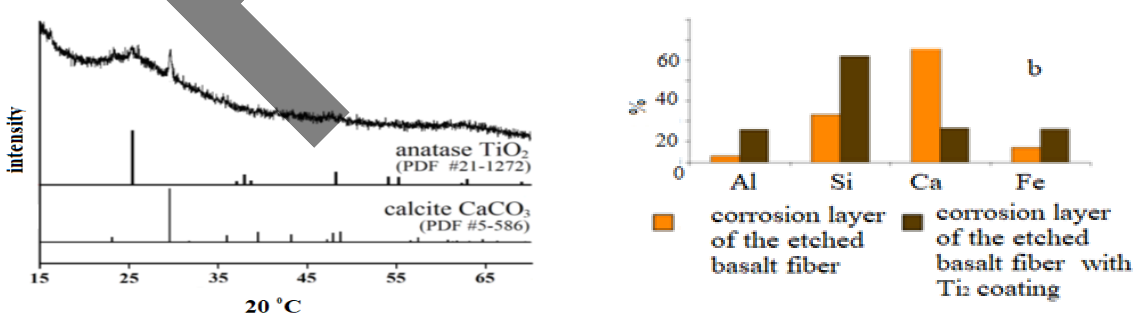
FIGURE 2. Normalized data of EDXA of the original and TiO_2 coated basalt fiber after its immersion in a 2H NaOH solution for 16 days

Corrosion in a saturated $Ca(OH)_2$ solution

The morphology study of a greater number of inclusions with TiO_2 coating immersed in a solution of $Ca(OH)_2$ for 16 days showed the absence of any signs of corrosion, such as the formation of hexagonal plate crystals of $Fe_6(OH)12CO_3$ (Fig. 3). Calcite crystals on the surface of the coated fiber are not numerous and were observed only in some inclusions (Fig. 4), which were placed on the outer part of the bundle of fibers, immersed in an alkaline environment.

FIGURE 3. PEM photos of basalt fiber with TiO_2 coating after immersion in a solution of $Ca(OH)_2$ for 16 days

FIGURE 4. Calcite crystals on the surface of basalt fiber with TiO_2 coating after immersion in a solution of $Ca(OH)_2$ for 16 days



a) b)

FIGURE 5. X-ray photograph (a) and normalized data of EDXA (b) after etching of TiO_2 - basalt fiber in the saturated solution of $Ca(OH)_2$ for 64 days

Increasing the duration of the interaction of alkali to 64 days does not lead to delamination of TiO_2 coating, which is confirmed by X-ray diffraction analysis. Peaks are present in the X-ray photograph of this sample (Fig. 5 a). From the data of EDXA, it is seen that the content of Si and Al in the surface region is closer to the values of the source fiber, while the composition of the source fiber under the same etching conditions changes significantly (Fig. 5 b).

A typical SEM image of TiO_2 - basalt fiber after immersion for 64 days is shown in Figure 6 a. Since most of the inclusions of calcite after washing and drying of the fibers are not stored on the surface of the fiber, the fiber has smooth areas. In Figure 6 b, c, some morphological features can be observed, such as traces of corrosion that have survived. In addition to lamellar $Fe_6(OH)12CO_3$ crystals, which densely cover the surface of the fibers, needle (elongated) crystals were also observed. Elemental analysis showed that the main component was calcium (Figu. 6 d), so it can be assumed that the needle crystals are calcite or any other calcium-containing compound. The results show that the TiO_2 coating does not provide sufficient protection of the basalt fiber when immersed in a highly alkaline medium, such as a 2H NaOH solution. However, its function becomes more effective in milder conditions, such as a saturated solution of $Ca(OH)_2$, which is quite close to the conditions of cement hydration. Virtually no traces of corrosion were detected after immersion of TiO_2 – basalt fiber for 16 days in a solution of $Ca(OH)_2$. Paying attention to the fact that the hardening of concrete occurs within 24 hours, it can be considered that TiO_2 coating has potential in terms of the protection of basalt fiber.

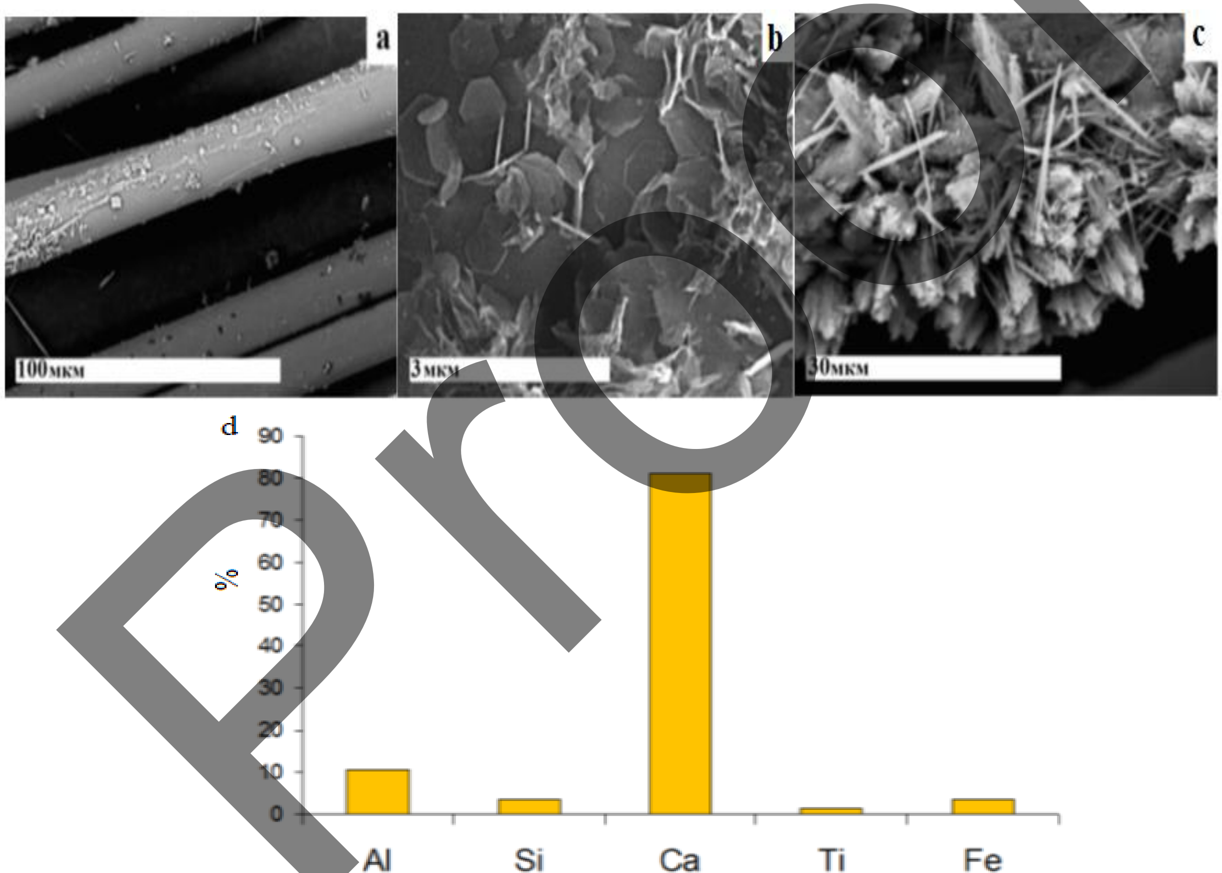


FIGURE 6. PEM/EDXA data of the TiO_2 –basalt fiber after immersion in a saturated solution of $Ca(OH)_2$ for 64 days: a – original basalt fiber; b – lamellar crystals; c – druses and needle crystals; d – normalized data of EDXA of needle crystals

According to the results of SEM and X-ray diffraction studies of the etching of basalt fibers in different alkaline media, we can assume the following scheme of etching (Fig. 7). In the alkaline solution, the interaction of the aluminosilicate composition with the alkali begins with the destruction of - Si - O - Si - and - Al - O - Si - bonds, and the aluminosilicate composition of the basalt fiber gradually dissolves. With increasing etching time, the reaction is transferred to the inner part of the fiber (core) and leaves insoluble oxides, hydroxides in the form of amorphous and crystalline phases. Iron hydroxides (iron carbonate hydroxide) are sparingly soluble under these conditions and form a corrosion layer on the surface of the basalt fiber, which consists of hexagonal crystals. Over time, the corrosion layer begins to peel off for some reason, namely, too weak a bond with the basalt fiber and the stress that occurs in the corrosion shell due to the mismatch between the mechanical properties of the basalt (glassy) fiber and crystalline neoplasms. Exfoliation of the corrosion shell leads to the formation of a "fresh" surface of the basalt fiber.

During the etching of the basalt fiber, the Si–O–Si bonds gradually disintegrate under the action of OH- [9, 10, 12]; reactions (4-1)- (4-4) can describe this process.

Dissolution of the aluminum-containing part of the framework Si – O – Al, Al – O – Al in an alkaline solution proceeds according to a similar scheme. In general, reactions (4-5) and (4-6) can describe these processes.

$$\equiv Si–O–Si\equiv + OH^- \rightarrow \equiv Si–O^- + H–O–Si\equiv \ / \ (4\text{-}1)$$

$$=Si(OH)–O–Si\equiv + OH^- \rightarrow \equiv Si–O^- + =Si(OH)_2 \ / \ (4\text{-}2)$$

$$=Si(OH)_2–O–Si\equiv + OH^- \rightarrow \equiv Si–O^- + –Si(OH)_3 \ / \ (4\text{-}3)$$

$$\equiv Si–O–Si(OH)_3 + OH^- \rightarrow \equiv Si–O^- + H_4[SiO_4] \ / \ (4\text{-}4)$$

$$nSiO_2 + 4nOH^- = n[SiO_4]_4^- + 2nH_2O \ / \ (4\text{-}5)$$

$$mAl_2O_3 + 2mOH^- + 3H_2O = 2m[Al(OH)_4]^- \ / \ (4\text{-}6)$$

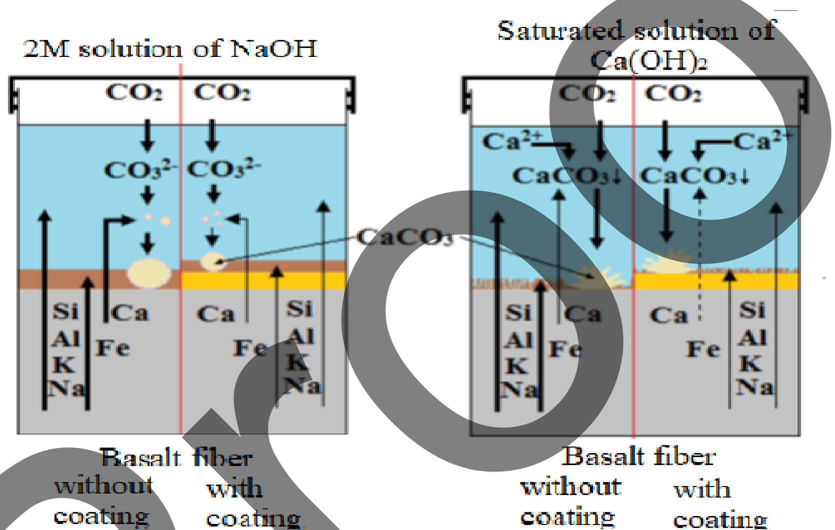


FIGURE 7. Etching scheme of the basalt fiber in the solution of NaOH and $Ca(OH)_2$ and effect of the applied coating

Polycondensation reactions for $[SiO_4]_4$- and $[Al(OH)_4]$-anions accompany the dissolution process (reactions (4-7) and (4-8)) [9, 11, 12]. The course of such processes is the reverse of the processes of dissolution of the aluminosilicate framework. The process of polycondensation leads to an increase in the viscosity of the sol and the gel-like shell formation around the fiber. This formation occurs due to the fact that the solid part of the corrosion layer is rather weakly bound to the fiber and easily peels off during manipulation with the fiber, for example, when washing the fiber. Literature data confirm this assumption [9].

$$2[SiO_4]_4\text{-}+H_2O=[Si_2\,O_7]_6\text{-}\ 2OH^- \ / \ (4\text{-}7)$$

$$2[Al(OH)_4]\text{-} = [Al_2O(OH)_6]^{2-} + H_2O \ / \ (4\text{-}8)$$

Reactions (4-9) and (4-10) describe the transition to the solution of sodium and potassium cations

$$\equiv Si–O–Na + H_2O \rightarrow \equiv Si–O–H + H–O^- + Na^+ \ / \ (4\text{-}9)$$

$$\equiv Si–O–K + H_2O \rightarrow \equiv Si–O–H + H–O^- + K^+ \ / \ (4\text{-}10)$$

To explain the formation of iron-containing products in the $Fe_6(OH)12(CO_3)$ corrosion layer, it should be noted that the solubility of Fe_{3+} under the same conditions is by several orders lower than the solubility of Fe_{2+} [10].

Thus, the solubility of freshly precipitated $Fe(OH)_3$ is ~ 10-38, and the solubility derivative of $Fe(OH)_2$ makes ~ 10-16, while the amphoteric properties of Fe_{3+} manifest themselves only when it fuses with alkalis [10]. Besides, oxidation of Fe_{2+} to Fe_{3+} by the oxygen contained in an alkaline solution complicates the study of the iron behavior.

The reactions (4-11) and (4-12) conventionally describe the solubility of iron in the aluminosilicate matrix. Iron hydroxides further interact with carbon dioxide from the atmosphere to form a product of the complex composition, namely Fe_6(OH)12(CO_3):

$$FeO + H_2O = Fe(OH)_2 \downarrow \ / \ (4\text{-}11)$$

$$Fe_2O_3 + 3H_2O = 2Fe(OH)_3 \downarrow \ / \ (4\text{-}12)$$

Mg and Ca also dissolve with the formation of hydroxides, which are subsequently converted into the corresponding carbonates, for example, by reactions (4-13), (4-14):

$$CaO + H_2O = Ca^{2+} + 2OH^- \ / \ (4\text{-}13)$$

$$Ca^{2+} + CO^{32-} = CaCO_3 \downarrow \ / \ (4\text{-}14)$$

A distinctive feature of the basalt fiber etching in solutions of NaOH and $Ca(OH)_2$ is different etching rates. In NaOH solution, the fiber degrades faster than in a saturated $Ca(OH)_2$ solution. The lower concentration of OH- ions in saturated $Ca(OH)_2$ solution compared to NaOH solution can explain this fact. Another hallmark of the etching of basalt fiber in solutions of NaOH and $Ca(OH)_2$ is the morphology of the formed crystals of calcite. The only source of calcium during the etching of basalt fiber in NaOH solution is the fiber itself. Under such conditions, the dissolution of the aluminosilicate skeleton controls the diffusion of calcium cations from the outside. Maybe due to the high ionic strength of the NaOH solution and the slow diffusion of calcium ions from the outside, the growth of larger crystals is limited, so we observe the formation of numerous spherical aggregates. On the contrary, the penetration of atmospheric carbon dioxide controls the growth of $CaCO_3$ in the $Ca(OH)_2$ solution. The ionic strength of the $Ca(OH)_2$ solution is much lower than the ionic strength of the NaOH solution. This fact promotes the formation of larger crystals of calcite on the surface of the fiber.

The application of titanium dioxide coatings to the basalt fiber leads to a decrease in the fiber tensile strength; and after etching the tensile strength of the fibers also decreases due to two factors: dissolution of the aluminosilicate skeleton of the basalt fiber and a more solid coating on the surface of its corrosion layer.

CONCLUSIONS

The presence of TiO_2 coatings on the fiber surface results in a change in the mechanism of fiber degradation in an alkaline environment. Dense alkali-resistant coatings prevent mass transfer between the fiber and the alkaline solution, as SEM data confirm. This type of coating has the potential for fiber protection from the aggressive action of alkalis. Therefore, research for the determination of protective coatings for basalt fibers has the potential.

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Research Parameter Surface Durability of Wood Flooring

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Abstract. There are many different types and methods of experimental tests that mimic the different types of loads of lacquered surfaces used. The main indicators of the quality of lacquered surfaces of wooden floors are adhesion, elasticity, impact resistance, wear resistance and resistance to various liquids, mechanical damage, abrasion, etc. During the test of wooden coatings for wear resistance, laboratory tests should simulate the operating conditions of wooden floors. However, mainly all methods of experimental tests are standardized, but some of them do not allow to determine the minimum requirements or control values of certain technical properties of different paint surfaces. Which in turn creates a dilemma for technologists or even consumers, who are expected to determine the quality requirements of certain products. The article presents the results of experimental research to determine the coefficient of abrasion of the surface layer of the parquet board and to establish the class of its resistance to abrasion according to the results of the Taber test. They can serve as information for the relevant properties of wooden floor surfaces and be aimed at better knowledge of information on experimental tests of floor coverings for wear resistance.

INTRODUCTION

Currently, wood is one of the most popular floor coverings. And the reason is quite simple: this floor is reliable, durable, comfortable and aesthetic. Due to the low electrical conductivity, wooden floor coverings do not give electrostatic charges. Therefore, dust and dirt particles do not stick to the parquet floor. In addition, such a coating can absorb water vapor from the air and emit it again. Unlike a number of other floor coverings, wooden coverings are characterized by long service life because floor boards can be easily repaired thanks to the top layer of solid wood. However, it should be noted that these qualities apply to almost all types of floor coverings, but there is a separate category – wear resistance, which is less in wood flooring compared to laminate flooring or tile. Wear resistance is the ability of a floor covering to resist natural abrasion and mechanical damage. At the same time, a wear-resistant layer of parquet flooring, which is made of valuable wood, must have a minimum thickness to be classified as parquet board or parquet. At the same time the applied paint and varnish covering acting as a decor, design or increasing commercial value of the made product has to differ in the increased resistance to gradual destruction of a surface at friction.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Wood has been used and is used around the world for thousands of years [1], and is one of the most common and attractive solutions for flooring. Its widespread use is mainly due to the availability of this material for everyone and

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reproducibility, but not every wood is suitable for the manufacture of various products [2-4]. Due to the fact that wood is a natural material and has different physical and mechanical properties, there is a need to carefully approach the assessment of its characteristics as a floor covering to ensure proper selection and use for its intended purpose, which will ensure the necessary durability according to consumer requirements and expectations. To achieve this goal, it is necessary to identify and identify factors that destroy wood, change its physical and mechanical properties, affect the durability and service life of wooden floors [5].

One of the factors influencing the durability of the product is the careful selection of paint, which can further affect the resistance of the surface of the product to abrasion, scratches and the action of chemicals [6-9]. In general, the service life of the floor covering depends on the quality of the used paints and varnishes, their resistance to abrasion and scratches, the type of wood from which the floor covering is made and its main properties, including density [10, 11].

Known methods of experimental research are based on the simulation of natural conditions of wood use, experimental data of which may indicate a significant or weightless influence of various factors on the performance of wooden floors over time [12]. Therefore, test studies use different methods to predict the service life of wood used indoors or outdoors. The information obtained provides an opportunity to gain knowledge about the impact of the characteristics of wood flooring on its service life.

THE PURPOSE OF THIS WORK

The purpose of this work is to check the abrasion of parquet board equipped with different materials at standard load, so the procedure should simulate the possible long-term impact on the parquet board of common factors – gait, movement of furniture and other factors that adversely affect the top floor.

MATERIALS AND METHODS OF RESEARCH

To determine the coefficient of abrasion of the surface layer of the parquet board and to establish its wear resistance class, three types of samples of common oak wood were used, which were treated with water, alkyd varnish and oil with anti-slip effect. In the process of the experiment used the techniques reflected in the regulations [13-16].

The essence of the experiment (test): a sample of parquet board is fixed in a special device with a rotating circle on which sandpaper is attached, after which the rotation of a special circle with two heads with sandpaper, scraping on the parquet board. Thus the surface of a parquet board is subject to abrasion in a short time, and the class of wear resistance of a covering depends on how many turns of a head with sandpaper the parquet board will sustain.

The methodology of experimental research included:

– weighing the test sample before and after the test;

– measuring the coating thickness of the test specimen in several places along the path to be ground and averaging;

– installation of a test specimen on the platform of the turntable to be ground;

– setting the number of revolutions;

– conducting the research stage.

Taber – test for parquet board is the use of a device with a rotating abrasive wheel (Fig. 1).

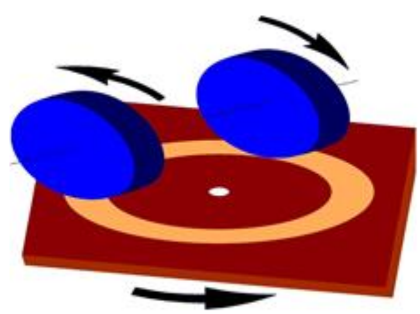

FIGURE 1. The principle of operation of the Taber device.

The device rotates in contact with the floor covering, thus checking the strength of its top layer. Manufacturers of floor coverings declare the number of revolutions until complete abrasion of the top layer of the coating from 6 to 20 thousand, depending on the type of paint. The number of revolutions of the Taber device indicates the class of wear resistance of coatings. In addition, during the experimental studies get three indicators:

– IP – which indicates the number of revolutions, after which the first traces of abrasion;
– FP – the number of revolutions at the level of wear of the coating is about 95 percent;
– AT – average value.

Analytical, experimental and statistical research methods were used in the research process.

Wear resistance, expressed in revolutions for each instance, was determined by the formula:

$$(IP + FP) / 2 \tag{1}$$

where is the *IP* – the initial point of wear (the appearance of the first visible areas of damage); *FP* – end point (visible damage to more than 3/4 of the test surface).

The abrasion index of the test samples (mg) was determined by the formula:

$$I = 1000*(A – B) / C \tag{2}$$

where is the *A* – the mass of the test sample before abrasion, mg; *B* – the mass of the test sample after abrasion, mg; *C* – the number of recorded erase cycles.

Weight loss of samples (mg), for the specified number of cycles was determined by the formula:

$$L = A – B \tag{3}$$

where is the *A* – the mass of the test sample before abrasion, mg; *B* – the mass of the test sample after abrasion, mg.

The number of cycles of wear of the surface coating (film) was determined by the formula:

$$W = D / T \tag{4}$$

where is the *D* – the number of abrasion cycles required for wear of the coating to the bottom; *T* – the thickness of the coating, cute (0.001 in.) (with one decimal place).

To compare the obtained indicators with the tabular ones, the indicators of the abrasion resistance classes of the surface layer are used, according to the results of the Taber test: according to EN 438-2: 1991 and EN 13329: 2000 (Table 1).

TABLE 1. Table of generally accepted correspondences of characteristics

Scope for EN 685	**Loading**	**Class wear resistance**	**Wear resistance EN 13329 (EN 438-2)**	**Coefficient abrasion IP (number of passages Taber roller)**	
				EN 13329	**EN 438-2**
Living quarters: bedroom, library, office	easy	21	AC1 (W1)	>900	>2000
Living quarters: children's, living rooms	average	22	AC2 (W2)	>1800	>4000
Living quarters: hallway, kitchen	high	23	AC3 (W3)	>2500	>6000
Public premises: small office, conference hall	easy	31	AC3 (W3)	>2500	>6000
Public premises: classrooms, office, reception, boutique	average	32	AC4 (W4)	>4000	>10000
Public premises: shop, gym, restaurant	high	33	AC5 (W5)	>6500	>15000
Premises without load restrictions	very high	34	AC6 (W6)	>8000	>20000

In general, the greater the number of revolutions, the more durable is the floor. There are six classes of wear resistance, each class has its own characteristics. Classes of wear resistance of parquet products with 7000…11000 turns are accepted to carry to 21…22 class, from 11000…15000 – 23…31, and 15000…20000 – 32…34 class. In addition, the wear resistance classes of parquet board can be divided into two categories: for operation in residential areas, as well as for commercial facilities.

During the experiment, the following parameters were observed:

– sample: square 100x100 mm with a central hole 6 + -0.5 mm;
– wheels and load: H-18 Calibrade with a load of 500 grams;
– Taber Industries Abraser Refacing Disc S-11 – sandpaper;
– evaluation of the experiment: the method of weight loss.

TABLE 2. Parameters of parquet board samples before the experiment

No sample	Length L, mm	Width B, mm	Thickness h, mm	Type of paint coating
1	100	100	16	water-based varnish
2	100	100	16	alkyd varnish
3	100	100	16	oil with anti-slip effect

The specification of the samples of parquet board made of oak wood, which were used during the main series of studies are given in Table 2, a schematic representation of the test sample is shown in Fig. 2. Abrasion tests were performed for the specified number of cycles or until wear of the coating was observed. When determining the point of wear of the coating, the device was stopped at certain intervals to study the sample – its weighing.

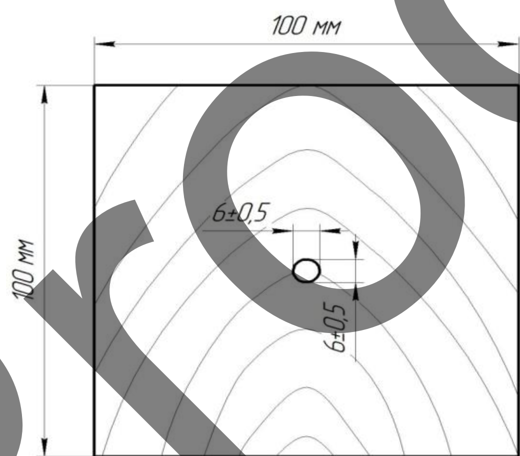

FIGURE. 2. Schematic representation of the test sample

RESULTS AND DISCUSSIONS

The process of studying the wear resistance of the surface of the parquet board using the Taber test involved the following: friction was achieved by rotating the sample in contact with a pair of rotating wheels covered with abrasive paper (Fig. 3).

The wheels are placed so that their surfaces are equidistant from the axis of rotation. The number of revolutions of the sample required to cause a certain degree of stability is used as a measure of resistance to surface wear. The meter of the device was set for 10 cycles, each of which provided 100 rotations of wheels. After each cycle, the rotating wheels with abrasive paper (sketch) were stopped to weigh the samples.

The investigated samples that have been tested for wear resistance are presented in Fig. 4. The main test results and the value of weight loss of different coating materials after the abrasion test are presented in Table 3.

FIGURE 3. The process of conducting research on wear resistance

FIGURE 4. Samples after wear resistance test

TABLE 3. Test parameters and weight loss values of different coating materials after abrasion test

No sample (material)	Sample weight, g		Weight loss, mg	Quantity cycles	Ambient temperature, ºC	Humidity of the environment, %
	before experiment	after experiment				
1	105.61	105.33	28.2	100	21.4	20.2
2	106.58	106.47	11.3	100		
3	107.21	106.97	23.6	100		

According to the data presented in Table 3, the greatest loss have samples of parquet board No.1 (28.2 mg), which were coated with water-based varnish, the least weight loss have samples No.2 (11.3 mg), which were treated with alkyd varnish.

Based on the obtained results (Table 3), the abrasion index (Taber index) of three different finishing materials was calculated. The results of the Taber index for different materials are presented in Fig. 5.

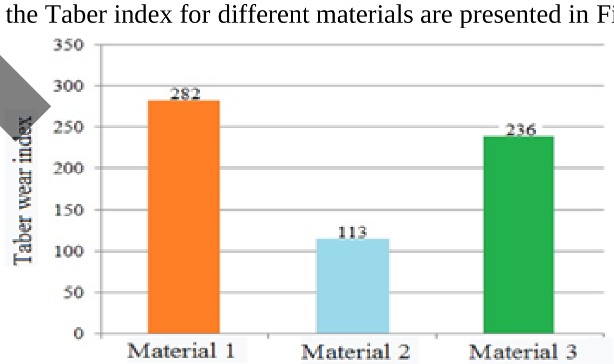

FIGURE 5. Abrasion index (Taber) of three different finishing materials

According to Fig. 5, material No.2 has the lowest wear rate. Hence, the material No.2 has the best abrasion quality with a wear index of 113 Taber, followed by the material No.3 with a wear index of 236. The highest wear rate and, accordingly, the lowest abrasion resistance according to research results has a material No.1.

According to the method of the study, after each of the erasure cycle, the test sample was weighed. Indicators of the amount of weight loss of the samples after each rotation cycle are presented in Fig. 6.

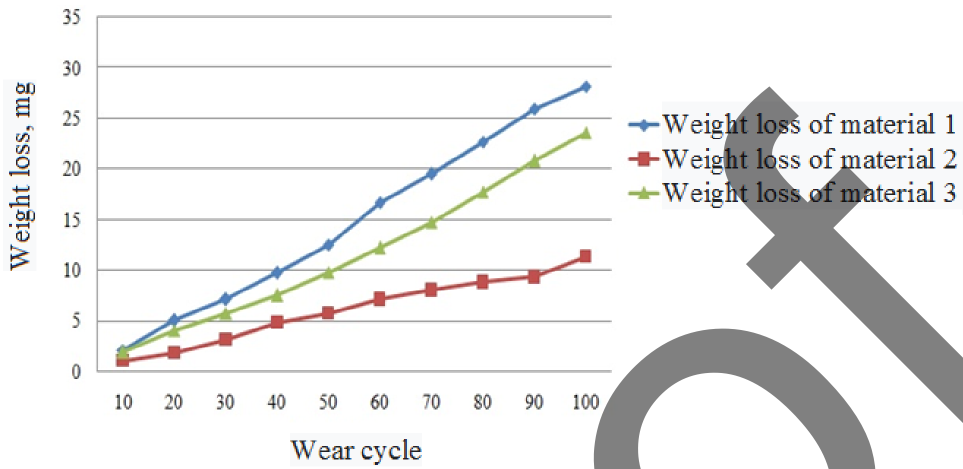

FIGURE 6. Weight loss in milligrams for every ten cycles of abrasion of three different finishing materials on samples of parquet board

From Fig. 6 shows that the material №1 shows the highest amount of weight loss for each wear cycle (28.2 mg) compared to the material) No.2 (11.3 mg) and No.3 (23.6 mg).

According to the analysis of research results presented in Table 3 and Fig. 5 it can be concluded that the parquet board is equipped with three different materials, which were tested for wear resistance (abrasion), according to a certain indicator of wear resistance regulates the use of this type of product for living spaces, bedrooms, living rooms, libraries, offices and more.

CONCLUSION

Experimental research of the Taber – test of a parquet board is a simple and effective way to define, how strong an external covering of a board. It is on how strong the protective layer depends on the protection of solid wood, the resistance of the parquet board to moisture, and most importantly – the appearance of the floor. In addition, much depends on the thickness of the parquet board, as well as the operating conditions in which to serve the floor, but usually the final service life is as close as possible to the results of Taber – test, which indicates its effectiveness.

According to the results of experimental studies to determine the coefficient of abrasion and wear resistance (Taber index) of the surface of samples of test materials, it is established that parquet board equipped with different materials corresponds to wear resistance, which refers to this type of product for use in living rooms etc.

Further research may be aimed at establishing the relationship between the components and properties of coatings and their wear resistance.

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The Role of Kaolinite Clay in the Evolution of the Structure and Properties of Slag-Alkali Cements

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Abstract. Slag-alkali cements are environmentally friendly, as they use industrial waste for their production. One of the perspective areas of control of the properties of slag cements is the introduction of complex modifying additives, which include clays of different composition and energy state. The use of such additives opens the possibility not only to control the physical and mechanical properties of cements, but also to provide them with the desired decorative effect.

Previous studies have shown that the introduction of slag cement up to 15% by weight of kaolinite clay provides a cement with a whiteness factor of ≥ 70%.

The role of kaolinite clay in the evolution of the structure and properties of white slag cement is investigated.

It is shown that the introduction of kaolinite clay in the amount of 5…10% by weight increases the water consumption from 23% to 24%, reduces the time of onset of hardening from 48 minutes. up to 45 minutes, slows down the set of strength in the initial curing period and activity at 28 days of age from 56,7 to 50,4 MPa.

But with an increase in the amount of clay to 20% by weight, the time of onset of hardening increases to 51 minutes. The introduction of clay up to 20% also helps to reduce heat dissipation from 84,2 J/g to 40 J/g.

The amount of introduced clay significantly affects the strength of cement, which with increasing its amount to 15% by weight decreases at 28 days of age from 56,7 MPa to 49 MPa, but after 90 days it exceeds the control strength without additives and is 67,5 MPa.

The study of structural processes showed that the introduction of kaolinite clay in the composition of slag-alkaline cement intensifies the binding of free alkalis in zeolite-like hydrated neoplasms such as analcim and hydronepheline.

To intensify the processes of structure formation, especially in the initial stages, the efficiency of the introduction of alkali cements up to 2% by weight of Portland cement has been demonstrated.

INTRODUCTION

Since industrial waste is used for the production of slag-alkali cements, it is associated with the instability of their composition and energy status, which can lead to unstable quality of the final product [1, 2]. Therefore, there is a need to develop effective ways to control the properties of slag alkali cements and materials based on them, which ultimately led to a range of different types of composite (hybrid) alkaline-activated cements [1, 3-9].

One of the promising areas of management of the properties of slag cements was the introduction of complex modifying additives, consisting of clays of different composition and highly active additives such as Portland cement clinker or substances containing clinker minerals [10]. In the presence of clay substances in the composition of new formations of slag-alkali cements, not only low-basic calcium hydrosilicates are synthesized, but also zeolite-like hydroaluminosilicates of alkaline, alkaline earth or mixed types. The slowing down of the processes of structure formation in the presence of clays can be compensated by the introduction of an active hydraulic additive such as clinker [10]. Thus, the use of a complex additive composition "clay + clinker" allows you to bring the control of the properties of slag-alkaline binders to a qualitatively new level.

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In particular, it has improved the quality of the pore structure of cement stone by shifting the balance of pores in the direction of increasing the proportion of micropores, thereby automatically improving a number of valuable performance characteristics such as water resistance, frost resistance, chemical resistance, durability [1, 10].

It also allowed very effective use of slag alumina cements with such a complex additive for immobilization of NPP radioactive waste, fixing in the cement matrix the most background-forming radioactive elements *Cs-134*, *Cs-137* and *Sr-90* due to their chemical binding in insoluble zeolite-like neoplasms of the pollucite type or strontium shabazite and due to the sorption properties of clays, which are significantly enhanced in the presence of an alkaline environment [1, 10-11, 23].

The use of heat-treated (fired) clays eliminates the risk of corrosion in the area of contact of the cement stone with the aggregate, which contains chemically active SiO_2 due to the formation in the contact area of a strong shell that provides high adhesion between the cement stone and the problem aggregate [12-14].

A number of works indicate the advantage of using unfired, ie less active clays in comparison with more active heat-treated ones. This is due to the need for a certain order and sequence of structural processes. So, for example, to obtain the optimal structure of slag-cement cement stone, it is necessary that first formed *CSH*-gel, then *NASH*-gel, and then carried out their interaction with each other [15]. But this order can be violated if a highly active alumina additive, such as metakaolin, is used. Therefore, for these reasons, it is better instead of metakaolin to use a less active clay additive – kaolin.

In addition, one of the new promising areas is the use of kaolin to obtain white and colored decorative slag cements [16], where the optimal amount of this additive is set, which is equal to 15%.

The role of kaolin in the structure of slag-alkaline binders is largely underestimated and requires more careful study. Previous studies [17, 18] did not pay enough attention to the study of internal processes at the level of physicochemical interaction of all components of the binder composition, which can significantly affect the level of whiteness and decorative alkaline cements.

Based on the analysis of literature data and theoretical preconditions, the aim of the work is to study the influence of kaolinite clay on the formation of the structure and properties of slag-alkali cements with the amount of kaolin additive in the range of 0…20%.

RAW MATERIALS AND RESEARCH METHODS

Blast furnace granulated slag, kaolin and Portland cement were used as aluminosilicate components of cement in the studies. The chemical composition of slag, kaolin and portlancement are presented in table 1.

Table 1. The composition of raw materials

Raw materials materials	**The content of oxides, % wt.**											**M_b**
	SiO_2	***Al_2O_3***	***CaO***	***MgO***	***FeO***	***Na_2O***	***MnO***	***TiO_2***	***SO_3***	**loss on ignition**	**Σ**	
Dniprodzerzhynsk blast furnace slag	37,90	6,85	44,6	5,21	0,31	1,13	0,11	0,35	2,6	1,34	100,4	1,11
Portlandcement OPC 52,5R	20,2	5,2	65,6	2,5	2,61	0,21	0,2	0,22	3,34	–	100,1	–
Kaolinite clay	48,77	30,94	2,62	0,8	–	1,7	–	–	0,25	13,06	–	–

The radiograph of the slag is presented in Fig. 1. Kaolin must meet the requirements of GOST 19285-73.

The slag granulation data is carried up to the main ones from Mo = 1,11 and representations in a very similar phase, which becomes 83%. Slag quality coefficient 1,49 will be added, but slag of reduced activity.

The mineralogical composition is represented by gelenite $Ca_2Al_2SiO_7$ (d = 0,286; 0,244; 0,241; 0,231; 0,176 nm), merwinite Ca_3MgSiO_8 (d = 0,264; 0,190; 0,186; 0,164 nm), rankinitis $Ca_3Si_2O_7$ (d = 0,385; 0,320; 0,302; 0,291; 0,273 nm), larnitis (d = 0,28; 0,278; 0,302; 0,260 nm) and a little quartz (d = 0,423; 0,333; 0,182; 0,155 nm).

The degree of slag grinding was 4414 cm^2/g according to Blaine. The slag was ground in a mill with alubite (high-alumina) grinding bodies and lining.

As an alkaline component of slag alkaline cements was used non-hygroscopic sodium metasilicate pentahydrate in powder form – $Na_2O \cdot SiO_2 \cdot 5H_2O$ and soda ash anhydrous $Na_2O \cdot CO_3$.

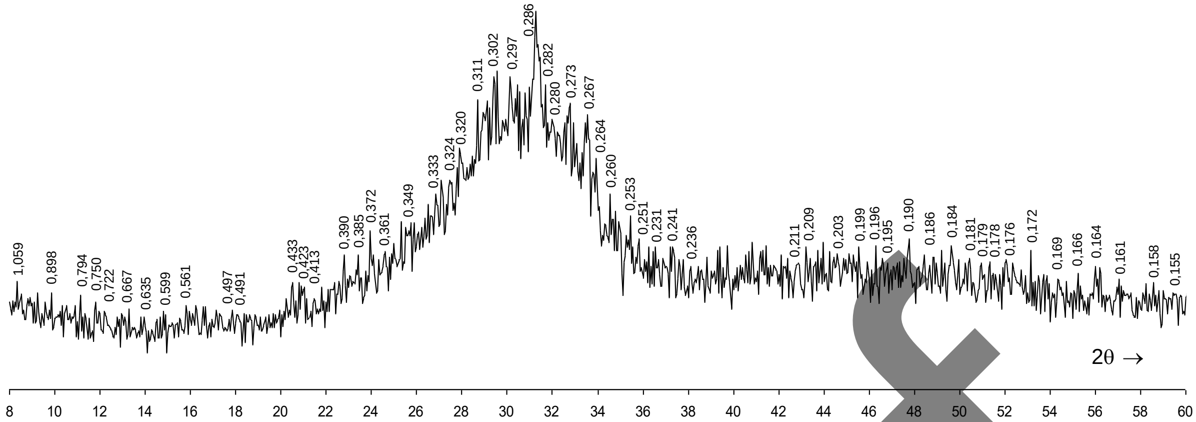


Figure 1. X-ray diffraction pattern of Dniprodzerzhynsk blast-furnace granulated slag

Portland cement class OPC 52,5 R with a clinker content of 95% was used as a modifying additive. Enriched kaolin class KN-84 was used as a bleaching additive (GOST 19285-73 Concentrated kaolin for the production of paper and cardboard. Technical conditions).

Preparing the sum of the viscous in the traditional way – by the way of mixing with water the viscous composition "slag + tin component + additives".

The phase storage of rivers was started for the additional X-ray phase analysis by the powder method from the microscope of the diffractometer. Product identification in hydration was carried out using the PDF-2 Data Base (type 1-50 plus 70-88) with the JCPDFWIN 2.1 software module (JCPDS-ICDD 2000).

Thermal imaging of hydrated cement composites started after an additional installation, the principle diagram of which is shown in Fig. 2.

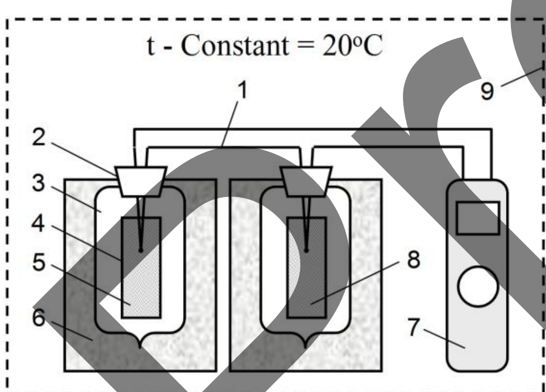


Figure 2. Scheme of installation for determining the heat of hydration of cement by thermal method:
1 – differential thermocouple; *2* – stopper; *3* – Dewar vessel; *4* – vessel for cement dough or mortar; *5* – cement paste or cement-sand mortar; *6* – thermal insulation; *7* – a device for recording indicators with a given frequency; *8* – cement dough model; *9* – closed volume (thermostat) with thermo-stabilized temperature

A feature of the installation is the use of a standard model of cement test, in which the cement is replaced by finely ground inert material having similar characteristics in terms of heat capacity. Finely ground quartz sand is used as such material. The data recorded on the device *7* was then used to digitally construct the temperature curve of heat dissipation on a computer.

Comprehensive differential thermal analysis was performed on a derivatograph Paulik-Erdey, MOM (Hungary). Maximum heating temperature – 1000°C. Calcined technical alumina was used as a reference. Data were used for identification [19, 20].

The distribution of elements in the samples was determined using a scanning scanning electron microscope with a microanalyzer REMA 102-02.

RESEARCH RESULTS AND DISCUSSION

Strength

Figure 3 illustrates the dependence of the strength of alkali cements on the content of kaolin additives. It was found that the presence of 2,5...5% kaolin has almost no effect on activity in standard time. Increasing the kaolin content from 5 to 10% increases the water consumption of cement paste from 23% to 24%, reduces the hardening time from 54 minutes. up to 45 minutes, slows down the set of strength in the initial curing time and activity at 28 days of age from 56,7 to 52,8 MPa.

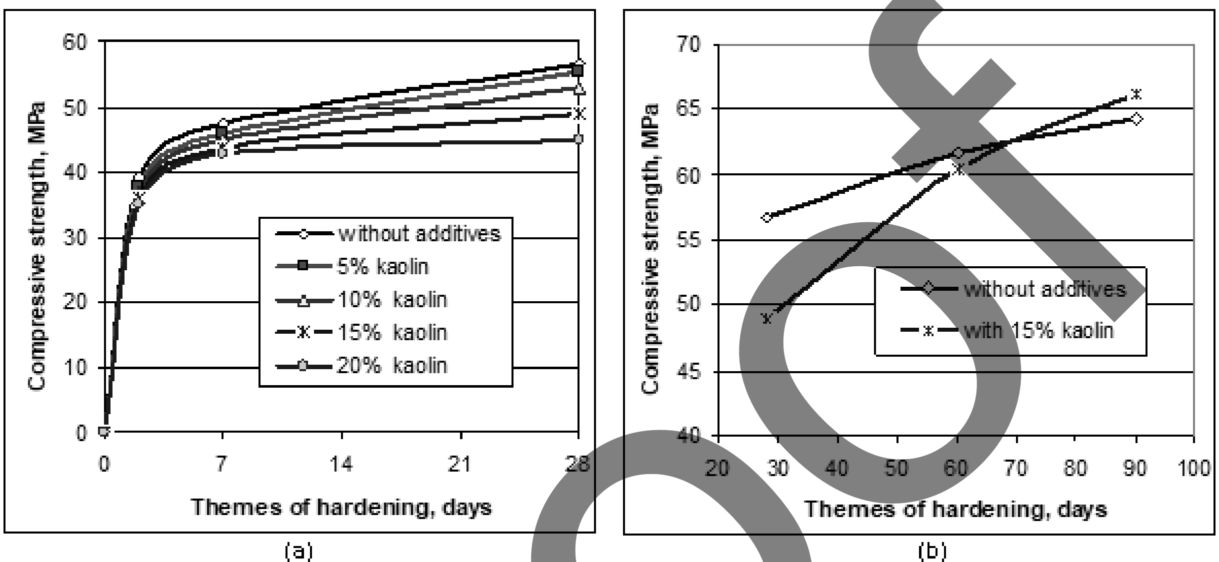


Figure 3. Dependence of strength of alkali cements on their kaolin content:
a – in standard terms; *b* – in the longer term

The introduction of the addition of clinker in the optimal amount allowed to eliminate this shortcoming and increase the level of acceptable amount of kaolin in the slag cement to 15%. For example, if the strength of slag alumina cement without additives for 28 days was 56,7 MPa, with the addition of 15% kaolin – 49 MPa, then with the addition of 2% Portland cement in the presence of 15% kaolin strength in standard terms increased to 54,3 MPa. Increasing the amount of kaolin additive to 20% reduces the strength to 44,9 MPa and is not acceptable.

It should also be noted the rapid dynamics of strength of all compounds, regardless of the content of kaolin additives. Thus, all compounds after 7 days had a strength of 83,6…95,5% of the strength after 28 days (Fig. 3, *a*).

Since part of the alkali binds to kaolin, the standard strength of samples activated by alkali is slightly lower (7...12%) compared to samples made of cement without additives. However, after 6...9 months this difference disappears and higher strength is achieved due to the deepening of hydration processes, synthesis of hydrates of low-basic calcium silicates, synthesis of zeolite and feldspar analogues and absence of destructive processes (Fig. 3, *b*).

The use of soda ash as an alkaline component instead of sodium metasilicate reduces the quality of cements from M400... M500 to M300...M400.

Setting time

Figure 4 shows that an increase in the content of kaolin in the slag-alkaline composition up to 10% leads to a reduction in the time of the onset of setting. But a further increase in the amount of kaolin additive increases the setting time.

It is possible that 10% – is a certain maximum amount of kaolin, which is able to actively interact with the alkaline component at the early stages of structure formation (up to 1…2 hours). Excess kaolin (more than 10%) in a given period of time is already ballast and a reserve for interaction in more distant periods.

The introduction of the Portland cement additive in the optimal amount somewhat reduces the setting time

(Fig. 4). The optimal amount of portlane cement clinker depends on the basicity of the slag and is determined by the empirical formula [21]:

$$D_{kl} = -10 \cdot M_b + 13, \ \%$$

where D_{kl} – the optimal amount of clinker additive, %; M_b – slag basicity modulus.

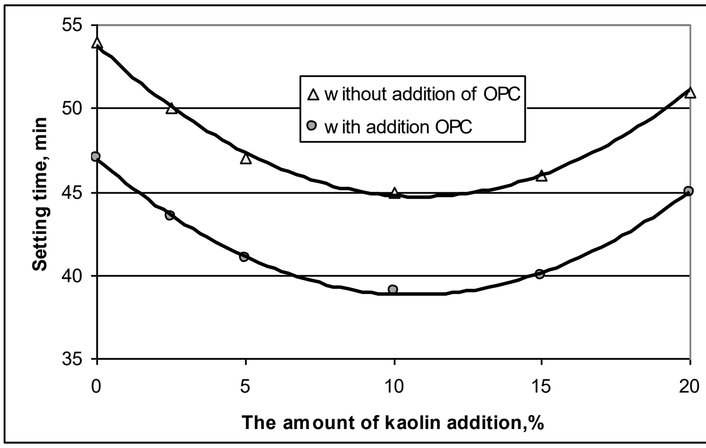


Figure 4. Dependence of the setting time on the amount of kaolin addition and Portland cement addition in the binder system "slag + kaolin + additives + sodium metasilicate"

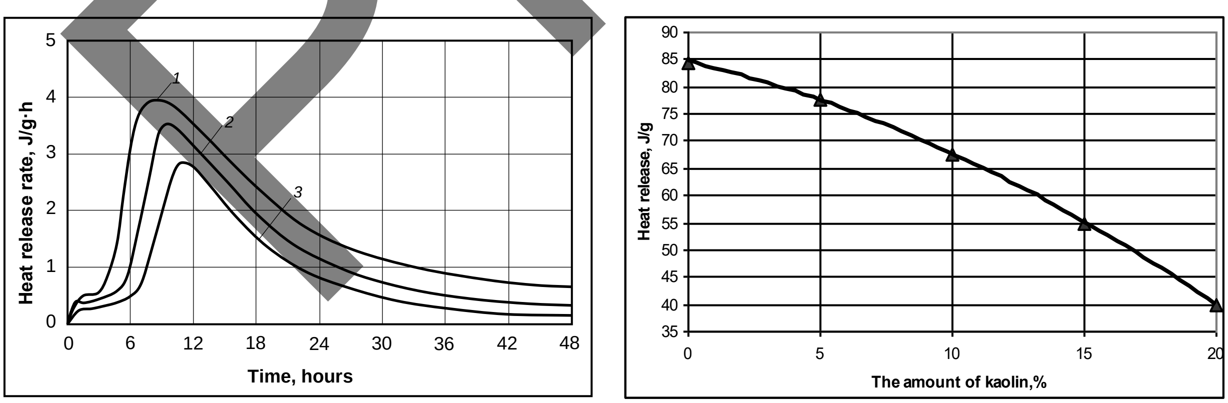
Given that the basicity of the slag is equal to M_b = 1,11, the optimal amount of clinker additive will be 1,9%. And taking into account 95% of clinker in Portland cement, the amount of Portland cement additive will be 1,9 / 0,95 = 2%.

Heat dissipation

Figure 5 presents the heat curves of slag-alkali cements depending on their kaolin content.

When mixing slag-alkaline binders with water, heat generation begins almost immediately, the nature of which is associated with chemisorption processes, dissolution (dispersion) of slag glass with the formation of alkaline colloidal sols, their spontaneous coagulation and the formation of the structure of the binder system.

It can be seen that as the addition of kaolin is added, the heat release of the binder composition decreases (Fig. 5, *b*), and the maximum peaks of heat release, in comparison with the composition without the additive, shift from 8 to 11 (Fig. 5, *a*). The total heat release is reduced by more than two times – from 84,2 J/h (without additive) to 40,0 J/g (with the addition of 20% kaolin). This occurs, firstly, due to a decrease in the proportion of slag in the composition and, secondly, due to the partial binding of alkali by kaolin.



(a) (b)

Figure 5. Heat release of slag-alkali cement compositions:
a – is the rate of heat release; *b* – heat release; alkaline component – sodium metasilicate (10%);
1 – without kaolin addition; *2* – with the addition of 10% kaolin; *3* – with the addition of 20% kaolin

Study of the phase composition of the binder composition "slag + kaolin + sodium metasilicate"

Depending on the degree of whiteness, white clinker Portland cement is divided into three grades: I ≥ 80%, II ≥ 75%, III ≥ 70% [22].

Proceeding from the fact that 15% of the addition of kaolin is the amount that provides that level of whiteness of slag-alkaline cements of 70.5% [16], which allows them to be classified as white cements and at the same time provides a sufficiently high strength (especially with the optimal amount of addition of Portland cement), we take the amount of kaolin addition in 15% as a base in further studies of the structure formation of white slag-alkaline cements.

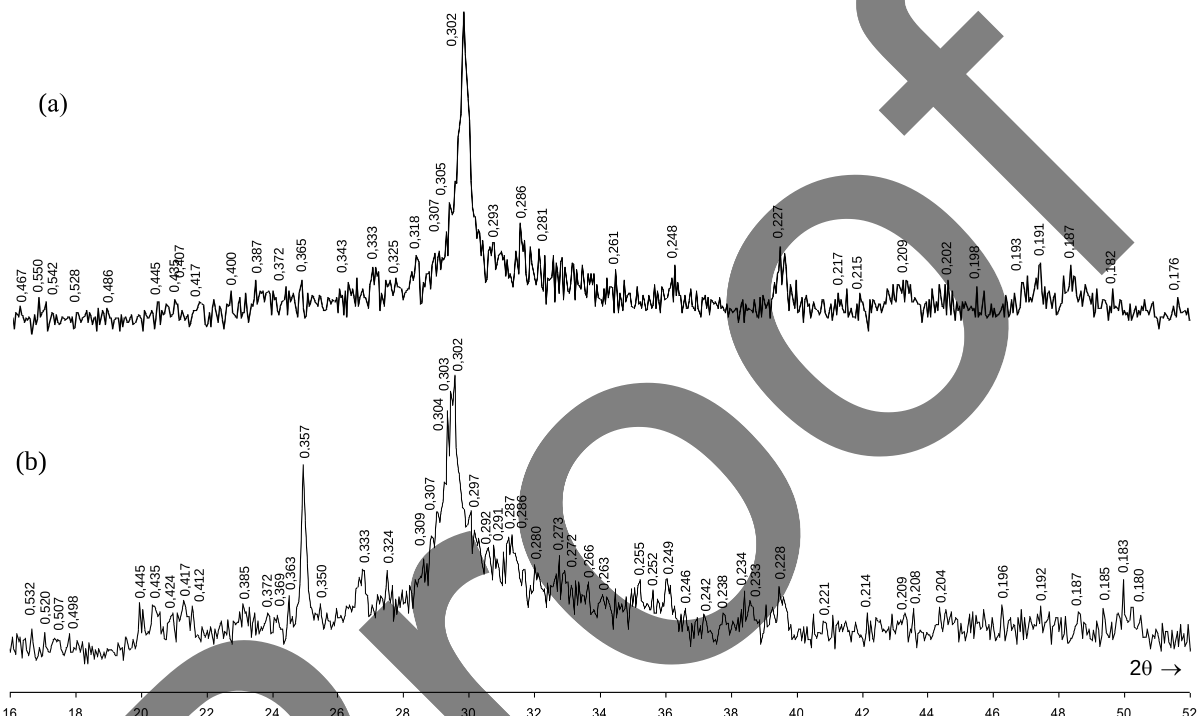


Figure 6. Radiographs of slag-alkaline cements at the age of 28 days:
a – composition "slag + sodium metasilicate"; *b* – composition "slag + kaolin (15%) + sodium metasilicate"

According to the data of X-ray phase and differential thermographic analysis (Fig. 6, Fig. 7), the phase composition of hydrated neoplasms of the composition "slag + kaolin + sodium metasilicate" is represented by tobermorite gel (d – 0,305; 0,28; 0,18 nm), *CSH(B)* (d – 0,304; 0,28; 0,180 nm), tobermorite (d – 0,333; 0,307; 0,297; 0,286; 0,214; 0,201; 0,182 нм), calcite (d – 0,385; 0,303; 0,249; 0,228; 0,209; 0,192 nm), weak diffraction of analcime (d – 3,43; 2,92; 0,286; 0,272; 2,52; 1,74 nm) and hydronefelin (d – 0,467; 0,435; 0,407; 0,385; 0,369; 0,343; 0,297; 0,283; 0,259 nm). The amount of analcime and hydronepheline, according to [1], will constantly increase over time. Slag phases that have not reacted, represented by gehlenite (d – 0,286; 0,242; 0,228 нм) and quartz (d – 0,424; 0,333; 0,183 nm). diffraction (d – 0,435; 0,417; 0,385; 0,357; 0,309; 0,234 nm) belong to kaolinite.

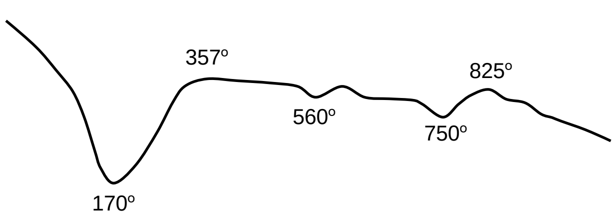


Figure.7. DTA curves of the binder composition "slag + kaolin (15%) + sodium metasilicate" at the age of 28 days

The endopikes on the DTA curve at a temperature of 170°C indicate the loss of physically bound water, and at 560°C, they indicate the dehydration of kaolin. The final dehydration of low-basic calcium hydrosilicates with their transformation into *CS* (wollastonite) is fixed by an endopic at 750°C. Exopic and endopic at 825°C may indicate recrystallization of *CSH(B)* and tobermorite with isomorphic substitution of Si^{4+} for Al^{3+}.

Study of the degree of free alkali binding in the composition "slag + kaolin + sodium metasilicate"

Using a scanning electron microscope with microanalyzers, we analyzed the distribution of elements and oxides in the center of the sample (at three points) and on its surface (at three points). The data obtained in the center of the sample and on the surface were averaged.

Analysis of the distribution of elements in the sample of the composition "slag + kaolin (15%) + sodium metasilicate" in the center and on its surface shows that the presence of kaolin has a positive effect on the degree of free alkali binding into insoluble hydrhanes of the neoplasm (Fig. 8, Fig. 6).

Kaolin has weak acidic properties and therefore significantly increases its cation exchange capacity in an alkaline medium [23].

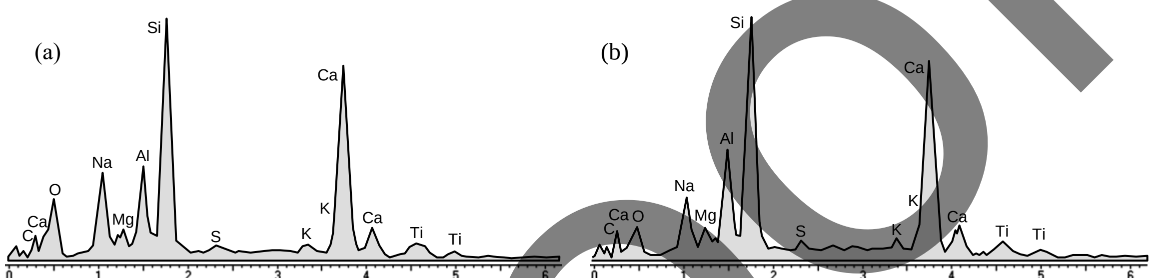


Figure 8. Distribution of elements in a cement paste sample of the composition "slag + kaolin (15%) + sodium metasilicate":
a – in the center of the sample; *b* – on the sample surface

Thus, the amount of Na_2O = 22,02% in the center of the sample and 14,2% on the surface of the sample indicates the absence of mass transfer of free alkali from the center to the periphery. This may mean that in the center of the sample there is a fairly active chemical binding of alkali in hydroaluminosilicate neoplasms such as analcime and hydronepheline, which is confirmed by X-ray phase analysis (Fig. 6) and significantly reduces the risk of efflorescence.

The presence of CO_2 = 3,6% in the center of the sample and 9,72% at the periphery may indicate the carbonization of calcium hydrate neoplasms with the effect of additional bleaching of the sample along the surface.

The distribution of elements in a slag-alkali cement stone without additives is shown in Fig. 9.

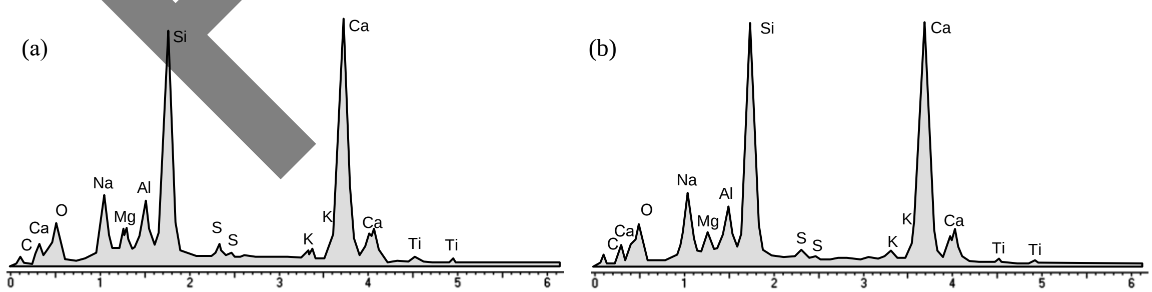


Figure 9. Distribution of elements in a cement paste sample of the composition "slag + sodium metasilicate":
a – in the center of the sample; *b* – on the sample surface

The presence of 17,7% Na_2O in the center of the sample and 19,9% Na_2O on the surface of the sample indicates a relatively small risk of efflorescence.

CONCLUSIONS

The paper investigates the role of kaolinite clay in the evolution of the structure and properties of white slag-alkaline cement.

It is shown that the introduction of kaolinite clay into the composition of the cement in an amount of 5...10% by weight increases the water demand from 23% to 24%, reduces the setting time from 48 minutes. up to 45 minutes, slows down the set of strength in the initial periods of hardening and activity at 28 days of age from 56,7 to 50,4 MPa.

With an increase in the amount of clay to 20% by weight, the time for the onset of setting increases to 51 minutes.

The introduction of clay up to 20% also helps to reduce heat release from 84,2 J/g to 40 J/g.

The amount of injected clay significantly affects the strength of the cement, which, with an increase in its amount to 15% by weight, decreases at 28 days of age from 56,7 MPa to 49 MPa, but after 90 days it exceeds the control strength without additive and is 67,5 MPa.

The study of the processes of structure formation showed that the introduction of kaolinite clay into the composition of slag-alkaline cement intensifies the binding of free alkalis in zeolite-like hydrated neoplasms such as analcime and hydronefelin.

To intensify the processes of structure formation, especially at the initial stages, the efficiency of introducing into the composition of slag-alkaline cements up to 2% by weight of Portland cement has been demonstrated.

ACKNOWLEDGEMENTS

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Resistance Of Protective Coating Based On Alkali-activated Aluminosilicate Binder To Influence Of SO_4-containing Medium

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Abstract. The paper is devoted to counteraction of SO_4^{2-} ions transport in concrete, exploited in sulfate mediums, for prevention of steel reinforcement corrosion. Protective surface coating based on alkali-activated aluminosilicate binder was proposed as a mean to restrict SO_4^{2-} ions transport in concrete. It was shown that the coating with thickness of 3 mm ensures total concrete protection. It was revealed that permeability of concrete depending on cation decreases in the row $(NH_4)_2SO_4$>Na_2SO_4>$MgSO_4$. The work of protective coating was simulated by adding of specified salts in the binder. Decreasing of pH values of water extracts during hydration of binder while using of 2.5 % $MgSO_4$ is evidence of advanced crystallinity of zeolite-like sulfate-containing hydroaluminosilicates with participation of Mg^{2+} ions equal to Ca^{2+} ions. While content of $(NH_4)_2SO_4$ was increased up to 5.0 % less pH was fixed due to decelerated formation of other zeolite-like minerals. Stability of pH values in presence of Na_2SO_4 (0.5…2.5 %) was caused by no influence on structure formation. Thus, the restriction of SO_4^{2-} ions transport in protective coating is due to their binding by alkaline aluminosilicate binder in zeolite-like minerals with higher crystallinity in presence of Na^+, NH_4^+ and Mg^{2+} cations from sulfates.

INTRODUCTION

Durability of reinforced concrete is one of the main demands in building production. Operating conditions, particularly in aggressive mediums, determine durability of constructions. Engineering constructions in chemical and energy industries, seaports, bridge foundations, tunnels etc. undergo the most destructive influence [1-3]. Sewage systems as well as drainage systems of bridges and mega-cities are exploited in aggressive conditions [4]. Still near 75 % of concrete constructions undergo destructive influence of aggressive mediums [5].

Sulfate mediums are among the most aggressive ones which cause steel reinforcement corrosion. This is because the presence of sulfates in almost all natural and sewage waters [6, 7]. It was shown that penetration of sulfate-ions in concrete is determined by cation in sulfate salt [8]. Sulfate-ions don't cause depassivation of steel reinforcement, but determine formation of hydrogen sulfide (H_2S), which catalyze oxidation (carbonation) of hydrates. Obviously, this effect is accompanied by less pH values of pore water as the main factor for stability of passive film on the surface of steel reinforcement [9].

The modern requirements for high consistency fresh concretes are governed by practice. This way the disturbance of reinforcement passive state can be caused by changes in hardened concrete especially in aggressive mediums. Thus, the restriction of SO_4^{2-} ions transport in concretes, which are obtained from high consistency fresh mixes and exploited in sulfate mediums, can be considered as an actual problem [10, 11].

Restriction of SO_4^{2-} ions transport in reinforcement concrete structures can be achieved due to their binding by hydrated phases of cements. Hydrosilicate C–S–H and hydroaluminosilicate C–A–S–H gel phases of portland cement are characterized by chemical adsorption [12, 13]. Sulfate-ions can be also chemicaly binded due to

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participation of tricalcium aluminate (C_3A) and fourcalcium alumoferrite in formation of *AFm* phases (Al_2O_3-Fe_2O_3-mono), which are able to include different anions [14, 15].

Durability of reinforcement concrete structures can be increased due to application of cements containing ground blast furnace slags (further, GBFS). Such cements conform the modern tendencies in construction engineering [16, 17, 18]. Their ecological benefits are based on less CO_2 emission [19] due to application of by-products as well as waste products [20]. Formation of *AFm* phases can be enhanced due to GBFS in cement in view of higher Al_2O_3 content [21]. *AFm* phases are characterized by advanced binding capacity if compare with calcium hydrosilicates [22].

Alkali-activated slag cements (further, AASC's) are the most perspective ones to ensure durability of reinforced concrete in sulfate mediums [23, 24]. The ecological benefits of AASC's are caused not only by reduction of CO_2 emission, but also by possibility to use radioactive wastes [25, 26] and manufacturing waters [27] in safety building materials. SO_4^{2-} ions are binded in AASC's by hydrosilicate C–S–H and hydroaluminosilicate C–A–S–H gels as well as by alkaline hydroaluminosilicates, which are analogues of natural zeolites [23, 28]. The mean to restrict aggressive ions in pore water due to binding by *AFm* phases in AASC was developed [29].

Advanced densification of structure due to surfactants is also known for minimization of SO_4^{2-} ions transport in concrete is [10]. Nowadays the most effective water-reducing surfactants for portland cement systems are polyesters [30]. However, increasing slag in cement leads to minor effectiveness of specified surfactants [31] and to its total loss in case of AASC [32]. The principles for choice of surfactants and complex admixtures based on them were proposed: plasticizers [33], for mitigation of drying shrinkage [34, 35, 36], for expansion [37, 38] etc.

Specified means for restriction of SO_4^{2-} ions transport in reinforced concrete structure should be taken account and used comprehensively while building of constructions. However, protective coatings, which prevent penetration of aggressive ions in concrete and ensure passive state of steel reinforcement, are used for protection of already constructed structures. There are different types of protective coatings: for covering of concrete surface; for sealing the surface with densification of porous structure; for impregnating [39]. For instance, water solutions of chlorides, nitrates and sulfates of alkaline-earth metals (Mg^{2+}, Zn^{2+}, Mn^{2+}, Cu^{2+}, Ni^{2+}) which can bind free alkali in insoluble compounds, ensure densification and advanced impermeability can be used in AASC's concretes [23, 40].

Inorganic protective coatings based on alkali-activated binders for prevention of aggressive ions transport in concrete and ensuring the passive state of steel reinforcement are known [41]. Protective coatings based on alkali-activated aluminosilicate binder with advanced durability due formation of analogues of natural zeolites and feldspathoids were proposed [23]. High performances, water resistance and durability of protective coatings based on alkali-activated aluminosilicate binder with formula $(0.8Na_2O+0.2K_2O)\cdot Al_2O_3\cdot 4.5SiO_2\cdot nH_2O$ are provided due to formation of zeolite-like hydrated phases as sodium та potassium heulandite ($Na_6Si_{27}Al_{36}O_{72}\cdot 24H_2O$ and $K_6Si_{27}Al_{36}O_{72}\cdot 24H_2O$ agreeably), phillipsite ($3Al_6Si_{10}O_{32}\cdot 12H_2O$), chabazite ($Al_2Si_4O_{12}\cdot 6H_2O$) and faujasite $(Na_2,Ca,Mg)_{3.5}(Al_7Si_{17}O_{48})\cdot 32(H_2O)$ [42]. Oxides ratios in the binder should be $SiO_2/Al_2O = 4.5$ and $R_2O/Al_2O_3 = 1.0$ to ensure necessary direction in structure formation [43].

It can be predicted that, while interaction of the mentioned coating with sulfate mediums, zeolite-like minerals will bind SO_4^{2-} ions and ensure their less penetration in protected concrete.

Thus, the aim of this research was to investigate the possibility of restriction SO_4^{2-} ions transport in concrete which is exploited in high aggressive sulfate mediums by protective coating based on alkali-activated aluminosilicate binder.

RAW MATERIALS AND TESTING TECHNIQUES

Alkali-activated aluminosilicate binder with formula $(0.8Na_2O+0.2K_2O)\cdot Al_2O_3\cdot 4.5SiO_2\cdot nH_2O$ was used in protective coating.

Aluminosilicate components of the binder were presented by:

- metakaolin (Ukraine) (by mass, %: CaO – 0.27, SiO_2 – 53.67, Al_2O_3 – 43.61, Fe_2O_3 – 0.77, Na_2O – 0.25; loss on ignition – 0.50 %), specific surface= 800 m^2/kg (by Blaine);
- tripoli powder (Ukraine) (by mass, %: CaO – 0.86, SiO_2 – 88.40, TiO_2 – 2.10, Al_2O_3 – 6.40, Fe_2O_3 – 3.25, MgO – 0.98, Na_2O – 0.69, SO_3 – 0.40; ignition loss – 0.20 %), specific surface= 800 m^2/kg (by Blaine);
- fly-ash (Ukraine) (by mass, %: CaO – 2.86, SiO_2 – 50.94, TiO_2 – 0.94, Al_2O_3 – 24.56, Fe_2O_3 – 13.25, MgO – 1.98, Na_2O – 0.69, SO_3 – 0.40; ignition loss – 1.64 %), fr. ≤ 0.16 mm.

Alkaline component of the binder is presented by sodium water glass, modulus M_s= 2.8, density= 1430 кg/m^3.

Quartz sands fr. 0…0.315 та 0.315…0.63 mm were used as fillers.

Complex additive, consisting $Na_3PO_4 \cdot 12H_2O$ (according to CAS № 7601-54-9) and sodium gluconate (according to CAS 527-07-1), was used to ensure consistency and workability retention time of fresh mortar.

Carboxymethyl cellulose («Gabrosa HV» AkzoNobel, Netherlands) for water-retaining capacity of fresh mortar was used.

Liquid and dry constituents of alkali-activated aluminosilicate coating were prepared separately. Liquid constituent (alkaline solution) consists of sodium water glass and water. Dry state constituent consists of all components of the binder. Liquid and dry constituents were mixed in mixer Hobart type.

Protective coating was covered on side surfaces of fine concrete specimens 40x40x160 mm (portland cement:sand – 1:3, W/C ratio= 0.5).

Effectiveness of protective coating was evaluated by penetration depth of sulfate-ions from aggressive mediums in structure.

The coatings were covered on side surfaces of hardened concrete specimens providing different thickness of layer (1, 2, 3 mm) and stored during 28 d at t= 20 ± 2 °C and R.H. = 95 ± 5 %. Then the specimens, both protected and unprotected ones, were placed vertically in water (the reference specimens) and aggressive water solutions of sodium, magnesium and ammonium sulfates (concentration – 30000 mg/l by SO_4^{2-} ions). The exposure class of aggressive mediums was XA3 according to EN 206-1.

After 360 d in aggressive solutions the specimens were sliced to determine penetration of sulfates from aggressive mediums. The penetration depth of SO_3 groups by mean of electronic microscope with microanalyzer was defined.

The exploitation of protective coating in sulfate mediums was simulated by adding of specified salts in alkali-activated aluminosilicate binder. Changes in pH of water extracts from the binder modified by sulfates during early four hours of hydration were investigated. Measurements were realized by mean of laboratory apparatus «EZODO PL-700AL» for analysis of water parameters.

Microprobe analysis was carried out by electronic microscope with microanalyzer REMMA 102-02.

RESULTS AND DISCUSSIONS

The influence of aggressive medium on penetration depth of sulfate-ions in structure is shown (Fig.1). Penetration of sulfate-ions in unprotected concrete was 5.8…7.6 mm depending on cation whilst in protected one was 0.1…1.5 mm depending on thickness of coating.

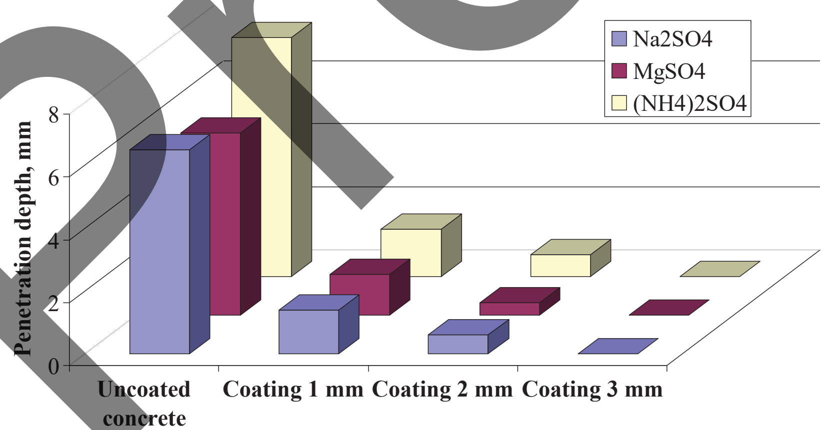
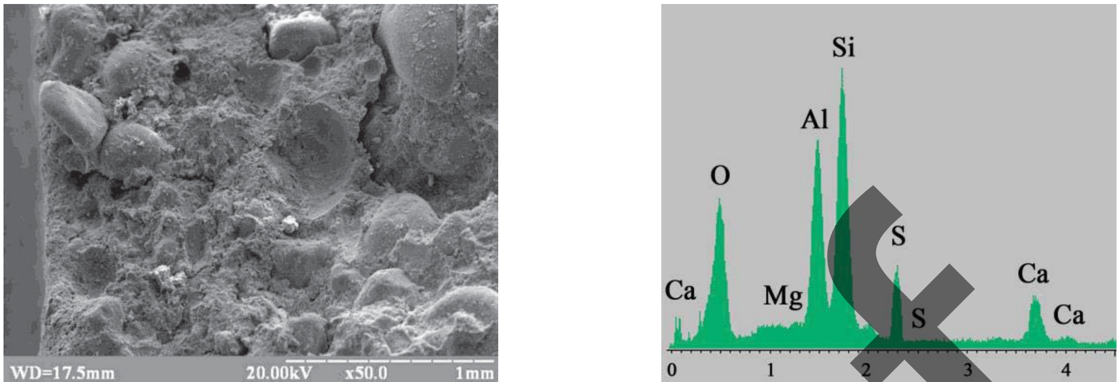


FIGURE 1. Penetration of sulfates in concrete after 360 d

It was revealed that coating with thickness of 1 mm determines penetration depth in the limits of 1.3…1.5 mm. According to microprobe analysis, increasing thickness of coating up to 3 mm ensure ions transport in concrete structure as impossible. Thus, sulfate content at depth of 1 mm for unprotected concrete was 4.0 % by SO_3 (Fig.2) while for protected by 3 mm coating ones it was 0.0 % (Fig.3).

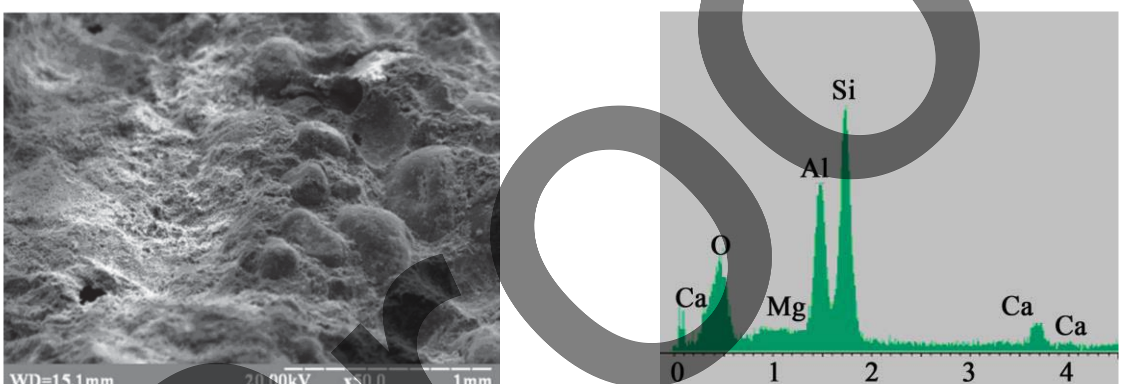
According to results, penetration of protected concrete regarding to sulfate-ions decreases in row $(NH_4)_2SO_4$>Na_2SO_4>$MgSO_4$ that is caused by different chemical activity of cation.

Binding of SO_4^{2-}, NH_4^+, Mg^{2+} ions in structure of zeolite-like phases while interaction of sulfate mediums with protective coating was confirmed by the changes of pH of water extracts (Fig.4).



(a) (b)

FIGURE 2. Microstructure of the unprotected concrete specimen after storing during 360 d in solution of sodium sulfate: (a) – SEM images; (b) – microprobe analysis



(a) (b)

FIGURE 3. Microstructure of the protected concrete (coating 3.00 mm) after 360 d in solution of sodium sulfate: (a) – SEM images; (b) – microprobe analysis

Thus, 2.5 % of $MgSO_4$ defines decreasing of pH values comparing with the reference binder (Fig.4 a). This is evidence of intensified hydration of alkali-activated aluminosilicate binder and crystallization of zeolite-like hydroaluminosilicates at normal temperature. Mg^2 ions equally to Ca^{2+} ions participate in formation of mentioned hydrates with binding of sulfate-ions. The admixture of $(NH_4)_2SO_4$ causes decreased pH values while its content is 5.0 % already. That is evidence of the same direction in structure formation, but delayed in view of lesser concentration of alkaline-earth metals and formation of another types of zeolite-like minerals (Fig.4 b). The admixture of Na_2SO_4 almost doesn't change the intensity of structure formation in view of no cation exchange, that is confirmed by stability of pH values while concentration is ranged from 0.5 % to 2.5 % (Fig.4 c).

The resistance of protective coatings based on alkali-activated aluminosilicate binder in sulfate mediums can be explained by formation of zeolite-like phases containing SO_4^{2-}, NH_4^+, Mg^{2+} ions. Thus, exchange of OH^- anions to SO_4^{2-} anions causes formation of such minerals as cancrinite $(Na,Ca)_8(Al_6Si_6)O_{24}(CO_3,SO_4)_2{\cdot}2H_2O$, biachellaite $(Na,Ca,K)_8(Si_6Al_6O_{24})(SO_4)_2(OH)_{0.5}{\cdot}H_2O$, franzinite $(Na,K)_6Ca_2(Al_6Si_6O_{24})(SO_4)_2{\cdot}0.5H_2O$ etc. In one's turn, exchange of Na^+ cations by NH_4^+ and Mg^{2+} cations can lead to formation of ammonium-heulandite $[(NH_4)_2Ca]_2Al_4Si_{14}O_3{\cdot}12H_2O$, ammonium-chabazite $[(NH_4)_2Ca]Al_2Si_4O_{12}{\cdot}6H_2O$, ammonium-thomsonite $(Na,NH_4)Ca_2[Al_5Si_5O_{20}]{\cdot}6H_2O$, faujasite-Mg $(Mg,Na_2,Ca)_{3.5}[Al_7Si_{17}O_{48}]{\cdot}32H_2O$, chabazite-Mg $(Mg_{0.7}K_{0.5}Ca_{0.5}Na_{0.1})[Al_3Si_9O_{24}]{\cdot}10H_2O$ and ferrierite-Mg $(Mg,Na_2,K_2,Ca)_{3\text{-}5}Mg[Al_{5\text{-}7}Si_{27.5\text{-}31}O_{72}]{\cdot}18H_2O$ [44].

According to electron microscopy, restriction of SO_4^{2-} ions transport is caused not only by their binding by zeolite-like phases, but also due to advanced crystallinity of structure in presence of Na^+, NH_4^+ and Mg^{2+} cations (Fig.5, 6).

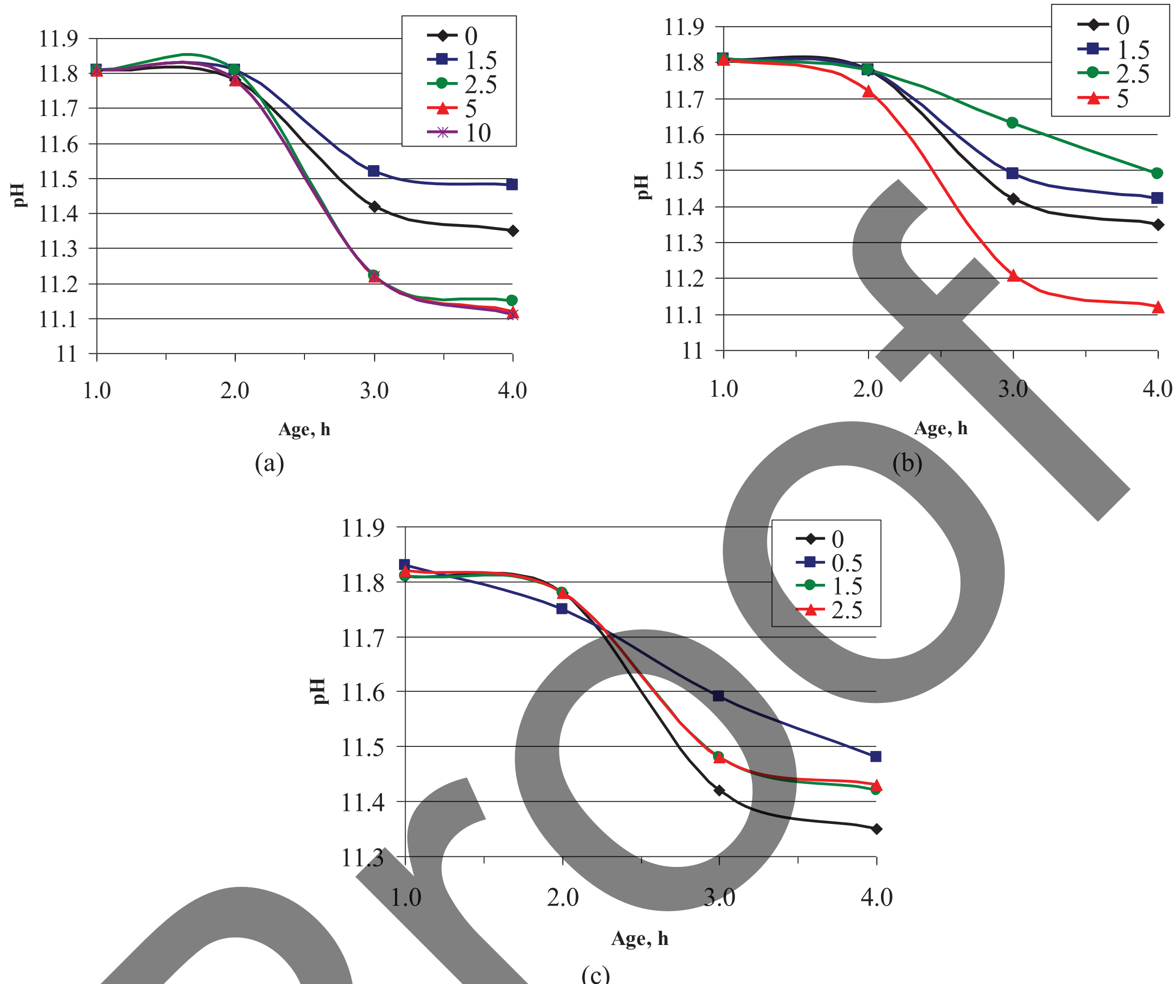
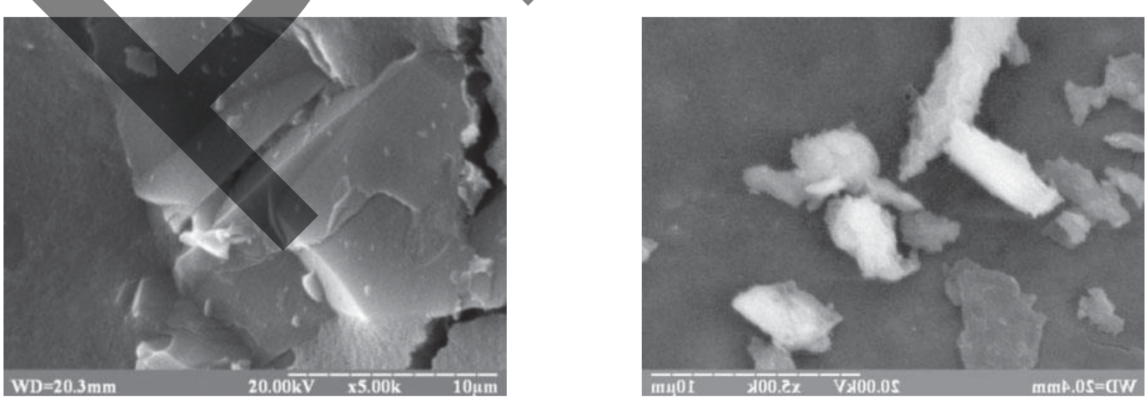
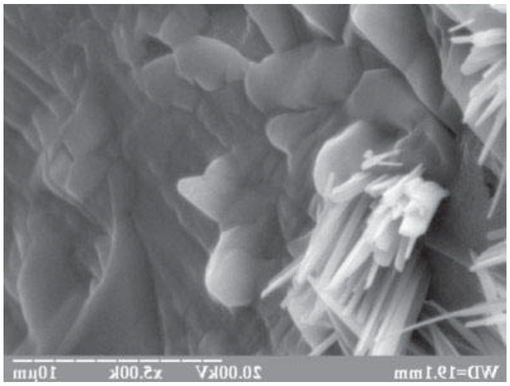


FIGURE 4. Influence of $MgSO_4$ (a), $(NH_4)_2SO_4$ (b) i Na_2SO_4 (c) on pH values of water extracts from alkali-activated aluminosilicate binder

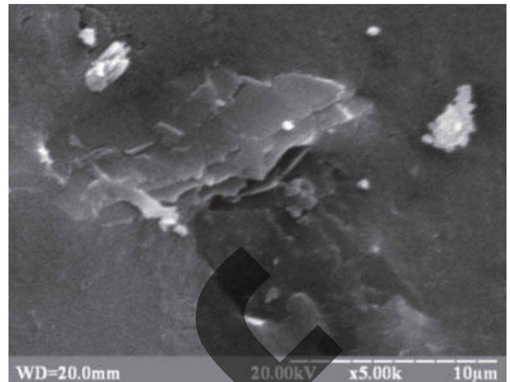


(a) (b)

FIGURE 5. SEM images of alkali-activated aluminosilicate binder: the reference (a) and modified by 2.5 % of magnesium (b) after hardening during 180 d



(a)



(b)

FIGURE 6. SEM images of alkali-activated aluminosilicate binder, modified by 2.5 % of ammonium (a) and sodium sulfates (b) after hardening during 180 d

(a)

(b)

(c)

(d)

FIGURE 7. The surface of foundation concrete: (a), (c) - without covering; (b), (d) – protected by coating

An application of the investigated protective coatings was realized while reconstruction of Kyivo-Pechers'ka Lavra's for protection of foundation, which undergo influence of sulfates according to exposure class XA3 (Fig.7). As provided by inspection, the state of coatings (strengthening, absence of cracks, no traces of leakage or extraneous inclusions etc.) and its performances (adhesion) are in compliance with mandatory requirements [45, 46].

CONCLUSION

1. Restriction of sulfate-ions transport in concrete, which is exploited in high aggressive mediums, is possible due to covering by protective coating based on alkali-activated aluminosilicate binder as the mean for steel reinforcement protection.
2. Total protection of concrete in the absence of traces of SO_4^{2} ions transport can be ensured by 3 mm of the coating. Transport properties of concrete regarding sulfates decrease in the row $(NH_4)_2SO_4$>Na_2SO_4>$MgSO_4$, that is explained by chemical activity of cation in these salts.
3. Less SO_4^{2-} ions transport is caused both by their binding in zeolite-like phases with additional increasing crystallinity in presence of Na^+, NH^{4+}, Mg^{2+} cations and by their occluding in already formed structure of the protective coating.

ACKNOWLEDGMENTS

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Influence of Organic Warm Mix Additives on Properties of Air Blown Pavement Bitumen

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Abstract. Last two decades a lot of attention all over the world was concentrated on reducing of asphalt concrete mixing and compaction temperatures. Due this the warm asphalt mixtures with organic additives became wide spread. Producers of these additives claim the reducing of the mixing and compaction temperatures up to 20 – 30 °C with their products using. As a result of the temperature decreasing the pollution of the environment on asphalt plant can be significantly reduced. The aim of this work is to assess the effect of warm mix additives (Sasobit, Licomont BS 100, Sarawax SX105) on air blown pavement bitumens. With the experiment results it was found that these additives structure bitumen, which leads to penetration decreasing, softening point temperature in-creasing, decreasing of ductility and increasing of viscosity at service temperature and significant widening of the plasticity interval. With this by the temperature dependencies of viscosity at high temperatures and temperature dependencies of contact angles there is no any energy saving effect is found for warm mix additives using.

INTRODUCTION

Last two decades in road building industry of USA and Europe methods of reducing of asphalt concrete mixing and compaction temperatures attracts more and more attention. These methods aim to limit the environmental pollution in accordance with Kyoto Protocol adopted in 1997 [1] and the global Europe program 20-20-20 goals (20 % increase in energy efficiency, 20 % reduction of CO_2 emissions, and 20 % renewables by 2020 in compare with 1990). The asphalt mixing and constructing of asphalt pavement requires a lot of energy, mostly for heating of mineral materials and bitumen binders. This is why the energy saving is a topical environmental aim in asphalt production and road building.

Warm mixture asphalt (WMA) technology is widespread now. It provides one of ways to reduce the temperature of asphalt mixture production. This technology was developed in the end of last century and based on use of specific additives (organic or chemical) or bitumen foaming process [2-3]. First WMA pavements in Europe were constructed in Norway at 1996 with a two stage technology WAM-Foam. The first stage includes mixing of mineral aggregates with low viscous bitumen; the second one compounds this mixture with foamed bitumen with a higher viscosity. In Germany (Hamburg) at 1997 was constructed WMA with Sasobit additive, at 1999 with Aspha-min additive [3]. Since 2004 implementation of WMA technology starts in USA and other countries all over the world. Since 2007-2009 research of influence of WMA additives on bitumen properties starts in Ukraine [4, 5]. The WMA production starts at 2010-2011.

Nowadays WMA technology is used in almost all countries of the world. Mostly WMA is presented in Germany, France, Spain and USA. WMA is implemented as a base (binder) course or a coating (surface course) of pavement [1, 3].

The list of the WMA additives on a market counts a lot of positions, and constantly updated with new products. This list can be divided in two groups: organic and chemical additives [6, 7]. As organic additives can be classified

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paraffin waxes (Fischer-Tropsch and Montan) and fatty acid amides (Asphaltan, Sasobit, Licomont). Accordingly to the developer's data the effect of these additives is based on a sharp decreasing of their viscosity with heating over melting point. The same observes for the binders with these additives. At the maintenance temperatures WMA organic additives make binder more solid (penetration at 25 °C decreases, viscosity increases) and expanding the plasticity interval with significantly increasing in softening point temperature.

The principle of WMA chemical additives (Evotherm, Cecabase RT, Rediset, Iterlow T) influence is based on increasing in ability of binder with these additives to spread on a mineral surface. This allows the mixing temperature to be lowered without compromising the mixing quality. At compaction process chemical additives decreasing the friction between mineral grains in WMA. In mostly cases WMA chemical additives are multi-component; they can include surfactants, emulsifiers, polymers and etc. in their composition [6, 7]. The reason is their aiming on increasing in adhesion of binder to mineral surface and increasing in water resistance of asphalt concrete.

WMA additives Sasobit and Licomont BS 100 have got wild spreading in Ukraine. Sasobit is one of the first WMA additives used to obtain warm mix asphalt [1, 3]. This additive is a fine-grained crystalline powder of a synthetic high molecular paraffin wax (long chain aliphatic hydrocarbon C40 … C115) which is obtained with a Fischer-Tropsch synthesis. Its melting temperature is in a range from 85 ºC to 115 ºC according to the manufacture's data. Sasobit completely dissolves in bitumen at temperatures above 210 ºC and forming a crystalline network with cooling at lower temperatures [8]. The weight concentration of additive set as a 2.5 % in European countries and in a range from 1.0 to 1.5 % in USA [6, 8]. With a research data [3, 5, 8 - 9] on Sasobit influence on bitumen and asphalt properties it was found that for bitumen with additive penetration is getting lower, softening point temperature is getting significantly higher, ductility drastically decreases and viscosity at service temperatures increases. At operation temperatures (higher than 120 °C) viscos decrease with concentration of the additive [10]. In result workability of the asphalt concrete with Sasobit additive and rutting resistance are getting higher. According to data [1, 6, 9] the better workability of the asphalt mixture with the additive lets decrease mixing and compaction temperature on 10… 30 °C. On the other hand viscosity-temperature relationships published in [5] points on decreasing range in no more than 5… 8 °C at 3% concentration of the additive in different grades of air-blown bitumens. In [5, 11] it is mentioned that Sasobit slightly increases adhesion property of the bitumen. Meanwhile no any effect of the additive on water resistance of the asphalt concrete is found [12].

The manufacturer of the Licomont BS 100 additive is Swedish company "Clariant". The additive is a fatty acid amide with a melting point temperature 141…146 ºC. Researchers [6, 9] claim that bitumen with the additive can retain its properties for up to 8 days at 160…180 ºC. Commonly used concentration of Licomont BS 100 additive is 3 %. By researchers from different countries [6, 12 – 13] it was found that modification of bitumen with Licomont additive results in penetration decreasing and softening point temperature increasing more in-tense that for Sasobit modification at same concentrations. The same way decreasing of binder viscosity at high temperatures is more intense for Licomont than for Sasobit modification [13 – 14]. According to the data of rolling bottle test [11] Licomont BS 100 increases adhesion of bitumen to the mineral aggregates. Higher strength and rutting resistance that is observed for asphalt concrete with Licomont BS 100 in its composition [4, 15] is a reason to recommend their use for road sections with a high traffic load [6]. According to the manufac-turer data Licomont BS 100 lets decrease asphalt mixing and compaction temperature on a range from 20 to 30 ºC.

Sarawax SX105, is a new organic additive, produced by company Shell MDS (Malaysia) Sendirian Berhad for warm mix asphalts. This additive is solid synthetic paraffin composed of linear alkane molecules, synthesized from natural gas with a Fischer-Tropsch process. The additive is stable, has no oil, sulfur or nitrogen in its composition and has a high resistance against oxidation. The melting temperature for Sarawax SX105 is in a range from 101 to 108 ºC. Its can be used as a bitumen modifier [16].

The early failure of flexible road pavements is stipulated by steady increasing in amount of traffic load and axial loads on a pavement all over the world. Early failure reduces the terms between overhauls as a common durability of a road pavement. Permanent deformation (as a rutting, waves etc.) initiated by a decline in quality of a road pavement as by a residual deformations of a base layers of a road construction is a wide spread reason of low durability of road pavement.

This research work is aimed on comparative evaluation of the effectiveness of Sasobit, Licomont BS 100 and Sarawax SX105 as an air blown pavement bitumen modifier by degree of binder properties changing. Also the energy saving efficiency of WMA additives trough the changing of mixing temperature of asphalt is considered in this research.

MATERIALS AND METHODOLOGY

The bitumen 70/100 produced by Mozyr refinery (Belarus republic) is an original bitumen for bitumen binders in this research work. For bitumen modification with 2 and 3 % of additives a laboratory blender was used at 180 ºC, 1000 rpm and during 60 min of mixing.

As a primary quality indicators it was used conventional indexes of binder with WMA additives (such as penetration, softening and breaking point temperatures, ductility at 25 °C). Besides these parameters that provides more complete information on binder properties and their temperature susceptibility is found. They include adhesion, contact angle in a temperature range from 90 to 150 °C and viscosity in a temperature range from 60 to 150 °C that is used in Ukraine to assign the temperature of asphalt mixing and compaction (the temperature must be high enough to reduce the viscosity of binder to 0.5 Pa·s at mixing and to 1.0 Pa·s at compaction).

Viscosity of the binders is obtained on a rotary viscometer in a wide range of temperatures (from 60 to 150 °C) and a wide range of shear rate (from 0.005 to 300 s^{-1}).

Temperature susceptibility of binders is assessed with Penetration Index calculated on softening point temperature ($PI_{TR\&B}$) and Penetration Index calculated on temperature of penetration 800 × 0.1mm (PI_{T800}). Both PI is calculated with equation 1.

$$IP = \frac{(20 \times T) + (500 \times \lg P_{25}) - 1952}{T - (50 \times \lg P_{25}) + 120} \qquad (1)$$

In this equation P_{25} is a penetration at 25 °C, T is a softening point temperature obtained with Ring and Ball test ($T_{R\&B}$) or a temperature of penetration 800 × 0.1mm (T_{800}), that is found with extrapolation of the temperature penetration relation, obtained with penetration at 5 ºC, 15 ºC, 25 ºC, 35 ºC on penetration level 800 × 0.1 mm.

Adhesion is obtained as a resistance of binder stripping from glass surface in distilled water at a temperature 85 ºC during 25 minutes. Samples are prepared by covering of one side of a microscopic slide (76 × 26 mm) by 0.35 g of binder. Even distribution of the 0.35 g of binder on this surface allows getting a layer with a thickness of 200 micron. The percent of surface that covered with bitumen after the test is assessed as an adhesion index.

Contact angle is obtained by method of binder drop on a glass surface.

RESULTS AND DISCUSSION

Research data of bitumen binders' quality are presented in table 1. It was found that modification of bitumen with chosen additives leads to its hardening that can be caused by forming specific structure in binder. This results in penetration and ductility at 25 ºC decreasing and increasing in softening point temperature of the binders. With penetration and ductility at 25 ºC decreasing the highest structuring effect is observed for bitumen with 3 % of Sarawax additive. Meanwhile the highest increasing in softening point temperature is found for bitumen with 2 and 3 % of Licomont BS 100, which can be explained with high melting point temperature of the additive (round 140 ºC).

The significant increasing in a softening point temperature results in increasing of Penetration Index ($PI_{TR\&B}$) values of binders which are obtained with softening point temperature values. This can leads to a misleading statement that the temperature susceptibility of these binders getting lower (Penetration Index values reaching range from 2.40 to 5.49). With the doubts in validity of $PI_{TR\&B}$ to be a correct parameter for the temperature susceptibility assessment of modified binders [17] in this research work the Penetration Indexes with T_{800} temperature (PI_{T800}) are calculated. According to PI_{T800} values and the slope of the penetration-temperature relation on Figure 1 the biggest decreasing in temperature susceptibility is observed for the binders with 3 % of Sarawax SX105 and Sasobit additives. Meanwhile for the bitumen with 2 % and 3 % of Licomont BS 100 additive the temperature susceptibility stays high. The researched additives increase the value of Plasticity Interval of the binders (Figure 2) that is getting wider with the additive concentration. This Plasticity Interval increases with the softening point temperature only. The breaking point temperature remains unchanged with increasing in the additive concentration. The stability in a breaking point temperature can be mentioned as an advantage of the organic additives, because for non-modified bitumen with the same penetration the breaking point temperature is higher. With a Plasticity Interval value (94.5 °C) and a temperature susceptibility value (PI_{T800} = 0.26) the effectiveness of Sarawax SX105 in bitumen is the highest.

TABLE 1. Indexes of the binder's quality

Indexes		Original bitumen	Bitumen with organic additive					
			Licomont BS 100		**Sasobit**		**Sarawax SX105**	
Sample marking		B	BL2	BL3	BS2	BS3	BSr2	BSr3
Concentration of the additive, %		0	2	3	2	3	2	3
Penetration at 25 ºC, 0.1 mm		98	75	65	57	48	58	43
Softening point temperature by Ring and Ball test ($T_{R\&B}$), ºC		46.9	61.2	83.2	62.1	74.0	66.6	78.0
Fraass breaking temperature (T_F), ºC		-16	-18.5	-16.5	-15	-15.5	-16.5	-16.5
Ductility at 25 ºC, cм		129	55	47	61	37	51	36
Adhesion at 85 ºC, %		11.7	8.5	15.5	10.3	23.6	24.5	70.1
Penetration Index, calculated with a softening point temperature ($PI_{TR\&B}$)		-0.27	2.40	5.49	1.78	3.35	2.66	3.65
Plasticity Interval, ºC		62.9	79.7	99.7	77.1	89.5	83.1	94.5
Temperature at 800 × 0.1 mm penetration (T_{800}), °C		44.0	50.0	51.0	51.5	57.0	52.5	58.0
Penetration Index, calculated with a T_{800} temperature (PI_{T800})		-1.19	-0.19	-0.32	-0.53	0.31	-0.24	0.26
RTFOT hardening	Residual penetration, %	65.3	74.7	81.5	84.2	79.2	81.0	86.0
	Changing in $T_{R\&B}$, ºC	2.3	-4.9	-22.3	1.7	0.6	0.2	0.8
	Fraass breaking temperature, ºC	-15.5	-17	-18	-16.5	-14.5	-17	-14
	Ductility at 25 ºC, cm	97	39	32	34	21	22	21
	Adhesion at 85 ºC, %	8.6	6.3	11.6	5.1	15.1	31.9	66.6

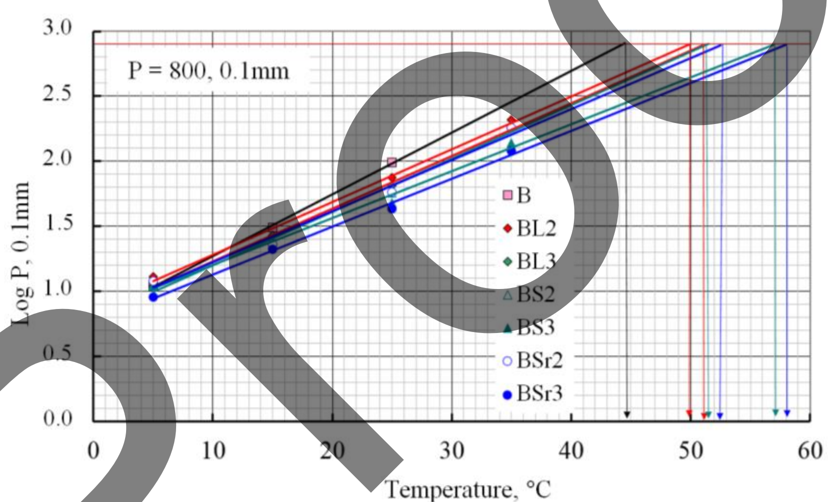

FIGURE 1. Temperature-penetration relations of the bitumen binders

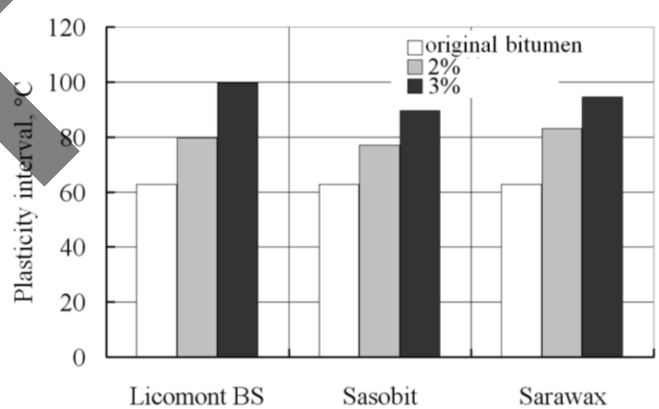

FIGURE 2. Plasticity Interval of binders

The hardening of bitumen binders is evaluated with RTFOT method. The obtained data can't be described with a simple model. On one hand the resistance of bitumen with additives to hardening getting higher. The increasing in residual penetration with increasing in additive concentration proves this (Table 1). Thereby bitumen with 2 and 3 % of Sarawax SX105 additive is the most resistant to hardening. On the other hand the increasing in additive concentration causes the significantly decreasing in binder ductility after hardening (for bitumen with Sasobit additive more and for bitumen with Licomont BS 100 additive less).

The values of softening point temperature after hardening are not in agreement with residual penetration values. While the penetration after hardening changes the least (residual penetration is the highest) for the bitumen with 2 % and 3 % Sarawax SX105 additive, its softening point temperature change reaches 6.1 ºC. For the bitumen with Licomont BS 100 additive softening point temperature getting lower after hardening on 4.9 ºC and 22.3 ºC (for 2 and 3 % of the additive respectively). Such a reducing in a softening point temperature is inherent to bitumen with Licomont BS 100 additive after hardening by research works [6, 18]. According to [18] data the higher penetration of original bitumen, the lower changes in softening point temperature of bitumen with Licomont BS 100 additive after hardening. This fact cans effect on workability of the asphalt with Licomont BS 100 additive in compaction process decreasing the temperature of compaction lower than obtained with a temperature dependence of viscosity.

One more advantage of bitumen with additives is an increasing in their cohesion properties. Stripping resistance in water medium of the glass slide covered with binder is increasing with increasing in additive concentration. The stripping resistance increases from 11.7 % for the original bitumen up to 70.1 % for binder with 3 % of Sarawax SX105 additive (Figure 3). The smallest increasing in stripping resistance is observed for binder with Licomont BS 100 additive. It increases up to 15.5 % only with the increasing in the concentration additive to 3 %.

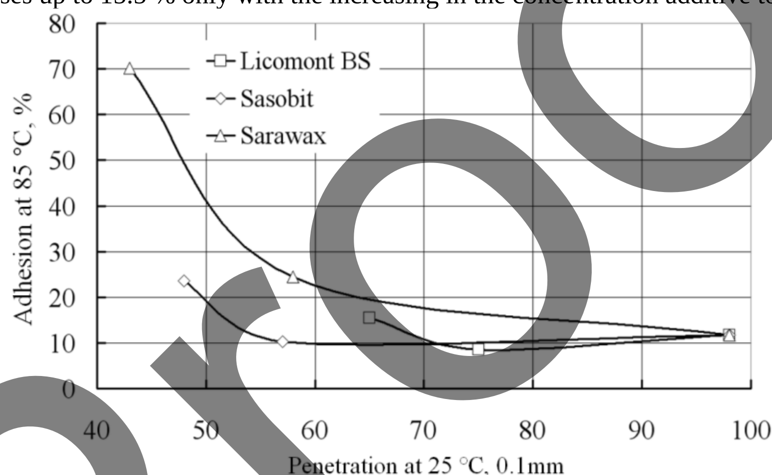

FIGURE 3. Stripping resistance of the binders with organic additives on glass slides

According to the manufactures data one of the main features of the organic additives applying is an increasing in the binder viscosity at service temperature and sharp decreasing in its viscosity at temperatures higher than the melting point temperature of additive [7, 8]. This process provides an opportunity to reduce the operation temperature of asphalt mixing and compaction.

Dynamic viscosity of the bitumen binders is obtained in a wide temperature and shear rate range. On the resulting relationships between viscosity and a shear rate with the obtained values of the viscosity anomaly for binders (table 2) it can be made a conclusion that binder with the additives is much more structured at service temperatures than the original binder.

At the 60 °C temperature the most structuring effect obtained for the Sarawax SX105 that's results in the lowest values of the viscosity anomaly. With the temperature rising above 100 °C viscosity anomaly disappears, index of the viscosity anomaly reaches 1.00 and binders demonstrates behavior inherent to the sol type bitumen.

For the all modified binders the decreasing of the viscosity is observed at a high temperature range. This leads to a situation when viscosity of the modified bitumen getting lower than viscosity of the original one with the temperature increasing. For bitumen with Licomont BS 100 the point of viscosity inversion is at 110 °C for 2 % of the additive and 116 °C for 3 %. For bitumen with Sarawax the point of viscosity inversion is at 103 °C for 2 % of the additive and 112 °C for 3 %. The lowest value of the temperature of viscosity inversion is inherent to the Sasobit modified bitumen. It is observed at 100 °C irrelevantly to the additive concentration (Figure 4).

TABLE 2. Values of the viscosity anomaly index for the binders with organic additives

Temperature, ºC	Viscosity anomaly for binders						
	B	**BL2**	**BL3**	**BS2**	**BS3**	**BSr2**	**BSr3**
60	0.89	0.76	0.57	0.60	0.50	0.56	0.43
90	0.92	0.92	0.82	0.88	0.86	0.85	0.85
100	0.94	0.95	0.88	0.97	0.94	0.98	0.90
110	0.97	0.97	0.91	1.00	0.95	0.99	0.93
120	1.00	0.98	0.96	1.00	0.98	1.00	1.00
130	1.00	1.00	1.00	1.00	1.00	1.00	1.00
140	1.00	1.00	1.00	1.00	1.00	1.00	1.00
150	1.00	1.00	1.00	1.00	1.00	1.00	1.00

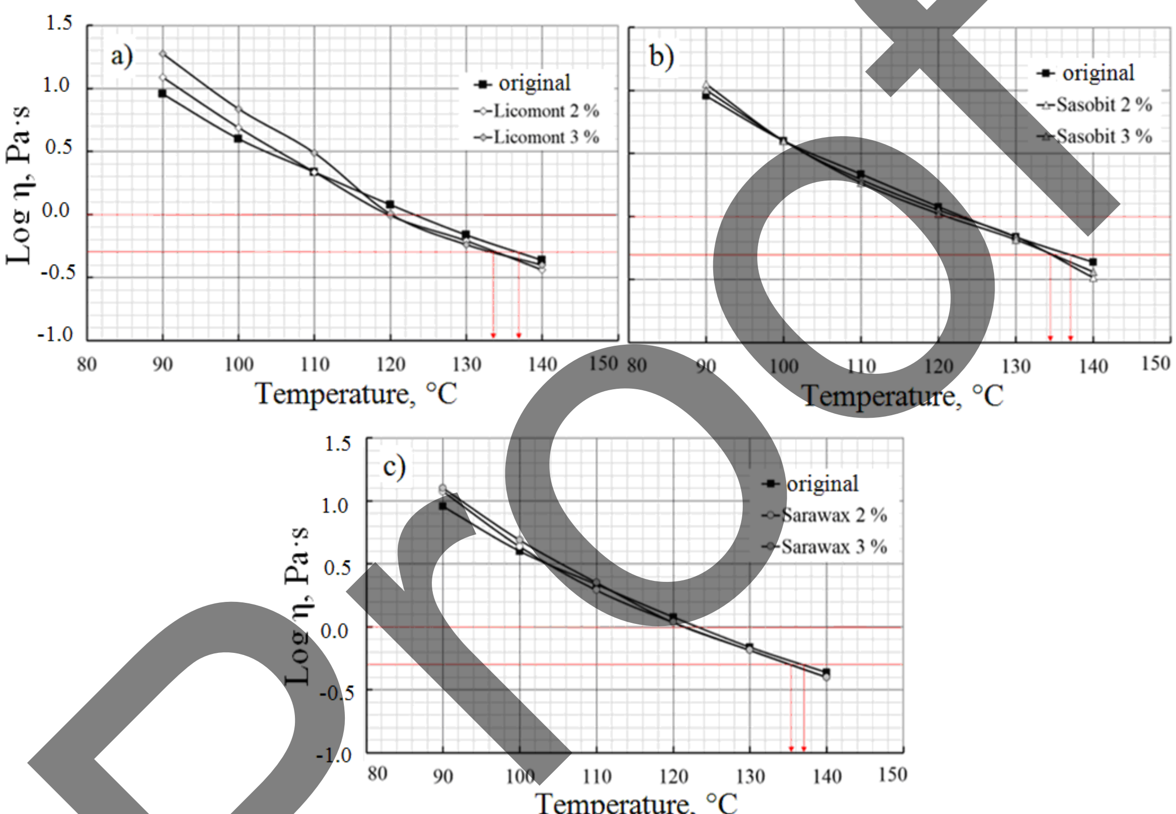

FIGURE 4. Temperature dependence of viscosity of binders, modified with Licomont (a), Sasobit (b) and Sarawax (c) additives

The heating temperatures of the binders at asphalt mixing (temperature at 0.5 Pa·s viscosity value) as temperatures of the asphalt mixture at the beginning of compacting (temperature at 1.0 Pa·s viscosity value) are founded on the temperature dependencies of binders viscosity. For the all researched modified binders there is no significant decreasing in these temperatures. This decreasing stays in a rage from 2 °C to 4 °C in relation to the temperatures of original bitumen (Figure 4). This means that there is no essential energysaving effect of the researched additives is found on temperature dependencies of binders viscosity.

The specific binder viscosity (that is regulated by the heating temperature) at the asphalt mixing process is required to guarantee the mixing quality. But the most important for the mixing process is a wetting of the mineral surface with the binder. If the additive improves this parameter the mixing temperature can be reduced (though the binder viscosity can exceed the required range).

The wetting of the mineral surface with the binder can be estimated by the contact angle value. With this purpose the Sessil Drop Method on a glass surface is used for the researched binders in the temperature range from 90 °C to 140 °C. The obtained contact angles for the researched modified binders (Table 3) shows the significant decreasing in values when temperature exceeds 100 – 110 °C. For the bitumens modified with Sasobit and Sarawax additives contact angles becomes equal, or even lower than the ones for original bitumen at 105 ºC and 125 ºC. This can indicates the better covering of the mineral surface with modified binder at higher temperatures. Meanwhile the values of contact angle for the bitumen, modified with the Licomont BS additive remains higher than the ones for original bitumen in all temperature range of experiment.

Following the data from Table 3 it can't be assumed that decreasing in contact angle values for modified binders can guarantee the significant decreasing in the temperature of asphalt mixing. Moreover for the bitumen with Licomont BS 100 additive the mixing temperature should be increased to avoid the low quality of obtained mixture.

The possible reason of insufficient energysaving effect of the wax additives in present study may be explained with structural peculiarities of original bitumen. In USA and Europe in road building industry distilled bitumen with sol type structure are widespread. The Ukrainian bitumen is obtained with the air-blowing technology and classified as a sol-gel type due its structure. This type of bitumen is characterized with an inner coagulation structure that is formed with linked asphaltenes in maltene medium. In this case the plasticized effect of the paraffin waxes can be much lower than the one for sol type bitumen, which behavior is depends on continuously macromolecular structure of resins.

TABLE 3. Contact angle values for the researched binders

Binder		Contact angle values, ° at the temperature				
Additive	**Additive concentration, %**	**90**	**100**	**110**	**130**	**150**
-	-	15.4	11.1	7.9	6.2	4.1
Licomont BS 100	2	58.5	28.7	15.7	11.3	11.1
	3	101.5	45.9	20.9	17.4	16.0
Sasobit	2	41.0	15.3	9.8	5.5	5.5
	3	73.7	16.5	7.5	6.0	2.7
Sarawax SX105	2	80.3	34.9	11.5	5.4	2.8
	3	115.0	70.7	17.9	4.6	3.6

CONCLUSIONS

On the base of experimental data the following conclusions can be made:

1. The all researched additives structures bitumen that results in penetration at 25 °C decreasing, softening point temperature increasing, decreasing in a ductility at 25 °C and significantly increasing in a plasticity range.

2. The Sarawax SX105 additive has the most influence on bitumen. In the complex the binder with Sarawax SX105 additive can be characterized by significantly high softening point and low penetration values. It is combined with the high adhesion, high residual penetration and low temperature susceptibility in comparison with the other modified binders. Such changes in properties can results in increasing in strength and water resistance of asphalt with this modified bitumen.

3. No significant energysaving effect of the researched additives is found with the data of present study. Both ways to decrease the asphalt mixing temperature with the temperature dependencies of binders viscosity and the temperature dependencies of contact angles results in insugnificantly changing of the mixing temperature. The same is observed for the asphalt compaction temperature.

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Decorative-Protective Epoxy Compositions for the Restoration of Natural Stone

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Abstract. The article substantiates the use of dispersed inorganic fillers of different chemical and mineral nature to create decorative-protective restoration materials based on epoxy oligomers and amine hardeners. It is shown that for the development of epoxy materials that can mimic the appearance of products and architectural structures made of natural stone: granite, marble and sandstone - it is possible to use quartz, clay and oxide disperse fillers. Physic-chemical methods were used to study: mineral composition, surface morphology, particle size, specific surface of dispersed inorganic fillers. An ED-20 epoxy oligomer was used to make the restoration epoxy polymer composite materials. Aliphatic hardener of the amine type diethylenetriamine of the DETA brand was used for hardening. Inorganic crystalline oxide, clay and quartz fillers were used to obtain restoration materials that mimic the appearance of natural stone. Selected quartz fillers - quartz sand (QS) and marshalite (MT), the addition of which allows to obtain materials with a matte surface of milk or milk with pink colors. Such materials can be used for the restoration of white and pink marble. In the case of the use of clay disperse fillers – diabase powder (DP) and kaolin clay (KC), you can get materials of dark gray and dark beige, respectively. Such materials can be used for restoration of gray granite, gray marble, sandstone, etc. The use of oxide fillers allows to obtain materials of red-brown (with the addition of red sludge (RS)) and pale orange (with the addition of rutile (RT)) colors. These composites can be used to restore red granite and red marble. The filled compositions were prepared by mixing pre-weighed components: epoxy resin, amine hardener and filler to a homogeneous mixture. The filler content was 10% by volume. Curing was carried out in air at a temperature of 20-25°C for 72 hours and 4 hours at a temperature of 200°C. As a result of research, it is established that resistance to high temperatures and absorbency of the filled composites in water and water acidic and alkaline environments largely depend on dispersion, chemical and mineral nature of inorganic fillers. It was found that to obtain decorative-protective epoxy polymer composite materials with high resistance to high temperatures and low absorption capacity, it is necessary to use oxide or clay fillers.

INTRODUCTION AND LITERATURE REVIEW

Natural stone has been used in construction for thousands of years. The use of natural stone in the construction of ancient times has significantly influenced the development of architectural forms. In almost all major epochs of architecture, stone was and remains the main building material - structural and finishing. Natural stone is an ancient material from which beautiful palaces, temples and cities were built, unique sculptures and decorative items were created all over the world and in Ukraine. The durability of this material has preserved to this day the masterpieces of castle architecture, which were created many centuries ago, and now need strengthening, restoration and restoration. Therefore, the development of new effective materials and technologies for the restoration, reconstruction and

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restoration of natural stone objects is an urgent problem today and a guarantee of preserving the architectural heritage for future generations.

The specifics of restoration work affect the principles and approaches to the choice of materials, which can be divided into four groups. The first group is materials that are identical or as close as possible to those from which the architectural object was originally built. This group includes: natural stone, brick, ceramics, wood, plaster, etc. The second group is represented by modern materials, which are used in case of need to supplement the details of architectural objects, for which technologies are developed separately. Materials from this group either imitate the real material of the monuments, or are visually different from it, as defined by the restoration project. This group includes both traditional (concrete, ceramics, wood, etc.) and synthetic polymer composite materials. The third group is special materials for conservation of various parts of architectural monuments, which strengthen the structure of monument materials, neutralize biological and chemical effects, as well as formed on the surface materials and coatings protective action. The fourth group - traditional building materials that can be used for the restoration of interior structures, as well as for painting and roofing. All materials must meet some general requirements: first, the materials that come into contact must have similar physicochemical and chemical properties; secondly, when choosing materials, it is necessary to take into account the possibility of maintaining vapor permeability; third, restoration materials must be durable.

Modern synthetic polymer composite materials in restoration works are used with caution and only in cases where it is impossible to use traditional and natural materials [1]. This is mainly due to the fact that the latest polymeric materials are considered to be insufficiently compatible in terms of physicochemical and chemical properties with the traditional ones, which were once used to create architectural monuments. However, the intensive development of modern materials science allows us to find among the synthetic materials that will meet the stringent requirements of the restoration industry. In addition, synthetic materials are becoming cheaper than natural, the price of which is rising rapidly.

Among the large number of synthetic polymers for the preservation, restoration and restoration of architectural heritage sites, composite materials based on epoxy oligomers and amine hardeners are increasingly used today [2-10]. Specialists and technologists in restoration work are attracted by the possibility of using epoxy polymeric materials due to some valuable qualities and characteristics: harden in air without heat treatment, which allows application to wet surfaces; simple manufacturing and use technologies; high adhesion to many traditional materials (stone, concrete, metals, wood, ceramics, etc.); high resistance to climatic and other corrosive factors (water, aqueous solutions of salts, alkalis and acids, organic solvents, solar radiation, temperature); resistance to bio damage and biodegradation; environmental friendliness and low toxicity; the possibility of external imitation of natural materials, such as natural stone (marble, granite, sandstone, etc.); the possibility of making individual elements of architectural objects to restore the lost; versatility (adhesives, mastics, protective coatings, impregnating, injecting, filling compositions, etc.); the possibility of creating hybrid materials, such as epoxy silicate, in order to increase compatibility with traditional ones; practically unlimited possibility of modification for the purpose of receiving additional functions and special properties.

Adhesives and mastics based on epoxy polymers are used for the restoration of glass and ceramics [9], impregnating compositions – to strengthen structures and wood products [10]. Most often, epoxy materials are used for conservation [2,3] and restoration of architectural products and elements of natural stone [4-8]. Epoxy adhesives and coatings are used during the repair of floors made of natural stone material [5]. During operation, due to mechanical loads, the surface of the stone floor is damaged: there are scratches, chips, cracks and potholes. In order not to replace the elements of ancient stone coatings, the masking of defects with a mastic mixture based on epoxy polymer, including pigment. Epoxy mastic after hardening provides hardness and necessary elasticity of a connecting element. Epoxy composite putties and mastics with marble or granite fillers are used to fill cracks and supplement the loss of stone products. Epoxy resin with polyethylenepolyamine is used as a hardener for granite restoration. To increase the viscosity and provide thixotropy to epoxy compositions are added 50-80% of disperse fillers: quartz sand, marble powder, fibrous asbestos, marshalite and sometimes pigments [1].

Addition to epoxy compositions of dispersed inorganic fillers of different chemical nature leads to a change not only in decorative and technological characteristics (viscosity, rate of curing reaction), but also physic-mechanical and operational properties (resistance to water and aquatic environments, high temperatures, solar radiation, etc.) [11-21]. Due to a set of valuable properties, the special appeal of epoxy materials is its versatility, i.e. the ability to perform several functions simultaneously during operation (protective, bonding, decorative, insulating, etc.). Another advantage of epoxy material is the virtually unlimited possibility of physicochemical modification of the compositions in order to provide special properties, such as fire-resistant, bactericidal, chemical-resistant, vibration-absorbing, hardening under certain conditions, and others. The modification process is simple and does not require special requirements and additional energy consumption.

Given the strict requirements for restoration materials and the peculiarities of the conditions of further operation of restored architectural monuments, it is necessary and relevant to study the effect of dispersed inorganic fillers of different chemical nature on the absorption properties of materials in water and aquatic environments and resistance to high temperatures. Until now, the influence of the amount of fillers in the composition of materials, particle size, chemical nature has been mostly studied, and almost no attention has been paid to the mineral composition and surface properties of filler particles. Therefore, the aim of the study is to determine the effect of mineral composition and surface properties of quartz, clay and oxide disperse fillers on the ability of epoxy polymer composite materials to absorb water and aqueous solutions and resist high temperatures.

MATERIALS AND METHODS OF RESEARCH

For the production of restoration epoxy polymer composite materials, an epoxy-dian oligomer of the ED-20 brand, a product based on diglycidyl ether of diphenylolpropane, was selected. For curing, the amine hardener diethylenetriamine (DETA) was used, which allows to obtain materials with satisfactory performance at low and normal temperatures.

Inorganic crystalline oxide, clay and quartz fillers were used to obtain restoration materials that mimic the appearance of natural stone. Selected quartz fillers - quartz sand (QS) and marshalite (MT), the addition of which allows to obtain materials with a matte surface of milk or milk with pink colors. Such materials can be used for the restoration of white and pink marble. In the case of the use of clay disperse fillers – diabase powder (DP) and kaolin clay (KC), you can get materials of dark gray and dark beige, respectively. Such materials can be used for restoration of gray granite, gray marble, sandstone, etc. The use of oxide fillers allows to obtain materials of red-brown (with the addition of red sludge (RS)) and pale orange (with the addition of rutile (RT)) colors. These composites can be used to restore red granite and red marble.

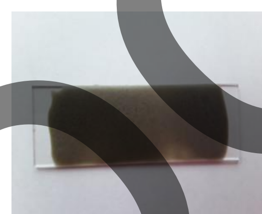
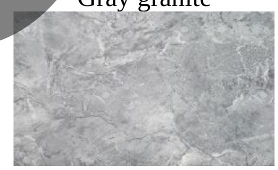
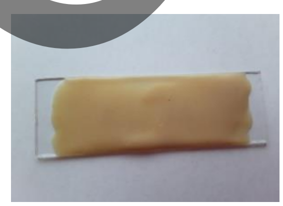
The filled compositions were prepared by mixing pre-weighed components (epoxy resin, amine hardener and filler) to a homogeneous mixture. Then the composition can be applied with a spatula on the surface or poured into molds. Composites with a filler content of 10% by volume were prepared. Curing was carried out in air at a temperature of 20-25 °C for 72 hours and another 4 hours at a temperature of 200 °C. The influence of the nature of fillers on the resistance of epoxy composites to the action of chemically aggressive aqueous media was investigated. Hardened samples in the form of disks with a diameter of 50 ± 1 mm and a thickness of 3 ± 0.2 mm were immersed in a liquid medium and at a temperature of 20-25 °C withstood a certain period of time. As chemical aqueous media were used: distilled water, 10% solutions of H_2SO_4 and NaOH. Samples of composites before and after immersion were weighed on analytical balances with an accuracy of 1%. Intermediate measurements of the mass of the samples were performed every 24 hours and then every 3-5 days. The maximum exposure time of the samples was 2700 hours (112 days). The change in sample weight Δm after each test period as a percentage of weight gain or loss was calculated.

For the selected dispersed inorganic fillers, surface morphology and particle size were studied using electron microscopic images taken by a scanning electron microscope brand JSM-6390LV (Japan) with the operating system for processing the results of MS Windows XP. X-ray phase analysis was performed on an X-ray diffractometer DRON-2. The values of the specific surface of the fillers were determined by the BET method (Bruner, Emmett and Teller). To assess the resistance of the obtained samples of filled epoxy composites to high temperatures, thermogravimetric analysis (TG) was performed using an SDT Q600 device manufactured by TA Instruments (USA). The studies were carried out in an argon atmosphere in the temperature range of 20–900 °C with a temperature rise rate of 5 ºC/min. The weight of the samples was 1.5-4 mg. The temperature intervals of the destruction stages were estimated from the temperature curve of mass loss.

THE RESULTS OF THE STUDY OF THE ABSORPTION CAPACITY AND RESISTANCE TO HIGH TEMPERATURES OF DECORATIVE-PROTECTIVE EPOXY MATERIALS

The appearance of the used fillers, composites and natural stone, for the restoration of which the materials are intended, are given in table 1.

TABLE 1. Characteristics of fillers and filled epoxy restoration materials.

Filler	Specific surface, S and particles d	Appearance of materials	Appearance of natural stone
Quartz Sand (QS)	S = 2,91 m^2/g D = 10-15 μm		 White marble
Marshalite (MT)	S = 2,75 m^2/g D = 5-10 μm		 Pink marble
Diabase Powder (DP)	S = 1,90 m^2/g D = 2-4 μm		 Gray granite  Gray marble
Kaolin Clay (KC)	S = 8,78 m^2/g D = 4-5 μm		 Sandstone
Red Sludge (RS)	S = 11,35 m^2/g D = 1,5-3 μm		 Red granite
Rutile (RT)	S = 1,30 m^2/g D = 5-10 μm		 Red marble

According to the results of X-ray phase analysis, the studied fillers were divided into two groups: clay - diabase powder (DP) and kaolin clay (KC); quartz – quartz sand (QS) and marshalite (MT); oxide - rutile (RT) and red sludge (RS). The mineral composition of the fillers is given in table. 2.

TABLE 2. Mineral composition of fillers

Filler	Mineral composition
QS	β-quartz SiO_2• Montmorillonite $(Al,Mg)_2(OH)_2[Si_4O_{10}]\cdot nH_2O$▪
MT	β-quartz SiO_2• Microcline $K_2O\cdot Al_2O_3\cdot 6SiO_2$▪
DP	β-qurtz SiO_2• Montmorillonite $(Al,Mg)_2(OH)_2[Si_4O_{10}]\cdot nH_2O$• Orthoclase $K_2O\cdot Al_2O_3\cdot 6SiO_2$• Leucite $K_2O\cdot Al_2O_3\cdot 4SiO_2$• Lymonit $Fe_2O_3\cdot H_2O$▼
KC	Kaolinite $Al_2Si_2O_5(OH)_4$• β-qurtz SiO_2▼ Biotite $(Fe,Mg)_3[OH]_2(Al,Fe)Si_3O_{10}$▼ Hydrous micas $(K,Na)Al_2(Si,Al)_4O_{10}(OH)_2\cdot nH_2O$▼
RS	Hematite α-Fe_2O_3• Goethite FeOOH• Limonite $Fe_2O_3\cdot H_2O$▼ Tetracalcium aluminate $4CaO\cdot Al_2O_3\cdot Fe_2O_3$▼
RT	Rutile TiO_2• Anatase TiO_2•

Remarks: ● – basic mineral phase; ▼ - side mineral phase; ▪- traces.

The results of absorption of filled composites of chemical media after 2700 hours are presented in table. 3.

TABLE 3. Weight gain of filled composites samples Δm, % for 2700 hours

Composites	H_2O	H_2SO_4	NaOH
Composite without filler (EP)	0,59	0,54	0,66
EP+QS	3,53	5,19	3,82
EP+MT	1,98	2,49	1,53
EP+DP	1,31	1,64	0,95
EP+KC	0,43	0,53	0,38
EP+RS	0,50	0,49	0,47
EP+RT	0,56	0,70	0,58

The results of thermal tests of filled composites are presented in table 4.

TABLE 4. Weight gain of filled composites samples Δm, % for 2700 hours

Composites	Weight loss of samples of filled composites (%) at temperature			
	5°C	10°C	50°C	90°C
Composite without filler (EP)	295	325	330	330
EP+QS	239	276	424	546
EP+MT	243	296	346	346
EP+DP	272	315	443	522
EP+KC	295	335	335	335
EP+RS	274	320	435	517
EP+RT	250	308	400	400

DISCUSSION OF THE RESULTS OF THE STUDY OF THE PROPERTIES OF DECORATIVE-PROTECTIVE EPOXY MATERIALS

In general, characterizing the effect of oxide fillers on the absorbency of filled epoxy composites, it should be noted the following. In the case of the addition of titanium oxide TiO_2 (RT), the absorption capacity of composites decreases by 5% in neutral and 14% in alkaline environment, and in acidic environment - increases by 30%. In the case of adding iron oxide Fe_2O_3 (RS), the absorbency of composites decreases in all media by 10-30%. Thus, it can be concluded that the use of oxide fillers helps to improve the stability of composites in aqueous chemical environments. The more effective action of RS can be explained by the fact that particles have an order of magnitude more developed surface ($S = 11.35\ m^2/g$) than rutile ($S = 1.30\ m^2/g$). Obviously, the surface of RS can interact with the epoxy polymer and contribute to the formation of a denser structure of the composite with less permeability [11- 13].

Characterizing the effect of clay fillers, it should be noted the following: the addition of KC reduces the absorption capacity of composites in all media by 2-40%; the addition of DP, on the contrary, increases the absorption by 2-3 times in all environments. The effect can be explained by the same reasons as in the case of oxide fillers. KC particles ($S = 8.78\ m^2/g$) the specific surface area exceeds DP particles ($S = 1.90\ m^2/g$) more than 4 times. It is obvious that the intense physicochemical interaction of the KC surface contributes to the formation of a structure with a large number of hydrolytically stable physical and chemical bonds. In addition, the filler surface may have a catalytic effect on the curing reaction of the epoxy resin with the hardener.

To characterize the effect of quartz fillers on the absorbency of filled composites, it is necessary to consider the chemical and mineral composition. This is due to the fact that both fillers: QS ($S = 2.91\ m^2/g$) and MT ($S = 2.75\ m^2/g$) - the specific surface area is approximately the same (Table 2). Therefore, it is obvious that the determining factor is the chemical nature of the surface of the fillers. It was found that QS and MT are 98-99% composed of quartz SiO_2. Montmorillonite $(Al, Mg)_2(OH)_2[Si_4O_{10}]\cdot nH_2O$ is present as a concomitant mineral in QS, and $K_2O\cdot Al_2O_3\cdot 6SiO_2$ microcline is present in MT. It is obvious that the properties of concomitant minerals determine the resistance of composites to aqueous solutions. In addition, the influence of the method of pre-treatment of fillers cannot be ruled out. For example, MT is ground and dried before use. In general, in the case of adding quartz fillers, the resistance of composites to the effects of aqueous chemical media is reduced. Thus, the absorption capacity of composites with QS increases 6 times in distilled water, 9.6 times – in acid solution and 5.8 times – in alkali solution. The absorption capacity of the composites with the addition of MT increases by 3.4 times in distilled water, 4.6 times in acid solution and 2.3 times in alkali solution.

In general, analyzing the results obtained, it can be argued that to obtain filled composites with improved or satisfactory resistance to aqueous chemical media, it is necessary to use oxide or clay dispersed fillers with a large specific surface area of the particles. The resistance of filled composites to the action of chemically aggressive aqueous media increases in a row: QS<MT<DP<RT<RS<KC.

Analysis of these thermal tests shows that the addition of inorganic oxide, clay and quartz fillers produces composites, the temperature of the beginning of the destruction of which (in the temperature range 200−330ºC with a weight loss of 5−10%) decreases by 8−56ºC. Obviously, the presence of fillers facilitates the process of thermal destruction of the polymer mesh with the destruction of the bonds −C−O− and −C−N− [17, 19, 20]. In the further process of destruction, there is an increase in the temperature of the beginning of decomposition (with a weight loss of 50−90%) by 70−187ºC for oxide, by 5−179ºC for clay and by 94−216ºC for quartz fillers. The increase in thermal stability of the epoxy-amine hydrocarbon backbone in the presence of inorganic fillers may be due to an increase in the total number of nodes and crosslinking density. It is established that the resistance of filled composites to the action of high temperatures increases in a row: KC<MT<QS<RT<RS<DP.

Obviously, resistance to aggressive aquatic environments (absorption capacity) and high temperatures can be criteria for the formation of a strong structure of the filled material. It should be noted that when comparing the obtained dependences, it was found that the full correlation of absorption capacity and thermal stability is observed for the properties of epoxy composites with MT, RS and RT. No correlation was observed for composites with KC, QS and DP fillers. Obviously, this is due to the fact that the fillers KC, QS, DP include crystal hydrates, which when heated primarily lose crystallization water. This distorts the results of thermal research and does not allow direct parallels between the properties of all studied composites.

CONCLUSIONS

Therefore, in order to create decorative and protective epoxy materials for restoration, which can mimic the appearance of products and architectural structures made of natural stone: granite, marble and sandstone - selected quartz, clay and oxide dispersed mineral fillers. The conducted researches allowed to establish regularities of influence of chemical and mineral nature, surface properties of disperse fillers on absorbency of the filled decorative and protective epoxy polymeric materials in water and water environments and resistance to high temperatures. It is shown that the intensive physicochemical interaction of the filler surface with the epoxy polymer promotes the formation of a large number of hydrolytically stable bonds and the formation of a denser composite structure with lower permeability. It was found that the increase in thermal stability of the hydrocarbon skeleton of the epoxy-amine network in the presence of inorganic fillers is associated with an increase in the total number of nodes and the crosslinking density. Analyzing the obtained results, it can be stated that to obtain filled decorative-protective epoxy materials with improved or satisfactory resistance to aqueous chemical media, it is necessary to use oxide or clay disperse fillers with a large specific surface area of the particles.

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Ware's 3D Modeling from Environmental Friendly New Polymer Composition

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Abstract. Experiments on products modeling and design from the new environmentally friendly polymeric materials based on polylactide and coffee waste are carried out in this work. New wares are pots for seedlings and vases for planting greenery that can be used for landscaping for urban territories. Optimization researches on most effective structure of the new ecologically safe polymeric materials based on polylactide and coffee waste are carried out. The products design was made, the mathematical modeling of the designed products was carried out.

INTRODUCTION

Currently, in the area of landscaping for urban territories, a numbers of different polymeric materials and compositions are widely used, which have a number of operational and aesthetic advantages over other materials. These include properties such as high strength and durability, light weight and ample opportunities in design, color scheme and other important aesthetic characteristics.

At the same time, the last 10 years the current world's trend is the use of environmentally friendly biodegradable polymeric materials. such environmentally friendly biodegradable polymeric materials implement the principle of "Zero waste" throughout the life cycle - "production-use-disposal", so this class of polymers today is widely used in the market [1]. Based on the possibility of using environmentally friendly polymeric materials in a wide areas in urban spaces landscaping, today research on the study, development and design of various parts, products from such materials are important and popular[2].

One of the trends in the development of wares industrial production from environmentally friendly polymeric materials is the increasingly active use of their properties modeling. While developing products from environmentally friendly polymeric materials, the focus, along with their design features, is also always the raw material, which must be processed using certain technologies and ensuring the specified parameters of the manufactured product. A characteristic feature of the products design from environmentally friendly polymer materials is the parallel decision-making both on the materials used and on the design parameters of the products, and at the same time, it is necessary to take into account their manufacturing technologies. In this regard, it is required to create an integrated cycle, including both separate systems for the design and ware production from environmentally friendly polymer materials, and an up-to-date database of environmentally friendly polymer materials. Based on the analysis of scientific and technological development in the area of environmentally friendly polymer materials designing and using, the task of developing a set of basic technological solutions for creating effective products from them, as well as new approaches to modeling technological processes and designing products using environmentally friendly polymer materials is very relevant.

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One of the main approaches that ensure the fulfillment of the tasks set is the transition to computer-aided design of products from environmentally friendly polymer materials. In such cases, it becomes possible to use complex models based on environmentally friendly polymer materials, take into account the physical, chemical characteristics, features and requirements of production processes, as well as the possible behavior of the material during the wares made from them operation. Modeling products made from environmentally friendly polymer materials cannot be carried out without understanding the areas of their application and predicting the prospects for use in specific products or functional systems.

Thus, the design of products from polymeric materials is a very difficult task in terms of creating new polymeric materials, because it requires appropriate technological and design information, for the developed wares, equipment for their manufacture, as well as different technological parameters of their processing. Thus almost always high quality and durability of polymeric products and details is caused by a complex of material's correct choice and selection of the most effective method of their processing.

Polylactide is today widely used in packaging as a special product. Many branded companies use products from this particular bio-plastic to pack their goods. Highly efficient polylactide grades can be used as an alternative to polyethylene, polypropylene, polystyrene and ABS plastics. Polylactide can be used even in fairly critical areas of engineering and instrumentation. The wide distribution of products from PLA in Ukraine is limited by the high cost of finished products. So, a 200 ml coffee cup costs about $ 25. The cost of polylactide products can be reduced by introducing of various fillers that do not affect the physicochemical and operational properties of the finished product. using of coffee grounds waste as a filler, you can get a product that haven't negative environmental impact with low price. That is why the development of biodegradable polymer composite materials based on PLA and coffee grounds waste is very relevant.

Bioplastic polymer matrices filled with coffee husk waste have also been studied in [3-5], however, these works are more research than applied industrial in nature. That's why it's very relevant to develop and study biodegradable polymer composite materials based on polylactide and coffee grounds waste in order to use them for the manufacture of dishes for catering establishments: coffee cups, glasses, plates, cutlery, etc. We have previously studied [6] chemical, physical, mechanical and operational properties of new high-filler composite based on polylactide. It is also noticed, that using coffee grounds as fillers for polymer materials can decrease the total volume of it at landfills faster than any other method of coffee ground reuse. Further research the level of sorption stability for developed materials to the most characteristic environments of their operation is perspective.

The aim of the research was to development and design modelling of environmentally safe plastics product for the improvement of urban spaces.

To achieve this aim in the work it was necessary to perform the following tasks:

-to carry out research on the optimization composition contains for new environmentally friendly polymer composite in order to further create wares from it for urban spaces landscaping;

- to model the design of waters for urban spaces landscaping using the optimized environmentally friendly polymeric composite.

RAW MATERIALS AND TEST METHODS

The objects of study were:

- extrusion polylactide of the Terramac TP-4000 brand;
- coffee grounds waste, gathered in 8 different coffee shops in Kharkiv and dried to moisture content 50% Coffee grounds waste have a polyfractional composition in the particle size limit from 0.5 to 1 mm. Using IR spectroscopy methods, it has been shown [6, 7, 8] that coffee grounds, in their chemical composition, are characterized by up to 6% or more content of caffeine, alkaloids and their companions, up to 1% of chlorogenic acids and their derivatives content. The general perfomance of the peak in the absorption length range from 2900 cm^{-1} to 1800 cm^{-1} indicates the presence of water in the samples. For the coffee grounds this is the expected result, since during the drying process the water content was reduced only to 50%, besides in the coffee grounds, as in any filler of organic (vegetable) origin, the phenomenon of intramolecular liquid is also present. If the coffee grounds are not completely dried to the polylactide, the available water prevents the thermal destruction of the coffee grounds, since it evaporates during heating and cools the mixture. This reduces the total temperature of mixture processing by extrusion. The temperature of the sample production is selected by the melting point of the polymer and the critical temperature for the coffee grounds. Thus, for the coffee grounds the temperature of self-ignition is 245 °C, the temperature of destruction

beginning is 210 °C. The optimum processing temperature is the range t = 180-190 °C. The decrease in the intensity of the peak responsible for water in the composite material as compared to the coffee grounds indicates that the water is distorted during the heating process. Characteristic of natural caffeine, theobromine, theophylline and trigonellin coffee (range 670 cm^{-1}, 1710-1717 cm^{-1}, 1690-1695 cm^{-1}, 1645-1658 cm^{-1}, 1548-1550 cm^{-1}) are not pronounced in the coffee grounds, as well as in the composite material. Peaks of chlorogenic acids and their derivatives (range 1625-1630 cm^{-1}, 1390-1440 cm^{-1}, 1210-1320 cm^{-1}, 2900-2975 cm^{-1}, 3490-3500 cm^{-1}) are present as in the coffee grounds, and in composite material. The melting point of chlorogenic acid is 208 °C, so since the processing temperature of the composite material does not exceed 190 ° C, it does not undergo exhaustion or destruction.

Composites were obtained by extruding pre-prepared raw materials in a single-screw laboratory extruder at a temperature of 170–200 ° C and a roll rotation speed of 30–100 rpm. The L / D ratio of the extruder is 25, and in order to increase the uniformity of dispersed waste distribution in the finish compositions, 2 mass passes were used to obtain finished samples. It was made 20 parallel experiments for each composition, statistical processing was made by characteristics such as arithmetic mean, standard deviation and variation coefficient.

The study of impact strength and breaking stress during bending of the samples without notching at a temperature of 20 ° C was carried out on a pendulum head according to ISO 180 and ISO 178, respectively.

The process of modeling products based on environmentally friendly composites was carried out in the SolidWorks 2020: 3D CAD environment with subsequent receipt of g-code, which is intended for machines for the production of molds for plastic injection.

RESULTS AND DISCUSSION

At the first stage, the designed environmentally friendly polymer composition was optimized for the most effective content of coffee grounds in it. the physical and mechanical properties of the obtained eco-friendly polymer composites material were measured: impact strength and breaking stress during bending (fig. 1).

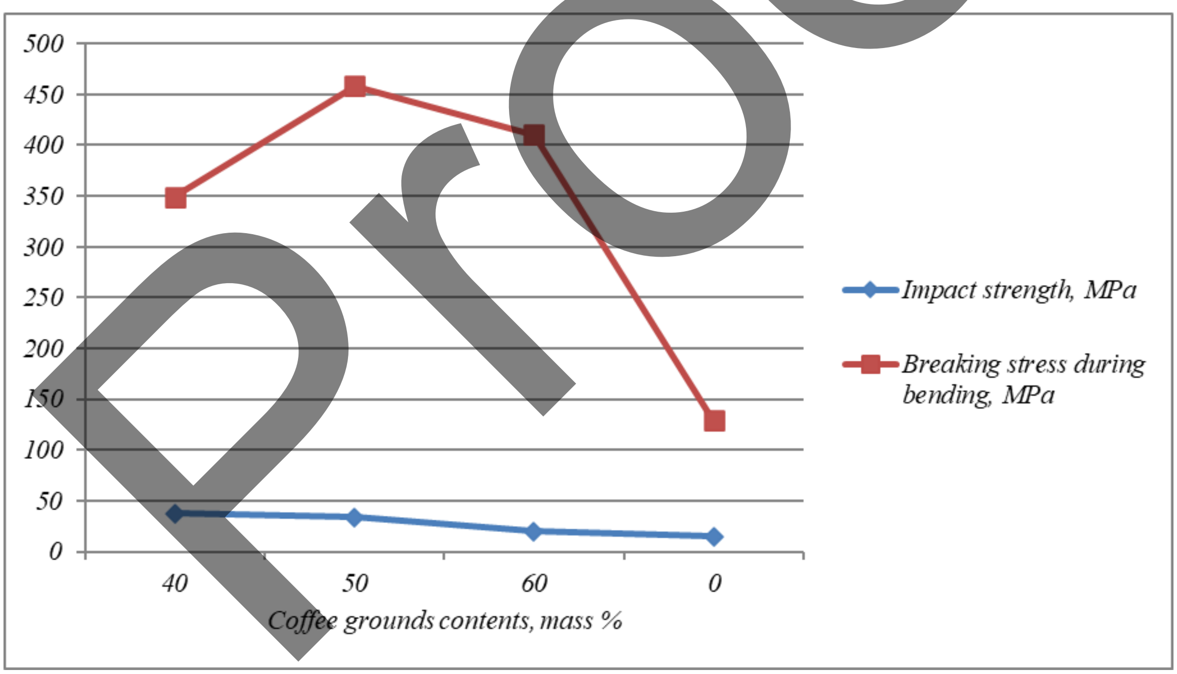

FIGURE 1. Optimization of physical and mechanical properties of designed composite material based on polylactide

We saw (fig.1) a 2,5 times increase in the impact strength for coffee-filled composite for the sample with a content of 40%, which is predictable, since the filled polymeric materials always have a higher impact strength than homopolymers. Comparing the dependence of the high-fill polylactide impact strength on the coffee grounds, there is a tendency to increase the value of impact strength with increasing filler content [6]. This behavior of the new material allowed to decide the possibility of long-term exploitation of the products, since the impact strength of the composite material are within the same range as for polyethylene, polypropylene [6]. The increase of breaking stress during bending (table 1) also indicates the manufacturability of the new polymer composite material. Thus, it becomes evident that the coffee grounds are evenly distributed in the polylactide matrix [20]. In addition, it even slightly "softens" the original rather rigid polylactide polymer. All this together with the impact strength suggests that the possibility of forming various products of composite material, with particular attention is deserved composition with a content of coffee grounds 40 mass%.

Further, the design of ware's outward appearance for urban spaces landscaping was carried out in the form of vases for gardening and vases for planting greenery on the basis of an optimized environmentally friendly polymer composite in the SolidWorks 2020: 3D CAD environment.

Below in fig. 2 presents the outward appearance of a typical wares for urban spaces landscaping in the form of pots for planting seedlings of greenery with the indication of the main dimensions that made of optimized environmentally friendly polymer composition.

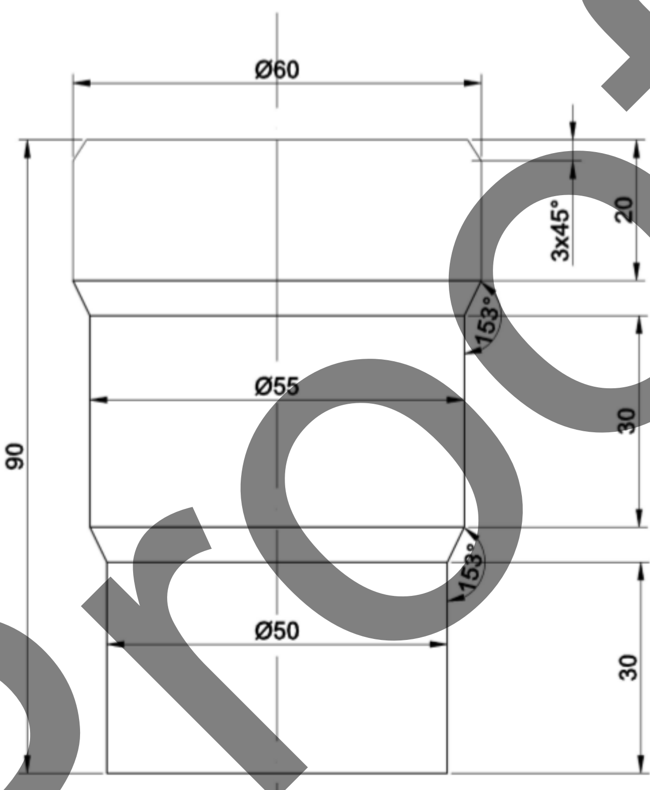

FIGURE 2. Outward appearance of a typical wares for urban spaces landscaping in the form of pots for planting seedlings of greenery with the indication of the main dimensions that made of optimized environmentally friendly polymer composition

Regardless of whether you will be using a CNC milling or turning machine, the typical process for creating injection molds for the production from polymer materials consists of the following steps:

- SolidWorks 2020: 3D CAD used to parts design;
- using additional tools SolidWorks 2020: 3D CAD to optimize the further use of CAD models for injection mold manufacture on a machine;
- SolidWorks 2020: 3D CAD analyzes the CAD drawing and outputs G-Code control commands to the machine controller;
-the operator of the machine, based on the commands received from the G-code-commands, activates the corresponding electrical circuits in the desired sequence and with the specified duration, which forces the machine to perform the operations specified by the program.

In fact, G-Code is the most common language understood by CNC machines.

Table 1 below shows the G-Code model for the ware design for urban spaces landscaping in the form of pots for seedlings and vases for planting from an optimized environmentally friendly polymer composite.

TABLE 1. G-Code models of ware design for urban spaces landscaping in the form of pots for seedlings and vases for planting from an optimized environmentally friendly polymer composite.

G-Code	Responsive action
O0001 (VAL);	Program number.
N5 G00 X40 Z50;	Accelerated movement to the tool change point.
N10 T0202 (Finishing Tool SVJC (08));	Changing the tool, turning on the corrector on the tool.
N15 M3 S2000;	Rotation of the spindle counterclockwise with a speed of 2000 rpm
N20 G00 X22 Z0;	Accelerated movement to point 1
N25 G01 X-2 F0.12;	Moving to point 2 with a feed of 0.12 mm / rev.
N30 Z1;	Moving to point 3.
N35 G00 X19 S1600;	Accelerated movement to point 4, changing the spindle speed by 1600 rpm
N40 G01 Z-20 F0.1;	Moving to point 5 with a feed of 0.1 mm / rev.
N45 X22;	Moving to point 6.
N50 G00 Z1;	Accelerated movement to point 7.
N55 X15;	Accelerated movement to point 8.
N60 G01 X18 Z-0.5 S1700 F0.05;	Moving to point 9 with a feed of 0.05 mm/min and the spindle speed of 1700 rpm
N65 Z-9.5;	Moving to point 10.

Below in fig. 3 presents 3d model outward appearance of a typical wares for urban spaces landscaping in the form of pots for planting seedlings of greenery with the indication of the main dimensions that made of optimized environmentally friendly polymer composition.

FIGIRE 3. 3d model outward appearance of a typical wares for urban spaces landscaping in the form of pots for planting seedlings of greenery with the indication of the main dimensions that made of optimized environmentally friendly polymer composition

SolidWorks 3d model outward appearance of a typical wares for urban spaces landscaping in the form of pots for planting seedlings of greenery with the indication of the main dimensions that made of optimized environmentally friendly polymer composition can be used for injection molds creation within the production processes of polymeric materials processing.

CONCLUSION

The article conducts research on modeling and design of wares from the new environmentally friendly polymeric materials based on polylactide and coffee waste for urban landscaping in the form of pots for seedlings and vases for planting greenery.

The designed and studied in article polymer composites on the basis of polylactide and coffee grounds solve the problems of recycling food industry waste in the form of coffee grounds and expand the possibilities of its rational utilization for agriculture. The use of coffee grounds as a filler for biodegradable polymeric materials can significantly reduce its quantity at landfills and obtain a new material that will be biodegradable. Thus, as a result of the conducted researches the rather high level of sorption resistance of the developed eco-friendly polymer composites on the basis of polylactide and coffee grounds is shown.

Optimization researches on definition the most effective structure of the new environmentally friendly polymeric materials on the basis of polylactide and coffee waste are carried out. It is shown the possibility of forming various products of composite material, with particular attention is deserved composition with a content of coffee grounds 40 mass%. The increase of breaking stress during bending also indicates the manufacturability of the new polymer composite material. Thus, it becomes evident that the coffee grounds are evenly distributed in the polylactide matrix. In addition, it even slightly "softens" the original rather rigid polylactide polymer. All this together with the impact strength suggests that the possibility of forming various products of composite material, with particular attention is deserved composition with a content of coffee grounds 40 mass%.

The design of new wares was constructed, the mathematical modeling of the designed products was carried out. Created in SolidWorks 3d, a model of a typical ware design for urban landscaping in the form of pots for seedlings of green plantings with the indication of the main dimensions making from optimized environmentally friendly polymer composite can be used to create molds in the production processes of polymer materials.

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Improving the Stability of Ettringite in Cement Systems with a High R_2O Content

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Abstract. The results of the study of the effect of metakaolin on the stability of ettringite in cement systems with high R_2O content are presented. According to the results of DTA and X-ray diffraction analysis, it was found that the increased content of R_2O promotes the decomposition of ettringite with the formation of monosulfate, even under normal temperature conditions. The introduction of metakaolin, which contains active aluminosilicates that bind Na+/K+ ions from the pore solution, shifts the balance toward the formation of primary ettringite and reduces the content of monosulfate, which prevent further crystallization of delayed ettringite.

INTRODUCTION

Increased R_2O content in cement and concrete causes an increased risk of internal corrosion of concrete due to the "Alkali-Silica Reaction" (ASR) and "Delayed Ettringite Formation" (DEF), which lead to premature failure of reinforced concrete structures [1]. The term "Premature Concrete Deterioration" (PCD) has been adopted to denote premature concrete failure due to ASR and DEF, as their individual destructive effect is often difficult to separate [2]. If the problem of ASR is sufficiently studied and can be solved by using inert types of aggregates, then the solution to the problem of DEF requires additional study. Dangerous formation of delayed (secondary) ettringite can occur in concretes that are exposed to temperatures exceeding the stability limit of primary ettringite and subsequent exposure to environment humidity. Although the decomposition of ettringite has been the subject of many studies, the exact temperatures, mechanisms, and kinetics of this process have not been defined, and the conclusions of different authors differ. Thus, according to Taylor [3], ettringite is unstable at temperatures above 70°C. The theoretical temperature of recrystallization of ettringite to monosulfate is approximately 90°C [4]. Studies [5] show that even at normal temperatures, ettringite becomes less stable with the addition of KOH and begins to slowly decompose at a concentration of KOH above 400 mmol / l. At higher concentrations of KOH this process intensifies, so at a concentration of KOH 770 mmol / l ettringite completely decomposed within 3 days [5]. According to [6], the content in the pore solution of concrete KOH and NaOH reduces the temperature of conversion of ettringite to monosulfate to 50-60 ºC. Thus, when heating such concrete at temperatures above 60°C, the maximum temperature of stability ettringite can be exceeded, which can lead to inhibition of the formation or decomposition already formed primary ettringite.

Alkalis (R_2O) get into concrete mainly from cement [7], in which they are represented mainly by sulfates (70-80% of R_2O) and in different quantities are present in silicate, aluminate (mainly) and in alumoferrite of cement clinker. The content of R_2O in Ukrainian cements is in the range of 0.6-1.2%, which is due to the chemical composition of raw materials, as well as production technology. The fly ash also contains R_2O, but mainly (90%) in glassy phases and only partially (30-35%) go into solution as they hydration [8], but at the same time, they are bonding [9]. Additional sources of R_2O can be fillers (gneiss, spar) [10] and chemical admixture containing sodium and potassium. Sodium and potassium can also get into concrete from the environment, anti-icing agents, sea salt [11]. The results of

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studies [12, 13] shows that the use of different types of superplasticizers can slow down the formation and decrease the temperature of stability of ettringite, which may be due to the content of Na^+/K^+ in admixture. In studies [14, 15, 16] shown a positive effect of 8% metakaolin, 15-25% fly ash and more than 25% blast furnace granulated slag on the control of expansion due to DEF, which is associated with the content of active Al_2O_3. In the same time, the replacement of cement by 8% of microsilica does not allow to control long-term expansion due to DEF, although the beginning of expansion is delayed [14, 15]. According to [17], the introduction of metakaolin in the cement leads to a decrease in the content of Na^+/K^+ and OH^- in the pore solution. At a content of 10% of metakaolin, the concentration of Na^+/K^+ in the pore solution decreases by 2-5 times. The probable mechanism of metakaolin action is the reaction of aluminosilicate and water-soluble alkalis with the formation of amorphized alkaline hydroaluminosilicates.

The above analysis shows that the Na^+/K^+ ions present in the pore solution of concrete adversely affect to the stability of ettringite and can cause internal sulfate attack. Therefore, increasing the resistance of concrete to internal sulfate attack is possible by increasing stability of ettringite at using active aluminosilicates to bind Na^+/K^+, which was the purpose of the following studies.

MATERIALS AND METHODS

In the studies, as an active aluminosilicate was used metakaolin VMK (LLC "Western Kaolin Company", Ukraine) with a specific surface of 10400 cm^2/g. Medium-aluminate Portland cement was modeled by using powders of clinker minerals, portlandite and two-water gypsum. The chemical composition of the metakaolin and the hypothetical composition of the cement are given in table. 1.

TABLE 1. Chemical composition of raw materials

Name	The content of oxides, %										LOI %
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	SO_3	
CEM I 42,5 N	22,4	-	5,26	4,09		0,63	65,95	0,69		0,46	0,52
Metakaolin	53,2	0,58	43,6	0,75		-	0,45	0,45		0,03	1,2

Products of hydration in model compositions were studied using X-ray diffraction analysis on a DRON-3M diffractometer with a copper tube at a voltage of 30 kV, a current of 10…20 mA and a range of angles $2\theta = 10…60°$, at a speed of 2° per minute. DTA of model compositions was performed on a derivatograph of the system by R. Paulik, I. Paulik, L. Erdey (MOM, Hungary). The study of the microstructure of the model compositions was performed on a raster - electron microscope - microanalyzer REMMA - 102 - 02.

RESULTS AND DISCUSSION

Physical-chemical studies of transformations in the ettringite-monosulfate system were performed on model compositions [17]: additive-free, medium-aluminate Portland cement (Fig. 1-2), Portland cement with the additive of 2% Na_2SO_4 (Fig. 3-4) and Portland cement with the additives of 2% Na_2SO_4 and 10% metakaolin (Fig. 5-6). Symbols on Fig. 1, 3, 5: A - C3A, P - $Ca(OH)_2$, E - ettringite, M - monosulfate, G - $CaSO_4 \cdot 2H_2O$.

From fig. 1 shows that C3A, whose intense reflexes were fixed on the 1st day of hardening, almost completely reacts up to 7 days, at the same time the intensity of ettringite reflexes is stabilize, which increase slightly up to 28 days. Reflexes of monosulfate, in fact, do not change their intensity at 1, 7 and 28 days. On the images of samples of this system (Fig. 2), taken with a scanning electron microscope at 28th day of curing, identify the inclusion of small crystals of ettringite along with crystals of monosulfate, portlandite and gypsum.

In the model of Portland cement with the additive of 2% Na_2SO_4 (Fig.3), is accelerating the conversion of C3A, the intensity of the reflexes of which (compared to the additive-free model on Fig. 1) is significantly reduce on 1 and 7 days. At the same time, from 1 to 7 days and especially at the 28th day there is an increase in the intensity of gypsum reflexes, which is explained by the reaction of Na_2SO_4 and $Ca(OH)_2$ (whose reflexes decrease) with the formation of $CaSO_4 \cdot 2H_2O$.

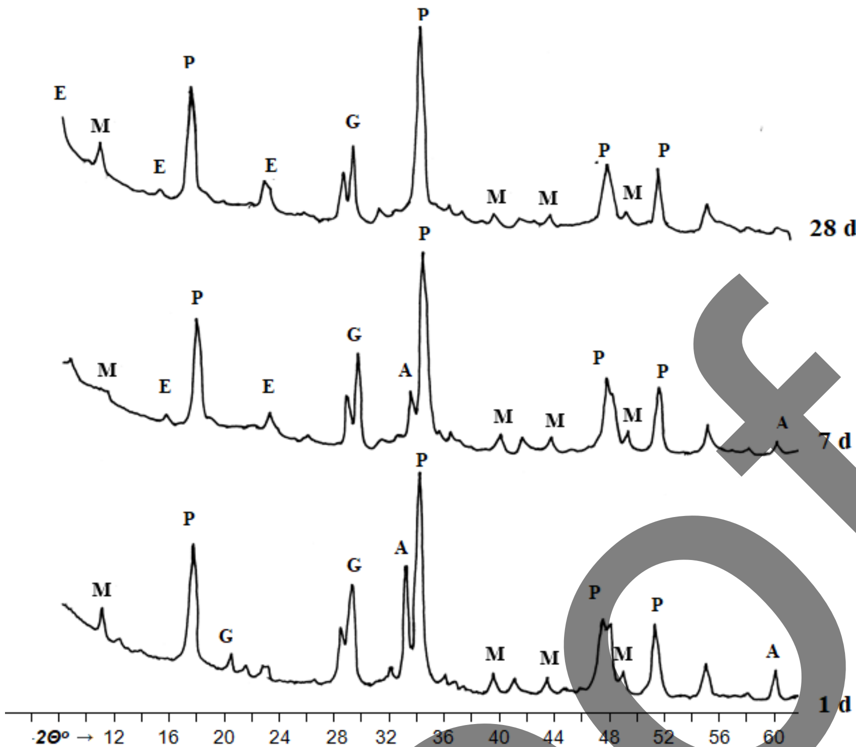

FIGURE 1. X-ray diffraction analysis of hydration products in the model of additive-free Portland cement

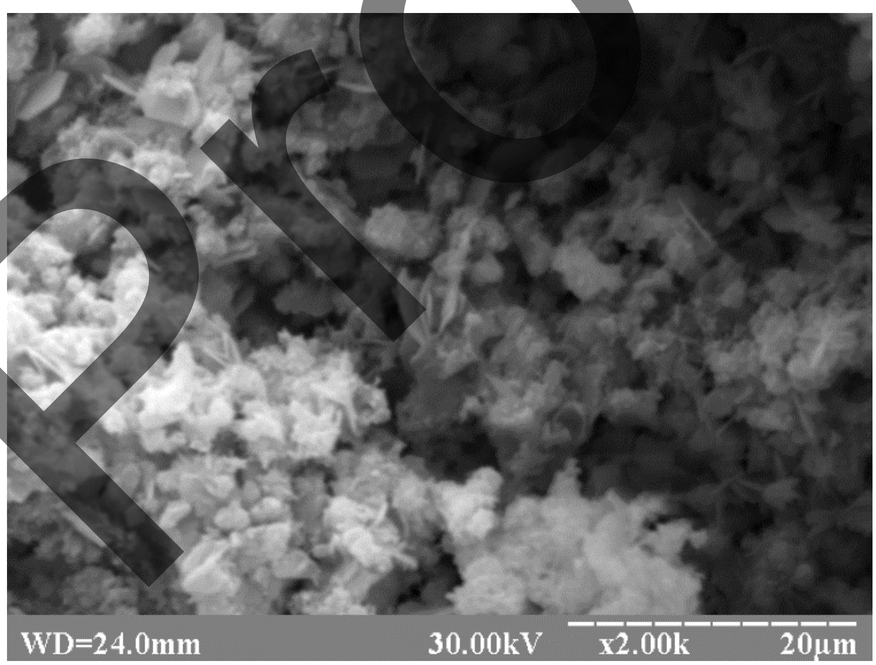

FIGURE 2. Electronic image (at the 28th days) of hydration products in the model of additive-free Portland cement

The intensity reflexes of ettringite on Fig.3 compared to Fig. 1 does not actually change, but at the 28th day significantly increase the reflexes of monosulfate. Electronic images of samples this system, taken at the 28th day of curing, allow to identify the increased content of large crystals of needle ettringite (Fig. 4).

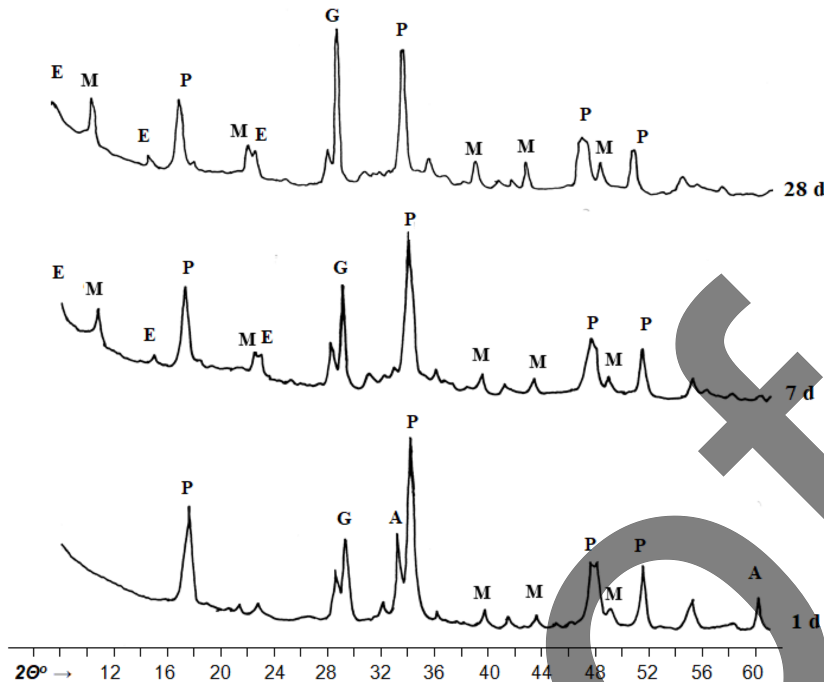

FIGURE 3. X-ray diffraction analysis of hydration products in the model of Portland cement with the additive of 2% Na_2SO_4

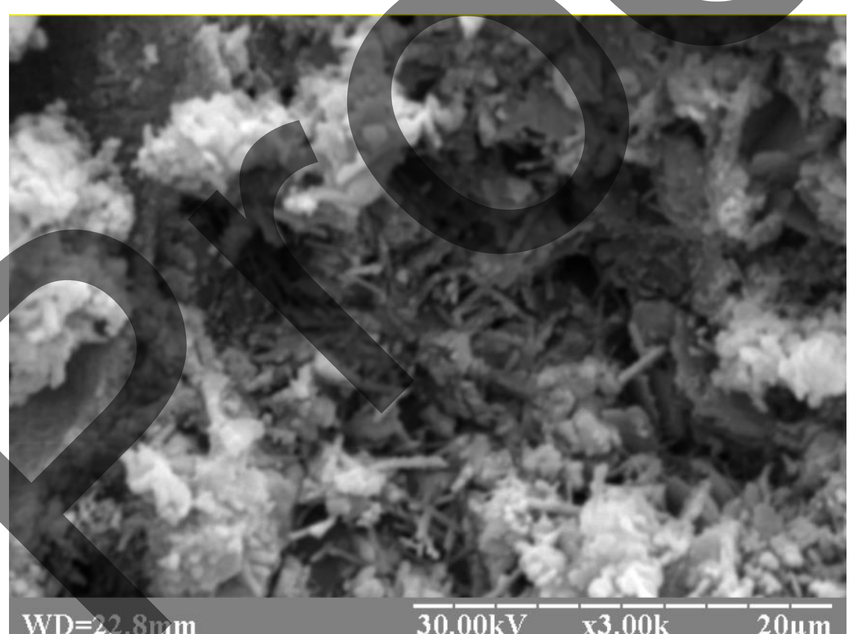

FIGURE 4. Electronic image (at the 28th days) of hydration products in the model of Portland cement with the additive of 2% Na_2SO_4

The content of metakaolin in the model system (Fig. 5) leads to a significant increase of the intensity of reflexes of ettringite (compared to Fig. 1 and Fig. 3) on both 7 and 28 day, while significantly reducing the intensity of reflexes of $Ca(OH)_2$, which actively reacts with metakaolin. Reflexes of monosulfate at 1, 7, and 28 days remain actually unchanged. On electronic images (Fig. 6) ettringite is identified in the form of small crystals.

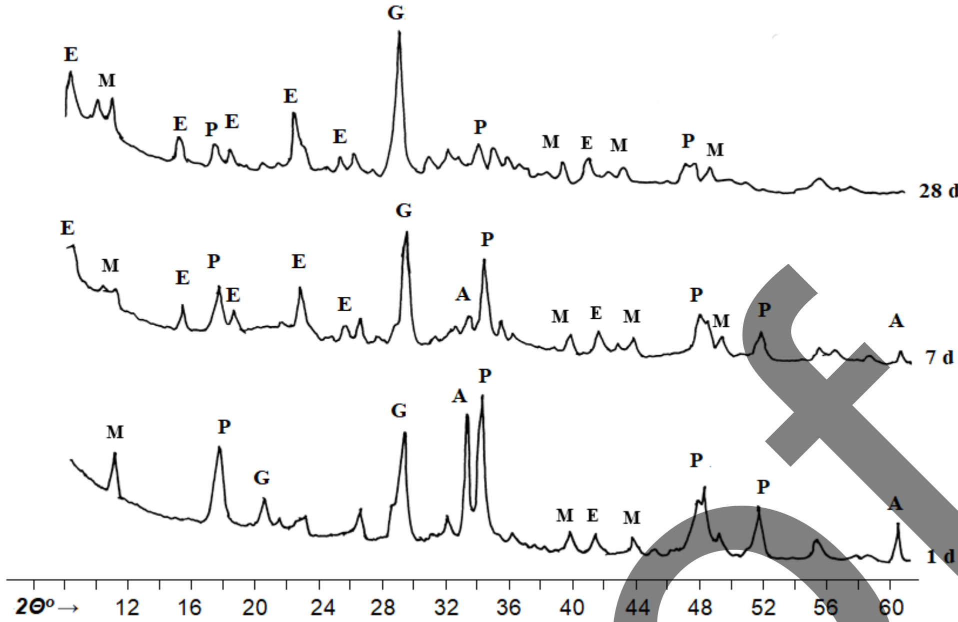

FIGURE 5. X-ray diffraction analysis of hydration products in the model of Portland cement with the additives of 2% Na_2SO_4 and 10% metakaolin

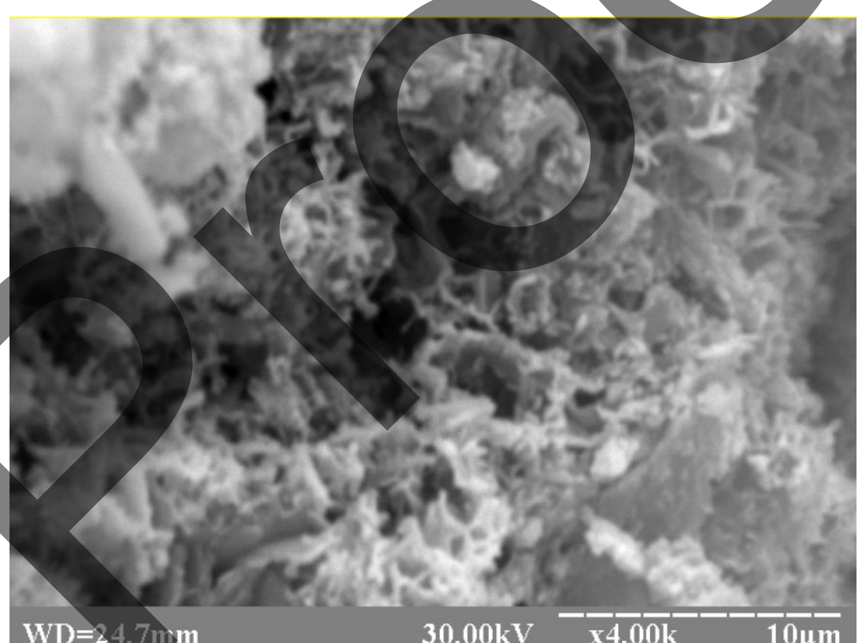

FIGURE 6. Electronic image (at the 28th days) of hydration products in the model of Portland cement with the additives of 2% Na_2SO_4 and 10% metakaolin

The balance in the ettringite-monosulfate system was investigated by DTA metod. According to Fig. 7 (a), the model of additive-free Portland cement at the 7th and 28th days of hardening has an equilibrium content of ettringite (140–165 ºC) and monosulfate (205–212 ºC). The increased content in the model of sodium sulfate (Fig. 7, b) shifts the equilibrium towards monosulfate on both 7 and 28 days. The introduction in the model of sodium sulfate and metakaolin (Fig. 7, c) return the equilibrium content of ettringite and monosulfate on both 7 and 28 days.

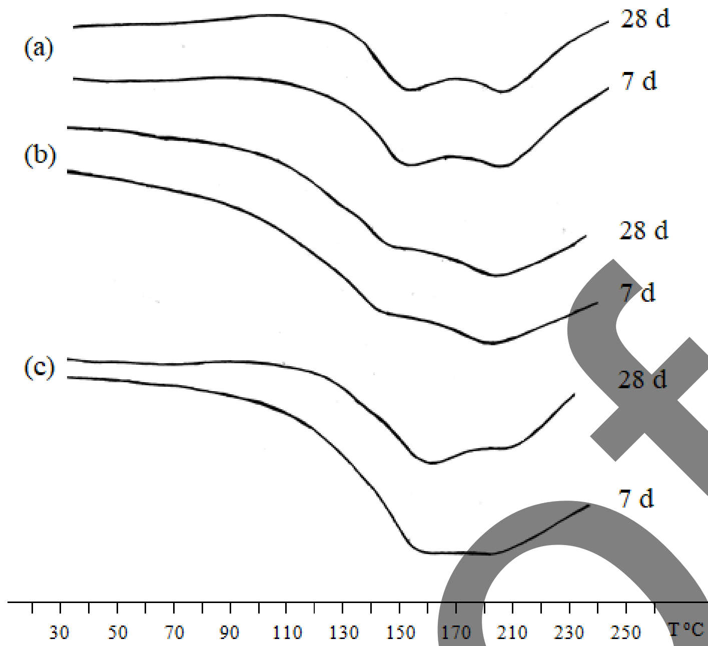

FIGURE 7. DTA of model compositions on 7 and 28 days of hardening: (a) - Portland cement; (b) - Portland cement with 2% Na_2SO_4; (c) - Portland cement with 2% Na_2SO_4 and 10% metakaolin

Thus, the increased content of sodium sulfate promotes the formation of monosulfate even under normal temperature conditions. The introduction of metakaolin in the system allows to shift the balance towards the formation of primary ettringite at the initial stages of structure formation, which excludes further crystallization of delayed ettringite.

SUMMARY

According to X-ray diffraction analysis and differential thermal analysis data, it has been confirmed that the increased content of R_2O promotes the decomposition of primary ettringite and the formation of monosulfate even under normal temperature conditions, which increases the risk of delayed (secondary) ettringite formation. The introduction of metakaolin in the cement systems with high R_2O content leads to a shift of the balance towards the formation of primary ettringite and a decrease of monosulfate content, which reduces the risk of internal sulfate attack due to delayed ettringite formation. Ensuring the resistance of cement systems with high R_2O content to internal sulfate attack by improving stability of primary ettringite in these cement systems is achieved by the introducing active aluminosilicates, which bind ions Na^+/K^+ from the pore solution and reduce the likelihood of dangerous processes of recrystallization of ettringite.

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Forecasting and Increasing the Crack Resistance of High-Strength Self-Compacting Concretes

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Abstract. By modeling the areas of elastic and microplastic deformations of high-strength self-compacting concrete was established of increased crack resistance by the criterion of crack opening due to restrained shrinkage of concrete with the addition of metakaolin. This is explained to the reaction of metakaolin and $CaSO_4 \cdot 2H_2O$ of cement with the formation of additional ettringite and low-calcium hydrosilicates with a decrease of shrinkage deformations and fragility of fracture. The positive effect on the shrinkage of concrete of replacing part of the cement by mineral additives is also explained by the reduction of autogenous shrinkage of concrete due to decreasing cement content, and reduction of drying shrinkage of concrete due to adsorption binding of capillary moisture by fillers. The introduction of mineral additives to replace of cement leads to a decrease of fragility of high-strength self-compacting concretes (increasing of area microplastic deformations) due to increased content of fine crystalline calcium hydrosilicates and gel-like neoformation.

INTRODUCTION

High-strength self-compacting concretes, compared to conventional concretes, have a number of advantages (laying without vibration, reducing the cross section of concrete structures, increasing durability), however, structures made of such concretes are characterized by reduced crack resistance. The problem of crack resistance of high-strength self-compacting concretes due to their increased shrinkage and brittle fracture requires a comprehensive assessment, which can be done by modeling. Self-compacting concretes were developed in Japan in order to exclude vibration during compacting, which reduced the cost of concreting [1]. One of the critical disadvantages of such concretes is the increased shrinkage, which significantly reduces their crack resistance [2, 3]. In the case of self-compacting concretes, there is an increase in all components of shrinkage: autogenous shrinkage due to chemical reactions between cement and water, drying shrinkage and plastic shrinkage [4, 5]. According to some research [6], the shrinkage of self-compacting concrete can be to 1.5 times more than the shrinkage of conventional concrete. With restrained shrinkage, when the tensile stresses of concrete reach the limit value, the formation of cracks begins [7]. In this case, the formation of shrinkage cracks in self-compacting concrete begins in the early stages of hardening (8-13 days) [8, 9]. To reduce the shrinkage it is recommended to provide curing of self-compacting concrete [1], to use shrinkage reducing admixtures [10, 11] and reinforcing fibers [12, 13]. Increased content in self-compacting concrete the cement and fillers leads to an increase of autogenous shrinkage and drying shrinkage of concrete [4, 14]. The value of shrinkage depends on factors related to the capillary pressure of water in the pores of concrete [15]. The shrinkage of self-compacting concrete can be reduced by using microsilica [16], fly ash, limestone [17] and metakaolin [18] when using them to replace cement. In addition to shrinkage, the crack resistance of concrete is depends on the flexural modulus, creep, tensile strength, etc. [19]. Therefore, all these parameters should be taken into account in a comprehensive assessment of crack resistance [20]. An attempt to estimate the crack resistance of self-compacting concrete with

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limestone and microsilica is given in research [2]. It is advisable to perform a comprehensive assessment of the crack resistance of high-strength self-compacting concrete with the metakaolin, which can have a positive effect on the deformability of concrete [18]. According to the literature review, it is possible to note the possibility of predicting and increasing the crack resistance of high-strength self-compacting concrete by modifying of concrete and modeling the crack resistance of concrete based on the results of complex studies of the shrinkage, flexural modulus and cracking parameters. Thus, the purpose of this work was to predict (according to a complex of criteria) and increase the crack resistance of high-strength self-compacting concrete.

MATERIALS AND METHODS

In the studies was used of Portland cement CEM I 42.5 R (CRH, Ukraine). Mineral additives: metakaolin METAVER I (NEWCHEM AG, Austria), silica fume Microsilica 940 (Elkem, Norway), limestone (Ukraine), fly ash (Ladyzhyn, Ukraine). Aggregates: river quartz sand, granite crushed stone of 2–5 and 5–10 mm fractions. Superplasticizers admixtures produced by MC-Bauchemie, Germany. Physico-mechanical studies were performed in accordance with the current regulatory documents. The flexural modulus of concrete was determined by DSTU B V. 2.7-217:2009. Crack resistance of concrete was evaluated by the criterion of critical crack tip opening displacement (CTODc) [2]. The parameters of crack resistance of concretes were determined by DSTU B V.2.7-227:2009.

Products of hydration in model compositions were studied using X-ray diffraction analysis on a DRON-3M diffractometer with a copper tube at a voltage of 30 kV, a current of 10… 20 mA and a range of angles $2\theta = 10…60°$, at a speed of 2° per minute. The study of the microstructure of the model compositions was performed on a raster - electron microscope - microanalyzer REMMA - 102 - 02.

RESULTS AND DISCUSSION

The main reason of the formation of cracks in concrete capable of self-compacting is shrinkage deformations. According to the results of previous studies, it was found that the introduction of 10% fly ash, microsilica and limestone to reduce the shrinkage of concrete (for 120 days) to 0.34-0.36 mm/m. The introduction of 10% metakaolin reduced the shrinkage to 0.29 mm/m. Shrinkage of the concrete composition without additives (for 120 days) was 0.38 mm/m. On the 7th day of hardening, the concrete composition without additives had less shrinkage (0.06 mm/m) than the compositions with mineral additives (0.11–0.14 mm/m). According to the results of research of high-strength concretes, the smallest flexural modulus of 36.6 GPa had the composition of concrete with 10% metakaolin, the largest flexural modulus of 50.4 GPa - the composition of concrete with 10% microsilica. The flexural modulus of 41–42 GPa showed concrete composition without additives and concrete compositions with 10% fly ash and with 10% limestone.

The size of the microplastic deformations area (1–2) was considered as an indicator of fragility of high-strength concretes (Fig. 1), and was defined as the difference between the deformations of the beginning of microcracking (1) and the beginning of the formation of the main crack (2). By this criterion, the most fragile destruction characterized the samples of high-strength concrete without additives with the size of area of microplastic deformations (1–2) ~ 7 μm and with the size of area of elastic deformations (0-1) ~ 30 μm. The least brittle destruction characterized the samples of concrete with fly ash with the size of area (1–2) ~ 13.5 μm and metakaolin with the size of area (1–2) ~ 12.5 μm. The size of the area of elastic deformations (0-1) of concrete samples with fly ash and metakaolin was ~ 26.5 μm. The average indicators of fracture fragility had the samples of concrete with microsilica (the area 1-2 ~ 10 μm) and with limestone (the area 1-2 ~ 10.5 μm). The size of the area of elastic deformations (0-1) of concrete samples with microsilica was ~ 23 μm, and concrete samples with limestone ~ 25 μm. The crack opening parameters were determined by modeling the deformations of samples prisms with an initiated crack: of the area of elastic deformations (0-1) and the area of microplastic deformations (1-2) before the formation of the main crack (Fig. 1).

By the models, the crack opening width was calculated, which corresponds to the beginning of microcracking and the beginning of the formation of the main crack. The beginning of formation of microcracks in concrete without additives begins at opening of the crack to 17,6 μm, at the subsequent opening of crack to 21,7 μm formation of the main crack begins (Fig. 2).

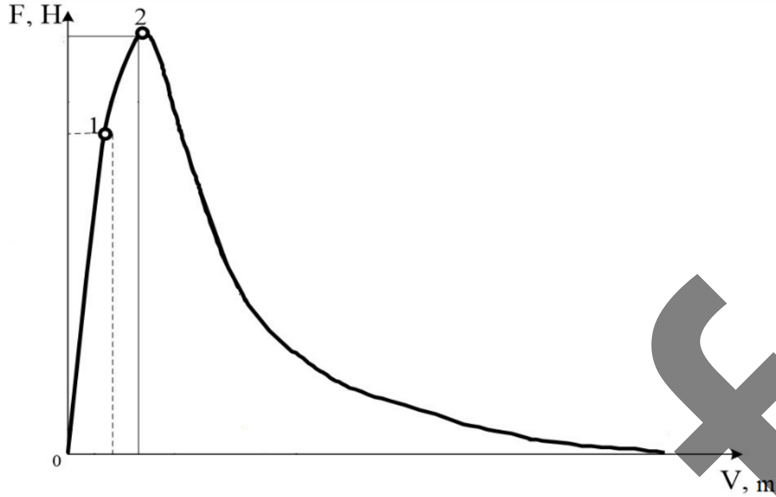

FIGURE 1. Bending deformation diagram of concrete prism with an initiated crack

Thus, the area of microplastic deformations corresponds to the opening of the crack ~ 4 μm. The beginning of the formation of microcracks in high-strength concrete with fly ash and microsilica begins at the opening of the crack 15.5 and 13.7 μm, respectively, and at the opening of the crack up to 23.5 and 19.8 μm, respectively, begins the formation of the main crack (Fig. 2). The onset of microcracking in concrete with metakaolin and limestone begins at the opening of the crack 15.6 and 14.8 μm, respectively, with the opening of the crack 22.9 and 21.1 μm, respectively, the formation of the main crack begins (Fig. 2). The crack opening parameters (by the model) were used to predict the opening of shrinkage cracks in the studied concretes. By the model, the value of cracks opening due to restrained shrinkage (for 120 days) is 1.5-2 times higher than the value of cracks opening of beginning of the formation of the main crack (Fig. 2).

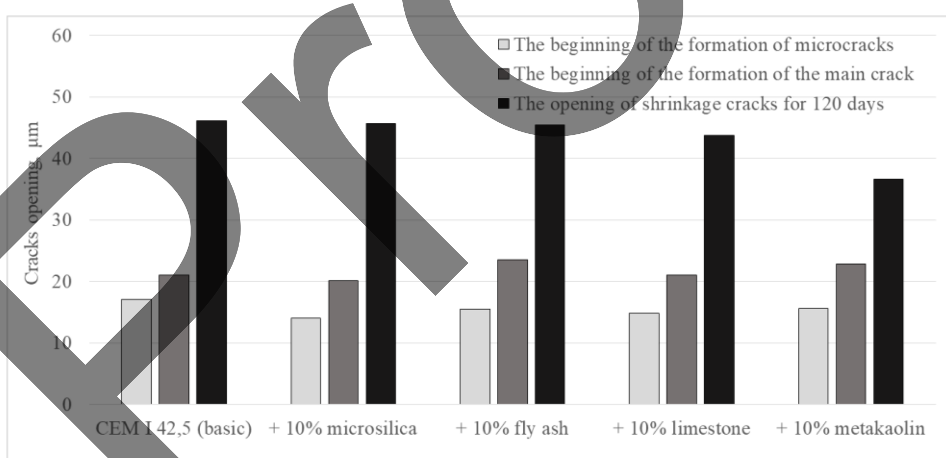

FIGURE 2. Cracks opening in the studied concretes by the model

By the model, microcracking due to restrained shrinkage of concrete without additives (Fig. 3) begins at the 9th day, and the formation of the main crack - at the 11th day of hardening. The beginning of the formation of shrinkage microcracks (by the model) in high-strength concrete with fly ash, limestone and microsilica begins at the 6th day of hardening, and at the 8th, 10th and 11th days of hardening, respectively, begins the formation of main crack (Fig. 3). The beginning of the formation of shrinkage microcracks in concrete with metakaolin begins at the 8th day, and the formation of main crack begins only at the 17th day of hardening (Fig. 3).

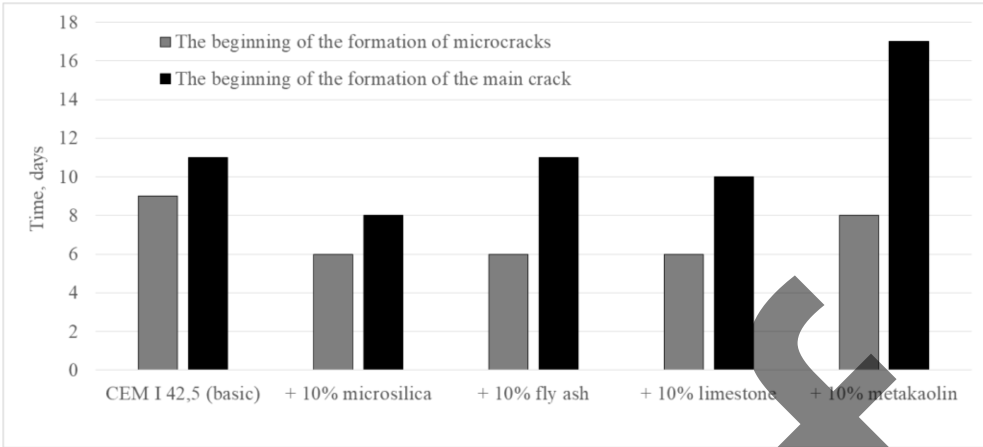

FIGURE 3. Predicted time the onset of shrinkage cracks by the model

Therefore, by the results of modeling the composition of high-strength self-compacting concrete with metakaolin can be considered the most crack-resistant. This is due to the lowest shrinkage and relatively larger area of microplastic deformations of concrete this composition.

To explain the results of crack resistance studies of high-strength concrete, were performed of X-ray diffraction analysis and electron microscopic studies of cement systems without additives (Fig. 4) and with the additive of 10% metakaolin (Fig. 5) at the age of 7 and 28 days. X-ray diffraction analysis results indicate the presence in all compositions of low calcium hydrosilicates of variable structure: (1-1.5)$CaO \cdot SiO_2 \cdot H_2O$ (d = 0.305; 0.279; 0.210; 0.184 nm).

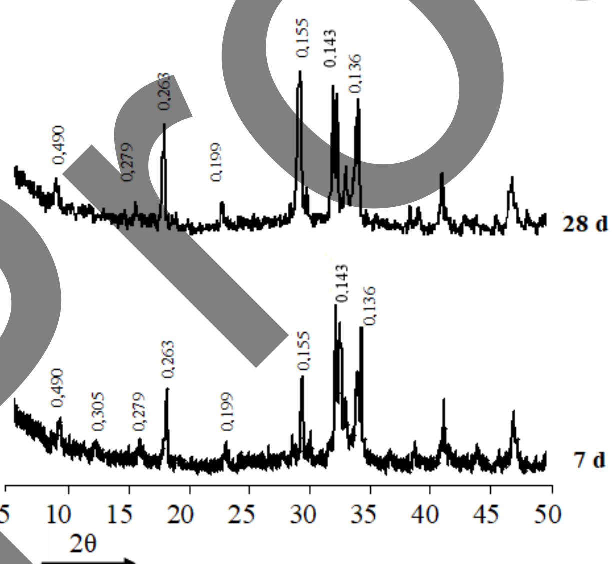

FIGURE 4. X-ray diffraction analysis of cementsystem without additives

When in the system is introduced of 10% metakaolin, the intensity of diffraction reflexes corresponding to low-calcium hydrosilicates increases. Also according to X-ray diffraction are fixed of reflexes of portlandite (d = 0,490; 0,263; 0,143 nm) which decrease at introduction of metakaolin. In the studied systems were fixed of ettringite reflexes (d = 0.561; 0.155 nm). The intensity reflexes of ettringite increases with the introduction of metakaolin in the system, what is explained by the reaction of metakaolin and $CaSO_4 \cdot 2H_2O$ of cement. Electron microscopic studies of hardening cement with the addition of metakaolin (Fig. 6) indicate a predominant content of fine crystalline hydrates and gel-like neoformation.

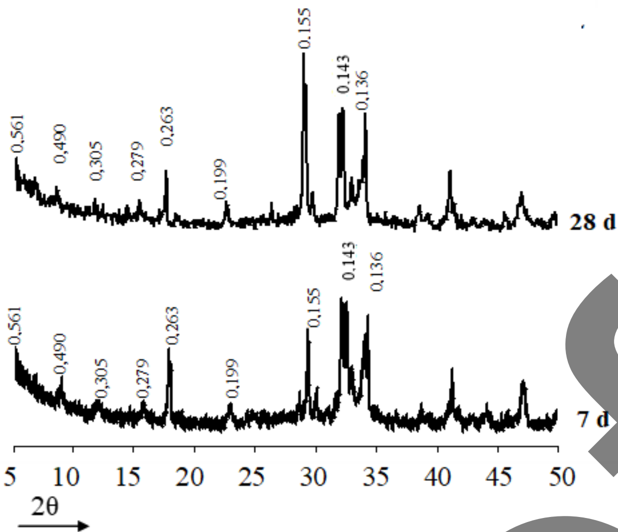

FIGURE 5. X-ray diffraction analysis of cement system with additive of 10% metakaolin

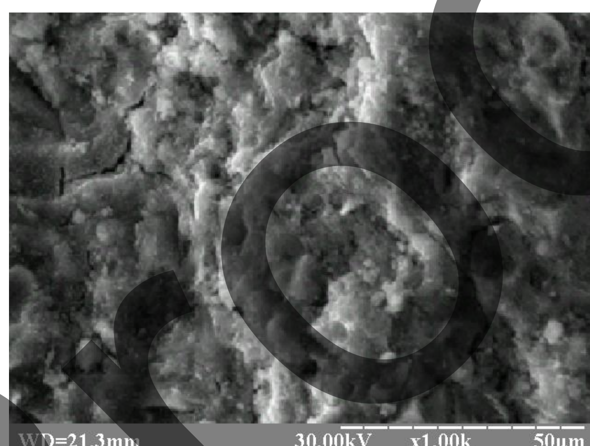

FIGURE 6. Electron microscopic study of cement system with metakaolin

Thus, the results of X-ray diffraction analysis and electromicroscopic studies of cement systems with metakaolin can be concluded to shift the balance in the direction of increasing the content of fine-crystalline low-calcium hydrosilicates and gel-like neoformation. The increase of the amount of ettringite, due to the reaction of metakaolin with $CaSO_4 \cdot 2H_2O$ of cement, explained a decrease of shrinkage deformations of this system.

SUMMARY

The parameters of crack opening in the studied concretes were determined by modeling the areas of elastic and microplastic deformations by bending deformation diagrams of prisms with initiated cracks. By the model, was found that the opening of shrinkage cracks in the studied concretes (for 120 days) significantly exceeds the value of the onset opening the main crack. By the model, the formation of microcracks due to restrained shrinkage of high-strength concrete without additives begins at the 9th day, and the formation of the main crack - at the 11th day of hardening. The onset of shrinkage microcracks in high-strength concrete with fly ash, limestone and microsilica begins at the 6th day of hardening. The formation of shrinkage main cracks in these concretes begins at the 8th, 11th and 10th days of hardening, respectively. The beginning of the formation of shrinkage microcracks in concrete with metakaolin begins at the 8th day, and the main crack - at the 17th day of hardening. Therefore, the composition of concrete with metakaolin can be considered the most crack-resistant among the studied. Increased crack resistance of high-strength self-compacting concrete with the addition of metakaolin is due to reduced shrinkage and fragility of fracture. The reduction of shrinkage deformations of concrete when using metakaolin is explained by the increase of the amount of ettringite due to the reaction Al_2O_3 of metakaolin with $CaSO_4 \cdot 2H_2O$ of cement. Decrease of fragility (increasing of area microplastic deformations) of concrete with mineral additives is explained by increased content of fine crystalline calcium hydrosilicates and gel-like neoformations.

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The Influence of Smart-Covering on the Formation of a "Green" Pedestrian Network in the Cities of Ukraine.

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Abstract. The process associated with the human mobility growth and the variety of motivations for its movement in a modern city leads to the inevitable functional transformation of the pedestrian streets in cities and changes the way of their use. There are specific problems of transforming urban walking routes and communications spaces in many cities of Ukraine, even small ones. On the contrary, in foreign practice, landscape organization and the creation city "greenways" (green paths) are widespread due to the important spatial and recreational meaning. In this article, the authors consider issues related to the landscape planning organization of green walking routes in large cities. The question of the influence of smart coverage on the formation of a "green" pedestrian network in the cities of Ukraine is considered.

ACTUAL PROBLEMS

Today street and road surfaces can be considered as an element of the "lithosphere" of urban ecosystems that harm the ecosystem because the percentage of asphalted floors of transport and pedestrian roads reaches incredible rates. The problems are that the intense heating of asphalt surfaces, the minimum amount of moisture that can be absorbed and penetrate deep into the depths causes the soil to overheat which leads to a number of negative consequences: the emergence of foci on the territory of cities, erosion etc. In large cities the influence of the road surface is even stronger - the air temperature rises in them, ultraviolet radiation decreases to 30%, visibility decreases, cloudiness and precipitation increase and air circulation changes. In addition, during the seasonal maintenance of the highway pavement in winter the roads are sprinkled with salt. This harms not only cars which corrode much faster than usual but also negatively affects the survival of animals and microorganisms, due to sodium and chlorine ions that enter water bodies, soil and drinking water [1].

An alternative solution to these problems especially in the context of global climate change is to manage the mobility of movement around the city and apply innovative measures to organize green routes.

In the long term, it is considered more effective in comparison with the strategies of widening the carriageway to increase pedestrian and bicycle traffic as well as non-motorized individual vehicles (unicycle, segway, electric scooters, etc.). Moreover, the issue of resolving the issue of covering not only bicycle and pedestrian routes but also roads in general becomes relevant.

By building more roads or expanding existing one's traffic jams can be reduced only for a short time and then they grow again from the induced (provoked) movement, are attracted by creating a new space for the movement of cars, and new heating areas also appear. In contrast, with the help of infrastructural measures for organizing greenways and mobility management in the city positive effects of promoting walking, cycling and other non-motorized traffic can be achieved initially small but mostly increasing over time.

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RELEVANCE

The growth of human mobility and the variety of motivations for its movement in a modern city leads to a functional transformation of the pedestrian network of cities changes the nature of its use. For a long period in Europe, “Greenways” have become widespread - green ways as an element of the green pedestrian network of cities. They remain the main European cultural, economic and political center and have an important spatial and recreational value in the structure of cities. In the construction of such green routes, the latest ecological building materials are used, that improve the ecological state of the environment [2].

Recently, there has been a growing trend in the popularity of new ecological non-motorized vehicles, including the bicycle, all over the world. This phenomenon is due to various factors ranging from the fashion for a healthy lifestyle and ending with the unwillingness to stay in traffic jams. However, not all settlements can boast of proper conditions and the availability of appropriate infrastructure for safe movement with the help of new non-motorized individual vehicles. In addition, since the start of the pandemic the use of public transport has dropped significantly, as more people choose to walk or ride bicycles and other non-motorized transport. This is due to advice from health authorities on physical distancing to avoid crowding in public transport. Therefore, the development of urban greenways today is very relevant.

NOVELTY

In Ukraine in connection with the massive use of new ecological non-motorized vehicles, it became necessary to develop and plan future strategies for the development of the organization of a green pedestrian network of cities. The landscape organization and design of a green pedestrian network at present is complicated by an insufficiently developed regulatory and legislative framework in matters of creating routes: "green" pedestrian recreational, cycling and for the movement of non-motorized individual vehicles and their integration into the street and road network of cities [3].

For the first time, the report substantiated the need for the development of regulatory and legislative documents in this area in Ukraine, the use of the latest building materials and various engineering systems associated with the development of new technologies. For the first time, it was formulated, that the development of urban green ways in our cities, the management of urban mobility and coverage of a new generation can give at the beginning small but over time the positive effects of promoting pedestrian, cycling and other non-motorized traffic are predominantly increased.

MAIN SECTION

Analysis of foreign experience made it possible to identify new construction tools, structures and engineering systems used in the world in organizing green routes.

Natural heating of the sidewalk is one of these newest construction tools. It is advisable to provide cable heating of sidewalks in conjunction with pedestrian routes, because snow and ice melting systems guarantee the safety of movement for pedestrians. The big advantage of the snow and ice melting system is that the roads are automatically cleaned and kept in good condition around the clock. This is especially important in certain situations where free passage is necessary, for example, for ambulances or other specialized vehicles [4].

Technologies for heating asphalt roads and sidewalks are actively used in places where there is a problem of ice formation and snow removal. One of the leading countries in this area is Japan. Japan is an amazing country. Here, houses in the north of the country do not have central heating, but Japanese roads and sidewalks do not freeze and do not need to be cleared of ice and snow since they are equipped with a heating system. In Japan the use of chemicals on the streets is prohibited but the use of heating is encouraged. In the northern regions of the state the climate is characterized by a pronounced winter with freezing temperatures and a lot of snow. The technology of heating asphalt itself is in many ways similar to the technology of "warm floor" in construction, when a mesh with a heating element is laid under the outer covering [5].

There are also heated roads in Canada, USA, Finland, Norway, Iceland and other countries. Therefore, for example in Iceland, geothermal waters act as a source of heat that is so rich in the territory of this state. Iceland is one of the coldest countries in the world. It is located in the northern part of the Atlantic Ocean and in summer, the temperature of the liquid there exceeds 20 degrees Celsius. However, in Reykjavik, even in the wintertime there is a fast city life on the streets.

The first heated sidewalks appeared in Kiev 2021. So, in the Solomensky district of the capital within the framework of the draft Public budget a cable heating system was installed in the sidewalks with a strong slope. The sidewalk where there is a slope of the surface is equipped with a heating system, which improves the conditions for the movement of residents - especially in winter. In addition to the new pavement, new curbs, additional lighting poles and landscape design elements were installed along the sidewalk.

One example of the use of innovative design and engineering systems is the Dome in London, an architectural project called Bubbles, developed by Orproject. This project envisages covering of individual streets or blocks with a dome to protect from rain and cold. It assumed that the distribution of air inside the bubble would be controlled by a powerful heat exchange system, for which energy will be supplied by solar panels installed on the surface of the dome. Such a system will allow zoning the space, maintaining in individual gardens the necessary conditions for the life of plants from a certain climatic zone. The construction of such structures to create an artificial climate on city streets for the appropriate organization of green continuous alternative walking routes solves a number of environmental problems and increases the comfort of the city environment.

The Bubbles concept consists in the construction of an entire block in which residential, office and commercial buildings will be located along the perimeter, and inside the development there will be a large space covered with a special membrane with a stable and pleasant temperature for people throughout the year. There you can arrange an evergreen park with paths for walking and cycling, playgrounds, sports and other types of recreation, as well as places for outdoor restaurants and cafes [6].

Thus, the use of appropriate innovative systems makes it possible to use urban green pedestrian routes all year round, where you can move on various non-motorized vehicles.

New ecological non-motorized vehicles are increasingly being used, especially in large cities overcrowded with vehicles. After all, an individual ecological non-motorized transport (IENMT) is a type of transport designed for 1 or 2 people, from the point of view of techno-ecology does not harm the environment. This type of transport includes:

• electric transport: electric vehicle, electric bike, electric scooter (vehicle on two wheels with an electric motor), segway (electric self-balancing vehicle with two wheels), mono-wheel (modernized segway - electric self-balancing unicycle-unicycle with one wheel and footpegs located along both sides of the wheel)

• pneumatic transport: vacuum train, air car etc.;

• rail: monorail vehicles and monocar;

• solar transport: solar vehicle, solar bicycle, electric motorboats with solar panels.

All these environmentally friendly vehicles are no longer a rarity. They are increasingly used, especially in large cities overcrowded with vehicles. As for the solar car, today they can be found on the roads very rare. This is a very expensive pleasure. However, over time, it will become available to everyone. The development of IENMV requires the implementation of the latest building materials. To organize alternative green routes it is advisable to use smart coatings.

For the organization of urban greenways and their further improvement, it is necessary to provide for a certain system of steps, including the appropriate means and techniques of landscape organization of the urban environment.

The means of landscape organization are tangible assets, mechanisms, devices, etc., with the help of which a new quality of the landscape environment is formed.

The following means can be attributed to the means of landscape organization of green pedestrian spaces: landscaping and improvement; engineering training, engineering, and technical equipment; constructive, compositional and innovative.

The traditional route paving is the paving stone sold in the construction markets in concrete, brick, clinker and other materials. Today, sidewalk clinker is one of the most versatile materials used in the construction of access roads, paving sites and the conclusion of the sidewalk. Nevertheless, the future belongs to the smart coating; first, it is paving slabs made of solar panels [7].

It is the innovative means of landscape organization of green routes that will contribute to solving a number of environmental problems. These tools include:

- smart cover:
    - paving slabs made of solar panels (this will make street lighting much more energy efficient);
    - energy-saving sidewalk tile (an example of such a tile is Pavegen - a coating that generates energy due to the movement of pedestrians on it, that is, the electric charge is indexed by dielectrics under the action of deformation. This "smart improvement" makes the street self-sufficient: there is enough energy for lighting and music and allows you to save on organizing street space);

- LED paving stones (such paving stones can be used for illumination and decorative finishing of sidewalks, paths on cottage plots, garages, parks, squares, alleys, swimming pools, etc.);
- tiles with built-in wi-fi access - this is the development of the American manufacturer ThermaHEXX called ThermaPAVER perfectly suits those historical areas of the city and cultural centers where you need to create wireless Internet access without violating the architectural integrity of the area;

- sidewalk with natural heating;
- technical means of regulation of bicycle traffic;
- "smart" traffic lights.

Solar energy is now on the rise - construction of large power plants is underway, the cost of producing solar panels is decreasing, and innovative photovoltaic cells are being developed. The latter include the joint development of Onyx Solar and Butech, which is a symbiosis of paving slabs and a solar panel [10].

It is noteworthy that this tile makes a "green" contribution not only at the stage of use, but also at the production, process for the manufacture of "solar tiles" produces less carbon dioxide than the creation of traditional sidewalk pavement. The innovative coating entered the market at the end of 2010, which made the joint product of the two companies the first photovoltaic pavement coating available to a wide range of buyers [8].

Solar architecture requires a high investment, but while pavement brick pavement provides enough flexibility for modern traditional structures offers strength and attractive designs that last for a long time, its cost pays off as residents have a renewable and sustainable environmentally friendly energy.

RESEARCH RESULTS

Until our cities suffocate from car smog and high temperatures from heating roads, suffering from oxygen deficiency, it would be desirable to adopt the unique experience of Japan, the USA, Curitiba, as well as the literate and abundantly landscaped ones, Portland, Reykjavik, Copenhagen and other cities of the world.

The unsatisfactory condition of roads and sidewalks, the lack of an innovative material and technical base for their current repair and maintenance, contribute to an increase in the number of environmental problems and a decrease in the confidence of residents in walking around the city.

Analysis of new trends in the development of non-motorized vehicles, the creation of a "green" pedestrian network of the city allows us to rethink the existing planning structure of cities and the role of active use of non-motorized transport, and make them more ambitious for residents. Efforts to expand the multifunctional eco-infrastructure should be accompanied by the creation of comfortable, innovative conditions for movement around the city along "green" pedestrian networks through the use of innovative building materials and coatings [9].

CONCLUSIONS

Thus, the use of the latest building materials makes it possible to improve the landscape-planning organization of alternative "green" routes, to stimulate cycling, walking and non-motorized individual vehicles. In turn, this will contribute to increasing the mobility of city residents and expanding sustainable sources of improvement: the ecological state of the environment, the health and safety of the urban population, the social integration of people with disabilities, economic prosperity and an overall improvement in the quality of human life in the city.

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Influence of Hardening Conditions on the Kinetics of Strength Gain in Alkali Activated Concrete Using Active Aggregates

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Abstract. One of the main problems in the case of use of active aggregates is the occurrence of alkaline corrosion during in the concrete artificial stone, that leads to the damages of concrete and then it can't be restored. That is why when solving the problem of alkaline corrosion it is necessary to find out the ways to prevent or reduce the rate of development of the corrosive processes, rather than possible ways to eliminate the consequences. The results of research aimed to determine the influence of component composition and curing conditions on the kinetics of strength set of materials based on alkaline cements, where basalt sand was used as a aggregates. The key factors influencing the strength of the hardened material are presented and the best curing conditions for the elimination of destructive processes in the concrete body are determined.

INTRODUCTION

The problem of use of the aggregates, which contents the active grains of silica, is actively investigated by the different researchers [1-5]. Changes in the cement production process, namely change of the fuel type from the natural gas to the coal, rises this question with the new force, because that leads to the increasing of the alkalis content in the cement, that together with the active silica in the aggregates results in the alkaline corrosion of concrete [6-10].

In the OPC concrete it has shown possibility to prevent such processes by using mineral admixtures [11-15]. Thus a way in alkali activated concretes could be used the same [16-20]. However, it should be mentioned that in the most part of the mentioned studies alkaline component was represented by alkaline solution with different composition, origin and density. But modern construction industry requires use of one-component cement systems, leading us to the use of alkaline component in the state of dry alkaline salts. As it was shown in the studies [21-23], such kind of alkaline component has its own peculiarities of work in such systems. Also, the question of possibility of reconstruction and use of constructions that have been damaged by alkaline corrosion of concrete is absolutely not investigated [24-26].

In the present paper there are shown possibility to influence structure formation processes and alkaline corrosion of concrete by changing of hardening and exploitation conditions. As main criteria at such stage of investigations were studied variation of strength characteristics of the material in time using different curing and storing conditions.

MATERIALS AND TEST METHODS

For investigation of possibility to influence on internal corrosion of alkali activated concrete gain the basalt rock was chosen as an active aggregate. The aggregate, taking into account results of previous studies [27-28] was represented by the fraction 0-2.5 mm. Chemical composition of basalt rock is given in Table 1.

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TABLE 1. Chemical Composition of Basalt Rock

	Oxides content, % by mass												Mass loses	Σ, %
	SiO_2	$A1_2O_3$	Fe_2O_3	FeO	TiO_2	MnO	CaO	MgO	P_2O_5	K_2O	Na_2O	SO_3		
Basalt	50,42	14,0	6,14	8,37	2,66	0,243	8,04	5,56	0,316	0,71	2,27	0,07	0,77	99,57

As main calcium - alumina silicate component of alkali activated cement was chosen granulated blast furnace slag (Kamenske, Ukraine), ground to the specific surface 450±20 m^2/kg by Blaine. Chemical composition of the slag is given in Table 2.

TABLE 2. Chemical Composition of Granulated Blast Furnace Slag

	Oxides content, % by mass						Mo
	SiO_2	Al_2O_3	CaO	MgO	MnO	TiO_2	
GGBS	37,90	6,85	44,6	5,21	0,106	0,35	-

As a hydrophobization agent was use admixture on the basis of silicon hydro siloxane liquid 136-157M, produced by «ANTALCOM» ltd.

As an active mineral admixture was used metakaolin from Glukhovetsky factory, ground to the specific surface 1000 m^2/kg by Blaine.

Specimens were prepared from fine-grain concrete (cement : sand mortar) in the ratio 1:3 according to DSTU B V.2.7-185 using standard "Hobart" mixer. Tests of the specimens were done according to recommendations DSTU B V.2.7-181.

Mix design of fine- grain concrete on the slag alkali activated cement basis is given in Table 3.

TABLE 3. Compositions of Fine-Grain Concretes on the Slag Alkali Activated Cement under Study

	Composition, %			
	GGBS	basalt sand	metakaolin	soda ash
ACP3	22,5	75%	-	2,5
ACP4	20,0	75%	2,5	2,5

Specimens were hardening in normal conditions (temperature 20ºC±2, humidity 95%±5). As a reference test dates for determining strength characteristics were 7, 28 and 90 days, because previous studies let us to classify our cement as Grade 42.5

According to the chosen test methods, specimens from fine grain concrete using slag alkali activated cement were cured for 7 days in normal conditions (temperature 20±2ºC and relative humidity 95±5%). After that specimens were divided onto four groups. The first one was dried to the constant mass and then returned to the normal curing chamber till the 28 days age. The second group was dried to the constant mass and then covered by the hydrophobization agent. Then specimens were also returned to the normal curing chamber. The third group was not dried, but covered by hydrophobization agent and then returned to the curing chamber. Fourth group (control specimens) was keep storing in the normal curing chamber.

TEST RESULTS AND DISCUSSIONS

Specimens of fine-grain concretes using slag alkali activated cement and active aggregate were tested at the age of 7, 28 and 90 days age. It has to be mentioned that before 7 days specimens were storied in the equal conditions thus they have equal strength properties. However, change of curing conditions, as it seems from the test results, influenced well on the structure formation process gain and hardening of the system, and also on the strength gain. Results of the provided tests are given in Table 4 and Figure 1.

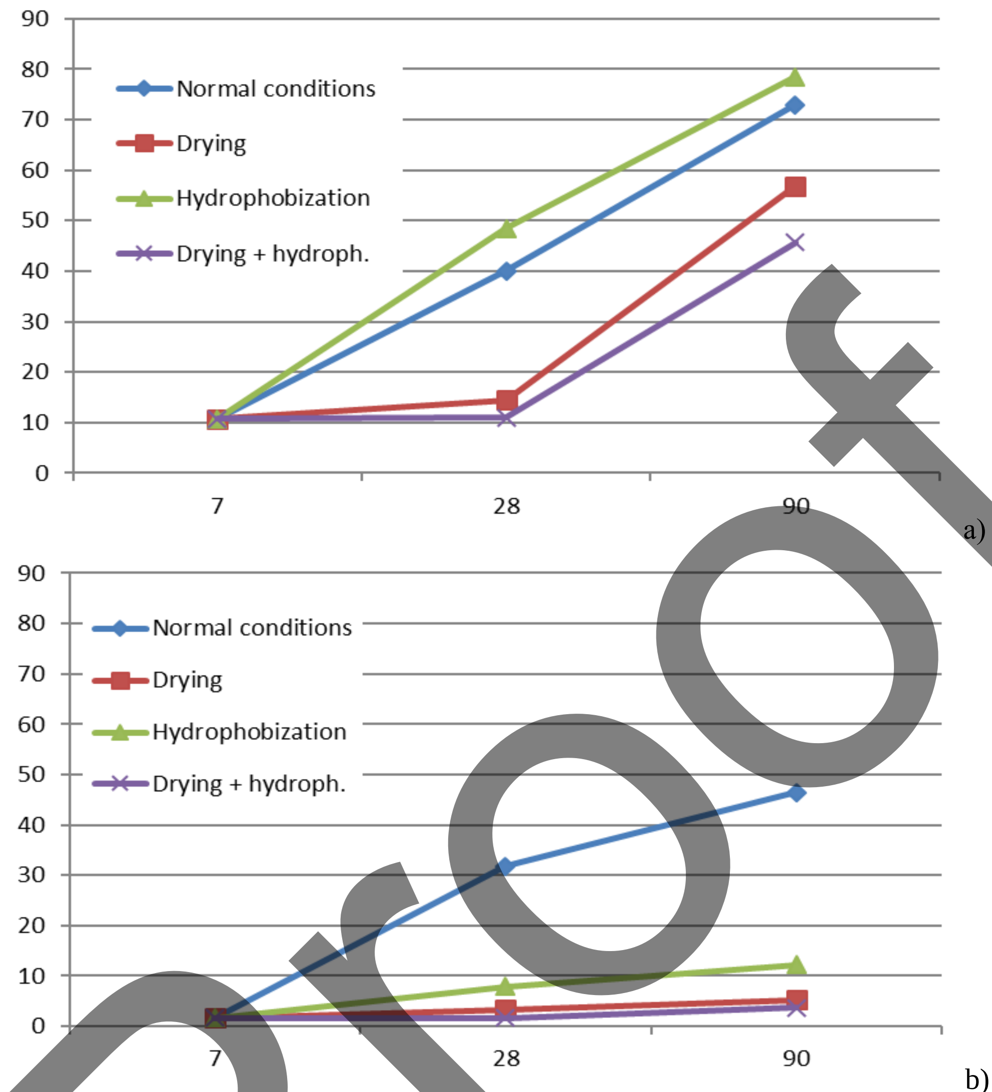

FIGURE 1. Variation of strength properties of fine-grain concretes depending from curing conditions: a) composition ACP3 (without metakaolin admixture); b) composition ACP4 (with metakaolin admixture)

Analysis of the obtain results showed great differences in the hardening process gain for the systems with and without metakaolin admixture. Thus, at the age of 28 days composition hardened in normal conditions are differ in the compressive strength in 9 MPa (40 MPa and 31 MPa correspondently). At the age of 90 days of normal hardening, this difference became wider (73 MPa against 46.5). Also here has to mentioned fact of high strength growth in the system with metakaolin (43 MPa at 28 days age versus 73MPa at 90 days age) -82.5% growths. For the system without metakaolin the strength is also growing, but in lower ranges (46.5 MPa at 28 days age in normal hardening conditions versus 46.5 MPa at 90 days age) – 46.2%. This fact shows higher strength growth potential for the system with metakaolin admixture. Principal scheme of ASR reaction in the systems under study is given in Figure 2 [18].

Changing the curing conditions leads to the slow structure formation processes of the systems using metakaolin, and systems are characterized by very low strength properties (3.7-12.2 MPa comparing to 31.1 MPa for control composition, which have been hardening in normal condition). This could witness about lack of alkaline component in the system, that acts with metakaolin and silicon acid and mostly totally vanishing. That means that alkalis content in the system became low to provide normal structure formation process gain under drying of specimen as a curing condition.

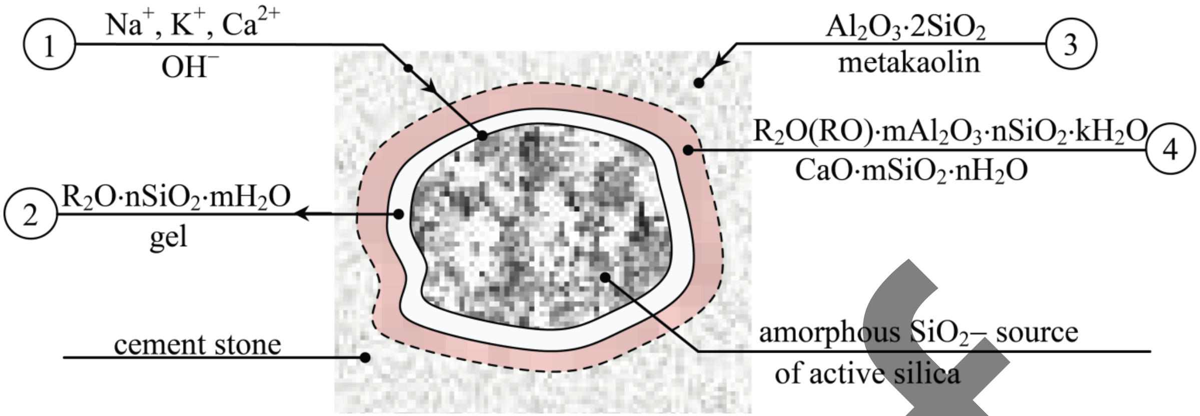

FIGURE 2. Principal scheme of ASR reaction in the systems under study

TABLE 4. Variation of Strength Properties of Fine-Grain Concretes Depending from Curing Conditions

	Curing conditions	Compressive strength, MPa, at the age, days		
		7	**28**	**90**
ACP3	Normal conditions	10.7	40.0	73.0
	Drying after 7 days	10.7	14.5	56.9
	Hydrophobization after 7 days	10.7	48.5	78.5
	Drying after 7 days and hydrophobization	10.7	11.0	45.7
ACP4	Normal conditions	1.7	31.8	46.5
	Drying after 7 days	1.7	3.3	5.2
	Hydrophobization after 7 days	1.7	7.95	12.2
	Drying after 7 days and hydrophobization	1.7	1.7	3.7

Low strength characteristics of both systems under study at the age 7 days also could be explained by relatively low content of alkaline component (content of alkaline component in the system is 5 % by mass calculating onto Na_2O), which at the initial stages is working mostly to bond silicon acid, reaching, however, necessary strength at the age of 28 days.

Drying of the specimens leads to the immediate stop of the hydration processes. This process is not fixing while specimens are returning to the normal hardening chamber. Probably, hygroscopicity of the concrete specimens because of dense structure is not enough to provide necessary moisture of the specimen and keep normal hardening process. However, at the age of 90 days compressive strength of such specimens is much higher (rising up to 4 times comparing with 28 days age for the systems with metakaolin). As for the system without metakaolin, the strength is rising but still is very low and gives us no possibility to check any regularity.

Hydrophobization of specimens after drying totally stops structure formation processes and the strength gain at the age of 28 days (compressive strength of the specimens is similar to the strength before drying at the age of 7 days.). On the other hand, at the age of 90 days compressive strength of the specimens is higher than at the age of 28 days, especially for the system with metakaolin admixture (11 MPa at the age of 28 days and 45.7MPa at the age of 90 days). Such behavior can be explain only by the fact that hydrophobic cover on the surface lost partially its properties and thus moisture of the specimens is rising, creating possibility to the binder and active part of aggregates to react. The possible way to remove such effect is to use other type of hydrophobization agent, durable in the high alkaline media.

Hydrophobization of not-dried specimens results in increasing of compressive strength of materials even comparing to the control composition, that could be explain probably not only by storing of moisture and continuation of structure formation processes, but also partially by the effect self-curing in the specimens after hydrophobization of the surface.

CONCLUSIONS

It was set that hardening of fine-grain concretes on the alkali activated cement bases depends a lot from the curing and hardening conditions. It was shown that in the case of drying of the material structure formation processes stops mostly total (compressive strength of the specimens keeps in the same range as it was before changing the curing conditions). Increasing of strength in hydrophobizated system comparing to the control composition hardened in normal conditions (78.5 MPa comparing to 73 MPa for the system without metakaolin) is caused, probably, because of self-curing processes inside the hydrophobizated material.

Joint use of metakaolin and active basalt aggregates in the alkali activated concrete composition with the alkaline component represented by dry sodium carbonate leads to the great strength drop for the systems, hardening in the not standard conditions, that could be explained by the lack of the alkaline component at the initial stages of hardening for development of structure formation processes after changes of curing and storing conditions.

Obtain results suggested to predict possibility to stop alkaline corrosion process in the real concrete constructions basing on the alkali activated cement in the way of changing of moisture gradient in the concrete body.

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Effectiveness Evaluation of Silicate Fillers for the Creation of Thin-layer Thermal Insulation Coatings

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Abstract. The use of thin-layer water dispersion thermal insulation materials can lead to significant energy savings in the field of housing and communal services. However, the thermal physical properties of such thermal insulation coatings has not yet been fully explored. The structure of such coatings is not homogeneous, and measurements of the temperature indicators of the coating surface using contact thermometers are inaccurate. Measurement of the thermal conductivity coefficient of the coatings needed to be carried out by a stationary method. Morphological analysis of the surface of styrene-acrylic coatings was carried out to analyze the influence of the distribution of silicate fillers on the thermal physical characteristics. It was established that the introduction of hydrophobic silicate filler allows to increase the thermal protection efficiency of styrene-acryl dispersions, due to the formation of a more ordered and less stressed structure. It is shown that the thermal conductivity coefficient for thin-layer thermal insulation coatings does not allow sufficiently reliable determination of their thermal insulation efficiency. This is due to the fact that the technological properties of the dispersed system itself have a significant effect on it, which significantly affect the distribution of fillers in the coating volume, internal stresses between the components and the defectiveness of the coating structure.

INTRODUCTION

The use of thin-layer water dispersion thermal insulation materials can lead to significant energy savings in the field of housing and communal services [1-8]. However, the thermal physical properties of such thermal insulation coatings has not yet been fully explored. The available research of various authors [9-13] on the determination of the thermal conductivity coefficient of the same types of thermal insulation paints often show a significant difference.

The difference in the results obtained is primarily due to the fact that there are no normative methods for determining the thermal conductivity coefficient of thin-layer thermal insulation coatings based on microspheres.

The structure of all such coatings is a lattice of hollow microspheres interconnected by a water dispersion film-forming substance. This composition is not homogeneous, and measurements of the temperature indicators of the coating surface using contact thermometers (thermocouples) are inaccurate, since in fact the temperature of the lattice is measured, which is significantly higher than the average temperature of the coating surface.

The main parameter of thermal insulation materials is thermal conductivity, which characterizes the ability to conduct heat. The indicator of the degree of heat conductivity by the material is the thermal conductivity coefficient.

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This indicator determines the thickness of the thermal insulation layer to protect the building structure, as well as the amount of heat loss.

Therefore, the research of the thermal conductivity coefficients of such coatings must be carried out by a stationary method. In this case, the thickness of the coating should be sufficient to minimize the error in measuring the temperature difference. Therefore, all tests performed in the laboratory required special preparation of samples. It consisted in layer-by-layer coating (its total thickness was about 10 mm) and obligatory drying intermediate of each of the layers.

MATERIALS AND METHODS

Such material provides an opportunity to exclude the toxic and fire-hazardous solvents, which are toxic to the environment when exposed to air during hardening. The formation technology and performance characteristics of coatings are determined by the properties of film-forming materials, which shall meet the following requirements: ensuring uniform thin-layer distribution on the surface of the substrate and forming of coatings with predetermined functionality. Such requirements are fully consistent with waterborne coatings [14-19]. Due to the functional properties and relatively low cost, waterborne coatings based on acrylic binders have become the most widely used. By rational combination of active ingredients: film-forming agent based on aqueous acrylate copolymer dispersion of the pigments, thickeners, targeted additives, mineral fillers and coatings with a given set of properties can be obtained.

Styrene-acryl dispersion (non-volatile compounds content – 50 % wt, pH 7.5-9.0, average particle size about 100 nm, viscosity at 23 °C (ISO 3219, DIN 53019) at shear rate – 100 s-1, 7-15 mPa·s) was used as a binder. Cellulose acrylic thickeners, polymer-based mineral oil free antifoam, a dispersant, coalescent agent based on a mixture of ether and alcohol, and a preservative additive were used as dispersion modifiers.

Hollow silicate microspheres (MS) and silicates based on hydrophobic Aerosil (A) were used as silicate fillers.

Currently, for heat insulation of buildings and structures, energy-efficient compositions based on hollow glass and ceramic microspheres are widely used. Microspheres can be evacuated or rarefied air-filled (depending on the conditions of their production) and, due to the successful combination of a spherical shape, controlled dimensions, low density, high compressive strength, heat, and sound insulation- and dielectric properties, are one of the most promising technogenic fillers to ensure the insulating properties of coatings based on water-based polymer dispersions. Hollow microspheres are finely dispersed, free-flowing powders consisting of spherical thin-walled aluminosilicate particles with a diameter of 10-100 μm and a specific surface of 0.61 m^2/g [20-22].

Hydrophobic Aerosil is highly dispersed amorphous silicon dioxide with a hydrophobic surface of the particles obtained by treating the surface of the particles with anchors that replace the silanol groups contained on the surface of the particles with non-polar organic groups such as methyl, with a specific surface of 200 m^2/g and an average density of 0.051-0.059 g/cm^3 [23-25]. Mineral composition of the fillers is presented in Table 1.

TABLE 1. Compound mineral powders.

Filler	Surface area, [m^2/g]	ρ, [g/cm^3]	pH	Mineral composition, [% wt]					
				SiO_2	Al_2O_3	MgO	Fe_2O_3	TiO_2	CaO
MS	0.61	0.58-0.69	8.5	52.2-64.3	18.0-39.0	1.0-2.0	1.2-10.0	0.6-1.0	0.1-5.8
Aerosil	300.00	0.05-0.06	4.5	99.9	0.05	–	0.003	0.03	–

A measuring complex was developed for the experiment. Its working part includes a concrete slab 30 mm thick, on the surface of which the coating is applied. Heating of the heat carrier and its pumping are carried out by a water thermostat. “Chromel-copel” thermocouples 0.2 mm thick are fixed on the surface of the concrete slab and concrete slab with coating, which register the temperature during thermal loading. Additionally, the temperature was controlled using a portable semiconductor electro thermometer.

The thermal conductivity coefficient was determined using the device THC-1, intended to measure the thermal conductivity and thermal resistance of building and thermal insulation materials by the method of stationary heat flow in accordance with ISO 8301: 1991 with a range of thermal conductivity of 0.02 ... 1.5 W/(m·K).

DISCUSSION

Since the studied water dispersion materials are thin-layer coatings, measurement of their thermal conductivity with the use of this device is possible only by applying them to a substrate with a known thermal conductivity coefficient.

Thermal resistance was measured, which is the sum of the thermal resistances of the composite layers. Using the value of the increase in thermal resistance ΔR, it is possible to calculate the experimental value of the thermal conductivity coefficient of the studied coatings by the formula, taking into account the thickness of the coating d_{coating}:

$$\lambda_{\text{expl}} = \frac{d_{\text{coating}}}{\Delta R}.$$

In the Table 2 presents the obtained data of thermal conductivity coefficient of the basic water dispersion styrene-acrylic coating (WD) and water dispersion styrene-acrylic coating filled with silicate microspheres (WD / MS) and hydrophobic Aerosil (WD / MS /A).

TABLE 2. Thermal conductivity coefficient of the studied thin-layer water dispersion coatings.

Components, wt. %.	d_{coating}, **[mm]**	ΔR, **[(m² K)/W]**	λ_{expl},**[W/(m·K)]**
WD	4.2	0.021	0.2000
WD / MS 20	4.5	0.070	0.0639
WD / MS 30	4.5	0.100	0.0444
WD/ MS 40	4.7	0.148	0.0320
WD/ MS 40/A 0.5	4.7	0.148	0.0320
WD/ MS 40/A 1.0	4.8	0.151	0.0317
WD / MS 40/A 1.5	4.8	0.151	0.0317

Based on the test results obtained, that the introduction of silicate microspheres allows to transfer studied styrene-acrylic dispersions (λ_{expl} =0.2 W/(m·K)) to the class of thermal insulation coatings with low thermal conductivity (λ_{expl} =0.032 W/(m·K)). It is shown that the introduction of Aerosil does not have a significant effect on the thermal conductivity coefficient.

However, this technique does not include the defectiveness of the structure of the obtained thermal insulation coatings. Therefore, an assessment of their thermal insulation efficiency was carried out on concrete samples.

The results of measuring the temperatures of the surface of a flat wall (t) and the heat flow density (q) depending on the temperature of the heat carrier are shown in Figure 1.

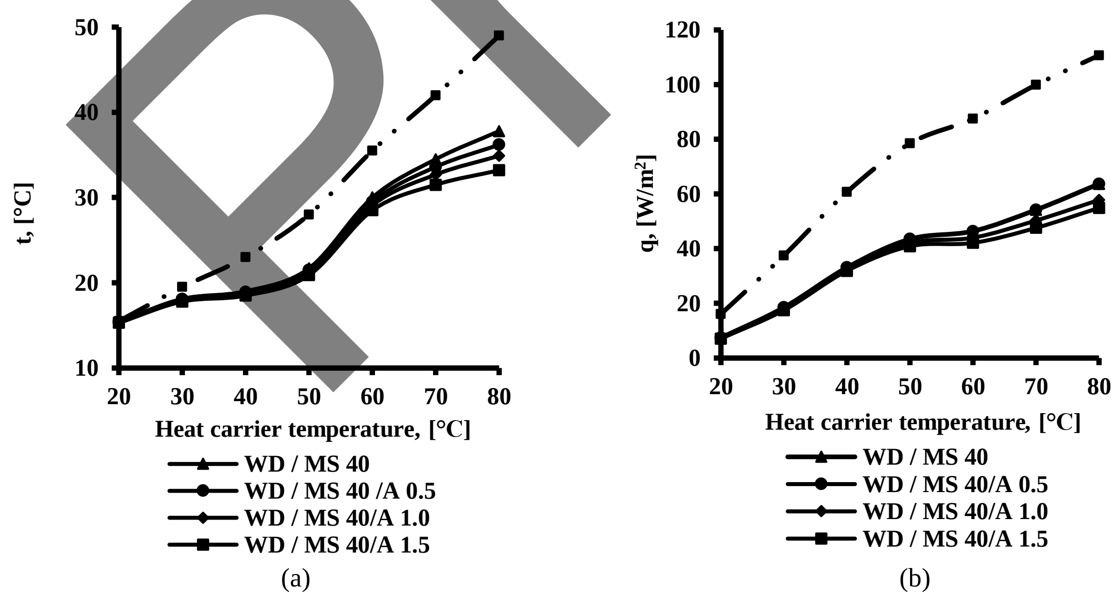


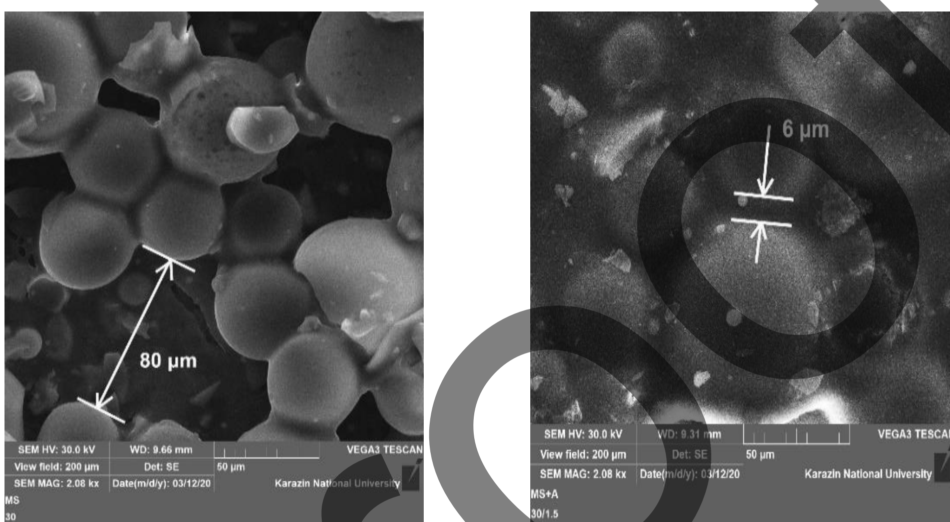
FIGURE 1. Results of measuring the temperatures of the surface of a flat wall (a) and heat flow density (b) depending on the temperature of the heat carrier.

As can be seen from the obtained dependences (Figure 1), the use of silicate microspheres allows to reduce temperature of an outer surface by 8-25% and heat flow by 5-40% in comparison with uncoated concrete slab. Thus, the efficiency of use a thin-layer thermal insulation coating containing 40 wt.% of silicate microspheres increases when the temperature rises.

It was established that the introduction of small additives of Aerosil 0.5-1.5 wt. % leads to increase thermal insulation properties of thin-layer styrene-acrylic coatings, which contain 40 wt.% silicate microspheres. Reducing the temperature of the outer surface by 5, 8 and 12 % (at the temperature of the inner wall 80 ˚C) and the heat flow by 6, 10 and 14%, respectively, when adding Aerosil.

Most likely this is due that the introduction of hydrophobic Aerosil allows to obtain a coating with lower internal stresses, a uniform distribution of microspheres throughout the coating volume, and a less surface defectiveness.

Morphological analysis of the surface of styrene-acrylic coatings was carried out to analyze the influence of the distribution of silicate fillers on the thermal physical characteristics [25, 26]. The distribution of fillers in the styrene-acrylic dispersion is shown in micrographs of the surface (Figure 2).



(a) (b)

FIGURE 2. Micrographs of the WD surface filled with 30 wt.% MS (a) and 1.5 wt.% Aerosil (b).

The analysis of the obtained micrographs confirms that MS form large agglomerates (Figure 2, a), between which there are free vacancies (30-80 μm), which negatively affects the thermal insulation properties of the developed coatings. At the same time, the introduction of Aerosil allows to obtain more ordered structure: layer of smaller particles of MS is formed in a circle of large particles of MS and free vacancies are filled with Aerosil particles (3-8 μm) (Figure 2, b). This allows to obtain a coating with lower internal stresses, increased aggregate stability and, as a consequence, with improved thermal insulation properties.

CONCLUSIONS

It is shown that the introduction of Aerosil does not have a significant effect on the the thermal conductivity coefficient but allows to increase the thermal protection efficiency of the studied coatings by 10-15%, as evidenced by reducing the temperature of the outer surface of the wall and heat flow, due to the formation of a more orderly and less tense WD structure.

Thus, it is shown that the thermal conductivity coefficient for thin-layer thermal insulation coatings does not allow sufficiently reliable determinated of their thermal insulation efficiency. This is due to the fact that the technological properties of the dispersed system itself have a significant effect on it, which significantly affect the distribution of fillers in the coating volume, internal stresses between the components and the defectiveness of the coating structure.

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The Renovation Technology of Structures that has Lost Reliability During Long-Term Operation in an Aggressive Environment

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Abstract. Some issues concerning the repair and chemical protection methodology of ammonium nitrate granulation RC technological tower shaft №1 of M-9 workshop PJSC "Azot" in Cherkasy was described. Variants of primary and secondary structures corrosion protection are given. Concrete deterioration and defects of secondary protection of concrete are described. It was revealed that during the initial inspection of ammonium nitrate granulation RC technological tower structures, the tower №1 concrete condition in a number of sections has both surface and through destruction. According to the technical assessment results and calculation analysis, which revealed the practical absence of RC tower trunk bearing capacity reserves, the design of its strengthening was proposed. It was implemented by a system of vertical and horizontal RC stiffeners for the possibility of its overhaul. A technological repair works sequence roadmap was developed. Sika Group offers a system of internal and external concrete surfaces chemical protection of tower trunk. Repair and chemical protection against aggressive influences on an internal and external surface of a RC trunk wsa offered. The use of concrete inside and outside continuous chemical protection system of tower trunk has shown that Sika's innovative products and innovative repair systems and technologies are making inroads in the practice of construction production in the absence of a regulatory framework.

INTRODUCTION

The technical assessment issues of RC and steel structures actual condition on existing enterprises are usually in the competence of special units from operating contractors. Regular and timely inspection allows to assess with sufficient accuracy the actual condition of structures by the concrete surfaces appearance, cracks presence, deflections and other defects. It is more difficult when there is no access to structural elements and when, in addition to atmospheric influences on concrete, there are various chemically aggressive environments in a wide temperature range. In the buildings and structures operation practice of existing chemical plants, it is especially important to

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determine which environments affect the reduction of load-bearing capacity of structures and, accordingly, what consequences should be expected.

At the design stage, options for structures primary and secondary protection against corrosion are being developed. Most of the Ukraine chemical industry buildings were built in the last century 50-60s, when the choice of reliable structure protection systems from corrosion was quite limited. In addition, there are various deviations from the original recommendations set out in the design documentation: instead of sulfate-resistant cement in the practice of construction ordinary cement was using; the relevant parameters for strength, frost resistance and water impermeability for concrete and reinforced concrete structures depending on the mode of operation are not maintained; structures underreinforcement by shrinkage and temperature deformations; defects in technological equipment.

The purpose of repair and chemical protection of ammonium nitrate granulation tower k.631G reinforced concrete trunk of the "AZOT" shop M-9 was strategy determine of repair and protective material systems and technologies for their application.

RESEARCH RESULTS

The possible consequences of deformations and microcracks formation in the structures concrete obtained under the action of temperature, creep and shrinkage should be taken into account by selecting the concrete mixture composition in the design and compliance with these solutions on the construction site.

Defects that are appeared in the secondary protection of concrete, for example: force cracks and poorly filled vertical joints in the acid-resistant bricks lining; sedimentary cracks and lack of adhesion to concrete of polymeric protective coatings and others. Over time, all these defects lead to the concrete structures saturation by technological solutions or melts, which interact first with the components of concrete (primarily cement stone), which leads to chemical corrosion of the 2nd or 3rd types with the formation or highly soluble joints, or tumors with an increase in the initial volume of cement stone, and then with steel reinforcement.

These processes lead to the concrete structures gradual degradation and, accordingly, to the loss of strength and load-bearing capacity of structures as a whole.

At the initial reinforced concrete structures inspection of the ammonium nitrate granulation technological tower it was found that the concrete condition of the granulation tower №1 in some areas has significant, both surface and through destruction (Figure 1; 2).

FIGURE 1. The tower trunk with large areas of concrete surface degradation

FIGURE 2. Full destruction of trunk, absence of horizontal steel reinforcement

Tower trunk concrete soaking and saturation by technological solutions or melts of ammonium nitrate salts is associated with these solutions and melts through the technological deck filtration of the expanded upper tower volume and the technological tray under the lower deck of this volume.

Areas of tower trunk through damage due to concrete chemical degradation on large areas of the outer and inner surfaces of the trunk, almost to the level of the main steel reinforcement rods, do not need repair, but complete replacement of degraded concrete.

The ammonium nitrate solution aggressiveness in relation to cement concrete is quite understandable from the point of view of its chemical interaction with cement stone, with the gradual replacement of hydration products by easily soluble or amorphous compounds that have almost no strength.

As a result, the concrete strength of the samples taken in 2018, according to [1], in some parts of the tower trunk reached <7,5 MPa, sometimes 21,7-26,8 MPa, which sometimes exceeded the initial design concrete grade M200 (R ≈ 20 MPa, now is class C12/15). Conclusions from the test results of concrete [1] is following:

- from the tower trunk inner surface the concrete strength is not enough and concrete destruction begins with minimal load;
- on the outside of the tower trunk, the strength of the concrete is partially provided, in general, it corresponds to the design strength of concrete (M200, class C12/15);
- in the central part of tower trunk outer side the concrete strength is provided with a margin (the actual brand of concrete is not less than M250, class C16/20).

According to the results of concrete strength control, the technical condition of reinforced concrete tower trunk was assessed by the authors [1] as the 3-rd category - unsuitable for normal operation.

The reinforced concrete trunk assessment results [2], which was done in late 2018, allowed us to conclude that the technical condition of the tower trunk №1 is reach "emergency" category of the structure technical condition. It was recorded that the concrete degradation areas at some points of the tower trunk make up 50-60% of its cross section, which made impossible to use the traditional technology of concrete repair by replacing destroyed concrete by "new" and need the installation of reliable strengthening system.

The clear location of concrete degraded areas and their penetration depth into the tower trunk body can be fully detected only in the process of gradual concrete dismantling and internal lining to prepare its surface for restoration by "dry" or "wet" shotcreting.

It was decided to develop a dismantling and complete concrete replacement project of the identified defective areas. But to ensure the safety of this type of work, a technical solution was proposed [3] to arrange the strengthening of the tower itself, which would take the loads and impacts from the reinforced concrete part of the tower and elements of higher structures and technological loads on the upper expanded volume of the tower.

Such a project [4] was developed by the R&D company "Rekonstrproekt" after analyzing the available documentation, instrumental mesurements and verification calculations analysis to determine the actual reserves of bearing capacity of tower trunk sections weakened by concrete losses.

After analyzing the assessment results and design documentation, it was decided that after transfer to the reinforced concrete sterengthening elements a significant part of design loads from the tower and the enfluenses acting on it, it will be possible to do the repair work to replace degraded concrete of tower between sterengthening elements. Within the design documentation, the all tower trunk area between the strengthening elements is divided into sections with the numbering of the technological sequence of repair work to replace the degraded concrete of the tower trunk, even with its through degradation in some areas. This technological repair work sheme made it possible to provide the spatial rigidity of the reinforced concrete tower trunk and the tower as a whole.

Technology of Repair Works

Disassembly of concrete in places of defects and corrosion damage, removal of weak, unbound particles and weakened parts of the concrete surface, removal of existing protective coatings, sand-blasting cleaning of the entire concrete surface and exposed reinforcement (up to Sa 2½ according to EN ISO 8501-1).

It was decided that the work in this case, more technologically perform the method of "dry" shotcreting, taking for "formwork" the outer surface of the tower trunk concrete, then repaired the inner surface of the tower trunk concrete.

Typically, concrete surface preparation involves removing old "degraded" concrete and cleaning the surface. The concrete surface of structures before work is checked for cavities, cracks and other hidden defects by tapping with a hammer. Places that make a muffled sound are cleared to the unaffected concrete.

The surfaces are cleaned in accordance with the work plans. If the project does not have work plan, the following instructions should be followed (Figure 3):

- removal of concrete must be performed in structure places that have various corrosion damage, in places with weak concrete, to "healthy" concrete. Especially in places of salt separation, where concrete is contaminated by corrosion and carbonization, in places of cracks with rust, where reinforcement and steel plates with signs of corrosion are located; sinks, cracks with a width of 0,4 mm - are opened;
- opening of steel bars and plates that have corrosion along the entire length, including uncorroded areas of at least 2 cm in each direction. If the entire lower half of the reinforcement rod opened area is corroded, it is necessary to remove a concrete layer over the entire area to a depth of about 1 cm per reinforcement rod;
- on the all surface of the processed reinforced concrete structure of areas that are contaminated with the remnants of waterproofing, old paint, dust and other substances (oil, fuel oil, petroleum products, etc.) must to be cleaning. These contaminations will reduce the repair layers adhesion to the substrate. The pull-off basement strength should be greater than 1,5 MPa.

(a) (b) (c) (d)

FIGURE 3. Sequence of disassembly of concrete in places of defects and corrosion damages: (a) - dismantling of damaged area concrete, removal of unbound particles or complete dismantling of concrete (if necessary); (b) - if there is corroded reinforcement on the damaged area, it is necessary to provide access to it from all sides not less than 10 mm and not more than 20 mm; (c) - cleaning of steel rods from corrosion to a condition of Sa $2^{1}/_{2}$ (metal shine). This can be done with a sandblasting machine; (d) - application of a protective anti-corrosion layer for steel reinforcement SikaTop®-Armatec® 110 EpoCem® or Sika®MonoTop®-910 Eco. Anti-corrosion protection of open fittings - immediately after cleaning (thickness of the protective layer after drying - at least 1 mm): 2×SikaTop®-Armatec® 110 EpoCem®

Surface preparation for the restoration of reinforced concrete structures should be carried out with the following equipment and tools: hammer, chisel, pickaxe; metal brushes, electric (pneumatic) perforators, jackhammers; cord brushes manual and electromechanical (pneumomechanical); sandblasting, waterjet units of low (6-8 atm.) and high (up to 4000 atm.) pressure.

The treated surface before applying the adhesive layer should be blown with compressed air and washed with a stream of water under pressure. Blowing and rinsing are performed immediately before applying the adhesive layer. The prepared surface must be protected from re-contamination.

It is forbidden to apply repair layers on an unmoistened surface as at the same time there is a water loss from a material which is just put that sharply reduces durability of concrete. For the manufacture of sterengthening RC structures used monolithic concrete modified with chemical Sika admixtures, to ensure high water and chemical resistance (Table 1).

TABLE 1. Approximate mix design of concrete for repair and its characteristics B40, F200, W8

Material for 1 m^3 of concrete	
Cement M500, kg	440
Water, l	160
Large aggregate, gravel 5-20 mm, kg	1130
Sand, kg	660
Superplasticizer SikaPlast®-2508 (1%), kg.	4,4
Microsilica SikaFume®, kg	12,5
Polypropylene fiber SikaFiber® PPM-12, kg	0,6

To restore the destroyed reinforced concrete surfaces the technology of "dry" shotcreting with modified additives of concrete compositions with characteristics not less than C25/30, F200, W8 was used.

Surface repairs are performed according to the next technology (Figure 4):

- dedust, wash and moisten the reinforced concrete structure surface to be repaired;
- the adhesive layer for the technology of "dry" shotcreting is not used, apply a layer of shotcrete-concrete with some excess on the entire surface from the shotcrete machine, after that to cut the excess with a hand tool, it is forbidden to "mash" the shotcrete layer.

(a) (b) (c)

FIGURE 4. Sequence of concrete repair. (a) - washing and moistening the repaired surface; (b) - to use shotcrete for mechanized repair: ready mixture Sikagunit®-03, in this case the adhesive layer is not required; (c) - providing "wet" care for concrete before gaining 50% of strength

In figure 5 shows a longitudinal section of the ammonium nitrate granulation tower and its cross section 1-1 at ref. +7,580 with the location of the strengthening ribs around its perimeter.

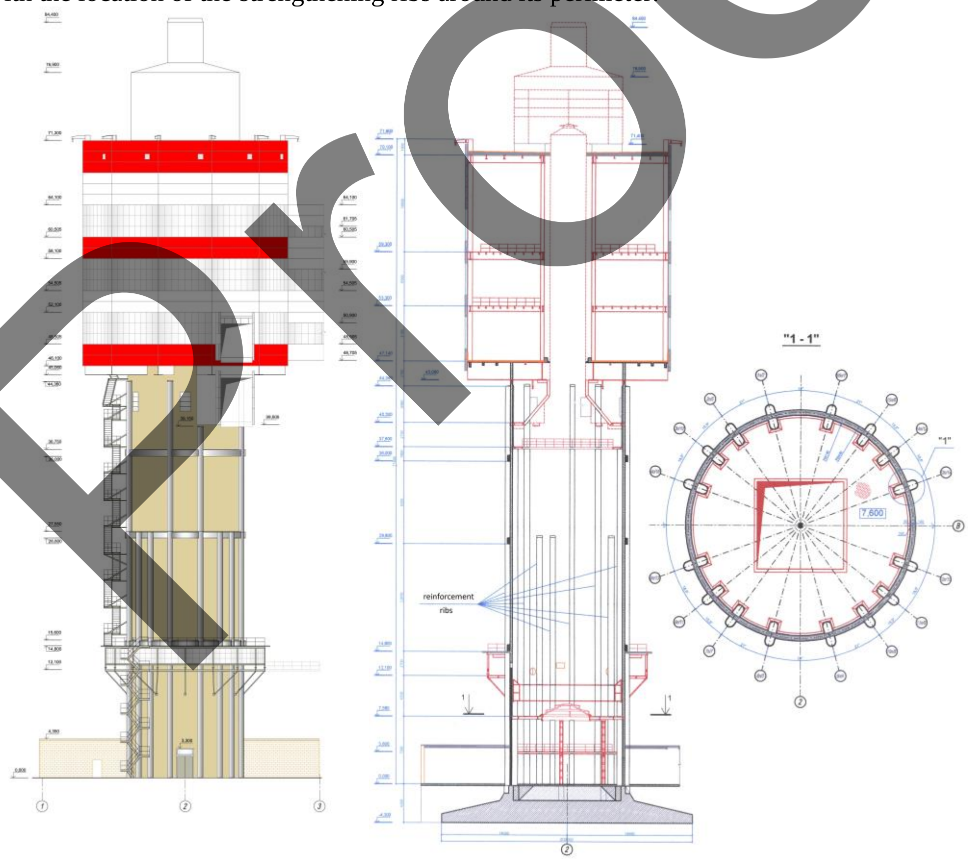

FIGURE 5. Fasade and longitudinal section of the ammonium nitrate granulation tower and its cross section (detail “1” shown in the figure 6)

In figure 6, for example, shows the detail "1" which presents a complex solution of fleshing the internal metal structures of the tower with the inner surface of its trunk using materials from Sika.

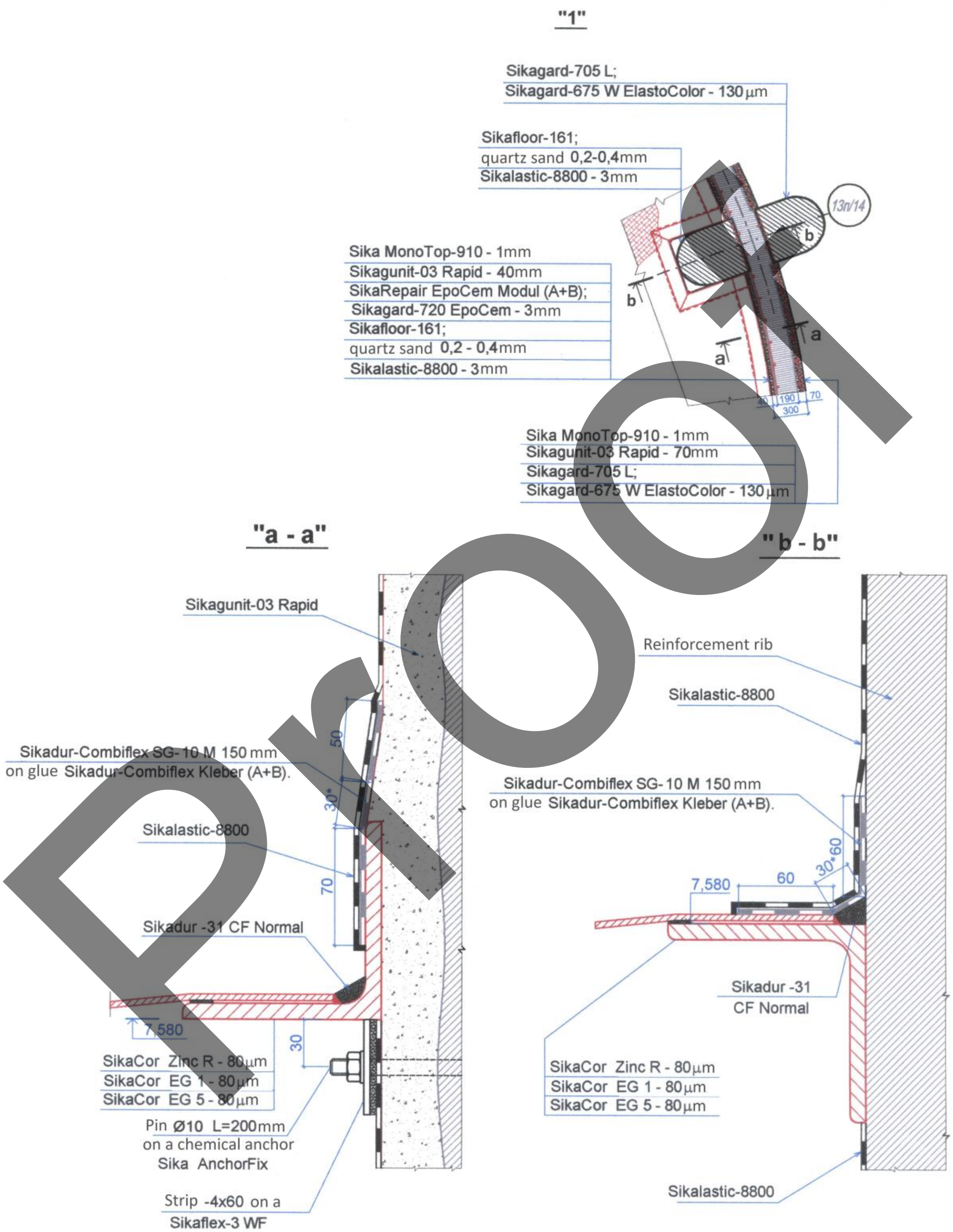

Figure 6. Detail "1" – solution of internal steel structures fleshing with an internal surface of its trunk by means of Sika company materials systems

Finishing Protective Coating of Concrete Tower Trunk Inner Surfaces

For further trouble-free operation of the reinforced concrete tower shell it was necessary to eliminate the infiltration of water and technological solutions into the "body" of concrete with subsequent degradation of concrete by installing reliable, chemically stable insulation inside the tower, as well as putting all tehnological equipment pipelines and overflows.

It was decided to apply chemical protection of the inner surface without the use of acid-resistant brick lining, and to use modern protective coatings with high chemical resistance.

A special coating Sikalastic®-8800 for such structures based on polyurea has been proposed for this area, which will provide reliable protection of concrete and steel in these conditions. But in any case, you need to prepare the surface for the application of this system. Special equipment (two-component reactor) is required to apply polyurea.

In addition, it is necessary to completely clean the concrete surface from cement laitance and corrosion products, residues of protective coatings. It is better to use Sikagard®-720 EpoCem putty to speed up repair work. After curing the putty is applied in 2 layers of epoxy primer Sikafloor®-161, the last layer is broadcast with quartz sand with a size of 0,4-0,8 mm, which forms a kind of mechanical "anchor" for the finish of the material Sikalastic®-8800.

CONCLUSIONS

Many years of Sika experience (more than 20 years) in Ukraine using the system for repair and strengthening of reinforced concrete structures allows us to interpolate it to new tasks. For example, the use of special cement-polymer adhesive layers between the "old" and "new" concrete Sika Mono Top®-910, SikaTop® Armatec-110 EpoCem®, Sikadur®-32 in combination with SCC (Self-Compactingg Concrete), allows us to perform repairs as horizontal and vertical and curved reinforced concrete structures with significant corrosion damages.

The use of shotcreting technology, namely ready-to-use dry mixes Sikagunit®-03 allows without the use of formwork to provide curved reinforced concrete structures of the desired profile with high performance. The results of independent tests of control samples made of fragments of structures made by the method of "dry" shotcreting showed that the concrete has a class C40/50, which is higher than stated in the technical map.

The use of continuous chemical protection of concrete inside and outside the granulation tower using innovative Sika products, systems and solutions allows us to conclude that innovative solutions are making inroads in the practice of construction production, despite the lack of adequate regulatory framework.

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Thermodynamic Calculation of Alkali-Silica Reaction

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Abstract. Concerning about the problem of climate change has motivated many scientists to look for ways to solve it. A lot of research work is devoted to the creation of "green" building materials due to the large contribution of building materials industry to the acceleration of warming processes. Glass concrete is an excellent example of a decorative material that uses recycled resources. But its long-term life can be threatened by the development of an alkali-silica reaction. The paper uses a theoretical method to study the possibility of the appearance of this reaction in concrete. Thermodynamic calculations showed that there is an exothermic process at the temperatures of 243K, 283K, 295K, and at 353 an endothermic one.

INTRODUCTION

Improving the durability of concrete structures has always been a topical issue. In the context of global concern about climate change and its causes, when the questions about the reasonable consumption of natural resources appear, the durability of concrete structures is a very important subject. [1,2]. A facility will meet all the criteria of the "sustainable technologies" in the case of using secondary resources and having an extended life [3]. Recycled glass concrete is one of examples of a building material that is produced using secondary resources in its technology. [4]. This material can be used for the production of decorative structures, where the principles of "green" building materials will be taken into account. Glass concrete is already widely used as a material for countertops, sidewalks and partitions. It is due to its visual resemblance to "terrazzo", which contains an expensive marble, quartz, etc. as decorative aggregates. [5,6].

However, the long life of the glass concrete structure can be threatened by a possibility of a developing reaction. It can be caused due to the high reactivity of glass, that has an active ion exchange surface. The reaction of alkalis with silica dioxide from the aggregates (alkali-silica reaction ASR) is one of the important problems that reduces the durability of concrete. It occurs between reactive silicon dioxide in concrete aggregates and alkali hydroxide together with calcium in the pore solution of concrete, which leads to the formation of the so-called ASR gel. The author [7] has proposed a model of the chemical-mechanical process of ASR expansion. The chemical part of the model includes two opposite diffusion processes occurring simultaneously:

a) Diffusion of hydroxide and alkali ions into aggregates with subsequent reaction of these ions with reactive aggregate;

б) Diffusion of the expansive ASR gel from the interface of the cement paste-aggreagate to the porous interfacial transition zone.

It is assumed that the deformation processes in concrete are initiated only in the case of the reaction product volume exceeds the porous volume of the interfacial transition zone.

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When alkalis interact with the reactive aggregate under the action of OH- ions, the Si-O-Si bonds in silica are destroyed. An alkali metal silicate gel with a porous structure is formed. The reaction may be considered to progress according to the following idealised equation, but the chemical composition of alkali-silica gel is variable and indefinite [8]:

$$2\,(\mathrm{NaOH})_s + (\mathrm{SiO_2})_s \rightarrow (\mathrm{Na_2SiO_3})_s + (\mathrm{H_2O})_l \tag{1}$$

The gel subsequently saturates with moisture and expands. This process causes deformation stresses and cracking of concrete. Typically, the substitution of silicic acid with alkali metal salts at the end of the reaction releases an alkali metal in the form of a hydroxide to react again in the deeper layers of the aggregate (2). This circumstance causes the danger of a prolonged reaction. According to various data, the consequences of the reaction can appear in the period from 1 to 10 years [9].

$$\mathrm{Na_2SiO_3} \times \mathrm{nH_2O} + \mathrm{Ca(OH)_2} \times \mathrm{H_2O} \rightarrow \mathrm{CaSiO_3} \times \mathrm{nH_2O} + 2\,\mathrm{NaOH} \tag{2}$$

Also, very few ASR products are formed within concrete aggregates on a micro scale. The small volume of ASR products significantly limits their chemical and physical characteristics which could be studied using conventional laboratory methods. These facts significantly complicate the investigation of this reaction by empirical research methods. Among the theoretical methods which help to understand the nature of the alkali – silica reaction thermodynamic calculation can be highlighted.

CALCULATION RESULTS

Any chemical reaction is accompanied by a change in the functions of the state of the system - internal energy ΔU, entropy ΔS, enthalpy ΔH, Gibb's energy ΔG etc.

The assertion of Hess's law that the thermal effect of a process does not depend on its individual stages and their sequence makes it possible to calculate the thermal effects of reactions for cases when it is difficult or impossible to determine them experimentally. The law has an important role in chemical thermodynamics. Knowing the thermal effects of some chemical reactions allows to calculate the thermal effects of other reactions that occur with the participation of the same compounds as in the first reaction [10].

The initial data for calculating the standard thermal effect of a chemical reaction are the standard formation heat of the substances which are taking part in the reaction and also the value of the arbitrary temperature at which the reaction will take place. [11]. Data for thermodynamic calculation are shown in the table 1.

TABLE 1. Initial data for the calculation of the ASR reaction

Substance	ΔH^0_{298} kJ/mol	ΔS^0_{298}, J/(mol·K)	$C_p = a + b \cdot T + c \cdot T^{-2}$		
			a	$b \cdot 10^3$	$c \cdot 10^{-5}$
NaOH	-426,6	64,18	7,34	125	13,38
SiO_2	-859,3	42,09	46,94	34,31	-11,3
Na_2SiO_3	-1518	113,8	130,3	40,17	-27,08
H_2O	-285,84	69,96	12,65	11,38	1,73

To determine the thermal effect of the alkali metal silicate gel formation reaction the following temperatures were selected: T_1=243 K, T_2=283 K, T_3=298 K, T_4= 353 K. As it has previously established, the ASR reaction can take a long time, so the temperatures T_1-T_3 for the calculation of the reaction were chosen as the largest minus temperature in winter, the average annual temperature in Ukraine and the average temperature in summer, respectively. The temperature T_4 is one from the conditions to determine the reactivity of the concrete aggregate by the speed method defined by the standard ASTM1260 [12].

Determination of the reaction enthalpy at the temperature 298 K:

$$\Delta H^0_{298} = \Delta H^0_{298}(\mathrm{Na_2\,SiO_3}) + \Delta H^0_{298}(\mathrm{H_2O}) - 2 \cdot \Delta H^0_{298}(\mathrm{NaOH}) - \Delta H^0_{298}(\mathrm{SiO_2}) = -91340\ \mathrm{J/mol} \tag{3}$$

Calculation the entropy changes of the reaction at 298 K:

$$\Delta S^0_{298} = \Delta S^0_{298}(\mathrm{Na_2\,SiO_3}) + \Delta S^0_{298}(\mathrm{H_2O}) - 2 \cdot \Delta S^0_{298}(\mathrm{NaOH}) - \Delta S^0_{298}(\mathrm{SiO_2}) = 13{,}31\ \mathrm{joule/mol} \tag{4}$$

We calculate the change in heat capacity during the reaction:

$$\Delta a = a\,(Na_2\,SiO_3) + a(H_2O) - 2 \cdot a(NaOH) - a\,(SiO_2) = 81{,}33 \quad (5)$$

$$\Delta\, b \cdot 10^3 = b(Na_2\,SiO_3) + b(H_2O) - 2 \cdot b(NaOH) - b\,(SiO_2) = -232{,}76 \quad (6)$$

$$\Delta\, c \cdot 10^{-5} = c(Na_2\,SiO_3) + c(H_2O) - 2 \cdot c(NaOH) - c\,(SiO_2) = -40{,}81 \quad (7)$$

$$\Delta Cp = \Delta a + \Delta\, b \cdot 10^3 T + \Delta c \cdot 10^{-5} T^{-2} = 81{,}33 - 232{,}76 \cdot T - 40{,}81 \cdot T^{-2} \quad (8)$$

The reaction enthalpy changes at the temperatures are:

$$\Delta H_T^o = \Delta H_{298}^o + \int_{298}^{T} \Delta C_p dT = \Delta H_{298}^o + \Delta a \int_{298}^{T} dT + \Delta b \cdot 10^3 \int_{298}^{T} T dT + \Delta c \cdot 10^{-5} \int_{298}^{T} \frac{dT}{T^2} = \\ = \Delta H_{298}^o + \Delta a T|_{298}^{T} + \Delta b \cdot 10^3 \frac{T^2}{2}|_{298}^{T} - \Delta c \cdot 10^{-5} \frac{1}{T}|_{298}^{T} \quad (9)$$

Calculation of the reaction entropy changes at the temperatures

$$\Delta S_T^o = \Delta S_{298}^0 + \int_{298}^{T} \frac{\Delta C_p dT}{T} = \Delta S_{298}^0 + \Delta a \cdot lnT|_{298}^{T} + \Delta b \cdot 10^3 T|_{298}^{T} - \Delta c \cdot 10^{-5} \frac{1}{2T^2}|_{298}^{T} \quad (10)$$

The change in the Gibbs energy is determined from the relation

$$\Delta G_T^o = \Delta H_T^o - T \Delta S_T^o \quad (11)$$

We enter the calculation results in table 2.

TABLE 2. The calculation results

T, K	$\Delta H_T^o, J/mol$	$\Delta S_T^o, J/mol$	$\Delta G_T^o, J/mol$
243	$3{,}37 \cdot 10^6$	$12{,}799 \cdot 10^3$	$-0{,}26 \cdot 10^6$
283	$0{,}898 \cdot 10^6$	$3{,}5 \cdot 10^3$	$-0{,}092 \cdot 10^6$
298	$-0{,}091 \cdot 10^6$	$0{,}013 \cdot 10^3$	$0{,}095 \cdot 10^6$
353	$-4{,}25 \cdot 10^6$	$-12{,}77 \cdot 10^3$	$0{,}257 \cdot 10^6$

Figure 1-3 shows the dependence of the enthalpy, entropy and Gibbs energy on temperature, respectively.

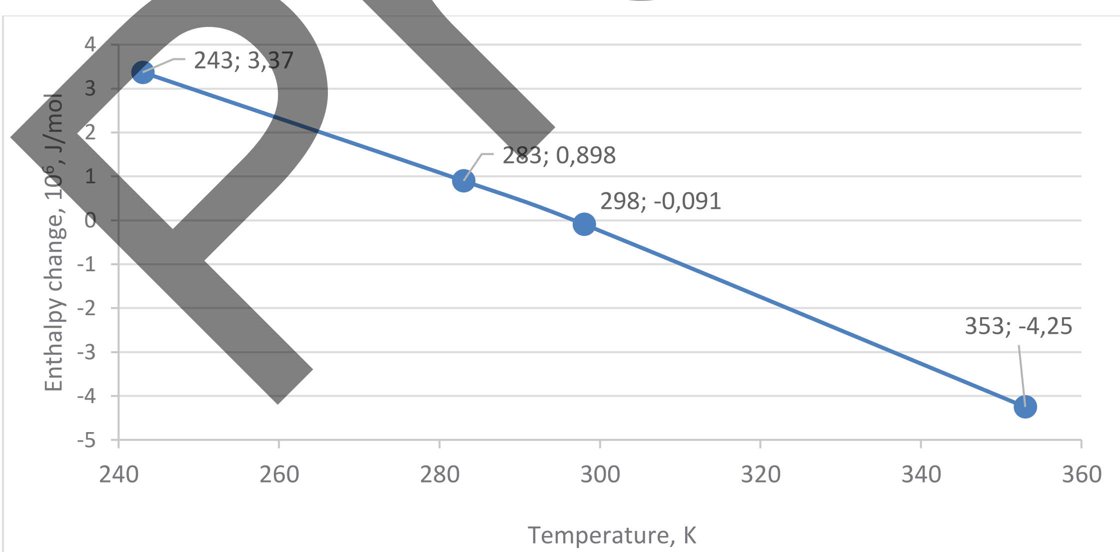

FIGURE 1. The dependence of the enthalpy on temperature

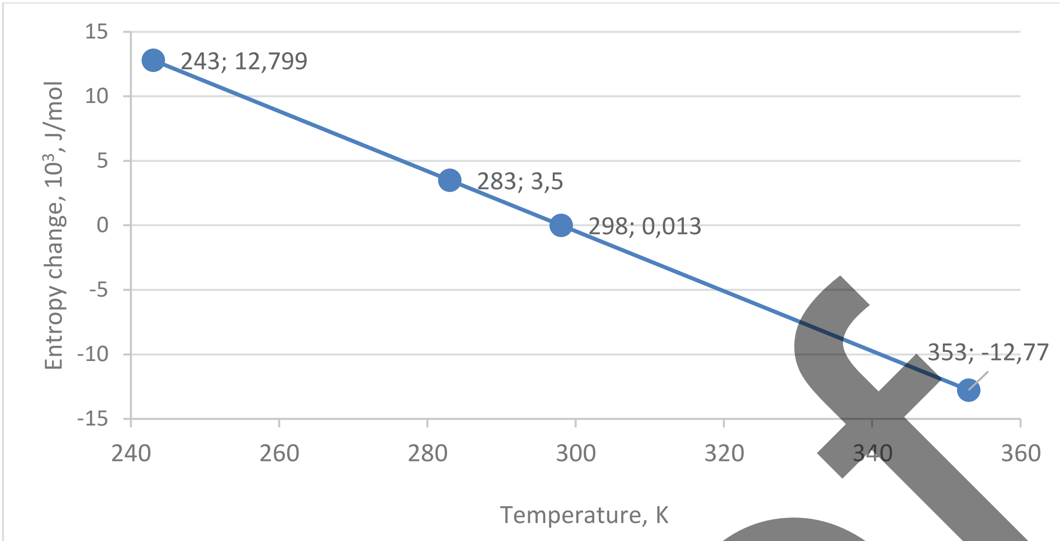

FIGURE 2. The dependence of the entropy on temperature

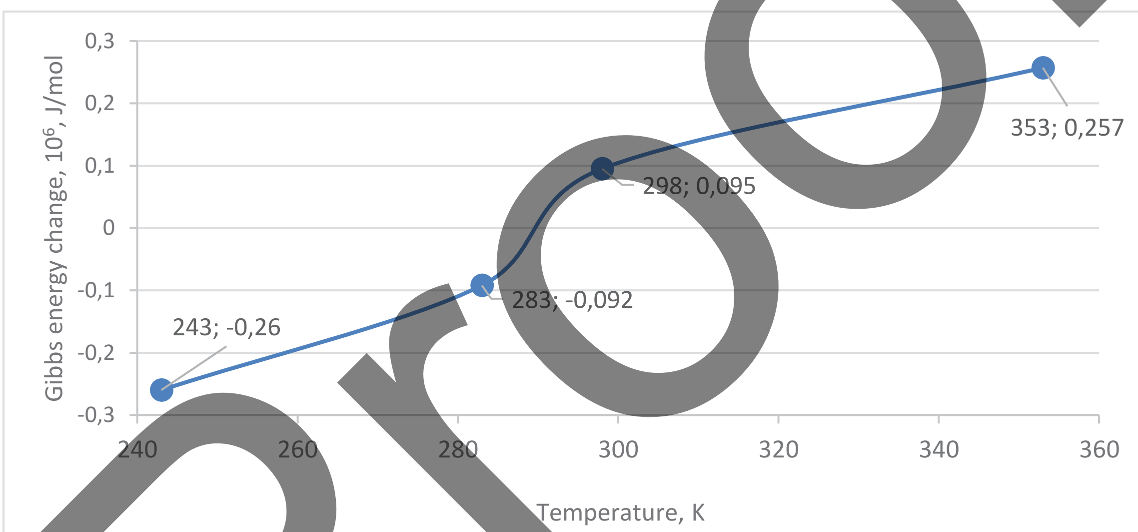

FIGURE 2. The dependence of the Gibbs energy on temperature

CONCLUSION

In this article the ASR response was investigated using thermodynamic calculations. The following conclusions can be drawn:

- The construction industry, especially the concrete industry, must provide more and more sustainable technologies to reduce its negative impact on climate change. Using secondary resources is one of the solutions.
- Glass concrete is a good example of a green building material, but its life can be compromised due to the ASR reaction.
- Thermodynamic calculations allow you to establish the temperature ranges in which there is a likelihood of spontaneous ASR reactions.
- Thermodynamic calculation of the enthalpy ASR showed that at temperatures T3-T4 the reaction is an exothermic process, and at temperatures T1-T2, on the contrary, it is endothermic. The calculation of the Gibbs energy allows us to conclude that the alkaline-silica reaction does not occur spontaneously at temperatures up to 21 ° C. As the temperature rises, the alkalis Na and K are able to more effectively interact with the silica of the filler, which causes the spontaneous occurrence of the alkali-silica reaction.

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A Rust Converter Based on Plant Components for Restoration Work

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Abstract. The main drawback of products based on ferrous metals is their low corrosion resistance in moist conditions. Secondary methods of corrosion protection include methods aimed at stopping the corrosion process and binding the corrosion products to stable compounds where the metal corrosion process has already begun. The paper is concerned with investigating the transformation of steel corrosion products into stable products in the presence of phenolic compounds of plant origin that are economically efficient and environmentally safe inhibitors. The results of the investigation confirm the effectiveness of using hydrolyzable tannins as rust converter, in particular those containing a sufficiently high concentration of gallic acid.

INTRODUCTION

This document was prepared using the AIP Conference Proceedings template for Microsoft Word. It provides a simple example of a paper and offers guidelines for preparing your article. Here we introduce the paragraph styles for Level 1, Level 2, and Level 3 headings. Please note the following:

Various metal products are widely used in construction; the materials for these are different types of steel (from carbon to high-alloy), non-ferrous metals and alloys (aluminum, copper, etc.). The use of metals in construction is determined by their advantages such as high strength, ability to significant elastic and plastic strains, the ability to be relatively easily processed by pressure (rolling, forging, stamping) and casting, the ability to obtain products of any profile. In industry and production, a wide range of metal products is used. However, products based on ferrous metals, alloys based on iron (steel, cast iron and ferroalloys) are most widely used. Rolled steel is used to erect frameworks of industrial buildings and facilities, towers, masts, supports, bridges, overpasses, tanks, and gasholders. Metal products such as reinforcement for reinforced concrete, pipes, bolts, rivets, nails are also widely used in construction.

The main drawback of products based on ferrous metals is their low corrosion resistance in moist conditions. Whatever the thickness of the steel is, rust can quickly render the material unusable, that’s why the protection of steel from corrosion is a priority in the construction and operation of structures.

TOPICALITY

The best option to eliminate corrosion is the use of special grades of steel that are not subject to oxidation for construction and installation. Otherwise, the owner of metal structures is to provide timely protection of steel from oxidation. Possible options of this approach are as follows: using chemically stable alloys that increase the chemical

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resistance of corrosion metals (alloying, heat and surface treatment, etc.) [1, 2]; insulating the metal surface from corrosive environment (application of protective coatings, rational design, etc.) [3]; reducing the corrosiveness of the production environment where metal products and structures are operated (inhibition and deaeration of the aquatic environment, purification, dehumidification and modification of the corrosive atmosphere, removal of corrosive agents such as salts, acids, etc.) [4]; electrochemical protection, and others.

The above listed methods of protection are classified as primary and aimed at protecting the metal surface from the effects of a corrosive environment. However, if the metal corrosion process has already begun, the primary objective is to stop the corrosion process and bind corrosion products into stable compounds. In this case, the main corrosion-preventive methods of metal treatment include the use of inhibitors [5] and corrosion stabilizers, rust converters [6]. Rust converters are, for the most part, toxic; therefore, it is currently relevant to search for new natural inhibitors and converters that would be much cheaper and more environmentally friendly.

NOVELTY

To date, a large number of organic and inorganic substances have been studied, which affect the corrosion rate of metals in a corrosive environment. At the end of the 20th century, plant materials, plant extracts (seeds of fenugreek, lupine, doom-palm fruits, eggplant, etc.) were widely used as inhibitors for the protection of metals. The aim of this work is to investigate the transformation of steel corrosion products in the presence of phenolic compounds of plant origin. These compounds can be obtained from agricultural production waste.

MAIN SECTION

Under ideal conditions, any metal retains its characteristics for a long time. Even if the composition of the material does not include additional admixtures, the absence of external influences allows maintaining the strength and rigidity of the structure. In real life, these conditions are almost impossible to achieve. Corrosion processes may be due to high humidity in the air, soil and stray currents, and exposure to chemically active elements. Corrosion of metals is most often reduced to their oxidation and transformation into oxides [7, 8]. Iron corrosion can be described by a simplified equation as follows

$$4Fe + 3O_2\ (\text{air}) + 2H_2O\ (\text{moisture}) = 2Fe_2O_3 \cdot H_2O$$

The resulting hydrated iron oxide 2Fe2O3 · H2O is very unstable, quickly loses water and turns into iron oxide in the form of a loose light brown powder, which is referred to as "rust". The newly formed compound (rust) does not protect the surface of iron from further corrosion, and even promotes its development, as it condenses moisture vapors, and iron continues to disintegrate. Therefore, rust must be removed from steel structures.

One of the ways of combating rust is to use corrosion inhibitors and rust converters [9]. Rust converters are chemical compounds that can be applied to surfaces showing signs of corrosion to convert residual rust on steel surfaces into chemical compounds that are harmless in terms of corrosion processes. Most of the known effective inhibitors are organic compounds containing nitrogen, sulfur, oxygen and multiple bonds in molecules that are adsorbed on the metal surface and used as protective coatings.

In the aquatic environment, tanning agents, in particular tannin, can be used as an alternative to known corrosion inhibitors and rust converters [10-14]. Tannins are a class of natural, non-toxic and biodegradable organic polyphenolic compounds extracted from plant sources, used as components of rust converters, pigments in paint and lacquer coatings, corrosion inhibitors for reinforcing steel in concrete, chemical cleaners used to remove iron-based deposits.

Tannins are hydrolyzable and condensed (non-hydrolyzable), Fig. 1. Hydrolyzable tannins are based on esters of gallic acid or related digalic and trigalic acids with polyatomic alcohol. Condensed tannins are flavonoid derivatives, mainly dimers of 3,4-flavanediol or 3-flavanol.

(a) (b)

FIGURE 1. The main components of tannins: a – gallic acid (hydrolyzable tannins), b – flavone (condensed tannins)

Using tannins as rust converters is based on their ability to form a strong complex like iron (III) phenolate, black in color, Fig. 2, after reaction with iron oxide.

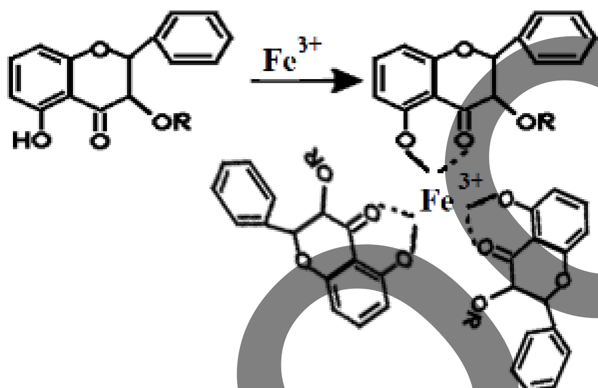

FIGURE 2. The reaction scheme of a phenolic compound with the iron (III) cation

MATERIALS AND METHODS OF THE INVESTIGATION

An aqueous extract of tannin obtained from plant raw materials was used for the investigation. To obtain the extract, the plant material was kept in water at a temperature of 100 °C for 1 hour. The resulting solution was greenish-brown.

To investigate the interaction between the tannin extract and steel corrosion products, steel rods with strongly marked corrosion damage were used.

To investigate the interaction between tannin and iron an optical microscopy method was used, involving the use of the LOMO laboratory optical microscope, with magnification of ×48, and infrared spectroscopy method were used. Infrared absorption spectra (IR spectra) were recorded using an ALPHA spectrometer, which is connected to an ECM with installed OPUS software, in the infrared wavelength range of 400 to 4000 cm^{-1}. In the study of the studied specimens an ALPHA-T auxiliary device was used, which is designed to study transmission spectra. The specimens were powders pressed under a pressure of 8 ÷ 8.5 MPa of the test materials with the addition of KBr. The infrared spectral analysis method is characterized by high sensitivity and allows responding to minimal changes in the chemical composition of the studied materials.

RESULTS OF THE INVESTIGATION

The metal rod showing signs of corrosion damage was covered with tannin extract, Fig. 3. After 1 hour, the surface of the rod was examined using optical microscopy.

(a) (b)

FIGURE 3. Steel rod: a – with corrosion products, b – covered with rust converter changed in color (from brown to black)

According to optical microscopy, the interaction between a rust converter and steel corrosion products produces black dense crystals, Fig. 4. Crystals are morphologically similar to dendrites.

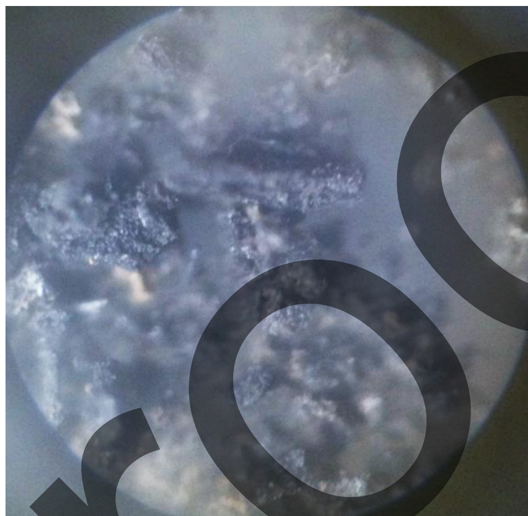

FIGURE 4. The product from the interaction between the rust converter and steel corrosion products. Optical microscope, magnification of ×48

The study of the phase composition of the rust converter, corrosion products and products of their interaction was carried out using the infrared spectroscopy method, Fig. 5.

The absorption spectra of tannin extract, Fig. 5a, shows bands 3430, 2920 and 2852 cm^{-1} belonging to the valence vibrations of water. The bands in the range of 1450 to 1620 cm^{-1} correspond to the valence vibrations of the C = C bonds of the aromatic ring. The deformation vibrations of phenolic groups are characterized by a band of 1372 cm^{-1}.

For iron oxide, Fig. 5c, low-intensity bands of 410; 470; 545; 650; 880; 1090; 1170; 1300; 1400 cm^{-1} corresponding to deformation vibrations, and intense bands of 460, 568 cm^{-1} corresponding to the valence vibrations v (Fe-O) are characteristic.

The comparative analysis of the IR spectra of tannin extract, rust and the product of their interaction allowed identifying the following characteristics. In comparison with the tannin absorption spectrum, on the spectrum of the interaction product the band 1518 cm^{-1} disappeared, the band 1454 cm^{-1} increased, the band 1372 cm^{-1} decreased and shifted to 1384 cm^{-1}; the intensities of bands 1240 and 1147 cm^{-1} also decreased; the broad band 1100 to 1000 cm^{-1} increased, a narrower band 1091 cm^{-1} emerged from it.

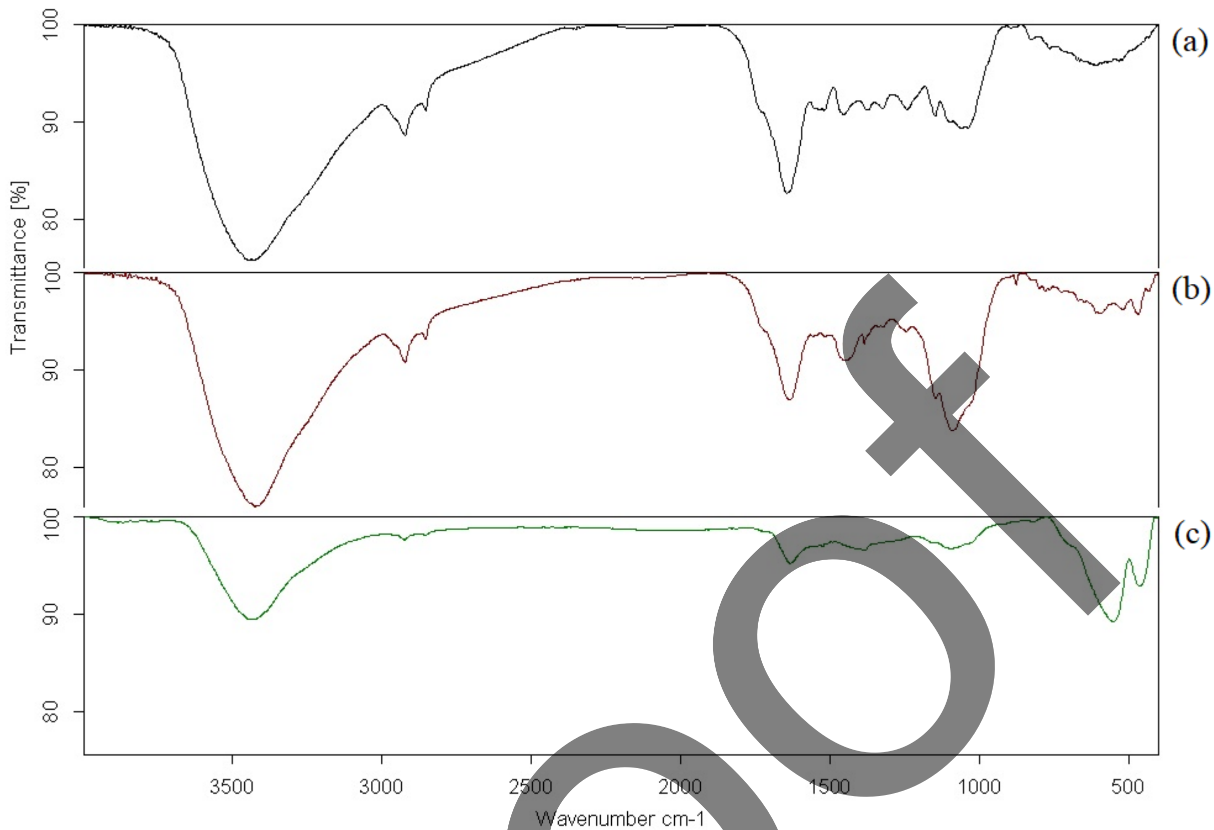

FIGURE 5. Infrared absorption spectra: a – rust converter; b – the product of the interaction between the rust converter and steel corrosion products; c – steel corrosion products (Fe_2O_3)

The investigation data show the binding of steel corrosion products, particularly Fe_2O_3 in the form of black iron phenolate, which is confirmed by a decrease in the intensity of the absorption bands in the wavelength range of the wave numbers of 460, 568 cm^{-1}.

CONCLUSION

The primary objective in the construction and operation of metal structures is to timely protect steel against corrosion. One of the effective methods of protection is the use of rust converters that inhibit corrosion processes in the event of foci of corrosion failure of steel. For the most part, rust converters are toxic, so it is now important to find new natural inhibitors and converters, the use of which is economically feasible and environmentally friendly. The use of tannins as rust converters is based on their ability to form a strong complex like iron (III) phenolate, black in color, after reaction with iron oxide. The results of the investigation confirm the effectiveness of using hydrolyzable tannins as a rust converter, particularly those containing a sufficiently high concentration of gallic acid.

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Chemical Industry Waste-based Oil-well Cement

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Abstract. The article considers several phase compositions of oil-well cement obtained from chemical industry wastes. They were investigated using an x-ray phase analysis method. Their mobility was determined using the cone precipitation test, as well as their strength. The influence of autoclave processing on the strength characteristics of these cements, as well as contraction and corrosion resistance, are considered.

INTRODUCTION

Oil-well cement that are mainly the sub-types of Portland cement are used during the exploratory and production drilling of oil and gas wells and during their overhaul. Oil-well cements are used for the well cementing and their purpose is to isolate the productive layer from water – bearing stratum and separate the layers from each other in the case of multilayer deposits. The well cementing (plugging back) is a very critical stage of a complicated drilling process; the cementing quality usually defines the well operation efficiency and during the exploratory drilling it enables the accurate estimation of the reserves of productive strata available in the explored field.

During the well cementing the strings of steel pipe casings of a different diameter are run into the well and the annular space between the well walls and the outer pipe diameter is filled with the quick-setting cement mortar. The conditions for the cement curing are exceptionally complicated; the cements are subjected to the action of overpressure and corrosive stratal waters that have a noticeable corrosive action on the cement stone especially in conditions of the elevated temperature and pressure when an essential water infiltration capacity of the cement sheath is possible. Gas well cement service conditions are especially complicated when the diffusion of gas from the stratum into the well occurs on completion of the cementing [1].

The multiyear research data and those of generalized experience of the operation of oil and gas sites allowed us to define the main requirements to the quality of the oil-well cement. These are mainly reduced to the following: the cement mortar (sludge) is supposed to have a sufficient flowability to provide an opportunity for its fast pumping into the pipe string with subsequent squeezing down of it into the annular space. Oil-well cements should be characterized by the appropriate strength during the first two days of setting. The strength of the matured quick-setting cement mortar should provide the clamping of the string in the well bore, the appropriate steadiness of it during the drilling out and perforation and an effective insulation from penetrative rocks. The cement stone should be stable to the action of corrosive stratal waters at deep horizons and it should be water resistant to protect productive layers from stratal waters and the casing columns from the penetration of corroding liquids that contain an ample amount of different salts. At the initial period of setting the cement stone should be rather ductile to escape the formation of cracks in it during the well perforation. At the same time it should be rather durable in conditions when it has to resist the action of not only corrosive stratal waters but also that of high temperature and pressure [2].

The cement of one type can not satisfy all the requirements relating to different conditions of its operation in the well. Hence, the development of the compositions of special oil-well cements including the use of waste is a vital technological and ecological problem [3].

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At the present time, the utilization of the substantial volumes of waste from the different branches of industry that results from the primary technological process is a rather vital task for Ukraine [4]. On the other part, the creation of special oil-well cement will contribute to high-quality drilling jobs and subsequent high-quality operation of oil and gas wells. Therefore, the purpose of this scientific paper is to develop the compositions of heavy oil-well cements using the iron-containing waste of chemical industry [5].

To obtain heavy oil-well cements we selected the CaO-Fe_2O_3-Cr_2O_3-Al_2O_3 system that includes hydraulically active calcium aluminates, brownmillerite and calcium chromite that has a substantial density. Therefore, to develop the compositions of heavy oil-well cements we selected the domain restricted by $CaAl_2O4$, $Ca_{12}Al_{14}O_{33}$, $CaCr_2O_4$, $Ca_4Al_2Fe_2O_{10}$ compounds [6].

To establish the opportunity for the use of the compositions of developed cements at elevated operation temperatures we calculated eutectic compositions and temperatures in binary and triple intersections of the selected system domain using the Epstein-Houlend method. The obtained computation data showed that the compositions of binary and ternary compounds have a melting temperature that exceeds 1100 °C; these are shifted to brownmillerite and can be used for the development of oil-well cements suitable for the cementing of "hot" oil and gas wells.

MATERIALS AND EXPERIMENTAL PROCEDURE

To develop the technologies for the production of oil-well cements the following raw materials were used: the calcium-containing water purification waste, the waste of spent iron-chrome catalyst CTK-1 used for the mean-temperature conversion of hydrocarbons, the waste of spent alumochrome catalyst GIAP-14C used for the steam-hydrogen conversion of hydrocarbons that are used by PJSC "Severodonetsk Agglomeration "Azot"". Insufficient amount of chrome oxide was replenished by the chromite concentrate of the South-Saranovsk field according to TU 14-9-144-77 [7].

To synthesize the specimens of a specified chemical and phase composition the raw mixtures were subjected to consistent milling, mixing and firing. The laboratory ball mill was used for the careful milling and mixing of raw components using the "wet method" (the sludge moisture content was 50 mass %). The fineness of grinding was controlled using the method of sieve analysis (a complete passage through the sieve No006). Prior to the firing, the raw mixtures were formed using the method of double-sided pressing under the specific pressure of 60 to 80 MPa. The briquettes were fired in the cryptol furnace at the synthesis temperatures of 1250 to 1300°C and the two-hour isothermal annealing [8].

Chemical composition of initial raw mixtures is given in Table 1.

TABLE 1. Chemical composition of raw mixtures

Composition №	**CaO**	**Al_2O_3**	**Cr_2O_3**	**Fe_2O_3**
1	32,54	40,99	18,26	8,21
2	40,02	34,25	18,26	8,21
3	45,97	22,31	18,26	8,21

The phase composition of obtained cements was studied using the method of the X-ray phase analysis. The obtained data showed that the composition of cement № 1 includes $CaAl_2O_4$, $CaAl_4O_7$, $CaCr_2O_4$, $Ca_4Al_2Fe_2O_{10}$ phases, the composition of cement № 2 includes $CaAl_2O_4$, $Ca_{12}Al_{14}O_{33}$, $CaCr_2O_4$, $Ca_4Al_2Fe_2O_{10}$ phases, and the composition of cement № 3 includes $Ca_3Al_2O_6$, $Ca_{12}Al_{14}O_{33}$, $CaCr_2O_4$, $Ca_4Al_2Fe_2O_{10}$. phases.

RESULTS AND DISCUSSION

Tables 2 to 4 give the research data obtained for the physical and mechanical properties of developed oil-well cements. The sand of a DSTU B.2.7-32-95-normalized grain composition was used as the filler. The DSTU B 2.7-88-99 was used to define the cement flowability using the method of the cone spreading of the cement paste with the water-to-cement ratio of 0.5 (Table 2).

The obtained research data showed that all the cement specimens display the standard cone spread of more than 200 mm and it corresponds to DSTU B. V.2.7-88-99 requirements. In addition, the hardening time of the cement composition № 3 fails to satisfy the standard requirements, because the cement hardening should start at least after two-hours and finish at least after 4 hours.

The obtained strength data that are given in Table 3 show that the developed cements have the ultimate compressive strength at the age of 24 hours more than 20 MPa and the ultimate bend strength at the age of 24 hours is more than 6 MPa that totally corresponds to the standard requirements.

TABLE 2. Defining of flowability of the oil-well cement

Composition №	Setting time, hours-minutes		The standard paste cone spread with w/c = 0.5, mm
	Start	Finish	
1	3-12	4-45	210
2	3-34	7-07	215
3	1-43	3-29	205

An important property defining the operational suitability of the oil-well cement is its capacity not to decrease in volume during the hardening, i.e. it is capable of the contraction and resistance to the corrosive action of natural sulfate waters [9].

TABLE 3. Defining the strength of oil-well cements

Composition №	Volumetric mass, kg/m³	Ultimate compression strength, MPa, age, days				Ultimate bend strength, MPa
		1	2	7	28	
1	3723	25,2	32,5	40,6	45,3	7,0
2	3480	38,7	39,9	42,3	48,4	7,2
3	3630	21,0	30,7	33,9	42,3	6,2

To carry out investigations to define the contraction of the specimens of oil-well mortars with different fillers we used the V.V. Kind method [4]. The sulfate resistance coefficient was defined using Y.V. Malinin methods [4] according to which the specimens were matured in the 3% $MgSO_4$ solution during six months. The test data are given in Table 4.

TABLE 4. Contraction and corrosion resistance of oil-well cements

Composition №	Contraction, cm³/g	Corrosion resistance of the packing cement in the 3% $MgSO_4$ solution		
		Ultimate bend strength, MPa (6 months in water)	Ultimate bend strength, MPa (6 months in the 3% $MgSO_4$ solution)	Sulfate resistance coefficients
1	0,07	7,0	7,1	1,01
2	0,01	7,2	9,5	1,32
3	0,12	6,2	5,3	0,85

The test data show that the oil-well cement № 2 composition has the lowest shrinkage during the hardening and the highest sulfate resistance. It was also established during the investigation that the packing cement No3composition is not resistant to sulfate solutions because it contains $Ca_3Al_2O_6$ in its composition and the totality of its features shows that it cannot be applied for the full-scale production.

Since the elevated well temperature and pressure are peculiar for the gas-bearing regions in Ukraine we studied the influence of the autoclave treatment on the strength of packing cements and the obtained data are given in Table 5.

TABLE 5. Influence of autoclave treatment on the strength parameters of packing cements

Composition №	Packing cement specimen strength	
	Before the autoclave treatment	After the autoclave treatment (P = 0.8 MPa, T = 172 ° C)
1	7,0	6,7
2	7,2	7,0
3	6,2	5,9

It was established that after the autoclave treatment, the packing cement bend strength is decreased in significantly and the technical performances of packing cements remain unaffected. As for the totality of basic physical and mechanical properties the cement composition № 2 that contains $CaAl_2O_4$, $CaCr_2O_4$, $Ca_4Al_2Fe_2O_{10}$, $Ca_{12}Al_{14}O_{33}$ phases is considered to be optimal.

CONCLUSIONS

Hence, the obtained research data show that the use of the calcium-bearing water purification waste, the waste of spent iron-chrome catalyst of the mean-temperature conversion of STC-1 hydrocarbons, the waste of the spent alumochrome catalyst of the steam-hydrogen conversion of GIAP-14 C hydrocarbons that are used by the PJSC "Severodonetsk Agglomeration "Azot" makes possible the production of packing cements suitable for the cementing of "hot" oil and gas wells.

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The Study of Liquid Mixtures Physical Properties for Shielding of Electromagnetic Fields

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Abstract. In this work, the colloidal-chemical, rheological properties of a liquid material for electromagnetic fields shielding with different contents of Fe-containing shielding filler are studied. Changes in a density of the protective composition and dynamic viscosity were determined depending on the concentration of the Fe-containing filler. Equations describing these dependencies are presented. These dependencies influence the choice of the method of applying protective compositions to the substrate surface. It has been shown that at filler concentrations of 15% and 30% (by weight) they can be applied to the surface by brush or spraying. At concentrations of 45%, it is advisable to apply with a roller, 60% - with a spatula. The wetting angles of the protective composition applied to wood and drywall for various filler concentrations are determined. It is shown that the change in the surface tension with an increase in the filler concentration occurs non-monotonically. The minimum surface tension corresponds to a concentration of 30%. At a concentration of 60%, the surface tension increases by 1.2 times in comparison with the initial value of the surface tension of the initial water-dispersed binder. It was found that an increase in the spreading coefficient leads to a more complete wetting. The paper presents complete data on the dependence of the surface tension on the filler concentration, the average wetting angles, the work of forces of adhesion, cohesion and wetting, the wetting and spreading coefficients.

INTRODUCTION

The most effective method of biological objects protecting from the influence of electric, magnetic and electromagnetic fields is a use of appropriate shielding materials and structures made of them. But the manufacturing and installation of such structures in many cases is associated with some difficulties: the complexity of the surface shape, limited space for placing the screen, etc.

The most acceptable is the application to the surface of equipment, wall and ceiling structures of the shielding material in liquid form, followed by drying or polymerization. But in this case, difficulties arise associated with ensuring reliable adhesion of the material to the application surface, degradation of the shielding layer due to the presence of a large amount of shielding substrate and peeling of the protective layer from the surface. Most of researches in this area is limited to measuring the protective properties of shielding materials, not paying attention to

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the functional properties of practical applications. At the same time, ensuring electromagnetic safety for a long time depends on the adhesion forces of the liquid, wetting coefficients, spreadability, viscosity, etc. The study of these parameters is an urgent scientific and practical task.

LITERATURE REVIEW AND PROBLEM STATEMENT

Much attention is paid to the development of composite materials for protection against electric, magnetic and electromagnetic fields of a wide frequency range. Most of the work concerns the development and study of the protective properties of rigid and elastic composites from which protective structures of the required configurations are made [1, 2]. They are not always suitable for cladding surfaces of complex structures. In work [3], a paint-based coating containing finely dispersed graphite is considered. However, only the mechanisms for ensuring the screening of the field have been investigated without obtaining data on a condition of the material during its practical use. Work [4] concerns the development of a protective mixture based on nanocarbon.

The results indicate its high protective properties, but it is not shown how it can be practically used, in particular, depending on the concentration of the protective substance. In studies [5, 6], the use of finely dispersed ferrites in a polymer matrix for shielding high-frequency electromagnetic radiation is shown, but the possibility of their deposition on the surface is not shown. In particular, there is no confirmation of their adhesion to the base during polymerization.

In the review work [7], almost all classes of screening materials were considered, but no attention was paid to compositions on a liquid basis. This is explained by the lack of reliable data on the possibility of using such materials in practice, taking into account their adhesion to the surface, methods of application on surfaces, etc. Thus, an urgent problem is to study the possibilities of the practical application of liquid materials with a screening filler of different concentrations. The main indicators are colloidal-chemical and rheological properties, dynamic and static viscosity, surface tension and contact angles on substrates.

MATERIALS AND METHODS

To obtain a composition for protection against electromagnetic radiation, a water-dispersive binder VD-AK-22L produced by ARSEN Unitary Enterprise, Republic of Belarus (TU RB 100136815.003-2004) was used.

As an active filler that scatters electromagnetic waves, we used a finely dispersed Fe-containing product - an iron ore concentrates with a Fe_3O_4 content of up to 65%.

The preparation of the protective composition with functional additives was carried out in a laboratory dissolver. To analyze the effect of a Fe-containing filler on colloidal-chemical, rheokinetic and absorbing or scattering properties the following parameters were chosen [8-10]: the work of the forces of adhesion, cohesion and wetting, the coefficients of spreading and wetting, dynamic and plastic viscosity, surface tension and angle wetting on substrates of pine wood and plasterboard.

The numerical values of the parameters were obtained on devices and according to the methods used in the study of varnishes and painting materials (VPM). The dynamic viscosity was determined with the help of Brookfield LVDV2T viscometer using an LV-3C spindle. Surface tension, wetting angle, work of forces of adhesion, cohesion and wetting, as well as the values of the coefficients of spreading and wetting were calculated by the formulas given in literature [11, 12]. The error in measuring the values of surface tension and contact angle, did not exceed 10%.

RESULTS OF RESEARCHES

The main objective of the study is to determinate the effect of the concentration of Fe-containing filler on the change in density, dynamic and plastic viscosity of the protective composition.

The amount of the protective composition applied per unit of surface area depends primarily on its concentration and viscosity, and secondly, on the required material thickness, the temperature of the substrate and the environment, and the quality of the substrate surface preparation.

In the initial water-dispersive acrylic binder VD-AK-22L with a density of 1.03 g/cm^3, the dry substance concentration is 32.5 %, and the dynamic viscosity is 5904 cP.

Let us consider how the concentration of Fe-containing filler, which changes the concentration of the protective composition on dry substance from 42.63 to 73 %, affects the change in the density and dynamic values in the range of low spindle rotation speeds. The change in the density of the protective composition, depending on the concentration of the filler, is described by the quadratic dependence – $\rho=0.0002C^2+0.0039C+1.0355$, at the degree of approximation reliability $R^2=0.9987$ (Fig. 1).

The change in dynamic viscosity curves refers to the “pseudoplastic” state of fluids. With the increase in filler concentration and spindle rotation speed, the values of dynamic viscosities decrease (Fig. 2).

So, at zero filler concentration, in the speed range 0.25… 0.3 revolutions per minute (RPM), the dynamic viscosity values change linearly from 5907 to 5040 cP and are described by the equation $\eta=-1728C+10274$ at $R^2=1$; in the speed range from 0.3 to 28.0 RPM, the value of the dynamic viscosity changes according to amathematical power dependence from 5040 to 4251 cP and is described by the equation $\eta=5471.2C^{-0.076}$ at $R^2=0.991$; the averaged value of the dynamic viscosity in the considered range of velocities has a power-law dependence of the form $\eta=5845.7C^{-0.099}$ at $R^2=0.8607$ (Fig. 2).

Introduction to the composition of the protective composition up to 15% Fe-containing filler leads to an increase in viscosity values by 1.32 times compared to the previous version. In the speed range from 2.0 to 20.0 RPM, the viscosity decreases from 7260 to 5940 cP and is described by a power-law dependence of the form $\eta=7821C^{-0.09}$ at $R^2=0.9942$.

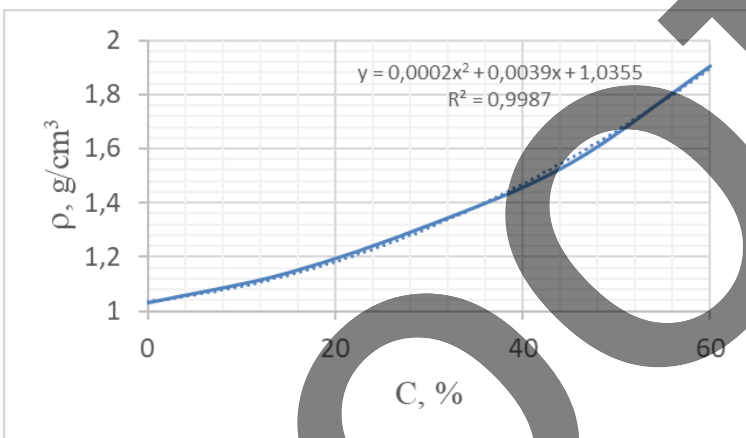


FIGURE 1. Change in the density of the protective composition depending on the concentration of the Fe-containing filler.

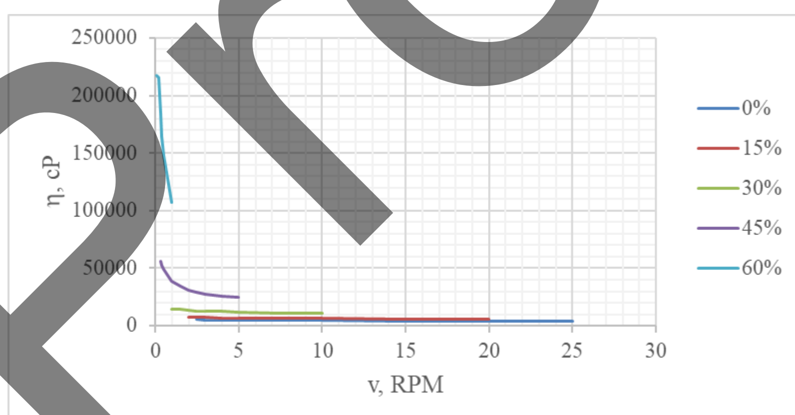


FIGURE 2. Kinetics of changes in the dynamic viscosity of the protective composition depending on the concentration of the filler.

Increasing the concentration of the Fe-containing filler up to 30% (by weight) leads to an increase of dynamic viscosity of 2.44 times in comparison with the no-additive option. In the speed range from 1.0 to 11.0 RPM, the viscosity changes from 14400 to 10410 cP and is described by an equation of the form $\eta=14833C^{-0.144}$ at $R^2=0.9875$ (Fig. 2). Increasing the concentration of the Fe-containing filler up to 45 % wt. in the composition of the protective composition contributes to a 9.6-fold increase in viscosity in comparison with the initial one. In the speed range from 0.3 to 4.9 RPM, the viscosity decreases from 56400 to 24250 cP and is described by an equation of the form $\eta=39230C^{-0.308}$ at $R^2=0.9992$ (Fig. 2). A further increase in the concentration of the filler up to 60 % wt. contributes to even greater thickening and an increase in viscosity of 36.8 times compared to the original sample. In the speed range from 0.1 to 1.2 RPM, the viscosity decreases from 217200 to 97100 cP and is described by the dependence $\eta=111872C^{-0.352}$ at $R^2=0.9209$ (Fig. 2).

The effect of the concentration of the Fe-containing filler on the change in the values of the plastic viscosity determined from the cotangent of the slope of the curves in the dependence $\nu=f(M)$ is more clearly seen (Fig. 3).

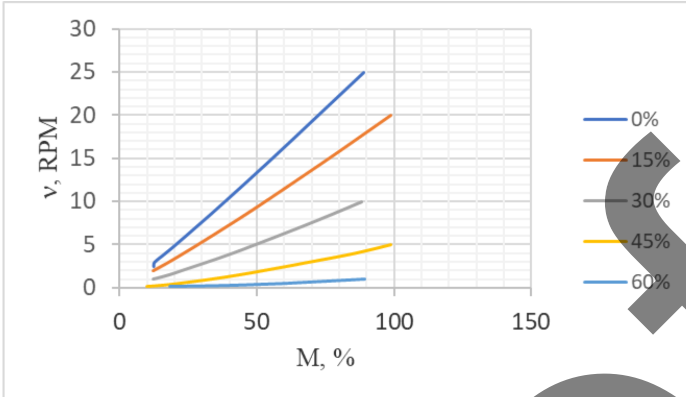


FIGURE 3. Kinetics of changes in the plastic viscosity of the protective composition depending on the concentration of the filler, speed and torque of the spindle.

In the range of speeds from 0.1 to 25.0 RPM, the value of plastic viscosity is significantly influenced by the torque of the spindle and the concentration of the Fe-containing filler. The plastic viscosity of the initial water-dispersive binder VD-AK-22L is 115.04 cP at a curve slope of 41°. With a decrease in the slope of the curves, respectively, 31°, 19°, 9° and 2.5° and an increase in the concentration of Fe-containing filler from 15 to 60% (in weight), there is a significant thickening of the protective composition with an increase in the values of plastic viscosity, respectively, 166.43 cP, 290.42 cP, 631.14 cP and 2290.38 cP. This growth of numerical expressions for plastic viscosity is connected, besides increasing the torque, with a decrease in spindle speed. It is noted that with the increase in the concentration of the Fe-containing filler, the spindle rotation speed decreases from 25.0 to 0.1 RPM (Fig. 3).

The noted dependences influence the choice of the method of applying protective compositions to the surface of the substrate. So, at concentrations of Fe-containing filler 15 and 30% (wt.) and plastic viscosity values of 166.43 and 290.42 cP, they can be applied to the substrate surface by brush and spraying, which is confirmed by an increase in the speed shift from 0.21 to 4.2 $s^{-1}$and a gradual increase in shear forces from 34.24 to 249.5 dyne/cm^2 (Fig. 4).

In the speed range from 0.042 to 1.05 s^{-1} and the weight concentration of the Fe-containing filler 45%, the shift force increases 10 times from 24.95 to 249.5 dyne/cm^2. Such composition, with plastic viscosity of 631.14 cP, can be applied to the substrate surface with a roller.

An increase in the weight concentration of Fe-containing filler up to 60% in the composition contributes to its even greater thickening and transfer to a state similar to a paste. In the range of speed shift from 0.021 to 0.21 1 s^{-1}, the shift force sharply increases from 45.4 to 225.3 dyne/cm^2 (Fig. 4). Such composition with a plastic viscosity of 2290.38 cP can be applied to the substrate surface with a spatula.

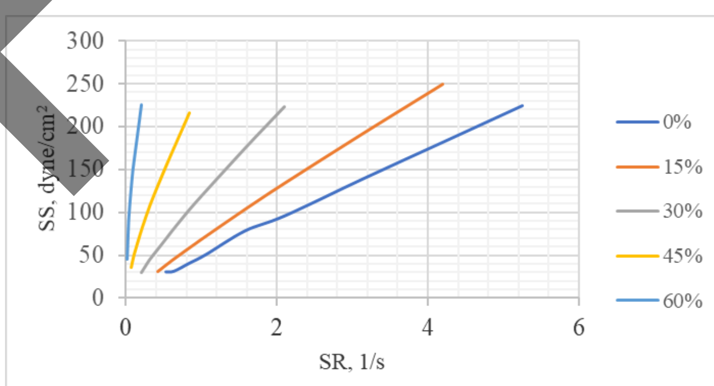


FIGURE 4. Kinetics of changes in the shift force of the protective composition depending on the shear rate and concentration of the Fe-containing filler.

The figures 5–9 shows the angles of wetting without additive water-dispersive binder VD-AK-22L and filled with Fe-containing filler on pine and gypsum board substrates.

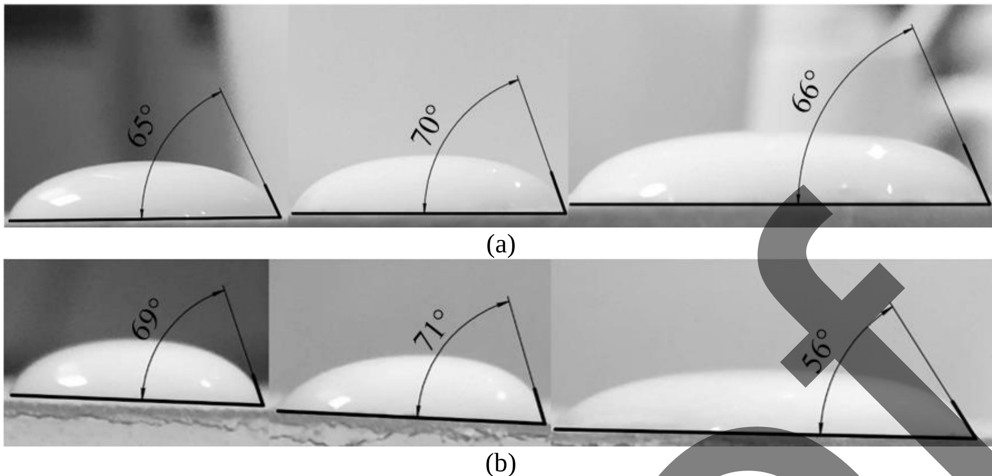


FIGURE 5. Angles of wetting of the water-dispersive binder VD-AK-22L on substrates pine (a) and drywall (b).

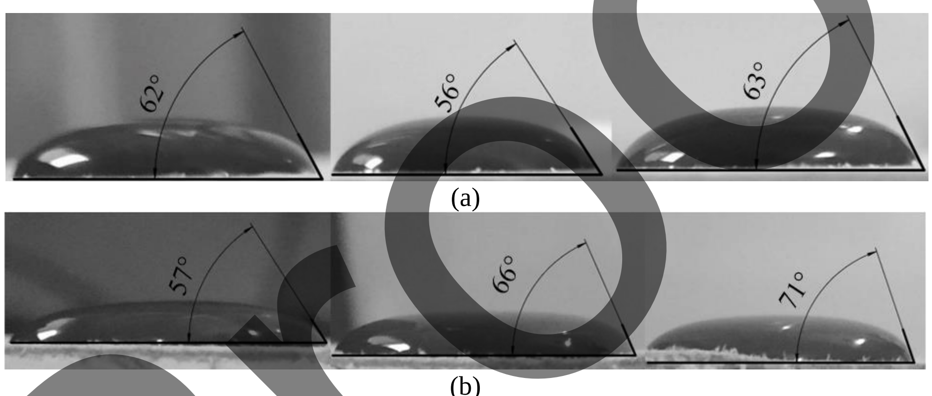


FIGURE 6. Angles of wetting of a protective composition containing 15% (wt.) Fe_3O_4 on substrates pine (a) and drywall (b).

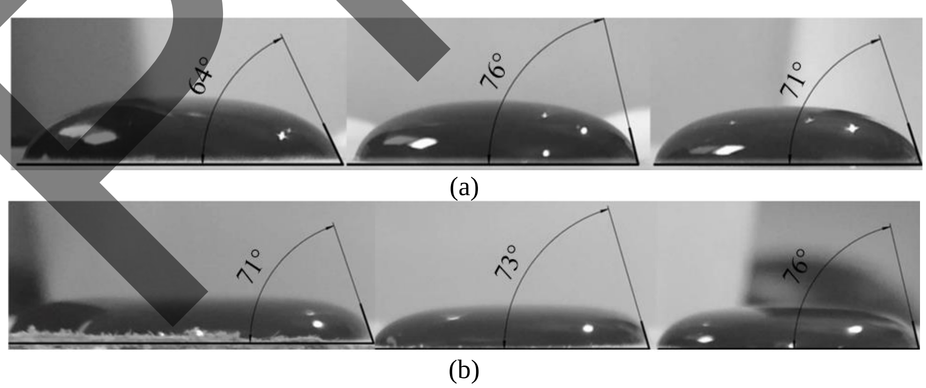
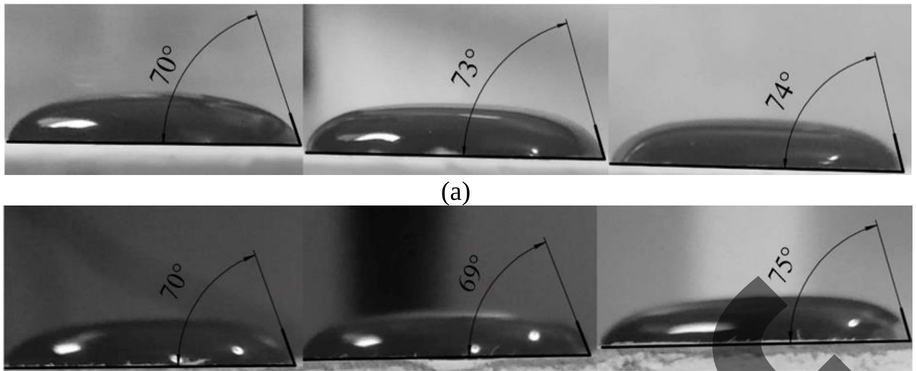


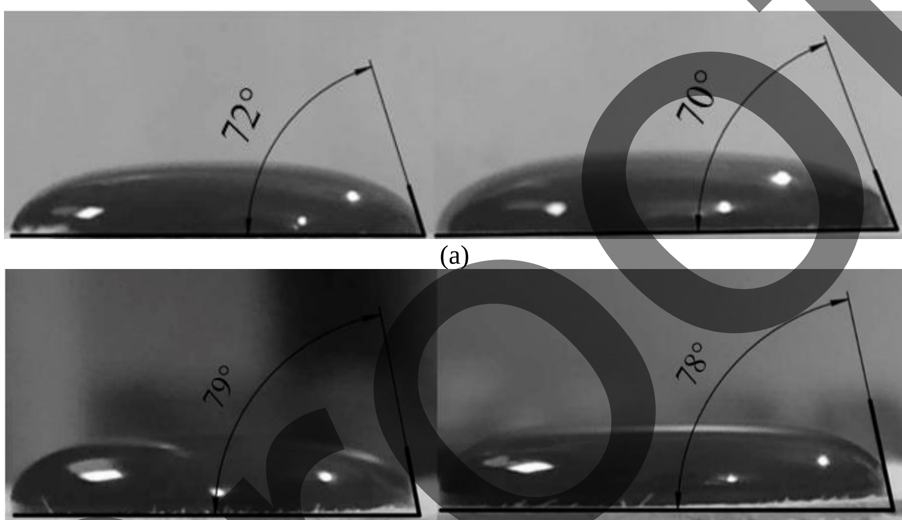
FIGURE 7. Angles of wetting of a protective composition containing 30% (wt.) Fe_3O_4 on substrates pine (a) and drywall (b).



(a)

(b)

FIGURE 8. Angles of wetting of a protective composition containing 45% (wt.) Fe_3O_4 on substrates pine (a) and drywall (b).



(a)

(b)

FIGURE 9. Angles of wetting of a protective composition containing 30% (wt.) Fe_3O_4 on substrates pine (a) and drywall (b).

As seen in Fig. 5-Fig. 9, the introduction into the composition of VD-AK-22L up to 15% (wt.) Fe-containing filler contributes to a decrease in the wetting angle in a comparison with the original binder and filled with a binder both on a pine substrate and on a drywall substrate.

DISCUSSION RESULTS

Fig. 10 shows data on the effect of the concentration of the Fe-containing filler on the surface tension of the protective composition.

The fig. 10 shows that with an increase in the concentration of the Fe-containing filler, the surface tension values increase by a factor of 1.2 in comparison with the initial value of the surface tension of VD-AK-22L. It is known that more completely the substrate is wetted by an adhesive, the greater loss of energy occurs (from the wetting condition):

$$S=s_c–s_a–s_a\text{-}c \geq 0,$$

where s_c – an adhesive; s_a – substrate; s_a-c – section adhesive-substrate.

The higher the spreading coefficient “s”, the more complete the wetting is. And for this it is necessary that the free surface energy at the adhesive-substrate (s_a-c) interface be minimal, which is possible only if the molecular nature of the adhesive and the substrate is close. Considering that the molecular nature of the mineral adhesive and the substrate is far from close, many factors must be taken into account for complete wetting and spreading of the substrate, namely: surface tension, contact angle, work of forces of adhesion, cohesion, wetting, etc. According to the criteria, this assumption can be displayed as follows: Θ_{av}<75°, s→max and f→min.

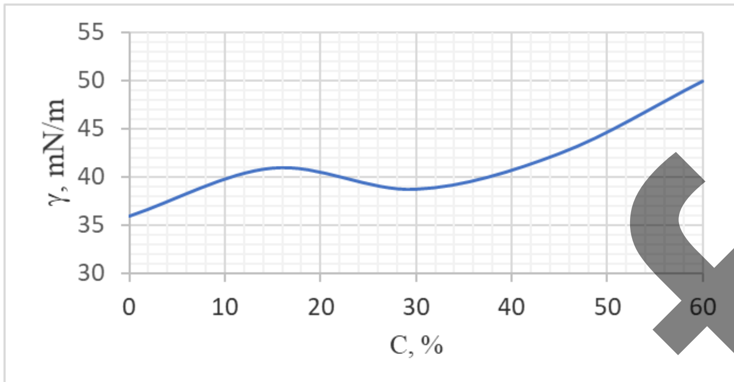


FIGURE 10. Change in the surface tension of the protective composition depending on the concentration of the Fe-containing filler

Let us consider the effect of Fe-containing filler concentrations on changes in the chemical-colloidal properties of protective compositions (Table 1).

TABLE 1. Chemical and colloidal properties of the protective composition

Indicators	**Units**	**C, %**				
		0	15	30	45	60
on the pine substrate						
γ	mN/m	35.9	40.9	38.7	42.4	49.93
Θ_{av}	°, ′	67	60.33	70.33	72.33	71
$\cos\Theta_{av}$	-	0.39073	0.4950	0.3366	0.30354	0.325568
W_a	mN/m	49.93	61.15	51.73	55.27	66.19
W_k	mN/m	71.8	81.8	77.4	84.8	99.86
W_a	mN/m	14.03	20.15	13,03	12,87	16,26
s	-	0,6954	0.74756	0.66835	0.651769	0.662828
f	mN/m	-21.87	-20.65	-25.67	-29.53	-33.67
on the drywall substrate						
γ	mN/m	35.9	40.9	38.7	42.4	49.93
Θ_{av}	°, ′	65.33	64.67	73.33	71.33	78.5
$\cos\Theta_{av}$	-	0.41739	0.42783	0.286859	0.20117	0.199368
W_a	mN/m	50.88	58.4	49.8	55.97	50.93
W_k	mN/m	71.8	81.8	77.4	84.8	99.86
W_a	mN/m	14.98	17.5	11.1	13.57	9.95
s	-	0.70864	0.713636	0.64341	0.66002	0.51001
f	mN/m	-20.92	-23.4	-27.6	-28.85	-48.93

Note: C – concentration of Fe compounds; γ– value of surface tension; Θ_{av} – the average value of the wetting angle of the substrate with the adhesive; W_a, W_k, W_w – work of adhesion forces, cohesion and wetting; s, f – coefficients of wetting and spreading of the adhesive over a substrate surface.

As can be seen from the data presented, the introduction of 15% Fe-containing filler helps to reduce the wetting angle on the pine substrate, and 30% - on the drywall substrate, by the main indicators. In terms of the wetting and spreading coefficients, the above-considered compositions are close to those of the original VD-AK-22L.

Changes in the work indicators of adhesion forces, cohesion and wetting are relevant similar to the change in the previous indicators and will be taken into account when determining the physical and mechanical properties of protective compositions. The chemical and colloidal properties of the protective composition are shown in Table 1.

The significance of the obtained results of the work is quite obvious and, first of all, is aimed at practical originality, which will help us to solve the problem of stabilizing the rheokinetic properties of highly filled protective compositions based on VD-AK-22L, namely: the values of dynamic and plastic viscosity in the range of operating speeds when applying a protective composition to substrates surface; ensure the formation of colloidal-chemical structures with minimum wetting angles and maximum values of the spreading coefficient.

CONCLUSION

The carried-out studies make it possible to determine the conditions and methods of applying a material for shielding of electromagnetic fields, depending of the shielding Fe-containing substrate.

The dependences of the change in the plastic viscosity of the protective composition depending on the concentration of the screening filler were determined.

The angles of wetting of the protective composition with different concentration of the filler applied to the wood and drywall substrates were determined, which made it possible to assess the possibilities of material resistance on the surfaces.

The changes in the surface tension of the protective composition depending on the concentration of the Fe-containing filler were investigated, it was found that its values increase by 1.2 times relatively to the tension of the liquid matrix.

All the main chemical-colloidal properties of the protective composition have been obtained depending on the concentration of the shielding substance, which will make it possible to optimize the screening coefficients of electromagnetic fields while ensuring the coating material resistance in real operating conditions.

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Technological Package of the Small-Sized Equipment for Preparation of Products from Polystyrene-Concrete Mixture

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Abstract. The design of the small-sized equipment package is presented, where the base machine was a gravity-forced mixer for the preparation of high-quality polystyrene-concrete mixture with the addition of fiber elements and its further use in production. All equipment included in the package works with the same production when combining operations over time. The design of the basic machine - the mixer working in the cascade mode is resulted. Dependencies to determine the main performance of machines (production, power), which show their relationship to each other are also given.

FORMULATION OF THE PROBLEM

Products made of polystyrene-concrete mixture are used in the construction of low-rise buildings, or houses of non-standard shape in the modern world. The mixture is used to make both individual blocks and entire sections of the house in the form of insulation. Most often, these are large machines that operate in the enterprise, and then the finished mixture or blocks are transported to the construction site. This creates inconvenience in the time between operations, thereby reducing the production of construction work.

Therefore, it is necessary to create a technological package of equipment that will work at the same pace, thus not reducing the quality of the finished mixture and polystyrene concrete product. Creating a technological package of equipment will reduce machine downtime, increase line production, and most importantly - get quality products.

ANALYSIS OF EXISTING DESIGNS OF MIXERS AND PACKAGES FOR THE PRODUCTION AND PREPARATION OF POLYSTYRENE CONCRETE BLOCKS

Analyzing the types of mixers for the preparation of polystyrene-concrete mixtures [1-6], we can conclude that the main and most common are gravity or forced mixers (one-shaft or two-shaft) [7-8].

The simplest option for the preparation of the mixture is a gravity cyclic concrete mixer of a typical design, which is used for the preparation of the mobile concrete mixtures.

The forced-action mixer is an RSG-1000 installation – a hermetic horizontal-type mixer designed for preparation and transportation of the foam concrete, polystyrene-concrete mixture of different density to the place of pouring [9].

The mixing mechanism of installation consists of two differently directed screws that provides high-quality mixing of components and homogeneity of mix.

The design of the mixer allows to refuse use of additional pumps for transportation of the mix. The supply of the mixture to the place of pouring is due to overpressure in the mixer created by the compressor. The mixer has a safety valve, which allows you to adjust the overpressure when unloading the mixture. The mixture can be transported at a distance of up to 20-30 m horizontally and up to 5-6 m vertically.

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The semi-automatic high-performance foam generator of installation allows to receive uniformly porous foam mix with a possibility of adjustment of the density.

The control panel mounted on the mixer case gives the chance to operate all functions of the installation to one operator. The installation can be installed in production complexes with an automated control system.

Technological complexes for the manufacture of products from polystyrene-concrete mix are different depending on the configuration of the base machine, line production and type of product.

Conveyor type complexes are maximally automated [10]. Involvement of manual labor is practically not required. This complex has a high cost and maximum production. Products made on such equipment will have accurate geometric dimensions, high quality, due to the exact dosage of components and adherence to technology.

The complex consists of hoppers for storage of components of mix, the mixer for preparation of polystyrene concrete, the manual vibropress, the crusher for crushing of polyfoam.

Thanks to the above technologies, it is possible to make blocks and bricks from polystyrene concrete [11]. An example of the use of polystyrene concrete are domed houses from SunHouse (Fig. 1) [12].

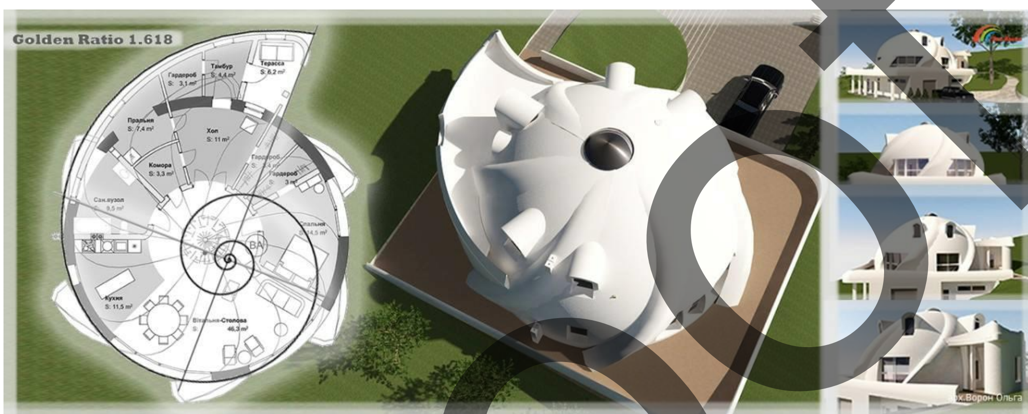

FIGURE 1. Dome house made of polystyrene concrete

The frame of the building is built using a unique formwork made of multilayer fiberglass. The structures can be of three diameters - 4,7 m and 9 m. The finished mixture is transported to the formwork by means of a concrete pumping station. The design of the frame is not used reinforcement. The walls are smooth and do not require additional leveling of the surface after removing the formwork.

DESCRIPTION OF THE SMALL-SIZED EQUIPMENT PACKAGE FOR THE PREPARATION OF BLOCKS OF POLYSTYRENE-CONCRETE MIXTURES

There are designs of the small-sized equipment that works as part of a technological package, with the same production. They are used for preparation of concrete mixes, and then for transportation of mix or carrying out shotcrete works. Such packages are mobile, compact and organized automatic work [13 - 15].

After the analysis of the existing equipment and technological lines of production of products from polystyrene-concrete the technological package of the small-sized equipment (fig. 2) is offered [16]. Thanks to this package it is possible to make high-quality polystyrene-concrete mix with addition of fiber elements. The presence of a cutter for grinding fiber allows you to get a homogeneous mixture and thus increase the strength of the products.

The package of equipment consists of a basic machine - a forced mixer, a cutter for fiber, a belt feeder for feeding the components of the mixture, an auger feeder for transporting the finished mixture. All equipment is mounted on one frame and works at the same pace (depending on the performance of the mixer), which reduces the time to feed the components of the mixture.

The package of equipment works as follows. The components of the mixture are stored in the hopper 5 and then on the tape feeder 4 are transported to the loading hole of the mixer 1. The fibers are cut with a fiber cutter 3 and placed in equal portions on the tape feeder 4 at this time. The finished polystyrene-concrete mixture is unloaded from the mixer 1 to the receiving hopper of the motor 8 and then transported to the place of formation of products.

Analyzing the existing designs of mixers used for the preparation of polystyrene-concrete mixtures, it should be noted:

- the complexity of the design of concrete mixers;
- uncertainty in the possibility of obtaining homogeneous mixtures; - adhesion of the mixture to the surface of the mixer;
- a long time of the process of preparation of the mixture.

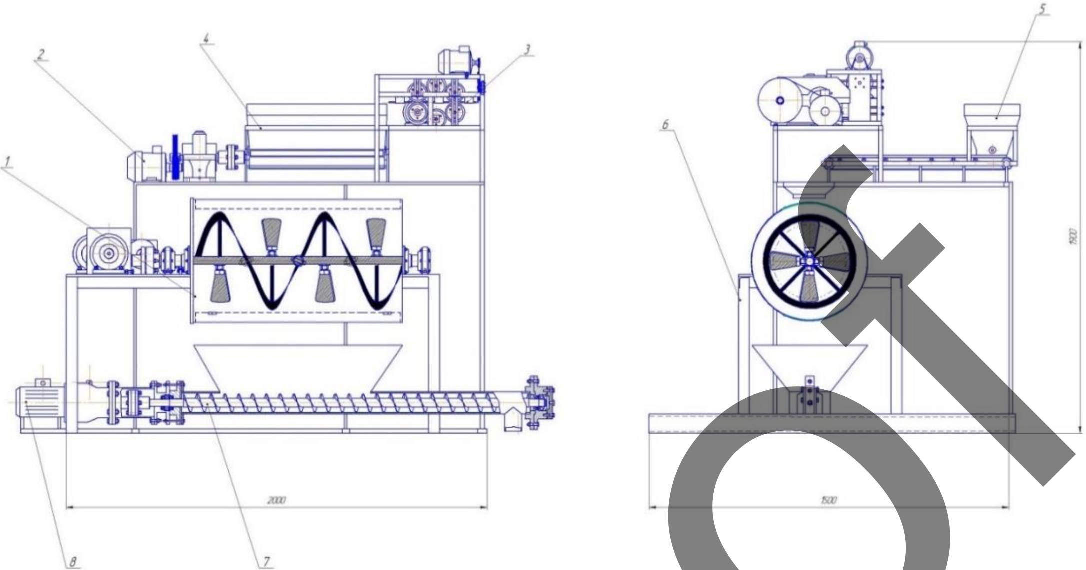

FIGURE 2. A package of equipment for the preparation of polystyrene-concrete mixture 1 - gravity-forced mixer; 2 - motor of the tape feeder; 3 - a cutter for fiber; 4 - tape feeder; 5 - hopper for components; 6 - frame; 7 - auger feeder; 8 - motor of the auger feeder

Given these shortcomings of existing machines, it is proposed to use a gravity-forced concrete mixer (operating in cascade mode) for the preparation of such mixtures.

The known design of the gravity-forced concrete mixer was used for preparation of low workability and low-slump concrete mixes, passed approbation in the conditions of the company.

A new design solution of such a mixer, which in terms of parameters will conform the conditions for the preparation of polystyrene-concrete mixtures with fiber elements is presented in Figure 3.

Gravity-forced mixer consists of a cylindrical shell. A horizontal tape-blade shaft, the blades of which are fixed to it along a helical line, is located in the middle of the shell. The mixer shell and the tape-blade shaft rotate in opposite directions.

The design of the mixer allows to prepare polystyrene-concrete mix by means of rotation of a tape-blade shaft. During the operation of the tape-blade shaft, additional rotation of the mixer shell is created in the opposite direction when using a fine aggregate (sand) for the preparation of polystyrene-concrete mixture. Also, when the volumetric coefficient kf is more than 0.5, it is recommended to use the simultaneous rotation of both the tape-blade shaft and the mixer shell.

The principle of operation of the machine is as follows: from the motor 6 through the connecting box 12 torque is transmitted to the reducer 8. In turn, from the reducer shaft 8 through the connecting box 10 begins to rotate the horizontal shaft 1 with fixed blades 5.

From the motor 7 through the V-belt transmission 13 torque is transmitted to the reducer 9. Next, the torque from the reducer shaft 9 through the connecting box 11 rotates the concrete mixer shell 2 by means of a chain transmission consisting of a sprocket 14 and a chain 15 fixed on the outer surface of the shell 2.

To the shell of the concrete mixer 2 are attached covers 3, which cover the loading and unloading hole of the machine and, if necessary, open or close.

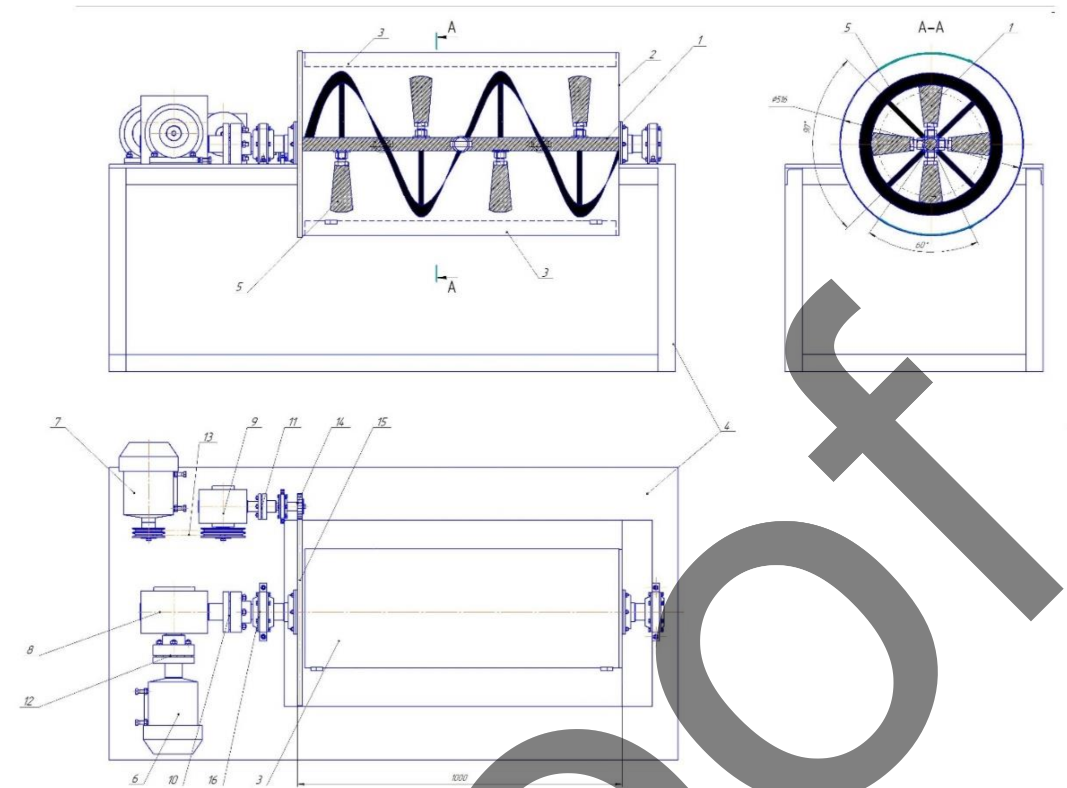

FIGURE 3. Basic diagram of the gravity-forced mixer 1 - auger shaft; 2 - shell; 3 - cover; 4 - frame; 5 - the blade of the shell; 6, 7 - electric motor; 8, 9 - worm reducer; 10,11,12 - connecting box; 13 - V-belt transmission; 14 - sprocket of chain transmission; 15 - chain; 16 - roller carriage

CALCULATION OF BASIC PARAMETERS FOR A PACKAGE OF EQUIPMENT

To determine the main parameters of the equipment, a method of their calculation is proposed. These parameters are the production and power expended on the process of preparation of the polystyrene-concrete mixture.

Determination of technical productivity of the mixer is carried out taking into account design parameters of the machine and features of working process:

$$P_t = V_{tot} \cdot K_f \cdot Z_c \cdot \rho_0, t/hour \tag{1}$$

where V_{tot} – the total volume of the mixture in the mixer shell, m^3; K_f – volumetric coefficient of the mixer; $Z_c = 3600/t_c$ – number of machine cycles by hour; $t_c = t_1 + t_2 + t_3$ – duration of one cycle, which consists of time for loading of components t_1, their mixing t_2 and unloading of the ready mix t_3, s; ρ_0 – is the average density of the mixture, t/m^3.

The total volume of the mixture in the mixer shell, can be determined by the formula:

$$V_{tot} = V_s - V_{sh} - V_b - V_{bl} - V_a - V_r, m^3. \tag{2}$$

Total volume of the shell:

$$V_s = \frac{1}{2} \cdot \pi \cdot R_{s.in}^2 \cdot L_s, m^3,$$

where $R_{s.in}$– internal radius of the shell at the mixer, m; L_s – the length of the shell, m.

The total volume of the shaft, $V_{sh} = \frac{1}{2} \cdot \pi \cdot r_{sh}^2 \cdot L_{sh}, m^3$, where r_{sh} – is the radius of the shaft, m; L_{sh} – shaft length, m.

The total volume bases of blades, $V_b = \frac{1}{2} \cdot \pi \cdot r_{b.in}^2 \cdot z_b \cdot C_b, m^3$, where $r_{b.in}$ – the inner radius of the base, m, m ; z_b – number of bases; C_b– base thickness, m .

Total volume of blades:, $V_{bl} = \frac{1}{2} \cdot z_{bl} \cdot b_{bl} \cdot h_{bl} \cdot C_{bl}, m^3$, where z_{bl} – is the number of blades; b_{bl} – width of a blade, m; h_{bl} – blade height, m; C_{bl} – thickness of a blade, m.

The total volume of the auger: $V_a = \frac{1}{2} \cdot \pi \cdot (L_a - l_a) \cdot (R_a^2 - r_a^2) \cdot C_a, m^3$, where L_a, l_a – the length of the auger in the expanded form of the inner and outer diameters $L_a = \sqrt{S^2 + (\pi + D_a)^2}, l_a = \sqrt{S^2 + (\pi + r_a)^2}, m$; R_a, r_a– external and internal radii of the auger, m; C_a – auger thickness, m.

The total amount of racks for mounting auger as: $V_r = \frac{1}{2} \cdot \pi \cdot R_r^2 \cdot z_r \cdot C_r, m^3$, where R_r – inner radius racks m; z_r, C_r – the number and thickness of the auger rack, m

The power of the mixer expended in the process of preparation of the mixture consists of: power expended to create torque; power expended to overcome the friction forces arising from the interaction of the mass of the concrete mixture with the blade shaft and the auger belt; the power expended to move the mixture in the axial direction; power expended to overcome the friction forces arising from the interaction of the mixture with the auger part of the shaft:

$$N_{p.m} = \begin{pmatrix} \omega_{sh} \cdot M_{bl.sh} + F_{fr} \cdot V_{abs.sh} \cdot z_{bl} + \\ + \frac{c \cdot \rho_0 \cdot s_{mid} \cdot \omega_{sh}^3 \cdot k_f \cdot z_a (D_{a.out}^2 - D_{a.in}^2)}{32 \cdot \pi^2 \cdot k_m} + k_f \cdot \omega_{sh} \cdot M_a \end{pmatrix} \cdot \frac{1}{1000 \cdot \eta_{sh} \cdot \eta_a}, \quad (3)$$

where ω_{sh} – angular speed of rotation of the blade shaft, sec-1; $M_{bl.sh}$– blade shaft torque, $M_{bl.sh} = P_{bl.m} \cdot R_{bl.sh} \cdot z_{bl}$, N·m; $P_{bl.m}$ – the force arising from the action of the mixture on the shaft blade, $P_{bl.m} = q \cdot b_{bl} \cdot h_{bl} \cdot c_{bl} \cdot \cos\beta \cdot R_{bl.sh.mid}$, N; q – the pressure of the mixture on the blade of the shaft, $q = C_0 \cdot \rho_0 \cdot V_{sh}^2$, P; V_{sh} – circular speed of the shaft, $V_{sh} = \omega_{sh} \cdot R_{sh}$, m/sec; where C_0 – the coefficient of resistance of the blade when interacting with the mixture; α_{sh} – the rise angle of the mixture, from which the mixture begins to climb from the shaft blade; $R_{bl.sh.mid}$ – the average radius of the blade shaft, $R_{bl.sh.mid} \frac{R_{bl.sh} + r_{bl.sh}}{2}$, m; F_{fr}– - the force of friction that occurs during the movement of mixture particles on the surface of the blade, $F_{fr} = G_m \cdot \frac{1}{3} \cdot (f_1 \cdot \cos\varphi_{sh} + \sin\varphi_{sh})$, N; G_m– gravity of the mixture, $G_m = V_{tot} \cdot \rho_0 \cdot g$, N; g – acceleration of gravity, m/sec2; f_1 – the friction coefficient of the mixture on the surface of the blade; z_{bl} – the number of blades on the shaft; η_{sh} – the efficiency of the drive shaft; $V_{abs.sh}$ – the absolute velocity of mixture particles on the shaft blades, $V_{abs.sh}$, $V_{abs.sh} = \omega_{sh} \cdot R_{sh} \cdot \sqrt{1 - \frac{R_{sh.in}}{R_{sh.out}}}$ m/sec; c – the resistance coefficient of the blade in the process of mixing the mixture in the direction of its movement in a circle; $S_{mid.a}$ – the pitch of the auger on its average diameter, $S_{mid.a} = \pi \cdot D_{mid.a} \cdot tg\alpha_{mid.a}$; $D_{mid.a}$ – the average diameter of the auger, $D_{mid.a} = 0.5 \cdot (D_a + d_a)$, m; $\alpha_{mid.a}$ – angle of climb spiral auger in average diameter, $\alpha_{mid.a} \approx arctg \frac{k_1 \cdot S}{D_{a.out}}$; k1 – coefficient equal to k1=0.4…0.45; S – step spiral auger; $S = E \cdot D_a$, m; E – the ratio of the auger pitch to the diameter of the auger; z_a– the number of the auger turns; k_m – the return ratio of the mixture; M_a – the moment of friction forces of the concrete mixture on the surface of the auger is determined by the following dependence, N·m.

$$M_a = \frac{\pi \cdot c \cdot s_{mid} \cdot \omega_{sh}^2 \cdot f_1 \cdot z_a \cdot tg\alpha_{mid.a} \cdot \sin\alpha_{mid.a} (D_{a.out}^5 - D_{a.in}^5)}{80 \cdot k_m}. \quad (4)$$

The design of the mixer offers the use of a rotating shell, which allows you to load a larger volume of components and make low-slump mixtures.

Therefore, the power required to rotate the faucet shell can be defined as:

$$N_s = \frac{0.85 \cdot G_m \cdot h \cdot Z \cdot \omega_s \cdot f_{fr.}}{\eta_s \cdot 1000}, \quad (5)$$

where G_m – the weight of the concrete mixture that rises under the action of friction forces, $G_m = V_{tot} \cdot \rho_0 \cdot g$; h – the coordinate of the vertical displacement (shift) of the mass of the mixture in the shell; Z – the number of circulations of the mixture in the shell of the machine; ω_s – angular speed of rotation of the mixer shell; $f_{fr.}$ – the friction coefficient of the mixture on the surface of the shell; η_s – efficiency of the shell drive.

CONCLUSIONS

- The analysis of the existing equipment and technological packages of the equipment is carried out.
- The technological package of small-sized equipment for preparation of polystyrene-concrete mix with fibers is offered. The design features of the mixer, which works in cascade mode, are revealed.
- Dependences for determination of production and power of components of a technological package of the equipment are resulted.

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Modeling the Flow of a Bingham Plastic Fluid Through a Circular Pipeline with Different Wall Properties

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Abstract. Modern construction technologies make it possible to erect buildings and structures with a variety of irregular shapes and unique architectural solutions. Such structures can be round, curved and have other shapes, for example, arched and other similar surfaces, in construction of which complex prefabricated equipment is used. Special transporting machines – concrete pumps – are commonly used in the manufacture of reinforced concrete blocks, floor slabs, large-diameter pipes and other assortment of products. A condition for the uniform transportation of media by piston concrete pumps through pipelines is the need for a detailed study of the processes occurring in the “piston group – gate valve distribution unit – pipeline” system. This approach will enable the rational choice of design parameters and operating conditions of a concrete pump, based on the development of working models of the movement of viscoplastic concrete mixtures, taking into account the design and actual performance of the “injection device – pipeline” technical system.

INTRODUCTION

The design solution of the gate valve distribution unit has been analyzed. A feature of this design is the location of the gate valve between the rear wall and the ends of the cylinders of the concrete pump and the movement of the concrete mixture inside a section of the gate distribution unit in the condition of different properties of walls made of different materials: half of the section is steel, and the other half of the section is concrete mixture. This problem is challenging, since concrete and mortar mixtures are viscoplastic Bingham fluids with specific characteristics and rheological parameters. These parameters are fluctuating as the medium is moving along a circular pipe with the gate distribution unit of the transporting equipment the wall of which have different properties which are poorly studied so far. The process of moving the medium in such a section of a pseudopipe of a certain length of the gate valve distribution unit will be determined by the inlet and outlet pressure difference created by the moving piston of the concrete pump. Such a flow of the medium, in turn, leads to an uneven change in the elastic limit arising between the inner radius of the metal surface of the pipe and the conditional radius, with a contour formation from the concrete mixture, and, accordingly, deformation of the flow core. The study of such models of the flow of viscoplastic media (Bingham fluids) through the gate valve distribution unit of injection equipment (concrete pump) allows further determination of the conditions for the optimal supply of the medium through a pipeline of various cross-sections.

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ANALYSIS OF RECENT STUDIES AND PUBLICATIONS

Physical processes occurring in non-Newtonian media, such as concrete mixtures, are usually considered within the well-known Shvedov-Bingham rheological model. The concrete mixture is a multicomponent medium that is described by the rheological laws of the flow of Bingham fluids [1, 2 and 4]. In-depth research of the processes of flow of Bingham fluids and the resulting mathematical models was carried out by such authors as W.L. Wilkinson, A. V. Gnoevoy, V. Prager, B. M. Smolsky, Z. P. Shulman, V. V. Gorislavets, S. S. Kutateladze, et al. The proposed models have become commonly used for rigid viscoplastic media, in particular, concrete mixtures, and many classical equations of the rheological state of fluids were later generalized on this basis [3, 5, 6 and 8].

STATEMENT OF THE OBJECTIVE AND TASKS OF THE STUDY

The purpose of this work is to determine the flow characteristics in channels with the following characteristics. Concrete mix as a complex rheological fluid has the properties of Bingham plastic. To solve such a problem, a circular channel should be considered, the perimeter of which is bounded by walls made of different materials, in particular, half of the cross-section is steel, while the other half is a concrete mixture. This is the case, for example, in the gate valves of concrete pumps, which are part of the technological equipment for the feed and transportation of concrete mixtures at different distances.

PROBLEM SOLVING

To solve the problem, let us denote the elastic limit of the liquid τ_y, the shear stresses on the steel wall as τ_w, on the concrete boundary as $\tau_{\delta w}$. We introduce a hypothesis: at the joints of the sections (walls) of the channel (points A and B, Fig. 1) no surges of shear stresses are allowed, therefore we will assume that the dependence of the shear stresses on the angle φ (on the section $0 \le \varphi \le \pi$) will have the form: $\tau_{\delta w}(\varphi) = \tau_w - \Delta\tau_\delta \sin\varphi$ It is known that as Bingham fluids flow, the central part of the flow (the so-called "core") moves like a solid body [7, 9]. The values of parameters τ_w and $\tau_{\delta w}$ can be established from the conditions of static equilibrium on the outer contour of the channel and on the boundary of the core. The flow characteristics of the medium should also be established and, in particular, the profile of the distribution of velocities in the cross section of the flow of the medium.

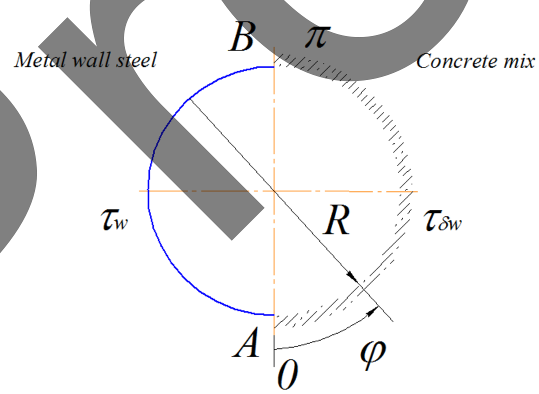

FIGURE 1. General view of the channel bounded by walls made of different materials

The main part of the study. Let us write down the conditions of static equilibrium, which make it possible to establish the distribution of shear stresses τ_w and $\tau_{\delta w}$ over the sectors between points *A* and *B*, which will allow a reasonable approach the determination of the curves of the distribution of velocities and flow rate through the section. The flow rate *Q* is determined by dividing the section into elementary sectors with subsequent integration of them. Let the length of the section be equal to *L*, the pressure difference at the ends of the section will be *ΔP*. The condition for the equilibrium of forces on the outer contour of the section is written in the form

$$\Delta P \cdot \pi \cdot R = \pi \cdot R \cdot L \cdot \tau_w + \int_0^{\pi} (\tau_w - \Delta\tau_\delta \sin\phi) \cdot L \cdot d\phi .$$

After integrating we obtain

$$\Delta P\cdot\pi\cdot R = 2\pi\cdot L\cdot\tau_w - 2\Delta\tau_\delta\cdot L, \tag{1}$$

where τ_w is shear stresses on the pipe wall; R is radius of the pipe; L is the length of the section.
At the boundary of plastic flow ($\tau=\tau_y$), the equilibrium condition has the form

$$\Delta P\cdot F_0 = \pi\cdot r_p\cdot\tau_p\cdot L + \tau_y\cdot L\int_0^\pi dS(\phi). \tag{2}$$

Here $dS(\varphi)$ is an element of the circuit arc of the right part of the core (Fig. 2).

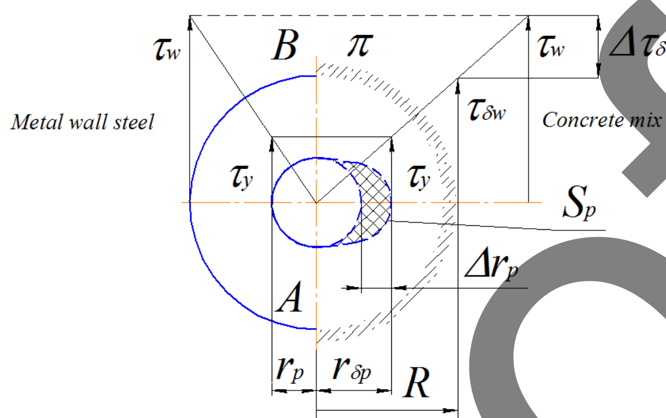

FIGURE 2. Design scheme of static equilibrium of shear stresses τ_w and $\tau_{\delta w}$ by sectors between points A and B in the channel of the gate distribution angle

Let us also assume that the radius of the contour of the right half of the core changes according to the law $r_{\delta p} = r_p + \Delta r_p \sin\phi$ Length of the contour S_p. In the polar coordinate system, the arc length of the contour element will be $dS = \sqrt{dr^2 + r^2\cdot d\phi^2}$. In our case, we get that $dr^2 + r^2\cdot d\phi^2 = \Delta r_p^2\cdot d\phi^2 + r_p^2\cdot d\phi^2 + 2r_p\cdot\Delta r_p\cdot\sin\phi\cdot d\phi^2$. Let us introduce a designation for the ratio: $\delta = \frac{\Delta r_p}{r_p}$, then: $dS = r_p\sqrt{1+\delta^2+2\delta\cdot\sin\phi}\cdot d\phi$. Hence, the integral of the contour length S_p can be found numerically

$$S_p(\delta) = \int_0^\pi r_p\sqrt{1+\delta^2+2\delta\cdot\sin\varphi}\cdot d\varphi = r_p\int_0^\pi\sqrt{1+\delta^2+2\delta\cdot\sin\phi}\cdot d\phi = r_p\cdot I_p.$$

Obviously, in the range of values $0\le\delta\le0.6$, the dependence $I_p(\delta)$ can be represented as a straight line. Its equation $I_p=2.32\delta+\pi$ (passes through the points $\delta=0$, $I_p=\pi$, $\delta=0.5$, $I_p=4.3$). Taking into account the indicated linear approximation, the equilibrium condition from dependence 2 can be represented as

$$\Delta P\cdot r_p\cdot\left(\pi+\frac{\pi}{4}\cdot\delta^2+2\delta\right) = 2L\cdot\tau_y\cdot\pi + L\cdot\tau_y\cdot 2.32\delta. \tag{3}$$

From the condition that the shear stresses are proportional to the radii of the liquid layers, we obtain $r_{\delta p}= r_p+\Delta r_p$ - amplitude values. $\frac{\tau_{\delta w}}{R} = \frac{\tau_y}{\tau_{\delta p}}$, or

$$\tau_{\delta w}\cdot r_p\cdot(1+\delta) = \tau_y\cdot R. \tag{4}$$

If we assume that $\tau_{\delta w}$ is known (found experimentally) along with the parameters of the system ΔP, R, L, τ_y, then from equation (3) we can find δ, and unknown quantities τ_w, Δr_p, r_p can be found from 3 equations (1), (3) and (4) (if $\Delta\tau_\delta$ is known). From equation (4) it follows: $r_p = \frac{\tau_y\cdot R}{\tau_{\delta w}\cdot(1+\delta)}$. Substituting r_p in equation (3), we get a quadratic equation for the relation δ

$$\frac{\Delta P}{2L\cdot\tau_{\delta w}}\cdot\left(\pi+\frac{\pi}{4}\cdot\delta^2+2\delta\right)=\pi\cdot(1+\delta)+1.16\delta\cdot(1+\delta). \quad (5)$$

If the channel had identical steel walls (on which the fluid velocity equals zero, according to the adhesion condition), then it would follow from the balance of forces that $\frac{\Delta P\cdot R}{2L}=\tilde{\tau}_w$. Let us denote this ratio as $A=\frac{\Delta P\cdot R}{2L\cdot\tau_{\delta w}}=\frac{\tilde{\tau}_w}{\tau_{\delta w}}$, then equation (5) takes the form

$$(0.785A-1{,}16)\cdot\delta^2+(2A-4.302)\cdot\delta+\pi\cdot(A-1)=0. \quad (6)$$

This equation obviously has 2 roots, the meaning of both depends on *A*.

For the range of parameter *A* within the values $1\leq A\leq 1.2$, the correlation $\delta(A)$ will be almost straight-line. The straight-line equation is represented as $\delta=1.595\cdot(A-1)$.

In the range $1\leq A\leq 1.4$, the dependence can be represented by a parabola. The equation of parabola has the form $\delta=1.595\cdot(A-1)$. $\delta=2.15\cdot A^2-3.135\cdot A+0.985$.

In view of the foregoing, the flow rate of the concrete mixture can be determined through a circular channel bounded by walls of different materials and represented by the expression

$$Q=Q_{left}+Q_{center}+Q_{right}. \quad (7)$$

The throughput of the left side of the circular channel Q_{left} bounded by a metal wall will correspond to the classical dependence of the flow of Bingham fluids [1,2]

$$Q_{left}=\frac{\pi\cdot R^3}{2\mu_p}\cdot\tau_w\cdot\left[\frac{1}{4}-\frac{1}{3}\cdot\left(\frac{\tau_y}{\tau_w}\right)+\frac{1}{12}\cdot\left(\frac{\tau_y}{\tau_w}\right)^4\right]. \quad (8)$$

Accordingly, the average velocity of the plastic flow of the concrete mixture for the left side will have the form [1, 10, 11]

$$U_p=\frac{\Delta\cdot P}{4L\cdot\mu_p}\cdot(R-r_p)^2. \quad (9)$$

Let us find the total area F_0 of the core of concrete mixture

$$F_0=\frac{\pi\cdot r_p^2}{2}+\frac{1}{2}\int_0^{\pi}r_{\delta p}^2\cdot d\varphi=\frac{\pi\cdot r_p^2}{2}+\frac{1}{2}\int_0^{\pi}\left(r_p+\Delta r_p\sin\phi\right)^2\cdot d\phi=\pi\cdot r_p^2+\frac{\Delta r_p^2}{4}\cdot\pi+2r_p\cdot\Delta r_p. \quad (10)$$

Throughput of the central part of the channel Q_{center} of a circular cross-section through the area of the core in the central part F_0^1 and average velocity U_{p1}

$$Q_{center}=U_{p1}\cdot F_0^1=\frac{1}{\mu_p}\cdot\left[\frac{r_p^2}{2R}\cdot\tau_{\delta w}-\tau_y\cdot r_p\right]\cdot\frac{\pi\cdot\Delta r_p^2}{2}\cdot\frac{\pi\cdot\Delta r_p^2}{4}+2r_p\cdot\Delta r_p \quad (11)$$

Flow rate through the elementary sector S_p of the right side of the channel Q_{right}

$$Q_{right}=\int_0^{\pi}dQ_{right}=\frac{R^3}{\mu_p}\int_0^{\pi}\left\{\frac{\tau_w-\Delta\tau_\delta\sin\phi}{8}+\tau_y\left[\left(\frac{r_p}{R}+\frac{\Delta r_p}{R}\sin\phi\right)\cdot 0{,}5-0{,}333\right]\right.$$
$$-\frac{\tau_w-\Delta\tau_\delta\sin\phi}{4}\times$$
$$\left.\times\left(\frac{r_p}{R}+\frac{\Delta r_p}{R}\sin\phi\right)^2+\left(\frac{\frac{r_p}{R}+\frac{\Delta r_p}{R}\sin\phi}{8}\right)^4\cdot(\tau_w-\Delta\tau_\delta\sin\phi)-\frac{\tau_y}{6}\left(\frac{r_p}{R}+\frac{\Delta r_p}{R}\sin\phi\right)^3\right\}d\phi. \quad (12)$$

Then the average velocity U_{p2} of the right side of the channel Q_{right} will have the form

$$U_{p2}(r)=\frac{1}{\mu_p}\left[\frac{r^2}{2}\frac{\tau_{\delta w}}{R}-\tau_y r-\frac{r_p^2}{2}\frac{\tau_{\delta w}}{R}+\tau_y r_p\right], \quad (13)$$

Where μ_p is the plastic viscosity of the concrete mixture.

CONCLUSIONS

From the Theoretical Research and Prospects, Further Development in this Field. The conducted theoretical studies of the channel of the gate valve distribution unit of a piston concrete pump bounded by walls made of different materials: half of the section is steel, and the other half is concrete mixture, are perspective for the study of concrete and mortar mixtures fed with concrete pumps. The conditions for the flow of Bingham fluids in a channel with radius R with different walls are considered, the dependences of the flow rate Q and average flow velocities U are obtained.

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Simulation of the Process of Iron Extraction from Groundwater in Heterogeneous Layers

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Abstract. The complex mathematical model of forecasting of iron removal from ground water in heterogeneous aquifers with heightened content of iron compounds in ones is proposed. Model uses the conception of the intralayer method of ground water treatment directly in the aquifer without using of the traditional water treatment constructions with a help of oxidized water that supplied in aquifers and promotes of the iron compounds sedimentation. Such approach is a new direction in the problems of ground water treatment and in some cases is more effective especially for cleaning of the aquifers with high collector properties. Model consists of the system of differential equations which describe the process of two-phase flow filtering (iron and oxygen) and takes into account the hydrodynamic and physical-chemical processes of mass transfer and kinetic exchange, accumulation and transformation the different iron and oxygen forms in porous solution and on the particles of the water saturated thickness too. The numerical method of solution is developed and the results of modeling of the methodic problem with using of the typical values of aquifer parameters for schemes of homogeneous and heterogeneous beds are presented.

INTRODUCTION

It is known that the problem of providing the population of Ukraine with quality drinking water today is one of the most important in our country. Ukraine belongs to the group of countries in Europe with the least water resources. Thus about 95% of surface waters do not meet the requirements for their quality. Therefore, the expansion of water supply to the population through groundwater which is more protected from pollution is a priority in most regions of Ukraine. However, in some cases aquifers which are mainly groundwater abstraction to provide the population with drinking water have a high iron content which significantly exceeds the existing regulatory requirements. Therefore, the development of methods and technologies for the extraction of iron from groundwater remains an actual problem today against the background of the existing shortage of fresh drinking water.

MATERIALS AND METHODS

In modern conditions the most common method of removing iron compounds from water is filtrating through granular loading from natural or artificial granular materials in special installations the main technological element of which is a filter. In recent years the use of the method of intralayer groundwater treatment has become widespread [1, 7, 8]. The technology of such treatment is that the sedimentation of iron hydroxide compounds occurs directly in the aquifer with high reservoir properties when pumping oxygenated water into injection wells and the treated water enters on the earth surface through withdrawal wells. We have analyzed the existing experience of practical application of systems of intralayer groundwater treatment from iron compounds in various natural conditions for different technological scheme and also performed a theoretical substantiation of geochemical modeling of mass transfer

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processes in groundwater and geological formations of different types. As the analysis showed there is an urgent need for further development of methods for mathematical modeling of hydrodynamic and physicochemical processes in the extraction of iron compounds from groundwater in the complex conditions of heterogeneous aquifers.

As a rule, in groundwater in the absence of dissolved oxygen and other oxidants there is mainly a form of dissolved iron in the form of ions Fe^{2+} or its unstable oxidative forms of various salts. Upon interaction with dissolved oxygen supplied to the purified water bivalent iron is oxidized to trivalent and then hydrolyzed to colloidal or suspended iron hydroxide $Fe(OH)_3$ in the form of mule flakes according to the written formulas of chemical reactions and phase transformations:

$$4Fe^{2+} + O_2 + 8OH + 2H_2O \rightarrow 4Fe(OH)_3$$

$$4Fe^{2+} + O_2 + 10H_2O \rightarrow 4Fe(OH)_3 \downarrow + 8H$$

At this the processes occurring in the aquifer can be described as follows: Fe^{2+} is adsorbed on the surface of the aquifer particles forming a monolayer of Fe^{2+} (catalytic film). In this case the oxidation Fe^{2+} occurs both on the surface of the particles of the porous layer by adsorbed oxygen O_2 forming a film of molecules $Fe(OH)_3$ and on the precipitated sediment $Fe(OH)_3$ and in the free interporous space. Over time there is dehydration of the sludge and its compaction (aging) which will influence on the hydrodynamic characteristics of the filtration flow.

The efficiency of iron extraction Fe^{2+} depends on the presence of dissolved oxygen in the liquid which to a large extent determines the nature of the reaction process (oxidation kinetics). In existing studies which were mainly conducted in the conditions of groundwater treatment from iron at concentrations not exceeding 10 mg / l it was believed that the supply of oxygen in sufficient quantities (more than 3-5 mg / l) can be provided by simplified aeration technology. In this case without proper scientific justification it was considered that the oxidation kinetics is sufficiently supplied with oxygen and in scientific researches (models and calculations) the presence of oxygen can be ignored. Therefore an important question in solving this problem is to assess the impact of oxygen consumption in the deironing of water in a wide range of concentrations $Fe^{2+}$and justification of its provision in sufficient quantities at the stage of operation of the intralayer groundwater treatment system.

To solve this problem in conditions of extraction of iron from groundwater in aquifers we used a new more complete mathematical model of filtration of two-phase flow (iron and oxygen) which was further developed in many other works. This model which takes into account the hydrodynamic and physicochemical processes of mass transfer and exchange kinetics reflects the accumulation and transformation of various forms of iron and oxygen in the pore solution and on the particles of the watersaturated formation.

The basis of the mathematical model are the fundamental equations of water filtration, convective-diffusion mass transfer of dissolved chemical compounds, taking into account various physicochemical and biochemical phase transformations [1, 2, 4, 7]. Particular attention is paid to the substantiation of the closing relations which reflect the dependence of the filtration coefficient and porosity on the concentration of stationary sediment in different types of sediment formation (surface, volume and combined) [3, 7].

Taking into account these features of the simulated processes the following system of differential equations may be used: the equation of non-stationary filtration of groundwater taking into account the weak compressibility of rocks, weak curvature of the roof and bottom of the formation as well as the dependence of the filtration coefficient on the concentration of iron hydroxide sludge:

$$\mu \frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\left(k(m_2 - m_1)\frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y}\left(k(m_2 - m_1)\frac{\partial h}{\partial y} \right), \quad 0 < x < L_x,\ 0 < y < L_y$$

$$V_x = -k\frac{\partial h}{\partial x}, \quad V_y = -k\frac{\partial h}{\partial y} \tag{1}$$

the equation of convective-diffusion transfer of iron Fe^{2+} taking into account its consumptions in the formation of iron hydroxide;

$$n_e \frac{\partial C_1}{\partial t} = \frac{\partial}{\partial x}\left(D_x \frac{\partial C_1}{\partial x} \right) + \frac{\partial}{\partial y}\left(D_{xy} \frac{\partial C_1}{\partial y} \right) - V_x \frac{\partial C_1}{\partial x} - V_y \frac{\partial C_1}{\partial y},$$

$$-K_1 C_1 - K^* C_1 C_2 \tag{2}$$

the equation of convective-diffusion oxygen transfer O_2 into account its consumptions for the formation of iron hydroxide:

$$n_e \frac{\partial C_2}{\partial t} = \frac{\partial}{\partial x}\left(D_x \frac{\partial C_2}{\partial x} \right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial C_2}{\partial y} \right) - V_x \frac{\partial C_2}{\partial x} - V_y \frac{\partial C_2}{\partial y} \qquad (3)$$

the equation of convective-diffusion transfer in the pore solution of sludge-like particles of iron hydroxide, taking into account the immobilization of part of the flakes in the formation of a stationary sediment:

$$n_e \frac{\partial C_3}{\partial t} = \frac{\partial}{\partial x}\left(D_x \frac{\partial C_3}{\partial x} \right) + \frac{\partial}{\partial y}\left(D_y \frac{\partial C_3}{\partial y} \right) - V_x \frac{\partial C_3}{\partial x} - V_y \frac{\partial C_3}{\partial y}$$
$$- \gamma(\sigma_{\max} - \sigma_0) C_3 + K^* C_1 C_2, \qquad (4)$$

the equation of kinetics of iron hydroxide formation on soil particles:

$$\frac{\partial \sigma_1}{\partial t} = K_1 C_1 - K^{**} \sigma_1 \sigma_2, \qquad (5)$$

the equation of the kinetics of the transition of dissolved oxygen to the composition of iron hydroxide due to the process of complexation;

$$\frac{\partial \sigma_2}{\partial t} = -\alpha_0 (C_2 - C_{2p}) - \beta'' K^{**} \sigma_1 \sigma_2, \qquad (6)$$

the equation of hydroxide deposition kinetics in the pore space:

$$\frac{\partial \sigma_3}{\partial t} = \gamma(\sigma_{\max} - \sigma_3) C_3 + K^{**} \sigma_1 \sigma_2, \qquad (7)$$

where x, y - spatial coordinates; t - time; h - hydrodynamic pressure in the formation; μ- storage; k- filtration coefficient; V_x,V_y– respectively velocity of flow in direction x,y; m_2,m_1 – level of the roof and buttom of the aquifer relative given plane; C_1 ,C_2 ,C_3 respectively mass concentrations Fe^{2+},O_2 and $Fe(OH)_3$ in the liquid phase (solution); C_{2p}- equally weighty concentration O_2 in water; σ_1,σ_2,σ_3 - respectively the mass concentrations in the solid, sludge (colloidal) and solid phases; σ_o,σ_{max}– respectively initial and limited concentration of sediment in water; n_e- effective porosity; K_1,K_0- respectively the rate constant of adsorption Fe^{2+} and Fe(OH)3 on the soil particles; K^*,K^{**}- oxidation reaction constants in solution and on the solid (stationary) phase; α_o- exchange rate constants; α- constant of possible separation of muleplasts from the surface of soil particles; γ- rate constant of adhesion (sedimentation) of particles on the surface of the medium; β''- kinetic coefficient which provides the stoichiometry of the oxygen oxidation reaction [1,5,6,7,9].

The initial and boundary conditions are given to obtain an unambiguous solution of the above equations system.

The initial conditions give the value of unknown functions in the region before the start of modeling the process of intralayer deironing:

$$t = 0, \quad 0 < x < L_x, \quad 0 < y < L_y,$$
$$h(x,y,0) = h^0,\ C_1(x,y,0) = C_1^0,\ C_2(x,y,0) = C_2^0,\ C_3(x,y,0) = C_3^0.$$
$$\sigma_1(x,y,0) = \sigma_1^0, \quad \sigma_2(x,y,0) = \sigma_2^0, \quad \sigma_3(x,y,0) = \sigma_3^0 \qquad (8)$$

where $h^0, C_1^0, C_2^0, C_3^0, \sigma_1^0, \sigma_2^0, \sigma_3^0$ - set values of the corresponding functions at the initial time.

Boundary conditions reflect the influence of natural and man-made factors on unknown functions at the boundaries of the modeling area.For the problem of extraction of iron in formation conditions the next boundary conditions of the 1st kind were adopted:

$$r = r_c, \quad r = R, \quad 0 < t < T$$

at

$$p(r_w,t) = p_w(t), \quad p(R,t) = p_R(t), \quad C_1(r_w,t) = C_{1w}(t), \quad C_1(R,t) = C_{1R}(t)$$
$$C_2(r_w,t) = C_{2w}(t), \quad C_2(R,t) = C_{2R}(t), \quad C_3(r_w,t) = C_{3w}(t), \quad C_3(R,t) = C_{3R}(t) \qquad (9)$$

Where $p_w(t), p_R(t), C_{1w}(t), C_{1R}(t), C_{2w}(t), C_{2R}(t), C_{3w}(t), C_{3R}(t)$ - set values of unknown functions on the well (bottom index - w) and on the circuit where the injection wells are located (bottom index - R).

To close the system of nonlinear equations (1) - (7) it is necessary to set the dependence of the filtration coefficient and porosity of the soil on the concentration of iron hydroxide sediment. Under natural conditions in soils of different mineral composition the sediment of salts of different chemical elements in the solid phase can be in various forms: surface (film), volumetrical (dispersed) and combined. In theoretical studies of the fundamental laws discussed above as well as in solving various practical problems both theoretical and experimental dependences of the soil filtration coefficient on the sediment concentration can be used [7].

In the case of surface (film) salinization of soil particles the next theoretical dependence may be used [3,7]:

$$k(\sigma^*) = k_0(1-\sigma^*), \qquad \sigma^* = \frac{\sigma}{\sigma_{\max}}. \tag{10}$$

In the case of volumetrical (dispersed) salinization of the pore space of the soil in the same works the following dependence is propozed:

$$k(\sigma^*) = k_0\left(1+\sigma^* + \frac{1-\sigma^*}{\ln\left(\sqrt{\sigma^*}\right)}\right). \tag{11}$$

Based on the processing of the results of experimental studies in the purification of polluted water from suspended contaminants for the filtration coefficient many authors obtained various approximation relations which can be written in the form of the following generalized two-parameter formula [7]:

$$k(\sigma^*) = k_0\left(1-\left(\sigma^*\right)^{n_1}\right)^{n_2}. \tag{12}$$

According to the results of experimental studies the values of parameters n_1 and n_2 are changed in intervals 0.5-1.0 and 1-2 respectively.

In addition to the two-parameter power dependence (12) the exponential formula has been widely used in the selection of approximating dependences [7]:

$$k(\sigma^*) = k_0 \exp(-\alpha\sigma^*), \tag{13}$$

where the parameter α is determined on the basis of processing the results of experimental data for the range of sludge concentration in which the experimental studies were performed.

In above work the next form of exponential dependence of the filtration coefficient of the porous medium on the concentration of sediment is proposed too [7]:

$$k(\sigma^*) = k_0 \exp\left(-\frac{\sigma^*}{A-\sigma^*}\right). \tag{14}$$

In (14) the value parameter A is equal to one at a purely theoretical consideration of the process of sediment accumulation (A = 1) but in real conditions the sedimentation process slows down significantly when approaching to the full saturation of the pore space with sediment. So it is recommended to take the value of parameter A within 0.7-0.8 [7].

And at last the dependence of the effective porosity on the stationary precipitate of iron hydroxide may be accepted as linear:

$$n(\sigma^*) = n_0(1-\sigma^*). \tag{15}$$

Thus the above equations (1) - (7) with boundary conditions (8) - (9) and closing relations (10) - (15) give the possibilities to provide mathematical modeling of the process of groundwater deironing in aqifer conditions using the conception of intralayer ground water treatment [1,8].

The solution of equations (1) - (7) with boundary conditions (8) - (9) and closing relations (10) - (15) is obtained by the widespread and well-studied numerical method of finite differences (MFD) which has proved itself well in solving different application problems [5,6,7]. An implicit difference scheme was used with a constant step in time and variable in space which allows for detailed consideration of different zones of soil heterogeneity. When approximating the convective component in the mass transfer equation (2) the so-called “against flow” difference was used [7]. The solution of systems of nonlinear difference equations is obtained by the well-known run method the features of which are described in detail for similar problems in the monographies [5,7]. To implement the computational algorithm a program has been developed to solve the equations of the general mathematical model with the appropriate initial and boundary conditions.

To approximate the original two-dimensional differential equation (1) a completely stable implicit conservative difference scheme is used and to solve systems of algebraic equations an iterative procedure with an intermediate computational layer is proposed which provides high convergence and required accuracy of the computational process for PC. Thus the system of difference equations approximating equation (1) can be written as:

$$G_{i,j}\left(h_{i,j}-h_{i,j}^{r}\right)=A_{i+1,j}\left(h_{i+1,j}^{s}-\frac{h_{i,j}+h_{i,j}^{s}}{2}\right)-A_{i-1,j}\left(\frac{h_{i,j}+h_{i,j}^{s}}{2}-h_{i-1,j}^{s}\right)+$$

$$+B_{i,j+1}\left(h_{i,j+1}^{s}-\frac{h_{i,j}+h_{i,j}^{s}}{2}\right)-B_{i,j-1}\left(\frac{h_{i,j}+h_{i,j}^{s}}{2}-h_{i,j-1}^{s}\right),$$

$$A_{i+1,j}=\frac{\Delta t}{2\Delta x_c \Delta x_i}\left(k_{i+1,j}h_{i+1,j}^{s}+k_{i,j}h_{i,j}^{s}\right),\quad A_{i-1,j}=\frac{\Delta t}{2\Delta x_c \Delta x_{i-1}}\left(k_{i-1,j}h_{i-1,j}^{s}+k_{i,j}h_{i,j}^{s}\right),$$

$$B_{i,j+1}=\frac{\Delta t}{2\Delta y_c \Delta y_j}\left(k_{i,j+1}h_{i,j+1}^{s}+k_{i,j}h_{i,j}^{s}\right),\quad B_{i,j-1}=\frac{\Delta t}{2\Delta y_c \Delta y_{j-1}}\left(k_{i,j-1}h_{i,j-1}^{s}+k_{i,j}h_{i,j}^{s}\right),\qquad (16)$$

$$A_{i+1,j}=\frac{\Delta t}{2\Delta x_c \Delta x_i}\left(k_{i+1,j}h_{i+1,j}^{s}+k_{i,j}h_{i,j}^{s}\right),\quad A_{i-1,j}=\frac{\Delta t}{2\Delta x_c \Delta x_{i-1}}\left(k_{i-1,j}h_{i-1,j}^{s}+k_{i,j}h_{i,j}^{s}\right),$$

$$\Delta x_c=0{,}5\left(\Delta x_{i-1}+\Delta x_i\right),\quad \Delta y_c=0{,}5\left(\Delta y_{j-1}+\Delta y_j\right),$$

$$G_{i,j}=\mu\left(1+\frac{h_{i,j}^{s}}{\Delta x_c}\left(\frac{h_{i+1,j}^{s}-h_{i,j}^{s}}{\Delta x_i}-\frac{h_{i,j}^{s}-h_{i-1,j}^{s}}{\Delta x_{i-1}}\right)+\frac{h_{i,j}^{s}}{\Delta y_c}\left(\frac{h_{i,j+1}^{s}-h_{i,j}^{s}}{\Delta y_j}-\frac{h_{i,j}^{s}-h_{i,j-1}^{s}}{\Delta y_{j-1}}\right)\right),$$

where: i, j - numbers of spatial nodes on the axes 0x and 0y;r - time step number;s - iteration number (superscripts s + 0.5, r + 1) in unknown functions $h_{I,J}=h_{I,J}^{s+0.5,r+1}$, $h_{i,j}^{s}=h_{i,j}^{s,r+1}$ for brevity are not written.

From equation (16) we can find the values of the unknown heads function on the intermediate iterative layer with index s+0,5

$$h_{i,j}^{s+0,5,r+1}=E_{i,j}/\left(F_{i,j}+G_{i,j}\right),$$

$$E_{i,j}=A_{i+1,j}h_{i+1,j}^{s}+A_{i-1,j}h_{i-1,j}^{s}+B_{i,j+1}h_{i,j+1}^{s}+B_{i,j-1}h_{i,j-1}^{s}-Fh_{i,j}^{s}+G_{i,j}h_{i,j}^{r},\qquad (17)$$

$$F_{i,j}=0{,}5\cdot\left(A_{i+1,j}+A_{i-1,j}+B_{i,j+1}+B_{i,j-1}\right).$$

The final values of the unknown functions at the time with the index r + 1 are obtained on the next formula:

$$h_{i,j}^{s+1,r+1}=h_{i,j}^{s,r+1}+\beta\left(h_{i,j}^{s+0,5,r+1}-h_{i,j}^{s,r+1}\right),\qquad (18)$$

where the optimal values of the relaxation parameter β according to computational studies are in the range 0.25-0.48.

At each time step the iteration process using formulas (16), (17) is extended for all internal nodes of the difference grid to achieve the required calculation accuracy.

To discretize the convective diffusion equation (2) an implicit balance finite-difference scheme with “upstream” differences was used. Taking into account the above remarks the finite-difference approximation of equation (2) can be written as follows:

$$n\frac{C_{i,j}^{s+0,5}-C_{i,j}^{r}}{\Delta t_{r+1}}=\frac{1}{\Delta x_c}\left(\frac{D_{i+1,j}+D_{i,j}}{2}\frac{C_{i+1,j}^{s}-0{,}5\left(C_{i,j}^{s+0,5}+C_{i,j}^{s}\right)}{\Delta x_i}-\frac{D_{i-1,j}+D_{i,j}}{2}\frac{0{,}5\left(C_{i,j}^{s+0,5}+C_{i,j}^{s}\right)-C_{i-1,j}^{s}}{\Delta x_{i-1}}\right)+$$

$$+\frac{1}{\Delta y_c}\left(\frac{D_{i,j+1}+D_{i,j}}{2}\frac{C_{i,j+1}^{s}-0{,}5\left(C_{i,j}^{s+0,5}+C_{i,j}^{s}\right)}{\Delta y_i}-\frac{D_{i-1,j}+D_{i,j}}{2}\frac{0{,}5\left(C_{i,j}^{s+0,5}+C_{i,j}^{s}\right)-C_{i,j-1}^{s}}{\Delta y_{i-1}}\right)-$$

$$-V_{x,i,j}\begin{cases}\dfrac{1}{\Delta x_{i-1}}\left(\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}-C_{i-1,j}^{s}\right), & V_{x,i,j}\geq 0\\ \dfrac{1}{\Delta x_{i}}\left(C_{i+1,j}^{s}-\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}\right), & V_{x,i,j}<0\end{cases} -V_{x,i,j}\begin{cases}\dfrac{1}{\Delta y_{j-1}}\left(\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}-C_{i,j-1}^{s}\right), & V_{y,i,j}\geq 0\\ \dfrac{1}{\Delta y_{j}}\left(C_{i,j+1}^{s}-\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}\right), & V_{y,i,j}<0\end{cases} \tag{19}$$

Equation (19) can be rewritten as:

$$\begin{aligned}\left(C_{i,j}^{s+0,5}-C_{i,j}^{r}\right) &= A_3\left(C_{i+1,j}^{s}-\frac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}\right)-A_1\left(\frac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}-C_{i-1,j}^{s}\right)+\\ &+B_3\left(C_{i,j+1}^{s}-\frac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}\right)-B_1\left(\frac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}-C_{i,j-1}^{s}\right)-\\ &-\begin{cases}\dfrac{V_{x,i,j}\Delta t_{r+1}}{n\Delta x_{i-1}}\left(\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}-C_{i-1,j}^{s}\right), & V_{x,i,j}\geq 0\\ \dfrac{V_{x,i,j}\Delta t_{r+1}}{n\Delta x_{i}}\left(C_{i+1,j}^{s}-\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}\right), & V_{x,i,j}<0\end{cases} -\begin{cases}\dfrac{V_{y,i,j}\Delta t_{r+1}}{n\Delta y_{j-1}}\left(\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}-C_{i,j-1}^{s}\right), & V_{y,i,j}\geq 0\\ \dfrac{V_{y,i,j}\Delta t_{r+1}}{n\Delta y_{j}}\left(C_{i,j+1}^{s}-\dfrac{C_{i,j}^{s+0,5}+C_{i,j}^{s}}{2}\right), & V_{y,i,j}<0\end{cases}\end{aligned} \tag{20}$$

In this case the coefficients of the difference equation (20) have the form:

$$\begin{aligned} A_3 &= \frac{\Delta t_{r+1}}{2n\Delta x_c \Delta x_i}\left(D_{i+1,j}^{s}+D_{i,j}^{s}\right), \quad A_1=\frac{\Delta t_{r+1}}{2n\Delta x_c \Delta x_{i-1}}\left(D_{i,j}^{s}+D_{i-1,j}^{s}\right),\\ B_3 &= \frac{\Delta t}{2\Delta y_c \Delta y_j}\left(D_{i,j+1}^{s}+D_{i,j}^{s}\right), \quad B_1=\frac{\Delta t}{2\Delta x_c \Delta x_{i-1}}\left(D_{i,j}^{s}+D_{i,j-1}^{s}\right).\end{aligned} \tag{21}$$

Rewrite the difference equations (20) in the form

$$\begin{aligned} C_{i,j}^{s+0,5} &= -FC_{i,j}^{s+0,5}+U_1C_{i,j}^{s+0,5}+W_1C_{i,j}^{s+0,5}+A_3C_{i+1,j}^{s}+A_1C_{i-1,j}^{s}+B_3C_{i,j+1}^{s}+B_1C_{i,j-1}^{s}-\\ &-FC_{i,j}^{s}+C_{i,j}^{r}+U_2+W_2.\end{aligned} \tag{22}$$

From equation (22) you can find the values of unknown functions $C_{i,j}^{s+0,5}=C_{i,j}^{r+1,s+0,5}$

$$C_{i,j}^{r+1,s+0,5}=\frac{E}{1+F-U_1-W_1}. \tag{23}$$

In equations (22) - (23) the coefficients have the following values:

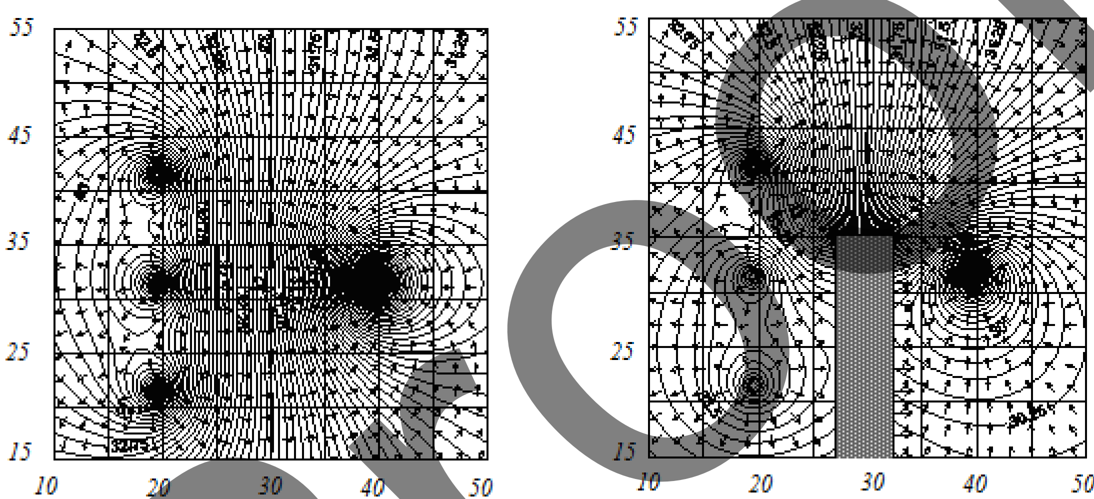
$$U_2=\begin{cases}-\dfrac{V_{x,i,j}^{r}\Delta t}{\Delta x_{i-1}}\left(\dfrac{C_{i,j}^{s}}{2}-C_{i-1,j}^{s}\right)\\ \dfrac{V_{x,i,j}^{r}\Delta t}{\Delta x_{i}}\left(\dfrac{C_{i+1,j}^{s}}{2}-C_{i,j}^{s}\right)\end{cases}, \quad U_1=\begin{cases}-\dfrac{V_{x,i,j}^{r}\Delta t}{2\Delta x_{i-1}}, & V_{x,i,j}^{r}\geq 0\\ \dfrac{V_{x,i,j}^{r}\Delta t}{2\Delta x_{i}}, & V_{x,i,j}^{r}<0\end{cases}, \tag{24}$$

$$W_s=\begin{cases}-\dfrac{V_{y,i,j}^{r}\Delta t}{\Delta y_{j-1}}\left(\dfrac{C_{i,j}^{s}}{2}-C_{i,j-1}^{s}\right)\\ \dfrac{V_{y,i,j}^{r}\Delta t}{\Delta y_{j}}\left(\dfrac{C_{i,j+1}^{s}}{2}-C_{i,j}^{s}\right)\end{cases}, \quad W_1=\begin{cases}-\dfrac{V_{y,i,j}^{r}\Delta t}{2\Delta y_{j-1}}, & V_{y,i,j}^{r}\geq 0\\ \dfrac{V_{y,i,j}^{r}\Delta t}{2\Delta y_{j}}, & V_{y,i,j}^{r}<0\end{cases} \tag{25}$$

The transition from the values of the unknown function in s iteration to the corresponding values in $s+1$ iteration is performed by a formula similar to (18) for the same values of the relaxation parameter β.

$$C_{i,j}^{s+1} = C_{i,j}^{s} - \beta\left(C_{i,j}^{s} - C_{i,j}^{s+0,5}\right). \qquad (26)$$

Based on developed above calculation scheme was considered the following methodical problem. The system of extraction of iron compounds from groundwater in aquifer conditions is modeled and it consists of the three injection wells the distance between which is 10 m with a diameter of 0.1 m through which oxygenated water with oxygen concentration of 11 mg / l is injected into aquifer. The filtration domain has a square shape(60x60m) and is isolated from other zones of the aquifer and its boundaries have non-flow conditions (boundary conditions of the second kind). The filtration parameters of the formation have the following values: k=7m/day,μ=0.01,n_e.=0.35. The iron content in groundwater is 37 mg / l and the oxygen content is 0.63 mg /l, K*=0.17, K**=0.042. Other parameters that characterize the processes of mass transfer in the aquifer have typical values and are used from monography [7]. The period of time for which the simulation was performed from the beginning of the ingress of oxygenated water into the wells was 14 days. The simulation was performed for the variant of a homogeneous formation (Fig. 1.a) as well as in the presence of a low permeability interlayer with a filtration coefficient of 0.1 m / day, the position of which is shown in Fig. 1.b.



(a) (b)

FIGURE 1. Isolines of hydrodynamic pressure,concentrations and kinematic structure of filtration flow in the case of: (a) homogeneous formation; (b) in presence of a low permeability interlayer with a filtration coefficient of 0.1 m / day.

Isolines concentrations and kinematic structure of the filtration flow when injecting oxygenated water for one of the calculation variant are shown in Fig. 1, (b).

Analysis of the results of the calculations shows that there is a significant impact of low permeability interlayer on the reduction of the withdrawal from the production well and deterioration of water quality (increasing of the concentration of iron in the production well) which requires a correction of the location of the injection wells project.

CONCLUSIONS

The mathematical model of forecasting of the removal iron compounds from ground water with a help of oxidation of injected water in aquifers has been proposed.Model consists of the system of differential equations which describe the complex process of transformation of the iron compounds in the sediment under influence of the dissolved in water oxygen.The results of numerical solution of the methodic problem with using of the typical values of the filtration and geochemical parameters are presented. The proposed methodic is a new approach in the problems of improving of the ground water quality without using of the traditional water treatment constructions that allows to decrease in some cases the material resources at realization the different projects of ground water cleaning from the iron compounds. In future the researches should be directed on the simplification of the developed methodic for using it in projects of forecasting of the processes of iron removal in regions where the main watersupply aquifers are polluted by the iron compounds.

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Architectonics Problems of Modern City in the Context of the Biosphere-Compatible Construction

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Abstract. In the context of considering the national construction industry, the factors influencing the formation of the concept of urban environment design, resource use policy, energy efficiency of production and operation of final construction products during the life cycle, etc., are considered as the main factors influencing the formation of ecological and economic development mechanism. It is especially important to form the concept and development strategy of the construction industry, which takes into account global, national, regional conditions and restraining (limiting) regressive effects in current circumstances of contradicting the principles of sustainable development by the industry. The analysis is provided for necessity of construction transition to functioning according to the principles of biosphere compatibility, based on generally accepted concepts of conscious consumption of resources and modified models of economy of urban society, which takes into account the social component. A comprehensive assessment of design solutions for biosphere-compatible construction is proposed, which is based on a system of not only economic factors, but also environmental and social, which meets the principles of sustainable development.

INTRODUCTION

The priority development of Ukrainian cities, their dominance in the social and household infrastructure of the population, is the reason for the deformation of the moral and ethical components of human consciousness as an element of the biosphere that is a unique self-regulatory system. Deterioration of urban ecology, population density and, consequently, lower requirements for the living conditions of urban society cause a number of problems, which result in a demographic crisis, extinction and biological and genetic degradation of the people. According to Stephen R. Mann's theory of chaos, small actions will be enough for the extinction of humanity as the "butterfly effect" leads to losing balance on the scale of global processes [1]. Usually, these processes of imbalance will return to equilibrium, because the stabilizing forces of nature are great, but it is unknown whether a human will exist at the time of stabilization. After all, the range of human existence is very narrow [2]. The balance between the spheres of the human and the natural must be preserved not so much from the position of the impossibility of existence from each other - human egocentric thinking, but from the position of the noosphere reality of V. Vernadsky - the possibility of existence and development of nature without humanity. Therefore, the dominance of anthropogenic factors in any area of human activity can no longer be considered an absolute axiom.

Given the environmental and biological threats of the modern world, the future of man depends on mandatory collective responsibility for the actions and consequences of technical civilization, affecting nature as a sine qua non, in terms of changing or significantly transforming development goals from economic to socio-environmental [3]. In this context, one of the possibilities of synergy of socio-ecological factors of human activity in the direction of greening the economy through the construction industry is relevant [4].

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TRANSITION TO BIOSPHERE-COMPATIBLE DESIGN SOLUTIONS

Any modern large city is a system of complex, inextricably linked natural and anthropogenic components, where the advantages of one lead to the dominate environmental impacts on city architecture. [2]. The anthropogenic component has the most irreversible consequences. But even in this case there is always a reverse effect of natural components. For example, air pollution of large cities in turn negatively affects the condition of materials of enclosing structures of buildings, and the construction of multi-storey buildings with a small building area affect the natural level and direction of groundwater, which leads to wetting of foundations, corrosion of structures, subsidence or removal of buildings and loss of bearing capacity of individual structures and buildings as a whole [3]. Therefore, the introduction of biosphere-compatible construction as a modern concept of urban development that meets the goals of sustainable development, aimed at meeting the complex of socio-ecological, economic and economic requirements of the population, is rather actual. What is biosphere-compatible construction? In the author's interpretation, it is a special type of complex socio-ecological-economic (complex and open) system, which is centrally subordinated to the normative-permitting base of acts in design, construction and operation, has a clearly defined regional aspect, socio-economic anomalies and depends on natural resources [5]. Modern design and construction of any local facilities or large urban complexes, as well as reconstruction of buildings and areas, can no longer be carried out without taking into account environmental standards.

Research by many international environmental organizations have shown that the search for efficiency of the environment can lead to negative consequences in the social and/or economic sphere. Therefore, it is almost never possible to make progress in three dimensions under the same period of time. Here is the conclusion that not every new production technology, which is profitable in terms of productivity and capital, is appropriate for the environment. The key to resolving a certain contradiction between economic growth and the environment, as foreign experience shows, is mutual understanding and coordination between the state and business.

In this context, the ecological and economic assessment of production should be based simultaneously on the principles of sustainable development, i.e. structurally and criteria-based indicators. Based on the research of E. Warhurst for Warwick business school [6] indicators of sustainable development can be represented as conditionally divided between environmental, social and economic components, which are also limiting parameters of the system "ecology" - "economy" - "society". This ranking of parameters is justified in terms of universalization of the assessment of biosphere compatibility of production through the use of data from the statistical and accounting database of information generated at enterprises in accordance with the requirements of doing business.

The grouping of sustainable development indicators by types is presented in Table 1.

The principles of biosphere-compatible construction, which are based on the principles of sustainable development, have a polymorphic affiliation to the group, provoked by the intersecting areas of the system "ecology" - "economy" - "society" (Fig. 1). The "aggregation" of indicators of the three components in the dimension of sustainable development may require analysis in order to determine the importance (significance) in the hierarchy of assessment of biosphere compatibility of construction.

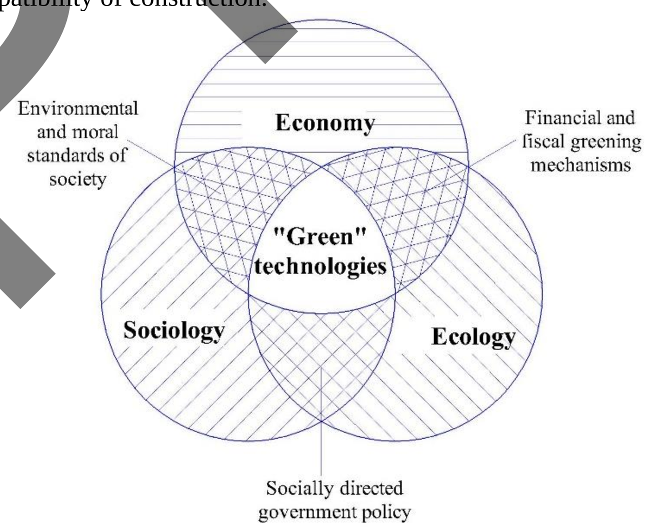


FIGURE 1. Schematic diagram of the polymorphism of the parameters of the system "geology"-"economy"-"society".

TABLE 1. Description of typical indicators of sustainable development (based on [6])

Types of indicators	Characteristics of the indicator	Use in terms of components of sustainable development		
		Ecological	**Social**	**Economic**
Descriptive	Descriptive indicators establish the presence of an influencing factor without assessing the positivity or negativity of the effect	+	+	+
Productive	Performance indicators are comparative, which assess the actual value of indicators with the desired	+	+	+
Effective	Performance indicators are relative, which measure the degree of compliance of the obtained results with the set resources	+		
Normative	Normative indicators meet the generally accepted meaning in different sectors	+		
Production	Production indicators meet the standards of management and production management	+		+
Regulatory	Regulatory indicators correspond to the normative values adopted in normative legal acts	+		
Accounting (reporting)	Accounting indicators are indicators of accounting and at the same time the source data for tracking the cost of greening production	+		+
Economic	Economic indicators are quantitative data for integrated assessment of environmental, social and economic components of production	+	+	+
Qualitative	Qualitative indicators that are related to the environmental friendliness of production (harmfulness of the production process and minimization of waste	+		+
Ecological	Environmental indicators reflect the impact of production on the ecosystem within the local, regional, national and global scales	+		

It is necessary to normalize the data, focused on the principles of biosphere compatibility of any production. Therefore, it is advisable to compare the components of sustainable development by type and components of biosphere compatibility.

The principles of biosphere compatibility of production, implemented on the basis of the concept of sustainable development are complex. Their analysis and evaluation should be based on a system-integrated approach, ie the identification of multifactor indicators (indicators) that reflect the relationship between economic, social and environmental components in terms of the usefulness of biosphere-compatible construction technologies at the state level. To this end, regrouping and specification of indicators of sustainable development in accordance with the principles of biosphere compatibility.

The main difficulty at the microeconomic level, where environmental and economic problems are localized and spatially determined, is the need to make a difficult choice between "economically exalted" and biosphere-compatible technical progress. This means the need to assess production according to the environmental standard in terms of emissions and/or the use of primary natural resources. Thus, the choice made by enterprises in connection with the greening of production and products will depend not only on a number of purely economic factors (economic calculation) but also on mandatory legal regulation and environmental expertise and - especially in the case of productive innovations - from the knowledge and environmental awareness of consumers and the economic benefits they produce, also taken into account in the form of a significant number of coefficients, indicators, etc. It should also be in mind that it is impossible to take into account the consequences of all factors, as this can lead to loss of control of the system. Therefore, an important task is to determine a limited set of basic factors that allows for targeted assessment of the studied in this case criterion of "biosphere compatibility" of production.

The results of the classification division of indicators for assessing the biosphere compatibility of production by areas are shown in Table 2.

TABLE 2. The system of subtracting indicators for assessing the biosphere compatibility of production

№	Indicator	Definition
		1. Socio-ecological direction
1.1	Index of compliance with the current conditions (norms) of work safety at the enterprise	Defines matching conditions for workers by selected technology requirements of the Labor Code requirements with technological scheme and the rules of the company
1.2	Emission factor of pollutants (greenhouse gases, wastewater, solid toxic waste, etc.) according to the results of environmental expertise	Detects changes in greenhouse gas emissions and other pollutants in the current year compared to the previous period. Is an integral indicator
1.3	Coefficient of occupational diseases	It states the number of occupational diseases during the reporting period among the total number of employees
		2. Ecological and economic direction
2.1	Growth rate of production costs	Characterizes the level of growth of costs associated with production
2.2	Close cycle resource ratio or recycling ratio	Characterizes the level of secondary resources use in the production of new products in accordance with the principles of sustainable development
2.3	Coefficient of energy consumption of products	Characterizes energy costs for the main and auxiliary technological processes of production
2.4	Indicator of specific resource consumption of products	It characterizes the ratio of material costs in cash to the volume of the final product
2.5	Index of compliance with certification requirements	Determines compliance of production conditions, level of quality of final products with the requirements set out in the standards on which the licensed certification on production conditions or quality requirements of final products is based
2.6	Index of compliance with environmental requirements of local, regional, national regulations	Determines compliance with production conditions, requirements set out in regulations of local authorities, regional regulatory authorities and by-laws of the national level on environmental safety and environmental protection
2.7	Fees for use of natural resources	Determines the amount of additional costs to attract natural resources in the production of final products
2.8	Fixed assets renewal ratio	Characterizes the share of new fixed assets put into operation in the reporting period as part of all fixed assets available at the end of the reporting period
2.9	Production growth rate	Characterizes the level of growth of costs associated with production
2.10	Turnover ratio of natural resources	Displays the share of recycled materials in manufactured products
2.11	Utilization rate of primary resources, related resources in production (packaging), defective products	Characterizes the number of primary resources accepted for utilization, associated resources in production (packaging) in order to reduce the level of environmental pollution, as well as defective (surplus) products due to the production and economic activities of the enterprise. Is an integral indicator.
2.12	Expenditure to overcome the consequences of environmental pollution in case of emergency	Characterizes the amount of costs for the elimination of the consequences of environmental disasters caused by production due to emergencies related to accidents at work
		3. Socio-economic direction
3.1	Labor productivity	Production indicator, which indicates the production capacity relative to the time spent
3.2	Labor productivity ratio of workers	Characterizes the degree of change in production when comparing existing (or traditional) production with what is analyzed and evaluated
3.3	Cost of labor resources	Characterizes the amount of labor costs.
3.4	Environmental efficiency ratio	Characterizes the degree of implementation of the principles of biosphere compatibility in the strategy of production development
3.5	Job creation ratio	Characterizes the level of development of the enterprise in the direction of attracting employees focused on the implementation of measures to achieve and maintain the biosphere compatibility of production
3.6	Coefficient of social prestige of production (relative to the subsistence level)	Characterizes the degree of social prestige of production relative to the minimum accepted state living standards
3.7	Coefficient of social prestige of production	Shows the extent of the deviation degree of social prestige production employees relative to the average wage in the country
3.8	The ratio of costs for training and retraining of personnel for the greening of production	Characterizes the share of costs associated with staff training, in terms of total labor costs

Listed in Table 2 indicators are different in their mathematical nature: one part of them are absolute values, and the other - the coefficients, partially integrated, which are the relative characteristics of production. In addition, there are a number of indicators that are in fact safeguards that automatically eliminate the need for further data analysis to determine the biosphere compatibility indicator due to non-compliance with regulations and additional (voluntary) restrictive requirements. It is necessary to take into account these nuances in the mathematical estimating apparatus of a complex indicator.

The effectiveness of design solutions that are accepted depends on the directional focus on one, two or all three areas of biosphere compatibility. Visualization of this model is presented in Fig. 2.

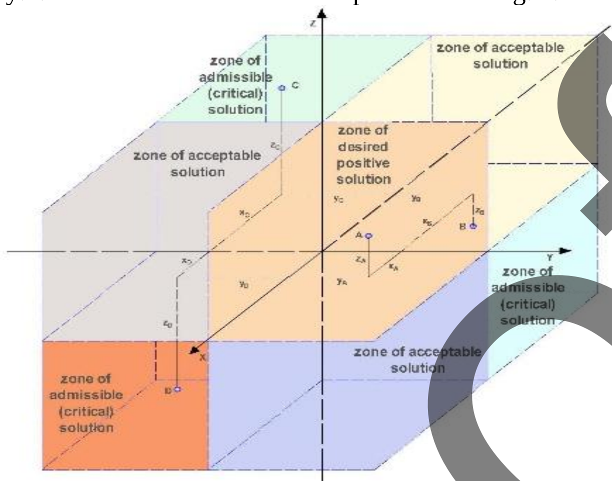
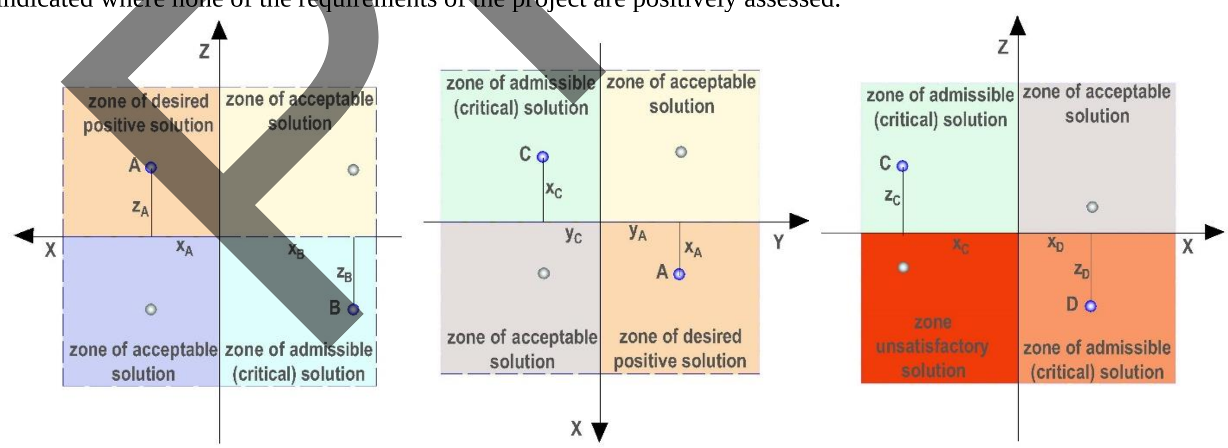


FIGURE 2. The space of project solutions' effectiveness modeling in the socio-ecological-economic system.

Quantitative assessment (positive or negative) of the environmental component of the solution on such a model is put, for example, on the X axis. In turn, the assessment of economic and social components - on the Y and Z axes, respectively.

The elements of effectiveness estimation of project solutions in the socio-ecological-economic system is shown in Fig. 3. From Fig. 3(a) it is seen that point A, i.e. the quantitative assessment of the project solution is in the area of the desired positive solution, which is the most attractive in the design of the project. The corresponding estimates marked with points B, C and D are less acceptable because they have two negative or minimum quantitative estimates from three areas, and are in areas of critical but acceptable solutions. In Fig.3 (c) an area of unsatisfactory solutions is indicated where none of the requirements of the project are positively assessed.



(a) (b) (c)

FIGURE 3. The elements of effectiveness estimation of project solutions in the socio-ecological-economic system: (a) projection on the socio-ecological plane of decision-making with a positive economic assessment; (b) projection on the environmental and economic plane of decision-making with a positive social assessment; (c) projection on the socio-ecological plane of decision-making with a negative economic assessment.

In Ukraine, the main indicator of environmental assessment is environmental expertise, which is performed by state environmental authorities. "Environmental expertise in Ukraine - a type of scientific and practical activities of specially authorized state bodies, environmental expert formations and associations, based on intersectoral environmental research, analysis and evaluation of pre-project, design and other materials or objects, the implementation and operation of which can negatively affect or affect the state of the environment and human health" [7, p. 241]. Modern world standards on the standardization of environmental parameters of the architectural and construction industry relate mainly to the environmental, energy and economic efficiency of the so-called "Green buildings". On their basis, in parallel with the European national norms (Directives) relating to the standardization of environmental quality, corporate and voluntary rating certifications on the environmental friendliness of production have been developed and exist. The most famous of these are the English BREEAM and the American LEED. The mechanisms of these systems are based on monitoring of environmental indicators, namely: monitoring the state of the biosphere, assessment and forecast of its state, identification of factors and sources of influence, determining the degree of anthropogenic impact on the environment.

But the data obtained as a result of observations of the state of the environment should be evaluated at the macro level of sustainable development of urban society as a whole, taking into account the component of greening of the city environment, industrial anthropogenic component. In turn, the assessment of the industrial anthropogenic component should take into account the symbiosis of regulatory design factors, construction conditions and economic reserves of the period of operation of buildings and structures in social responsibility and future commercial potential of the object for customers, developers, owners [7].

Under such conditions, the implementation of the concept of biosphere-compatible construction for an urban society is divided into the following stages.

The first stage is the creation of a targeted strategy for biosphere-compatible construction of a modern city, taking into account the infrastructure and the city-forming factor (industrial, resort, tourist, etc.).

The second stage is the creation of a symbiotic system of mutual development of man and city" sine qua non", which   takes into account the mutual criteria-based influence of natural and anthropogenic components.

The third stage is the creation of a unified system of diagnostics, assessment and monitoring of the system of biosphere-oriented existence, which is aimed at studying anthropogenic criteria (population of the city) and the natural potential of the territories.

The fourth stage is the consolidation of regulatory boundaries for the implementation of biosphere-compatible construction, relating to the requirements for the design, construction, operation, reconstruction and / or disposal of facilities throughout the life cycle, in compliance with national, international environmental standards and socio-humanitarian paradigms.

The fifth stage is the creation of a national system of environmental certification of construction products, aimed at a comprehensive assessment of environmental, social and economic parameters of projects, existing buildings and structures [5].

This formalized approach is aimed at following a clear logic of consistent implementation of biosphere-compatible construction at the request of urban society, creating a clear architectonic of relationships in the system "ecology" - "economy" - "society", and phased implementation of the strategy allows to solve local problems. Those local problems include legislative base at the macro level, taking into account the peculiarities of the construction site in the design at the micro-level with the subsequent unification into a single industry-wide program of state reform. The structural and logical scheme of the strategy does not provide the removal of any of the stages, as this will lead to an imbalance of the system and a waste of time for the development of the industry in terms of sustainable development.

Each of the proposed stages should have its practical results. At the first stage, the orientation of the city within the industrial complex of the state as a budget-forming unit should be clearly formed, which will avoid contradictions between socio-environmental restrictions and regulations for the design of facilities and urban infrastructure, ie the priority of the city will be taken into account. design solutions for construction and modernization of territories, which will correspond to the practical results of the second stage of the strategy. The result of the third stage is the development of a national system for monitoring the biosphere-oriented existence of society, its adaptation to international environmental quality standards and comprehensive use within a single coordinate system to assess the state of the industry in real time. This approach will allow you to quickly respond to changes in the system that lead to progressive or regressive consequences of development. In the fifth stage, based on the monitoring of biosphere compatibility within the construction industry, a rating scale of national producers should be formed, supported by the state apparatus by image and fiscal incentives (national quality certificates, tax benefits and environmental fines, etc.). The basis for the application of state regulatory mechanisms should be the legal framework - the practical result of the fourth stage.

CONCLUSION

In order to determine development priorities, evaluation criteria and recommendations for the implementation of mechanisms for regulating the relationship between man and nature at the macro level, which bear mostly socio-environmental burden, and business and government at the meso- and macro level, where the nature of relations is more clearly traced in the environmental and economic plane, should be determined with the tools used to determine the complex biosphere compatibility index. Based on studies of indicators of sustainable development, statistical data of the construction industry, developments of domestic and world scientists proposed a method of calculating indicators for assessing the biosphere compatibility of production [5], which is based on an analytical set of diffuse indicators that take into account the entropy data of construction companies and assess the development of the system (project) in accordance with the declared regional, national or international environmental standards on the integrated indicator of biosphere compatibility.

The general formula of the indicator of biosphere compatibility of production can be presented in the form:

$$Z_{bs} = \sum_{i=1}^{n} \frac{\{K_{bs}\}}{\{I_{bs}\}} (Z_i \cdot m_i) \tag{1}$$

where Z_i- indicator of biosphere compatibility of the i-th component of the overall assessment; $m_i = \{m(K_i); m(I_i)\}$ - weights of the relevant factors influencing the biosphere compatibility depending on the industry, determined by different methods (method of preferences, method of ranks, method of pairwise comparison, etc.); $\{K_{bs}\}$ - system of coefficients of socio-ecological, ecological-economic and socio-economic components of biosphere compatibility assessment of production; $\{I_{bs}\}$ - system of indicators of socio-ecological and ecological-economic components of biosphere compatibility assessment of production.

It should be noted that the system of indicators defined in the binary system (1 or 0) is a fuse for removing from the calculation of incorrect data or those that do not meet the specified standards.

The global focus on the ecological existence of urban society began only in the twentieth century. It was not until 1993 that the 18th World Congress of Architects (Architecture Crossroads - Designing for a Sustainable Future, Chicago) adopted the Declaration of Relationships for a Sustainable Future, which recognized the main goal of ensuring the sustainability of the environment and taking into account environmental requirements as a priority in design and construction, and in 2002 the European Organization of the Construction Industry decided to implement a set of measures to protect the environment during construction [8]. However, the Ukrainian state and the construction industry in particular should be promptly involved in the concept of introducing biosphere-compatible construction in the context of our country's policy to achieve sustainable development goals. In this regard, the development of a system of standards for balanced development of biosphere-compatible construction requires profound changes in economic, social, environmental and ethical spheres, as well as their harmonization with the laws of biosphere development and the principles of humanism [9, 10].

However, it should be noted that biosphere-compatible construction should not be adapted to maximize the economic downturn based on the linear model of production inherited from post-industrial revolutions in the country. The linear model assumes the growth of raw material (resource) costs in direct proportion to the volume of production, which contradicts the task of their preservation. In the conditions of sustainable development, the model of circular economy is optimal. Therefore, there is a need for simultaneous transformation of relations in the national economy as a whole.

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Formation of Urban Void Typology

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Abstract. The phenomenon of urban voids is the result of socio-political and economic changes that happened in the past few decades. Abandoned spaces create a disruption of city fabric and pose a severe problem for human-centric city development. Unlocking the full potential of urban voids within the city borders is crucial for creating a diverse city environment. However, to create a successful design architect requires a framework of typology and understanding the difference between problems that require solutions. Typology helps to determine what exactly type of intervention is needed in each case study. The importance of precise and versatile classification cannot be underestimated. This article focuses on the concept of urban voids in the context of modern cities, analyses various attempts of classification of abandoned territories created before and finally suggests a comprehensive and universal urban void typology.

INTRODUCTION

Currently, many cities experience rapid changes such as continually rising population growth, increased demand in housing, transport and the problem of supplying new residents with essential services. In addition to this, urbanisation with an uncontrolled expansion of cities also creates side-effects in the form of inequality, abandoned sites, unemployment, high crime rates and climate change. Another challenge is the desire of each local government to transform their city into a convenient, smart and livable place.

In the past few years, revitalisation of abandoned urban areas and buildings became a topic of great importance in the professional community of architects and among the urban policymakers. However, despite the numerous projects created to develop and improve the quality of city life, the comprehensive typology of urban voids that can be universally recognised and applied to the shared body of knowledge still does not exist.

Previous Research

In his book «Finding lost space» Roger Trancik identifies several approaches to integrated urban design: the figure-ground theory, linkage theory and place theory. They suggest the division of city fabric into two groups – urban solids and voids. The first group includes public monuments or dominant buildings, the field of urban blocks, directional or edge-defining buildings. The second one is divided by Trancik into five categories:

- Entry foyer space (a transition between public and private realm).
- Inner block void (a semiprivate residential space for leisure/utility or midblock shopping district).
- The network of streets and squares (contains active public life of the city).
- Public parks and gardens (create contrast with architectural forms).
- Linear open-space system (often related to major bodies of water).

The lost space, according to these theories, is a result of the unbalanced relationship between solids and voids, as well as a preference that architects give to both objects/buildings (figures – in the figure-ground theory). To avoid this situation, Trancik suggests designing the object and its components in conjunction with structuring the space around it.

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The next linkage theory emphasises the understanding of connections within the city. This theory is concerned with lines that connect buildings and spaces. A spatial datum gathered from these linear connections can be an axis, a building edge, directional flow of movement or a site line. All of them must be taken into consideration when changes in the city environment are made.

Moreover, the last theory presents a particular interest since it deals with spaces, purposeful voids that possess the potential of linking things. Space can transform into the place only when it gains a contextual meaning. Here Trancik states that when spaces can be categorised according to their physical properties, places are unique and closely tied to their surroundings [3].

Placemaking often appears in literature as a solution for underutilised spaces in cities. It is closely tied to the ideas of strengthening the community through simple design projects and creating a strong sense of identity that defines a place helping it to evolve. The secrets of great places and how to create them are explored in research and projects made by non-profit organisation “Project for Public Spaces”, whose members push the idea of the “power of 10+”. It means that a thriving and lively city needs at least ten destinations, places to spend time and enrich one’s experience [4].

Another classification primarily inspired by “Finding lost space” is suggested in A. Ansari’s thesis “Rethinking urban voids”. Here voids are studied at the smaller scale of a single plot, block or neighbourhood. Author of the thesis distinguishes planning, functional and geographical voids. He devises typology in relation to the Indian urban context. The main criteria were the ownership, the role that space plays in street life and its potential for transformation. The thesis focuses on small scale voids present in the public realm of the city:

- Edge and buffer voids (spaces between buildings, edges of the sidewalk and others).
- Infrastructural voids (spaces around public infrastructure).
- Transportation voids (mainly large oversupplied roads).
- Large scale plots (parking lots, unused land, other abandoned spaces) [5].

Authors of master thesis “Urban voids unpacked” written by Y. Vakarelov and S. Fracasso explain urban voids as “not functioning parts of the built urban environment”. Acknowledging the existence of various void types, this thesis focuses on one type in particular – the one that is closely connected to the transport system of the city [6].

Urban territories can be classified according to the level of concentration of vacant lots in certain neighbourhoods [1] or population density, topography and public perception [2].

In conclusion, urban voids and their typology could be interpreted in a number of different ways. Some researches, like Trancik, talk about voids as a spatial phenomenon rather than functional, the opposite of built-up and developed territories. This idea allows us to distinguish positive and negative voids, where the first type is crucial for the diverse city environment.

In other cases, urban voids are viewed as leftover functionless spaces. However, definitions of different categories within suggested typology have more country or region-specific nature, and such classification is not universal. Several types of abandoned spaces are intentionally excluded from the typology altogether. In addition to this, distinctions between types of voids that remained are not clear enough, and explanations lack consistency.

Typology of Urban Voids

Typology in architecture separates buildings based on similarities in their function or form. Functional typology is quite straightforward and focuses on the use of different buildings, structures and their complexes. Basic examples of categories within it include residential, industrial, commercial and infrastructure facilities. The second typology is not based on overall form alone, but it also takes into account the configuration of rooms and hallways inside the building, sometimes even briefly touching upon the site masterplan.

At the same time in urban planning, all districts within the city belong to several functional zones too. When area cannot fulfil its purpose any longer, it receives a new function and corresponding «in development» status on the map. However, since masterplan is revised only every five years, the real state of abandoned sites is never reflected in the documentation. This way, a territory can only exist on paper either as the functional zone or the place for prospective construction with a predetermined function.

However, to create a detailed classification the commonly accepted definition of urban void must be analysed: it is an urban space whose function and appearance have not yet been determined or was lost due to natural, social, economic and political changes. At the same time, the term "void" can be applied to both built-up and undeveloped territories [7].

Urban voids are formed in the absence of function and over time lose connections with the rest of the city on all of its hierarchical levels. After analysing the process of devising typology, we can ask the following question: “How to classify abandoned urban spaces according to the system that requires the presence of a certain function from its components?” The answer lies in the logical conclusion of using qualitative analysis to determine into which group urban voids should belong.

Based on previously gained understanding of urban voids, we can attempt to divide them into the following categories:

1. **Transport voids** are abandoned urban spaces, whose location, formation and existence are directly related to the transport infrastructure or a part of it and its service networks. Examples include: garage complexes, parking lots, old subway or railway stations, unused railway tracks, spaces under overpasses/flyovers.
2. **Geographic (natural) voids** are abandoned urban spaces of natural origin that are unfit for development due to terrain formation, geology and climate features. Examples include: undeveloped waterfronts/beaches, bodies of water that were artificially created or redirected underground, wild overgrown areas of greenery, areas riddled with gullies, steep slopes, ground with unstable soil prone to erosion or shifting, dangerous types of wetland (marshes, swamps, mires or carrs).
3. **Transit (edge) voids** are urban spaces located on the border between one functional or territorial zone and another. Examples include: temporary structures chaotic in layout and built close to the most prominent pedestrian routes, undeveloped parts of inner space in residential blocks and sidewalks, spaces between buildings, undeveloped territories around newly constructed residential neighbourhoods or public buildings.
4. **Built-up void areas** are abandoned urban spaces located inside and around existing buildings. Examples include: historical buildings without function (officially recognised architectural landmarks and those that lost such status), inactive military camps, bomb shelters, abandoned warehouses, ruins, partially demolished buildings, unsafe structures that are no longer used, long-standing unfinished buildings, reconstruction sites, closed and/or abandoned industrial enterprises.
5. **Vacant void areas** are abandoned urban spaces that are suitable for land development, but are not used according to their intended purpose or have been negatively impacted by human activity and are located on empty sites. Examples include vacant sites without geographical or natural disadvantages (terrain, climate, geology), areas left after building implosion, places for unauthorised storage of household and industrial waste, fenced areas without buildings, forgotten sites with burials.

Based on their own experiences and theoretical knowledge of the situation in Ukrainian cities, authors suggest a more detailed classification of urban voids by several aspects. The first one is the form of site ownership, where voids are located:

- State property.
- Private property.
- Joint property.

According to their origins, voids can be divided into two main categories:

- Geographical voids – created as a result of the influence of environmental factors on the site, where these factors are ignored during the planning process.
- Planning voids – created as a result of changes, inaction or unsuccessful planning decisions and functional zoning of urban areas made without studying the full picture.

Another classification is based on location on voids within the city fabric:

- Central – located in the central part of the city (radius of the centre depends on the city size).
- Inner-city – located within the city borders.
- Peripheral – located on the outskirts of the city.
- Suburban – located outside of the city but are functionally connected with it.

CONCLUSION

After conducting a detailed analysis of the existing typology of abandoned urban spaces, we were able to create a new classification which can be applied in different situations regardless of the city context. According to this typology, urban voids are divided into the following groups:

1. Transport voids.
2. Geographic (natural) voids.
3. Transit (edge) voids.

4. Built-up void areas.
5. Vacant void areas.

Clear definitions provided for each group would help determine the course of action that must be taken to successfully transform the space giving it a new meaning and opportunities for growth in the future.

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Principles of Morphogenesis of Ecological Architecture of Energy-Efficient Areas and Ecovillages

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Abstract. The article considers the main techniques and methods of using biological approaches in shaping the architecture of buildings that are part of ecovillages and energy-efficient areas: the method of visual prototyping, which consists in using living organisms and structures as prototypes to create the appearance of the future building; the method of using living organisms, their systems or products of their vital activity as a building material; method of structural prototyping, which is characterized by the use of patterns, forms and structure of living matter in order to create new architectural structural forms. The basic methods of forming buildings due to the use of alternative energy generators in their structure are also considered: solar collectors, photovoltaic panels and wind generators.

INTRODUCTION

Nowadays, in the conditions of active urbanization, value-oriented connections of city dwellers with nature are broken, there is an acute shortage of natural components in cities, and modern megacities become unsuitable for healthy physical and psychological functioning of people living in them. One of the most effective ways to solve emerging problems has been the emergence of the concept of sustainable development, eco-settlements (ecovillages) and energy-efficient areas. Eco-settlements today are usually small communities with a closely linked social structure, united by common ecological, social or spiritual views. These communities can be urban or rural, technologically high or low, depending on the circumstances and beliefs. They express deep respect for nature and for human as an integral part of natural cycles. Ecovillages are integrated into the social, environmental and economic aspects of sustainability, and human communities are an integral part of a balanced environment [1, 2]. In their development, ecovillages strive to meet all the requirements of sustainable development. The concept of sustainable development was developed in the 1990s in accordance with the global strategy of sustainable development of society (Sustainable Human Development) adopted at the Earth Summit in Rio de Janeiro in 1992. "Sustainable Development" is a model of moving forward, which achieves the needs of the current generation of people without depriving future generations of such an opportunity [3].

Due to the active implementation of the above concepts around the world, the development of energy efficient technologies and the creation of new methods to improve the environmental condition of buildings and the surrounding space, it is necessary to consider the impact of these factors on the formation of environmental architecture.

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USING BIOLOGICAL APPROACHES IN SHAPING THE BUILDING ARCHITECTURE

One of the most characteristic features of the formation of ecological architecture is the tendency to apply certain properties of the natural environment and wildlife in the design of buildings. The natural factor as a source of inspiration is an integral part of the organization of architectural space. The formation of the principles of biosocial interaction is of particular importance today, despite the fact that its search has been conducted since the 60s of the twentieth century. The complex relationship between the architectural and natural environment has been historically determined and has undergone significant changes. The unconscious reproduction of natural forms was replaced by a fascination with natural forms and their decorativeness. Technical developments have led to exclusively functional requirements for the use of natural analogies [4].

As a result of the analysis of architecture based on the principles of using natural phenomena and structures in architectural design, we can distinguish the method of visual prototyping, the method of using living organisms, their systems or products of their life as a building material and the method of structural prototyping.

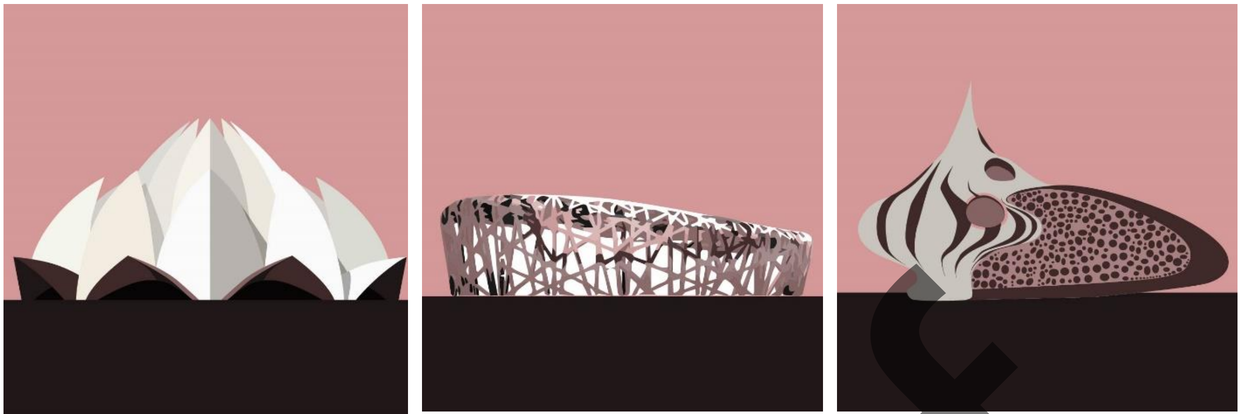
Method of visual prototyping

The basis of this method is in using of living organisms and structure as the prototypes of creation of exterior of future building. This allows architectural structure merge with landscape organically, and contributes to creation of original architectural forms. Usually, geomorphological landscape forms give the most valuable influence on building's exterior shaping. External similarity in this case is provided by means of biomorphic curved forms, shells and self-similar fractal forms.

This method is the most clearly demonstrated by the most common direction of architecture of recent centuries – architectural bionics. The term itself appeared at the beginning of the twentieth century; and the scientific direction – on the edge of biology, architecture and cybernetics. Architectural bionics – is the part of bionics which studies the natural shaping and possibilities of its usage in architecture. J. Steel proposed the name in 1960. In the USSR since 1984 there was a laboratory for the study of architectural bionics – Central scientific research and experimental project laboratory of architectural bionics, headed by Yu. S. Lebedev [5].

There are several direction of developments of architectural bionics: *architectural-constructive bionics*, which studies the laws of shaping and structuring of living tissues; *technical bionics*, which uses the models of theoretical bionics for realization of different technical tasks; *neurobionics direction (neurobionics)*, which is an innovative area of bionics and is connected with realization of natural morphological principles in construction and development of neural networks of different levels and bionic modelling, which searches the ways and methods of realization in project of particular parts of complex biological forms. The last direction is the brightest example of architectural prototyping. Bionic modelling differs of modeling in other scientific fields by several aspects: bionic models are more complex and dynamic structures. Shaping in nature is characterized by plasticity and combinatory connections of structural elements, variety of both regular geometry figures – circles, ovals, diamonds, cubes, triangles, quadrates, different polygonal shapes, and infinitely many complex and wonderfully beautiful, light, dense and economic constructions, made as result of combination of those elements. In this sense, shaping in natural shaping reflects not only evolution of living organisms, but also a numerous corrections of their forms to achieve the ideal variant.

Success of building technics in XIX–XX centuries created novel opportunities for interpretation of architecture of nature, which reflected in architects' creations, among which we can name the creations of Antonio Gaudi, which are characterized by wide usage of bionic forms in architecture of XX century. Designed and built by A. Gaudi residential buildings, Parc Güell and famous Sagrada Familia (Basilica of the Holy Family) in Barcelona are still the most talented a typical example of assimilation of natural architectural forms – their usage and development [6]. For now, architectural bionics is innovative style: so-called "bionic architecture" of soft curved lines, derived from nature and interacting with the world around us. The brightest example of modern bionic architecture include The Lotus Temple in India, which reflects the lotus flower (architect – Fariborz Sahba); Beijing National Stadium (Bird's nest) with external metal construction, which reflects the form of bird's nest (architect bureau "Herzog & de Meuron"); residential building "Nautilus" in Mexica with the design of natural structure – clam shell (architect studio "Arquitectura Organica"); swimming complex in Beijing with exterior construction of "water bulbs" and reflects the crystal lattice (architects "PTW", "CSCEC", "CCDI", i "Arup"); and public buildings of Zaha Hadid and others (Fig. 1).



(a) (b) (c)

FIGURE 1. Examples of bionic architecture: (a) The Lotus Temple in India – architect Fariborz Sahba [8]; (b) Beijing National Stadium “Bird’s Nest” in Beiging, architect bureau “Herzog & de Meuron” [9]; (c) residential building “Nautilus” in Mexica, architect studio “Arquitectura Organica”. Source: images by the author

Method of using of living organisms, their systems and their products of live as a building material

Biological technologies are one of the main worldwide directions of scientific and technological progress, which provides breakthrough to getting the novel materials, which possess unique properties, and is an integrated combination of biochemistry, microbiology and engineering providing possibilities of technological (industrial) application of microorganisms. Materials, which are received by means of biotechnology, have high innovative potential and for now are in demand in building.

Microbiologist Henk Jonkers from Netherlands Delft Technological University developed unique self-healing concrete, which automatically repairs the cracks in concrete. During production of building material, solution is filled in advance with capsuled non-harmful bacteria Bacillus genus, which are unique in vitality and adjustment to any temperature conditions [6]. Lactate of calcium is used for provision of bacteria with nutrients. During interaction of bacteria with calcium lactate, chemical reaction produces calcite, which fills the cracks. Using of self-healing concrete decreases labor intensity and costs of building repair, and decreases hydrocarbon emissions during production of composite [10].

Spanish scientist Antonio Aguado with colleagues from Polytechnic University of Catalonia (Universitat Politècnica de Catalunya) developed “biological concrete”, which is both building material and substrate for vertical garden. In novel concrete instead of regular mixture of substances – Portland cement – magnesium phosphate is used, which not only provides excellent consolidating functions, but also produces acidic environment – favorable condition for sprouting and development of various plants, such as lichen and moss. Surfaces with sprouted organisms support processes of natural air purification of gassed metropolis. Dutch scientist Henk Jonkers in TU of Delft discovered bacteria, which live in sand-lime bricks and are both building material and nutrient medium.

Researchers changed Portland cement binder of building mixture for magnesium phosphate. It is both binding material and acidifier, which makes the environment suitable for sprouting of algae, fungi, lichen and moss. The scientist found that bacteria could live up to 200 years preserving their properties. Due to direct intervention of bacteria into recovery processes, it is possible to prevent huge and small cracks, which appear under changes of temperature of environment and water impact [11].

Method of structural prototyping

Architects use environment not only to borrow the exteriors. Natural structure and vital activity of organisms are studied to find open patterns and properties for solving peculiar architecture tasks. Unlike method of visual prototyping is not only in external similarity of building with natural structures, buy in exploration of laws of functioning and shaping of natural objects (biological objects) to use them for improvement of architectural solutions, formation of complex architectural and urban planning, harmonization of connections of architecture and natural environment.

This method is illustrated by such complement to each other architectural directions – "building bionics", "biotectonics", "biomaterials science" as components of "bionics", and "biomimetics". Architectural bionics solves several architectural tasks such as specification of theory of architecture relating to principal sides of its development; improvement of theory of systems; future directions of differentiation of functional structure of architectural forms and architectural space; deepening of compositional methods – tectonics, proportions, equilibrium, symmetry, rhythm, light and colors; rationalization of existing constructions and implementation of new construction forms; production of building materials with new effective complex constructive and heat-insulating properties. In the book "Architectural bionics" Yu. S. Lebedev says: "We strive for new architectural forms, for their more accurate and clear expression. However we are interested not only in new architectural forms, but also logical system of constructions, which reflects impulses of scientific and technical progress" [5, 12].

Continuing the ideas of bionics, biomimetics uses approaches to architectural designing, based on natural properties. American biophysicist Otto Schmidt introduced the term "biomimetics" in 1957. Modern idea of "the second Nature" is artificial landscape, which should correlate with processes, typical for natural environment [13].

Biomimetics is not limited to formal imitation of objects of fauna and flora, but more closely studies evolution, which allows living organisms effectively adapting to environment, and in architecture – to predict the development on the principles and likeness of living organism. It estimates industrial, organizational and technical strategies on different levels (organism, behavior, and ecosystem) and that is why is considered one of the most perspective principles of eco-sustainable designing of the XXI century. Biomimetics uses the natural systems and materials as a basis, studying, analyzing and improving their structure, form and "anatomy". Principle of biomimetic include metabolism, synergy, bioclimatology, steadiness, genetic information, adaptation, openness and variability [14].

A large number of scientists have dealt with biomimetics. Thus, during his research, the French professor Robert Le Ricollet found that bone, although it is an extremely fragile material, is able, due to its inherent special structure, to withstand heavy loads, about 1200–1700 kg/cm^2. Hence, the logical conclusion is that the strength of this material depends on how its tissue is built. A comprehensive and careful study of the human skeleton has shown that it is an extremely complex set of spatial systems. Since it is impossible to statically determine the smallest number of connected rods in nodes, Le Ricollet concluded "It is not nodes that should be considered, but the distribution of holes. The order of repetition of these holes can give the key to the true meaning of the whole construction." Therefore, his work opened a new chapter: perforated structures. The professor concluded that the main thing is the appropriate location in the material of empty spaces. The question is not the location of the planes, but the framing of the holes, which are connected in different ways. Various ways to connect the frames of the holes, according to Le Ricollet, can solve a number of complex problems of material resistance [15].

THE INFLUENCE OF THE NOVEL ENERGY EFFICIENT TECHNOLOGIES ON THE CONSTRUCTIVE-SPATIAL STRUCTURE OF THE BUILDING

An extremely important principle of the formation of ecological architecture is the technological principle, which is characterized by the influence of the novel energy efficient technologies and technical capabilities on the structural and spatial "anatomy" of the building. Today, renewable energy sources are actively used in the design of energy-efficient buildings.

One of the most important advantages of alternative energy is its environmental friendliness: the process of obtaining energy from renewable sources is not accompanied by the formation of polluting waste, does not lead to the destruction of natural landscapes, virtually eliminates hazardous biological substances, i. e. does not endanger the environment.

Depending on the accepted orientation on use of various natural sources of energy there distinguish:

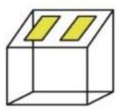
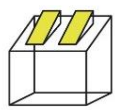
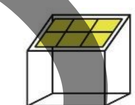
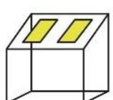
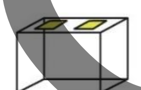
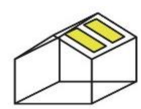
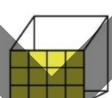
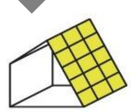
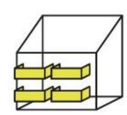
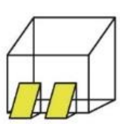
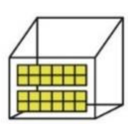
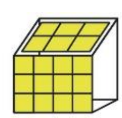
- solar energy-efficient buildings (efficient use of solar energy);
- wind energy buildings;
- buildings that use geo-, hydro- and aerothermal energy;
- buildings with the combined use of different natural energy sources.

Artistic methods of using alternative energy objects in architecture are based on the principle of stylistic unity, which involves solving a number of problems related to the design of engineering equipment and its integration into the structure of buildings and master plan to create a distinct stylistically coherent architectural composition. Artistic methods of integration of alternative energy are primarily related to the architecture of the building and the nature of its environment.

Among all energy resources used in energy-efficient buildings, solar energy occupies a leading position. Based on the use of solar energy, a special type of architectural structures was formed – solar energy-active buildings. The architecture of solar buildings, thanks to the use of modern design solutions and purposefully designed form of the object with surfaces for installation of helioactive modules, based on advanced scientific and technical achievements in various fields of solar energy, makes a special contribution to new shaping techniques of environmental architecture. The composition of enclosing structures with integrated solar power plants may consist of a number of sequentially arranged inclined planes forming a toothed profile, but to reduce mutual shading of the structures, it is desirable to combine solar panels into a single surface. Although less efficient, the integration of solar energy facilities into horizontal and vertical structures with a southern orientation is allowed [16, 17].

Numerous examples of solar energy-efficient buildings were analyzed during the study. Analysis allowed separating the methods (Table 1) of integration of solar panels and photovoltaic panels into the structure of buildings.

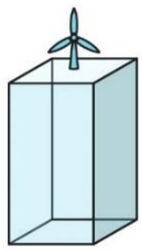
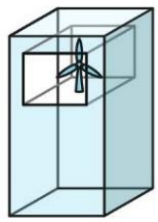
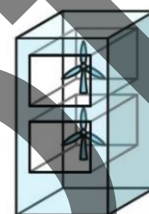
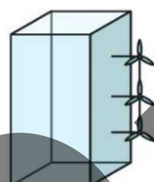
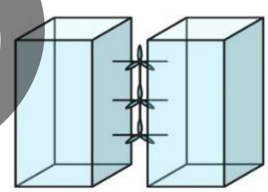
TABLE 1. Methods of integration of solar panels and photovoltaic panels into the structure of buildings.

Types of installation of photovoltaic panels on the surface		
Solar panels flush with the roof	**Solar panels at an angle to the roof**	**Solid roof of the panels**
		
Example: Residential solar power systems in Minnesota, USA. Image source: image by the author	Example: Solar panels on house in Rovno, Ukraine. Image source: image by the author	Example: Solar Roof in Suurupi , Harju County, Estonia. Image source: image by the author
Placement of solar collectors on different types of roofs		
Solar panels on a pitched roof	**Solar panels on a flat roof**	**Solar panels on a two-sided pitched roof**
		
Example: Solar panels on house in Goshen, Utah, United States. Image source: image by the author	Example: Solar panels installed on a flat roof in Toowoomba, Australia. Image source: image by the author	Example: Solar panels on house in California, USA. Source: Image source: image by the author
Placement of solar energy collectors on other structural elements of the building		
Solar panel on a vertical walls	**Solar panels on an angled walls**	**Solar panels on balcony and loggias**
		
Example: Urban Health Plan's Simpson Pavilion, New York, USA. Image source: image by the author	Example: Fire and Emergency Services Training Institute, Toronto, Canada. Source: images by the author	Example: Balcony solar systems in Bern, Switzerland. Image source: image by the author
Solar panel at the basement	**Solar panels instead of windows**	**Combined type of placement of solar collectors**
		
Example: solar panels in the residential building in Moscow region. Image source: image by the author	Example: 5575 m2skylight with 20% transparency in former Bell Building by Onyx Solar. Image source: image by the author	Example: Powerhouse Brattørkaia in Trondheim, Norway is almost completely covered in integrated solar cells. Image source: image by the author

Wind energy facilities are actively used in the structure of buildings and provide 3.7 % of world energy production from renewable sources. Windmills have been used by humanity for several thousand years, and today the use of windmills is more important than ever. Architectural solutions for the integration of wind energy facilities into the structure of buildings are mainly related to the design of the shape of the future structure, which provides the maximum speed of airflows in the area of the wind turbine, and directly to the design of wind turbines [16].

Large wind energy projects have been implemented in Sweden, China, Ireland, Canada, New Zealand, Switzerland, USA, Germany, Spain and Denmark [19, 20]. Most wind turbines are superstructures, but there are examples of attached and included in the structure of the building. Table 2 presents the basic techniques for placing wind turbines in the structure of the building.

TABLE 2. Methods of integration of wind turbines in the structure of building

Types of placement of wind turbines in the building structure		
Placement on the roof as a part of composition	**Placement on the roof as a part of composition**	**Placement on the roof as a part of composition**
		
Example: Twelve West apartment and office building located in downtown Portland, Oregon, United States. Image source: image by the author	Example: Strata SE1 building at Elephant & Castle in the London, UK. Image source: image by the author	Example: Envision Green Hotel project, Miami, USA. Image source: image by the author
Placement of wind turbines at the side part	**Placement between paired buildings**	
		
Example: Kinetica building, Dalston, London. Image source: image by the author	Example: Bahrain World Trade Center in Manama, Bahrain. Image source: image by the author	

As a result of assessing the impact of these technologies on the formation of the building, a number of characteristic techniques can be identified: the use of these technologies as additional elements of the facade, their partial integration into the building structure and complete fusion of power generators with the building structure.

CONCLUSION

Thus, using modern technologies, biotechnology in construction and environmentally friendly materials inherent in the design area, it is possible not only to increase the energy efficiency of architectural objects, but also to modernize the aesthetic and artistic features of their design, using the above principles and methods, namely method of visual prototyping, method of using living organisms, their systems or products of their life as a building material, method of structural prototyping, use of traditional materials inherent in the design area, as well as the use of alternative energy generators to create a successful visual image of the future building or improve stylistic features of the existing building. All this will contribute to the creation of an environmentally friendly, aesthetically pleasing building that meets all the requirements of modern architecture and the concept of sustainable development.

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Features of Formation of Burial Areas of Historical Cities (on the Example of the Old Town Cemetery of the City of Slovyansk)

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Abstract. The article reveals the historical stages of the formation of burial areas on the example of the Old Town Cemetery in Slovyansk. The historical preconditions of formation of compositional - planning structure of a cemetery is considered. The place of the burial area in the general structure of the city at the time of its foundation and at the present stage has been studied. The planning and compositional component of the cemetery in particular is considered. Features of the structure and improvement at different stages of its formation. Preserved architectural monuments, including the «Zalessky» Chapel, have been studied in detail. As a conclusion, the peculiarities of the formation of burial areas of historical cities are determined, and possible models of rehabilitation of such territories are named.

RELEVANCE

Often, historic urban areas lose their primary function due to the absorption and surrounding of such areas by modern areas. Burial areas (which are the territories of temples, cemeteries, areas of burial mounds and any other burials) of historic cities, today, may be unexploited and neglected. The cemetery, as an environmental object, has changed its function. From the central burial-park, with objects of monumental and architectural art. To the "exclusion zone", which is located on the outskirts, in the communal zones of cities. Thus, such areas require analysis of the peculiarities of the formation, and the study of possible methods of rehabilitation.

GENERAL HISTORICAL PRECONDITIONS FOR THE FORMATION OF THE COMPOSITIONAL-PLANNING STRUCTURE

Slovyansk (Tor) urban development began to take shape in the late 18th and early 19th centuries. In ordinary times, the number of inhabitants was about 20 thousand people [1, p. 21]. Bread and salt trade were significantly developed. There were about 20 factories in the city, mostly saltworks. In addition to them - porcelain, earthenware and brick, mechanical workshops. Three fairs were held [2, p. 706-708; 3, pp. 174-175]. The center of the building, first of all, gravitated to the Tor fortress on Solonchaky, forming the corresponding compositional and planning structure.

In 1869, a section of the Kursk-Kharkiv-Azov (later Sevastopil) railway was laid through Slovyansk and the Slovyansk station was founded. Later, the Osnova-Slovyansk branch was laid across the Lyman. The opening of the railway connected the development of the city and the resort.

In 1870-1880, the building center was moved to Cathedral Square.

At that time, the planning structure of the city was quite irregular. The building is formed by a system of squares: the central is the Cathedral Square, the others are located in different parts of the city. The city limits on the river were "closed" by industrial zones, which have the opportunity to expand, however, prevent the growth of residential and

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central areas. Communal areas are also located on the outskirts. So that closes the planning and compositional structure (Figure 1).

FIGURE 1. Scheme of the planning structure of Slovyansk, 1890

ENVIRONMENTAL CONTEXT

From 1890, T. Shevchenko Street (until 1917 - Kiselyova, Izyumska, Kharkivska) became the main transport artery of the city, when a wooden bridge across the Torets River was built in the area of Taganrozhskaya Street.

The beginning of intensive construction comes in 1880-1900 (Figure 2 [1, p. 75]): "blue" gymnasium, hotel Kotlyarova, pharmacy of Mikolaev, hospital Shnurkova, "Grand Hotel", school, house of Zalessky, Alexandrov, etc. [1, pp.74-75; 24]. In 1869, the State Bank was opened at the corner of Zaliznychna and Kharkivska streets.

FIGURE 2. On the left - the scheme of building Kharkivska Street (T. Shevchenko), the middle of the 19th century. [1, p. 75, p. 96]. On the right - the building of Kharkivska Street in the middle of the 19th century. (above), early 20th century. (bottom). All Saints Church - on the left on the horizon

The street was built according to the structure typical for that time. The buildings were very dense. So that adjacent to each other, forming a single composition of buildings. The main facades were decorated with a large amount of decor, which is typical of modernism and eclecticism. The use of modern style was not typical of provincial cities. Kharkiv architects (S I Zagoskin, M O Babkin, EN Serdyuk, etc.) were often invited to design. The pedestrian and roadway are paved with stone, curbs and lighting lanterns are installed.

By the beginning of the 20th century, there were four churches in the city (Figure 3): Holy Resurrection Church (built in 1775, to the present), Alexander Nevsky Church (built in 1897, to the present), Trinity Church (built in 1840, destroyed in 1973), All Saints Church (built in 1836, destroyed in the early XX century).

FIGURE 3. The layout of the temples in Slovyansk at the beginning. 20th century [1, 20]

COMPOSITIONALLY - PLANNING STRUCTURE OF THE CEMETERY

Slovyansk Old Town Cemetery was founded at the end of the 18th century [4]. The area is limited by the streets: Botanichna (from the north), T. Shevchenko (from the east), Trunova (from the southeast), Yaroslav Mudry (from the south), Odeska (from the west) (Figure 4)

In the general structure of the building, the territory of the cemetery was located in the northwest, on the outskirts of the city. Between residential (in the north) and central (in the south) zones. The territory was separated on four sides by a carriageway, which forms a small protective boundary zone to another building. However, in general, the cemetery was inscribed in the general structure of the city and was not separate, but formed the appearance of a park area.

By decree № 237 «His Imperial Majesty, the All-Russian Autocrat, of the Kharkiv Provincial Board» of March 22, 1850 in September 1852, the cemetery was expanded [5]. «Geometric Special Plan of the Kharkiv Province, Izyum County, the place cut for the cemetery in the regular city of Sloviansk, by the Decree of the Kharkiv County Board of June 13, 1851 for № 13065 Correcting Sumy County Surveyor Kotlyarevsky land two tithes and 1,200 square yards. This place is located to the left of the postal road to the city of Izyum» (Figure 4) [6].

The main alley was oriented along the axis northwest - southeast, parallel to Trunova Street (Kladbyshchenska) and paved with natural stone. The main gate faced T. Shevchenko Street (Kharkivska). To the north of the gate was the All Saints Church and the parish school (Figure 11).

All Saints Church is one of the four oldest in the city. The historical and statistical description of the Kharkiv diocese states: «The current cathedral in the name of the Holy Trinity, built on the site of the Vvedenskaya wooden church, those metrics date back to 1766, and which was recently moved to the cemetery. The new council was begun, with the blessing of the blessed memory of Archbishop Meletius, in 1836 and completed in 1840. Such a rapid construction of this temple was facilitated by significant donations» [7, p. 221].

The official date of creation of the temple is 1852. The temple is described as follows: "Regular city of Slavyansk. All Saints Church was built in 1852 ...., wooden, single-throne…. There is no land… The priest is placed in his own house [8, p. 304-305].

In 1863, a bell tower with an altar and a tent dome was added to the built wooden church [9, p. 254]. Later, a domed part with an octagonal ribbed dome was added (Figure 5).

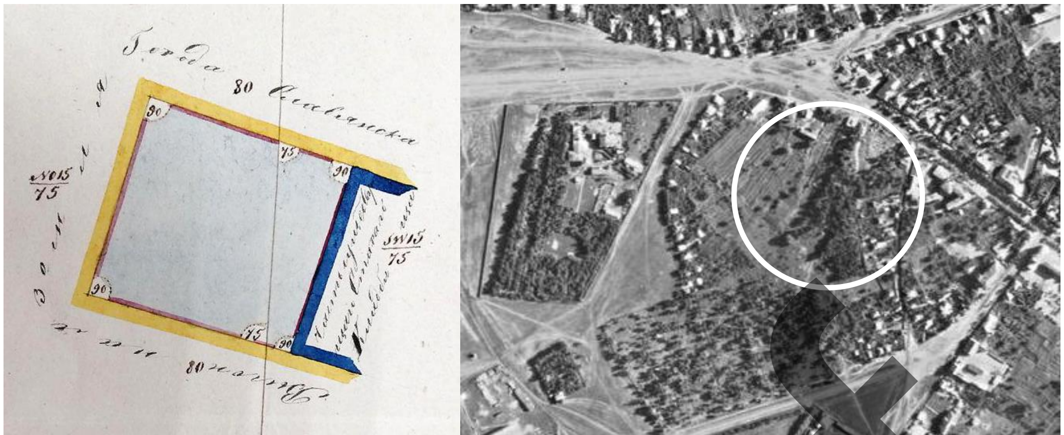

FIGURE 4. On the left - a fragment of the plan of the site in 1852, cut to the previously existing old cemetery in Slovyansk [6]. On the right - a section of the Old Town Cemetery in an aerial photograph of 1941 [5].

The temple was located to the right of the main entrance to the cemetery (Figure 11), as evidenced by the preserved fragments of the foundation. The area in front of the entrance was paved with stone. The building with small architectural forms was located behind, deep into the site, creating a background for the overall composition of the street.

In the 1870s, a parish school was opened in the priest's house at the expense of the merchant Karyakin [1, p. 76]. Saved until now. Now - the laboratory building of the Central City Hospital.

In the pre-war period, the church building was lost. Full images of the temple have not yet been discovered, it can be seen only in engravings, postcards and panoramic photos of Kharkivska Street in the mid-19th - early 20th century. (Figure 5).

1877 first half XX cent. first half XX cent. first half XX cent.

FIGURE 5. Image of the All Saints Church in the panoramas of the city [1, 5, 13, 20 respectively]

The beginning of the 20th century is a period of active development of the city. A large number of plants and factories attract people from different parts of the empire and abroad. This is evidenced by the metric books of the dead and buried in the city [4].

Probably (according to locals), there were three burial sites in the cemetery (Figure 6):

- military, where soldiers of different epochs, retired, were buried (right part, where the monument to the heroes of the Civil War is now located);
- "Jewish corner" (in the central part in depth) and "corner of foreigners" (now - the site of the children's clinic);
- civil, where the inhabitants of the city of various strata and famous figures and philanthropists of the early twentieth century were buried. (central part, near T. Shevchenko Street).

There were three crypts on the territory of the cemetery (Figure 6). In 1840, an order was issued for the construction of chapels in cemeteries, where the bodies of the dead could be buried (Decree of December 27 № 16.988) [9, p. 210]. Preserved to this day crypt (probably Zalessky) with a chapel above it; Shnurkov's crypt with a gazebo above it - to the left of the main alley; crypt made of marble (probably Mamontov). The tombstones were mostly made of white and black marble and cast iron. Decorated with bas-reliefs and sculptural compositions (Figure 12, 13).

This indicates the presence of a certain planning structure and compositional solution. The territory had a clear zoning. The dominant features of the building were crypts and chapels, which were located near the main alley on the second line of the building. Monuments and tombstones were of high artistic value and were made by professional sculptors and artists. Famous architects were invited to decorate the crypts, which belonged to the richest families of the city.

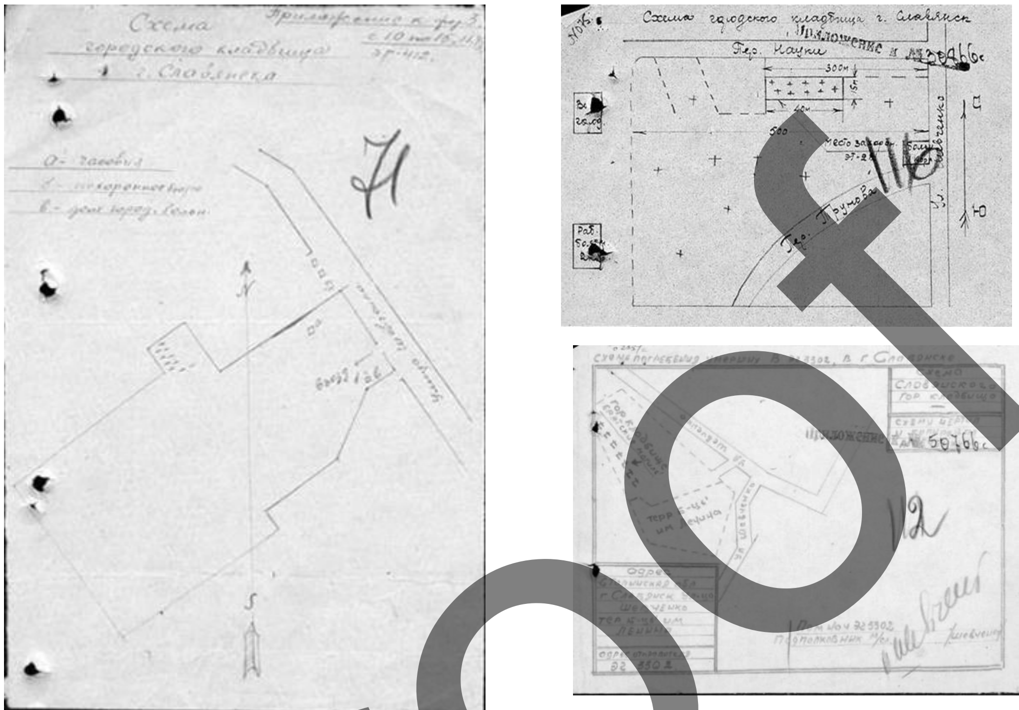

FIGURE 6. Plan-scheme of the Old Town Cemetery, 1950s. (The letter "a" indicates the chapel); Schemes of building the Old Town Cemetery [20].

The «Zaleski» Chapel was built in the early 20th century.

The building is designed on the example of Alexander's Chapel in Kharkov, built in 1885-1886 on the Railway Station Square (architect S I Zagoskin) [10, p.81; 11; 17]. (Figure 7). The central octagonal structure was crowned by a tent on a high plinth. There were double holes on the sides of the volume, oriented around the world. Stairs led to the entrance to the building. Ancient sources were guessed in the decorative details of the building. In the pre-war period, the building was lost [12].

FIGURE 7. Alexander Chapel, architect S I Zagoskin. Kharkiv. General view (left) and location in the structure of the city, 1874 (right) [7].

The Slovyansk chapel is similar in architectural and planning composition to the one in Kharkiv, from which it can be concluded that the project was authored by the architectural bureau of S I Zagoskin (Figure 8).

The chapel was located in a fairly free area near the All Saints Church near the main alley of the cemetery (Figure 11). It did not influence the composition of the building on Kharkivska Street (T. Shevchenko), however, it was dominant for the architectural environment of the cemetery itself.

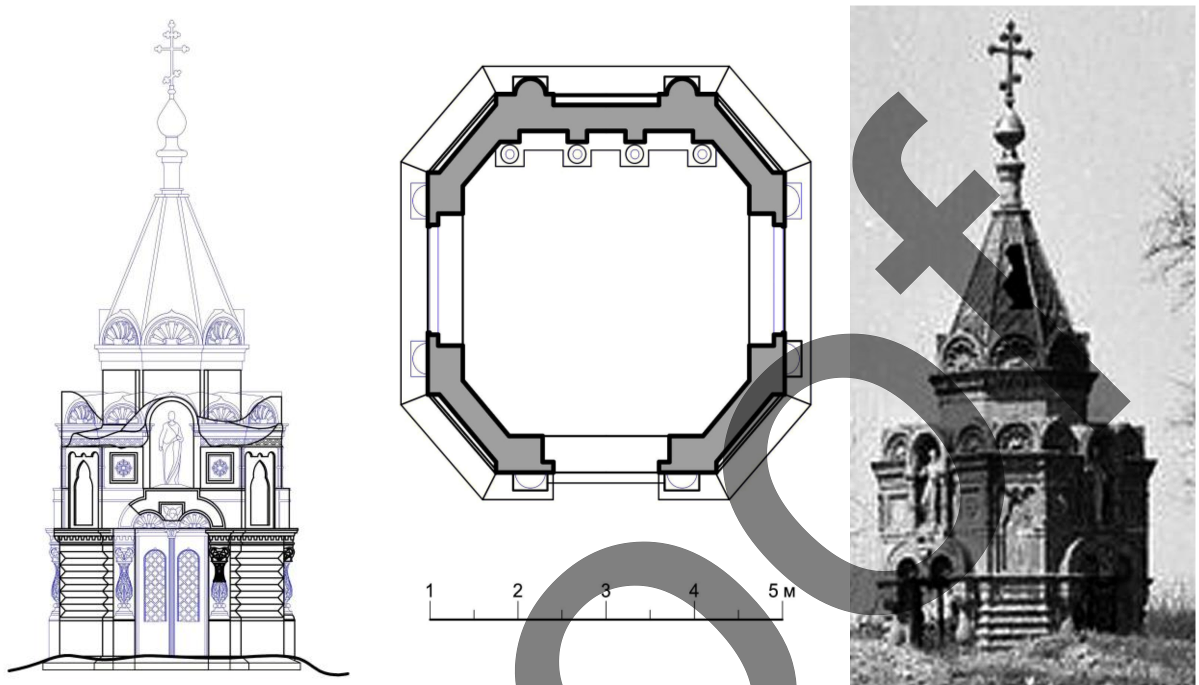

FIGURE 8. Modern facade and plan, as well as photos of 1941. «Zalessky» Chapel in Slovyansk (developed by S. A. Boroznov, O. V. Hubanov, I. V. Honcharova)

Thus, we can conclude about the high culture of the organization of the sacred zone with the use of modern, at that time, methods of landscaping, with the involvement of professional architects and artists. The burial area was planned to have a park structure of the organization and was not separated from the general development of the city.

During the First and Second World Wars, the cemetery in general and the «Zalessky» Chapel in particular were not damaged. Burials of military and local residents were held on the territory (Figure 9). The general composition of the building was not changed and was subject to the existing planning.

FIGURE 9. Burial of Wehrmacht soldiers in the Old Town Cemetery. On the left in the background - the main gate. On the right - the territory of the cemetery [4].

During the Soviet period, the cemetery was closed, and in the early 1980s the construction of individual sites began, due to which a significant part of the burials was destroyed. Thus, the "corner of foreigners" was given to the city children's hospital, part of the civil burials was built up with residential buildings, the territory of the temple was given under residential, and later public buildings. Metal elements were carved from the construction of the «Zalessky» chapel. The tent and stucco on the facades and statues in the niches above the portals were destroyed. The decorative vases near the chapel portals were partially damaged or destroyed (Figure 12, 13).

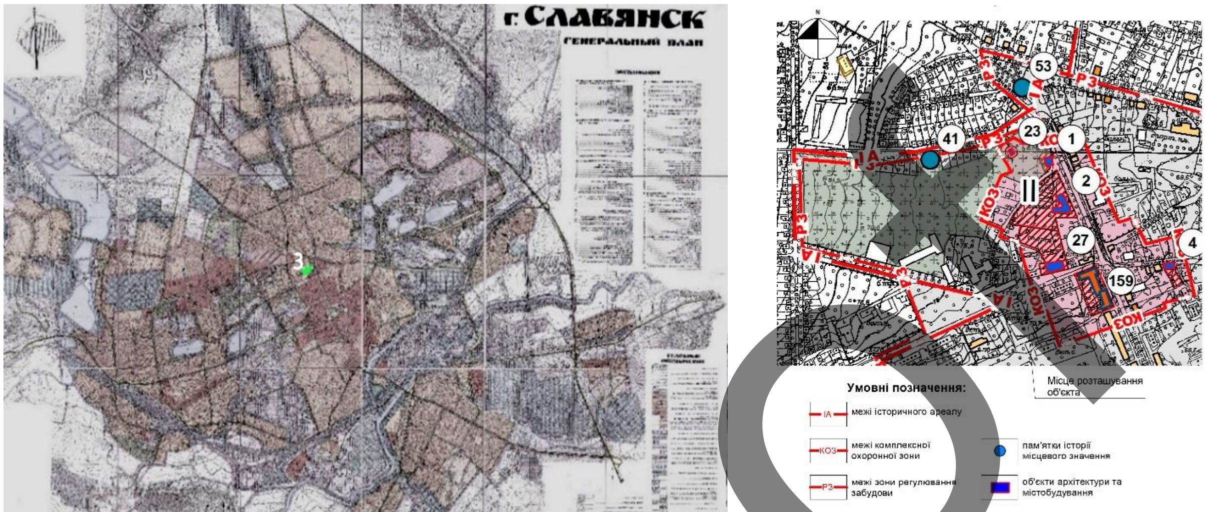

FIGURE 10. On the left - Site of the Old Town Cemetery in the modern structure of Slovyansk (3); on the right - copying from the project of protection zones of architectural monuments of Slovyansk (proposal of Kharkivproject Institute)

The adjacent transport and traffic planning scheme were changed. The composition of the building has lost its dominance. When considering the facade of the street building as a whole, the structure of the integral composition was lost during dense construction. With the development and new construction of the surrounding public and residential buildings, the cemetery became a degrading area. In the general structure of the city, the site was in the central zone. The park-like environment changed to unexploited and depressed (Figures 10, 11).

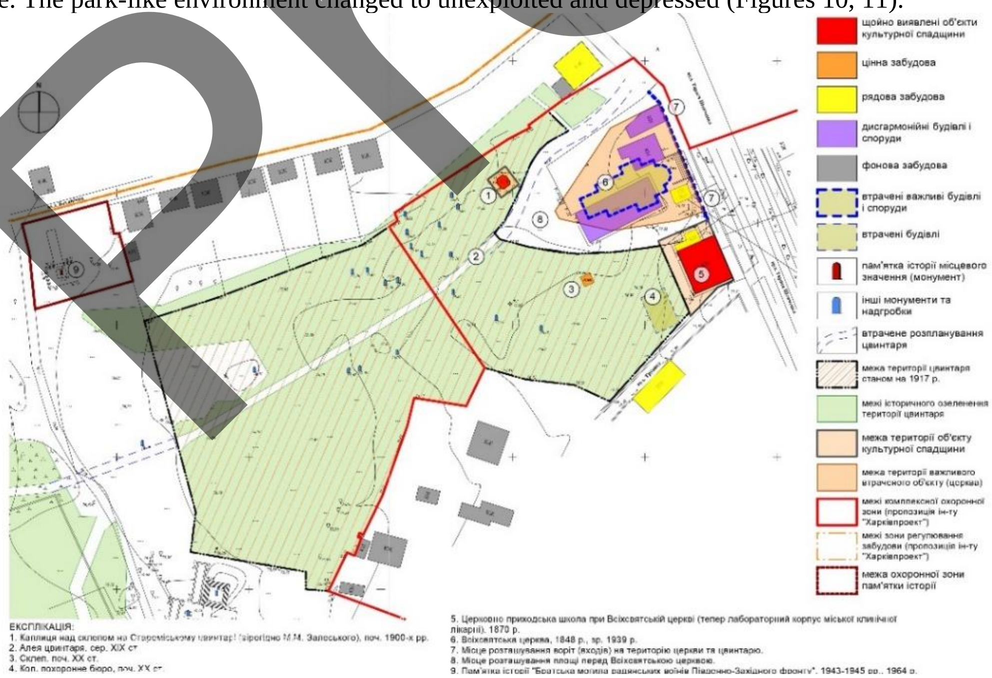

FIGURE 11. Historical - architectural reference plan of the Old Town Cemetery (developed by S. A. Boroznov, O. V. Hubanov)

The territory has not been exploited since the 1990s. In 2019, a land allotment was made for the construction of a memorial park "Memory of Generations" on the territory of the cemetery and a decision was made to bring land under it.

Today, the territory of the cemetery is an abandoned area overgrown with wild plants. As a result of the city's development, its zoning has also been changed. Thus, the territory that was once on the outskirts of the city, became part of the central zone. The territory of the former cemetery in 2019 is included in the boundaries of the historic area. However, it remains unused and requires the use of rehabilitation methods.

RESEARCH RESULTS

As a result of the research conducted by the method of field surveys, a historical and architectural reference plan of the Old Town Cemetery was developed. For the first time, a reliable planning structure of the cemetery was discovered within the modern boundaries, and the location of the All Saints Church on its territory was discovered and plotted. The boundaries of the complex protection zone, the boundaries of building regulation and the boundaries of the protection zone of monuments have been determined (Figure 11).

Modern construction of burial areas of historic cities requires a rethinking of the functional and aesthetic component, because due to the development of cities, such areas have become part of public development, but are abandoned. Therefore, they can be compared with historic industrial sites, which as a result of development also found themselves in popular central urban areas. However, if industrial areas need reclamation and revitalization, then such historic burial areas require rehabilitation of areas with preservation of historical function, restoration of existing monuments of history and architecture, reconstruction of landscaping. It is also necessary to change the exclusively sacred modern content of cemeteries, as objects of alienation and the creation of special park areas, with a thoughtful design of the environment, which will affect the tourist attractiveness of the place.

FIGURE 12. The current state of the Old Town Cemetery, 2019, view of the remains of tombstones (photo by O. V. Hubanov)

FIGURE 13. The current state of the Old Town Cemetery, 2019, view of the ruins of the chapel (photo by O. V. Hubanov)

Thus, in the research of S. A. Boroznov on the examples the analysis of modern forms and models of cultural heritage protection was carried out, and it was found that both regional models and local tourist-excursion routes are closely connected with sufficient types of cultural heritage and transport accessibility. Tourist and excursion routes are supported by facts of history, legends, geographical toponyms. The popularity of routes created on the basis of heritage conservation programs shows that the combination of activities of specialists in various fields of science for the study and protection of cultural heritage leads to success [15].

Under these conditions, such burial objects can become expressive compositional and planning elements in the structures of modern historical cities.

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Principles and Techniques of Architectural and Planning Organization of Mother and Child Shelters

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Abstract. Unfortunately, in our society there is an opinion that the issue of any kind of domestic violence is an internal problem of this family and does not require public intervention. And more and more often society and the state are meeting halfway to people who need help. Humanity began to talk more about domestic violence during the quarantine, when almost everyone was forced to stay at home and work remotely. Most often, women and children are subjected to violence by men. At this moment, they are in the role of a victim, who is in a situation where she does not know how to protect herself and her child. Therefore, the design and construction of shelters for mothers and children is the creation of a new rehabilitation environment where you can recuperate, look at the situation "from a different angle" and decide how to live further. The architect needs to plan the object so that the entire space works for health improvement. Much attention should be paid to the location of the "shelter", external and internal content. The place should be as safe as possible so that everything contributes to a quick recovery. The specificity of the design and construction of such an object is that it must be closed from prying eyes, since we are talking about the safety of people and even the cost of life. The article discusses the principles and techniques of the architectural and planning organization of shelters for mothers and children. Research and conclusions are made on the basis of a deep study by the authors of world and domestic experience in the design of such facilities.

INTRODUCTION

The relevance of the research topic is associated with the social need to create this type of institution, is to identify the best features in the architectural and planning organization of shelters in various leading countries of the world and to create a universal environment. Unfortunately, there are times when women suffer from domestic violence, so the establishment of shelters is timely and necessary. Such institutions are focused on the temporary residence of women and children in difficult family circumstances. The specificity of the design of this new type of rehabilitation facility lies in the fact that it is necessary to combine several functions in one building: accommodation, meals, rest, provision of emergency complex assistance (psychological, social-pedagogical, socio-medical, informational, legal, etc.) and various types of rehabilitation - social and pedagogical, physical culture and sports and labor rehabilitation can be provided.

FORMULATION OF THE PROBLEM

Today, there are numerous cases when women and children suffer from domestic violence. Unfortunately, this problem is still latent, often because the victims are afraid of public censure and decide to face the problem one-on-one. If the victims manage to escape, they usually have nowhere to go to live. By creating shelters for victims of domestic violence, the safety needs of many women and children can be met. For the design of such facilities, an

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integrated approach is required, taking into account the specifics of the facility and the functional-planning orientation for each visitor, taking into account his age, gender, health status.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The problem of studying the architecture of shelters for victims of domestic violence, emergency shelters an their role in society has been repeatedly raised by theorists and practitioners of architecture, psychologists, and sociologists. In particular, these studies are analyzed in works S. Dean, C. Williams, S. Donnelly and T. Levett-Jones [1], M. A. Grieder, A. Chanmugam [2], S. Owen, K. Carrington [3], A. Chanmugam [4], F. Cemre Karaoğlan, S. Alaçam [5], N. Graham, K. Brickell [6], N. Riham [7], S. Luoni [8], A. H. Abulnour [9], D. Perrucci, H. Baroud, B. A. Vazquez and C. B. Aktas [10,11], R. Aburamadan, C. Trillo and B.C.N. Makore [12]. The problems of architectural aesthetics, including the design of medical buildings, were considered in the works of I. Bulakh [14-22].

THE PURPOSE OF THE ARTICLE

To form the principles and techniques of the architectural and planning organization of mother and child shelters.

THE NOVELTY OF THE RESEARCH

The novelty of the research lies in the formation of the principles and techniques of the architectural and planning organization of shelters for mothers and children, as a new and specific type of multifunctional social object, which are based on and take into account the advanced world trends in the design of such objects.

Research results. It is determined in the work that the following principles should be taken into account when shaping the architecture of buildings of shelters for mothers and children:

- confidentiality principle;
- principle of an individual approach;
- principle of functional flexibility;
- principle of accessibility;
- principle of rationality.

1. Confidentiality principle (Figure 1).

The principle of confidentiality is to ensure that the premises are closed from prying eyes. If a woman wants to be here incognito, she must be sure of her privacy and protection [4-9]. Taking into account this need, the architect needs to create the most closed areas for living, food and minimize transit zones between various visitors to the building. Different people, such as staff, trainees, clients, children and volunteers use shelter housing. Having a sense of privacy among a range of users provides the opportunity for clients to develop a sense of belonging to the shelter and personalize their space in a much easier way. Shelters should provide lockable bedrooms for all private rooms to provide clients with a certain level of personal control during their stay.

2. Principle of an individual approach (Figure 2).

Taking into account the fact that women with children can be in the building, it is necessary to organize separate blocks for mothers with infants and school-age children, as well as arrange children's playrooms for children of different age groups. To meet the needs of the residents of the shelter, it is necessary to provide individual living blocks, which should consist of: living quarters, a recreation room, a kitchen, a separate exit to a balcony or terrace, if it is prescribed in the project. Also need to design convenient access to the premises where correction and rehabilitation work will be carried out.

It is important that the services in the shelter are provided on the basis of an individual work plan, which is formed taking into account the life experience of the person who asked for help, and taking into account the results of an assessment of his needs, in particular: the form and duration of the violence; physical, psychological, legal and socio-economic status at the time of seeking help; other individual factors in the family environment and the immediate environment that affect the ability to avoid violence in the future.

Domestic violence is a widespread problem. Unfortunately because of budget and time constraints domestic violence shelters are often not designed to best meet the needs of residents and shelter staff. Moreover, shelters are rarely built from scratch. They are mainly redesigned into existing structures, and such spaces have problems such as the short on space and commercial interior spaces.

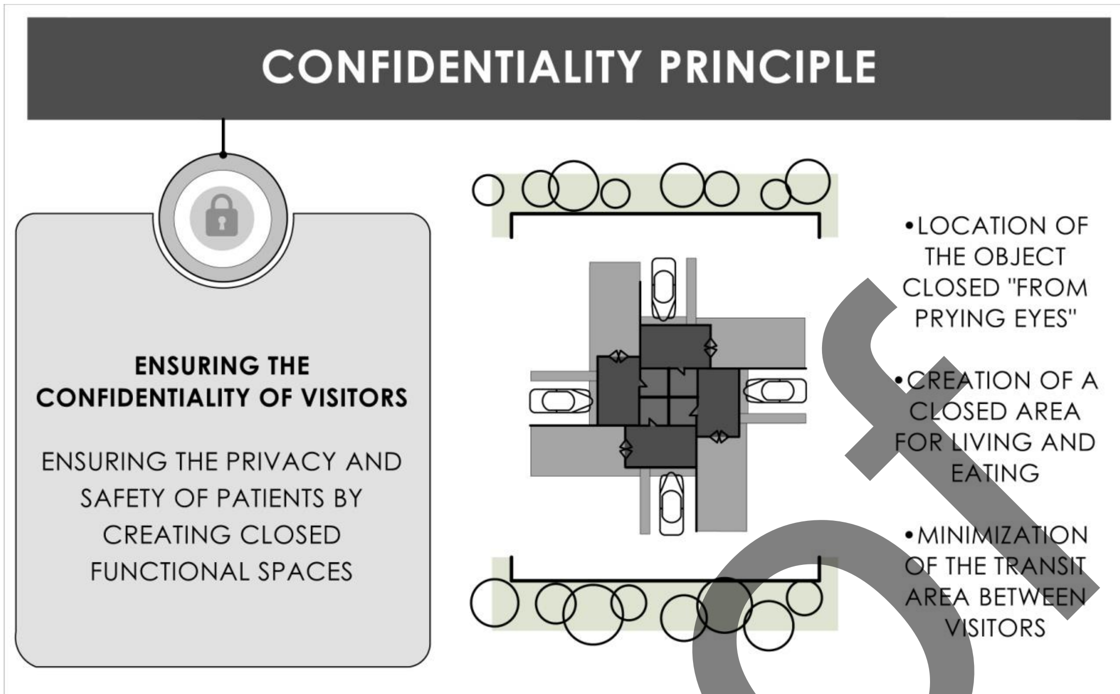

FIGURE 1. The principle of confidentiality of the architectural and planning organization of shelters for mothers and children

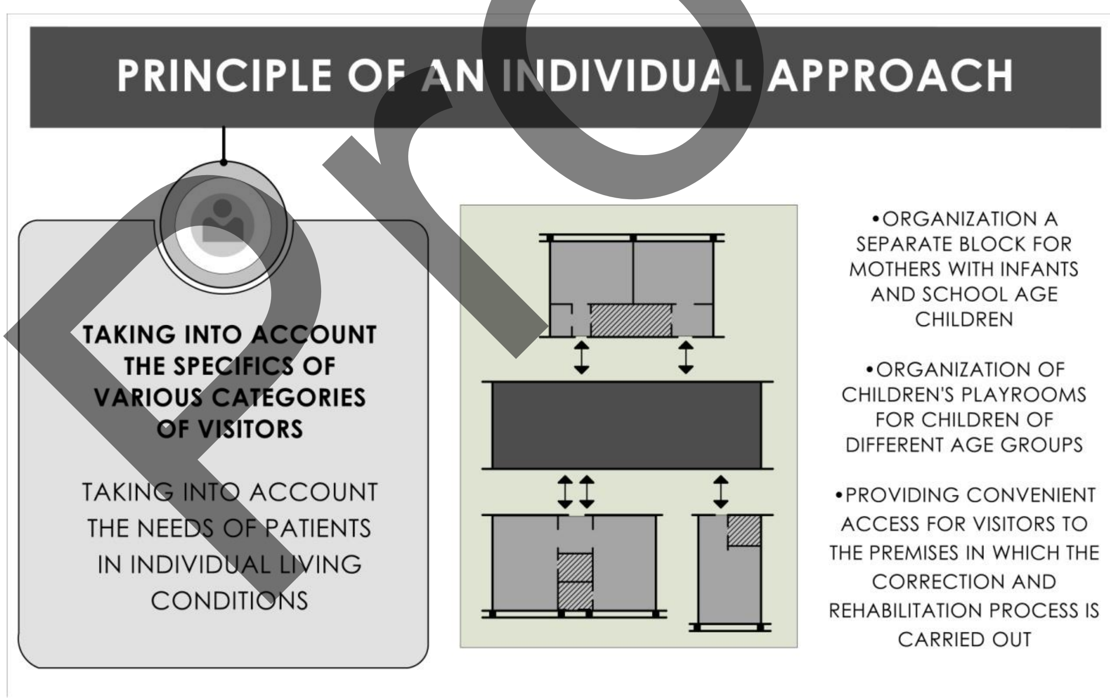

FIGURE 2. The principle of an individual approach to the architectural and planning organization of shelters for mothers and children

It is also necessary to store in the shelter and administrative offices. Because domestic violence shelters must be appropriate to the neighboring community and neighborhood, the construction of new structures is not always possible or justified. The use of existing structures has the advantage of being combined with the surrounding area, but the disadvantage is the inability to specify everything to exactly meet the needs of the organization. Using space for maximum benefit becomes important. As a rule, victims living in shelters do not bring many things with them. However, storing these items in the shelter is important; the availability of storage space for personal belongings gives residents the opportunity to make the space their own and personalize it [10-12].

3. Principle of functional flexibility (Figure 3).

Since the shelter can provide various kinds of services such as education, training, rehabilitation services and consultations with a psychologist and a lawyer, in this regard, it is necessary to organize premises that can be used for various functional needs, that is, to design a space capable of transformation. Group work is also one of the common forms of rehabilitation programs that are used with girls and women who have experienced violence. As practice shows, this form is effective, since it helps patients to understand the situation of violence through the example of other victims, and it also creates a supportive protective environment where a girl or woman begins to feel safer, begins to understand that not only she has experienced violence and this is not shameful.

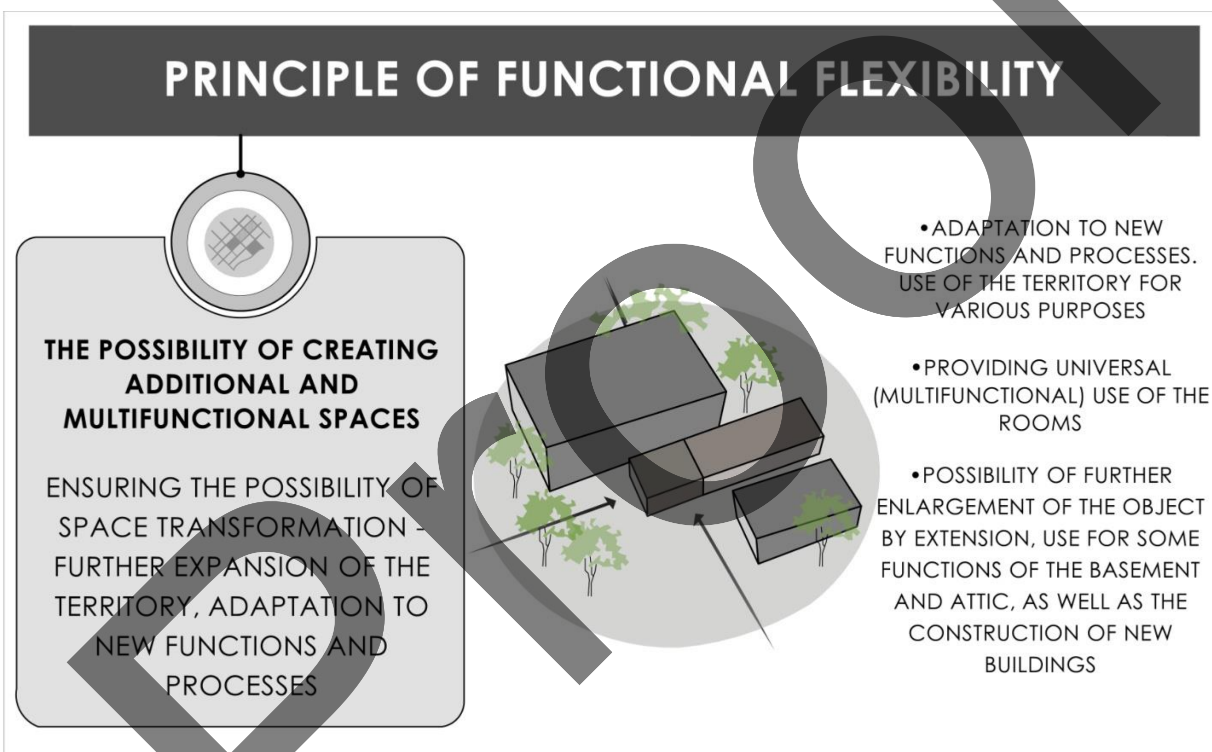

FIGURE 3. The principle of functional flexibility of the architectural and planning organization of shelters for mothers and children

4. Principle of accessibility (Figure 4).

Due to the fact that the shelter for mothers and children who survived domestic violence is a temporary home, it is necessary that it is located close to other functional facilities. For safety reasons, school children can change schools for a while, and preschool children kindergarten, so it is necessary to arrange shelters in maximum accessibility to the above facilities. It would also be good if such a facility was located near a church, children's playrooms where children can be left for a while, and in convenient accessibility to the city center, so that women can conveniently solve their work and legal issues. It is also necessary to design a universal space, taking into account the fact that among the victims there may be people with disabilities.

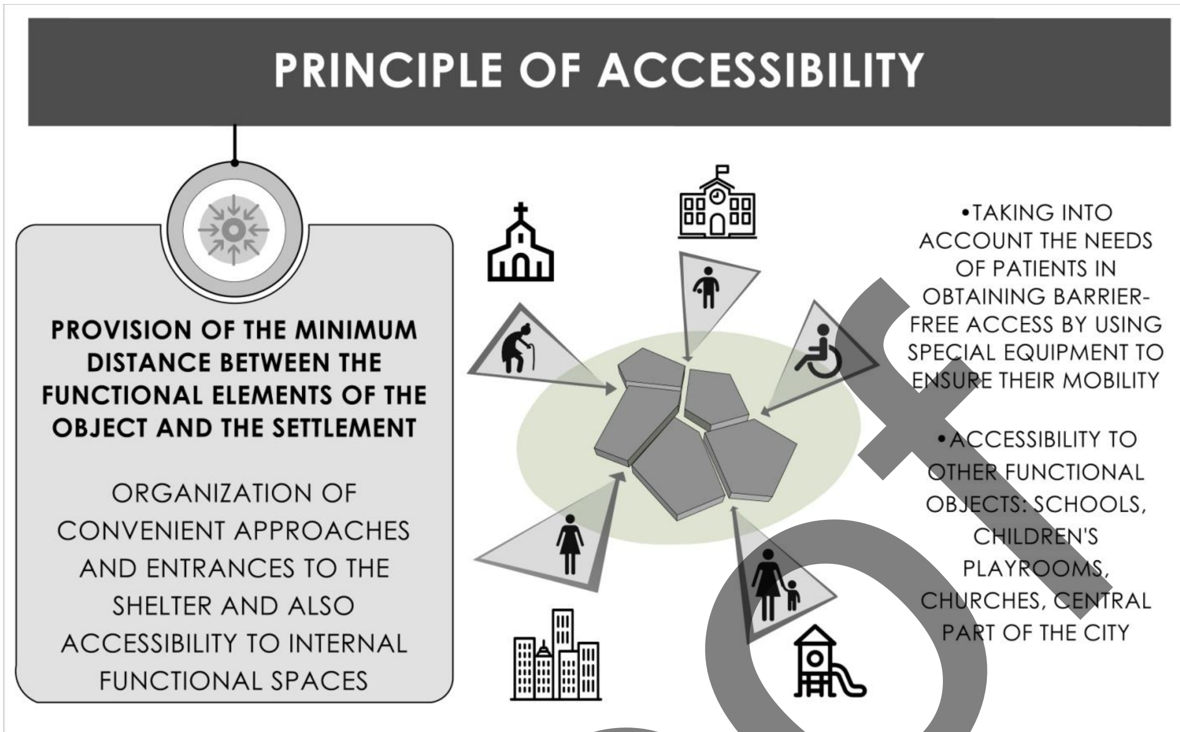

FIGURE 4. The principle of accessibility of the architectural and planning organization of shelters for mothers and children

5. Principle of rationality (Figure 5).

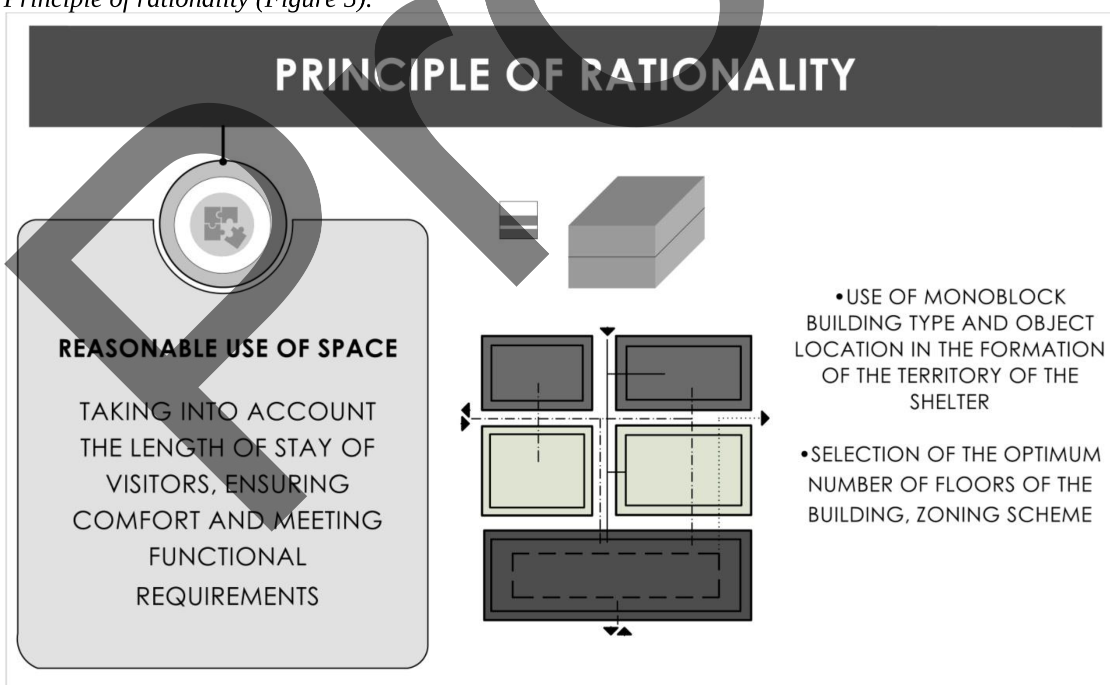

FIGURE 5. The principle of rationality of the architectural and planning organization of shelters for mothers and children

The principle of rationality implies a reasonable use of space, appropriate comfort, and compliance with functional requirements [1-3]. As a result of studying the specifics of the functioning of such objects, usually the minimum stay period is from 1 to 3 months. It is difficult to determine the maximum period it is an indefinite period of time, which provides for living until the moment when the woman and her child no longer need to stay in the shelter. As a rule, six months are enough for this. A well-designed facility will create an expanded environment for residents, contributing to the development of personal identity, goal setting and decision-making; creating a solid foundation for the operational elements of domestic and family violence support services.

In international practice, such shelters are intended exclusively for women (women with children) victims of violence. Ideally, the calculation of places in a shelter is determined by the formula: 1 place per 10 thousand population, but even in the countries of the European Union it was possible to achieve this coverage only by 42-45%.Young children may be with women in the shelter. Places are then defined as "family places". The number of places in the shelter and the volume of provided social services are determined by the founder and can be changed.

6. Techniques for ensuring the proposed principles (Figure 6).

With the aim of organization of a rehabilitation architectural environment, space-planning techniques are proposed to ensure the above principles:

1. Technique of isolation

The technique of isolation provides for the location of the facility in a place inaccessible to the public, the creation of separate closed functional areas for each category of visitors, ensuring noise protection and minimal environmental impact. Fencing in parking areas will help protect the privacy of visitors. Particularly in a sparsely populated area, people can recognize each other's car, so the residents of the shelter will feel safer when their car is hidden from the public. Even when the public knows where the shelter is, the visual privacy of the parking space helps to maintain the privacy of the person among the shelter's inhabitants. A fence from a hedge or next to tall thujas will obscure the view from the street and provide a beautiful view of the green space for residents and staff.

Many people who abuse domestic violence expose their victims to the breach of privacy, denial of confidentiality and interference with reflection, recreation and parent-child bonding. For that reason, private accommodation for survivors is an integral part of trauma-focused therapy, restoration of autonomy and parenthood. With this in mind, shelters should create the necessary foundation for a safe home for each of the residents. Interior settings may include private bedrooms, small reading rooms and meditation rooms. Since women are very vulnerable in the first days of their stay in the institution, the device of a separate residential block and a functional block for the implementation of correctional and rehabilitation work is very necessary [14-20].

2. Technique of differentiation

The technique of differentiation is to create the most comfortable environment for each group of shelter residents. It is advisable to design such an object in the form of a combined volumetric-spatial architectural space, ensuring the multifunctionality of the architectural space. When designing such an object, the architect and designer must take into account the fact that the residents of the shelter are forced to live here under different life circumstances, therefore, when organizing the environment and creating the interior, it is necessary to arrange a universal space, and the housing model should be deliberately designed as an apartment [21-24].

The shelter can provide comprehensive assistance to people who find themselves in difficult life circumstances, will contribute to their early return to normal living conditions. Asylum dwellers can gain skills in cooking, sewing, entrepreneurship. Therefore, the project needs to provide premises for occupational therapy, as well as gyms for fitness, pilates and yoga classes. Public gathering spaces provide a connection with residents and open up new opportunities for learning and support.

Creating a harmonious landscape environment will allow women to quickly adapt, tune in to positive thoughts and find strength for a "new life"[13]. The creation of a medical park in such a shelter will speed up the psychological recovery of the victim from the current situation. For faster recovery of patients, it is possible to set up an economic garden plot in the backyard of the shelter. When planting flowers and vegetables, women can distract themselves from negative thoughts. For children who will be in the shelter, it is necessary to set up playgrounds for active and passive recreation. Also, possible to set up a sensory garden, which will allow children to concentrate on their feelings and will allow psychologists working in the shelter to quickly bring the child out of a depressed state. When designing, remember that any open space must adhere to the principle of safety for the emotional well-being of victims.

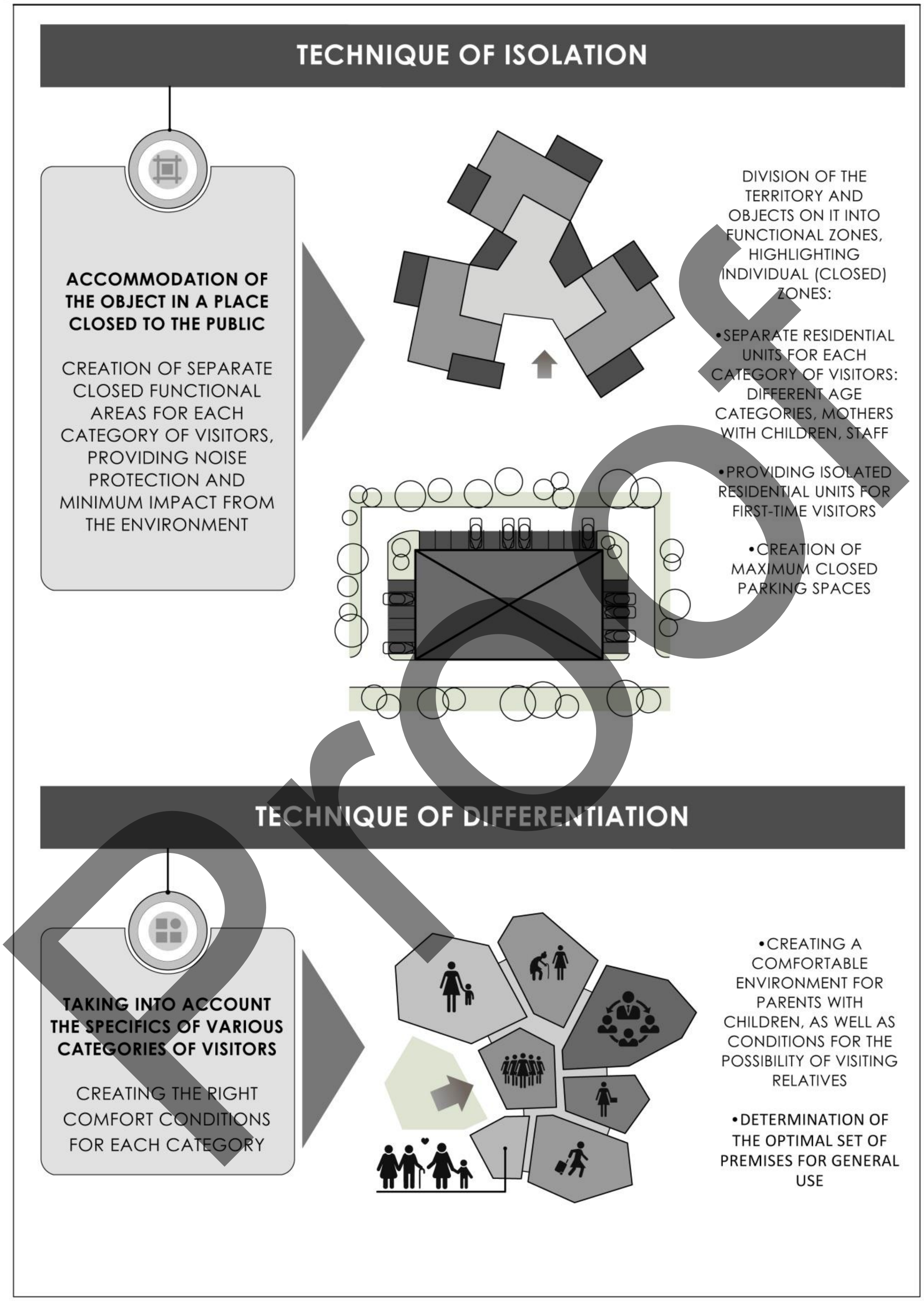

FIGURE 6. Techniques of architectural and planning organization of shelters for mothers and children

Domestic violence is widespread and it has devastating health, social and economic consequences, not only to the victim, but also to children and the community generally. The task of providing solutions to such a complex problem requires input from a range of disciplines: law, finance, social policy, housing, psychology and so on. Crisis accommodation in the form of refuge services provides a front line service and when considering the design of refuges, input from the health discipline is especially relevant because family violence and homelessness are a major cause of physical and mental harm. The contribution from architecture is also important because of the need for good design of both permanent and temporary accommodation [1, p.140].

All premises must meet sanitary and hygienic requirements, fire safety rules, and must also provide visitors with the necessary safety, coziness and comfort.

CONCLUSION

The creation of crisis centers, which include shelters for mothers and children, is relevant and timely, since it is included in the list of new state steps of Ukraine provided for by the State Social Program for the Prevention and Counteraction of Domestic Violence and Gender-Based Violence for the period up to 2025.The construction of such shelters will be a new step for society and the state to help a vulnerable group of people who need comprehensive assistance. In order to create the most comfortable environment for persons suffering from domestic violence, a number of principles and techniques were derived that affect the functional planning organization and placement of mother and child shelters. The main principles are the principle of confidentiality, the principle of individual approach, the principle of functional flexibility, the principle of accessibility and the principle of rationality. The techniques included the technique of isolation and the technique of differentiation. The main goal of the shelter is to create a supportive environment for women and children affected by domestic violence, where they can recover and heal physically, emotionally and spiritually. The architect needs to take into account the needs of people who find themselves in difficult living conditions and circumstances, creating a comfortable rehabilitation space that will contribute to the early return of the victims to normal living conditions.

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The Use of Various Materials in the Formation of the Urban Environment as a Phenomenon of Architectural Aesthetics

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Abstract. The purpose of the article – explore the use of various materials in the formation of the urban environment as a phenomenon of architectural aesthetics. The study of the architectural environment was conducted on the ground of systematic, comprehensive, functional, and historical approaches. Some research methods are used in the article: inductive statistical, abstract-analytical, comparative and historical analysis method, qualitative and quantitative analysis method, data collection, and systematization from various information sources. Modern understanding of aesthetics as a synthetic science and one of the important sections of philosophy is associated with the diversity of perceptions and classifications of existing art forms, among which special regulation, status, and place are always given to architecture and city planning. The gradual deprivation of this leading position, bridgeheads, and traditions have stimulated the need for the revival and restoration of artistic status by architecture and urban planning, which, beginning in the nineteenth century, has initiated a modern movement in architecture and urban planning. One of the key points in the formation of the architectural aesthetics of the urban environment is the use of various building and facing materials.

INTRODUCTION

Today, aesthetics is considered to be a philosophical science or a section of philosophy, where various phenomena are associated, firstly, with the phenomenon of aesthetic, as the manifestation of the value-based attitude of the individual to the world; and secondly, the peculiarities of artistic activity of people are studied in aesthetics. The first chapter deals with the nature and peculiarity of aesthetics in the value-system; the differentiation mechanisms; aesthetic values (beautiful and ugly, sublime and unworthy, tragic and comic, etc.), aesthetic perception and aesthetic role in the social life of man and society, historical evolution of philosophical view, etc. The second chapter focuses on the initiation and progression of artistic activity, its structure and place in culture, the connection of artistic creativity, its artworks and the nature of their man`s perception; as well as laws that become the source of forms variety of artistic activity (types, forms and genres of art) and its historical transformations and modifications (trends, styles, and methods).

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In other words, modern aesthetics, as a section of philosophy, is marked by its synthetic content and systemic character and includes axiology and sociology, gnoseology and psychology, ontology and history of culture, morphology, and history, criticism, etc. In accordance with the purpose and objectives, the emphasis in the article is transferred from the fundamental theoretical and methodological points of aesthetics to the applied questions of artistic activity, which are related to the place and role of modern architecture in plastic and tectonic arts, with the principles and methods of forming artistic appearances of the architectural and urban planning area, architectural works and styles, views, sorts and genres of architectural and urban planning and project long-range plan activity. Such an approach becomes possible in the way to the revival of the architecture artistic status, which modern architecture, beginning with the nineteenth century, loses up to this time gradually and irrevocably.

Obviously, these losses were associated with the evolution peculiarities of the third evolution stage of modern aesthetic view. It in series included bourgeois aesthetics based on the of “art for art” and “art for art's sake” principles; democratic aesthetics associated with utopian-socialist theories; end of the century aesthetics, which is connected with the so-called modern movement in architecture and which has depreciated beauty as the most important component of the Vitruvius triad; finally, the aesthetics of the post-modernism era of counter-modern movement, as the aesthetics of programmable and radical eclecticism. It should be added that the aesthetic ideas of the twentieth century, including in architecture and urban planning, were shaped by the influence of pragmatism and critical realism, symbolism, and abstractionism, in which there were diverse trends and styles similar to functionalism and constructivism, internationalism and regionalism, neo-rationalism and surrealism, etc. The systematization and generalization of these and other aesthetic doctrines and the return of architecture to the elegant arts bosom becomes possible subject to the historical experience of the classifications offered by prominent philosophers and researchers.

Also, in this article, an attempt is made to consider the formation of an architectural environment from the point of view of the use of various building and finishing materials.

FORMULATION OF THE PROBLEM

Today, most cities in the world are faced with the problem of the aesthetics of the architectural and urban environment. Investigating this problem, it is also necessary to comprehend the use of building and finishing materials that are used by architects to form space.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The problem of studying the aesthetics of the architectural and urban planning environment has been raised many times by theorists and practitioners of architecture. In particular, these studies are analyzed in works K. Alexander [1, 2], Y. Borev [3], P. Eisenman, R. Koolhaas [10], K. Frampton [11], C. Jencks [12], K. Lynch [13, 14], P. Rand [15], F. Schelling [16], G. Semper [17]. Among the works of Ukrainian researchers, it is necessary to note the book by V. Timokhin [18], in which the urban space is considered in a comprehensive manner, including from the standpoint of the problems of aesthetics. The problems of architectural aesthetics, including the design of medical buildings, were considered in the works of I. Bulakh [4–9, 21].

THE PURPOSE OF THE ARTICLE

Explore the use of various materials in the formation of the urban environment as a phenomenon of architectural aesthetics.

METHODOLOGY

The study of the architectural environment was conducted on the ground of systematic, comprehensive, functional, and historical approaches. Some research methods are used in the article: inductive statistical, abstract-analytical, comparative and historical analysis method, qualitative and quantitative analysis method, data collection, and systematization from various information sources.

PLACE AND THE ROLE OF ARCHITECTURE IN GENERAL CLASSIFICATION AND ARTS MORPHOLOGY

The aesthetics growth, which unfolds during the three stages, in the first stage has been several stages, from the ancient era, the Middle Ages, the Renaissance era and age of Enlightenment to the middle of the XVIII century. At that time, aesthetics was not yet considered a scientific discipline in its own right, and its main constitutive laws were formulated by separate ancient philosophers (Socrates, Plato, Aristotle), as well as were published in separate treatises addressed to various kinds of arts. Such a basic treatise in architecture is the treatise by Vitruvius De architecture, known today as “The Ten Books on Architecture”. In the medieval period, when art, science, and philosophy were considered from theological positions, the aesthetic features of architecture were analyzed in the treatises of church philosophers and theologians (Augustine, Aquinas etc.).

Architectural treatises became especially popular in the Renaissance when the beginning of ethics, philosophy and architectural theory was closely interwoven with aesthetic and artistic principles. Treatises by Alberti “The Ten Books of Architecture”, A. Palladio “Four Books on Architecture”, “The five orders of architecture” by Vignola, G. Vasari “The Lives of the Most Excellent Painters, Sculptors, and Architects” should be added to these works. Aesthetic problems from the positions of gradual involvement of scientific methods, criticism, and substantiation of one or another creative method, style or trend - baroque, classicism, and realism have continued to be considered in the treatises of philosophers and artists in the Enlightenment. These works should include the doctrine of the proportions by F. Blondel, N. Bualo treatise and “Conversations about architecture” by Viollet-le-Duc. In these and other books there was a tendency to compare and match between different types of arts and artistic creativity, and in the future attempts to combine them under the roof of “elegant arts” [3].

Starting from the mid-18th century, O. Baumgarten, proposing the allocation of aesthetics as an independent section of philosophy, initiated a new stage in its evolution towards of creating “knowledge of acquaintance theory”, the doctrine of beauty and art as the beauty embodiment. This way was taken to the next stage at the systematization of the types, trends, and genres of various art forms represented in the works of German classical and romantic philosophy. Architecture along with music, painting and plastic arts was included in the subsystem of picturesque figurative arts as a component and stage of plastic arts in the art system, which was designed by F. Schelling and based on the allocation of real and perfect aspects of the arts. The hierarchy principles and the synthesis of arts allowed F. Schelling to define architecture as “music in plastic arts”, putting it into the classical five-arts line – music, painting, sculpture, architecture, and literature. Unlike F. Schelling, A. Schopenhauer concept puts the architecture on the lower step, and the music is on the top.

The art forms system proposed by G. Hegel – architecture – sculpture – painting – music – poetry, more nuanced and is variable in historical time. In other words, poetry, as the supreme spiritual arts, in certain historical epochs and in different countries may change over with architecture in accordance with the law of lop-sided development of arts [16]. The third, modern stage in the aesthetic evolution view, which covers the 19-20th-centuries, related to three fields: the bourgeois aesthetics of “art for art”, reproducing the principles of “art for art's sake”; with the democratic aesthetics that appeared in the writings of utopian socialism exponents; in the aesthetics time of scientific and technological revolution and modernism. They are replaced by today's post-industrial and postmodernism society.

All these trends in a great measure have contributed to the gradual loss of architecture by art status and the fundamental transformation of aesthetic ideas and ideas about artistic and creative activities. At once in certain periods, in select concepts and works, the tendency to return architecture to the sphere of spatial, in other words, plastic or architectonic arts began to emerge, where architecture played the role of the center of synthetic artistic creativity of architects, designers, sculptors [7–9, 18].

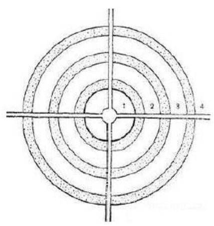
It should be noted that the study of the historical architectural environment demonstrates respect for the choice of building and finishing materials. Buildings located side by side are usually made of the same materials or mutually combined. Thus, the architects managed to organize an architectural environment that is diverse and at the same time interconnected. The most common building and finishing materials typical for the historical architectural environment are: brick, various types of stone (marble, granite, sandstone and other types), wood, tiles and ceramics. It was thanks to the use of similar and compatible materials that it was possible to create the unique architecture of the old cities of France, Italy, Austria, Poland and other historical European cities (Fig. 1, Fig. 2).

FIGURE 1. Historic center of Milan – harmony of building and finishing materials [19].

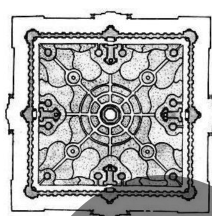
FIGURE 2. Prague – the historical center of the city as an example of the consistency of building and finishing materials [20].

AESTHETIC UTOPIA OF MODERN MOVEMENT IN ARCHITECTURE AND CITY-PLANNING

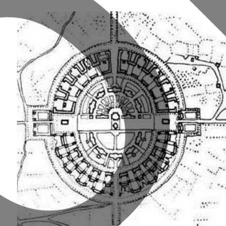
The modern movement, which emerged in the architecture of the early 19th and mid-20th century, brought with its new ideas for rethinking aesthetic visions, principles, and methods of artistic creativity which dominated in classical architecture and urban planning. It`s worth noting among these ideas the concept of new communities with new planning and redevelopment, illustrated by the perfect city's projects, presented in the utopian treatises Henri de Saint-Simon, Charles Fourier, and Robert Owen. The harmony to which the socialist-communist communities of new settlements, perfect cities` phalansteries, and familyists sought, was recognized as a source for new aesthetic principles. Some of the treatises were illustrated by projects (Claude Nicolas Ledoux, Etienne-Louis Boulle), in which new aesthetic doctrines and new methods of creative activity were developed – the symbolization of artistic appearances, the forms monumentality on the basis of simple geometric scopes usage, the architectural and urban planning realm harmonization with natural surroundings, symmetrization and rhythm of planning and redevelopment, their proportioning etc. New aesthetic ideas about the organic and harmonious embodiment of beautiful natural landscapes with architectural and urban planning art emerged against the background of the struggle with uncontrolled cities growth and urbanization in the course of critical research by John Ruskin, William Morris. The latter are capable of reproducing human thoughts and feelings similar to the “truth” and “power”, “beauty” and “order”, “mind” etc., in symbolic images. “Fathers of Functionalism” and its followers, including G. Semper and L. Sullivan, Bauhaus representatives and Higher Art and Technical Workshops in Moscow, A. Loos and Le Corbusier, F. L. Wright etc. had made a special contribution to the initiation and development of a new aesthetics of the modern movement in architecture. Departing from the Vitruvian Triad, they proposed new commitments to the aesthetic and artistic activity problems` solution in their theoretical and creative work [17]. This way of revolutionary rethinking of “beauty” and “harmony”, “universal” and “unique”, “artistic appearance” and “style”, stimulated the emergence of various “-ism” – functionalism and constructivism, internationalism and minimalism, futurism and suprematism, etc. – with their own artistic and aesthetic programs based on inventive creative activity and modernist beauty understanding as novelty presentations (Fig. 3).



Ideal city,
Charles Fourier

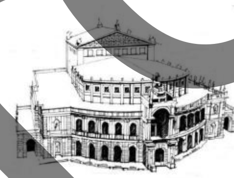


City with population of 2-2,5 thousand inhabitants,
Robert Owen



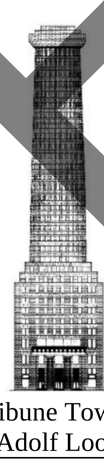
The Royal Saltworks at Arc-et-Senans,
Claude Nicolas Ledoux

Etienne-Louis Boulle

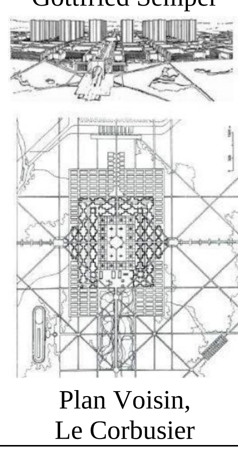


Semperoper,
Gottfried Semper

Wainwright Building,
Louis Sullivan



Tribune Tower,
Adolf Loos



Plan Voisin,
Le Corbusier

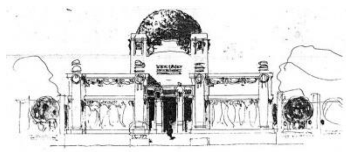
Solomon R. Guggenheim Museum, Frank Lloyd Wright

Larkin Administration Building, Frank Lloyd Wright

FIGURE 3. Formation of a new aesthetics in modern architectural and urban design [31].

Aesthetics and artistic creativity of the modernist representatives and his versions in various European countries (Secession, Jugendstil, Liberty) had taken the individual place of the modern movement. J. Hoffman, J. Olbrich, A. Wagner, C. Sitte, V. Horta, C. Mackintosh, A. Gaudi, etc. are among them. They aimed in their works to come close to the architect and decorator, artist and sculptor creativity to one another, and thus return the architecture to the relevant place in the elegant arts system (Fig. 4).

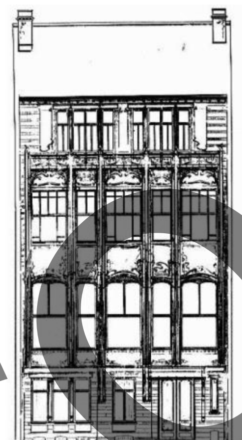
Stoclet Palace,
Josef Hoffmann



Secession Building,
Joseph Maria Olbrich

Majolica House,
Otto Wagner

Mekhitarist Monastery,
Camillo Sitte

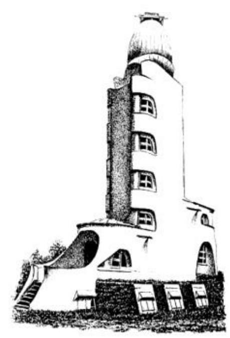


Hotel van Eetvelde,
Victor Horta

Glasgow School of Art,
Charles Rennie Mackintosh

Casa Mila,
Antoni Gaudi

Werkbund Exhibition Theater,
Henry van de Velde



Einstein Tower,
Erich Mendelsohn

FIGURE 4. Aesthetics of European Modernism in architectural and city planning projects of Secession, Jugendstil, Liberty etc. [31].

AESTHETIC LAYERS OF THE URBAN ENVIRONMENT

The urban environment, as a complex hierarchical system, includes several layers [11, 13, 14, 18]. Urban matter and city frame are the most important of them. At the same time, internal cells of the city framework, which are formed by highway, railways and other main roads and networks of municipal centers, stations are filled with city matter [10, 13, 14, 15]. If in the territory of overbig cities several frame structures are formed, then, superimposing one by one, they form urbanized cityscapes, which coalescing together, are unfolded in an urbanized shell of a planet-scale [4, 5, 18].

The architectural and urban planning environment with specific aesthetic features gradually develops at each of these levels within the relevant layers. The historicism aesthetics, which is characterized by a microscale building, dominates in the central zones and areas of historical cities in the cells of the city framework. It is characterized by the special focus to the historical context and to the genius loci (good genius), as well as the historical styles' preservation signs, their artistic visualization in the processes of reconstruction and renovation of the architectural and urban planning environment.

Mesoscale, densely urbanized space, which due to its infrastructure is saturated with various technical devices and communications, is formed in the zone of influence of the city framework with multi-story buildings (Fig. 5). As a result, the architectural and urban planning environment receives features and characteristics of technicisms aesthetics, which is dominated by the artistic imagery of "elegant engineering" of transport, trade and recreational centers and engineering buildings` megastructures, according to K. Frampton [11, 14, 18].

Urban landscapes are the next level and layer of the urban environment. They form a mega-scale space of entirely urbanized territories, which becomes a competitor in natural landscapes conflict. To remove these dialectical contradictions and establish harmonious proportions of the deployment of urbanized landscapes between them, it is compulsory to focus on, so to speak, the organismic aesthetics based on analogies with the plant life and animality, with the human world [4, 18] (Fig. 6).

The super-urbanized shell of a planetary scale is the last level. It is most underexplored, the formulation of its artistic and aesthetic principles has not yet been fully explored, although there are separate creative proposals for continental and planetary resettlement (Le Corbusier, K. Doxiadis, O. Hansen). In the future, based on the deployment of these studies, obviously, there should be a new direction in the aesthetic thinking development, for example, noosphere aesthetics, which may determine new principles, artistic methods and harmonization techniques of the planet urbanized shell, its surface, and underwater settlements, as well as near-Earth orbital resettlement on artificial satellites [1, 2, 10, 12, 13, 15].

Thus, the multilevel nature of the modern architectural and urban planning environment is closely linked with layers of artistic methods and styles of micro- and meso-, mega- and hyper-scale artificial people surroundings with its historicism and technicism aesthetics, artificial naturalness and cosmic [18].

THE CITY COMMUNITIES' DIVERSIFICATION, THEIR AESTHETIC SENSES, AND ARTISTIC TASTES

Total depersonalization of the inhabitants and their communities is one of the key formation problems of a modern aesthetically and artistically full architectural and urban planning environment. This is due to the unmanaged processes of global urbanization and the gradual disappearance of the remnants of urban culture. According to F. L. Wright, there is a larger class of "urbanized" people along with the city people, who tend to host an ordinary lifestyle in entirely urbanized territories. Both of them need an environment that is different from each other, which would suit their aesthetic senses and artistic tastes. Solving to the issue, F. L. Wright sees in lives harmonization of these communities – settled and nomad tribes – and their relevant environments as the substratum and public promise of beauty and new aesthetics (Fig. 7).

From the ancient times, settlers and frontiersman were added to the archetypes of the urban inhabitants – settlers and nomad tribes. In the first half of the 19-th century C. Fourier, in his utopian treatises, distinguished more than 800 people types on the basis of "penchant for passion", for which he proposed a harmonious association in a "series" with a specific type of environment. Even in modern architecture in the pilot projects of the avant-garde group "Superstudio", the division of inhabitants into nomads and settlers was determined by a leading factor, whose influence ensured the formation of two types of global spaces and environments with its own aesthetics – monuments and surfaces. In the American, Soviet and other urban planning structuring theories of the urban population and taking into account their aesthetic needs were carried out according to a simplified scheme.

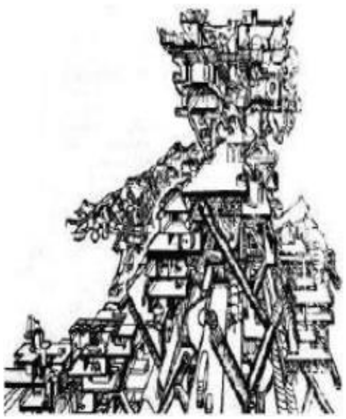
Historicism`s Aesthetics of a microscale building

Federal Courthouse and IRS Complex, Robert A. M. Stern

Museo dell'Ara Pacis, Richard Meier

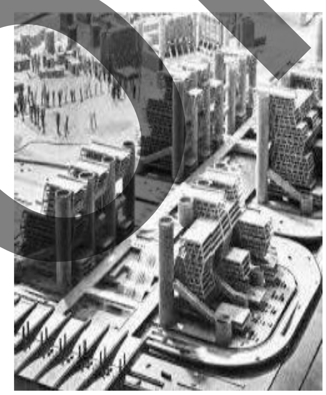
Village Hall, Leon Krier

Aesthetics of the urban frame of mesoscale multistory construction



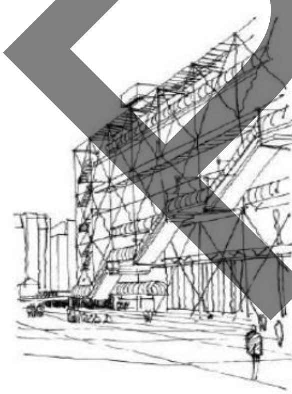
Layer of city structure, Gutnov Alexey, Lezhava Ilya

The Tokyo Plan – 1960, Kenzo Tange

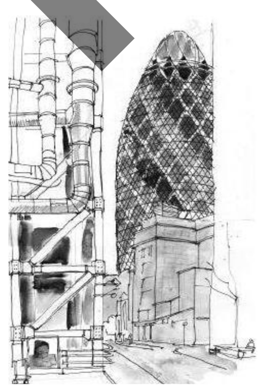


The redevelopment of Skopje, Kenzo Tange

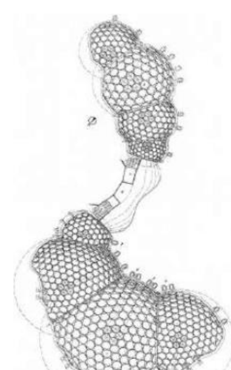
Aesthetics of technicism of architectural and urban planning environment



Centre Georges Pompidou, Richard Rogers and Renzo Piano



30 St Mary Axe, Norman Foster



Eden Project, Nicholas Grimshaw

FIGURE 5. Aesthetics of urban fabric historicism, multistorey construction of urban framework and technicism of architectural and urban planning environment [31].

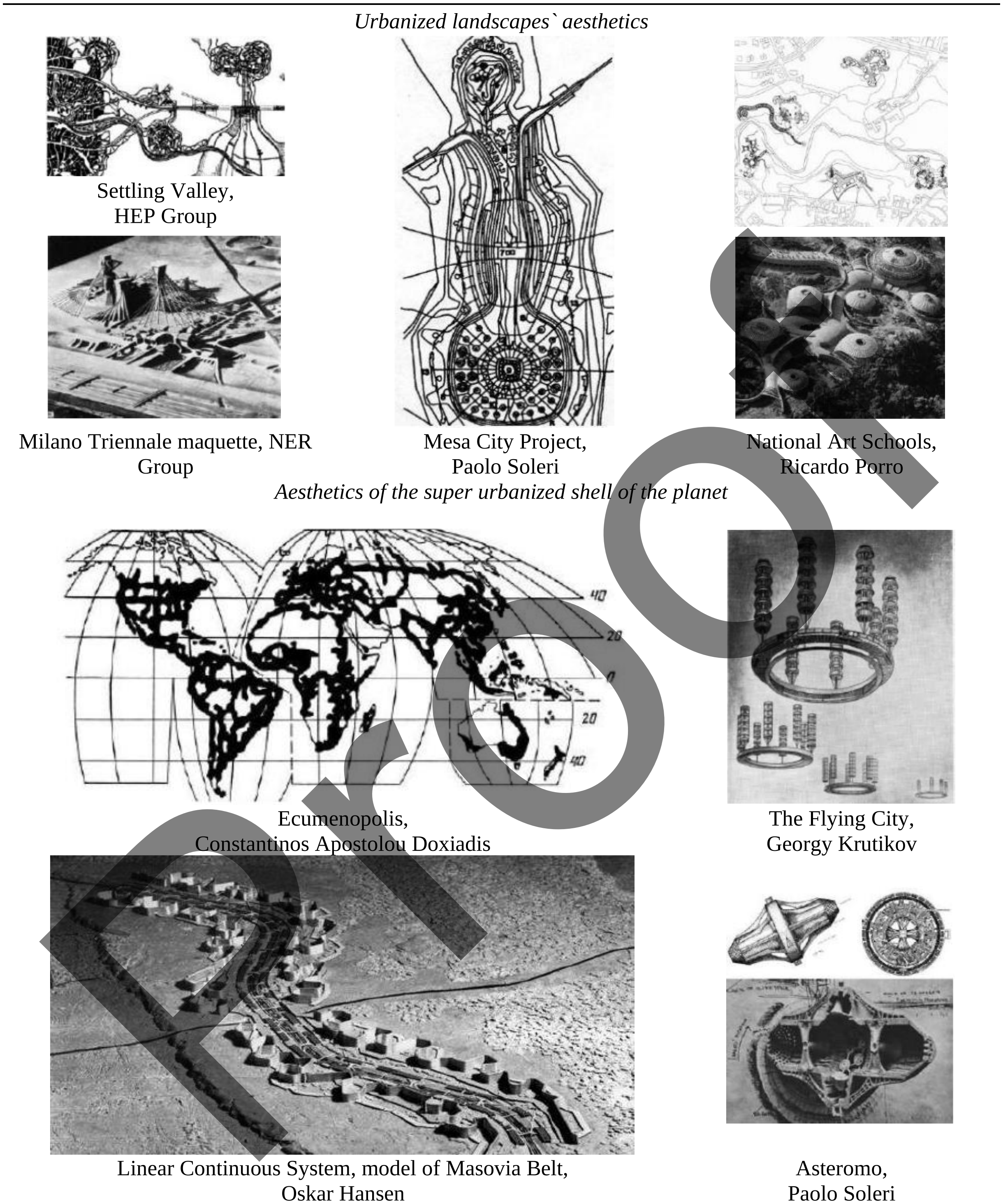
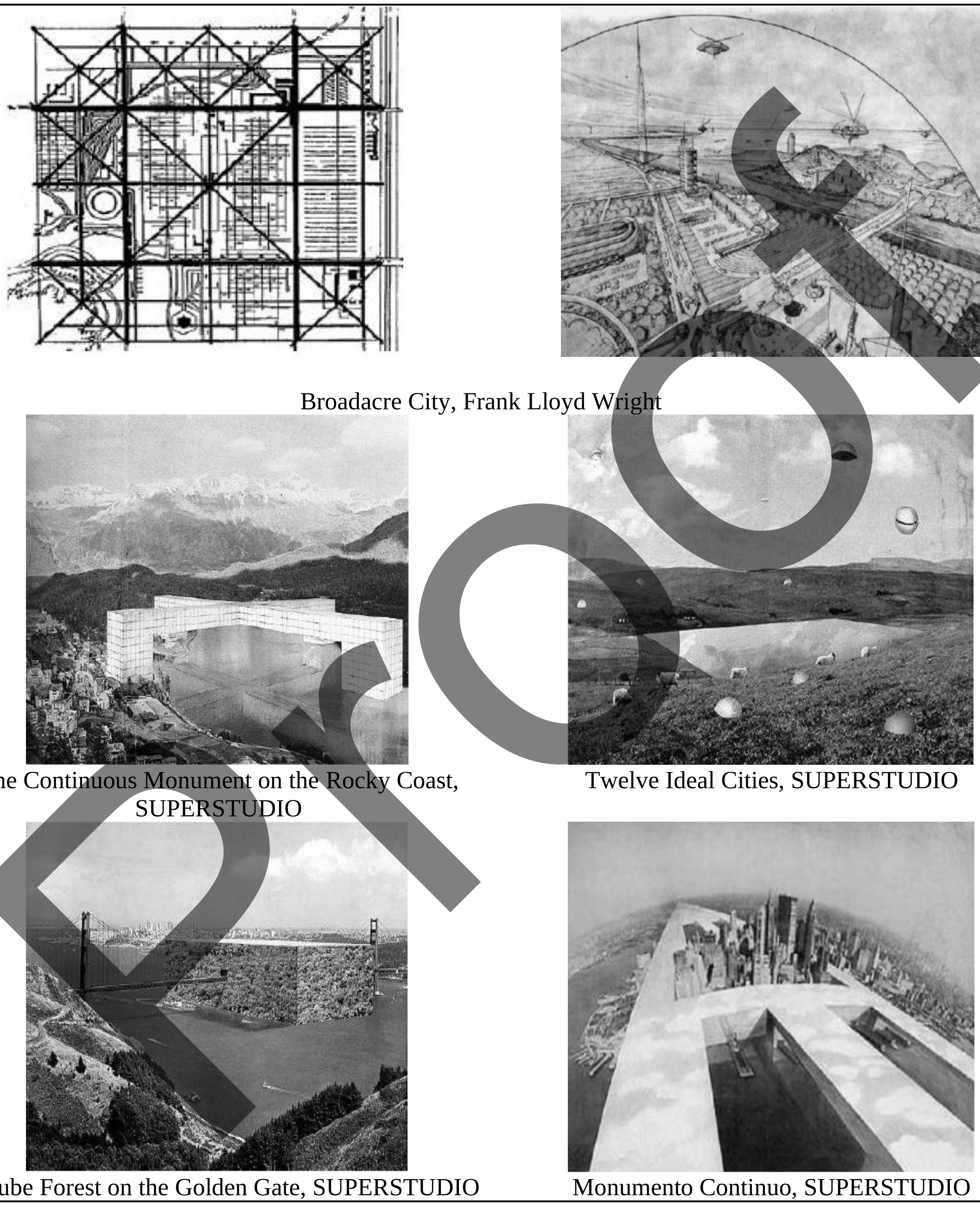


FIGURE 6. Aesthetics of urbanized and super-urbanized architectural and urban planning environment [31].

The categories of employed, partly employed, the unemployed, residents belonging to the city-forming and city-servicing branch were allocated among urban residents. In other proffers, it was proposed along with "pedestrians" and "passengers" to allocate "communicants" and "computers" more active residents who move much more. Another approach proposed in urban synergy is to identify the communities of urban residents and residents of urban lands, taking into account their mentality in the spatiotemporal perception, places, and spaces for their settlement, as well as the peculiarities of their aesthetic senses. Based on ethnogeny theory by L. Gumilev, which distinguished three groups of ethnic groups that perceive the past, present and future in different ways (Passeists, Actualists, and Futurists), in urban-synergy the emphasis is placed on communities of cities, suburbs, urbanists, and country-people, for which priority becomes the past, the present, the future, and undated timeless values.



Broadacre City, Frank Lloyd Wright

The Continuous Monument on the Rocky Coast, SUPERSTUDIO

Twelve Ideal Cities, SUPERSTUDIO

A Cube Forest on the Golden Gate, SUPERSTUDIO

Monumento Continuo, SUPERSTUDIO

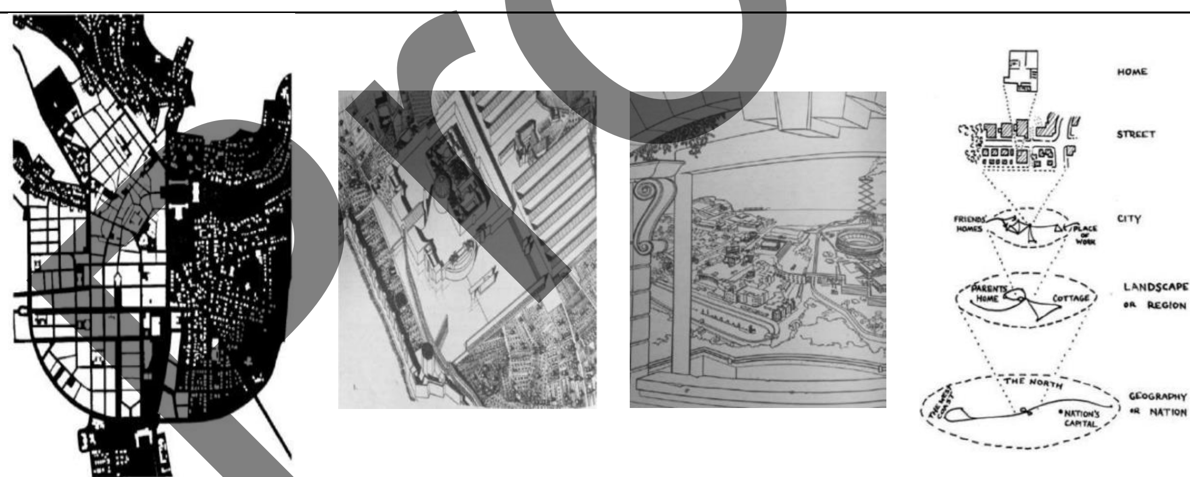
FIGURE 7. Aesthetics of the urban environment based on the diversity of urban communities [31].

Accordingly, different levels and types of layered architectural and urban planning environment, which are suitable for each of these communities are formed [31].

FORMATION`S AESTHETIC CONCEPTS OF MODERN ARCHITECTURAL AND CITY PLANNING ENVIRONMENT

Many contemporary and counter-modern movement concepts are among the ideas search of a harmonious combination of aesthetic senses and tastes of individual inhabitant communities and their corresponding architectural and urban planning environment, its history, present, and future. The greatest attention among them is given to theoretical developments and creative proposals for parallel-band co-existence of "slow down" urban and "fast" densely urbanized territories [14]. City-collage concepts in space and time are joined to them, that is, the architectural and urban environment created by gradual overlaying of various forms in complex compositions; the idea of a medium palimpsestic type, structurally similar to the new appearance, written on the surface of the old and at the same time retains all the processing (Fig. 8).

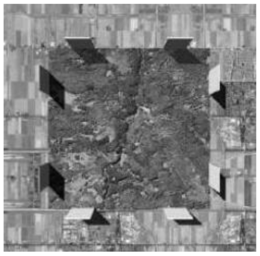
The ideas of "archipelago architecture" occupy a special place between the concepts of contemporary and counter-modern movements in architecture, which so far did not form their own aesthetic doctrines. On the background of continuous urbanization, islands and archipelagos of the new urban environment, which preserve and revive urban culture and urban aesthetics (A. Rossi, R. Koolhaas) are gradually formed there (Fig. 9). These proposals should be supplemented by the concept of a topologically connected quasi-hierarchical environment oriented on the determining role of symmetry in its formation and evolution [1, 2]. There are also proposals for the complete refusal for the usage of aesthetic doctrines in the urban environment and the replacement of their vitality, which is associated with the creation of a fully-fledged and harmonized living environment capable of meeting the requirements and needs of urban dwellers today and in the future (K. Tange). All these aesthetic concepts were taken into account in the urban-synergic visualizations about the harmonious interaction between urban communities and their artistic and aesthetic requirements and senses. City people (passivists and sedentary societies) with a stable, more balanced and slow-lived lifestyle, with love for the past, prefer the symmetrical, relatively closed, autonomous and chamber architectural and urban planning forms and spaces in the most prestigious city parts with strong historical stylistics. The inhabitants of a suburbanite and urbanists (actualists and futurists, colonists and nomads) with a rapid life pace tend to settle in semi-autonomous formations near the communication corridors and urban frames, giving them symmetrical, asymmetrical and rhythmic artistic form with stylistic features of megastructure and productive aesthetics.



Collage City, Colin Rowe	Rome Interrupted, Aldo Rossi	On the further side of modernism, A. Chimakov	City Construction, Kevin Lynch

FIGURE 8. City-collage concepts in space and time, environment`s ideas of palimpsest type [31].

The country-people (anomalists, migrants and passionaries), who are forced to move much faster and more than others while settling on the periphery and on the city border and suburban areas of fully urbanized area, give these territories a new artistic and aesthetic imagery based on the search for hyper-scale eurhythmy for the form and composition of mega-spaces along the valleys and basins of resettlement, interstate transport and communication corridors, innovative channels, etc. [28–30].

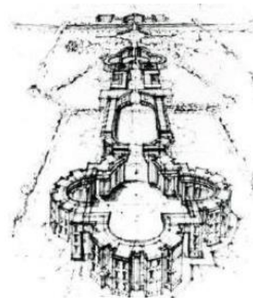


Stop City, Pier Vittorio Aureli, Dogma

The Town Hall of Borgoricco, Aldo Rossi

Messe Torhaus, Oswald Mathias Ungers

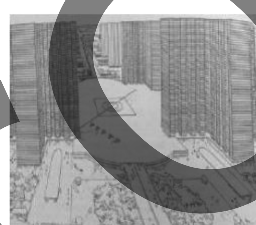
CMG Headquarters, Rem Koolhaas



The Golden Number Plaza, Ricardo Bofill

St. Mary's Cathedral, Kenzo Tange

Design of development of Markets District in Paris, Aldo Rossi (City people)



Plan Voisin, Le Corbusier (Inhabitants of a Sloboda and Urbanists)

Petronas Towers, Cesar Pelli & Associates (Country-people)

FIGURE 9. Aesthetic Concepts of Modern Architectural and Urban Planning Space [31].

CONCLUSION

The aesthetics evolution as a synthetic and an important part of philosophy was concerned with a variety of arts classifications, among which architecture and urban planning occupied an honored place. This leading position regression, bridgeheads, and traditions stimulated the need for artistic status revival and restoration by architecture and urban planning, which, beginning in the 19th century, initiated a modern movement in architecture and urban planning. Harmonious liaison and coexistence, behavior and four categories activity of inhabitants in the self-organization processes causes the cyclic-ordered nature of the deployment and transformation of architectural and urban planning and urban forms and structures between symmetry and rhythm, asymmetry and eurhythmy, as stable and unchanging, archetypic and artistic and aesthetic categories with main trends` stylistic elements of modern and counter-modern movements - modernism and historicism, populism and productivism. These features` layering and coexistence and levels of the architectural and urban planning environment makes for the birth of a new artistic and aesthetic phenomenon, a kind of environmental ornamentals, which requires the further deployment of search and experimental design, scientific and artistic research. An important point in the design of an architectural environment is attention to consistency, harmony and mutual complementarity of building and finishing materials. This approach was widespread when it comes to historic cities. Unfortunately, it is not often taken into account in the formation of modern architectural spaces, which certainly leads to mosaicism and variegation. This article attempts to draw the attention of architects to the important issue of context and environment design, including through the interconnection of new and traditional building and finishing materials.

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Placement of Equestrian Centres in Urban Structures Accounting for the Precepts of Sustainable Modern City Development

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Abstract. Developed and paved areas in Polish cities are constantly expanding. It is a natural process for developing metropolises. Unfortunately, we can observe the gradual shrinking of green areas associated with this process, in addition to increasingly smaller numbers of planted trees, bushes and new areas with biologically active surfaces. This considerably reduces the comfort of citizens and has a significant impact on human health. People require housing, employment and rest—engaging in sports and recreation. In the period of today's rapid pace of life, attention to one's health is increasingly often neglected. People start to search for human-friendly spaces, both in cities and outside of them. One often selected form of recreation is horsemanship. An increasing number of equestrian centres is built in urban agglomerations, satisfying public demand and creating a network of popular sports and recreation centres. Contact with horses satisfies the atavistic need for experiencing nature that is imprinted into the human subconscious.

The subject matter of equestrian centres that is discussed in this paper is presented on the example of three such facilities located within the metropolitan area of Kraków, Poland. The subject matter discussed here can also be referred to other equestrian centres, both in Poland and in Europe. The common denominator is an equestrian centre whose stable has a minimum of sixteen boxes for horses. The objective of this study is to present, among other things, the best possible areas for siting equestrian centres in cities and urban agglomerations. I attempted to answer the question as to how to optimally site an equestrian centre so that it could be as close to people as possible—their places of residence (accounting for everyday commuting to the stables)—and that would also meet requirements for horse breeding and provide animals with a proper living space. To explain this problem, I performed a range of analyses on three equestrian centres located in the Kraków Metropolitan Area, each located at a different site.

Keywords: hippic architecture, equestrian centres, sustainable development, natural environment protection.

INTRODUCTION

Potential Uses of Equestrian Centres – Why do We Need Them? Benefits to People [1]

Equestrian centres can offer multi-directional opportunities for development—in the form of recreational activities and field trips. They have excellently proven their suitability for activities for special needs persons (hippotherapy) and by offering sports classes that teach consistency and responsibility. Contact with horses and space has a healing effect on a significant number of diseases of affluence caused by the rapid pace of life, working under pressure and the resulting atmosphere of nervousness, further compounded by the pandemic. Taking horse-riding classes and contact with animals can be seen as a form of preventing diseases of affluence in city dwellers. The most common diseases of affluence include: stress, depression, heart attack, spine disorders, obesity, diabetes, digestive system disorders, burnout etc. We can also observe increasing problems among children and youth, associated with psychophysical and social development and caused by, among other things, a lack of physical exercise, long hours spent in front of a computer, etc. Horse riding and caring for these demanding animals can also train 'problematic

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youth' in responsibility and awareness of the consequences of one's actions. This is especially true for young girls. Inspiring early interest in horsemanship and responsibility for a horse's well-being can lead to the development of a lifelong passion.

Contemporary Requirements and Principles of Siting Equestrian Centres, Accounting for Zootechnical Conditions

Synthetically presented major needs of horses can be found in documentation for the theoretical section of the PZJ examination (Polski Związek Jeździecki, Polish Equestrian Union) required for the bronze equestrian badge. The bronze equestrian badge is the first step in the sports career of a person, who engages in horsemanship. It allows participation in L-class equestrian competitions (the lowest). The first from among the several dozen questions [2] is 'list the needs of horses as dictated by their nature'. The answer is short and accounts for all the major needs of the animal: 'The horse is a steppe animal, which is tied with: the need for physical activity, the frequent consumption of small amounts of food, and needs associated with light, air and temperature'. Without this essential knowledge of the nature and needs of horses it is impossible to establish a proper equestrian centre. An animal whose basic needs are not met cannot be put to use – whether in sports, recreation or hippotherapy. The ethical principles of using horses have been accurately discussed by Wacław Pruchniewicz in his book Akademia Jeździecka [3], (Equestrian Academy) which is treated as essential reading material in classical Polish horsemanship.

TABLE 1. Equestrian centre component

	Equestrian centre component
Facilities for horses	Stable
	Internal horse washing station
	External horse washing station
	Feedhouse
	Solarium for horses
	Paddocks (a fenced area where horses are let in, its surface is natural: it consists of sand, earth and grass. A paddock can be a fenced section of a grazing field)
	Grazing field (a type of green land use, on terrain covered with multi-year grasses, typically larger than a paddock)
Horsemanship infrastructure	Riding hall
	External riding space (It is assumed that the centre shall be equipped with a professional horse-riding surface—with an upper layer consisting of quartz sand with interlining shavings. Such a surface must be regularly irrigated.) [7]
	Illuminating riding space
	Riding pen
	parcour/obstacle course
	Covered lunge
	Open lunge
Anicllary buildings and spaces	Saddle storage
	Locker rooms and showers
	Staff spaces
	Office spaces
	Stable personnel spaces, Owner's house

Ethical essentials of horse use:

1. Humans and civilisation have stripped horses of their natural surroundings and the conditions in they originally lived. In a new, unnatural environment, humans took over complete responsibility for them.
2. Maintaining a horse must meet its natural needs to the greatest possible degree.

3. Regardless of how a horse is used, maintaining their physical and psychological health should be of the highest priority.
4. People should treat every horse equally, regardless of their breed, age, sex or whether it is used for breeding, recreation or sports.
5. Knowledge of the natural history of horses, their use, needs and means of preparing them for work is a cultural treasure. This knowledge should be preserved and passed on to future generations in an unaltered state. (…)'.

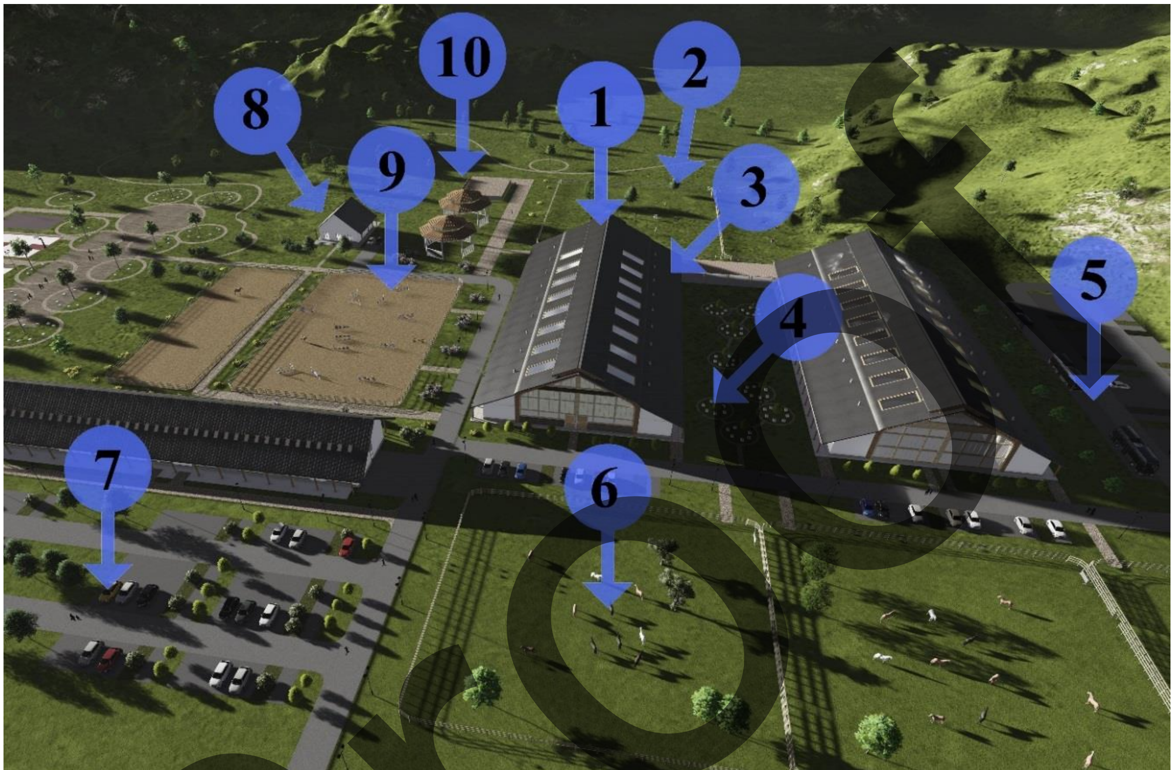

FIGURE 1. Visualisation from a Master's thesis project by A. Kuśmierska, entitled 'Olympic Modern Pentathlon Centre', whose primary use is an equestrian centre (A. Kuśmierska)
1 – hall, 2 – paddock, 3 – stable, 4 – external horse washing station, 5 – parking space for coaches and horseboxes, 6 – grazing field, 7 – parking lot for cars, 8 –owner's house, 9 – external, illuminated riding space, 10 – covered lunge.

In summary, to function correctly, a horse requires [4]: the company of other horses (it is a herd animal), a proper dose of physical activity – in reference to its natural atavism of residing in the natural environment – providing an optimal amount of open-air physical exercise. Horses also need properly selected and portioned food – in their natural environment, horses spend twenty-two hours eating and two hours sleeping every day.

In Table 1 is a presentation of elements that form an equestrian centre [6]. They have been divided into three groups: facilities for horses, horsemanship infrastructure and ancillary buildings and spaces.

MAIN PART

I chose three facilities as cases for analysing equestrian centres located within the Kraków Metropolitan Area: The Kraków Horsemanship Club located within Kraków's city limits, the 'Szary' (Grey) Horsemanship Club located in Michałowice, and 'Zaczarowane Wzgórze' (Enchanted Hill) which is located in Raciechowice near Dobczyce, ca. 30 km from Kraków's city centre. Each of these centres has its strengths and weaknesses associated with their location relative to the city centre.

An equestrian centre should be placed as close to the places of residence of horse-riding class attendees as possible [5]. This especially applies to people who ride horses regularly or compete in equestrian competitions). Horses require regular (daily) training, which stems from the previously listed needs arising from their nature (the need for physical activity). Everyday commutes to facilities located far from the places of residence of athletes or horse owners can prove burdensome both financially and economically (money and time spent on commuting). At the same time, it is not possible for equestrian centres to be located in close proximity to the centre of a large city due to the lack of the space necessary for paddocks. The Kraków Horsemanship Club is an example of such a solution – it is located relatively close to the city centre and has excellent transport linkages. However, this is not sufficient to convince most athletes to have their steeds kept in this facility – as the Club is not equipped with paddocks. It cannot meet the essential needs of the animals (both physical and psychological). Of the centres analysed, the facility that provides the best conditions for horses is the one sited furthest from the city centre – 'Zaczarowane Wzgórze' (Enchanted Hill). The facility offers beautiful views and very good horse-keeping conditions. However, due to distance and travel time to the centre, many athletes who live in Kraków do not use it for regular training.

TABLE 2. Analysis of human needs concerning equestrian centres

	Analysis of human needs concerning equestrian centres				
Equestrian centre name	**Address**	**Distance to the city centre (travel time) along with average travel time using an individual mode of transport**	**Access with public transportation**	**Main services offered (sports/ recreation/ hippotherapy)**	**Possibility of riding out of the facility**
KJK (Klub Jazdy Konnej)'Szary' Michałowice	131 Krakowska Street, 32-091 Michałowice	13.4 km (30 minutes)	municipal transport (bus)	sports	yes
KKJK (Krakowski Klub Jazdy Konnej)	175 Kobierzyńska Street, 30-382 Kraków	6.9 km (15 minutes)	municipal transport (bus)	sports, recreation	no
Ośrodek jeździecki 'Zaczarowane Wzgórze'	233 Czasław, 32-415 Raciechowice	30.5 km (50 minutes)	none	recreation	yes

TABLE 3. Analysis of horses' needs concerning equestrian centres

	Analysis of horses' needs concerning equestrian centres				
Equestrian centre name	**Horse housing (boxes, stations, open-space stable)**	**Paddocking (herd/individually)**	**Amount of time horses spend on the paddock**	**Providing contact with other horses (can horses see each other while in the boxes, box partition construction)**	**Paddocks/ grazing fields**
KJK (Klub Jazdy Konnej) "Szary" Michałowice	Boxes	Individually	Depends on owner preferences. Every horse has a separate paddock	Correctly built boxes (partitions between boxes have a correct height and an openwork structure)	Paddocks
KKJK (Krakowski Klub Jazdy Konnej)	Boxes	None	None	Correctly built boxes (partitions between boxes have a correct height and an openwork structure), stable is too low (horses can hit their heads)	None
Ośrodek jeździecki "Zaczarowane Wzgórze"	Boxes and open-space stable	Herd	As much as possible	Correctly built boxes (partitions between boxes have a correct height and an openwork structure), most horses stand in the open-space stable which meets their social and physical needs to the greatest extent [8]	Paddocks, grazing fields

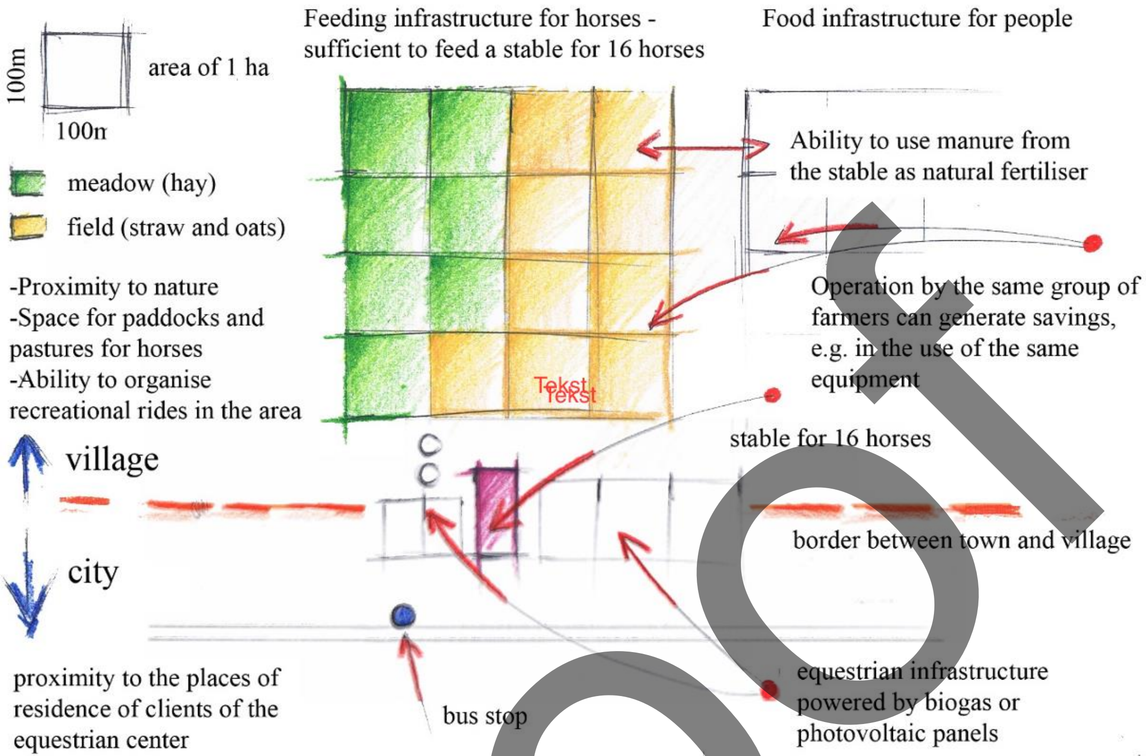

FIGURE 2. Optimal siting of an equestrian centre so as to balance the needs of people and horses, original work, 2021

The model presented above can be implemented provided the following principles are adhered to: a bus stop should be located in close proximity to the centre (ca. 70% of horse-riding class attendees are minors without driver's licenses and their own means of transport). Providing regular mass transport adapted to specific hours when horse-riding classes take place is also an essential element. B. Podhalański and E. Arvay Podhalańska write in their article [9], 'Taking into account the Metropolitan Area of Krakow and the existing underdevelopment of the road network, it is obvious when planning the development of the entire metropolitan area and wanting to maintain its pro-ecological and sustainable direction, more attention must be paid to the use of the existing and the development of a new personal tram network. This type of communication is considered to be the most efficient and effective in relation to transport work - occupied space.'

Permanent and temporary places of residence should also be accounted for, in addition to providing conditions for maintaining the equestrian centre, meeting the needs of stable personnel, providing a smith (most horse deaths are caused by intestinal malrotation. Most can be prevented with an expedient veterinary intervention) and veterinarian for horses and ensure that the centre is self-sufficient in terms of energy – with its installations powered by biogas or photovoltaic panels. ‚Taking into account the difficulties that arise from the necessity of producing energy and the costs that are required for its distribution, two strategies for its production are seen to emerge: one that relies on a central, focused production method with high parameters, losses and costs of distribution and one that is decentralized, locally based and diverse in terms of energy production methods with local consumption, low quantity and parameters regarding distribution and with smaller distances that lead to lower losses and costs.'[10]

Horses must either wear shoes or 'walk barefoot' – depending on how a horse is used and their physical characteristics. A horse without shoes must be visited by a smith every 6-8 weeks [11], while a horse that wears shoes must be visited regularly every 4 weeks. As per the precepts of sustainable development, equestrian centres should be self-sufficient. This is why horsemanship infrastructure and stables include a space for a field on which to grow oats and hay (for feed) and straw (to lay on box floors). Calculations (The calculations were performed based on an interview with Zbigniew Pedryc, a horse breeder, farmer and owner of 'Stajnia Hiromacja' (Stable Hiromancy) in Lgota, 64 Północna Street) concerning the needs of 16 horses for these elements are as follows: a horse requires 4 kg of oats and 10 kg of hay per day. The amount of oats provided depends on a horse's size, breed, age and its use. The value listed is an average – 16 large horses who work regularly for 2 hours [12] per day, 5 days a week, were assumed for calculations. Over a year, a stable housing 16 horses would require around 250 bales of hay, 400 bales of straw and around 230 t of oats. A farmer who intends to be able to feed 16 horses would require a grazing field of 7 ha and 9 ha of farmland to cultivate oats.

CONCLUSIONS

Properties of a Sustainable City (as per UN and EU Standards)

Cities should be designed so as to minimise their negative environmental impact. In the case of equestrian centres sited too close to dense housing structures, there can be a risk of nuisance caused by noise (human-generated noise as a nuisance to horses and noise associated with operating a stable to the people living in the vicinity of equestrian centres), unpleasant smells associated with horse keeping and the possible danger posed by a horse escaping from a centre. With proper placement (as concluded in this paper—at the border between the city and the country), equestrian centres can be secured against these problems. Cities and their sections should be designed with respect towards local communities. In the case of siting equestrian centres in agricultural areas, place-based identity shall be preserved and the land shall be used to cultivate plants and animal husbandry. Buildings designed with their economy in mind are an essential element of a sustainable city. The equestrian centre proposed is planned to utilise power generated from biogas and photovoltaic panels as a means of hybrid energy generation.

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Designing Kindergartens in Context of Sustainable Urban Development: Foreign Experience

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Abstract. The article is devoted to the study of the features of designing foreign kindergartens in the context of sustainable development of modern cities to analyze and identify positive aspects of design to implement best practices of the creation of these objects in Ukraine. The definition of sustainable development is considered and the fact of the existence of many international legal documents is noted for implementation and observance of the basic provisions of the concept of sustainable development, including some regulatory legal acts of Ukraine. The importance of the role of kindergarten in the formation of a human person in the future is accented. Foreign samples of kindergartens are analyzed: features of their architectural and planning structure, location in an urban and natural landscape environment, use of building materials, energy-saving technologies, etc. The main factors of designing foreign children's preschool institutions, which are based on the principles of sustainable development of settlements are formulated.

INTRODUCTION

Sustainable development is a socially, economically, and ecologically balanced evolution that does not destroy the environment and ensures the continuous progress of society. Since the proclamation of the concept of sustainable development at the UN session in 1987 many international legal doctrines have been formulated, in which the principles of the concept have been further developed. Specific measures for sustainable development are formulated in the Plan of Implementation of the World Summit on Sustainable Development, approved by the participants of this meeting, which took place in 2002 in Johannesburg (South Africa) [1].

According to the Istanbul Declaration about Human Settlements, adopted at the UN Conference (Habitat II) in Istanbul in 1996, the central place in the aspiration of sustainable development is occupied by man. The Declaration focuses on the special needs of children and young people in stable, healthy, and safe living conditions [2]. According to the Report of the UN Conference about Human Settlements, architectural and aesthetic solutions are one of the most important factors in the improvement of the settlements [3].

Ukraine has officially supported several international solutions of sustainable development and is developing its own projects of this concept. So, the ideas of the concept of sustainable development were reflected in the Law of Ukraine "About Environmental Protection" of 1991, the Concept of Sustainable Development of Human Settlements (approved by the Verkhovna Rada of Ukraine in 1999), and other regulations [1].

According to the Resolution of the Verkhovna Rada of Ukraine "About the Concept of Sustainable Development of Settlements" among the main directions of the State politics of sustainable development is such as improving the social infrastructure of settlements to create conditions for preschool education, education, culture, health, physical culture, and recreation, improving the demographic situation. Among the main measures to implement state politics to ensure sustainable development of settlements is improving the social living conditions of the population (in particular, ensuring the development of networks of preschool institutions in compliance with social standards and local socio-economic and demographic conditions) [4].

It is an indisputable fact that a person's early childhood is very important for further development of man and stay in society. Therefore, kindergarten is the object and institution where the personality begins to take shape and the ways and methods of identifying a person among his peers are laid, where a person acquires basic skills for

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existence in society to improve them in the future. The children's preschool institution provides the necessary somatic development and socialization skills and in combination with the influence of family, relatives and educators it provides psychological development. Kindergarten is an institution that should also help the child to receive aesthetic education, initial knowledge of basic disciplines, to develop skills in drawing, music, choreography, etc. Therefore, these aspects determine the actuality of the selected issue. It is interesting and important to study the peculiarities of designing kindergartens in terms of sustainable development of settlements, as one of the promising and defining concepts of planning for future humanity.

THE MAIN PART

Now architecture is focused on ecological ideas and ideas of sustainable development, which declared themselves in the 1970s of twentieth century, as a result, two main directions such as eco-architecture and sustainable architecture were formed and exist. Architects are responsible for ill-considered spatial decisions, inhumane design of buildings and structures, unbalanced landscape and natural strategies; they are responsible for the use of low-quality and harmful construction technologies, environmentally hazardous materials. [5, C.70] According to the 2009 Copenhagen Declaration, the sustainability strategy should extend to all areas and stages of design, it proposes the use of renewable energy, the most environmentally friendly technologies and materials. The Copenhagen Sustainability Strategy is to improve the existing situation through architectural methods (to promote the preservation of natural and cultural heritage) and to influence the further development of social and economic aspects. To implement a large number of priorities, architecture must apply a systematic approach and integrated methods during the construction of buildings and structures [5, p 72].

Modern architects-scientists state that the design of children's preschools must be as creative as possible because these institutions are important objects in terms of urban planning and aesthetics [6, p 184].

All this is certainly true, but in Ukraine, for the most part, it is a spatial planning and color solution, while other principles of sustainable development (social, environmental and economic components) are not taken into consideration. The foreign experience of designing children's preschool institutions is largely illustrative of this aspect. Let's explore the main aspects and features of designing these institutions in terms of the concept of sustainable development.

Thus, sometimes to provide the needs of residents of urban districts there is a necessity to place children's preschools in such urban conditions, in which there are no vacant areas with optimal conditions of construction. One of the possible solutions to this problem is the use of territories with unfavorable conditions, in particular, with difficult relief [7, p 291].

An illustrative example of the design of a preschool institution with difficult relief is the kindergarten Pajarito La Aurora in Colombia in the suburbs of Medellin in the mountains, which is most integrated into the environment. An economical, ecological and modular approach was used to place the building on the territory as opposed to clearing the site by blasting rocks. The modular structure of the building consists of flexible modules, the use of which allows to place the building compactly. The shape of the building resembles a snake, and the terraces overlook the surrounding landscapes [7, p 292].

Another example of the location of a building on difficult terrain is the Segrt Hlapic children's institution in Zagreb, Croatia. The main format of the building develops along with the active relief of the irregularly shaped area, so the terracing of the interior of the building is typical. The main children's rooms are located on the ground floor, but at different levels due to the development of the planning structure along with the relief. The building is skillfully integrated into the surrounding landscape thanks to the combination of a smooth concrete surface with facade glazing and sunscreen elements made of natural wood, which give the facade dynamics [7, pp 292-293].

Kindergarten-farm in Donghai, Vietnam also has the concept of the integration of architecture into the environment. The surface of the roof, which descends to the ground in two places, is covered with grass and plants, where children learn to grow food and farm. Thanks to the plan of the building in the form of a knot cozy green courtyards with safe children's playgrounds are formed. The kindergarten was built using ecological materials of local origin (brick, tile) [7, p 295].

Fuji Kindergarten in Tatikawa, Tokyo is an example of the rational use of limited territory - the kindergarten has an oval plan and a glazed format formed around the trunk of a fifty-year-old tree, the roof is operated and used as additional space for learning and children's games. The project embodies the concept of open space - the planning structure is characterized by the absence of separate rooms and offices (for the main educational spaces) and the child can be anywhere [7, p 293].

The architectural and planning solution of the institution, which demonstrates the formation of an open plan of the study zone with the location of furniture for different types of classes (games, reading, yoga, dance, etc.) is also present in the primary school WeGrow, which was built in New York. The preschool training center is completely built as a play space by the Montessori education system, which is known not to differentiate between children by age [8, p 102-103].

The "Stiffened Lava" Kindergarten in Beijing is an example of the rational use of the territory in difficult conditions and taking into account the urban context and demonstrates the similarity of architecture with a natural phenomenon. To preserve the historic traditional 18th-century housing that took place on the site, the architects proposed to create a flowing format that would bypass the modern high-rise buildings of the 1990s, which bound the site on all sides and would "absorb" historic buildings. The main architectural concept of the kindergarten building is to form a humane and spiritual atmosphere that combines old and modern architecture [7, p 295].

The urban context was also taken into account when designing the Forfatterhuset kindergarten in Copenhagen. The facade contains a clear color reference to the red brick buildings of the district, but instead of using traditional horizontal bricks, the facade and fence of the territory consists of vertical wooden slats that perform both a decorative and sunscreen function. The institution consists of small formats of houses with an original covering of facades, green roofs, and gardens, which create an individual and new image of the kindergarten [9, pp 305-307].

Flexible planning and open space are typical of Tellus nursery school in Stockholm, which is located between the forest and the former industrial zone in the area, which is now under development and expansion. The facade has a plastic shape in the form of a wave, it is covered with bright yellow wooden slats, and the main hall is spacious and contains children's groups for games and training sessions. Organic forms of the building determine its planning - the internal space is flowing, without corners, resulting the rooms of complex interesting shape are formed [10, pp 4-5].

Kindergarten Dalian School in Dalian, China, is also based on the idea of using natural plastic forms. The plan is built of individual modules in the form of pods that protect the seeds. Each module consists of a classroom in two levels, the lower level is combined with the general space of the hall [10, p. 5]. The use of natural materials in the decoration of the facades, thanks to which the building fits harmoniously into the environment, is demonstrated by the Fagerborg kindergarten in Oslo, Norway, which is located in the city park [10, p 6].

An example of combining into one architectural ensemble of a community center and a preschool is a kindergarten designed by MUMA Architects in Cambridge (UK). The composition is formed around the courtyard, which in turn is the center of the landscape and is completely safe for children, and does not need additional fences. The courtyard is a meeting place and a playground [11].

The Bath House Children's Center in London, designed by Lipton Plant Architects, is a prime example of the transformation of neglected buildings into Kindergartens. The institution was created during the renovation of part of the London plant, which served as a public bath in the 1930-80s. The accent was placed on the central wooden structure that connects the ground floor of the open plan with a raised platform for quiet play, reading, and relaxation [8, p 102].

The Children's Center Children's Home of the Future in Copenhagen is an example of an innovative project of a new type of 24-hour child care center. With the help of decorative tiles and wood, the architects managed to use traditional elements and forms of the building to create a home environment. The architectural image of the building combines the concept and idea of a safe environment of traditional housing with new pedagogical ideas about the space of a modern kindergarten [9, p 307].

An interesting example of a metaphorical building is the Giraffe Childcare Center, located in Boulogne-Billancourt, France in a compacted and formed urban environment. The purpose of the authors of the project was to create an interesting cityscape for children - it seems that the building is supported by a huge giraffe, which feeds by the leaves of the surrounding trees, and polar bears roam the area. The facades of the building are made of white corrugated iron, which provides a suitable minimalist background for large-scale surreal sculptures of wild animals. The building changes its identity and itself becomes a landscape - a metaphor of the urban jungle, where plants and wild animals become a natural and integral part of the architecture of the object. The project is an illustrative example of the skill of combining modern architecture with the historical context of the existing architectural and urban environment [9, p 309].

Kindergarten Wolfartsweier in Karlsruhe, Germany, is based on the image of a cat preparing to jump. The entrance to the building is located in the "mouth" of the animal, playrooms - in the paws, and the locker room, classroom, kitchen, dining room, and stairs - in the belly. The second floor is the head, which locates the hall, which is illuminated through eye windows. The roof has landscaping in the form of grass that mimics a cat's fur located [12].

Kindergarten Barbapapa in the municipality of Vignola in Italy is designed for 4 groups and 60 children in total. The location of the building is interesting in terms of urban planning and natural landscape - it is located on the edge of an urban building and in a picturesque locality on a hill near the historic center of Vignola. The planning structure of the kindergarten provides a green courtyard for children's walk in the fresh air. The building has dormer windows, the skillful location of which allows sunlight to enter the room at different times of the day. The roof is equipped with solar panels that provide electricity to the building, besides, there are special tanks that collect rainwater for further it cleaning and using in the household [13].

Kensington International Kindergarten, located in Bangkok, Thailand, demonstrates a harmonious combination of play space and architectural minimalism. The main purpose of creating such kindergarten is the maximum development of children's imagination and creative abilities. The building has transparent walls, no corners, crooked curved glazed partitions, which serve as a fence between the children's rooms and the street. All this allows children to contemplate the natural environment. In the territory adjacent to the kindergarten, in addition to lawns, toys, and recreation areas, there is also a roadway with markings, where children can ride cars or bicycles and learn the rules of the road [13].

Kindergarten in the village of Terenten in Italy is also located in a fairly picturesque locality, which belongs to the region, which is a border zone separating the three cultures - this factor influenced the architectural decisions in the formation and search of the image of the building. According to the architects, the kindergarten combines modern multifunctionality, fashionable design, and traditional motifs (using natural materials, decoration, and interior elements), which are quite successfully integrated into the mountain landscape. The kindergarten was built on the site of a former golf course, located near the primary school, which visually forms an architectural ensemble with it. The planning structure of the kindergarten provides large spaces for games. Besides, the kindergarten has a warm design with bright green elements, lots of sunlight, creative niches and stairs, terraces, and courtyards [13].

Kindergarten 8Units in Veles Rubio, Spain was created to develop children's psychomotor skills and their proper mental and social development. The architects created a bright and compact, as comfortable as possible for children one-storey building with large windows, sloping roofs, round windows with colored glazing. In the interior, the sharp corners were replaced by rounded ones. An interesting approach is the choice of colors in interior design: rooms for children of different ages have different colors (blue, orange, green), and common rooms have a set of all colors [13].

Kita Gottingen Kindergarten in Gottingen, Germany is an example of an energy-efficient eco-house that is fully self-sufficient in electricity. The walls of the building have a special construction that minimizes heat loss by keeping it indoors but allows fresh air to circulate freely in the space. There are also large dormer windows, so that sunlight enters the building at any time of year [13].

An interesting architectural complex is a kindergarten in Frederiksberg, Denmark. Even at the level of the announced competition, the winning architects proposed a non-standard project: a small complex of buildings that was stylized as a village and contained 11 small houses with different orientations. The visual image is based on how the children themselves could draw houses. Sloping roofs are laconic, the windows are designed to give the impression that they have no frames - this is what the windows in children's drawings usually look like. The rooms of the building have good natural light: all houses have large windows, and in some rooms, the walls and ceilings are replaced by a lattice frame, through which light also enters the room.

The interior of the rooms is made with a predominance of white. Each of the 11 children's houses is equipped with a large number of playrooms and playgrounds, many of which can be transformed if necessary for different needs. Several buildings have been set aside for the storage of children's toys, prams, and bicycles. At the ends of the building, two atriums connect different floors and serve as central collection points for children, parents, and kindergarten staff. The houses are slightly offset from each other, which allowed them to form small open zones for games and to provide access to daylight in the room.

Two winter gardens were created in the kindergarten, where children can relax all year round. There are playgrounds in the gardens among the plants, and in the summer the surrounding territory of the kindergarten turns into a large open-air playground. The purpose of the project was to create a suburban atmosphere for children, which is very lacking for residents of large cities [14].

It should be noted that the design of new kindergartens in Ukraine in cities is not a priority, in contrast to the housing. Developers prefer residential complexes, shopping and entertainment centers, business centers, and other commercial facilities that are more attractive for investment. The topic and problem of designing and building new kindergartens is considered very rare. Usually, when constructing a new residential complex, developers do not take into account this type of everyday service buildings such as kindergarten, and residents are forced to use the services of existing preschools in the territory, which are usually overcrowded by the number of children in the group.

However, there are some cases when developers understand how effective it will be to have a kindergarten in the structure of a new residential complex or residential area, which is being built to attract new buyers with children.

At the present stage of designing children's preschool institutions in Ukraine, there is a general direction of the individual approach. There is a trend of a qualitative leap in the design, construction, organization of educational buildings. However, unfortunately, the existing network of children's institutions is unable now to fully respond to social and demographic changes in society. [15, pp 452-453]. Examples of newly established kindergartens in Ukraine include LeapKids kindergarten in the Novopecherskie Lypky residential complex in Kyiv [16], kindergarten in Obukhivka (Dniprovskyi district, Dnipropetrovsk region) [17], and Babyland kindergarten in Rivne in the "Na Schaslyvomu" [18].

CONCLUSION

Thus, based on the performed research it is possible to indicate the main positions of designing foreign children's preschool institutions, which are based on the principles of sustainable development of settlements (Figure 1).

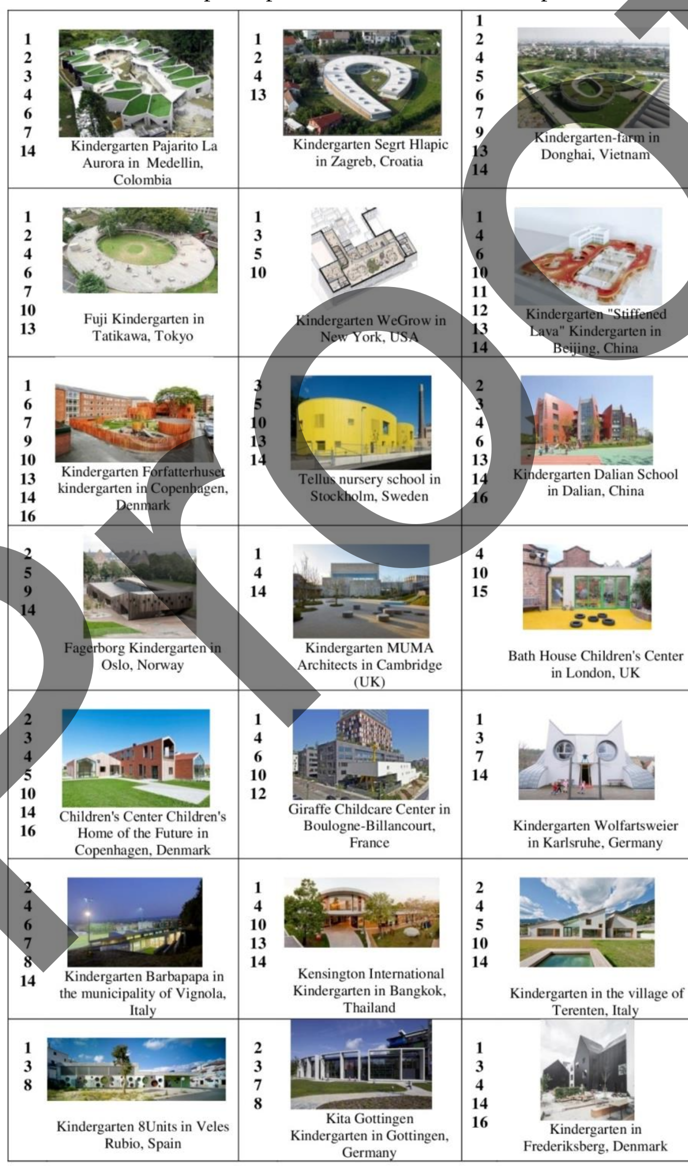

FIGURE 1. Taking into account the main factors according to the proposed nomenclature in the design of foreign kindergartens that use the principles of sustainable development. 1 ... 16 - characteristic factors according to the proposed nomenclature

1. Rational use of available territories in the conditions of the dense building of settlements, including sites with a difficult relief.

2. Inscription of new objects in nature and landscape conditions with their minimum transformation; use of existing natural and landscape factors to give expressiveness to the building and to create its architectural identity.

3. Using an economic, environmental, and modular approach.

4. Using open spaces in the structure of kindergartens (terraces, courtyards) for maximum merging with the environment and its contemplation.

5. Using natural building materials in the construction and decoration of buildings (stone, wood).

6. Design of landscaped operated roofs (recreation and training and research function), landscaped courtyards.

7. Application of energy-saving technologies (green roof, green facades), use of special wall constructions to minimize heat loss.

8. Using alternative energy sources: solar energy (solar panels on roofs), water energy (water collection tanks for rain and meltwater); using wastewater after treatment.

9. Application of local building materials.

10. Application of the concept of open space (accessibility of the child at any time to different rooms as needed and desired) as a result of taking into account the latest methods of education and training of children.

11. Careful attitude to the existing historical buildings, which have value in terms of architecture and urban planning.

12. Skillful combination of the formed historical building and new modern architecture.

13. Application of organic, flowing, smooth forms in the external image of the building and its architectural and planning structure.

14. Forming the image of a building based on a complex interesting shape.

15. Transformation of abandoned old objects of different typology for the needs of kindergartens.

16. Using simple forms of modules to form a complex form when combined.

Thus, it can be noted that these positions of foreign experience in designing kindergartens in the context of sustainable development of settlements require more detailed study and analysis to learn from the positive experience and implementation them in the development and construction of children's preschools in Ukraine.

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The Architecture of Eco-hotels as a Factor of Sustainable Development of the Territories of United Territorial Communities

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Abstract. The aim of the research is to highlight the features of architecture and design of eco-hotels in the context of sustainable development of the territories of united territorial communities. The European integration processes taking place in the country, and related to decentralization, are prerequisites for the transition of rural areas to the principles of sustainable development. In accordance with the developed goals of sustainable development for 2016-2030, one of their priorities is security, vital and environmental sustainability of territories. In the conditions of development of united territorial communities special attention can be paid to the extremely rich natural potential and cultural heritage of the region, they can be used efficiently and rationally for tourism development, in particular, the construction of an ecological hotel of small capacity. Ensuring the environmental sustainability of the building and increasing its comfort depends on the features of architecture, design and engineering systems that serve it. The concept of sustainable development of the UTC territory and the concept of low-capacity eco-hotels are proposed for successful functioning. Peculiarities of architecture formation of low-capacity eco-hotels are determined and ways of promoting sustainable development of united territorial communities are outlined, developing ecological, social, economic and cultural sustainability.

INTRODUCTION

In September 2015, the UN Summit on Sustainable Development in New York approved new development guidelines, including 17 Sustainable Development Goals (SDGs) and 169 tasks [1]. Ukraine, as a UN member state, has also joined the global process of sustainable development. A draft Strategy for Sustainable Development of Ukraine for the period 2016-2030 was developed, which included the national system of SDGs, taking into account the Ukrainian context and the principle of “leave no one aside” [2].

The developed strategy formed the population's vision of the conditions of the environment that the state should achieve in 2030. The strategy paid special attention to the new environmental policy, in particular, control of environmental pollution, improving the quality of life for all generations, including the following ones. Environmental

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priorities are included in all sectoral programs and plans. As a result of this work, society should get cleaner air, cleaner rivers and reservoirs, more forests and protected natural areas, separate collection of household waste, introduce resource-efficient wind and solar energy and other innovative technologies.

In most rural areas of Ukraine there are unstable working conditions with unstable material security of the population, low level of living and housing conditions, which encourage the migration of rural residents. Problems related to the deteriorating demographic and environmental situation, the destruction of social infrastructure and reduced life expectancy of farmers do not meet the needs of society, do not contribute to sustainable development of rural areas, so measures are needed to develop and implement local sustainable development strategies.

It is possible to increase the level of income of the rural population by conducting business activities. One such area may well be the development of tourism, which gained popularity before the Covid-19 pandemic. Accordingly, volumes of the hotel industry have increased. In the struggle for consumers, hotels actively use various concepts, including the "ecological hotel", which is especially relevant in times of environmental problems and unsatisfactory environmental conditions.

The development of eco-hotels, especially in the Western region of Ukraine, is potentially facilitated by an organic combination of the specific settlement of the rural population, natural and historical, ethnic and cultural values. However, the lack of developed infrastructure in areas suitable for eco-hotels; "Negative image" formed as a result of the Chernobyl Nuclear Power Plant accident; lack of requirements for state environmental certification of hotels; high cost of environmentally friendly products; inadequate state environmental control in the field of construction materials production; insufficient practice of eco-hotel management; lack of sufficient awareness of the population about the functioning of eco-hotels slow down the practice of their development.

First of all, eco-hotels must preserve the health of guests and rationally use natural resources, they must also cultivate environmental awareness and responsibility for their presence on the planet and for the consequences of their activities, and contribute to the sustainable development of territories [3]. Since the environmental safety of guests staying in eco-hotels depends not only on the work of hospitality establishments, but also on the design features, architectural and planning organization of the building, engineering systems that serve it, which proves that the topic of the research is relevant.

The aim of the research is to highlight the features of architecture and design of eco-hotels in the context of sustainable development of the territories of the united territorial communities on the example of the Western region of Ukraine. To achieve this goal, theoretical and empirical research methods (scientometric method, analysis of domestic experience in designing and constructing eco-hotels based on literature sources and field surveys), comparative analysis, classification, generalization and modeling are used.

MAIN MATERIAL PRESENTATION

In 2014, Ukraine began the reform of "decentralization", which changed the system of governance of local communities, namely, gave them financial authority to shape their effective development [4]. As a result of the order of the Cabinet of Ministers of Ukraine of June 12, 2020, 1469 territorial communities were created in the country (including 31 – in the uncontrolled territory within the Donetsk and Luhansk regions). As of October 25, 2020, the first elections of local chairmen and local council deputies took place in 1438 united territorial communities (UTC) [5].

European integration processes related to decentralization are prerequisites for the transition of rural areas to the principles of sustainable development. In accordance with the developed goals of sustainable development in the country, one of the priorities is to determine the security, vital and environmental sustainability of the territories. These tasks also include both economic growth and social responsibility and rational use of nature in the community. The process of decentralization allowed each UTC to independently use the resource potential of the region, increase the role of local culture in community life and choose the trajectories of its development. Natural and cultural features of the territory are increasingly perceived as a valuable asset of the community.

Sustainable development of UTC includes programs and strategies that will allow the community to adapt to the changes taking place in the country, to be competitive in terms of factors: human, natural and cultural resources; economic capacity, available infrastructure, innovative technologies and information capacity. The sustainable development of UTCs aims to improve the lives of both residents and guests of communities and involves the development of a concept that in turn includes social sustainability, economic sustainability, environmental sustainability and cultural sustainability (Figure 1).

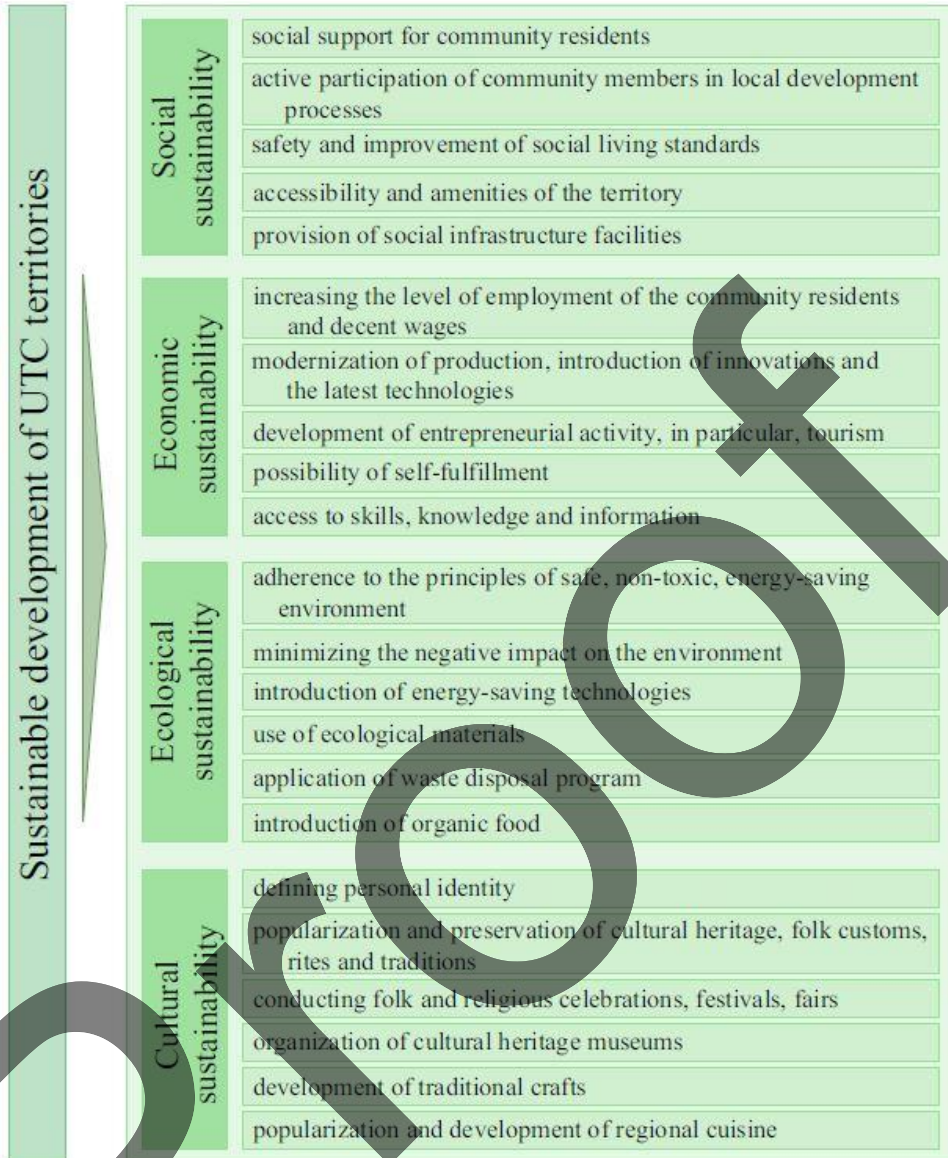


FIGURE 1. Structural model of the concept of sustainable development of UTC territories (developed by Kolodrubska O.I. on the basis of processed literature sources).

Promotion and preservation of cultural heritage, folk customs, rituals and traditions for their descendants in combination with the extremely rich natural potential of the region can be effectively and rationally used by the community for the development of the tourism industry and, accordingly, the hotel industry. The construction of an ecological hotel of small capacity – a hotel with a reduced load on the environment will especially help to solve ecological problems in the territory of the natural landscape of the community [6].

Ecological hotel or eco-hotel is an ecologically certified housing, the purpose of which is to improve the state of the environment by minimizing its own negative impact on the environment. Eco-hotel as an innovative concept of hospitality has a number of features: dependence on the natural environment; environmental sustainability; contribution to environmental protection; consideration of local culture; providing environmental support for staff; ensuring economic benefit for the local community. In addition, it is important for eco-hotels to adhere to strict "green" principles - visitors must be sure that they are in safe, non-toxic and energy-efficient housing. Certification by an independent third party or the country in which it is located is a prerequisite for the hotel to be granted "environmental" status [7].

The development of eco-hotels is influenced by a lot of factors. We will consider those that are also components of sustainable development of UTC, in particular, climatic and environmental, social and economic, cultural and traditional features.

In the decision-making process when placing an eco-hotel, a significant role is played by natural and climatic factors that require a careful analysis of the natural conditions in which the hospitable activity is carried out. For organized tourism, the recreational and recreational and economic area of Western Ukraine is used: they form a cultivated landscape, place recreation areas, tourist and cognitive trails [8]. It is especially important to have natural components (landscaping, ponds, terrain) on the site of the hotel and in the adjacent territory to achieve an organic connection with them; sufficient area for operation; optimal geometric contours of the territory; rational placement taking into account transportation and communications [9].

The environment is characterized by increasing pollution and increased interference in the processes of rational use and reproduction of natural resources. Today, two thirds of the territory of Ukraine is affected by an acute environmental crisis. Therefore, it is necessary to take into account the natural conditions and resources, as well as other components in the design and operation of eco-hotels and the reproduction of the natural environment. To do this, in the construction of eco-hotels it is necessary to use environmentally friendly materials, in operation - to use energy-saving technologies, save fresh water, treat wastewater without the use of chemicals by a special institution, sort all waste. Environmental factors determine primarily the comfort of the territory: compliance of sanitary and hygienic parameters of the environment with regulatory requirements, cleanliness of the air basin, noise level, aeration, insolation, etc.

The development of hotels, as one of the most important components of the tourism industry, is influenced by socio and economic factors designed to ensure economic balance in production and social activities. The daily practice of hotels depends on the perceptions of guests - consumers of products and services, suppliers of material and natural resources, competitors, environmental infrastructure, the work of qualified personnel, etc. In Ukraine, there is a rapid development of small hotels (with up to 100 beds), which are promising and in demand and can bring a stable income, especially located in the UTC. They are in high demand among a lot of tourists, as they aim to improve service, reduce prices and expand the list of services.

Cultural and traditional features are the features of the UTC society, regional identity, folk customs and traditions of the local population, the place of religion in public life and increasing the spiritual needs of residents, holding folk and religious celebrations, festivals, fairs, traditional crafts and traditional local cuisine. Their preservation and promotion should attract tourists, especially the use of natural materials in the construction of the building, elements of folk architecture in the exterior and interior, and local regional cuisine in restaurants or fairs.

The spatial structure of the hotel is built taking into account the complex technological processes that take place in it and should provide a clear division: the flow of guests staying at the hotel and staff.

The hotel building is divided into two functional groups: residential and public. The residential group consists of hotel rooms and rooms that serve them, and should be functionally and planning separate. Room types, their ratio and area depend on the hotel category. All hotels provide access and accommodation for disabled people in wheelchairs. At the same time, they provide single and double rooms with appropriate equipment, a certain width of passages and doorways, which have devices for unimpeded movement of people with disabilities, both horizontal and vertical communications.

The public group includes: reception and lobby; catering establishment; premises for consumer services and trade; cultural and leisure; sports and health; office, economic and production. Visitors of public buildings operating in the settlement where the hotel is located should not cross paths with hotel guests.

Catering establishments at hotels are restaurants, cafés, canteens, buffets, bars. Their activity at the hotel is the organization of food for residents (breakfast, lunch and dinner, etc.). Regional cuisine with a local flavor is especially welcomed by guests. In restaurants, it is recommended to allocate up to 10% of seats for people in wheelchairs, and seats for the visually impaired – at least 3 square metres each [7].

The main condition of eco-hotels should be considered as the degree of impact on the environment. Studies have shown that the number of accommodation and their distribution in the system of nature reserves do not always meet modern requirements for ecology and comfort. First of all, eco-hotels should have a positive influence on the health of guests and rational use of natural resources. Therefore, they are usually built in recreational areas with environmentally friendly building materials, and renewable energy sources are used for energy supply.

Ensuring the environmental sustainability of the building and increasing its comfort depends on the design features, architectural and planning organization of the hotel and engineering systems that serve it. To successfully operate and provide comfortable living conditions for guests, it is necessary to develop the concept of an eco-hotel. The purpose of the concept is to create comfortable living conditions, rational use of natural resources and energy-saving technologies, economic independence, determination of the identity of the area and in general to promote sustainable development of the UTC territory (Figure 2).

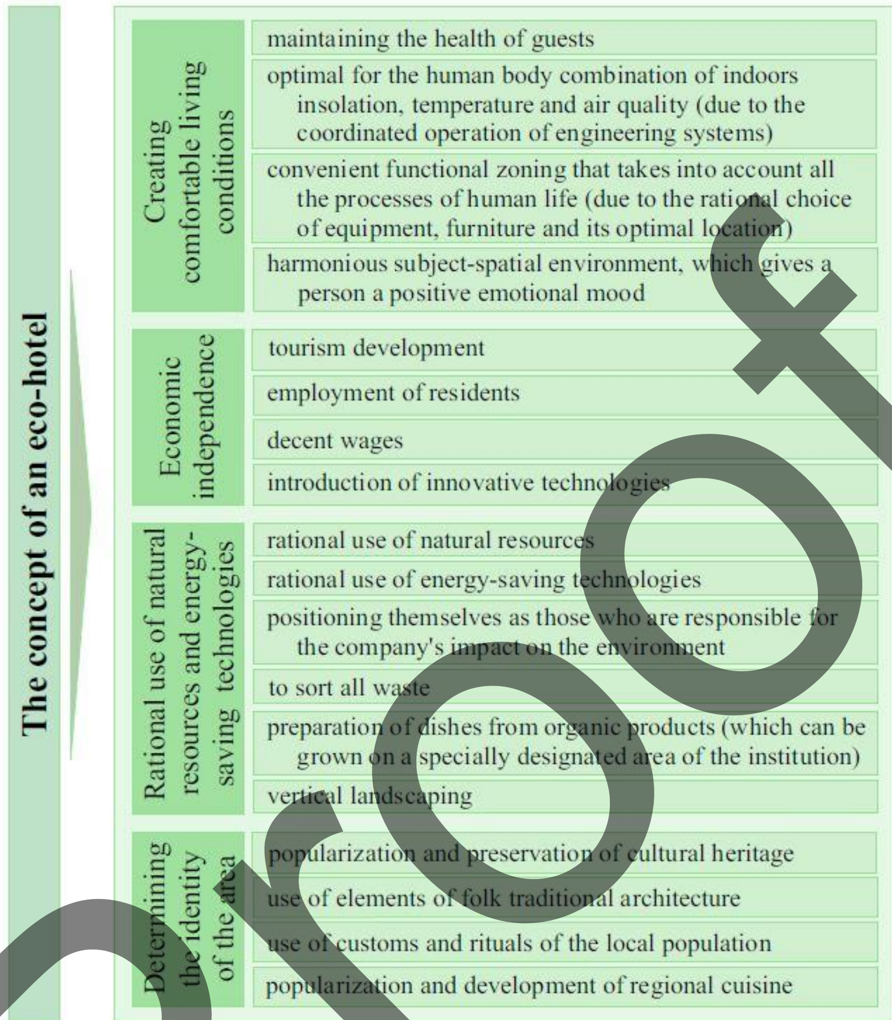


FIGURE 2. The concept of an eco-hotel (developed by Kolodrubska O.I. on the basis of processed literature sources).

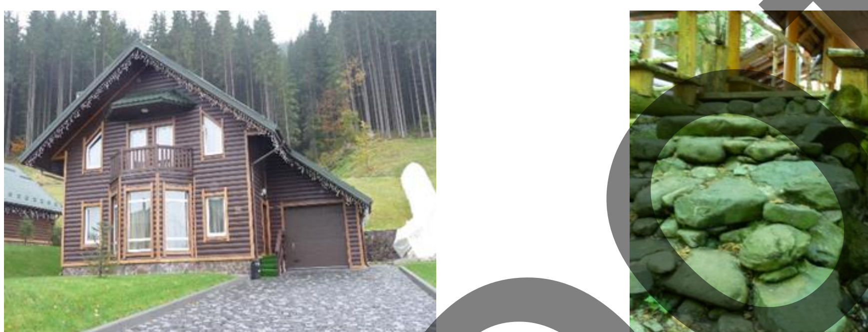
The peculiarities of the operation of eco-hotels include: environmental sustainability of the building; adherence to strict "green" principles of safe, non-toxic, energy-saving environment; minimizing one's own negative impact on the environment; introduction of organic food for guests; application of waste disposal program; providing environmental support for staff in the field of hospitality; appropriate hotel certification; taking into account local, regional culture and traditions, etc.

On the basis of the conducted research of architecture of eco-hotels of small capacity it is possible to define certain features of their formation, namely:

- definition of identity;
- concept creation (Figure 3);
- integration with the natural environment (Figure 4);

(a) (b)

FIGURE 3. Concept creation: a). Polyanytsya, Ivano-Frankivsk, region; b). Truskavets, Lviv region (a). photos from O. Kolodrubska's archive, b). photos from O. Diachok's archive).



(a) (b)

(c) (d)

FIGURE 4. Integration with the natural environment: a). Bukovel, Ivano-Frankivsk region; b-c). Lisarnya, Trans Carpathian region; d). Oryshkivtsi, Ternopil region (photos from O. Kolodrubska's archive).

- adherence to strict "green" principles of safe, non-toxic, energy-saving environment;
- use of elements of folk traditional architecture (Figure 5);
- adherence to the principles of space composition, color scheme, lighting, landscaping (Figure 6).

The task of architects in developing an eco-hotel project is to design an optimal environment for the human body, easy to operate, which takes into account all functional processes of human life, creates a harmonious subject space, takes into account regional construction materials, architecture and traditions and promotes sustainable development.

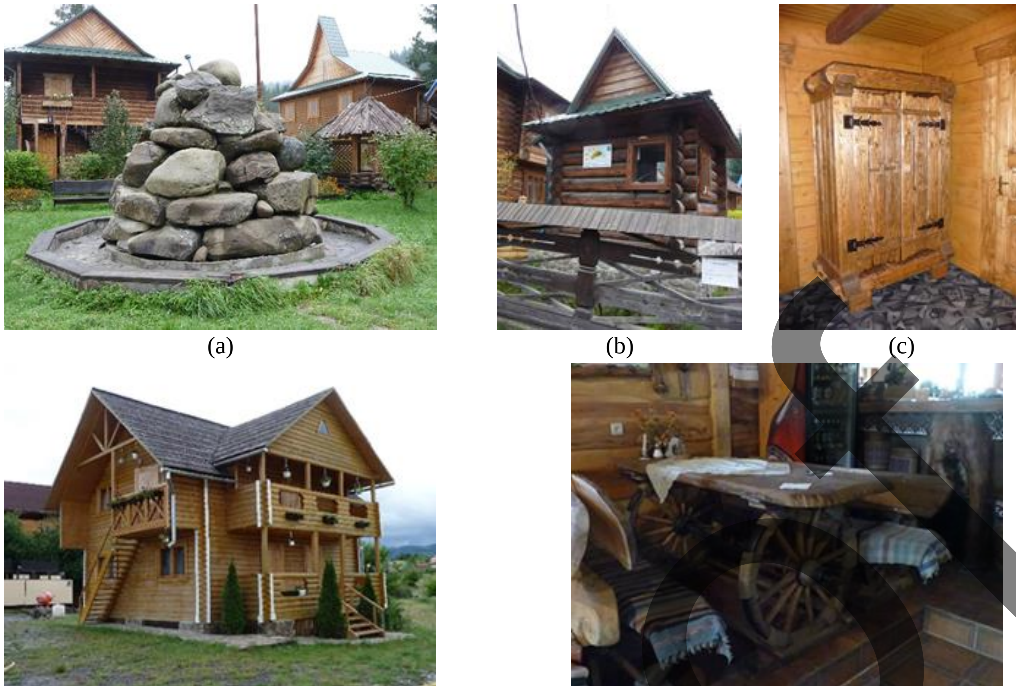


FIGURE 5. Use of elements of folk traditional architecture: a-c). Yaremcha, Ivano-Frankivsk region; d). Solotvyno, Trans Carpathian region; e). Yasinya, Trans Carpathian region (photos from O. Kolodrubska's archive).

FIGURE 6. Adherence to the principles of space composition, color scheme, lighting, landscaping: a). Solotvyno, Trans Carpathian region; b). Yasinya, Trans Carpathian region; c). Truskavets, Lviv region; d). Yaremcha, Ivano-Frankivsk region; e). Bukovel, Ivano-Frankivsk region (a, b, d, e). photos from O. Kolodrubska's archive, c). photos from O. Diachok's archive).

CONCLUSIONS

Found identity, uniqueness with organized tours, festivals, fairs, local attractions and traditional local cuisine will make the community popular with guests and tourists and bring economic benefits to the community.

The concept of sustainable development of the UTC territory and the concept of eco-hotels of small capacity are offered.

Peculiarities of architecture formation of low-capacity eco-hotels are determined and ways of promoting its sustainable development of united territorial communities are outlined, developing ecological sustainability – observance of "green" principles of safe energy saving environment, social sustainability – providing jobs for residents, economic sustainability – income for local community and cultural sustainability – defining personal identity and promoting and preserving cultural heritage.

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Reconstruction of Typical Residential Buildings as the Main Method of Architecture Development of a Modern City

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Abstract. The cities of our country are shapedof public and residential buildings. They were built in different years, each of the houses reflects the historical stage of the development of our society. Continuing the analysis, we can observe that typical residential buildings are the main component of our cities, they form frontal and three-dimensional compositional solutions of streets and squares of our country. Typical residential buildings had stages and trends in their development. With each decade, during 1955-1990, due to the increase in area and change of functional zoning, planning solutions were improving. Frontal and three-dimensional solutions differ little, and only by increasing the number of storeys, a variety of block sections and finishing the exterior walls the aesthetic qualities of buildings were improved. However, residential buildings have exhausted their life cycle. The main disadvantages: frontal and three-dimensional solutions spoil the aesthetic qualities of the city, the lack of comfort of landscaping, the entrance group planning does not meet the needs of people with disabilities. The author argues that reconstruction is the only method by which it is possible to improve and develop the architecture of the modern city. The structure of the internal functional space with the external environment is asingle system that determines the comfort of living. The article covers the methods of reconstruction, namely the re-planning of the interior of the entrance group and the apartment, additions and extensions to the existing building, modernization of facades, replacement and re-equipment of heating networks, creating a multilevel functional space of the yard. Techniques are the main component of reconstruction, which can be used to improve the functional-typological and three-dimensional solutions of the existing residential accommodation. Reconstruction is the main method of architecture development of a modern city.

INTRODUCTION

Typical residential buildings were constructed in the cities of Ukraine during 1955-1990. Residential buildings of industrial origin were needed to solve the housing problem, but today they have drawbacks. The main disadvantages: housing is obsolete, spatial solutions are in a state of disrepair, functional and planning solutions do not meet the needs of the population, and landscaping has become a continuous parking lot, which leads to harmful consequences for the population. Thus, the main problem is that typical residential buildings do not meet the comfort indicators for different segments of the population, especially those with limited mobility and negatively affect the architecture of the modern city.

RELEVANCE

Typical residential buildings, constructed according to building codes and regulations of the Soviet Union, were built using the latest technologies of the time. Typical site development has solved the main problem - lack of accommodation, but today they need reconstruction.

Nowadays there is a large amount of scientific work, project proposals, foreign experience in the modernization and reconstruction of typical residential buildings. There are scientific works with the analysis of experience of typical construction.

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In order to prove **the relevance** of this study, let us consider the work of experts who worked on the creation of project proposals. Thus, scientists who have studied the questions of reconstruction and modernization: Candidate of Architecture, Professor Bachynska L. G. in her works considers the analysis and development of residential buildings. [1], also analyzes and provides a classification of techniques that can be used during the reconstruction. [2]; doctor, professor Gnes I.P. dedicates his work to the evolution of apartment housing [3], Doctor, Professor Kutsevich V. V. considers the formation of a typical housing development [4], also participated in the development of state building codes [5].

The following specialists were engaged in the formation of practical areas, economics, urban planning, structures, planning solutions: doctor, professor Sleptsov O.S. devotes his work to such research: "Stages and trends in the industrialization of construction in Ukraine" [6], as well as devotes his work to the development of architecture of civil buildings; doctor, professor Yezhov V.I. worked on the problems of formation of residential buildings [7], participated in the development of master plans of residential areas of Kyiv: Teremky, Troyeshchyna, Obolon, Kharkivskiy, highlighted his vision in the practical work of reconstruction of residential buildings and new construction in the historically formed environmentand highly cherished the skyline of Kyiv; Doctor of Architecture Yablonsky D.N. engaged in potential areas of housing construction and in addition formed a systematic approach to the structure of the building [8] and others.

Dissertation research related to the study of housing reconstruction, Novosad I.G. [10], Akulenko I.V. [11], Zhydkova S.V. and others. State programs were developed in Ukraine, related to the reconstruction of typical residential buildings of 1955-1960 (five-storey small buildings) - State program "Reconstruction of residential buildings of the first mass series" (Approved by the Cabinet of Ministers of Ukraine, developed in accordance with the order of the President of Ukraine dated 18.11.1997 № 1-14/840 cl. 15 [12]. In 2011, the State developed the "Law on complex reconstruction of quarters and micro districts of obsolete housing stock" [12], but the program was not implemented due to the economic and political situation in our country.

The analysis of scientific works, project proposals, government documents, as well as self-study of typical residential buildings and landscaping allows us to conclude that the *reconstruction* is the only method to improve *the architecture of the modern city*. Existing proposals are mainly devoted to the reconstruction of five-storey typical housing and it should be noted that the proposals do not have a systematic approach to the reconstruction of typical housing with landscaping, do not take into account modern traffic load on the yard, which leads to spontaneity and chaos in functional zoning. Also, the existing works do not consider the reconstruction of the street, quarter as a single compositional system. All the disadvantages in the existing works emphasize ***the relevance*** of the chosen study and proves that only a complex approach to the internal space of a residential building with the external environment in the city system will solve the main problems of typical residential architecture. Reconstruction is the main method of developing the architecture of the modern city.

NOVELTY

It is argued that typical housing is obsolete and does not meet the needs of different segments of the population. Improving the structure of a typical housing stock is possible with a comprehensive approach to the reconstruction of the interior of a residential building with an external environment. The novelty lies in the disclosure of reconstruction techniques that can be used to upgrade a typical housing development, namely: spatial and functional-typological solutions of the existing housing stock and changes of the functional solution of the environment. The author provides techniques for the reconstruction of typical residential buildings in the city system and proves that the reconstruction is the main method of developing the architecture of the city.

THE MAIN SECTION

Architectural and urban compositional solutions are formed from public and civil buildings. Cities were built at different times and each of the buildings has architectural features, reflecting the time. The residential buildings are more common in building cities of Ukraine. Compared with public buildings, they create the main compositional solutions of streets, quarters, micro districts, and they are also the main volume in the organization of depth-spatial compositional solutions of Ukrainian cities. When analyzing housing construction, it can be observed that all residential buildings have distinctive features in architectural solutions and can be classified according to the time periods of their construction: historic, typical residential buildings, and residential buildings built by individual projects.

After the Second World War, the path of industrialization was chosen in the Soviet Union. Construction of factories and plants began, jobs were created in the cities and at the same time the population was growing, which led to a critical shortage of housing. To solve the problem, the construction of typical residential buildings began. Today, the typical housing stock of Ukraine is 72 million m2 [9, p.49], in Kyiv 70% of the total housing stock [12, p.15]. Therefore, we can conclude that a typical residential building is the main object in urban compositional solutions.

Typical residential buildings had stages and trends in their development. This is proved in the work of O.S. Sleptsov: "Architecture of civil buildings: industrialization" [6]. Five main stages have been identified, of which: 1955-1960 - mass construction of typical projects of residential buildings with small apartments; 1960-1970 - adjustment of standard projects; 1970-1980 - design and construction of houses with increased level of comfort; architectural and artistic formation of new residential areas and since 1990 the construction of residential buildings by individual projects begins.

To submit proposals for the reconstruction of typical residential buildings, it is necessary to analyze the planning decisions of the city master plan within the residential building and functional and spatial solutions of the existing housing stock.

The structure of a residential building is formed from the interconnections of the premises, which in turn are inextricably linked. ***The structure of a typical residential building should be considered as a combination of internal functional space with the external environment. This is a single system that determines the comfort of living and creates aesthetic qualities of the city***. Thus, the internal space of a residential building can include functional and typological areas: of common use: the vestibule of the house, corridors, places for mailboxes;typical apartments are the area of personal use. Residential buildings have different number of storeys. The connection between the floors is arranged with the help of stairwells, elevators, they are the main vertical communications. Each of the houses has a connection with the external environment of landscaping - these are: playgrounds and sports grounds, landscaping and economic areas - garbage collection areas, transformer vaults, ancillary facilities.

Typical residential apartments were designed at different times, according to different regulations and architectural solutions were changing. Let us consider the features of architectural solutions of typical residential buildings by stages of development.

Typical residential buildings of 1955-1960 were built mostly as five-story without an elevator. Distinctive features of the apartments are walk-through rooms, small kitchen - $5m^2$, combined bathroom. Each of the apartments has a summer room, mostly a balcony. The houses have transverse, longitudinal and mixed structural systems. The walls were made of panels and local materials.

The main disadvantages: the lack of elevators and ramps, which hinders the movement of people with disabilities; old heating networks, lack of meters, which does not allow you to independently control energy and save money; large heat losses from lack of insulation. The houses formed the compositional solutions of Kyiv, the residential districts of Nyvky, Vidradny, Pechersk, Chokolivsky Boulevard, and others were constructed.

Residential buildings constructed in 1960-1970 have insignificant different features in planning and volume solutions, the number of storeys in residential buildings of this period begins to increase to nine floors, which leads to a change in the planning decision of the entrance group of the building, elevator and garbage containers are designed. The main disadvantages are the lack of ramps, the size of the elevator car does not allow the movement of disabled people in wheelchairs, the kitchen and bathroom have a small area for modern equipment, and so on.

From 1970-1980, in the cities of Ukraine typical residential buildings with perfect planning solutions were designed and built, they were developed in accordance with the building codes and regulations II-Л.1-71. It is believed that the houses of this period are with comfortable living conditions for people. Residential buildings of this period have five, nine and sixteen storeys. Structural schemes: longitudinal and transverse-longitudinal. The walls are made of industrial panels and local materials. Regarding the functional and typological solution of the apartments, the apartments have a division into a living room and a separate recreation area (bedrooms and children's rooms), the kitchen area according to standards is $8m^2$, the apartments have a separate toilet and the bathroom, also in the house there are summer rooms - loggias are designed in the south, balconies – in the north. It should be noted that the area of the apartment increased by 10-11% compared to the previous years of construction. The entrance group of the house has a vestibule, an elevator, a place for mailboxes.

Negative features of functional and typological solutions: the lack of ramps for less mobile segments of the population, the dimensions of the elevator car do not allow the transportation of a wheelchair. Also, self-glazing of loggias and partial insulation of facades leads to the creation of a chaotic system of three-dimensional solution of houses.

Typical residential buildings built in 1980-1990 have sixteen floors made of reinforced concrete panels. The structural system has transverse load-bearing walls. Functional and typological solutions add auxiliary rooms: pantries, built-in closets, as well as halls in addition to corridors. During this period, one of the main goals is to increase the industrialization of housing construction using large-panel structures. The main disadvantage of residential buildings of this period is the large heat loss of the outer walls.

Landscaping, for all houses, has one drawback - an increase in traffic and lack of parking spaces, which leads to chaos. This is especially relevant to those buildings located near the central highways, where the first floors of residential buildings have been converted into shops and offices or public areas. The cars are parked near such houses and a continuous parking zone is created; the yards are turned into large parking lots. Playgrounds and recreation areas are located near vehicles, which is very harmful to human health.

General conclusion on the disadvantages of interior and exterior space and functional-planning space of typical residential buildings of 1955-1990: lack of ramps and elevators, inability to transport disabled people in wheelchairs by elevator, small area of bathrooms, neglected heating networks, lack of free space for people with disabilities, lack of comfort in landscaping.

The three-dimensional solutions of typical residential buildings have different number of storeys, the plasticity of the facade is based on metric and rhythmic compositional principles. The main disadvantage is the lack of spatial expressiveness, high heat loss of external walls, chaos in the glazed summer rooms, etc.

The structure of a typical residential building has exhausted its service life, this applies to typical residential buildings of all stages, and they need to be reconstructed. ***The reconstruction of internal functional space with external environment provides***: transformation of internal space of the house, replacement of external architectural elements, updating designs, improvement of networks of engineering and technical maintenance, as well as changing the space of the environment around the house in accordance with modern requirements for comfort and compliance with three-dimensional solutions within the urban situation.

Let us consider the basic techniques of reconstruction of the internal functional space with the external environment of typical residential buildings.

Re-planning of the internal functional-typological space of the apartment, considering the structural system of load-bearing walls.

With longitudinal load-bearing walls, partitions are non-load-bearing and can be dismantled, which contributes to the creation of individual planning decisions. You can perform re-planning, change the space of the apartment by combining rooms, bathroom and toilet, increase the space by using the area of summer premises, combine several apartments, change the configuration of partitions. Apartments with a longitudinal system are flexible. Also, with a longitudinal load-bearing system, additional volumes can be added to the main volume of the house. The connection between the existing building and the new one can be created by dismantling the apron wall, which is not load-bearing, and the door of balcony blocks. While carrying out the extension, it is necessary to consider normative indicators on insolation and urban planning situation.

In case of a transverse system, the external walls are non-load-bearing and can be dismantled and additional volumes added. The extension of additional volumes allows you to create flexibility in the interior and exterior of the house. Extension of terraces allows you to design green areas, recreation areas, and it is appropriate to design parking lots or garages under the terrace. The extension also makes it possible to create independent entrances to the apartment with the adjacent territory, which is convenient for less mobile groups of population.

As for the entrance group of five-storey buildings, it is necessary to change the functional and typological structure of the building, to add additional volumes with elevator cabins and a developed entrance group of premises. In nine-storey buildings, the layout of the first floor needs to be changed. Examples are 87 and 134 typical residential series of 1970-1980. Negative features of the entrance group of this period is the lack of such premises as: a place for a concierge, a developed lobby system, ramps, inadequacy of the elevator car for people in wheelchairs. The author proposed to redesign the entrance group by using the space of the apartment, redesigning the elevator shaft and installing a cabin for people with disabilities. (see Fig. 1).

Changing the three-dimensional and functional-typological solutions of a typical residential building can be done by the method of superstructure. The volume superstructure creates additional space. They can be used for apartments on two levels with a flexible planning solution. Flexibility is created by new design solutions. For example, the structural system of an existing house is with longitudinal or transverse load-bearing walls, in the superstructure we design a frame system, this technique will create a new free space.

Superstructures can be on the whole floor and of cascade type. The superstructure of cascade type gives the chance to organize an exit from apartments on a terrace with independent landscaping. In addition, you can create functional areas for general use by residents of the house. The addition of the superstructure improves the typical facade and makes it possible to create individual facades by changing the plasticity of the facade. The main positive feature of typical residential buildings is that they have different number of floors (varying volumes in the city). This makes it possible to create a variety of spatial solutions within the street, city, city panorama.

Figure 1. Examples of reconstruction of the entrance group in typical residential buildings. Plan of a tupical 87 series P-1-2-3-3, (a). Plan of a tupical 134 series P-2-2-3-3, (b). Option redevelopment of 87 tupical series (c)., Option redevelopment of 134 tupical series (d). Autor of the project Nivosad Iryna

The next approach - decoration and warming of facades. This technique makes it possible to create individual composite building solutions, to achieve minimal heat loss of the house. The decoration of a typical residential building must be approached comprehensively and necessarily considering the existing urban development.

To create comfortable conditions for landscaping, it is possible to use the techniques of superstructure of the floor slab over the existing landscaping at the level of 2,100 - 2,200. The constructive decision is a frame system with monolithic racks and an overlapping plate made of reinforced concrete. Functional and typological solution: arrangement of the parking lot, closed garages under the roof. On the floor slab can be arranged: playgrounds and sports grounds, you can grow trees and flowers, organize areas for walking animals. The main idea of this method is the separation of transport from the recreation area. The connection between the ground level and the floor is ramps and stairwells. When designing this type of sites, the urban situation and each case must be considered individually. This technique can be used with a large yard space, it is mainly the construction of typical residential buildings along the perimeter of the street.

CONCLUSIONS

Thus, the analysis of the study of a typical housing stock showed negative features in architectural and planning decisions. Residential buildings of industrial origin do not meet the requirements of the population and spoil the aesthetic qualities of Ukrainian cities. One of the positive features of a typical house is a strong structural system, and the difference in storeys creates a comfortable spacious space for a person. During reconstruction it is necessary to consider structure of internal functional space with external environment as the single system which defines comfort of living of a person. It is proved that during the reconstruction, with the help of techniques: re-planning of the entrance group and apartment space, superstructure and extension of additional volumes to the existing house, modernization of facades, replacement and re-equipment of heating networks, the creation of a multi-level functional space of the yard makes it possible to improve the functional-typological and three-dimensional solutions of the existing housing stock. **Reconstruction of typical residential buildings** is the main method of developing the architecture of the modern city.

The work can be useful for the educational process in the field of reconstruction, design, and further research in this area.

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Cumulative Development and Strategic Model of the Complex Process of Restoration-Reconstructive Transformations of the Historical Centers of Small Towns to improve the Life Quality in them

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Abstract. The article substantiates and gives a definition of the cumulative development of historical small towns. According to the positively assessed state of the existing dominant resources, the most promising three starting directions-activators have been identified, namely: touristic, cultural (ethnocultural), recreational, which can stimulate other resources for their joint influence on the cumulative development of historical small towns. Depending on the number of dominant resources, assessed positively, the starting direction-activator was defined as optimistic or inertial. A strategic model of the complex process of restoration-reconstructive transformations of the historical centers of small towns is proposed in accordance with the selected optimistic starting direction-activator: a small historical town is a tourist, cultural and recreational center. It has 5 components: ecological, historical, and cultural, infrastructural, social, and economic. Key scenarios and corresponding strategies for qualitative changes have been identified for each component: ecological - “green city”; historical and cultural - "cultural cluster"; infrastructural - "tourist hub"; social - “multi-comfortable city” and “active locals”; economic - "creative economy" and its resulting "rich locals", for their joint assistance in transforming the existing urban environment into a multi-comfortable one for living.

INTRODUCTION

The relevance of the study is determined by the need to solve the complex existing problems of historical small towns, which cause their degradation and to find new approaches for their future development. The novelty lies in the proposed new concept of the cumulative development of historical small towns and the developed strategic model of the complex process of restoration-reconstructive transformations of their historical centers.

Restoration-reconstructive transformation (RRT) is a complex process of interrelated restoration and reconstruction changes in buildings, open urban spaces, and the urban architectural environment as a whole to increase value and integrity and move them to a new qualitative level [1].

Cumulative development is a total qualitative development based on the accumulation of the historical small town's various positive properties, a combination of traditions and innovations (preservation of historical heritage, its maintenance, and supplementation with new, modern ones), which ensures its “revival” and continuity [1]. The external manifestation of the use of the accumulated properties of the city lies in its attractiveness (visual appeal, interest, and convenience for different people). Increasing the attractiveness of its historic center triggers a cumulative process in it. It is planned to determine the starting direction-activator for the activation of all urban resources that will stimulate each other for the final socio-economic development of the small town.

Researchers from different countries of the world dealt with the issues of the modern development of historical cities. They studied various aspects of the problem. It is necessary to highlight the significant contribution to the solution of the issues of protective zoning of historical cities, made by M. Dyomin [2], A. Gutnov [3], J. Jokilehto [4], E. Vodzinsky [5]; to the disclosure of the problems of preservation and restoration of their historical and architectural

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heritage - M. Orlenko [6], A. Tomashevsky [7]; regeneration and revitalization of historical buildings - M. Bevz [8], O. Rybchinsky [9], A. Golovatyuk [10], K. Skalsky [11]; their complex reconstruction - V. Vechersky [12], G. Osychenko [13], A. Pleshkanovska [14], Y. Raninsky [15]; revitalization and renovation of their industrial territories - V. Kodin [16], D. Kuśnierz-Krupa [17], V. Tovbych [18].

However, there is a need for a new approach to the development of historical small towns and a new methodology for carrying out restoration-reconstructive transformations in their historical centers. The issues of improving the quality of the urban environment of different value and destruction, which is characteristic of the historical centers of small cities of Ukraine, must be resolved at different levels, combining all restoration and reconstructive methods into a single complex. The balance between maximum preservation (conservation), restoration and introduction of a new one, change (renewal and transformation) of the historical urban environment can be established thanks to its cumulative development, which combines the best accumulations of the historical and contemporary for the transition to a new quality level and ensures its sustainable continuity [1]. At the same time, all existing buildings and open spaces should be considered not separately, but in the current context and as components of a single whole (historical center), where the structure, properties, connections, functions of each component and a single whole have a mutual influence [1]. And the chosen starting direction-activator will contribute to their activation, interest, and attraction of people to the historic small town, and thereby its "revival" and economic development.

STARTING DIRECTIONS-ACTIVATORS OF THE CUMULATIVE DEVELOPMENT OF THE HISTORICAL SMALL TOWNS

Starting directions-activators for the perspective cumulative development of the historical small town are determined based on the identified positive state of the existing dominant resources (natural-ecological, historical, cultural-ethnic and architectural, infrastructural, socio-economic). These resources were formed during the entire existence of the town under the influence of various factors (natural, historical and cultural, national and religious, socio-economic, historical and political, legal, information technology), depending on their activity. Using the methods of questioning and expert assessment, their state and degree of regulation were determined, namely: preservation and amplification (for a positive), correction (for inertial), and change (for a negative) state. A positive state - the resource is now actively used by residents for their mandatory and optional social practices, arouses interest to the town, and allows attracting people to visit it and spend time in it comfortably, and thus is an active source for improving the economic and well-being of the locals. Inertial - the resource is still underutilized and is not an effective source for improving the economic condition of the locals. Negative - a resource in an abandoned (or undeveloped) state, for the activation (development) of which more should be spent than is currently possible to get from it for the town's development.

The positive state of the resource is a marker for determining a possible starting direction-activator for the perspective cumulative development of the small historical town. It will contribute to the regulation of the state of other resources, their stimulation, and connection for further joint influence on the multifunctional and, as a result, the socio-economic town's development. The identified positive existing dominant resources, such as natural-ecological, cultural-ethnic and architectural, and historical, determine the corresponding recreational, cultural (ethnocultural), and tourist starting directions-activators.

The dominant resources should be considered as the sources for the development of urban places, which are associated primarily with the optional social practices of a person, with recreation and spending free time. This is because the presence and number of such places increase the quality of the urban environment and life in the town. It attracts the attention and interest of all participants in urban life at different levels (residents and tourists; scientists and designers; representatives of business and government; public organizations and local self-government). And, as a result, it has a positive effect on its economic situation. That is, the economic development of the town not only through the development of places associated with any specific industrial production, but the possibility of its development should be considered through the activation and improvement of the social, cultural, and environmental components of urban life, which will reinforce each other and together lead to an increase in economic well-being and quality life of locals. And the historic center is the center for their activation.

In accordance with the identified existing dominant resources and their assessed state as positive, the most perspective three starting directions-activators have been identified that can stimulate other resources for the cumulative development of the historical small town, namely: 1) touristic (for Klevan, Letychiv, Pochaiv, Shargorod) 2) ethnocultural (for Nova Ushytsa, Berezne) 3) recreational (for Kamin-Kashyrsky, Kopaygorod, Mizoch). They do not directly depend on the presence of any specific productions in these small historical towns, but they will actively stimulate the cultural, ecological, infrastructural, and social components of their urban life, which together will contribute to its attractiveness, economic development, and an increase in the well-being of the locals.

Depending on the number of dominant resources, assessed positively, the starting direction-activator was defined as optimistic or inertial. Optimistic (a combination of several of the above) can be: touristic-cultural (ethnocultural) (for Volodymyr-Volynsky, Lyuboml, Dubno, Korets, Lyubar, Ovruch, Olevsk, Gaisyn, Ilyintsi, Pogrebyshche, Dunaivtsy, Medzhibizh, Slavuta, Cherny Ostriv); touristic-recreational (for Berestechko, Melnytsya Podilska, Khmelnyk, Bilogirre); touristic, cultural and recreational (for Olyka, Ostrog, Vyshnivets, Kremenets, Gusyatyn, Skala Podilska, Bar, Brailiv, Bratslav, Voronovytsa, Mogiliv-Podilsky, Tyvriv, Tulchin, Nemyriv, Izyaslav, Polonne, Sataniv, Starokostyantyniv). The starting direction-activator, formed on the basis of one, positively assessed, existing dominant resource, should be considered as inertial. It can be considered as a part of the optimistic directions-activators proposed above. That is, separately taken touristic, cultural (ethnocultural) and recreational are inertial and can be considered as components of an optimistic starting direction-activator, namely: a small historical town - a tourist, cultural and recreational center.

In accordance with it, it will be expedient to create the strategic model of the complex process of restoration-reconstructive transformations of the historical center of the small town. It is necessary to highlight its various components, their key scenarios, and strategies for their development, which can also be applied to other small towns with an inertial starting direction-activator, which was proposed to be considered as the corresponding part of the above optimistic one.

RESULTS AND DISCUSSIONS. THE STRATEGIC MODEL OF THE COMPLEX PROCESS OF RESTORATION-RECONSTRUCTIVE TRANSFORMATIONS (RRT) OF THE HISTORICAL CENTERS OF SMALL TOWNS

The strategic model of the complex process of RRT of the historical centers of small towns is proposed in accordance with the selected starting optimistic direction-activator: a small historical town - a tourist, cultural (ethnocultural), and recreational center. Its 5 components (ecological, historical-cultural, infrastructure, social and economic) are highlighted. Key development scenarios and relevant strategies are defined for each component (Fig. 1). So:

1. **Ecological component**. Includes natural and energy (energy saving). It is necessary to take into account: the existing natural-ecological resource of a small town, the presence, development, and use of existing natural and artificially created "green" urban zones; as well as the ecological trace of the use and processing of fossil energy sources to ensure the functioning of buildings and transport; and thermal emissions from buildings. The existing natural-ecological resource of the overwhelming number of studied small historical towns was defined as positive. So, it is proposed its preservation and amplification for their further development and transformation of their urban environment into the multi-comfortable. The energy component (energy saving) was defined as inertial and negative. So, it is proposed its correction and change. The key scenario is "green city". The following strategies are proposed:

1a) transit transport and transport-intensive enterprises are outside the historic center, the development of ecologically clean public transport and bicycle transport: This will reduce CO2 emissions into the atmosphere;

1b) combining the natural and artificially created existing "green" urban areas into a single system of flowing "green" pedestrian spaces by complementing and creating high-quality equipped and functionally filled interconnected city parks, promenade embankments, squares, intra-quarter courtyards, parklets;

1c) "green quarters" - the organization of intra-quarter "green" zones after the rehabilitation of the territory from dilapidated buildings;

1d) organization of city parks on the territory of abandoned industrial and warehouse enterprises after its deactivation within the framework of revitalization;

1e) "green gardens" - the organization of green public areas and areas for public use by residents on the flat roofs of existing public and residential buildings, respectively, after their renovation;

1f) "green roofs" and "green facades" - the application of these techniques in the design of new buildings and during the modernization and renovation of existing buildings, which will help both clean the city air from pollution and reduce the effect of the urban "heat island", and reduce overheating of the buildings themselves in the summer and obtaining a comfortable microclimate in their premises without additional energy consumption for their cooling. Also, green roofs allow better management of stormwater runoff, reducing the simultaneous load on urban rainwater systems;

FIGURE 1. The strategic model of the complex process of RRT of the historical centers of small towns. Developed by N. Leshchenko. The concept of RRT of the historical center of Bar. Developed: V. Bogdanov, D. Dudchenko (students), N. Leshchenko (tutor).

1g) the use of alternative energy sources for the functioning of engineering systems of new and buildings after RRT;

1h) ecology and energy efficiency, as criteria for the sustainable development of buildings in each city, should be decisive in the choice of materials, technologies for the construction and operation of new buildings and in carrying out the RRT of existing ones. Ideally, newly built buildings should be passive and active, and buildings after PPT should be at least energy efficient. This will enable their residents not only to save on operating costs but also to earn at the same time [19].

2. **Historical-cultural component** and architecture as its reflection and material representation. It is necessary to take into account the existing historical, cultural, ethnic, and architectural resources. Depending on the definition of the existing state of the architectural resource of the investigated small town as positive, inertial, or negative, it is proposed to preserve and amplify, correct, or change it, respectively.

The question arises about the possibility and necessity of restoration-reconstructive transformations of the existing buildings and open spaces of the historical center to improve its quality (value and integrity), considering it as a basic resource for the cultural, social, ecological, and, as a result, economic perspective development of a small historical town. Since all transformation processes are aimed at developing and improving the quality of the existing historical urban environment, then, first of all, issues related to the weak points of small towns must be resolved. At the same time, in order to increase their attractiveness, emphasis should be placed on the use and enhancement of their existing individual advantages.

The historical center of any town should be seen as a cultural center. The key scenario for its activation and future development is the "cultural cluster" (filling the historical center with places, various functions, performance, and information that together will contribute to its development as a cultural center). The strategies for its implementation are as follows:

2a) preservation and amplification of the positive architectural resource of the town through conservation, restoration, rehabilitation, revalorization, and regeneration of the existing historical urban environment; correction and activation of an architectural resource defined as inertial by means of reorganization, renewal, and revitalization of the existing historical urban environment; and change defined as a negative state of an architectural resource through renovation and restructuring of the existing architectural urban environment;

2b) recreating the destroyed elements and lost monuments, if it is necessary to preserve the stylistic unity of a disturbed architectural ensemble, or as a revival of its historical and cultural memory. The construction of new buildings as compensation in place of those lost to restore the compositional integrity of the historical center, renew it after reorganization, and activate degrading areas. The formation of new buildings and quarters should keep the existing context, preserve the historical features of planning and development, provide for the preservation of the angles of the view of existing architectural monuments as the main ones in a given place [20]. Traditional planning, volumetric-spatial and functional features of the historic town center should be continued and reflected in its new buildings and spaces;

2c) preservation and revival, as well as the creation of new local traditions and their transfer to the modern functional content of the historical center, will increase its attractiveness and emphasize the uniqueness of each town, attract attention to it, and activate it [20];

2d) development of existing and creation of new public open spaces in the historical center of the town, high-quality for a long stay in it. They should be filled with places and functions associated with the optional social practices. People should be interested, convenient, comfortable [20];

2e) their importance should be restored or formed as key places of attraction, venues for all urban cultural events and favorite places for spending free time, by creating “objects-performances” of urban life and activating various types of “urban performance”;

2f) adaptation or functional addition of architectural monuments and historical buildings with cultural functions, namely the creation of town cultural and information centers on their basis; public media libraries; exhibition and museum complexes; creative ethnic-art workshops, where the demonstration of original art and handicraft products, typical for a given region, their sale and masterclasses for their production will be combined;

2g) complementing open urban spaces with cultural functions by transferring and extending the functions of buildings to the territory of the space in front of them. Creation of "art quarters", "ethnic streets", "cultural yards", "craft squares" as "objects-performances" and creative urban space;

2h) creation of an information portal dedicated to cultural events in the town to disseminate information about them and attract all potential users and “producers” of “urban performance” (residents, tourists, investors, activists, specialists), which together will contribute to the “revival” of the small historical town.

So, the above strategies for the implementation of the key scenario ("historical center - cultural cluster") for the development of the historical-cultural and architectural components of this strategic model of the complex RRT process in the historical centers provide a solution to the problems that violate the sustainable development of the small historical towns, and also reveal the proposed concept of their cumulative development in the system "place - person - tradition", based on a combination of preservation, restoration, competent modern use of the historical-cultural heritage and renewal of the existing architectural urban environment to make them more comfortable for living, interesting for visiting and investment, at the same time "revive" and emphasize the originality.

Thus, rich history in combination with preserved unique monuments of architecture and urban planning surrounded by historical and high-quality new modern buildings, complemented by excellent ecology and unusually beautiful nature should become the basis for the development of a small town as a cultural and recreational center and improve the quality of life in it. The next question is the availability of a developed infrastructure, interesting various functions, and equipped places for a long stay in an open urban space, which would attract the attention of tourists, fill and improve the daily life of locals. This is what is now lacking in most small historic towns.

3. **Infrastructural component** (tourist-service, pedestrian-transport). The issue of assessing the infrastructure resource of historical small towns for their perspective development was considered on both sides, as the presence and development of tourist-serving and pedestrian-transport infrastructure. Determining the quality of their existing state was carried out on the basis of the survey with the help of an expert assessment. The existing position of the tourist-serving infrastructure of the studied small historical towns was determined as negative, so it requires a change; pedestrian-transport - as inertial, which requires correction and activation. This offers the scenario "tourist hub". In accordance with the selected starting optimistic direction-activator: a small historical city - a tourist, cultural and recreational center, its historical center should also be positioned as a center for the provision of various tourist services and places for various types of tourism: event, historical-cultural, spiritual, recreational, "green" or ethnic tourism, and when combined them - to be considered as a tourist hub. For this, the following strategies are offered:

3a) creating a unified chain of tourist routes by combining small towns in the common infrastructure. The small historical towns of the studied region are very close to each other, have a common story, similar natural conditions, but different ethno cultural traditions and architectural and urban-planning features. This should be determined in the possibility of creating a common tourist route, for example, the "architectural necklace of small historical towns of Volyn and Podillia", where every small town will be a separate highlight and at the same time will complement and strengthen others for their joint cumulative development. The emphasis should be done on the development of event tourism, as the most effective to attract visitors to the town and finance for its development;

3b) the formation of town’s branding. Promotion of its individual qualities related to traditions, formed on the basis of natural, cultural, national-mental, historical production (craft) features, and its significant places to attract tourists’ attention. These places should be filled with functions that will help maximize the features of this town. They should be places of ethno cultural festivals, thematic fairs, open lectures, theaters, exhibitions, master classes, creative workshops of traditional crafts for the manufacture of souvenirs and transmission experience at the same time;

3c) the creation of tourist information centers in existing monuments or historical buildings, which are currently not used for their intended purpose, with their holistic restoration, revalorization, regeneration (for monuments), revitalization or modernization (for abandoned historical buildings), and functional addition or adaptation to new functions;

3d) the development of the tourist infrastructure of a small town through the creation or addition of the existing chain of hotels and hostels by adapting abandoned monuments and historical buildings during their holistic restoration, revalorization, regeneration and revitalization or functional renewal and re-functionalization of low-value buildings during their modernization and renovation, respectively, as well as if necessary, by providing a new tourist and hotel function to a new building during regeneration, revitalizing and renewal the historical center as a whole;

3e) creating interesting places of attraction by filling existing monuments and historical urban environments with various functions. Combining them (monuments, ordinary buildings, and open urban space) by common thematic scenarios of the historical center attractive disclosure, associated with the architectural and natural features of the small town, outstanding personalities and events, traditional life of citizens, and traditional folk crafts for transforming them into the "objects-performances” of urban life, for example, "Architectural Treasury", "Spiritual Center", "Green Beach", "Ethno City", "Art Courtyard", "Craft Quarter", "Street Masters of Folk Creativity". This was tested in the conceptual projects of the RRT of the historical centers of Bar, Starokostyantyniv, Olyka, Medzhibizh, and Klevan;

3f) creating convenient places for a long stay in open urban space, cozy rest, and creative free time;

3g) limiting the transport movement in favor of pedestrians. In general, the small-town historical center should be predominantly pedestrian, which will increase the quality of stay in it;

3h) ensuring convenient access to all cultural and tourist locations of the historical center and combining their common pedestrian zone;

3i) creating the interesting routes of attractive disclosure the historic center, which will be connected in a single chain all existing monuments, interesting sites, and places for recreation and spending free time; ensuring cognitive comfort and a long stay in them;

3j) landscaping of riverside territories and transform them into urban recreational zones; the disclosure and connection of them with the main architectural ensembles, the squares and streets of the historical center to create a single pedestrian space, as was suggested in the conceptual projects of the RRT of historical centers of Bar and Olyka;

3k) organizing the urban areas for rest and recreation on the basis of existing natural and artificial "green" zones; combining suburban "green" territories with existing urban "green" territories into a single recreational system [21];

3l) organizing the river tram network for tourist walks and water communication of urban "green" zones with suburban "green" zones (proposed for Olyka and Bar);

In general, to attract the attention of locals and tourists to a specific place, "to bring" them there, you can only increase its quality through the functional and physical filling. Therefore, the place that combines various functions, including the cultural, tourist-serving, and recreational, should not only be interesting, but also convenient and accessible to everyone, and only then will become socially active.

4. **Social component**. Its development should be considered from two sides. First of all, it is the creation of the conditions for improving the quality of living and staying in the town. Secondary, it is the locals' active participation in this process. Its existing state was defined as inertial. So, it is proposed its correction. The key scenarios are "multi-comfortable city" and "active locals". The first one should be considered generalizing and the most important. The scenarios "green city", "cultural cluster", and "tourist hub" with the corresponding strategies should be added as components to it.

A multi-comfortable city – is attractive for living and for different times of stay in it for different people, residents, and guests. The following issues should be resolved:

4a) maintaining a traditional pedestrian scale for all new buildings and open urban spaces. To create a comfortable and cozy stay in the historical center, it would be advisable to provide open parts of the ground floors of new buildings overlooking pedestrian streets or squares. They should be equipped with portable cafes, platforms for meetings, communication, recreation;

4b) ensuring the high architectural and utilitarian (functional) quality of the open spaces and buildings that organized them. When carrying out the RRT of the existing development and the creation of a new one, traditional compact residential quarters should be preserved, in which the courtyard belongs to residents for their joint use, and the first floor of buildings from the street side is given for various public functions that can be used by all. This will improve the convenience of living in these quarters and ensure their multifunctionality and the historical center as a whole;

4c) functional filling of existing buildings and the open urban space, that connects them, with the functions of optional social practices to improve the quality and maintain the traditional multifunctionality of the small town's historical center. The urban historical environment should be interesting and accessible for all its residents and guests, regardless of their age, social status, wealth, taste, needs, and capabilities. It should be adapted for a multi-purpose and for comfortable different times of stay and convenient movement for everyone in it. This will contribute to its socialization;

4d) the created pedestrian space of the historical center should be combined with various urban functions: residential, religious, cultural, commercial, places for work, study, recreation. The combination of functions and places associated with mandatory and optional social practices, by the single pedestrian space, will greatly enhance the convenience of the historical center.

An active social component also includes:

4e) engaging locals in dialogue about the development of their hometown. Their participation and decision-making at various levels from preparing and conducting surveys, forums, and urban festivals to evaluating projects for town development and their direct implementation;

4f) organizing international conferences with the participation of local communities, scientists, specialists, investors on the theme of revitalizing urban culture and bringing the existing architectural heritage into modern urban life.

The development of partnerships between all stakeholders in the creation and use of a multi-comfortable urban environment, namely: ordinary residents (urban community) - city authorities - business – scientists, and specialists, should become decisive in the proposed strategies for the development of the historical small city and the complex process of RRT of its historical center, aimed ultimately at improving the quality of life and economic well-being of its residents.

5. **The economic component**. The well-being of residents and the economic development of the small historical city is a result of the joint incentive and mutual influence through strengthening each other of the above four components. Assessed as inertial and negative, it requires correction and change.

The key scenario should be the “creative economy” and its resulting – “rich locals”. Emphasis should be placed on creating places and conditions for employment and creative disclosure of locals. In addition to traditional economic development based on existing material resources, emphasis should be placed on the development of a "creative economy" - not tied to material resources, based on creativity and the promotion of traditional cultural values. Namely:

5a) adaptation or re-functionalization of existing, respectively, historical or low-value buildings, which are not used, to new functions associated with local traditions and their propaganda. It is important to transform them into clusters of the "creative economy" (places for presenting creative works, selling them, exchanging ideas, working together on them, knowledge, culture, exchange of experience, high-quality spending free time). They will simultaneously become new places of work for locals and new places of attraction for tourists and investors;

5b) increasing the economic value of low-value residential buildings through renovation, thermal modernization, and ground floor's functional renewal;

5c) synergy of efforts and interest of locals, private investors, scientists, designers, territorial communities, and state authorities in the cumulative development of small towns and the complex process of RRT in their historical centers;

5d) quarterly development, as the distribution of interest in the urban environment (between residents, business and government) and prevention of mono functionality, equal distribution of functions and development of the entire street (historical center) and improving the quality of living;

5e) creation the perspective development' programs for each small historical town on the basis of the proposed strategies or the coordination of the proposed strategies with existing programs;

5f) the cumulative development of the historical small town through the activation of its accumulated best historical achievements and supplementing them with new, modern ones. Increasing their attractiveness (visual appeal, interest, and convenience for different people) will start the cumulative process and will further attract interested people and funds to the town for its development.

CONCLUSION

In general, the historical center should become a center where the existing dominant positive historical, architectural and natural resources together will create the basis for its transformation into a cultural center with developed green areas, social infrastructure, and tourist services that will actively function, reinforcing the importance of each other leading together to further economic development of the small town as a whole and improving the quality of life in it.

For all studied small historical towns, the perspective starting directions-activators for cumulative development, which will ultimately lead to their socio-economic development, is proposed, and the strategic model of the complex process of RRT of their historical centers is determined.

Each historical small town of the studied region should be considered as an independent integral entity in terms of territory and functions and with its own characteristics, as a sustainable carrier of national cultural identity. The same functions and territories (for example, the historical center) within a particular town acquire their own special features, which help to diversify them, make them interesting and unique. The acquired features depend on the context of the place, the townspeople, and their traditions. The formula "Place + Residents + Traditions = "Spirit of the place" works, it determines the uniqueness of each town. In addition, there are generally accepted laws in each town that allow the coordination of all its elements and make them function as a single independent whole.

Together, all historical small towns can form a unified system, where each of them will occupy a special place, and at the same time complement each other. Thus, it is possible to create a common tourist route through the small towns of Volyn and Podillya, where each town will become a separate "highlight", and at the same time an element of a common "necklace". The unification of small towns into a common tourist cluster will simultaneously become the basis and impetus for the activation of all components, namely: historical, cultural, environmental, infrastructural, social, and economic, of the proposed strategic model of the complex RRT process of their historical centers for the cumulative development of each small town and improving the welfare its inhabitants.

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“Habitus of the City” as a Sign of the Invariance of the Historic City and the Variability of its Structure

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Abstract. The study is based on a combination and generalization of existing scientifically based knowledge about the form and structure of the material structure of historically formed cities in Europe. It is constructed a concept of a typical city of a certain historical epoch (linked to a specific territory). It is known as *habitus of the city*. Such generalized knowledge can be described by the morphology of the city and its habitus. It is a certain innovation aimed at determining the formal features which are typical for a certain era and area. The meaning of this term is variable and depends on the living conditions, age and stages of development of the object under study. Therefore, it is proposed to consider ancient cities in different ways in the conclusion of the study. The habitus of the city may be a form of the material structure of the ancient settlement that is typical for a certain historical epoch and culture. There may be even modern historical cities, where *habitus* is a physical form and morphological structure, which expresses the uniqueness of the historically formed city in a particular area. Fifty historic cities are described in this study. The value of historically formed cities of the western region of Ukraine is emphasized. Their habitus is determined. It generalizes and defines the predominant type of their material structure on a morphological basis.

INTRODUCTION

It is an undeniable fact that today's theory of city planning has an unenviable position and is associated with conceptual heterogeneity and theoretical ambiguity (in this study, the theory of city planning is considered as a field of scientific activity. The peculiarities of the formation and functioning of the material substance of the city in this area are investigated. In this case, it is a component of urban planning). These factors are presented in the methodological approaches to the study of city planning. Truly relevant are those aspects which are related to the formation of new ideas and different application of the same concepts and methods. This creates misunderstandings not only within city planning, but also complicates the process of its development and interaction with other scientific disciplines.

Today urban science is meeting the challenges and can produce new knowledge and explain the nature of the different states and the relationships between them. This trend forms a comfortable environment for modern cities in various ways. There is a clear connection between city planning and urban planning. This connection determines the development of its theoretical foundations in the direction of interdisciplinarity.

Forms of interdisciplinarity in city planning can be quite different: application of new concepts, formation of new methods, development of classical theories, etc.

So, one of the most effective and promising tendency that helps to integrate modern scientific knowledge about the city is the development of new methodological concepts for the study of complex urban objects and related life problems: *urban sociology* [1] or *participation* – the social aspect, *urban ecology* [2, 3] – ecological aspect, *artificial neural network (ANN)* [4] – *philosophical* (artificial intelligence) and *robotics* – technical aspects, etc.

This situation determines the importance and relevance of studying a number of categories. They can describe and analyze the objects of city planning. Still, a number of concepts require clarification and specification of their content. Moreover, it is necessary to place these categories in the context of urban planning theory. There is some king of

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another reality. On the one hand, cities are constantly undergoing transformations under the influence of today's challenges and this process is related to the rhythm of life and its economic reality. On the other hand, there is an urgent necessity to preserve the national architectural and urban heritage of historic cities.

At the same time, even these aspects need some improvement of traditional thinking in relation to urban planning, developing the methodology, expanding the available theoretical and methodological tools in city planning and supplementing them with the achievements of other scientific fields which are not always related to each other.

In fact, this research of theoretical character is directed on the solving of these multifaceted problems. Current situation reflects the modern needs of city planning in the direction of eliminating research gaps which are characterized by lack of analytical study and expansion of traditional thinking in relation to the formation of material content.

BASIC THEORY PART

This study is aimed at expanding abstract cognitive ideas, concepts and theories about the formation of the material and spatial environment of the city. Such environment contributes to the development of urban planning theory and its relationship with other branches of science. Professor Anne Vernez Moudon (president of ISUF (International Seminar on Urban Form) between 1997 and 2005) notes that she uses a “scientific approach” to understand the objective and subjective aspects of the city. In her interview [5], she critically but quite objectively assesses the role of urban planners in the design. She points out that the morphology of the city and its objective reality is very important.

She also notes the next: “This object quality of the city may not (even never) really exist as such in people’s minds, but it is an essential baseline component of the planning process: it is the only thing we can measure objectively, meaning that the physical object is what we can agree on, and what we necessarily share. This physical dimension of the city is a common baseline from which we can then assess subjective aspects such as preference, meaning, usefulness, etc.”.

Given this fact into account, we can assume that the morphology of the city is able to generalize knowledge about the patterns and features of the formation of the material structure of the city. It is also possible to allow a partial interpretation of the judgments made about it. The morphology of the city is defined extremely broadly in modern research. It can be considered as one that has an ontological and epistemological basis for the philosophical understanding of reality in the context of general theoretical discourse. Moreover, it is an integral part of it. The issues of ontological principles are related to the components of the morphology of the city as a scientific doctrine (methods, principles and means). They serve as a certain tool for morphological research. Epistemological principles define the morphology of the city as a field of scientific knowledge. It is a doctrine of form and structure [6]. The morphology of the city is considered as a set of theoretical, methodological and methodical provisions in city planning studies. They are based on the systematization of knowledge about the form and structure of the material structure of the city [7].

Research objects are concentrated in the hands of the supporters of the theory of urbanism from the United States, Canada and Europe. They cover the theoretical and applied principles of urban morphology and develop different approaches to the study of morphological characteristics of urban objects. There is a large number of studies, but the key role has the ideas of A. Moudon [5], the concepts and methodological approaches of C. Alexandr [8, 9], J. Beirão [10], G. Caniggia & G. Maffei [11], M.R.G. Conzen [12], G. Curdes [13], S. Kostof [14], L. Krier [15], R. Krier [16], K. Kropf [17], S. Muratori [18], V. Oliveria [19], E. Raith [20], J. Whitehand, B. Cherkes [21] and many others.

The theoretical bases of the study are:

1) the principles of compliance with the relationship to the existing system of scientific knowledge about morphology and complementarity – it is the relationship of the subject to the object and subject of study;

2) concepts that reflect the formal qualities of city objects: a) *geometric characteristics of the physical form of the city* (by its general form, the nature of the contour and numerical values) and b) *system parameters* (complexity, homogeneity and physical size) that are typical for its morphological structure (by distribution and textural characteristics). The physical form of the city should be understood as an objective characteristic of the connected part of the city bounded by a closed conditional line. It can be considered as the one thing with all available natural and anthropogenic components. The morphological structure can be considered as the internal structure of the city (or any another city object), that consists of properly located and ordered components of its material structure (structural elements) and is determined by the most significant morphological features (fig. 1).

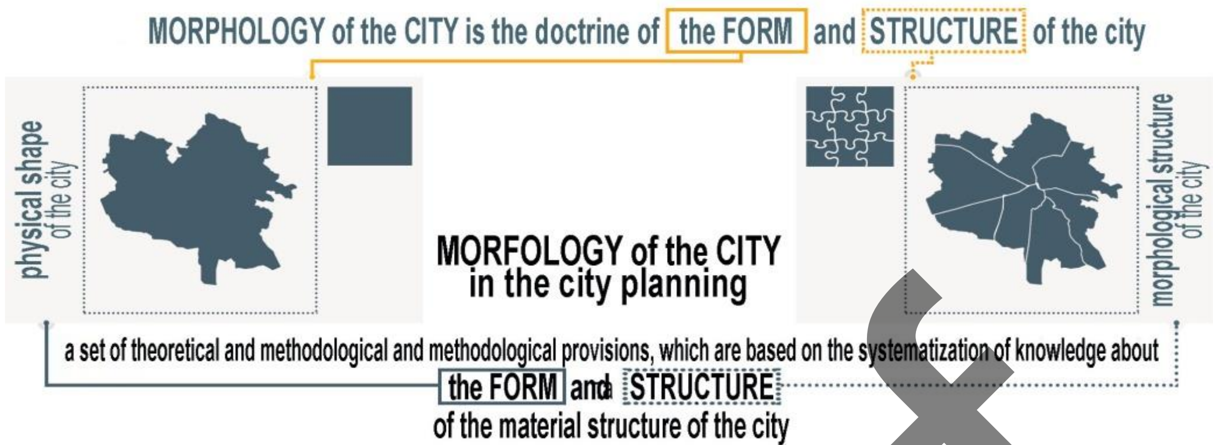

FIGURE 1. Definition of the morphology of the city and the peculiarity of its definition in city planning

The basic morphological types of the material structure of the city are assumed on the basis of the whole set of values (possible to determine the qualitative and quantitative characteristics of the form and morphological structure) (fig. 2).

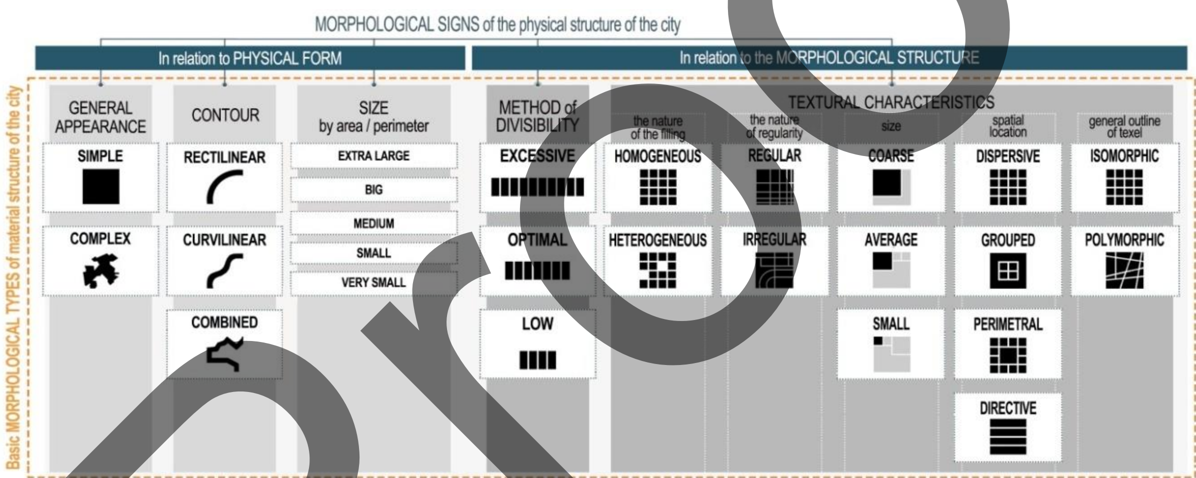

FIGURE 2. Systematic classification of the main types of hard (material) structure of the city by morphological features

The study of morphological characteristics of the material structure of historically formed cities is not limited to a thorough description of their formal properties, which were at a certain territory and are recorded at present. For example, there are many examples of ancient settlements in the history of European city planning. The shape and structure of these settlements were established over time and today they are a source of deepening and expanding knowledge about the development of the territory and defining the factors influencing its formation.

So, it is better to integrate objects with modern and historically developed morphological characteristics to the morphology of the city, as well as ancient ones that were typical objects of that certain period. However, the developed theoretical and methodological tools can be used to study the material structure of cities that are randomly selected and exist now. Ancient settlements need to be confirmed by the basic characteristics of the object morphology that meet the criteria of objectivity, formal integrity and divisibility. Such information is mostly based on the results of archaeological research. Peculiarities of material content and organization of ancient historical cities may be seen in traditions, legends, folk memory, experience, plans and other possible sources. Still, only archaeologists can make a full objective conclusion of the formal qualities of the object known in the morphological context. They detect and confirm data concerning the quantitative and qualitative composition of structural elements of ancient settlements, such as quarters that show the nature of the material content of the city, fortifications that define its boundaries, their structural organization, size, configuration, location in relation to other buildings, side of the world, natural components, etc. These features have formed the appearance of settlements and now influence the perception of the relevant culture in a broad sense: aesthetic tastes, world trends, lifestyle, factors of development etc.

Morphographic, historical and typological methods constitute the methodological basis of the study. So, the similarity with the morphological features selected at the synchronous level is established by reproducing the structural elements of specific, historically established cities at different stages of their formation. A certain morphological type is established in accordance with its meaning. The result of this approach is obtaining ready-made schemes that indicate the typical form and structure of the material structure of a particular historical city (including the ancient one) in a certain period of time (fig. 3). It is proposed to use the idea of practical meaning of P. Bourdieu to implement it – *"habitus"*.

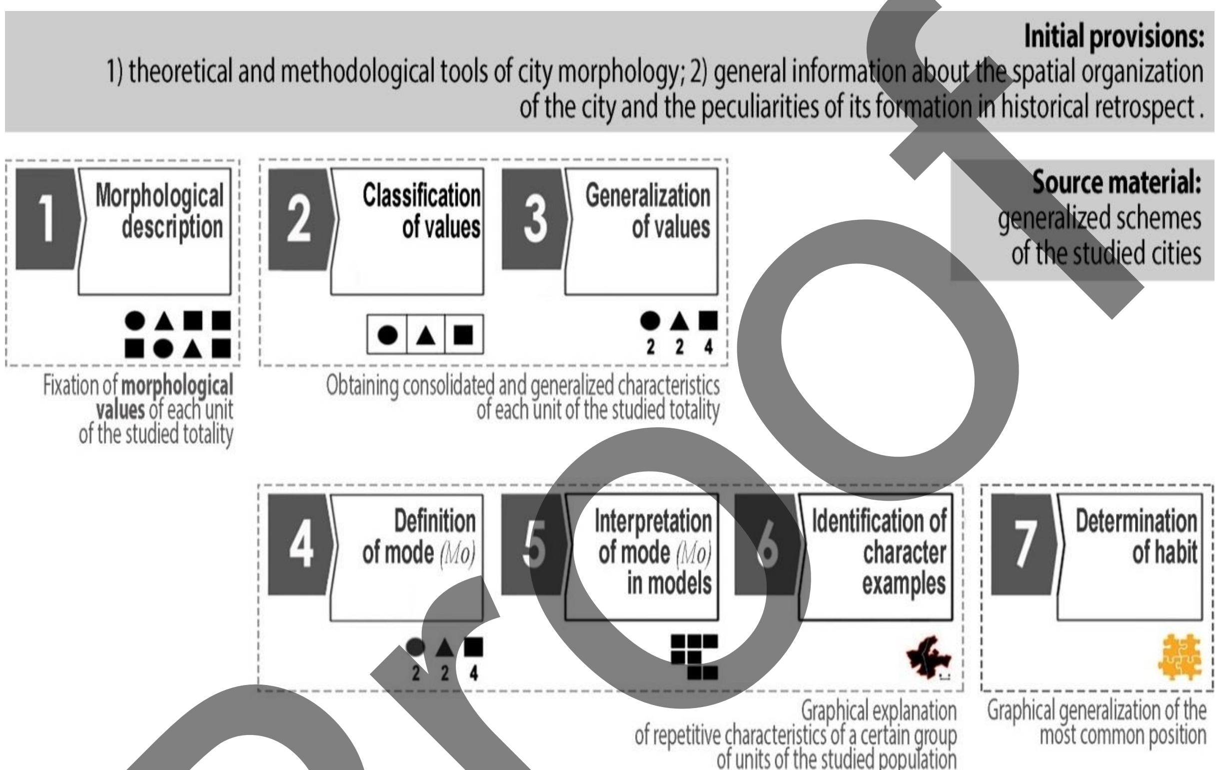

FIGURE 3. Systematic classification of the main types of hard (material) structure of the city by morphological features

The origins of habitus and its etymological significance

With the concept of *habitus*, which embodies the practical content and specific form of evaluation of the object of knowledge, you can conceptually set the framework. In this framework it is possible to analyse only the material component of the city and the formal side of its expression.

The word habitus is etymologically related to the word *habitus* ("habit"), which is borrowed from Latin and means "*appearance, look and posture*". It is associated with the verb *habeō* "*to hold, store, contain or have*" [22, 23].

Habitus reflects a set of characteristic features of the object of knowledge at the general scientific level. These characteristics are expressed in its form and structure. Habitus is not permanent and can change depending on the location of the object and a variety of factors that affect its development. Habitus has found its place in many fields of knowledge. As a scientific term it accurately and clearly defines a special concept of the characteristic form and appearance of the object of knowledge. The term has received the greatest scientific use in biology, mineralogy, philosophy and in sociology (especially recent decades).

Using and generalizing the classifications proposed at different times, the biologist I. Serebryakov proposed to call the life form of certain groups of plants as *habitus*. "*We can understand the uniqueness of certain group of plants as a life form. It is expressed in the specifics of their seasonal chanchings, annual growth and regeneration, in the* *internal and external structure of their organs and, as a consequence, in its type or habitus of the plant, which historically appeared in certain soil and climatic zones and reflects the adaptation of plants to these conditions"* [24].

So, the botanist understands the life form as a kind of habitus (appearance/exterior) of groups of plants that were historically formed in certain environmental conditions. They have appeared in ontogenesis in the result of growth, development and adaptation to different environmental conditions.

This term is used to describe the features and clarify a particular concept, phenomenon, form, era in other branches of science. For example, the phenomenon of habitus was studied by the philosophers G. Hegel, E. Durkheim, M. Weber, O. Spengler and many other prominent people. O. Spengler was a German philosopher, a representative of a "philosophy of life" and one of the founders of modern philosophy of culture, explained culture as the image of a living super-plant.

In his opinion, habitus covers the whole set of life manifestations of integral cultures at the level of comprehension of the style of culture. In addition, habitus has all properties associated with determining the signs of life expectancy and a certain rate of development of a culture [25]. He used the concept of *habitus* to define the features of *a particular historical culture* and considered it as *a clarification of such notion as style*. O. Spengler believed that the identity of culture is poorly fixed in the concept of "style", but the term "habitus" makes it possible to clarify this identity more clearly and deeply.

P. Bourdieu was a sociologist and philosopher. He was the first who scientifically substantiated the concept of *habitus*. He interprets this notion as a quality that combines such concepts as positions, dispositions, traits, properties and practices and is a result of mastering certain knowledge and experience [26]. P. Bourdieu was a sociologist, which is why his research was sociological one. He explained the concept of "habitus" in his own way: "… *we get a world of common sense through habitus, a social world that seems so obvious*."

Functional and semantic principles of habitus in city planning

An attempt to apply the concept of *habitus* in city planning was made by sociologists to point a certain place, city or region [27].

Taking into account that habitus can outline the formal side of the object of knowledge and bearing in mind the whole set of specific and fundamental provisions for the morphology of the city, it makes sense to apply it in city planning in the context of studying the formal expression of the material structure of the city.

Habitus can indicate form and structure which can be typical for a certain historical epoch in terms of time. If we are talking about space, then it can be applied for certain territory. Its content will be manifested in the context of morphological research more specifically. It is done in order to identify the uniqueness of historically formed cities of a particular region that is expressed by its morphological features. There is a definition: *habitus of a city* is a set of morphological characteristics of the material structure of the city, which are typical only for a certain epoch and a certain culture (specific area).

The concept of *habitus* was first used in the context of city planning by the author in order to highlight unique forms and structures of the old cities of ancient Greece that are manifested in the external outline and internal structure of their material content [28]. The definition and generalization of such features was based on a sufficient evidence base and is confirmed by numerous archaeological finds, written evidence and graphic materials.

Let's assume that knowledge of the form and structure of the material structure of the historical city of the western region of Ukraine is enough to describe the morphology of the city. Let's say that those *morphological features that are typical for a particular area at a given time will correspond to habitus as a kind of concept of typical shape and form material structure of the city, which is created at a certain territory in a defined historical epoch.* It is worth noting that historical city has the values that are typical for traditional urban civilizations. It is a city that has preserved a unique form, traditional planning structure, appropriate cultural, historical and architectural environment over the centuries [29]. The concept of *habitus* will have diagnostic value at this stage. It will determine a formal assessment of the uniqueness of certain settlements, expressed in the specifics of their development and ways of transformation (or the ability to adapt to certain conditions). It can easily draw attention to the problem of preservation of the originality of historically formed cities and can be described as a normative category in the practice of city planning.

Age and stages of development of the city, the specifics and significance of habitus may differ depending on the conditions of existence. They are especially important for ancient and modern cities. Material structure of the settlement that is typical for a certain historical epoch and culture might be habitus for *ancient historical cities*. If we are talking about *modern historical cities*, then it is about form and structure, which expresses the originality of the material structure of the historically formed city in a particular region.

It should be noted that the application of habitus to ancient historic cities is more correctly compared to its application to modern historic cities. This is due to the fact that ancient historic cities have already completed their so-called “life cycle”. It gives grounds to distinguish forms and structures which are typical for a particular historical epoch. Instead, the application of the concept of *habitus* to the modern city is not correct enough, because such cities are in the process of their development. However, a concept *habitus* is also applied to a modern and historically formed city as it defines the morphological features which are typical for a historically formed city and a certain region.

Comparative and typological analysis of the material structure of ancient European cities has shown that their habitus may differ in the context of place and time. For example, habitus is defined by a simple form and irregular structure for the cities of ancient Greece. It is a simple form and regular structure for Ancient Rome. It is a simple form and irregular structure for medieval cities.

There is a fact that most cities lost their original form and structure in the process of development. Still, using habitus it is possible to assume how they have been developing and changing over time and what factors have influenced this process: natural or anthropogenic.

For example, the material structure of the ideal city of Palmanova and Roman Fluentia (modern Florence) has not changed its morphological characteristics. We have other examples of ancient cities which do not have their original forms. These are Londinium (modern London), Vindobona (modern Vienna), Colonia Claudia Ara Agrippinensium (modern Cologne) and many others. So, we can trace the features of their formal development by comparing habitus and places of concentration of ancient Roman settlements.

Habitus of modern historical cities is expressed by the change of a simple form to the complex one and a combination of different types of structures, such as regular and irregular.

Signs that determine the originality of the material structure of historic cities in the western region of Ukraine

Determining the uniqueness of modern historical cities in the western region of Ukraine is based on the morphological features which are typical of their material structure. The generalization of such features can determine habitus. Habitus has historically formed at a certain territory and in a certain period of time. At the same time, the most expressive morphological characteristics of the material structure of historical cities are taken into account. Moreover, the study has a complex and generalized assessment of morphological features in accordance with the values that is presented on the figure 2.

Legal norms and standards were the criterion in the choice of historic cities:

1) the concept of a city is recognized at the legislative level (by the resolution of the Cabinet of Ministers of Ukraine on July 26, 2001 № 878) as a historical settlement with adoption of Magdeburg law in XIV–XVII centuries due to the significant influence of this system on its formation;

2) Ukrainian classification of cities by the number of population and accepted values of at least 5 thousand people.

The morphological description of 50 historical cities located in the territory of *Ivano-Frankivsk (Ivano-Frankivsk, Kalush, Kolomyia, Nadvirna, Dolyna, Bolekhiv, Snyatyn, Tysmenytsia, Horodenka, Tlumach, Rohatyn, Halych), Lviv (Lviv, Drohobych, Stryy, Sambir, Zolochiv, Brody, Sokal, Stebnyk, Gorodok, Zhovkva, Yavoriv, Zhydachiv, Kamyanka-Buzka), Ternopil (Ternopil, Chortkiv, Kremenets, Berezhany, Terebovlya, Buchach, Borshchiv, Zalishchyky, Pochaiv, Khorostkiv, Zboriv, Kopychentsi, Monastyrska), Volyn (Lutsk, Kovel, Volodymyr-Volynsky, Rozhysche, Kamin-Kashyrivsky, Lyuboml) (Rivne, Dubno, Ostrog, Berezne) regions and Chernivtsi* was carried out according to the defined criteria. The integration and generalization of the combined values of the characteristic features of the material structure of historical cities have shown the morphological types of historical cities that are typical for the western region of Ukraine (the *mode* – (statistics) is the value that appears most often in a set of data values (*Mo*).

These types include the following characteristics:

a) general form – a complex type that is typical for the material structure of 50 cities, which is 100% of their total number. 4% – correspond to the III, 42% – to the IV and 54% – to the VI class of complexity. For example, let’s have a look at Zhovkva (Lviv region). The general lines of the physical form correspond to a complex type (the V class), as the whole figure is not integral and consistent;

b) by the nature of the contour – the combined type is typical for 66% and curved – 34%. The most common combination is rectilinear + jagged and rectilinear and gapped subtypes. For example, let’s take Ostrog (Rivne region). The contour of the physical form corresponds to the combined type, which is a combination of straight and curved lines;

c) 64% correspond to the small type *by the size of the area and perimeter*. 30% of the cities belong to the V class and 34% to the VI. Volodymyr-Volynskyi (Volyn region) is not big and it's the area is 16.5 m^2, which is determined by the VI class. Volodymyr-Volynskyi belongs to the type of small cities;

d) by the nature of distribution correspond to the *low type* and make up 62% with the most common division into 2, 3 and 4 parts. Let's take a closer look at Sniatyn (Ivano-Frankivsk region). The distribution of the material structure of the city is defined as low. It is divided only into 4 parts, which corresponds to the first class of morphological features;

e) by textural characteristics – morphological types cover the values that are defined as *heterogeneous* by the nature of the filling (91%), by the frequency of regularity – irregular (100%), by size – *average* (52% of the total number of similar elements), by spatial location – *grouped (*47%), by type of texels – *polymorphic* (100%). Now, let's take Berezhany (Ternopil region). All components of the material structure of the city are dissimilar, have different size, spatial location and type of texels, which gives grounds to define it as heterogeneous. There is a city Chernivtsi. The material structure of the city is referred to the irregular type by the nature of uniformity, as the constituent elements do not have a proper and systematic organization. Now it is time for Sambir (Lviv region). The predominant elements in size are those that defined as medium (medium – 4 elements, small – 1 element), as the ratio of the size of the dominant elements to the whole is in the range of 1: 1 – 1: 7 (or meet the criteria of 30–70%); Terebovlia (Ternopil region) – all elements of the material structure of the city are defined as grouped, as the nature of grouping is consistent and can be traced around one point. Dubno (Rivne region) – there is a variation of texels of different shapes in the material structure of the city, which gives grounds to define it as polymorphic.

They determine the habitus of formal expression of the material structure of the historic city of the Western region of Ukraine (fig. 4).

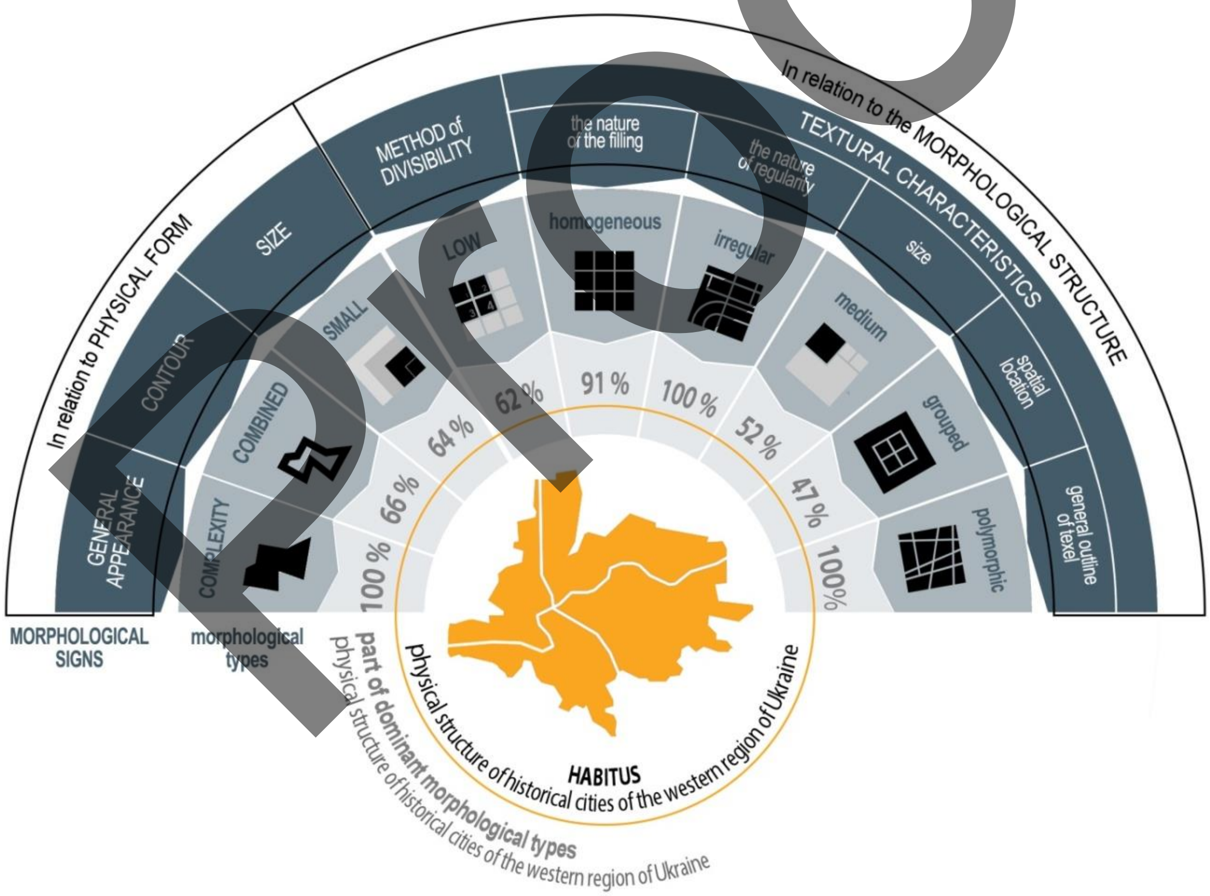

FIGURE 4. Determining the habitus of the material structure of the historic city in the western region of Ukraine (part of dominant morphological types)

CONCLUSION

Habitus is a new concept in the theory of city planning. It can serve as a unit that is able to accommodate knowledge about the shape of the city. This idea has developed significantly in Biology (it originated in this science), mineralogy and philosophy. In recent decades, this term got a thorough scientific explanation in sociology. The etymological meaning of the term *habitus* is related to general appearance, and the essence is reduced to an objective definition of the characteristic form. The specificity of the habitus is expressed in the ability to change depending on the location of the object and a variety of factors influencing its development.

Taking into account the whole set of fundamental provisions for the morphology of the city we can say that in city planning habitus can denote the typical formal expression of the material structure of the city in certain period of time and space.

Based on the combination and generalization of existing scientifically based knowledge about the form and structure of the material structure of historically formed cities in Europe, the concept of a typical city of a certain historical epoch (on a specific territory) was constructed. It denotes the term *habitus of the city* in city planning. Such forms and structure can be described by the morphology of the city and habitus as a kind of innovation aimed at determining the characteristic of a particular era and a particular area of formal features.

Habitus of the city is variable and depends on the conditions of existence, age and stages of development of the object under study. So, it is proposed to consider ancient cities in different ways. In this case, habitus can be typical for a certain historical epoch and culture form of material structure of the ancient settlement. Also, habitus is the physical form and morphological structure in modern historical cities. It expresses uniqueness of the historically formed city.

The proposed concept can allow conducting researches at a qualitatively different level. Moreover, it can update and emphasize the value of historically formed European cities.

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Impact Assessment of PM_{10} from the Confectionary Enterprise on Urban Air Quality

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Abstract. The people's quality of life is affected by ambient air quality. In Ukraine, the confectionery enterprises are a significant emission source of organic PM_{10}. The organic PM_{10} is a pathogen, an allergen and indirect emission source of CO_2. There is a need to determine the contribution organic PM_{10} from confectionery enterprise in the surface air on the outside of confectionery enterprise sanitary protection area. In this study, PM_{10} concentration was determined through the direct measurements method. The measurement in the winter season were performed in a residential area near the sanitary protection area of the enterprise. The mean value of PM_{10} at all direct measurement sites was 78.0 μg/m^3 (standard deviation, SD: 6.1 μg/m^3; 95 % confidence interval, CI: 74.2–81.8 μg/m^3). PM_{10} in ground air outside the sanitary protection zone near apartment buildings in the winter period outweighs daily means limit values of PM_{10} for the protection of human health applied in EU by a factor of 1.6. PM_{10} particles by 89.8 % consist of the most environmentally dangerous particles with a size of up to 2.5 μm. Apply ionization treatment of cocoa dust emissions to increase the efficiency of collecting PM_{10} is proposed.

INTRODUCTION

The main priority goals of the Kharkiv region development include the ensure a high quality of life for population and providing a clean environment [1]. These goals are provided by the Strategy of development of the Kharkiv region for 2021–2027. The goals correspond to the Sustainable Development Goals approved at the UN Summit in 1992. The people's quality of life is affected by ambient air quality [2]. Thus, improved air quality and the elimination of sources of environmentally dangerous pollution are priorities of sustainable development of Kharkiv region. Effective improvement of the air quality is possible when the types of pollutants, their emission sources and factors affecting dispersion of pollutants in the air are clearly established. The key factor is availability of promising emission reduction methods.

Total suspended particles (TSP) rank fourth in the list of the main air pollutants in Ukraine (TSP emission for Ukrainian enterprises is than 310,300 tons per year) [3]. In the Kharkiv region, TSP emission for Ukrainian enterprises for the year 2019 was 22,700 tons, which is 12,100 tons more than for the year 2018.

Air pollution with particulate matter continue to be a very important environmental issue. Particles with diameter equal to or less than 10 μm (PM_{10}) and especially particles less than 2.5 μm ($PM_{2.5}$) can get deep into lungs, and some may get into bloodstream [2]. Such air pollution cause respiratory problems, increase morbidity and exacerbate allergy [4]. $PM_{2.5}$ have short-term (acute) and long-term (chronic) negative exposures and lead to chronic

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diseases [5]. Therefore, EU particulate matter standard is carried out for particles less than or equal to 10 μm and less than or equal to 2.5 μm in aerodynamic diameter (PM_{10} and $PM_{2.5}$) (table 1).

TABLE 1. Limit values of PM_{10} and $PM_{2.5}$ for the protection of human health (daily means)

Organization or country	**Limit values (μm/м³)**		**Country**	**Limit values (μm/м³)**	
	PM_{10}	**$PM_{2,5}$**		**PM_{10}**	**$PM_{2,5}$**
EU [6]	50	–	Australia [8]	50	25
WHO [7]	50	25	Russian Federation [9]	60	35

In Ukraine, the particulate matter standard (PM_{10} and $PM_{2.5}$) is only in the development stage. Implementation of Directive 2008/50/EC in Ukrainian environmental law is underway [6]. Continuous real-time measurement of PM_{10} and $PM_{2.5}$ in Ukraine has been carried out since 2018. Measurements are performed by SaveEcoBot and Eco City systems [10, 11]. Concentrations above the PM_{10} daily limit value (50 μg/m^3) in 2019 winter period were monitored at seven stations of all the reporting stations (95 stations). Air pollution reached hazardous levels in large cities of Ukraine (Air Quality Index from 101 to 200). The daily average PM_{10} concentration was 90 μg/m^3 [11], which is 1.8 times higher than the permissible value for the EU [6].

Industrial processes and product use make a significant contribution to emissions of PM_{10} (20 %) [12]. To improve the quality of urban air quality, it is necessary to reduce or to completely eliminate sources of PM_{10} emissions. The contribution of different types of industrial processes to the total PM_{10} concentration is necessary to know to reduce the amount of PM_{10} in the urban environment.

The confectionery industry is one of the fastest growing industries in the Ukraine [13]. Confectionary enterprise “Kharkovchanka” (Eastern Ukraine, Kharkov city centre) is a city-forming enterprise and a leading manufacturer of confectionery products in Ukraine and on the international market. The confectionery enterprise are a significant emission source of PM_{10} (complex organic dust from flour, starch, sugar and cocoa). In confectionary production, organic dust is formatted during processing of food powdery substances (cocoa, sugar, flour, starch) [14]. The organic dust is an allergen [15] and indirect emission source of CO_2, i.e. potential greenhouse gas [16]. Ecological hazard of organic dust emissions from confectionary enterprises is intensifying due to location of such enterprises mainly within the city boundaries near to apartment blocks. Even though many research has been investigated the PM_{10} pollution in a large cities, few experiments have been carried out to discover the organic PM_{10} emissions from confectionery enterprise. According to the data of scientific and technical literature, the more attention is paid to organic dust explosion hazard and work safety of the employees due to allergic and non-allergic reactions [17]. Much less, attention is focused to the contribution organic PM_{10} from confectionery enterprise to the total PM_{10} concentration and hazard influence of organic PM_{10} outside the confectionary enterprise during their dispersion in the urban air. No studies to date have examined whether organic PM_{10} emissions from confectionery enterprise do indeed more contribution to the total PM_{10} concentration in the surface air on the outside of sanitary protection area (SPA) near to apartment blocks.

The object of the article is the quantitative assessment contributions organic PM_{10} from confectionary enterprise located in the residential area on the total PM_{10} concentration in the surface air on the outside of SPA near to apartment blocks.

OBJECTS AND RESEARCH METHODS

This study focuses on analysis of organic PM_{10} formed in confectionary enterprise “Kharkovchanka”. It is located at 49.98° latitude and 36.27° longitude (Kharkov city centre). The total area of this enterprise is about 17,066 square meters (m^2). The enterprise specializes in the production of chocolate, sweets, caramel, toffee, marshmallow, fruit jelly and chocolate-waffle cakes. The confectionery enterprise capacity of 22,204 metric tons per year. This confectionery enterprise is maximum performance during the winter holidays time, which lasts from December to February. In this period, the equipment works 24 hours a day and produces a daily average of 116 tons of sugary confectionery production. The “Kharkovchanka” is one of the few enterprise in Ukraine with a full processing cycle of cacao beans (annual average of 7 tons).

There are 11 controlled emission sources of organic dust at the enterprise (sources 1, 2, 3, 4 and 5 – cocoa dust, 6 and 7 – sugar dust, 8, 9 and 10 – sugar and starch dust, 11 – flour dust (fig. 1). Intensity of emission from the stationary source of organic dust – 181.5 μg/s (cocoa dust – 150 μg/s, sugar dust – 21.8 μg/s, starch dust – 6.8 μg/s and flour dust – 2.9 μg/s). Cocoa dust prevails in the organic dust emission.

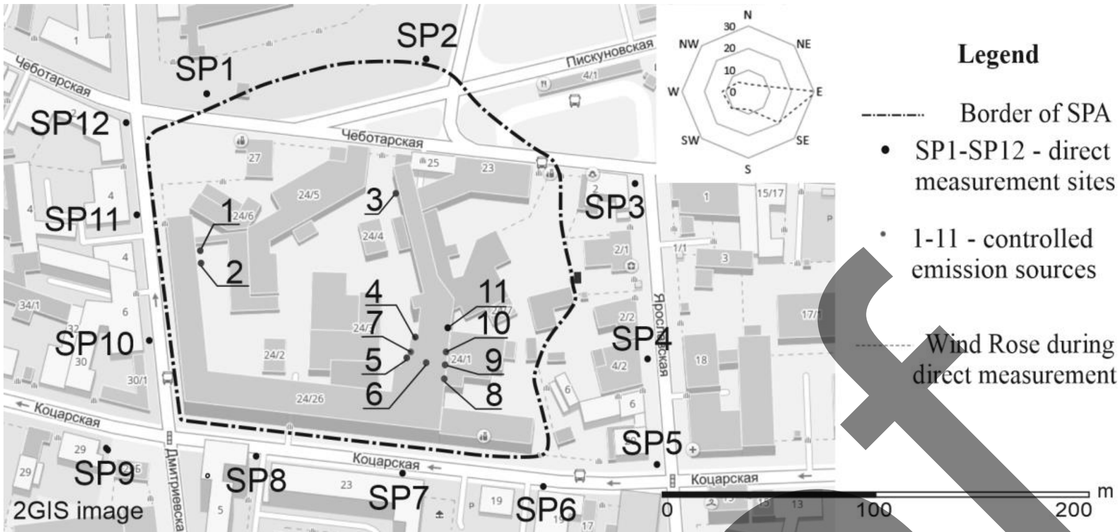


FIGURE 1. Location of the 12 direct measurement sites

Analysis of organic dust particles showed that 96.4 % of cocoa dust particles, 76.2 % of starch dust particles, 78.4 % of sugar dust particles and 50 % of flour dust particles are less than or equal to 10 μm [18].

During the study, the PM_{10} and $PM_{2.5}$ concentration in the surface air on the outside of SPA near to apartment blocks was determined by a direct method based on measurements of PM_{10} in the ambient air using a WP 6910 Vson particle counter. Hand-held Air Particle Counter WP 6910 Vson, equipped with the camera of laser detection of the PM_{10} (without separation of the elemental composition). Counter WP 6910 are shown a good agreement with reference measurement (coefficient of determination, R^2, higher than 0.75).

The data of direct measurements were acquired for the January 2019. Averages meteorological data during the measurement period: temperature of +1°C, pressure value 1013 mbar, relative humidity of 90 %, wind velocity of 4 m/s. It wasn't snowing during the direct measurement of PM_{10} and $PM_{2.5}$. Measurement was performed at a height 1.5 m above ground in twelve representative sites in a residential area near the border of the SPA (fig. 1). Totally by 150 measurements of PM_{10} and $PM_{2.5}$were performed.

The theoretical calculation and statistical data processing were performed in the software programs Microsoft Excel. The random error was considered as the measurement error (number of single measurements for each point and each value was not less than 10, confidence limits were determined by means of Student's t-test). The systematic error was considered as an instrument error (the error for WP 6910 is equal to the quanta of count 1 μg/m^3). As the random error was higher than systematic one by several times, the absolute error was considered as equal to the random one. Exception of faults was performed upon Irving's criterion. The confidence level of the obtained results P is taken to be equal to 0.95 that is enough for presentation of the research insights.

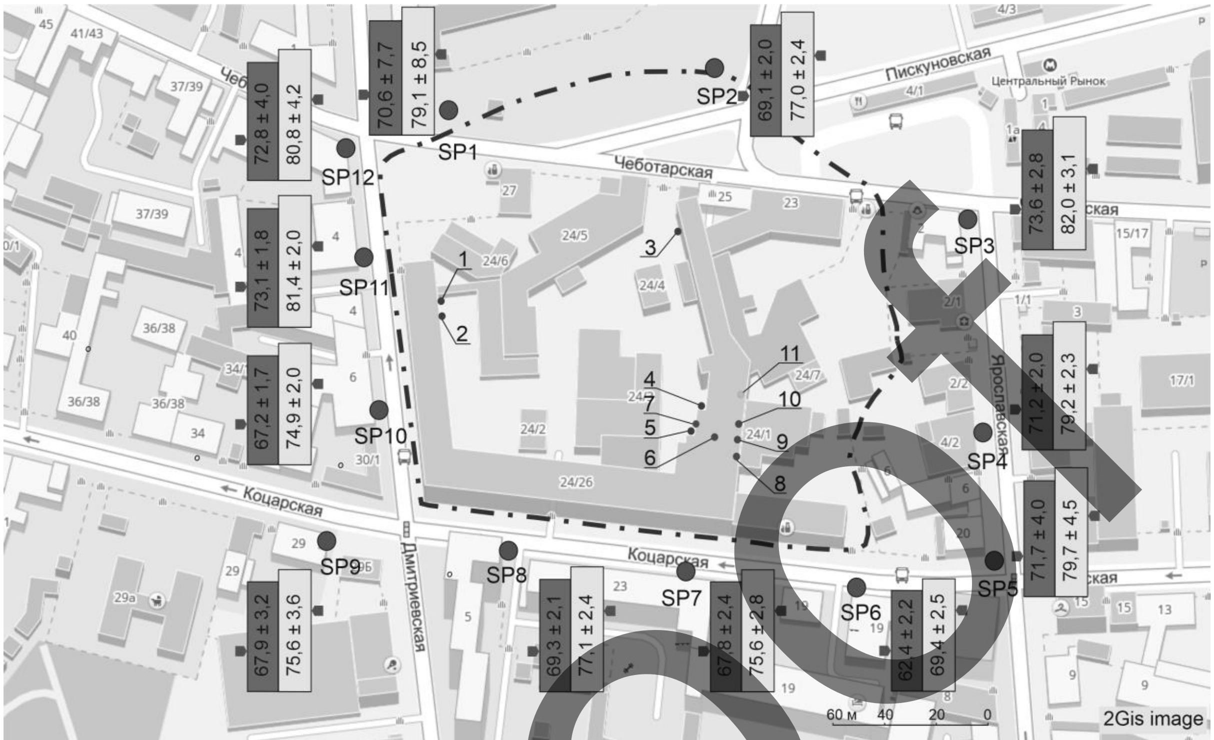
RESULTS AND DISCUSSION

The results of direct measurements PM_{10} and $PM_{2.5}$ in surface air in the territory, bordered to the boundary of the enterprise SPA on the side of the residential area are presented in fig. 2, 3.

The analysis results of direct measurements in the winter period showed that the PM_{10} at all direct measurement sites was in the range from 63 to 99 μg/m^3 (fig. 3). The maximum value (99 μg/m^3) was observed in the point SP1. The minimum value (63 μg/m^3) was observed in the point SP6. The mean value of PM_{10} at all direct measurement sites was 78.0 μg/m^3 (standard deviation, SD: 6.1 μg/m^3; 95% confidence interval, CI: 74.2–81.8 μg/m^3). Daily means limit values of PM_{10} for the protection of human health applied in EU (50 μg/m^3) were exceeded in all of direct measurement sites [6].

PM_{10} include smaller hazardous to health particles ($PM_{2.5}$). It is important to note, that the $PM_{2.5}$ at all direct measurement sites was in the range from 57 to 89 μg/m^3. The maximum value $PM_{2.5}$ (89 μg/m^3) was observed in the point SP1. The minimum value $PM_{2.5}$ (57 μg/m^3) was observed in the point SP6. The mean value of $PM_{2.5}$ at all direct measurement sites was 70.0 μg/m^3 (standard deviation, SD: 5.5 μg/m^3; 95% confidence interval, CI:

66.6–73.4 μg/m^3). Results shown that $PM_{2.5}$ constitutes 89.8 % of PM_{10} (ratio coefficient $PM_{2.5}/PM_{10}$ was 0.898; CI: 0.897–0.899).



SP1-SP12 - direct measurement sites

- $PM_{2.5}$, μg/m^3;
- PM_{10}, μg/m^3;
- Limit values ($PM_{2.5}$) = 25 μg/m^3;
- Limit values (PM_{10}) = 50 μg/m^3.

FIGURE 2. Daily means PM_{10} and $PM_{2.5}$ in surface air in the territory, bordered to the boundary of the confectionery enterprise SPA on the side of the residential area (winter period)

Measurements at sampling points SP1, SP9, SP10, SP11 and SP12 showed an increase PM_{10} value at the wind direction from the confectionery enterprise. A specific cocoa smell was sensed. A significant range of variability of the measured values was observed for points SP1, SP3, SP5, SP7, SP9 and SP12. These points are located near the crossroads where air flows change, so the values at these points are variable. In the analysed direct measurement sites, the largest range of variability of recorded values was observed for SP1. The lowest measured value for this point was 66 μg/m^3 and the highest 99 μg/m^3. Maximum values were observed in the south direction of the wind. The mean value of PM_{10} for SP1 was 79.1 μg/m^3 (standard deviation, SD: 11.8 μg/m^3; 95% confidence interval, CI: 70.6–87.6 μg/m^3). The mean value of PM_{10} for SP9 was 75.6 μg/m^3 (standard deviation, SD: 5.0 μg/m^3; 95% confidence interval, CI: 72.0–79.2 μg/m^3). The lowest measured value for this point was 69 μg/m^3 and the highest 85 μg/m^3. The highest PM_{10} value at this point (85 μg/m^3) was recorded with an easterly wind from the side of the confectionery enterprise.

The mean value of PM_{10} for SP12 was 80.8 μg/m^3 (standard deviation, SD: 5.6 μg/m^3; 95% confidence interval, CI: 76.6–85.0 μg/m^3). The lowest measured value for this point was 73 μg/m^3 and the highest 92 μg/m^3.

The insignificant range of variability of recorded values was observed for SP2, SP4, SP6, SP8, SP10 and SP11. These factors could have influenced this: prevailing wind direction during the measurement period; this points are located between buildings where airflow is largely constant.

Daily means limit values of PM_{10} for the protection of human health applied in EU (50 μg/m^3) were exceeded in all of direct measurement sites. Daily means limit values of $PM_{2.5}$ for the protection of human health applied in WHO (25 μg/m^3) were exceeded in all of direct measurement sites [7].

The ratio coefficient $PM_{2.5}/PM_{10}$ was 0.898, this data proves that such pollution is along with harming human health, can cause a variety of environmental problems. The obtained data of direct measurements indicate the need for an introduction of measures to reduce emissions of fine dust (PM_{10} and $PM_{2.5}$) at the confectionary enterprise "Kharkovchanka".

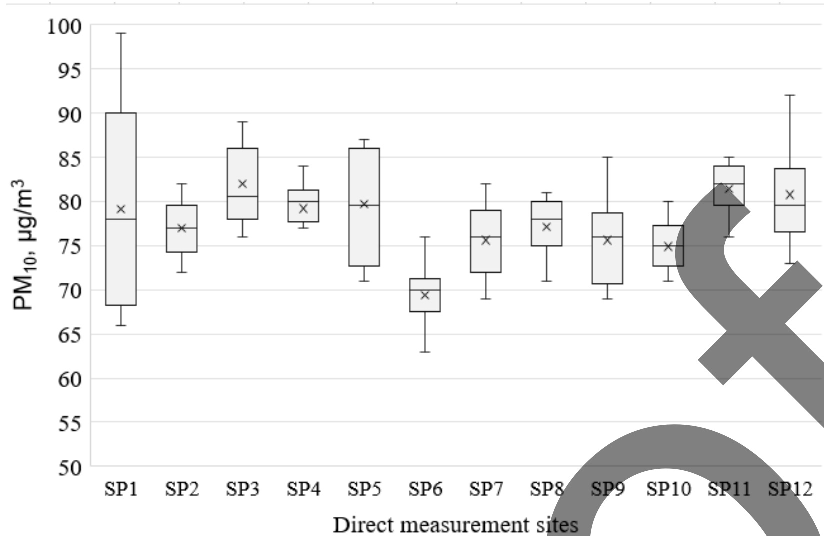


FIGURE 3. Ambient Air Quality Data (Box Plots): 24-hour values of PM_{10} in January 2019 (x – arithmetic mean, — – median, □ – interquartile range, ⊤ – maximum concentration, ⊥ – minimum concentration)

To improve the environmental situation and increase the level of environmental safety of the confectionary enterprise "Kharkovchanka" it was proposed to apply ionization treatment of cocoa dust emissions. Cocoa dust ionization treatment reduces fine dust emissions by 77 % [19].

CONCLUSIONS

PM_{10} in ground air outside the sanitary protection zone near apartment buildings in the winter period outweighs daily means limit values of PM_{10} for the protection of human health applied in EU by a factor of 1.6.

In the surface air on the outside of sanitary protection area near to apartment blocks PM_{10} particles by 89.8% consist of the most environmentally dangerous particles with a size of up to 2.5 µm. Such particles are very dangerous to humans and the environment.

An increase in the concentration of PM_{10} in the ambient air was observed when the wind direction prevailed from the confectionery enterprise to the direct measurement sites. A specific cocoa smell in the air was sensed. Apply ionization treatment of cocoa dust emissions to increase the efficiency of collecting PM_{10} is proposed.

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Problems of Providing Kharkiv with Ecologically Safe Recreational Zone Based on the Studenok River

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Abstract. In the course of intensive urbanization of the territories, water objects' condition and characteristics in respective recreational areas are of particular value in terms of sustainable development maintenance. Surface drains and rain waters mainly pollute water objects which are located within the city. Besides, water objects' ecological condition is negatively affected by authorized and unauthorized industrial wastewater discharge. Pollution of the aquatic environment and bottom sediments by microplastic particles poses an extremely high environmental risk due to the slow degradation of this material and its high permeability to biological objects, making for unpredictable negative consequences.
This study investigates the aquatic environment's current condition using the example of the Studenok river (Kharkiv, Ukraine) located on the territory assigned for recreational use; the aquatic environment's current condition was investigated. An experimental study of microplastic content in bottom sediments is carried out. The prospects for riverbed restoration and recreation zone arrangement within the studied object is studied as well. Studies of the aquatic environment have revealed areas of increased pollution of the Studenok river and have identified some of its anthropogenic sources. Studies of bottom sediments for microplastic concentration have shown a high level of this pollutant - 318.6-1709.2 mg/kg. To create a recreational area at the study site, further monitoring and detailed identification of pollution sources and ecological rehabilitation of the water reservoir and its underground sources are needed which supply it.

INTRODUCTION

A country that once has embarked on the path of scientific and technological progress and large-scale use of its results cannot ignore such objective factors as environmental vulnerability, ecological sustainability and ecological capacity of the environment, depletion of many natural resources, limits of ecological strength, and resistance to negative and harmful anthropogenic influences. These factors must be fully considered when determining the pace and scale of social-economic development for the future, balanced and adequate to the environmental situation, and coherent with natural laws. This is possible only if the economic activity of the society is based on the concept of sustainable environmental development, especially in urban areas. Sustainable development must meet the needs of the present and, at the same time, not jeopardizing the ability of future generations to satisfy their own needs [1–3].

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In sustainable urban development, there are many difficulties associated with accumulating chronic social, economic, and environmental problems that significantly affect the quality and safety of the urban population in Ukraine [4–6]. To solve most of the ecological issues facing humanity today, the existing economic paradigm requires changes. New concepts of balanced and sustainable development are to be introduced to prevent global and local environmental crises. In this paradigm, an important place is occupied by practical measures to create comfortable living conditions in urban areas. One of the elements of the current level of livelihood of megacities is recreational areas, in which water sources occupy the central place.

Landscape planning is a promising information about the territory's actual condition. Among the primary tasks to be solved in the framework of the first stage of such planning is inventory procedures of collection and generalization of deterioration by natural and anthropogenic factors. In recent years, many countries around the world are particularly concerned about the problems of water use in urban areas. Most water sources have suffered a significant deterioration in their quality due to natural and anthropogenic factors As an obvious result, one can observe the violation of the water reservoirs' natural hydrochemical and hydrobiological regime [7]. Significant factors that negatively affect their quality are high population density in cities, heavy traffic, housing, and industrial complexes [8–11]. Innovative methods of improving the condition of surface waters are the introduction of adsorption [12], biological [13] and membrane [14] treatment methods.

Since recent years, pollution of the aqueous environment and bottom sediments by microplastic fragments (particles 0.2-5 mm in size), about 90% of which is represented by polyethylene, polypropylene, polyvinyl chloride, polystyrene, and polyethylene terephthalate, has been a particular danger. By origin, microplastics are divided into [15]: primary (produced for industrial and household needs in different size ranges: scrubbing additives in household chemicals and cosmetics, sequins, paillettes, etc.) and secondary (formed as a result of fragmentation and disintegration of plastic objects - packages, food containers, bottles, etc. – into the particles under the influence of various factors). The increase in the content of microplastics in water reservoirs and oceans, its particles' size, and its chemical properties determine its bioavailability to microorganisms. Studies by many scientists have shown that microplastic particles enter the food chain by accumulating in aquatic organisms. More than 90% of fish contain microplastic that implants in the body's fibers. Information on their impact on human health is minimal. Still, the ever-increasing number of studies on this problem indicates the extreme threat of microplastics to biota in general and human beings in particular. It is challenging to estimate the number of particles that enter the body. Firstly, not every microplastics source is known yet, and secondly, the existing methods do not allow tracking particles smaller than a specific size. Since the microplastic is present in the environment of individual particles, its distribution in the bottom sediments can be very uneven.

UNRESOLVED ISSUES

As a necessary condition for a complete human life, compensation for stress, recharge for energy reserves, comprehensive development of the spiritual sphere, general recovery (mental, spiritual, and physical), one can perform cultural and cognitive recreation activities. The latter include sports, tourism, spa treatment, recreational and sport fishing, hunting, and other forms of active leisure, essential for continuing social production. It is carried out within the recreational areas based on recreational lands [16]. These lands are used for organizing mass recreation, tourism, and sporting events. Water objects are a desirable element of recreational areas.

The city of Kharkiv is a megapolis with about 2 million population. It requires an increase in the number of recreational areas, having some water objects inside. Unfortunately, water objects located within the city borders are experiencing intense anthropogenic pressure from the city's enterprises and utilities. Water resources of small rivers maintain the ecological balance in the region of their location. Still, the extensive use of small rivers, their violent regulation, use of their water flow for irrigation and household needs, and the transformation of these rivers into sewage collectors have disrupted their natural state. Rivers have become polluted, straightened, shallow, silted, and eutrophicated. The main hazard is the pollution of their aquatic environment and bottom sediments by microplastics (plastic particles 0.2-5 mm in size).

Nowadays, plastic waste in surface water objects has become a global problem. As a result of human activity, the World Ocean receives from 4.8 to 12.7 million tons of plastic every year. The danger of the presence of microplastics in the aquatic environment has several aspects [15]: the formation of a film on the water surface that changes the structure of water; thermal, microbiological, and chemical decomposition by exposure to sunlight; the release of decomposition products (e.g., phthalates); sorption and transfer of various pollutants, including heavy metals, direct pathological effects on aquatic organisms. Many countries have already established or are implementing regulations prohibiting the production, sale, and use of primary microplastics (e.g., microgranules), which will reduce both the number of microplastics in the aquatic areas and associated negative impact on the environment.

Landscape planning, which is based on considering the possibilities of natural potential, is a promising tool for solving problems of greening and adaptation of territories for the organization of recreational nature use. Among the primary tasks to be solved within the first stage of such planning is inventory procedure. The latter means collecting and generalizing information on the actual condition of the territory, which is assigned for recreational use.

The purpose of the research is to assess the ecological situation of the Studenok river in the domain planned for recreational use in Kharkiv.

MAIN PART

The experimental research object was natural waters and bottom sediments of the Studenok river, located in the south-eastern part of Kharkiv. It flows through the Kharkiv region and is a left tributary of the Udy river. The river's total length is about 20.4 km, the basin - 75.3 km^2 [17]. Floodplains of the river are often swampy. The river's width in some areas reaches 5-6 m, but, on average, this is from 1.5 to 2.5 m. The depth of the river in some areas in summer is a few centimeters; however, there are places where the depth is much greater.

Sampling of water and bottom sediments was carried out in the Studenok river in the areas is shown in figure 1. In the course of the research, a hydrochemical analysis of the composition of natural waters was carried out and a study to determine the content of microplastics in the bottom sediments of the Studenok river.

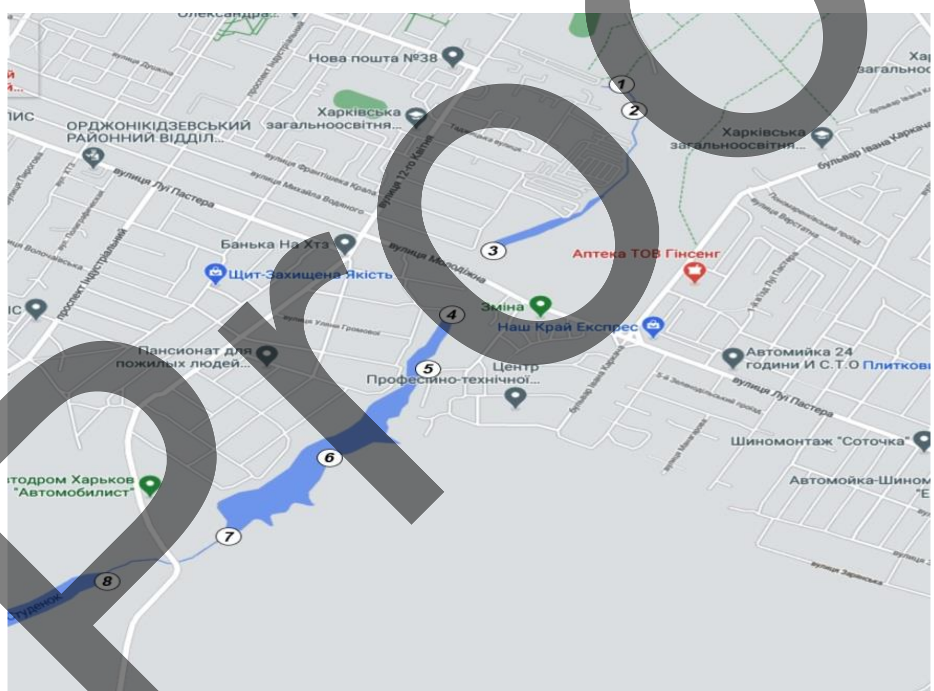

FIGURE 1. Sampling points for natural waters and bottom sediments in the Studenok river (Kharkiv map from [18])

Water samples from the Studenok river were taken according to normative methods [19, 20], and their analysis was performed on the day of sampling. Water samples were examined for suspended solids, ammonium nitrogen, nitrites, nitrates, phosphates, chlorides, pH reaction, hardness and alkalinity of water, dense residue, and mineralization using the methods recommended by the regulations of Ukraine [20].

Still, there is no standard method for determining the content of microplastics in aquatic and soil environments. The selection of bottom sediments in the Studenok river was carried out using a dredger. The study on microplastics' content was carried out according to the research method [15] for quantitative analysis of synthetic particles in water and bottom sediments. Analysis of samples of bottom sediments for the content of microplastic particles of the different composition includes the following stages: sieving; drying (to determine the mass of solid particles in the sample); liquid oxidation with hydrogen peroxide in the presence of a catalyst - Fe (II) to dissolve the labile organic matter; density separation (flotation) in NaCl solution to separate plastic particles from other particles using a separator; visual sorting under a microscope. Screening operations were performed several times during each analysis. This method can determine the following types of plastic: hard and soft plastics, films, hair-like particles, fibers, sheets. The particle size of the microplastic was determined by microscopy using an ocular micrometer and object micrometer. Microplastic particle concentration in bottom sediments, soil, and sand was expressed either in the number of pieces per kg of substrate or in mg/kg.

The results of hydrochemical analysis of the waters of the Studenok river are given in the table I.

TABLE I. Chemical analysis of the waters of the Studenok river, Kharkiv

Research area	**Quality indicators of the studied water**									
	pH	**Water Hardness (mg eq / dm^3)**	**Alkalinity (mmol / dm^3)**	**Ammonium nitrogen (mg/dm^3)**	**Nitrites (mg/dm^3)**	**Phosphates (mg/dm^3)**	**Chlorides (mg/dm^3)**	**Dense residue (mg/dm^3)**	**Mineralization (Dry residue) (mg/dm^3)**	**Concentration of suspended solids (calculated) (mg/dm^3)**
Standard	6.5÷ 8.5	1.5 – 7.0	0.5 – 6.5	0. (2.6*)	0.02, (0.5*)	3.5*	150, (350*)		1000	
T1	8.33	8.7	2.2	6.52	0	4.3	78.1	440	350	90
T2	8.45	14.2	5.0	3.94	0.19	4.6	103.0	600	340	260
T3	8.34	21.0	16.4	4.63	0.06	2.3	94.1	1520	650	870
T4	8.48	6.6	5.6	9.95	0	3.7	103.0	980	510	470
T5	8.3	12.0	10.0	2.52	0	3.2	81.7	8140	1680	6460
T6	8.75	6.0	4.8	1.20	0.6	1.8	79.9	670	320	350
T7	8.76	6.1	5.0	1.32	0	2.5	79.9	650	350	300
T8	9.07	5.4	5.6	1.09	0.02	2.9	104.8	1150	590	560

Note: The standard is the value of indicators according to DSTU 7525: 2014 "Drinking water. Requirements and methods of quality control (Water of decentralized drinking water supply)".

* Only for centralized drinking water supply

The results of research obtained during the hydrochemical analysis of water characterize the water samples of the Studenok river as water of medium mineralization, which is characteristic of river water. The exception is the water sample taken at point 5. This water is characterized by extremely high values of all controlled pollution indicators and indicates intense local pollution because significant deviations are not detected in the water downstream. In points 3 and 5, in comparison with the whole data set, the increased values of hardness correlate with the increased values of alkalinity and dry residue concentration, which indicates the receipt of alkaline element compounds, most likely dissolved and suspended (increased concentration of suspended solids) calcium salts in these points. Point 2 revealed high water hardness, which is not supported by other indicators. The pH of water is typical for surface waters of the Kharkiv region. Exceptions are samples taken at points 3 and 5, in which abnormal alkalinity values are observed. Analyzing the concentrations of ammonium and nitrites in the Studenok river, one can note that they are slightly elevated but generally within acceptable limits. The concentration of phosphates in the Studenok river is slightly increased, which can be explained by the active destruction of organic matter accumulated in the water reservoir during the warm season and the anthropogenic load. The concentration of chlorides in water is also in the typical range of values for the Kharkiv region [20], with some increase at points 2-5 and point 8.

Based on the hydrochemical analysis results, we can state that according to the level of pollution and the flow dynamics, the studied section of the Studenok river can be divided into three parts:

1 – (point 1) relatively clear water before the area of active water use;

2 – (points 2-5) zone of increased water use and pollution (although point 4 shows typical hardness and alkalinity, but there is an increase in the concentration of compounds of nutrients - nitrogen and phosphorus);

3– points 6-8 show relatively cleaner water (compared to the second zone), reduced water use activity, and pollution, the predominance of self-purification processes.

The second section shows the intensive pollution of the river with inorganic compounds (controlled indicators of hardness, alkalinity, mineralization) and suspended solids, so it needs to identify pollution sources. The mineralization levels of water in the first and third sections are generally almost the same.

Photomicrographs of plastic particles extracted from the bottom sediments of the Studenok river presented in figure 2.

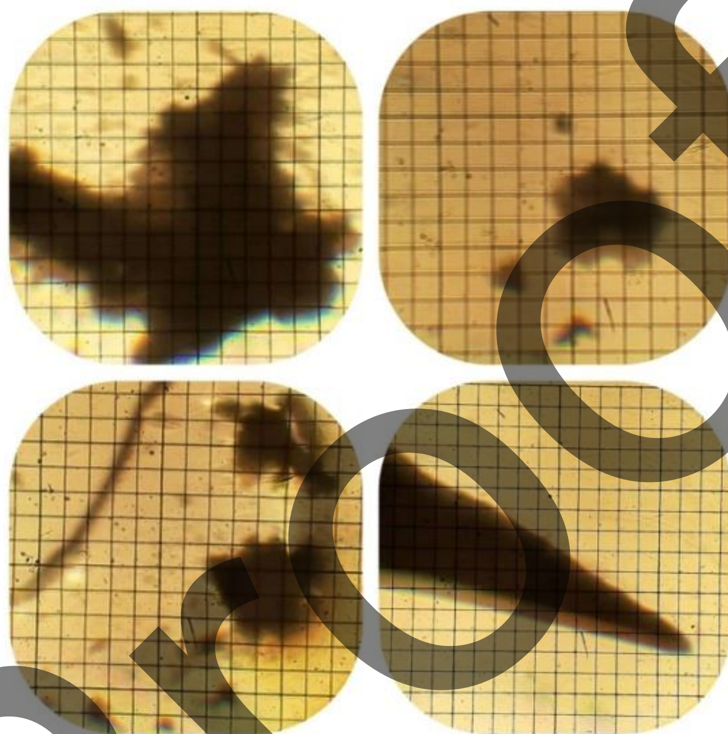

FIGURE 2. Photomicrographs of microplastic particles extracted from the bottom sediments of the Studenok river, at a magnification of × 70

It was found that the dimensions of the removed plastic particles ranged from 5 μm to 0.2-0.3 mm, which makes it possible to classify them as microplastic pollutants. As can be seen, the particles of microplastics removed from the bottom samples are transparent and opaque, while some are hair-like. Visually opaque particles probably belong to polystyrene and polyvinyl chloride particles, the most toxic types of this pollution.

The results of determining the concentration of microplastics in the bottom sediments of the Studenok river are in table II.

TABLE II. The content of microplastics in the bottom sediments of the Studenok river

Research object	Content of microplastics (mg/kg)	Fractionation of microplastics by specific weight (pcs.)		
		2.1-2.3 (g/cm^3)	0.8-1.7(g/cm^3)	≤0.8 (g/cm^3)
T2	1709.2	4	11	215
T4	475.0	11	31	220
T6	318.0	0	24	177
T7	1139.0	19	41	542
T8	938.8	18	37	487

At the study points, there are fluctuations observed in the content of microplastics in the bottom sediments in the range from 318.0 to 1709.2 mg/kg with a predominance of particles of the lowest specific gravity (≤ 0.8 g/cm^3). The most dangerous river sections in terms of microplastic content in bottom sediments were found at points 2 and 7. These are points where the garbage dumps are focused. Near point 2, there are unauthorized construction waste dumps, and close to point 7, there are side pilings from the territories of industrial enterprises of Kharkiv.

Hydrochemical analysis of water indicates that the Studenok river has not yet lost its ability to self-restoration. Thus, taking measures to prevent further pollution and damage to this ecosystem, we can hope that the self-restoration of this river basin will take place in a certain period. Also, to prevent further pollution of the water object, it is necessary to carry out measures for its ecological rehabilitation, which will include the following:

- implementation of design and survey works (description of the object: field surveys of adjacent territories, mapping);
- laboratory monitoring studies: sampling and analysis;
- recommendations on the technical and biological stages of rehabilitation of reservoirs, cleaning of the reservoir bed from pollution deposits;
- ponds waterproofing project, bottom reinforcement;
- accumulation and purification of drainage and stormwater that supply water reservoirs;
- reclamation of catchment basin;
- shore protection project, anti-landslide, and anti-erosion measures;
- settlement of reservoirs with aquatic organisms, planting of aquatic vegetation;
- ecological rehabilitation and improvement of floodplains;
- beautification and landscaping of coastal and recreational areas.

CONCLUSIONS

1. A study of the Studenok River in Kharkiv (water quality and bottom sediments) was conducted to determine measures for improving the territory and further recreational use.
2. The studied section of the Studenok River, according to the hydrochemical analysis, can be divided into three sections: relatively clear water till the area of active water use; area of increased water use and pollution; area of reduced water use activity and pollution with the predominance of self-purification processes.
3. Dangerous areas of the Studenok River were identified by microplastics' content in the bottom sediments. At these places, unauthorized construction waste dumps, and side pilings from the territories of industrial enterprises of the city of Kharkiv are focused.
4. Identification of pollution sources and further monitoring of this river basin is necessary. Also, to use the territory in the vicinity of the Studenok river as a recreational area and rehabilitate the adjacent territories, it is essential to carry out ecological rehabilitation measures.

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Exploited Roof as an Additional Functional and Territorial Resource in a Dense Urban Development

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Abstract. Trends in urban population growth and intensification of urban territory use motivate the search for additional territorial resources, especially in the context of dense historical development. The most common way to solve this problem is to use the underground space of cities and exploited roofs. This article considers the exploited roofs as an additional functional and territorial resource. Substantive differences between the terms "territorial reserve", "territorial resource" and "functional and territorial resource" are formulated. A calculation method for determining the potential territorial resource considering the geometric type of roof, its design features, physical wear of the building and the presence of the status of a cultural heritage site is proposed. Experimental verification (on the example of blocks and separate groups of residential buildings of different construction periods in Kyiv) confirmed that attracting the area of exploited roofs can give an additional 9.4…27.6 %% of the assessed areas. Criteria for assessing the feasibility of using the exploited roofs to increase the level of comfort and cost-effectiveness of buildings and structures are proposed.

INTRODUCTION

Population growth in cities, especially in large and the largest ones, is observed both in the world as a whole and in Ukraine in particular. Urbanization causes a constantly growing deficit of territory, which is necessary for the placement of new housing and public buildings, places of employment, urban infrastructure, and services [1]. Intensification of the use of urban areas along with the negative phenomena (increasing anthropogenic load, increasing the level of motorization and complicating transport links, deteriorating environmental conditions of the urban environment) has positive signs – improving the availability of jobs and services, and, consequently, increasing productivity, intensity of social contacts [2].

The practical lack of vacant land, significant limited reserve areas, and high land value make it almost impossible to locate additional modern facilities, especially in the central areas of cities, in the conditions of historical development, and leads to a decline in the quality of the urban environment. Limited available territorial reserves necessitate the intensification of use and development of the territory, its multifunctionalities, increasing the compactness of the city plan [3, 4].

One of the most common areas of attraction of additional territorial resources is the use of underground space in cities or underground urban planning. The traditional use of underground space for the construction of utilities and transport communications, in particular the subway, has undergone significant transformation in recent decades. The construction of powerful shopping, and entertainment complexes in combination with underground transport hubs, which serve up to 100 thousand people daily [5], actually forms a parallel underground city with its own architecture and public space [6]. Recently, the attention of designers is increasingly turning to the roofs of existing buildings as a potential place to put certain objects. Back in the middle of the last century, the famous French architect Le Corbusier said: "... Indeed, it contradicts any logic when the area equal to the whole city is not used and the slate is left to admire the stars! ... » [7].

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The areas under buildings in large cities ranges from 5… 20% in the areas of manor buildings to 15… 30% in areas of mass development, and in historic areas up to 70… 100% of the area of the blocks [8, 9]. The most typical in the absence of free areas is the placement of greenery and landscaping elements on the roofs of buildings. This not only helps to increase the level of living comfort, but also has a positive effect on the ecological condition of the urban environment [10, 11], 12. The involvement of exploited roofs as one of the possible decisions within search for additional territorial resources will help increase the level of comfort of living and efficient use of urban areas. That is why the inclusion of the roofs' area in the total area of free from development areas is a promising way to increase the territorial resources of cities. The purpose of this study was to develop a calculation method for determining potential territorial resources by attracting the area of exploited roofs. This would allow to analyse the quantitative indicators of potential territorial resources to increase the necessary elements of landscaping and landscaping, engineering and transport infrastructure, other functional facilities during the implementation of detailed planning areas, projects for construction and reconstruction of blocks, microdistricts and individual land plots.

MATERIALS AND METHODS

The development of a method for determining potential territorial resources in a dense urban development is based on the use of general and special research methods. The factual basis for verification of the proposed calculation method for determining potential territorial resources through the involvement of exploited roofs are the materials of the actual state of use and development of blocks and microdistricts of Kyiv.

Basic Definitions

Urban area is characterized by the presence or absence of a territorial reserve. However, a distinction should be made between the concepts of "territorial reserve" and "territorial resource". The study clarifies the terminological difference between these concepts.

- *Territorial reserve* – the presence of an excess of free territory in relation to the normatively required for this type of use territory.

The situation of lack of territorial reserve is typical mainly for the central and middle zone of the city. It is in the conditions of dense urban development that the issue of multifunctional use of the territory and distribution of functions vertically (vertical urban planning) becomes relevant. One of the promising areas for increasing the capacity and efficiency of urban use is the use of exploited roofs as a functional and territorial resource.

- *Territorial resource* – additional areas that can be attracted using underground space or exploited roofs in the absence of excess of normatively required areas.
- *Functional and territorial resource* – additional areas that can be attracted using underground, underwater space, or exploited roofs to accommodate the necessary or additional facilities of a certain functional type, elements of landscaping and greening.

Additional area with a certain functional load, which may be involved due to the use of underground space or operated roofs in the absence of free areas to accommodate the necessary or additional facilities of a certain functional type, elements of landscaping and greening forms a functional-territorial resource of the estimated planning element – block or plot.

Trends of Intensification of Urban Area Development

A retrospective analysis of the main and relative normative indicators shows that with each stage of urban planning development, an intensification of the use and development of territories, an increase in their territorial capacity, takes place.

The analysis of the dynamics of normative indicators regulating the intensity of use and development of territories has been carried out on the basis of building standards and rules on urban planning of different periods (PiN 1929, SN 41-58, SNiP II-K.2-62, SNiP II-60-75, SNiP II-60-75**, SNiP 2.07.01-89, DBN 360-92**, DBN B 2.2-12: 2019 "Planning and development of territories").

The dynamics of growth of normative indicators of use and development of residential areas (the population density and the density of housing funds) is shown in Figure 1 and Figure 2.

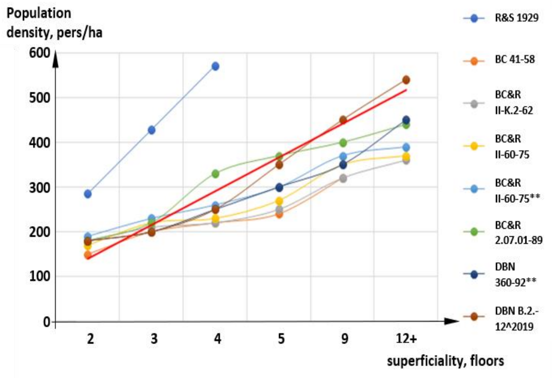

FIGURE 1. The dynamics of standard indicators of population density of microdistricts, persons/ha. *Source* – own research.

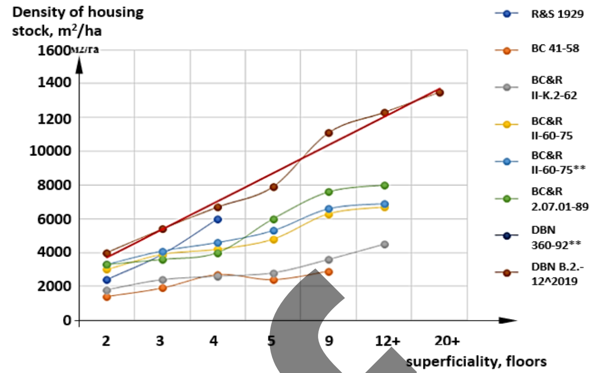

FIGURE 2. The dynamics of standard indicators depending on the density of housing funds stories, m^2/ha. *Source* – own research.

The formation of building areas of the modern city, and in particular the city of Kiev, in different historical periods according to different regulatory requirements has led to a situation of uneven intensity of development of urban areas. This, in turn, led to the unevenness of the existing territorial reserve of existing buildings. The experimental part of the study was based on the analysis of information on the type and intensity of buildings on the example of 51 blocks, microdistricts, groups of buildings (in total – 524 houses) in Kiev. As a cartographic basis, materials of topographic and geodetic surveying of the city of Kyiv M 1: 2000 are used (detailed information can be found in the materials of the author's dissertation research K.Bakun, supervisor – A. Pleshkanovska) [13].

Differentiation of the Exploited Roof

The generalization of theoretical bases and practical foreign and domestic experience of application of the operated roofs allowed to differentiate roofs on geometrical type, on prevailing kinds of functional use, on frequency of visiting of objects which can be placed on the exploited roof.

Differentiation of Roofs by Geometric Type

The variety of roofs of existing buildings in geometric shape can be represented in four groups (see Figure 3):

- *sloping* – single-sloping (flat, slope); multi-slope (double-slope, cross-shaped, broken, tent, trapezoidal, hip, semi-hip);
- *cylindrical* – vaulted, conical, conoidal, toroidal;
- *domed* – dome faceted, petal-shaped or sailing;
- *curvilinear* – tent, double curvature (roofs of shells of positive and negative Gaussian curvature; roofs of hipper components, paraboloid, hyperboloid, and hyperboloid-paraboloid roofs).

Differentiation of Roofs by Types of Functional Use

Summarizing foreign and domestic experience, we can distinguish the following four types of exploited roofs for the main types of functional use, see Figure 4:

- *engineering infrastructure facilities* – “solar” roof (for placement of energy-generating solar panels and hot water sources), “blue” or “blue” roof (for retention and slow release of rainwater, reduction of peak load on storm sewers), roof boilers, mobile antennas;
- *objects of transport infrastructure* – roof-parking (for temporary or permanent storage of motor transport), for the passage of traffic and pedestrian flows;
- *facilities that help increase the energy efficiency of the building* – “cold floor”, also known as “white”;
- *other functional objects, elements of landscaping and greening* – residential buildings (penthouses), ponds, swimming pools, terraces, cafes, restaurants, exhibition grounds; “Green” roof, for placement of lounge zones, sports, games, economic and other grounds, etc.

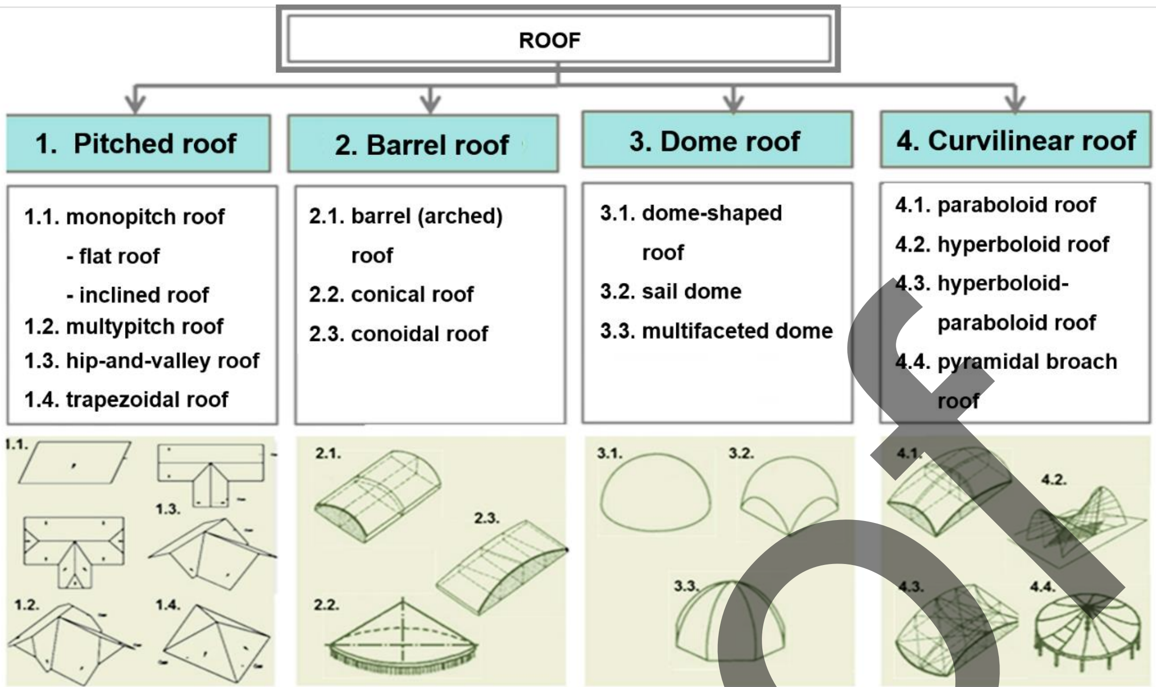

FIGURE 3. Differentiation of roofs by geometric type.
Source – [14], own research; illustrative material – from online sources; designed especially for this paper.

FIGURE 4. Directions of functional use of exploited roofs.
Source – own research, illustrative material – from online sources designed especially for this paper.

Differentiation of Roofs by Frequency of Visits

An important factor influencing the choice of the possible type of functional orientation of the objects to be placed on the roof is the frequency of visiting such an object. Depending on the frequency of visits, the used roofs can be divided into the next:

- with objects of mass attendance;
- with objects of restricted attendance

Under mass attendance it is understood that on a roof people (visitors) will be constantly (or seasonally) present. Roof with restricted attendance is a roof that is designed for a specific purpose, but the presence of people on it is limited, is there can only be service personnel, the roof does not provide additional load from a large number of people and other objects.

RESULTS AND DISCUSSIONS

One of the promising directions for increasing the capacity and efficiency of urban use is to attract the area of exploited roofs as a functional and territorial resource.

The Need of Use of Exploited Roofs

The need to use exploited roofs of buildings and structures should be based on the analysis of the availability of territorial reserves or excess area of the territory within the estimated planning element - a block or a separate land plot. There are two possible options, see formulas (1) and (2):

$$S_{free\ spaces} \geq S_{necessary\ regulatory} \quad (1)$$

$$S_{free\ spaces} > S_{necessary\ regulatory} \quad (2)$$

Where $S_{free\ spaces}$ – is an area free from development within the site under evaluation, that is, the existing territorial reserve; $S_{necessary\ regulatory}$ – area of the site under evaluation that is free from development, that is in accordance with regulatory requirements, is necessary for the placement of facilities for land improvement and landscaping, that is, the territorial reserve is absent.

In the case of a territorial reserve there is no urgent need to use the exploited roofs, but it may be appropriate and possible for:

- improving the energy efficiency of individual houses and buildings in general;
- increasing the environmental friendliness of the environment by increasing the number of greenery (reducing the effect of urban "heat island");
- increasing the aesthetic appeal and attractiveness of the building.

When the free area is not enough, the territorial reserve is absent, the use of exploited roofs is extremely important for obtaining additional territorial resources. This will allow the possibility, in addition to increasing the energy efficiency, environmental friendliness, aesthetic attachment and attractiveness of objects:

- placement of normatively necessary sites for various functional purposes;
- obtaining additional areas of green spaces of limited use;
- placement of objects accompanying the main ones (objects of engineering and transport infrastructure).

Determining the Potential Territorial Resource of Urban Areas

In order to increase the efficiency of urban use through the use of exploited roofs, the study proposed a new calculation method for determining the potential territorial resource of developed areas, especially in the conditions of the condensed development, in the form of a mathematical model (see formula (3)).

$$S_{pot.\ terr.\ res.} = \alpha\beta\gamma\lambda \times S_{dev.} \quad (3)$$

Where $S_{pot.\ terr.res.}$ – potential territorial resource of the assessed plot (microdistrict, block, land plot), sq. m; $S_{dev.}$ – developed area of the assessed area, sq. m; *α, β, γ, λ* – coefficients that consider specific conditions and characteristics of the development.

α – the coefficient that considers the geometric type of the roof. Since the predominant geometric type of roof for post-war and modern buildings is a slope (or rather, subtypes: single-, double-sloped, tent roof), it is proposed to determine this coefficient according to the schedule (see Figure 5) depending on the angle of the roof.

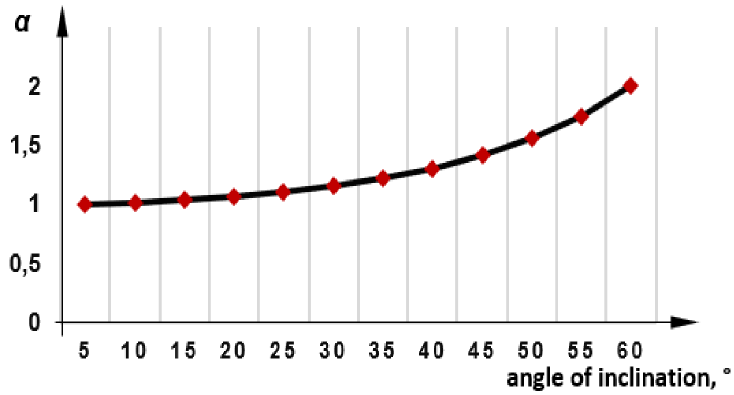

FIGURE 5. Coefficient of increase of the area for one-, two-sloped, tent roof for definition of the actual area of a roof. *Source:* own research, designed especially for this paper.

$$S_{exp.roof} = \alpha \times S_{dev.} \tag{4}$$

Where $S_{exp.roof}$ – area of roof that can potentially be used, sq. m; α – the coefficient, that takes into account the geometric type of roof (angle of inclination); $S_{dev.}$ – developed area of the assessed area, sq. m. β – a factor that considers the design features of the roof, i.e., the useful area of roof (excluding the area of ventilation shafts, elevator shafts, parapets, etc., design features of roofs, the area of which cannot be used) depending on the type of building (see (5)).

$$S_{exp.roof} = \beta \times S_{dev.} \tag{5}$$

Where $S_{exp.roof}$ – area of roof that can potentially be used, sq. m; β – coefficient that takes into account the design features of the roof, depending on the type of building (yield of usable area without taking into account the area of ventilation shafts, elevator shafts, parapets, etc. design features of roof whose area cannot be used); $S_{dev.}$ – developed area of the assessed area, sq. m.

The value of the coefficient β was calculated experimentally for each subtype of post war development. Approximately they are [15]:

- *β = 0.7… 1.25* for the construction of the first period of industrial housing;
- *β = 0.7… 1.2* for modern construction.

γ – *coefficient that reflects the weighted average physical wear of the building* within the assessed area. Its essence is that the higher the rate of physical wear of the house, i.e., the loss of load-bearing capacity of structural elements, the lower the probability of using its roof for any additional function. In this case, the area of the exploited roof is determined by formula 6:

$$S_{exp.roof} = \gamma \times S_{dev.} \tag{6}$$

Where $S_{exp.roof}$ – area of coverage that can potentially be used, sq. m; γ – coefficient, coefficient that takes into account the technical condition of the building; $S_{dev.}$ – building area of the assessed area, sq. m. The value of the coefficient γ is determined by formula 7:

$$\tilde{\gamma} = \frac{\sum_{i=1}^{n}(\gamma_i \times S_{dev.i})}{S_{dev}} = \frac{\gamma_1 S_{dev_1} + \gamma_2 S_{dev_2} + \cdots + \gamma_5 S_{dev_5}}{\sum S_{dev_i}} \tag{7}$$

Where S_{dev} – developed area of buildings with the corresponding indicator of technical condition (physical wear), sq. m; γ_i – the share of developed area of buildings with the appropriate indicator of technical condition (physical wear) of the total building area within the assessed area; *i* – respectively:

- *1* – good technical condition (physical wear 0… 20%),
- *2* – technical condition satisfactory (physical wear 21… 40%),
- *3* – technical condition unsatisfactory (physical wear 41… 60%),

- *4* – dilapidated technical condition (physical wear 61… 80%),
- *5* – technical condition is unsuitable (physical wear 81… 100%).

λ – a coefficient that takes into account the share of developed area of buildings that have the status of cultural heritage sites in the total developed area of the assessed area (see formula 8).

$$S_{exp.roof} = \lambda \times S_{dev.} \qquad (8)$$

Where $S_{exp.roof}$ – area of coverage that can potentially be used, sq. m; λ – is a coefficient that takes into account the presence of cultural heritage status in the building. Determined by formula 9; $S_{dev.}$ – developed area of the assessed area, sq. m.

$$\lambda = 1 - \frac{S_{her.}}{S_{dev.}}, \qquad (8)$$

Where $S_{her.}$. – building area of buildings with the status of a cultural heritage monument, sq. m; $S_{dev.}$ – developed area of the assessed area, sq. m.

The Law of Ukraine "On Protection of Cultural Heritage" prohibits any interference and change in the appearance of a protected object [16]. Therefore, the decision on the possibility of installing exploited roof on such building should be made very carefully and individually, respectively, the developed area of such buildings should be removed from the total developed area of the assessed area.

The proposed mathematical model allows to determine the potential territorial resource of urban areas by including in the operation of roofs of existing and designed buildings. Such analysis can be performed both at the city level when developing master plans, zoning plans of settlements and detailed plans of individual planning entities, and at the local level when implementing pre-project proposals and sketch projects for individual land plots.

CONCLUSION

Trends of intensification of urban area development.

The study confirmed the trend of intensification of use and development of the modern city. Thus, the analysis performed on the example of 51 planning elements - blocks, microdistricts, residential groups of buildings in Kyiv, confirmed this trend (see Figure 6).

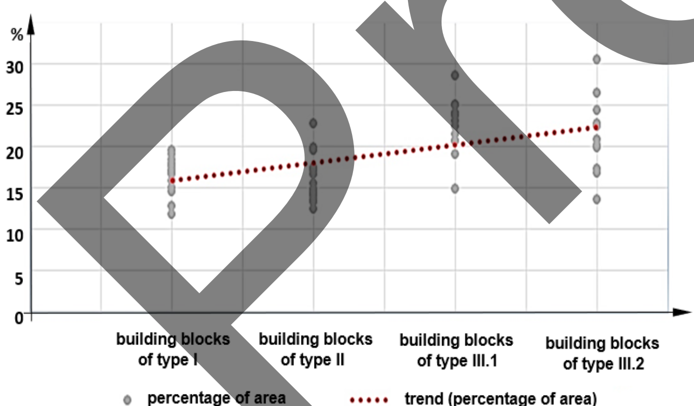

FIGURE 6. Percentage of developed area within the assessed areas of different building periods (consolidated graph)/ *Source:* own research, designed especially for this paper.

The proposed mathematical model allows to determine the potential territorial resource of urban areas due to the inclusion in the operation of exploited roofs of existing and design buildings and structures. The calculation is based on the area of existing buildings and structures and a system of coefficients that consider geometric type of roof, historically formed type of building, technical condition (physical wear) and cultural value of each building within the assessed block.

Experimental Verification of the Proposed Method

Experimental verification of the proposed method shows that the decision to attract exploited roofs as an additional functional and territorial resource makes it possible to obtain from 9,4% to 27,:% (of the area of the estimated planning element – blocks, microdistrict, group of buildings) of additional areas depending on the type of building, namely:

- *Type I* – blocks of buildings of the first mass series of the industrial period of housebuilding (50-60 years of the XX century) – 9,6… 19,3 %%;
- *Type II* – blocks of buildings of mass series in the 70-80s of the XX century – 9.4… 22.1 %%;
- *Type III.1* – modern high-rise buildings (up to 16 floors) – 12.2… 27.5 %%;
- *Type III.2* – modern high-rise buildings (over 16 floors) – 13.0… 27.6 %%;

Substantiation of Expediency of Application of the Operated Roofs

The final decision on the expediency, physical capability, and admissibility of placement of certain objects must be made in each case separately based on the analysis of a set of decision-making factors on the feasibility of using exploited roofs to improve urban use and to raise comfort of living conditions.

When there is not enough free space, there is no territorial reserve, the use of exploited roofs is extremely important to obtain additional territorial resources. This will provide an opportunity, in addition to improving energy efficiency, environmental friendliness, aesthetic appeal and attractiveness of facilities:

- • placement of normatively necessary sites for various functional purposes;
- obtaining additional green areas for limited use;
- location of additional facilities (engineering and transport infrastructure facilities);

When assessing the acceptability of the exploited roofs and areas of their functional use, the following factors should be considered:

- *urban planning* (functional purpose of the territory; type of building; urban planning value; intensity of building; architectural-landscape connection with the environment);
- *structural* (geometric type of roof; technical condition of the building; load-bearing capacity of building structures);
- *economic* (land value; intensity of land use; profitability of the building; increase in the value of facilities and territory);
- *environmental* (microclimate regulation; energy saving requirements; increasing the level of landscaping and greening).

Establishing the feasibility of using exploited roofs as an additional functional and territorial resource of blocks and plots of urban development is determined on the basis of calculating the total economic efficiency from the implementation of the project decision. This assessment is based on three components:

- cost-effectiveness of investing in the implementation of the project solution;
- cost-effectiveness of saving of operating costs in the case of the project solution implementation;
- social efficiency of the implementation of the project solution due to increased comfort and diversification of service facilities.

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The Method and Research of a Horizontal Settler with Improved Design

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Abstract. Near 80% of the Ukrainian citizens are received drinking water from surface sources. The quality of them deteriorates in terms of physical and chemical parameters. Nowadays, despite the development and improvement of membrane technologies for high quality drinking water, coagulation process is the main process of natural surface water treatment. The most common technological scheme of water clarification, which is used in Ukraine at water treatment plants, includes in the first stage, horizontal settlers. This article is claimed about increasing the efficiency of horizontal settlers in drinking water supply. We propose a method which based on construction changes to intensify the process of sedimentation suspended particles and improve the quality of clarification natural water. The design of horizontal settler with improved design for surface water treatment has been developed and proposed. The method of its research is substantiated and the results of experiments are given.

INTRODUCTION

It is difficult to find surface water bodies in Ukraine that are not polluted by human activities. So the problem of supplying water with high drinking quality to citizens remains relevant for the last few decades. Supplying drinking water from underground sources is decreased by almost 25%. At the same time, near 80% of the Ukrainian citizens are received drinking water from surface sources. The quality of them deteriorates in terms of physical and chemical parameters [1-5].

Nowadays, despite the development and improvement of membrane technologies for high quality drinking water, coagulation process is the main process of natural surface water treatment. [1, 6].

The most common technological scheme of water clarification, which is used in Ukraine at water treatment plants, includes in the first stage, horizontal settlers. [1]. They have proven to be easy to operate and reliable facilities which can work at different physical and chemical parameters of water quality. However, disadvantages include the inefficient operation of water distribution system in the cross section at the inlet to the settling tank and the collection of clarified water at the outlet.

Today there are many structures and devices for distribution and collection water in horizontal settling tanks [7-11]. The main disadvantage of them is their design for equal distribution of source water. It does not evenly distribute water evenly along the cross section of the settling tank, and the dispersed drainage system begins to drain water from the horizontal settling tank after 1/3 of its length [7]. This reduces the time to remove more suspended solids from the water. The concentrated system takes water from the settling tank in trays, which are located at the end of the settling tank with drains of different designs [12]. With increasing water consumption, they do not provide complete drainage of clarified water (part of the clarified water is returned to the settling tank) and from the bottom the drained water with sludge. Thus there is a longitudinal circulation [11].

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MATERIAL AND METHODS

To eliminate the above-mentioned shortcomings of horizontal settlers for clarifying natural water we suggest a horizontal settler with improved design. The plan and cross-section of such tank are shown in Fig.1 and Fig 2.

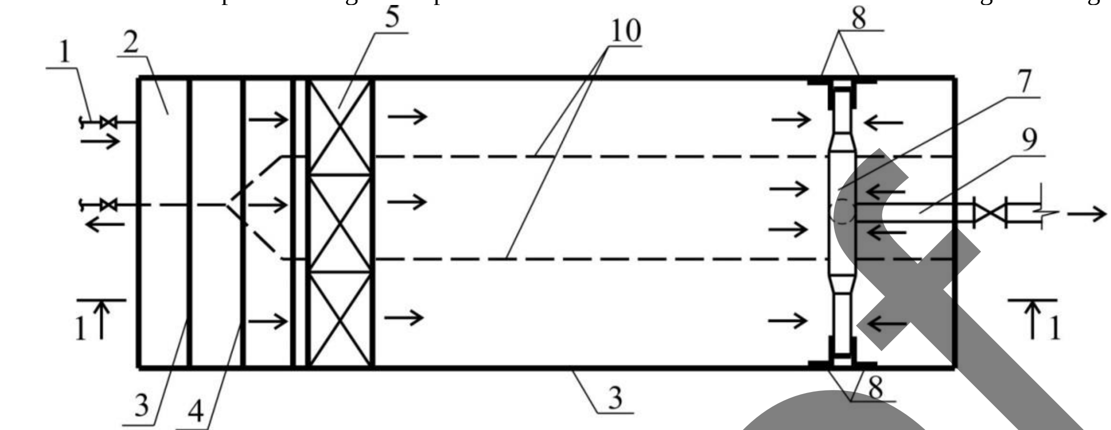

FIGURE 1. The plan of horizontal settler with improved design.

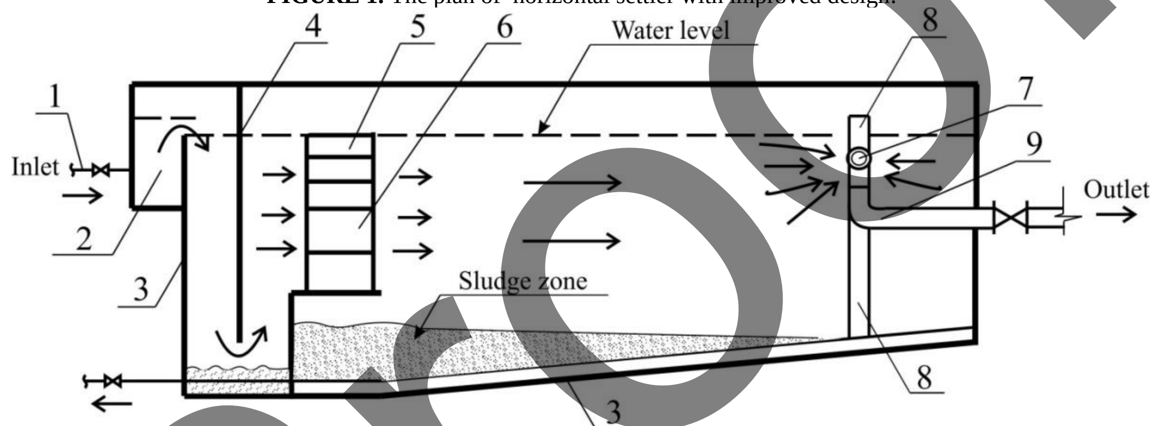

FIGURE 2. Cross-section of horizontal settler with improved design.

The horizontal settler with improved design consists: a pipe which supplies water after the sludge flaking chamber 1, a water supply tray 2, a settling tank 3, a training wall 4, removable modules 5 in which horizontal plates or pipes 6 are located, the diameter of pipes or the distance between plates decreases from bottom to up, a drainage system for clarified water 7, which consists of a porous or perforated telescopic pipe 7, and can go down and up by a direction line 8 depending on the physic-chemical parameters of water quality, flexible hose (pipe) 9 for water drainage, perforated system pipes for periodic discharge of sludge 10, which are located at the bottom of the settling tank 3.

The horizontal settler with improved design works like: water from the chamber for the formation of sludge flakes through the pipe 1 enters in the supply tray 2 and further into the settling tank 3, flows between the walls of the settling tank and the training wall 4 and returns under the wall rises between pipes or between the plates 6 and the modules 5, moves along the body of the settling tank to the porous or perforated telescopic pipe 7, which can go down and up by direction line 8 depending on the physic-chemical parameters of water quality, a flexible hose (pipe) 9 for drainage. The accumulated sludge in the horizontal settlers is periodically formed through a system of perforated pipes 10, which are located at the bottom of the settling tank 3.

The proposed design of the settler allows improving the quality of water after clarification, reducing longitudinal circulation in the facility and additional water consumption in the moment of discharging sludge from the distribution system.

The research for water treatment plants are usually carried out on models in laboratories because in natural conditions it is almost impossible to do, due to their operation.

In a process of modeling hydraulic phenomena, the main force that affects the process under study is determined. In horizontal settlers, the main force acting on the process of deposition of the suspension (floc) is the force of gravity. Therefore, such structures are modeled according to the Freud's criterion. In this case, water velocity in the model is determined by the dependence [13-15]:

$$V_m = \frac{V_n}{\sqrt{\frac{L_n}{L_m}}}, \tag{1}$$

where V_m is water velocity in the model; V_n is water velocity in natural conditions; L_n is a length of a full-scale system; L_m is a length of a model system.

The water velocity in full-scale horizontal settler is assigned in the range from 6 to 8 mm/s (for low-turbidity waters) and from 7 to 10 mm/s (for medium-turbidity waters) [7]. Therefore, if you take the value of 7-8 mm/s, it makes it possible to clarify both low-turbidity and medium-turbidity waters. If we take the coefficient of scale of geometric similarity as L_λ= 12, then:

$$L_\lambda = \frac{L_n}{L_m} = 12 \tag{2}$$

The water velocity in the model will be:

$$V_m = \frac{7 \div 8}{\sqrt{12}} = \frac{7 \div 8}{3,46} = 2,02 \div 2,31 \tag{3}$$

The height of sedimentation zone in horizontal settling tanks is assigned 3-3.5 m [7].

For the model, it will be:

$$H_m = \frac{3 \div 3,5}{12} = 0,25 \div 0,29 \tag{4}$$

The length of the full settlers L_H (m), determined by the follow equation [7]:

$$L_n = \frac{H_n \cdot V_n}{u_0} \tag{5}$$

where u_0 is sedimentation rate in settlers. For such conditions we can take into account this rate as 0.45 mm/s [7].

In this case, the length of full-scale settler will be:

$$L_n = \frac{(3 \div 3,5)\cdot(7 \div 8)}{0,45} \approx 47 \div 62 \tag{6}$$

The length of model will be:

$$L_m = \frac{47 \div 62}{12} \approx 3,9 \div 5,2 \tag{7}$$

Thus, we accept the model of a horizontal settler with the following geometrical parameters: length of a settler is 5.0 m; the height of sedimentation zone is 0.29 m, taking into account the height of the sludge zone and the construction stock is 0.4 m, and the width is 0.25 m.

EXPERIMENTAL AND NUMERICAL DATABASE

Experimental studies are conducted on the model of the horizontal settler with the coefficient of scale of geometric similarity as L_λ= 12. The scheme of the experimental setup is shown in Fig.3. It includes: a tank for preparation of a water turbidity 1 (we use the silt from the River of Seversky Donets as sludge), a mixer 2 which rotates by the electric motor 3, and the float batcher 4. Water moves in a tank by the pipe 5. Constant pressure is reached by a tank of constant water level 6. Coagulant or potassium permanganate ($KMnO_4$) supplies from a water tank 8 through a hose 9 by Boyle-Marriott vessels 7. From the water tank 8 by pump 12, water goes into the tank 6. It mixes quickly with the reagents. From the constant water level tank 6, water enters in the distribution system 14 of the vortex-type sludge flake chamber with vertical walls 15 through the hose 13. Their diameter decreases upwards from 32 to 15 mm. Finally, water gets into horizontal settlers with improved design 19. The clarified water is collected by a telescopic perforated pipe with a diameter of 25-32 mm, which can go up and down 20 by the direction line 21, and the hose 22 is discharged into the sewer. Sediment from the settling tank is periodically discharged through the pipe 23. For visual observation and removal clarified water in the locations of the modules observation windows are designed.

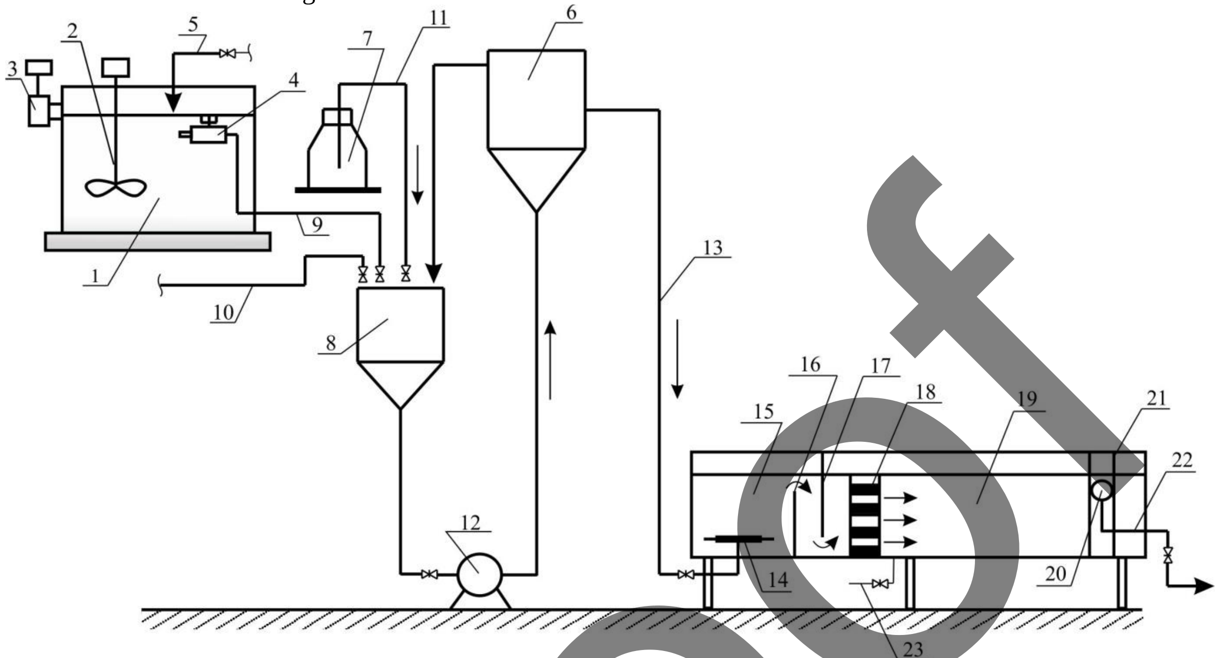

FIGURE 3. The scheme of experimental installation

All researches for the horizontal settlers with improved design must be carried out at all times of the year. For visual observation of the process and removal clarified water, a chemical reagent like potassium permanganate is used. For studying the modes of water movement in the horizontal settling tank with improved design is fed into the Pitot tubes, which are located on a movable platform. Pitot tubes are placed at different depths of the settling tank, the number of them at least three.

In the process of studying the efficiency of the horizontal settlers with improved design, the transparency of the water is determined by the colorimeter and the weight method. Water samples are taken at the outlet of the settling tank and along the length by samplers which are located on a movable platform and moved along the settling tank. The samplers are placed at different depths of the settling tank, the number of them at least three. The measurement data of these samples are equal to the experimental data of other authors [13, 16-18]. The efficiency index of settling tank is used as an indicator of efficiency:

$$K = \frac{C_i}{C_y} \tag{8}$$

The first series of experiments is devoted to determining the influence of the distribution system on the process of sedimentation sludge along the length of the horizontal settling tank. The experiments are carried out in conditions close to the conditions under which the studies of the horizontal settling tank with a perforated water distribution partition were carried out. The water distribution partition was arranged at the beginning of the settling tank, in front of which there was a porous partition (or without). In this case, the concentration of particles in the water at the inlet of settling tank in the first series of experiments are 70-80 mg/dm^3, and the average flow rate is 2,58·10^{-3} m/s, the temperature near 15°C. This conditions help to make it possible to compare experiments with each other. It should be noted that during this series of experiments, the perforated pipe for drainage of clarified water was located at the water level.

The results of measuring the depth of sludge along the length of the horizontal settling tank are presented in Fig. 4. This data shows three different situations: when the perforated water partition arranged at the beginning and the end of collecting tray in front of which is a porous partition (line 1), and without it (line 2 [19]), and the last line 3 is the depth of the sludge along the length of the horizontal settler with improved design with a tubular water distribution system and a perforated drainage pipe for clarified water.

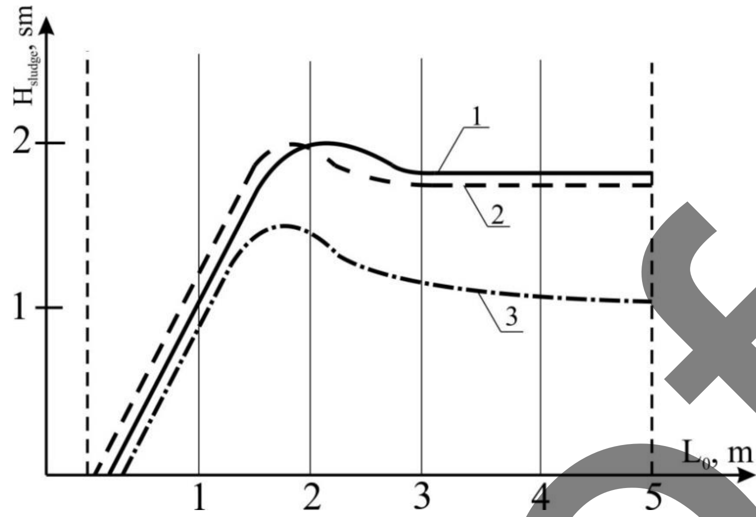

FIGURE 4. The data of measuring the depth of sludge along the length of the horizontal settler
1 - with the perforated water partition; 2 - without perforated water partition; 3 - the horizontal settler with improved design

The results on Fig. 4 are shown that pipes with different diameters are better for distribution water in the cross section in the horizontal settlers. The turbulence of flow will be lower than behind the perforated partition. This is indicated by the closer deposition and accumulation sludge to the tubular water distribution system.

The turbidity of clarified water in the horizontal settler with improved design is slightly higher (6-7%) than in the horizontal settling tank with a porous partition, but much less than without it. It should be noted that the efficiency of particles sedimentation in the horizontal settling tank is influenced not only by the water distribution system, but also by the clarified water drainage system. So our next research will determine the effect of perforated pipe immersion depth on turbidity.

DISCUSSION

These studies are continuing of previous studies on this topic. They considered increasing the efficiency of work of the horizontal settler. It can effect on clarifying water and get drinking water with high quality after water treatment plant [17, 18].

CONCLUSION

A horizontal settler with improved design for drinking water supply is proposed and investigated. The method of research of the horizontal settler with improved design which allows research technological processes of deposition of a suspension in such construction is developed. The expediency of using a tubular system with different pipe diameters for water distribution in a horizontal settling tank has been experimentally confirmed.

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Municipal Solid Waste Composting as a Factor of Sustainable Development of the Modern City

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Abstract. Proper municipal solid waste management is relevant in the context of sustainable development of modern cities. It is especially essential for developing countries. The organic fraction of municipal solid waste is significant and biodegradable. Extraction of organic matter and its composting is classified as the most preferable approaches of the strategy of sustainable management of municipal solid waste. Composting technology is characterized by its economic efficiency compared to other alternatives and is most commonly used worldwide. In Ukraine, there is no practice of municipal solid waste composting. For the first time, the pilot project on the practice of composting the organic component of municipal solid waste was introduced in Ukraine in the Lviv city. The paper presents the results of research of physical and chemical properties, agrochemical parameters and heavy metals content of the formed compost in accordance with the Ukrainian Standard of fertilizers. Due to received data, the city's municipal solid waste compost can be used as fertilizer in agriculture.

INTRODUCTION

Municipal solid waste (MSW) is one of the most important by-products of the urban lifestyle. Around the world, it generation rates are rising even faster than the rate of urbanization. According to the World Bank, in 2025 urban residents will produce an average of 1,42 kg / person of solid waste per day compared to the current 0,74 kg [1].

Compared to those in developed nations, residents in developing countries are more severely impacted by unsustainably managed waste. In low-income countries, over 90 % of waste is often disposed in unregulated dumps or openly burned. These practices create serious health, safety, and environmental consequences. Poorly managed waste serves as a breeding ground for disease vectors, contributes to global climate change through methane generation [1].

Managing waste properly is essential for building sustainable and livable cities, but it remains a challenge for many developing countries and cities [1]. MSW management is the biggest challenge for both small and large cities in developing countries [2].

Since the organic fraction of MSW is significant and biodegradable, it can be removed, processed and used as a potential source of plant nutrients, rather than lost due to improper disposal/treatment [3, 4]. Extraction of organic matter from MSW for reuse and recycling is classified as the most preferable approaches in integrated solid waste management systems in a framework of a circular economy [5].

Today composting is the most widely used worldwide technology for the disposal of sorted organic waste and which can be practically implemented at any scale [5].

Composting technology is characterized by its economic efficiency compared to other alternatives [6].

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The composting process is the conversion of organic matter into stable, sanitary and high-quality final product «compost» through biochemical / biological actions.

The recycling of organic waste through composting is viewed as a sustainable approach for waste management as it provides a valuable source of organic matter for enhancing soil organic matter content that is being deteriorated due to various anthropogenic activities, and it is recognized as a reliable approach for improving different soil properties [5].

Compost is characterized by a high content of organic matter as well as a much of microelements and macronutrients.

The application of compost improves soil structure, prevents erosion. It is useful in bioremediation of contaminated soil and plant disease control. Composting also increases soil biodiversity [7].

Importantly, compost can replace inorganic fertilizers, which are used in large quantities in agricultural activities. Therefore, compost application is being promoted as an alternative to heavy chemical fertilization to enhance agricultural sustainability [8].

Composting has a lot of benefits like: reduce landfill space, decrease surface and groundwater contamination, reduce methane emissions, and also lower air pollution from burning waste.

The quality of compost can be different and depends on the quality of organic waste. The main problem is the high content of heavy metals.

It was investigated that the content of heavy metals is higher by 43-194 % in compost prepared from organic wastes of large cities in comparison with small towns. Composts prepared from separated biogenic wastes contained higher organic matter (by 57 %), total N (by 77 %) and total P (by 78 %), but lower concentrations of heavy metals (63-84 %) as compared to those prepared from mixed wastes [9].

The quality of compost as an organic fertilizer must comply with certain requirements.

To limit the usage of compost as a fertilizer, as well as the potential for soil and food chain contamination, standards for compost prepared from organic matter (OFMSW) have been set in some countries.

Due to variations in compost quality, it is not always possible for compost to be beneficially used on soil. In such cases, compost may be used as alternative daily cover in landfills [10].

The problem of solid wastes is one of the urgent environmental problems of Ukraine. Despite the fact that over the last 20 years the population of Ukraine has been constantly declining, the volume of MSW is increasing. The main method of MSW management is their removal and disposal in landfills and dumps, most of which do not keep environmental safety requirements.

The signing of the Association Agreement between Ukraine and the European Union in 2014 and the approval of the National Waste Management Strategy in Ukraine until 2030 require local authorities to take immediate and decisive actions to implement European standards into MSW management.

According to the National Waste Management Strategy in Ukraine until 2030 it is planned to recycle 15 % of MSW in 2023, and in 2030 – 50 % of MSW from the total volume of their generation.

Due to the fact that 70 % of the population of Ukraine lives in the cities, the removal of the organic component of biodegradable MSW can significantly reduce the load on urban landfills and dumps.

The pilot project on the practice of composting the organic component of municipal solid waste was first introduced in Ukraine in the Lviv city in 2020. As of January 2021, population of Lviv was 721 510. The city's residents generate about 150 tons of solid waste daily.

In this work, we investigated the quality of prepared MSW compost in accordance with the Ukrainian Standard of fertilizers formed from organic fraction of municipal solid waste [11]. The purpose of the research was to establish the intended use of the finish compost.

MATERIAL AND METHODS

Compost Production

The technology of processing organic fraction of MSW at the Composting Station in Lviv city has preparatory and main stages.

At the preparatory stage, the organic matter of solid waste is manually sorted by householders and loaded into special containers. The types of wastes that can be disposed into containers are food wastes, tea infusions and coffee grounds, mown grass, withered flowers, dry leaves.

Containers with organic matter are taken to the City Station for composting process. The composting site is located so that the liquid formed during the composting process falls on the sewage treatment facilities of the city.

The composting process has three stages – Start, Peak and Finish. At each stage, professional equipment and appropriate biological products are used. Humidity and temperature are controlled throughout the all composting period.

At the first stage organic waste materials are loaded into a special container for disinfection. Sterilization of wastes takes place within 72 hours at a temperature of up to 72-80 degrees and ensures the destruction of bacteria and removal of various odors.

At the second stage the organic matter is stacked in the large piles which are aerated, moistened and added microbiological preparations (start and finish) using a special aerator. The waste is being up to two months in the piles depending on the time of year and air temperature.

At the third stage the formed compost is sieved through a special equipment to separate the large fraction which can be used as a natural bacterial preparation to enrich other piles.

Sample Selection and Methods

Sample selection for research was carried out from different batches of formed compost. Subsamples were collected from different parts of one batch manually using a scoop. The weight of a single sample was not less than 0,3 kg. The number of subsamples aggregated into one sample for further experiments was not less than 30. To obtain an average sample, the combined one was thoroughly mixed on polyethylene coverage, distributed in a layer of equal thickness and reduced to a weight of at least 1 kg by the method of quartering. The obtained sample was placed in a double plastic bag, tied and labeled. It was transferred to the laboratory and stored in a cold room at a temperature of 4ºC for further analysis.

The quality of compost was evaluated as an organic fertilizer according to the Ukrainian Standard [11]. Since the compost can be applied in agriculture, forestry, green building and land reclamation, it is necessary to analyze its basic physical and chemical properties, agrochemical and toxicological parameters before use. By the Standard, quality indexes for compost were measured(the content of large fractions (> 50 mm), the content of organic matter, humidity, pH value, total nitrogen, phosphorus, potassium, the content of Cd, Co, Cu, Ni, Mn, Pb, Sr, Cr, Zn, Hg, Fe).

The content of large fractions in compost was determined by selection of particles larger than 50 mm manually. Treatments were replicated three times.

Determination of moisture content was carried out according to the State Standard 26713-85. This method is based on measuring the weight loss of the compost sample during drying to constant weight.pH value was measured in a sample of compost with the original moisture by potentiometric method with a glass membrane electrode(based on the State Standard 27979-88).Organic matter content was determined by the thermogravimetric method according to the State Standard 8454:2015. The method is based on determining the loss of mass of the compost sample after calcination in a muffle furnace at a temperature of 800 °C.

The total nitrogen was determined based on the State Standard 7911:2015 by spectrophotometric method (at the wave lengths of 430 nm) with Nessler's reagent. The total phosphorus content in the compost was determined according to the State Standard 26717-85 by photometric method. The total potassium content in compost was determined according to the State Standard 7949:2015 by flame-photometric method.

The content of heavy metals was determined with the atomic absorption spectrometric method (AAS) on a C-115 MI.

The results of chemical analyses were processed statistically using the standard statistical package. Results expressed as mean values ± standard deviation (n=9).

RESULTS AND DISCUSSION

Physical and Chemical Properties

The physical and chemical properties of compost are strongly dependent on particle size. Thus, bulk density of the compost increases as particle size decreases. However, with the decrease of particle size there is a trend to decrease some soil parameters as pH, porosity, saturated water holding capacity, organic content, and Ca, Fe, Mg, and Mn contents. Based on the physicochemical properties of different composts, the coarse compost particles larger than 0,8 mm have considerable potential in agricultural applications as soil amendments [12].

Particle size affects oxygen movement, as well as microbial and enzymatic access to the substrate. Smaller size particles of organic material increase the surface area available for microbial attack. Large size particles reduce surface area for microbial attack which slows down or may stop composting process altogether [13].

The Ukrainian Standard limits the content of large fractions in compost at the level less than 2 %. The studied compost contains particles larger than 50 mm in the amount of 1,5 % (Table 1). Thus, it is allowed to be used as an organic fertilizer.

TABLE 1. The physical and chemical properties of MWS compost.

Parameters	**MSW Compost Test Sample (Lviv Composting Station)**	**Limits for MSW Compost According to the Ukrainian Standard**
Content of Particles Larger than 50 mm, %	1,5±0,2	no more than 2
Organic Matter Content, %	43,0±2,3	no less than 40
Moisture Content, %	38,0±3,1	20-80
pH	7,0±0,3	6,5-8

The quality of compost as an organic fertilizer is closely related to the content of organic matter. The organic matter content depends on the quality of raw materials and composting conditions.

The content of organic matter affects the physical structure of the soil and biological activity, which, in turn, affects other properties and thus determines the suitability of the soil for various activities, mainly agricultural.

Soil organic matter consists of a variety of simple and complex carbon compounds and thus provides food for a variety of organisms. It provides much of the cation exchange and water-holding capacities of surface soils. Certain components of soil organic matter are largely responsible for the formation and stabilization of soil aggregates [14]. Soil organic matter also contains large quantities of plant nutrients that act as a slow-release nutrient storehouse, especially for nitrogen. Furthermore, organic matter supplies energy and body-building constituents for most of the microorganisms. However, the reduction of soil organic matter content is of worldwide concern. An increase in soil organic matter can be obtained by external organic amendments. Among these, compost belongs to the most stable sources of organic matter [15]. Organic matter and N are associated with macro aggregates [16]. Coarse compost size fractions could be used in increasing soil organic matter and total N content of soil more effectively than fine fractions [12].

The quality of compost as an organic fertilizer is closely related to the content of organic matter. The organic matter content depends on the quality of raw materials and composting conditions. The average bio-compost must contain about 33,3 % organic matter, but not less than 20 % [17].

The test compost is characterized by a high content of organic matter – 43 % (Table 1).

The humidity of compost is very important and can change widely.

Moisture management requires a balance between microbial activity and oxygen supply. Moisture content lower than 30% or higher than 75% inhibits microbial activities due to early dehydration or anaerobiosis. This in turn would create anaerobic conditions and brings about putrefaction, resulting in disagreeable odor and undesirable products [13].

In the present study, moisture content is at the optimal level – 38 % (Table 1).

The quality of compost and its use is limited by the pH value. The range of pH values suitable for bacterial development is 6,0-7,5, while fungi prefers an environment in the range of pH 5,5-8,0. A rise in pH beyond 7,5 could make the environment alkaline, which may cause loss of nitrogen as ammonia [18]. The optimum pH for most microorganisms is between 6,5 and 7,5 [13].

The pH value of the studied compost accords to the requirements of the Ukrainian standard of MSW compost (Table 1).

Agrochemical Parameters

Remarkably, compost contains significant amounts of nutrients, especially the macronutrients [19].

Nitrogen, phosphorus, and potassium (NPK) are macroelements available in the soil for plant health and play a major role in plant metabolism.

Compost has been reported to contain optimum N content required for plant growth [20]. High accumulation of nitrogen in compost fertilizer is not a common occurrence because due to mineralization, nutrients in compost fertilizer are released gradually [7].

The total nitrogen is contained in the studied compost with in an acceptable limit according to the requirements of the Ukrainian Standard (Table 2).

TABLE 2. Agrochemical parameters of MSW compost.

Parameters	Content of Nutrients, % (Dry Matter)		
	MSW Compost Test Sample (Lviv Composting Station)	[1]UA Standard	[2]UA Standard
Total N	2,0±0,2	no less than 1,8	no less than 1,5
Total P(P_2O_5)	2,7±0,3	no less than 2,0	no less than 1,8
Total K(K_2O)	0,5±0,1	no less than 0,1	no less than 0,1

[1]Limits of Ukrainian Standard for MSW compost intended for use in agriculture
[2]Limits of Ukrainian Standard for MSW compost intended for use in forestry, green building and land reclamation

As macronutrient, phosphorus is essential for plant growth. Phosphorus is important in plant's cell division generation of new tissue and complex energy transformations in the plant. Adding phosphorus to soil low in phosphorus promotes root growth, winter hardiness, stimulate stilling, and often has tens maturity in plants.

Compost has been reported to contain optimum phosphorus concentration necessary for plant growth [7, 20].

Potassium is amacronutrient necessary for proper plant growth. It plays a wide variety of roles in plant biochemistry and ecophysiology. Potassium increases plant growth, carotene, and chlorophyll contents.

Potassium is needed for the plant to create sugars. It is also essential because it helps the plant to resist disease and survive adverse weather conditions such as drought and cold [7].

P and K deficiency could be improved by adding fertilizers to soils.

Phosphorus mainly exists in the organic matter component, which is higher in coarse compost size fractions. High potassium concentration in fine compost fractions is attributed to K presence in the mineral elements as inorganic form. As compost particles decrease, inorganic components increase, thus mineral content increases [12].

Due to received data, macronutrients content in test compost samples is sufficient to increase phosphorus and potassium content by compost applying into the soil.

Heavy Metals Content

Concentrations of heavy metals in the formed compost compare with the permissible norms for fertilizers [11] are presented in Table 3.

TABLE 3. Heavy metals content in MSW compost.

Element	Content, mg/kg on Dry Matter		
	MSW Compost Test Sample (Lviv Composting Station)	[1]UA Standard	[2]UA Standard
Cd	0,50 ±0,08	30	250
Co	4,47 ±0,53	100	300
Cu	67,48 ±13,69	1500	6000
Ni	18,98 ±2,60	200	900
Mn	214,55 ±16,25	2000	7000
Pb	8,31 ±0,94	750	2000
Sr	0,81±0,17	300	600
Cr	3,45±0,58	750	5000
Zn	383,22 ±13,46	2500	9000
Hg	0,03 ±0,01	15	50
Fe	2185±65,55	25000	45000

[1]Limits of Ukrainian Standard for MSW compost intended for use in agriculture
[2]Limits of Ukrainian Standard for MSW compost intended for use in forestry, green building and land reclamation

The high concentration of heavy metals in composts can exclude the possibility of their use in agriculture [21].

The potential risk of heavy metals in compost is related to their uptake by plants and the entry of these elements from the soil into the food chain. Therefore, the assessment of such toxicological parameters is necessary before using compost as a fertilizer.

The results of studies of the heavy metals content in compost did not show exceeding the limits set in the Ukrainian Standard for fertilizers (Table 3).

The study indicates that such toxicological characteristics of compost, as heavy metals content, are much lower than the requirements for fertilizers (according to Ukrainian Standard), and therefore formed MSW compost of Lviv city can be used as fertilizer in agriculture.

CONCLUSION

Composting of organic matter is a necessary measure of the sustainable MSW management strategy. Physical and chemical properties, agrochemical parameters of the MSW compost of Lviv city agree with the requirements of the Ukrainian Standard for fertilizers formed from organic matter of MSW. The content of organic matter and basic macronutrients (N, P, K) in compost is sufficient to increase soil productivity. The studies of the heavy metals content in compost did not show exceeding the limits set in the Ukrainian Standard for fertilizers. The results of the assessment of the quality of MSW compost of Lviv city indicate the possibility of its use as a fertilizer in agriculture. Therefore, the introduction of composting of organic matter in the cities of Ukraine should be considered as a necessary condition for their sustainable development.

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MIPS Analysis as an Informative Assessment of the Environmental Friendliness of Production Processes, Sustainable Development of Natural Environment Objects and Efficient Use of Resources

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Abstract. MIPS analysis (Method of generalized assessment of the quality of ecological and economic systems) is a tool for assessing environmental friendliness. The specificity of the method allows identifying hazardous factors affecting complex objects of natural and man-made content, which is the basis for preventing violations of the provisions of sustainable development and reducing the cost of compensation for environmental damage. The advantage of this method is the ability to detect hazardous factors at each stage of the product life cycle, specific factors of environmental damage. The considered method corresponds to the studied concept of sustainable development and can be used in conducting a comprehensive assessment of the environmental friendliness of a company and/or products with regard to environmental, economic and social components.

INTRODUCTION

The main principles of MIPS analysis are the focus on input and services. The MIPS concept is based on the fact that resources that are introduced into the system of production and consumption (technosphere) eventually turn into outputs (results) that affect the environment (climate change, eutrophication and acidification). Thus, resources or input flows (material expenditure, including energy), taken from nature (ecosphere), lead to increased outputs (emissions, waste) and their potential impact on natural environment objects.

The concept of the principle of input follows from the law of conservation of matter energy, assuming quantitative equivalent inputs and outputs. Accounting for input material flows allows pre-assessing the potential impact of products and services on the environment (1). Thus, MIPS is a practical solution to reduce the complexity of the assessment, as well as the uncertainties associated with result-oriented (output-oriented) assessments such as ISO 14040/44 LCA (2).

Reducing material flows at the input will help to avoid and minimize outputs and known and unknown negative impacts. In addition, the impact of toxic substances can be directly avoided or minimized on the input side, adhering to the boundaries set at the enterprise and following a more holistic understanding of resource management (1, 3). MIPS is not designed to quantify specific results (emissions of specific toxic substances) and assess their impact (acidification, greenhouse gases), but supports optimized management of input resources (4, 5).

The MIPS concept is a method of assessing the sustainability and environmental performance of companies (6-8) based on the conditions of consistency (6) and sufficiency (6, 9, 10). Eco-efficiency is defined as the saving of resources and energy per unit of service in production processes or throughout the life cycle (less resources and energy costs per service), the sequence factor determines ways to achieve environmental efficiency (closing cycles, changing the composition or quality of resources and energy costs). Sufficiency is a reduction in production and consumption (increasing the life of the product with decreasing demand for resources). These sustainability strategies complement

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each other (11). Together, they reduce the value of the material intensity index MI and increase the number of finished products S. a comprehensive analysis of sustainability strategies aims to reduce the use of resources per capita in absolute terms (11-13).

The MIPS concept takes into account the multilevel effects between the micro-, meso- and macrolevels of economy [6-10] and can be applied to management processes at the microlevel as it is a reliable measure of their impact. The method for calculating MIPS is an analysis of material intensity.

According to the eco-efficiency method in the environmental management system MIPS values take into account all sources of resource consumption at each stage of the product life cycle, evaluate its potential impact at the macrolevel and take into account the negative impact on environment components (14).

The MIPS analysis takes into account all phases of the product:

- Production (extraction of raw materials, production of semi-finished products, transportation and sale);
- Use (consumption, transportation and repair);
- Recycling and/ or disposal.

A comprehensive study of the product life cycle is necessary as it is not always obvious what environmental impact is of importance during production and what impact is associated with the use of the product. The products carry an invisible "environmental backpack", i.e., according to the MIPS concept, the impact on the environment.

The total amount of inputs "from nature" and outputs "into nature" is the basis for further analysis and evaluation of the impacts of the production system on natural environment and human health.

The main idea of MIPS is that resource extraction causes changes in natural material flows and cycles. Over time, the entire material input becomes an output (waste or emissions), so by measuring the input, you can evaluate the potential impact on the environment. Most methods of evaluating the environmental quality of a product investigate various outputs (emissions), the significance of which is well known or partially described. Of the large number of substances emitted (from several hundred thousand to one million), the number of substances that have been carefully and comprehensively studied for their effect is insignificant (several hundred). Owing to these output-oriented (result-oriented) constraints, MIPS focuses on the number of inputs being much fewer in number and easier to analyze.

The MIPS concept makes it possible to calculate the use of resources in terms of their extraction from nature: all data correspond to the number of displaced tons in nature, i.e. the categories of biotic (renewable raw materials), abiotic (non-renewable raw materials), water, atmospheric air and land in agriculture and forestry. Raw materials include metallic and non-metallic minerals (ores, rocks, sand), extracted energy (coal, mineral oil, natural gas). Energy and transport are calculated as the sum of all raw materials needed for its production, including the necessary infrastructure [6]. Different categories can be divided according to different materials and their use throughout the life cycle, so that the amount of each material or substance is precisely determined for making environmental and sustainable management decisions.

The consumption of materials in the production, use and processing or disposal is calculated as the consumption of resources. The MIPS analysis takes into account the entire life cycle.

In the general case, the MIPS concept is a method of life cycle assessment, but with an emphasis only on input data. For this reason, many aspects of MIPS, especially at the level of input data collection, can be compared to LCA in terms of defining system boundaries and product service units.

RESULTS. INFORMATION ABOUT THE ECOLOGICAL STATUS OF THE STAGES OF REPROCESSING AND RECYCLING OF WASTE

The combination of methods of MIPS analysis and LCA of a product is appropriate to determine the environmental, economic and social aspects of economic activity, take into account the potential environmental impact of a product or service in the form of emissions, discharges, waste generation during the production process, establish the amount of material and energy resources that are part of the load on the environment (Fig. 1).

Therefore, the input-oriented MIPS concept is complemented by LCA, which is output-oriented.

The use of MIPS analysis and LCA procedure makes it possible to consistently determine the level of compliance with environmental requirements. For each stage of life cycle (LC), there are identified "inputs", i.e. the use of resources, raw materials, components and products, energy, and "outputs", i.e. emissions, discharges, waste, by-products. The output function of the production system is compared with the functional characteristics of the reference values of inputs and outputs. It reflects the production system in accordance with the specified purpose and scope of application of the finished product.

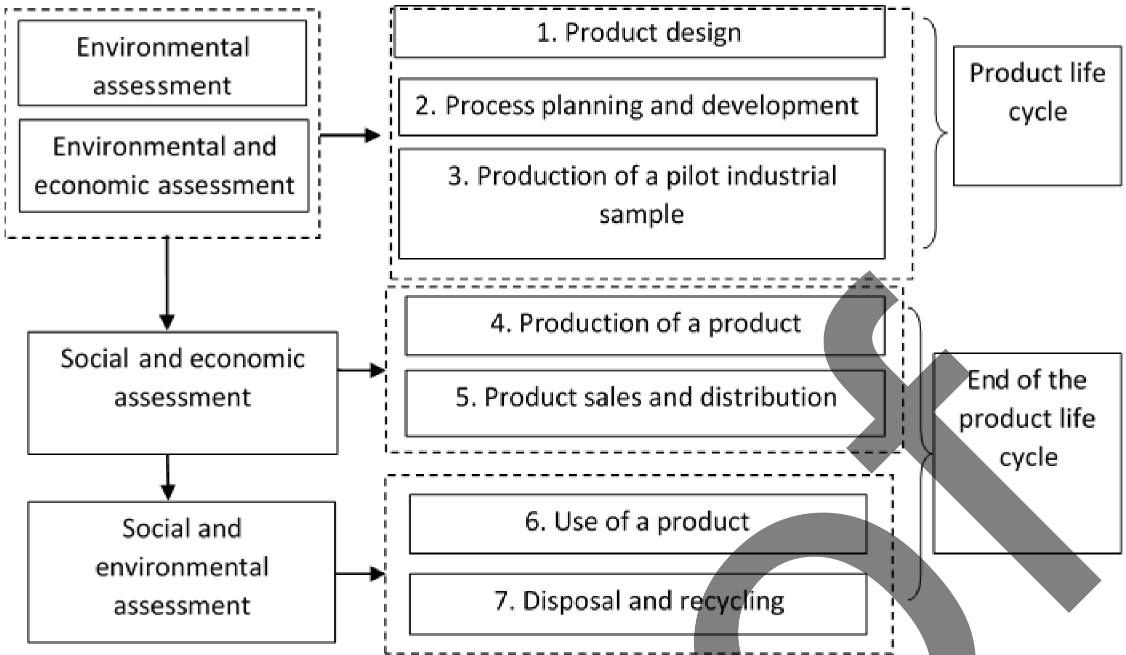

FIGURE 1. Assessment of the life cycle of the production system

Figure 2 shows the stages of impact of the product at different stages of the LC according to MIPS analysis. On the left, the estimate from the cradle to the gate reflects the material costs at the production stage (including resource extraction, production processes, packaging and transportation). MI increases before use (t_1). On the right, the MIPS estimate from the first stage of production to the final phase of product use is equal to the sum of MI values of production, use and disposal: $MI_{production} + MI_{use} + MI_{disposal}$ per unit of service for a certain estimated service life.

As the number of services increases and the MI setpoint is set, the MI/S (MIPS) value decreases. At the time of repair (t_2), MIPS increases due to the required additional inputs, but further decreases due to the extension of the service life (t_3). The gray graph shows MI_{use}. The longer the use phase, the more MI is consumed (e.g. energy consumption). Repair not only extends the service life, but also reduces the value of MI. MIPS calculation also includes MI of disposal. Obviously, the second life of the product (re-use, recycling, sharing) is appropriate only if the MI for recycling or similar processes is not higher than for primary production (6, 12, 13).

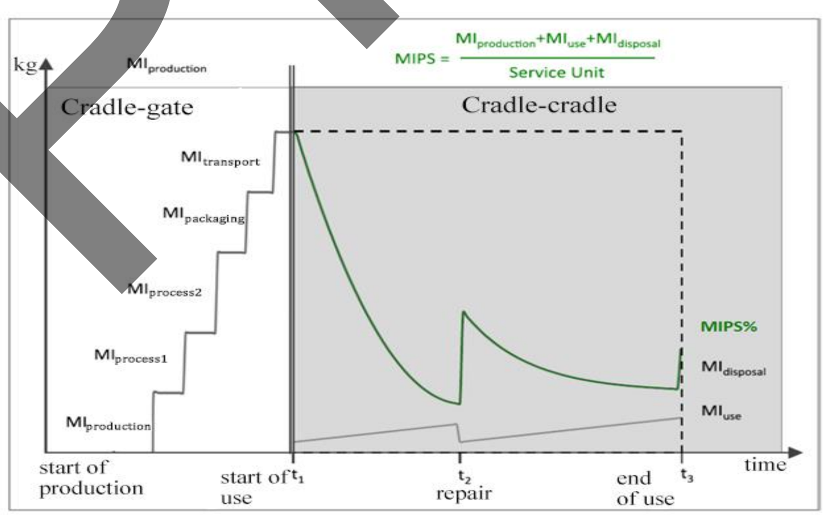

FIGURE 2. Stages of MIPS analysis

The sequence of determining MI numbers describes the strategy of closing environmental cycles within the processes (parts of technological chains), at production sites (for example, by returning waste or adding waste to production processes) or throughout the life cycle (for example, by developing materials and products that are completely recycled or decomposed) provided that the consumption of material on the circuit that closes is not more than in the primary production. Thus, sufficient consumption models with consistently and efficiently developed products and services are obtained (13.15).

At the macrolevel, the application of the MIPS analysis determines the overall level of environmental friendliness of an industrial facility, subject to the release of the final product or service. The calculation of MIPS numbers involves the implementation of seven stages of environmental assessment, which include the formulation of the purpose and objectives of the study, the selection of the basic unit of service, the establishment of control actions on the source information (Fig. 3) (6, 16).

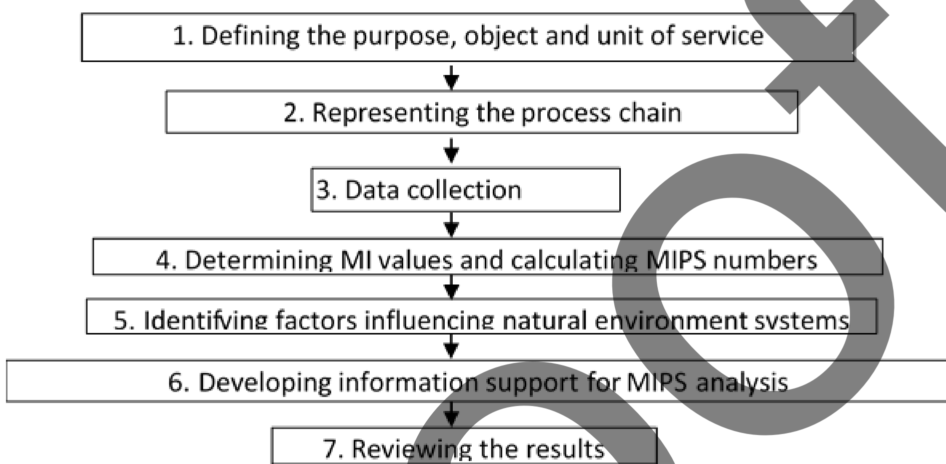

FIGURE 3. MIPS analysis flow chart

Obtaining information on the environmental friendliness of the stages of use and reprocessing and disposal of waste is the final stage of MIPS analysis of the product life cycle.

The total MIPS value of a product is calculated according to the formula

$$MIPS = MI/S, \quad (1)$$

which shows how much of the primary material or actually “nature” is removed to produce a product or service. The term “material” includes all necessary natural resources. Resources are defined as raw materials, including for energy and transport.

MI indices are indicators of quantitative assessment of probable violations of the natural organization of ecosystems; they establish the specific resource intensity and level of environmental friendliness of production, identify negative factors influencing input flows, identify processes of factor change that cause a decrease in environmental safety for natural environment (Fig. 4).

Total costs in the production life cycle, resources used and emissions into natural environment are determined at the macrolevel.

The inverse value of MIPS (S/ MI) is a measure of natural resource productivity, which corresponds to the number of services that can be obtained from a certain number of natural resources.

The MIPS concept takes into account the direct and indirect use of the material, as well as used and unused extraction (6, 17). Used and unused extraction means that material costs include both the resources used in the production of a product and the unused part of the extraction of raw materials (18).

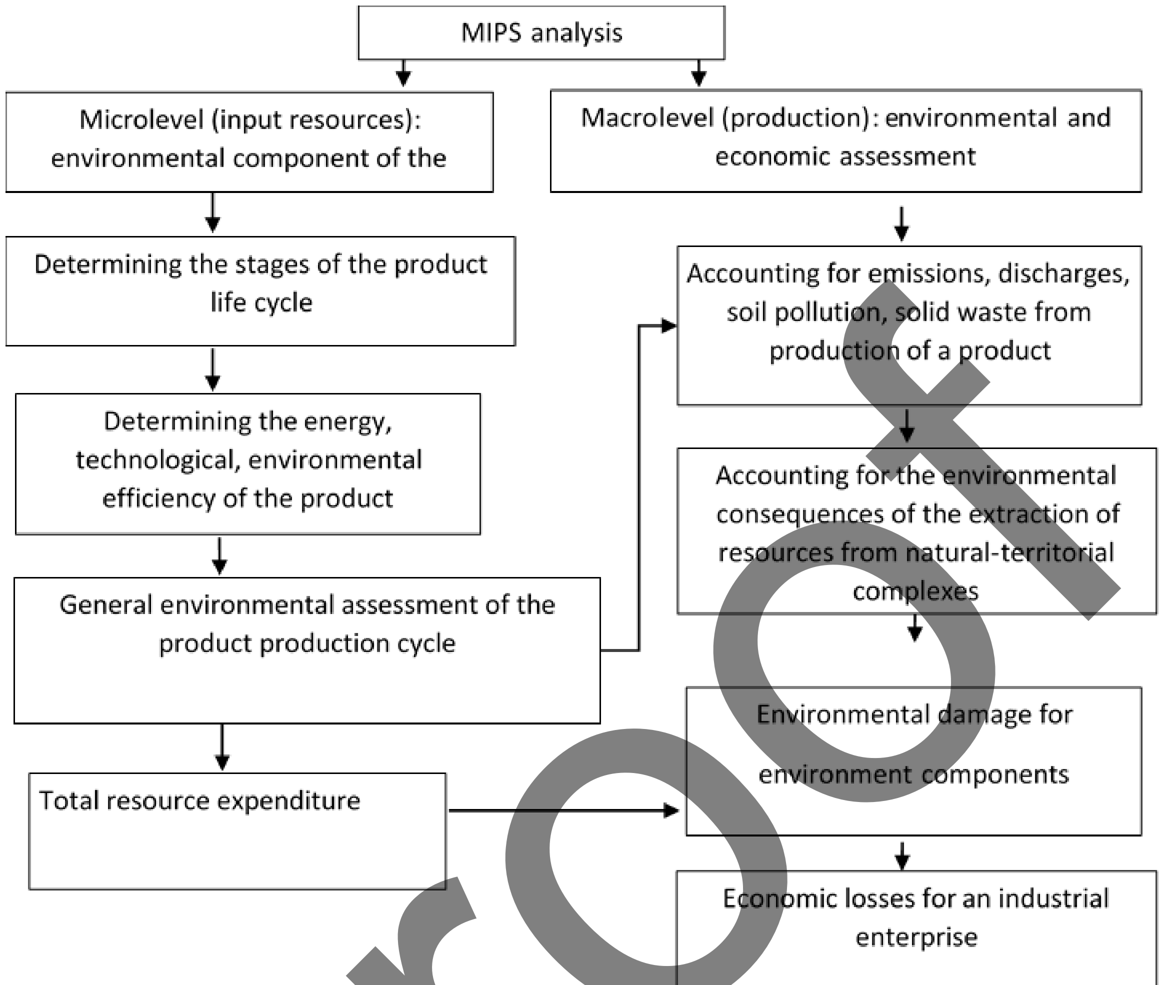

FIGURE 4. Flow chart of MIPS analysis at the micro- and macrolevels of assessment

MIPS is calculated by multiplying the input data (e.g. mass, energy) by their material consumption (MIT coefficients) and summing them up by MIPS category.

$$MIPS(x) = \frac{\sum_{i=0}^{n} m_i \cdot MI_i}{Use(x)}, \tag{2}$$

where x is the product/service; MIPS (x) is the MIPS result of a specific product x; m_i is the number of input resources i; n is the number of inputs; MI_i is the material consumption of input resource i; Use (x) is services of product x (Table 1) (6, 19).

MIPS values are an economic assessment of environmental value: the greater their value, the greater the environmental value per unit of output. The obtained results of MIPS assessment of a company are taken into account when choosing suppliers, conducting production audits, carrying out environmental certification, making investment decisions (11).

MIPS supports the analysis and search for the best possible ways to reduce and prevent the extraction of resources from nature, i.e. to reduce material costs and, consequently, the impact on the environment, while improving the quality of service. Although the MIPS concept allows weighing resource categories, each resource category is usually calculated in a separate way (unbalanced). The results of MIPS analysis can be used to manage resources, assess the condition of soils, aquatic environment and atmospheric air (6).

TABLE 1. Calculation of material intensity indicators.

partial process 1 up to partial process n			**Abiotic (ab)**		**Biotic (bi)**		**Earth movement (ea)/erosion (er)**		**Water (wa)**		**Air (ai)**	
substance /pre-product	amount	unit	MIT factor	kg/unit	MIT factor	kg/unit	MIT factor	kg/unit	MIT factor	kg/unit	MIT factor	kg/unit
			kg/unit	main product	kg/unit	main product	kg/unit	main product	kg/unit	main product	kg/unit	main product
[name] 1	m_1		MI_1	$m_1 \times MI_1$	...	...	...	...	...	...	...	...
[name] 2	m_2		MI_2	$m_2 \times MI_2$	...	...	...	...	...	...	...	...
[name] 3	m_3		MI_3	$m_3 \times MI_3$	...	...	...	...	...	...	...	...
...	...		...	...	...	...	...	...	...	...	...	...
[name n]	m_n		MI_n	$m_n \times MI_n$	...	...	...	...	...	...	...	...
∑ partial process 1				$\sum m_i \times MI_i$		$\sum m_i \times MI_i$	...	$\sum m_i \times MI_i$		$\sum m_i \times MI_i$		$\sum m_i \times MI_i$
(...) calculation of further partial processes (e.g., life cycle stages)			...	...	...	...	...	...	...	...	...	...
∑ MI (sum of all partial processes)				MI ab		MI bi		MI er MI ea		MI wa		MI ai
Total amount of service units												
MIPS (MI per one service)				MIPS ab		MIPS bi		MIPS er MIPS ea		MIPS wa		MIPS ai

The concept of service (S) in MIPS (MI/S) is based on the idea that any product provides a particular service or meets a specific need (6). In this sense, MIPS compares not only products, but services or needs that can usually be met in different ways.

The use of total MI numbers as criteria for specific resource consumption was substantiated by D.Yu. Dvinin (20). This approach allows taking into account all types of natural resources that are extracted and consumed and components of the environment, and reducing them to a single value based on the targets of the integer programming function for resource conservation planning in environmental management systems of industrial enterprises. However, this analysis does not take into account the load on individual components of the natural environment or does not provide a detailed definition of the severity of the impact of negative factors on natural systems.

The MIPS tools allow small and medium-sized companies to increase profits by reducing the material costs of producing their products, processes or services. This helps companies to develop eco-innovative products and services and reduce their material footprint. The tool provides information on the material consumption of products, processes and services, thus emphasizing the potential for savings and impact on the environment.

The constraints and advantages of applying the MIPS analysis concept have been reviewed. constraints of the application of the MIPS analysis concept are as follows (13,15):

- They do not take into account the specific ‘use of the surface” for industrial, as well as agricultural and forestry;
- They do not take into account the specific environmental toxicity of material flows. The approach is not intended to quantify the environmental hazards of ecotoxicological materials, only to supplement it, based on material and energy consumption of economic services;
- They do not determine the relationship between soil and resource use intensity and biodiversity (survival, species extinction).

The advantages of using MIPS analysis are as follows (13,15):

Material and energy costs are measured in the same units. Therefore, discrepancies in environmental assessments can be avoided, and the assessment becomes stable for different components of environment.

The MIPS concept helps in designing industrial products, in planning environmentally friendly processes, facilities and infrastructure, as well as in the environmental assessment of services.

Compared to other life cycle approaches, MIPS values are easy to calculate using simpler mathematical models without compromising the end result of the assessment, requiring less information.

The MIPS concept can serve as a basis for a comprehensive eco-labeling strategy, and can also help in making purchasing decisions and providing customer advice.

CONCLUSION

Hence, the indicators of MIPS analysis are characterized by the informativeness of the obtained data of environmental assessment: sustainable development of natural environment objects and resource conservation. The use of the concept of eco-efficiency based on MIPS analysis provides a new approach to arrange for marketing, which allows a company to carry out production processes and produce products with the least impact on the environment and receive additional economic profits. To establish the level of environmental friendliness of a particular type of economic activity, it is proposed to apply environmental efficiency assessment in accordance with the degree of impact on the environment.

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Strategic Planning for Solving Problems in the Field of Municipal Solid Waste Management as a Necessary Condition for Sustainable Development of the City

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Abstract. The article considers the existing waste management systems in the city of Lviv. The most important features of each method of waste utilization are compared and the efficiency of separate waste collection is emphasized. Sustainable municipal waste management is seen as one of the key elements for achieving urban sustainability. Particular attention is paid to the development of integrated strategies for municipal solid waste management. The aim of the work is to determine the best available waste disposal systems for their minimization and rational management.

INTRODUCTION

Solid waste management is one of the key environmental problems, without the solution of which the balanced development of urban areas is impossible. Along with the problem of municipal wastewater and drinking water treatment [1], prevention of landslides and anthropogenic earthquakes [2, 3], chemical and industrial impacts [4], the introduction of solid waste management is a necessary condition for sustainable development of the modern city.

Currently the city of Lviv like almost all cities in Ukraine is facing a serious problem which is the growing amount of municipal solid waste (MSW) and their accumulation in temporary storage (landfills). These objects pose a serious threat to the environment by polluting surface waters with ammonium ions [5], heavy metals [6, 7] and organic compounds contributing to the eutrophication of water bodies [8]. Growth of population, rapid urbanization and rising living standards have accelerated the rate and amount of municipal solid waste, which has led to a shortage of space available for disposal. The main problems in the field of waste management are imperfect management practices, changes in the morphology of solid waste with an increase in the share of non-biodegradable components; low innovation and investment activity of economic entities in the field of solid waste management; low level of citizens involved in sorting and separating waste collection; submission of hazardous waste to solid waste containers.

Recycling practically does not happen, which leads to high levels of waste production and low levels of use as secondary raw materials. Utilization and disposal of waste is carried out improperly and with significant violations. The lack of waste management infrastructure has negative consequences for both the environment and society as a whole [9].

These problems require political actions aimed at reducing the amount of waste, developing a comprehensive, integrated waste management strategy. Its main goal is to promote the processing of MSW into valuable products and energy.

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The purpose of this article is a comprehensive, systematic analysis of the current state of municipal solid waste in Lviv, the search for an effective and sustainable waste management and treatment system, which will solve the city's waste problems and improve the environmental situation.

METHODOLOGY

The methods used for this study include the analysis of:

- laws of Ukraine and the European Union as well as local waste management programs;
- literature review of modern, efficient systems for integrated solid waste management;
- monitoring the situation with MSW waste in Lviv to understand the system settings.

RESEARCH RESULTS

For sustainable and efficient waste management, there is a need for strategic planning regarding their quantity, morphological composition and characteristics of sustainable waste management systems including recycling and recovery of resources [10].

This study is based on the Laws of Ukraine: "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine until 2030" [11], "On Waste" [12], "On Environmental Protection" [13], Solid Waste Management Program in Lviv for 2014 - 2018 [9], Waste Management Strategies in Lviv Region until 2030 [14], Program of Measures to Establish a Solid Waste Management System in Lviv for 2017 - 2019 [15] and corresponds to the main directions of Ukraine's environmental policy.

Resolving problems in the field of MSW management and avoiding environmental crisis led to the signing of the Memorandum of Cooperation [16] between Lviv City Council and EGIS on consulting services "Strategy for Solid Waste Management, Including Collection, Recycling and Disposal of MSW".

Solutions for MSW management require a systematic approach: they must be financially sustainable, technically feasible, socially acceptable and environmentally friendly. It is necessary to create a balanced waste management system, identify long-term strategic priorities that will combine environmental efficiency and rational consumption of material and energy resources. That is why the policy of the European Union (EU) in the field of MSW management is aimed at building the most environmentally friendly waste management system.

According to EU Directive № 2008/98/EU, the choice of solid waste management methods is based on the principle of waste hierarchy, namely waste prevention, reuse, recycling and other types of utilization such as energy recovery and disposal.

In the EU countries, the implementation of the first three stages of the waste hierarchy is part of the Zero Waste initiative. The slogan of this initiative is: "No Burn! No Burry!". As of today, Zero Waste is a direction not an end goal. The participants of the initiative together with communities in European cities are working to reduce waste amount and implement the first steps of the waste hierarchy. The members of the association also decided to add a little to the waste hierarchy and added another step that precedes waste prevention which is "reload" and redesign (rethink, redesign). Thus, the main elements of this initiative are: waste collection by "door to door" system, including organic waste; introduction of a payment system for waste management services by the principle "pay as much as you throw away"; take measures to prevent waste generation; proper management of organic waste; analysis of waste composition, especially mixed waste; communication between all participants (residents, businesses, municipalities and waste management utilities) [17].

Factors affecting waste management: political (laws, multilevel governance, government regulations, taxes, subsidies, data collection and monitoring); economical (business model, cost-benefit analysis, availability of financing, cooperation and transparency along the value chain); environmental (sustainability policy, impact on human health); social (community perception); technological achievements (innovations, infrastructure); educational (research centers, cooperation projects) [18] all of them are largely intertwined. Waste management includes a multi-level management system that includes central authorities to define strategies, create national plans, then regional plans established by local authorities concerning development and implementation of policy and organization of tools for waste collection, treatment and disposal.

Particular attention should be paid to environmental education, public awareness of the negative impact of waste on the environment and the promotion of waste management and the MSW potential of solid waste used as an energy resource. Along with renewable energy sources [19-21], the use of combustible waste as energy raw materials helps ensure energy independence of the country. The main purpose of the information and educational campaign for the city's residents is to destroy the stereotypes created over the years and change their behavior. The well-established practice of solid waste management in developed countries shows that there is no universal method that would meet the modern requirements of ecology, economy, resource conservation and market. These requirements are met by the introduction of a comprehensive system of collection and utilization of MSW, which ensures the use of waste as a source of secondary raw materials.

Analysis of Ways of Solid Waste Management in Lviv

The main form of household waste management in Ukraine and in Lviv is still a landfill. Accumulation of waste at landfills causes air pollution, disruption of ecosystems. Regardless of the conditions of solid waste disposal at landfills, waste often ignites spontaneously. This causes air pollution by harmful combustion products such as carbon monoxide, nitrogen oxides, dioxins, furans, etc. According to the EU Landfill Directive, the landfill is considered the least preferable method of MSW management and requires Member States to reduce the amount of buried biodegradable materials [22].

Landfilling from the point of view of secondary use causes the loss of valuable components that are part of MSW because in addition to the negative environmental impact of waste it can also be beneficial. They can be both a source of energy and a source of valuable resources that may be reused. Therefore, the accumulation of waste without further use is unprofitable even economically.

Hrybovychi Landfill is one of the largest landfills in Ukraine and the most pressing problem in Lviv. Landfill reclamation is part of a comprehensive plan to solve the problem of MSW in Lviv. Therefore, the search, allocation and arrangement of a new site for a modern facility for waste disposal in the city remains relevant. Illegal landfills are also an acute problem today and solving this problem is a key priority for regional and state authorities. Because it is difficult to achieve economic success in legal waste management operations the growth potential of the recycling system will not be fulfilled as long as they are operational.

Waste Sorting

The functioning of an effective MSW management system requires pre-sorting of waste by the population with storage of waste by different types in separate containers. Waste management systems based on waste collection and transportation to landfills are outdated. Waste collection costs in range from 40 to 60% of community costs for solid waste management [23]. In practice, in case of separate waste collection up to 70-80% of useful resources can be removed from waste total volume and in the absence of sorting no more than 15% [24].

TABLE 1. Implementation of separate collection of municipal solid waste in 2019 [24]

Name of city	**Lviv**
The total number of inhabitants, thousand people	755,55
The number of people engaged in separate collection of household waste, thousand people	755,50
Percentage of the population engaged in separate collection of household waste, %	100,00
Year of introduction of separate solid waste collection	2010
The volume of solid waste generated in the city, thousand m^3 per year	246,74
Volume of resource-intensive components of household waste that are collected by the method of separate collection, thousand m^3 per year	1,20
Number of containers by type of individual components. List of solid waste components that are collected separately.	PET-1480, glass-877, paper-556, mixed waste-5472

The city of Lviv is a scientific and cultural center of the western region. Administratively the city is divided into 6 districts characterized by a high density of buildings in a limited area with an area of about 171 km^2 [9]. According to statistics for 2019, the volume of waste generated by the city is 246.74 thousand m^3 [24]. So, it turns out that every inhabitant of the city generates 0.33 m^3 of garbage. However, the generation of MSW is more influenced by the level of income than the number of urban population [25].

The morphological composition of MSW varies depending on the way of life, the economic situation of the region, the rules of waste management and industrial structure, containers and seasons. The study of waste morphology is part of the preparation of the city's strategy for waste management methods and makes it possible to determine the optimal collection system for the recycling of municipal waste. The morphological composition of solid waste in Lviv was studied by Egis specialists, "it consists of the following fractions: food waste - 31%, garden waste - 7%, paper - 2.4%, cardboard - 2.9%, composite materials - 1.4%, textile materials - 1.1%, sanitary textile materials - 11%, plastics - 13%, glass - 10%, metals - 1.5%, hazardous waste - 1.8%, small elements - 15%. In general, it should be noted that the organic fraction is above the national average and paper / cardboard is below. Almost 27% of the waste that enters the general containers is construction waste that cannot be recycled. The study was conducted in June and found that a third of waste is organic waste, almost as much in the containers is recyclables as well as construction waste [26].

Waste Recycling

According to the EU Waste Directive 2008/98/EU, recycling is a recovery operation in which waste is reprocessed into products, materials or substances for a specific purpose. This operation includes the recycling of organic materials as a separate type of waste, but does not include energy recovery or recycling into materials to be used as fuel or refill materials, which is already included in the next 4th step of the waste hierarchy. Waste recycling depends on separate collection and sorting, which must precede the 2nd, 3rd, 4th and 5th steps of the waste hierarchy. Separate collection is necessary to ensure high quality processing.

The following waste categories are sorted: paper, metal, plastic and glass from both households and other sources. The processing of each of these wastes has its own technology. These wastes become valuable if the requirements for their separate collection are met. Moreover, energy costs for their processing are much lower than during production of new. Separate collection is most effective at places of waste generation [27].

In September 2020, three surveys were conducted in Lviv by volunteers and representatives of the NGO Zero Waste Lviv to determine the composition of waste in a container for mixed waste. For morphological analysis of waste, the composition of waste in three containers for mixed waste was checked. It was found that 65% of them are filled with organic [28].

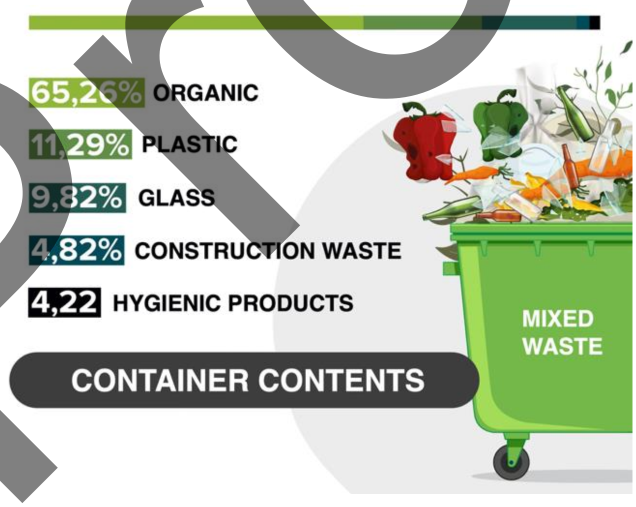

FIGURE 1. The contents of the container with mixed waste [18].

Due to the aggravation of environmental problems, relevant question is to identify promising areas of recycling organic waste, namely studying the prospects for biological processing of organic waste to obtain useful products such as compost and biogas.

Waste Composting

Composting is a natural aerobic process of biodegradation of organic waste, which reduces weight and volume. The end product of the process is a valuable organic fertilizer (compost) which increases soil fertility, provides nutrients to new plants. In 2020 the first composting station in Ukraine started operating in Lviv. Advantages of its implementation include reduction of the waste amount that falls into landfills. As of today, the city does not have its own landfill and a waste processing plant has not been built yet, so the city's waste is forced to be taken to other regions of Ukraine. The cost of compensation for transportation of 1 ton of waste to carriers is UAH 1,024. Therefore, thanks to composting in 2020 the city budget saved almost UAH 2.6 million. Waste at the station comes from residents, utility companies and businesses.

At the composting site there are four sections for aeration and storage of waste with their preliminary analysis on each section to prevent inorganic waste. The obtained high-quality compost can be used for fertilizing trees and in agriculture. During the first year of operation the composting station processed more than 2,500 tons of organic waste and received a profit for composting organic in the amount of UAH 300,000. The solution to the problem of accumulation of fallen leaves in autumn, processing of Christmas trees in winter and the formation of a separate collection of organics is really positive. Now the collection containers are located all over the city in almost 600 locations but their geography is constantly expanding. The interactive map of the organic waste containers placement was created and uniform standards of the containers appearance for organic collection were approved in Lviv. The dynamics of the organic sorting quality among the residents of Lviv is growing. Currently, the contents of 94% of the containers are sorted correctly. Such a procedure for separate collection of organics requires some training. More than 200 consultations were held for residents. It is expected that every year the composting site capacity will increase and it will process about 30 thousand tons of waste per year. In order to transfer experience to other cities of Ukraine on the organization of the organic waste composting seminars, exhibitions, round tables and forums were organized. Zelene Misto Lviv Utility Company (owner of composting site) has received new specialized equipment for the composting site [29].

One of the successful solutions for Lviv is the construction of a waste processing plant that will be able to accept for recycling all the waste generated in the city. The waste processing plant in Lviv will utilize 250,000 tons of waste per year by mechanical and biological processing.

Mechanical and biological waste processing is a process of MSW processing. It consists of the following stages: preliminary sorting of waste; bio-drying and composting, separation by components, production of fuel from waste. The project concept of a mechanical and biological construction complex for reloading and recycling of MSW is based on the idea of maximum reduction of the volume and residual volume of the recycled waste that should be sent for disposal [30]. The concept provides separate collection of waste to be recycled. Separately collected food and garden waste is sent for composting, separately collected glass is shipped to glass factories for use as raw materials and separately collected plastic is processed according to the known technologies.

CONCLUSIONS

Therefore, modern municipal solid waste management system should consider the entire cycle of waste management from collection to disposal, rely on the experience of the developed EU countries that effectively pursue policies in the field of waste management based on economically reasonable tariffs and take into account the need for informational and educational work with waste generators. All this requires significant investment, professional approach and support of the population.

The construction of the planned waste processing plant will lead to a significant reduction in municipal waste, improving the environmental situation in the city and will enhance the efficiency of separate collection to increase the level of processing. This will be cost-effective as it is cheaper to reuse waste for production.

Strategic planning has, first of all, a long-term goal to separate economic growth from waste generation and is guided by the principles of the waste hierarchy to achieve a systematic approach to waste management.

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Substantiation of Technological Parameters of Granular Filters Operation

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Abstract. The technological schemes of water treatment with granular filters are often used for water preparation for the population drinking purposes. It is advisable to use mathematical modelling and modern software to substantiate the optimal technological parameters for the granular filters operation. We propose a mathematical method for calculating the duration of filter runs in this article, taking into account the consolidation of the deposit of granular filters. The hydrodynamic stability coefficient was used to quantify the deposit consolidation. The experimental studies results allowed us to establish the mathematical form of the hydrodynamic resistance coefficient. We propose to use three criteria to determine the medium's service life. The article showed that the calculation of filtration with a consolidated deposit is significantly more difficult in comparison with a stable deposit. Two technological schemes of the rapid filter operation were analyzed, taking into account the consolidation criterion. The results of the technical and economic analysis of the medium's service life of the rapid filter are presented using the real values of the model parameters.

INTRODUCTION

Increasing requirements for water quality used for a variety of human needs, the need to improve technologies for the recycling water use, reduction of specific water expenditure and cost of it preparation require modern innovative solutions and approaches for the reasonable use of technological parameters of water treatment equipment [1, 2].

Provision of the population with high-quality drinking water should be one of the main priorities of every developed country, which provides both its sustainable development so it is a matter of national security. The human neglectful treatment of the water resources increases their pollution, which is the cause of many diseases. According to the World Health Organization (WHO) by 2025 a half of the world population will live in water-stressed areas. Therefore, the preservation and restoration of water resources are the most important tasks of the mankind [3].

The underground or surface water sources are used for centralized drinking water supply purposes [4]. Diverse water composition of water supply sources determines the presence of a large number of technological schemes for water treatment, which also affects the cost of treated water [5, 6]. The choice of water treatment method depends on a number of factors, among which, first of all, the quality of water at the source and the consumers' requirements for treated water should be highlighted. There are two types of the technological water treatment schemes: with or without the preservation of the physiologically adequate water composition. The first scheme is a classical approach and involves the transfer of coarsely dispersed, colloidal and other contaminants into other classes according to the phase-dispersed state using special preliminary processing methods and subsequent extraction of the contaminants from water. We use the filters with granular medium of natural or artificial origin in such technological schemes as independent structures or after the first degree of the surface water clarification. It is possible to reasonably accept rational design and technological parameters of filtration plants even at the design stage using the reliable calculation methods, information and material support [7]. The use of mathematical modeling provides great opportunities, which

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allows to fully investigate the behavior of water treatment systems under various operation conditions [8, 9]. The availability of modern computer technology and specialized applications greatly facilitates the implementation of simulation [10, 11].

MATERIALS AND METHODS

The properties of the deposit formed in the medium of rapid filters and its strength practically do not change with prolonged filtration of low-concentrated aqueous suspensions [12, 13]. Therefore, the deposit amount in the medium of filtering material after regular flushing is stable. It gives the opportunity to perform predictive and technological estimations during an arbitrary filter run and to distribute the obtained results to all other filter runs [14]. Filter runs at the end of the medium's service life may be an exception, when the sizes of the medium elements reduce noticeably due to abrasion.

The special occasions with the deposit formation take place in the filtration practice too, which has anomalous properties due to the specific physical and chemical processes in it [15, 16]. It is important that their specific time is commensurate with the specific time of the clarification process and the duration of the filter run. Thus, the newly formed deposit has time to noticeably transform during the current filter run and its ability to resist the significant hydrodynamic forces progresses, which develop at a high-speed washing flow. As a result, not only the current deposit content within each filter run, but also its residual amount in the sequence of filter runs constantly increases. Naturally, the filter efficiency inevitably decreases and its further exploitation becomes unprofitable for economic reasons. In such situations, it is advisable to take special action to partially restore the previous properties of the medium material. However they often require too large material expenses so it is easier and cheaper to replace the clogged medium with a new one. The question of the time of radical measures realization and the service life of the medium T_f becomes relevant there. First of all, it is necessary to establish the regularity of the deposit strength increase over time for its theoretical solution (or the minimum permissible duration of the filter run $t_{\min}$, the optimal duration of the operation period of the filter run t_{opt}). The special function of the hydrodynamic $f_s(t_a)$ can serve as a quantitative measure of the deposit resistance, where t_a is the age of the deposit. The specified function is the ratio of the deposit concentration (or deposited particles of the suspension) after (ΔS_s or ΔS) and before (S_s or S) its active washout from the medium.

$$f_s\left(t_a\right)=\Delta S_s\left(t_a\right)\cdot S_s\left(t_a\right)^{-1}=\Delta S\left(t_a\right)\cdot S\left(t_a\right)^{-1}. \tag{1}$$

The dependence $f_s(t_a)$ is established only empirically and can be linear or non-linear. In the examples calculated below, its exponential form was taken

$$f_s\left(t_a\right)=1-\exp\left(-\alpha_h t_a\right). \tag{2}$$

Then the experimental studies must be supplemented by a method for determining the coefficient of the deposit consolidation rate α_h. It should be noted about the deposit transformation that its dehydration also occurs together with the strengthening of structural connections in it. The amount of bound water decreases. We should also specify the critical value of the indicated function f_{s*} based on economic considerations. The total time T_f decreases when this value is exceeded and the cost of the water treatment increases. The corresponding consolidation criterion is formulated as inequality

$$f_s\left(t,\ V\right)\le f_{s*}. \tag{3}$$

The calculation of filtration with the consolidated deposit is seriously difficult in comparison with the stable deposit primarily due to a significant increase in their volume. However, now it is necessary to calculate the required characteristics (concentrations, pressure losses and technological times) throughout the entire service life of the medium. Confirmation of the specified period becomes the new main purpose of technological analysis in addition to the previous ones. And the reliability of such analysis results depends on the reliability of establishing the hydrodynamic stability function and the criterion parameter f_{s*}.

This function allows to calculate easier the initial concentration of the deposited particles (and deposit) for the next filter run during filtration with constant rate V and the variable content of suspended particles in the initial suspension

C_0 and therefore we used it in the calculations of each filter run. By the end of the i -th filter run with duration t_{fi}. The relative volume $\Delta\bar{S}_i$ of suspension particles which entered the medium in a relative time interval $[0, \bar{t}_{fi}]$ and were strongly fixed in it is calculated as follows

$$\Delta\bar{S}_i = \int_0^{\bar{t}_{fi}} \left[1 - \bar{C}_{ei}\left(\xi\right)\right] f_s\left(\bar{t}_i - \xi\right) \mathrm{d}\xi = \int_0^{\bar{t}_{fi}} \left[1 - \bar{C}_{ei}\left(\bar{t}_i - \xi\right)\right] f_s\left(\xi\right) \mathrm{d}\xi . \tag{4}$$

Where C_{ei} is the outlet volumetric concentration of suspended substance; S_i^0 is the initial volumetric concentration of deposited particles; $\bar{C}_{ei} = \frac{C_{ei}}{C_0}$, $\Delta\bar{S}_i = \frac{\Delta S_i}{(n_0 C_0)}$, $\bar{t}_i = \frac{V_0 t_i}{(n_0 L)}$ for a given filtration run; n_0, L is the porosity of the clean medium and its height.

So at the beginning of $i+1$ filter run the constant relative concentration of unwashed particles of the suspension by the medium height will be

$$\bar{S}_{i+1}^0 = \bar{S}_i^0 + \int_0^{\bar{t}_{fi}} [1 - \bar{C}_{ei}(\bar{t}_{fi} - \xi)]\, f_s(\xi)\, \mathrm{d}\xi . \tag{5}$$

Before the final (N) filter run the initial concentration $\bar{S}_N^0$ reaches the maximum permissible value $\bar{S}_{max}^0$ in the conditions under consideration, which is determined depending on the ratio between the relative technological times $\bar{t}_{pN}$ and $\bar{t}_{hN}$. For $\bar{t}_{hN} < \bar{t}_{pN}$ according [17] the desired value is found by selection from the equation

$$\int_0^1 \left\{ f_k\left[\bar{S}\left(\bar{z}, \bar{t}_{hN}; \bar{S}_{\max}^0\right)\right]\right\}^{-1} \mathrm{d}\bar{z} = \Delta\bar{h}_* . \tag{6}$$

If $\bar{t}_{hN} > \bar{t}_{pN}$, then the equation is used

$$\bar{C}_{eN}(\bar{t}_{pN}; \bar{S}_{\max}^0) = \bar{C}_* . \tag{7}$$

The sequence of calculations is limited due to the adoption of the minimum possible for $\bar{t}_{fN}$ value $\bar{t}_{min}$ using the consolidation criterion as in the Eq. 3. It is obvious that the number of the filter runs (N) in this (first) technological scheme is equal to the number of the calculated stages. In this case the sum of all $\Delta\bar{S}_i$ should be approximately equal $\bar{S}_{max}^0$, so

$$\sum_{i=1}^{N} \Delta\bar{S}_i = \int_0^{\bar{t}_{fi}} [N - \sum_{i=1}^{N} \bar{C}_{ei}(\bar{t}_{fi} - \xi)]\, f_s(\xi)\, \mathrm{d}\xi \approx \bar{S}_{\max}^0 . \tag{8}$$

Formally the described procedure of step-by-step calculations makes it possible to maximally extend the operation of the filter after each backwashing, but at the same time, the accumulation of the residual deposit in the medium significantly accelerates. As a result, the clarifying potential of the medium is quickly exhausted and it is necessary to replace it prematurely. Naturally, the relative service life $\bar{T}_f$ is the sum of the duration of all N filter runs.

In the practical implementation of the second technological scheme, its theoretical confirmation begins with the establishment of the most important technological parameter, the optimal duration of the operation periods t_{opt}. The relative value $\bar{t}_{opt}$, as well as $\bar{t}_{min}$, is determined using the consolidation criterion from the equality

$$f_s(\bar{t}_{opt}) = \bar{f}_{s*}. \tag{9}$$

At the next stage, two values $\left(\bar{S}_h^0, \bar{S}_p^0\right)$ of the relative concentration are calculated of the suspension particles which firmly fixed in the medium bed before the corresponding operation periods (they are initial for them). One of them becomes the last one for the given medium change. Two main criteria are used for the filtration mode with a constant rate and unconsolidated deposit of the criterion in this case. The equations for $\bar{S}_h^0$ and $\bar{S}_p^0$ by analogy with [17] using the formal representation for in the Eq. 6 and Eq. 7 takes the form

$$\int_0^1 \left\{ f_k \left[\bar{S}\left(\bar{t}_{opt}, \bar{z}; \bar{S}_h^0\right)\right]\right\}^{-1} \mathrm{d}\bar{z} = \Delta\bar{h}_*, \tag{10}$$

$$\bar{C}_e(\bar{t}_{opt}; \bar{S}_p^0) = \bar{C}_* \tag{11}$$

the lower of them obviously, i.e.

$$\bar{S}_m^0 = \min(\bar{S}_h^0,\ \bar{S}_h^0)$$

should be approximately like in the Eq. 8 equal to the sum of all $\Delta\bar{S}_i\,(i = 1,2,\ldots,N)$, so

$$\sum_{i=1}^{N} \Delta\bar{S}_i = \Delta\bar{S}_{tot} \approx \bar{S}_m^0, \tag{12}$$

$\Delta\bar{S}_{tot}$ the relative service life of the medium now is

$$\sum_{i=1}^{N} \bar{t}_i = \bar{T}_f = N\,\bar{t}_{opt}. \tag{13}$$

Considering in the equations Eq. 5 and Eq. 8, we have obtained

$$\int_0^{\bar{t}_{opt}} [N - \sum_{i=1}^{N} \bar{C}_{ei}(\bar{t}_{opt} - \xi)]\, f_s(\xi)\,\mathrm{d}\xi \approx \bar{S}_m^0. \tag{14}$$

Further, the two situations which differ in the ratio between $\bar{S}_h^0$ and $\bar{S}_p^0$ are considered one at a time. In practice $\bar{S}_h^0 \le \bar{S}_p^0$ is more often due to the high sorption capacity of the filter material. Then, it is confirm to accept in the first approximation $\bar{C}_e \approx 0$ taking into account regular early backwashing and with modern water treatment standards $\bar{C}_e \ll 1$. Consequently, the difference between $\Delta\bar{S}_i$ becomes insignificant and in the Eq. 5 validates for any periods the following equality

$$\Delta\bar{S}_i \approx \int_0^{\bar{t}_{opt}} f_s(\xi)\,\mathrm{d}\xi = F_s(\bar{t}_{opt}) = \bar{t}_{opt}\, f_{sc}. \tag{15}$$

Where the average value f_{sc}.

Therefore

$$\Delta\bar{S}_{tot} \approx \bar{S}_h^0 = N\,F_s(\bar{t}_{opt})\,. \tag{16}$$

It follows from (16) that the total number of the operation periods will be

$$N(\bar{t}_{opt}) = \bar{S}_h^0(\bar{t}_{opt}) \cdot F_s(\bar{t}_{opt})^{-1} \approx \bar{S}_h^0(\bar{t}_{opt}) \cdot \bar{t}_{opt}\, f_s(0.5\bar{t}_{opt})^{-1}\,. \tag{17}$$

Knowing *N*, the required working capacity time after one medium replacement is calculated by the formula in the Eq. 13.

In the second situation (low sorption capacity of the filter material) $\bar{S}_h^0 > \bar{S}_p^0$ and removal of the suspended particles from the filter may already be noticeable in relation to their total amount entering the medium. Then it is also expedient to consider the quantities $\bar{C}_{ei}(\bar{t}_{opt} - \xi; \bar{S}_i^0)$ in the integrand function. As values $\bar{C}_{ei}$ remain small and increase with time in an almost linear manner, so their generalized estimation can be significantly simplified with minimal additional errors. Then the refined number of periods in a term $\bar{T}_f$ is

$$N = \bar{S}_h^0 \cdot \left[F_s(\bar{t}_{opt}) - \int_0^{\bar{t}_{opt}} \bar{C}_{e,(N+1)/2}(\bar{t}_{opt} - \xi; \bar{S}_p^0)\, f_s(\xi) \mathrm{d}\xi \right]^{-1} . \tag{18}$$

Accordingly, the longer period is determined according to the Eq. 18 taking into account the equation Eq. 13.

So, the consolidation criterion in the first technological scheme allows to limit reasonably the sequence of the same type calculations. It serves to select a single duration for all working periods in the second scheme. If the function of hydrodynamic stability is unknown, then its equivalent replacement can be reliable information about the minimum permissible duration of the specified period in the considering conditions. The above-mentioned duration can be interpreted in the implementation of the first scheme as t_{min}, and the second as t_{opt}. And the question about the rational choice of the duration of working periods arises again, which cannot be solving without technical and economic calculations.

RESULTS AND DISCUSSIONS

The real values of the model parameters are selected for the quantitative analysis of the long-term action of the rapid filter with the consolidated deposit. However, in combination they correspond with the extreme filtering conditions, because the medium is quickly depleted its absorption capacity. Therefore, the basic set of specified fixed values includes: $\bar{\lambda}_0 = 0.05, \bar{S}_m = 300, \bar{\gamma}_c = 0.002, m_{k1} = 1,\ m_{k2} = 3,\ \Delta\bar{h}_* = 10,\ \bar{C}_* = 0.1$ the extent form f_k according to [14]. The values $\bar{\alpha}_h, \bar{t}_{min}$ were varied. Two technological schemes described above are considered on the basis of a strict solution of one problem of the suspension continuous filtration. The second scheme is a sequence of the filter runs of the same duration in this case.

The calculations were carried out in stages for the first scheme based on the total number of the filter runs. We analyzed it using two examples. In the first, the required duration was determined strictly in accordance with the traditional procedure of technological calculations with filtration at a constant rate [17]. In the second example, the time of the first five backwashings was deliberately and uniformly reduced (by 10 conventional units) and the durations of all subsequent filter runs were similar to the first example. The basic technological parameter $\bar{t}_{opt}$ was varied, starting from a value that is noticeably less than the real minimum value $\bar{t}_{min}$ in full scale work of the filter simulation $\left(T_f \geq t \geq 0\right)$ in accordance with the second technological scheme.

As the result of many calculations in relation to the second technological scheme it was established that the one-time filter backwashings earlier than the time established by traditional technological calculations do not allow to increase its service life under these conditions, despite the delayed accumulation of the non-washable deposit in the medium.

The calculations of the second series of examples in relation to the second technological scheme turned out to much simpler than at the first series due to the above estimates for the removal of impurities from the medium for examples 1, 2 and recommendations for the theoretical substantiation of rational technological parameters. First of all, it turned out that the relative period T_f demonstrates a high sensitivity in relation to a single relative duration t_{opt}

(coincides with t_h due to the small impurity breakthrough. The Fig. 1 shows the sharply nonlinear nature of the dependence $\bar{T}_f(\bar{\alpha}_h)$ at the argument changes from 0 to 10^{-3}. Following that it is important to study the strength properties of the deposit by experimental methods and to accurately determine the function of hydrodynamic stability.

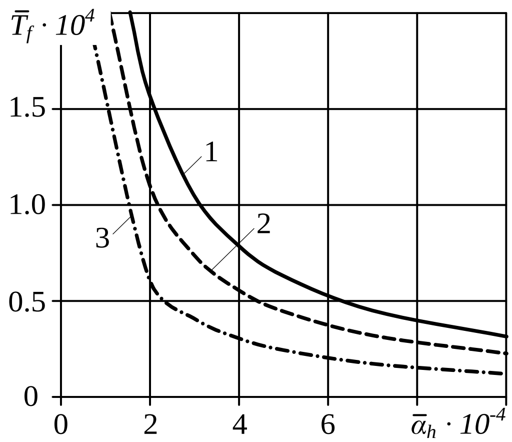

FIGURE 1. Dependence $\bar{T}_f(\bar{\alpha}_h)$:
$1 - \bar{t}_h = \bar{t}_f = 100$, $2 - \bar{t}_h = 120$,
$3 - \bar{t}_h = 150$.

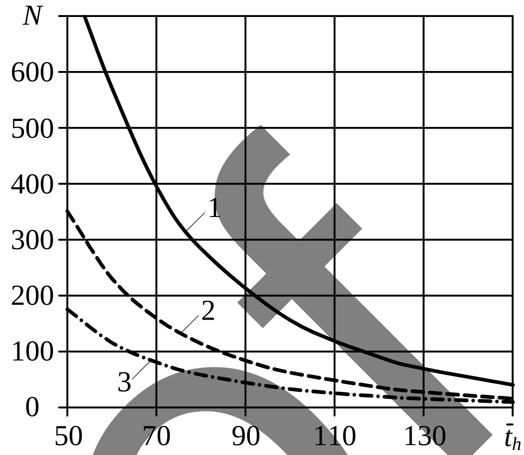

FIGURE 2. Dependence $N(\bar{t}_h)$:
$1 - \bar{\alpha}_h = 0.0002$, $2 - \bar{\alpha}_h = 0.0005$,
$3 - \bar{\alpha}_h = 0.001$.

Additionally, the study by experimental methods of the strength properties of the deposit and the accurate determination of the function of hydrodynamic is very important. The Fig. 2 shows a set of curves which describes the relationship between the number of the operation periods *N* that fit into the total calculation period $[0, \bar{T}_f]$ and their duration t_{opt}. The results of such calculations are especially useful for technical and economical calculations, because they give a clear idea of the total non-productive costs of treated water. It is logical that such losses increase dramatically $\bar{\alpha}_h$ and $\bar{t}_h$decrease.

In conclusion, the results of the technical and economic analysis of the operation time of one change of the rapid filter medium in relation to the physicochemical iron removal of groundwater are presented in Fig. 3. The method described above for improving the rational medium's service life with a progressive accumulation of deposit is put in its basis. It was established that when only at the iron removal of ferrous iron it is advisable to carry out regular washing after 3 days or more. If the initial water contains the same amount of ferrous and ferric iron, then the optimal duration of the filtration run is reduced to 2 days.

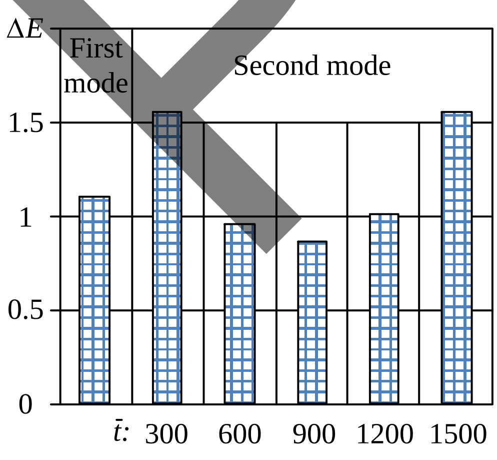

FIGURE 3. The dependence of the washing and replacement consumption of the medium is reduced to a unit of beneficial filtrate from the filter operation modes ΔE.

CONCLUSIONS

We made the following main conclusions based on the results of the work:

- The reduction and unification of filters run duration can significantly increase the service life of one medium replacement.
- The early backwashing in the first technological scheme does not allow to prolong the operation of the medium.
- In principle, it is possible to reduce the removal of suspended solids significantly from the medium over its service life due to the implementation of the second technological scheme and at the same time there are good reasons for neglecting it in the technological calculations.
- The rational choice of the operation period duration in the second technological scheme is fundamental, because it determines not only the service life of the medium, but also the purified water losses for its regular washing.

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Origin and Degradation of Production Territories - a Historical Phenomenon of the XX Century

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Abstract. For many decades, from the end of the XVIII - beginning of the XIX century, industrial production itself caused migration of the population from rural areas to cities, hypertrophied extensive territorial growth of settlements, formation on their basis of agglomeration and supraglomeration forms of settlement, their gradual structuring, and in the urban environment - changes in the nature of construction, increasing its density, especially in the central core, the emergence of new types of buildings, depletion of territorial resources within the city and the gradual reduction of greenery. The industrial revolution and the concentration of production determined the principles of zoning of the industrial city, its complex functional and planning organization and the leading importance of the industrial function in the structure of the settlement. At the same time, it is in the first half of the XX century that the preconditions for the formation of a post-industrial society are being formed. Structural changes in the economic complex cannot but affect the functional and planning organization of urban settlements and bring to the fore the problem of preserving industrial areas not so much as functional areas, which, being not needed as before, begin to degrade, creating depressive centers in the urban environment, and as town-planning formations capable of further existence in a new quality of system-forming elements of the city structure. For Ukraine, the need to restore degrading industrial areas in the structure of urban settlements in the post-industrial relations coincides with the development of an independent state and its integration into the European community and seems quite relevant in the context of ensuring further life not only individual cities but also the entire settlement system in the country.

INTRODUCTION

The industrial revolution and the concentration of production determined the principles of zoning of the industrial city, its complex functional and planning organization and the leading importance of the industrial function in the structure of the settlement. For many decades, from the end of the XVIII - beginning of the XIX century, industrial production itself caused migration of the population from rural areas to cities, hypertrophied extensive territorial growth of settlements, formation on their basis of agglomeration and supraglomeration forms of settlement, their gradual structuring, and in the urban environment - changes in the nature of construction, increasing its density, especially in the central core, the emergence of new types of buildings, depletion of territorial resources within the city and the gradual reduction of greenery.

At the same time, it is in the first half of the twentieth century that the preconditions for the formation of a post-industrial society are being formed. At the same time, it is in the first half of the twentieth century that the preconditions for the formation of a post-industrial society are being formed. According to D. Bell, in the economy of post-industrial society, the priority shifts from the predominant production of goods to the production of services, research, organization of the education system and improvement of the quality of life, in which the class of technicians becomes the main professional group and, most importantly, in which innovation more depends on the achievements of theoretical knowledge [9], the main production resource is information, the main product of production - services, and the place of fund is occupied by knowledge [2].

In such conditions, the global change of technological epochs leads to a change in the structure of employment of the able-bodied population in the economic complex of settlements. If a hundred years ago in the United States up to 90% of production staff were engaged in manual labor, at the end of the twentieth century this figure was not more

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than 10%. In many post-industrial countries today, the share of those employed in traditional industries (industry, mining and manufacturing, agriculture, construction, etc.) does not exceed one third of the working population.

Structural changes in the economic complex can not but affect the functional and planning organization of urban settlements and bring to the fore the problem of preserving industrial areas not so much as functional areas, which, being not needed as before, begin to degrade, creating depressive centers in the urban environment, and as town-planning formations capable of further existence in a new quality of system-forming elements of the city structure

THE URGENCY

For Ukraine, the need to restore degrading industrial areas in the structure of urban settlements in the post-industrial relations coincides with the development of an independent state and its integration into the European community and seems quite relevant in the context of ensuring further life not only individual cities but also the entire settlement system in the country.

A novelty in such conditions is the study of the emergence, development, degradation and recovery of the productive component of the city as one of its main subsystems from the standpoint of a systems approach.

THE MAIN SECTION

The functional organization of the planning structure of the city, in which the production component plays a leading role, is formed within industrial society and originates from the "industrial city" of Tony Garnier. The novelty of Garnier's planning ideas at the time was that a clear delineation of the city's functions (housing, work, leisure, education, traffic) was proposed and, as a consequence, the organization of transport and pedestrian traffic, planning of residential areas without enclosed courtyards permeated by continuous green spaces with transit-free footpaths and squares, with schools in open areas and a large number of sports grounds. Thus, for many decades to come, Tony Garnier foresaw the main ways of developing the theory and practice of urban planning.

The International Congress of Modern Architecture (CIAM), which brought together many of the leading architects of Western Europe, led by Le Corbusier, in the first half of the twentieth century, made some contributions to the theoretical and practical development of the principles of integrated functional organization of cities. Thus, the first CIAM declaration defined the program of functional zoning of the city: «Urban planning is the organization of the functions of collective life, which can be equally applied to both rural settlements and urban agglomerations. It can not be due to established aesthetic claims - the essence of urban planning in its functional nature».

In 1933, the IV Congress of CIAM was held in Athens, which formulated the principle of functional zoning as one of the main principles of modern urban planning. The final document of the Congress, named after the Athens Charter, formulated by one of its authors, the architect H. L. Sert, is "the alphabet of urban planning"[7].

The principle of functional zoning retained its significance in the practice of forming Soviet cities, based on the peculiarities of the planned economy, almost until the collapse of the Soviet Union. The territories of the industrial zone in the structure of the city were determined depending on the nature of production and its harmfulness and were surrounded by sanitary-protective gaps to the settlement from 50 to 3000 meters. In case of need in large sanitary-protective zones, the territories of which were greened up to 50%, industrial enterprises, complexes and units were taken to the suburban zone. In addition to technological areas and buildings, industrial zones included administrative and public centers, landscaping, transport facilities and roads, reserve sites.

At the same time, for the sake of justice, it should be noted that the implementation of the functional zoning of the city in some way led to the development of its planning structure in the unity of the links of individual elements, nodes, zones. That is, the functional zoning and differentiation of territories according to the intensity of their development (allocation of the structural framework) began to be considered as a single functional-planning organization of the city, which eventually showed its hierarchical organization.

In addition to industrial enterprises and related production facilities, the production areas include complexes of scientific institutions with research enterprises, utilities, enterprises for the production and processing of agricultural products, sanitary-protective zones of industrial enterprises, special purpose projects (for the needs of defense), construction of external transport and ways of outside urban and suburban communication of the inner city street-road and transport network, areas of public institutions and places of common use for the population working at the enterprises of the city.

Industrial enterprises that did not emit environmentally harmful, toxic, dusty and flammable substances into the environment, did not create high levels of noise, vibration, electromagnetic radiation, did not require access railways, were allowed to be located within or near residential areas with observance of sanitary and hygienic and fire-prevention requirements..

It is the rapid development of industrial areas in the second half of the twentieth century, according to I.O. Fomin [5], led to the formation of intensively developed areas in Ukraine, in the bowels of which first began to appear systemic signs of group forms of settlement, which allowed which allowed to apply a systematic approach to urban and suburban systems as real, complex, open urban formations.

The general crisis of urban settlements in the first half of the 1990s in Ukraine - falling production, closure of industrial enterprises, unemployment, migration of able-bodied people abroad, etc. for some time was associated with the collapse of the Soviet Union and the rupture of technological and socio-economic ties in the post-Soviet space. Later, in the process of developing the first town-planning documents of independent Ukraine - the General Settlement Scheme, Regional Territorial Planning Schemes, city master plans, the movement of economic complexes of populated cities towards the development of tertiary and quaternary sectors of the economy became clear. That is, the state gradually embarked on the path of post-industrial development, receiving a negative legacy in the form of degrading production areas from the industrial period.

In the context of the global challenges of society, the degradation of industrial areas has emerged as an objective phenomenon that accompanies the changing technological epochs and which Europe faced in the middle of the twentieth century. In Ukraine, it received its time frame and regional features, among which, of course, the transition from a planned economy to market relations and overcoming the effects of "Soviet industrialization", which since May 1929 (approval of the first five-year plan of the USSR) was considered a concept , which opened up prospects for the development of new industries, increasing production of all types of products, production of new equipment and, consequently, the deployment of large-scale construction.

On the other hand, the development of a systematic approach and its application to urban formations, allowed to consider production areas as a spatio-temporal projection (subsystem) of the economic base of the city - one of the main elements of the urban system, which in its development goes through certain stages [1, 8].

The evolutionary stage, however, is associated with the formation of a comprehensive functional approach to the formation of the city and the manifestation of its hierarchically organized functional and planning structure.

The modern bifurcation stage is characterized by significant changes in the industrial complex from the reduction of production to its closure, and in the territorial aspect - the emergence of degrading production areas in various stages of depression - from partial stagnation to the destruction of urban environment - abandoned and environmentally unsafe [3].

If the depressive processes cover not a separate production area, but the entire functional area, it is possible to destroy the economic base as the most important subsystem of the settlement, which calls into question the very existence of the city in terms of its economic complex orientation to industry (with employment of 80 - 90% of the working population) or with a developed multifunctional complex, which is typical for the largest cities, leads to important problems of a functional and structural nature.

In such conditions, the restoration becomes an integral part of the self-organization of production areas, which is seen as a choice of ways for their further development in order to be included in the urban system at a new system-forming level.

RESEARCH RESULTS

Restoration of the production area can begin at any stage of its degradation. Making such a decision for her is a kind of "bifurcation point", a way out of the crisis and the choice of development paths.

In all cases, the restoration of production areas is implemented at different hierarchical levels of the urban system and should take place in relation to a single enterprise, industrial complex, node, functional area and the whole settlement, as the largest cities usually include not one but several industrial zones in their structure. At the same time the influence (resonance) of separate intervention on the general condition of the settlement is traced.

For Ukrainian cities, which for many years have developed on the basis of industrial production, in modern conditions there are also all the prerequisites for maintaining the industrial function in the structure of the economic complex. A similar process is taking effect in many developed countries in Europe, the United States and Asia under the concept of "New Industrialization".

When, after a long recession, economic growth began to recover in 2013, EU industrial policy set a course for a renaissance, which included counteracting deindustrialization, supporting the innovative orientation of European industry, and increasing the number of jobs. Particular attention was paid to structural changes in industry at the local and regional levels. This was due to the fact that industry, in the global economic crisis, was the most stable sector of the economy. Today, industrial development is a prerequisite for stabilizing the EU economy. In turn, for the industry of the European Union an important task is the creation of environmentally friendly industries and transport, and digital products and technologies, at the same time, play a key role in the renaissance of European industry.

In such conditions, the main economic reform in the context of the Association Agreement between Ukraine and the EU, according to leading economists, should be the introduction of new industrialization in Ukraine, able to really ensure the dynamic development of the economy [6].

In addition to preserving industry, it is possible to change the functional purpose of the former production area - the formation of a new city-forming direction of city development, the equivalence of which is achieved through the use of an integrated approach to improving urban development potential. Thus, the introduction of the settlement function should be accompanied by the development of transport infrastructure and individual complexes - carriers of the tertiary or quaternary sectors of the economy.

A striking example of such a decision is the transformation of an industrial area into a residential neighborhood in the city of Malmö in Sweden. In the 1990s, industrial Malmö degraded rapidly. Its economic complex depended entirely on shipbuilding, and the Swedish authorities proceeded to curtail this activity as uncompetitive. Twenty-seven thousand people lost their jobs, the unemployment rate became the highest in the country. Structurally, the city was divided into industrial zones, warehouses, sand embankments, and half consisted of port areas.

Local authorities and citizens saw the way out of the crisis in the development of Malmö as a center of knowledge and eco-settlement. Thus, on the site of the former industrial zone, a unique area of Vastra Hamnen ("Western Harbor") emerged (Fig. 1), which was focused on saving resources, alternative energy and a variety of buildings with few floors and a contrasting accent - the famous Turning Torso tower by Santiago Calatrava.

FIGURE 1. Eco-settlement Vastra Hamnen ("Western Harbor"), Malmö, Sweden (Photo: highshot.se / Flickr) [10]

Two other factors also contributed to the further development of the city - the construction of the Oresund Bridge, which connected the city with the Danish capital - Copenhagen, and the opening of the University of Malmö.

Point intervention is also possible, which for a certain area will be a stimulus for its revival, and in the case of its location within the city, in the presence of additional degrading areas in its structure, the starting point for the restoration of the entire subsystem.

Therefore, the new subsystem of the restored territories is formed as a multifunctional entity, which may include industrial, rural, recreational territories (gardens and parks, such as Bernard Chumi's La Villette Park in Paris (Fig. 2) on the site of the slaughterhouse and cattle market; High Line Park in New York City James Corner Field Operations (Fig. 3); Duisburg-Nord Landscape Park (Landschafts Park Duisburg-Nord) Latz + Partner office in the Ruhr (Fig. 4) area on the territory of the former metallurgical enterprise "Mayderix").

FIGURE 2. La Villette Park, Paris, France [11]

FIGURE 3. High Line Park, New York, USA [12]

FIGURE 4. Duisburg-Nord Landscape Park, Germany [13]

Recently, there has been the creation of art objects on the site of degraded areas - the formation of «land art» (park Crawick Multiverse by Charles Jencks) in the south of Scotland (Fig. 5), an example of how to turn an abandoned mine into a place of pilgrimage for tourists from around the world), providing a museum function to the monuments of industrial architecture, as well as the use of the principles of landscape urbanism for the restoration of industrial areas (park Freshkills park (Staten Island, New York) architectural firm James Corner Field Operations on the site of a former landfill).

All this contributes to the sustainability of the subsystem, its ability to respond quickly to changes in consumer demand and other challenges of society.

In its form, the elements of the renewed subsystem of degraded industrial areas are actively included in the life of the city, establishing direct and reverse connections not only with each other, but also with the entire functional and planning structure, which is subordinated and improves the urban framework.

That is, restoration, in turn, is seen as complex, with separate multifunctional elements that are organized through connections into a holistic unity at the city level, a hierarchically organized, dynamic subsystem capable of self-organization (Fig. 6).

FIGURE 5. Crawick Multiverse park, Scotland [14]

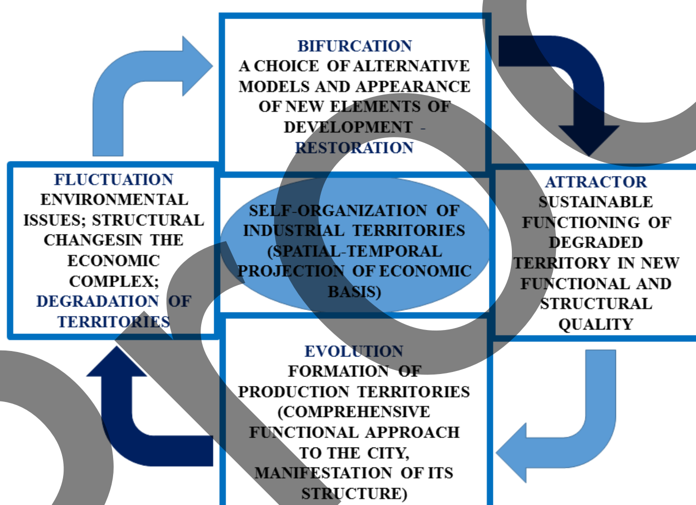

FIGURE 6. Self-organization of the urban system

CONCLUSION

1. The emergence, development, degradation and restoration of industrial areas in a new capacity in the structure of the city - an objective, historical process that reflects the two stages of formation of one of the main subsystems of the settlement - economic base, its territorial projection.

2. The emergence and development of industrial areas corresponds to the stage of evolutionary development of industrial society from the end of the XVIII to the middle of the XX century.

Degradation is a bifurcation stage and demonstrates the response to global, regional (state) and local challenges of society development, which arise and gain momentum since the middle of the twentieth century as a result of deepening, above all, environmental problems and in-depth preparation for technological epochs.

3. Restoration of degrading production areas - a way out of the crisis, choosing a new path of evolution - a process unfolding in time and space, a complex subsystem with integrity, hierarchical organization, openness through direct and feedback, dynamism and the ability to self-organize. The concept of "restoration" is used in the context of a systematic understanding of the city and its structural elements.

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Multifunctional High-Rise Complexes as Complex Systems in Urban Environment

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Abstract. The article proposes to consider multifunctional high-rise complexes (MHC) and their surrounding environment on the basis of a systems approach. The system of MHC is conditioned by the surrounding environment and creates its own environment, which, in turn, affects the system and structures it. Complexity, emergence, activity of the complex and its environment are connected properties that arise in interactive cooperation. MHC and the surrounding urban environment mutually determine each other.

INTRODUCTION

High-rise buildings have become an integral part of the largest modern cities around the world. They form the urban skyline, act as architectural dominants, articulate urban nodes. At the beginning of the industrial period, the emergence of high-rise buildings reflected changes in the urban environment under the influence of agglomeration processes – an increase in urban density, shortage of territorial resources, high cost of land in the central, most demanded part of the settlement, and introduction of scientific and technological innovations in production. Nowadays it is also a business card of the state, a demonstration of abilities and consolidation of a certain status at the global level of world cities – the strongholds of civilization. It is possible to treat high-rise construction in different ways, but it is difficult to deny the objectivity and historicity of this process [1].

Ukraine has embarked on the path of introducing high-rise complexes into its largest cities relatively recently, which is caused by the transition to market relations and the development of the national real estate market based on the improvement of the construction industry and the introduction of new technologies.

By this time, central areas of many Ukrainian cities had already been densely built up. The presence and quantity of historic buildings led to rather strict requirements for the construction of new objects, especially high-rise buildings – the skyscrapers. In such conditions, practice sees a pointed, selective placement of individual high-rise buildings or complexes on vacant sites and sites formerly occupied by demolished structures. Meanwhile, at a certain distance from the city center, high-rise complexes are erected in place of degraded industrial areas – as subcenters of development, residential complexes in the format of «microdistricts» or «city within a city» structures. Hence, the problem of interaction of a new urban high-rise with its existing environment comes to the fore.

In the context of the active use of high-rise construction for the development of largest Ukrainian cities in modern conditions, it is considered **relevant** to develop scientifically sound approaches to the introduction of high-rise complexes into an urban environment, taking into account its functional and planning organization and structural features.

The novelty of work is in studying the conditionality of multifunctional high-rise complexes and their environment on the basis of a systems approach.

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THE MAIN PART

The complexity of urban formations as an object of research, design and management during the twentieth century in Ukraine, and the emergence of new types of high-rise buildings, claimed to be system-forming in their structure, determine the use of a systems approach to their study.

The modern theory of complex adaptive systems suggests that the properties of multifunctional high-rise complexes (MHC), when they are considered as complex systems, and the urban environment in which they are situated, mutually determine each other. Complexity, emergence, activity of the complex and its surrounding environment are connected properties that arise in interactive cooperation. The system of MHC is conditioned by the environment and creates its own environment, which, in turn, affects the system and structures it. It is impossible to improve the system without changing the environment, introducing innovations to it, and vice versa [2].

The complexity which is inherent in both the high-rise complex and the environment of its activity is the most important concept of a systems approach. The complexity of the high-rise complex, its internal variety, which manifests itself as multifunctionality, makes the object flexible, able to change its behavior depending on external conditions. In this case, the high-rise complex as a complex multifunctional system has a multilevel quality, so it should be analyzed in terms of the hierarchy of interactions. That is, among the many functions one can be formed, which will determine the viability of other elements.

Being an open system, MHC exchanges matter, energy and/or information with the surrounding environment. These are cash flows, goods, services, etc. Emerging phenomena appear in a high-rise complex as a complex system – new unexpected properties manifested at the dynamic level of the system as a whole. These properties cannot be "subtracted" from the analysis of the behavior of individual elements. Such manifestations can include the phenomenon of "resonant influence" when the emergence of MHC in the urban structure attracts new flows of residents or stops rural migrants on the threshold of the city by meeting their needs.

Another important property of a complex system is its fragility. The more complex the system, the more it is unstable. Any action to improve or enhance its organization can destroy such a system. Complex systems are believed to balance on the brink of chaos, and their behavior is described by the theory of self-organized criticality.

In this situation, since complex systems are built in an active environment, the sustainability of MHC can be achieved by its mutual adaptation with the environment, the converging path of evolution - the so-called coevolution, which S P Kurdyumov considered an important constructive principle of modeling the future on the basis of synergetics. The complex system of MHC changes, transforms and renews itself in interaction with the surrounding environment, it builds its own environment (Umwelt) for itself, which, in turn, inversely affects it and determines it [3].

RESULTS OF STUDY

The development of industrial society in Ukraine has not only brought to life agglomeration processes since the second half of the twentieth century. As a result of these processes, urban settlements began to change fundamentally, by extensively developing and going beyond their traditional framework. On the one hand, urban settlements began to form urban supersystems with their zones of influence. On the other hand – they determined the formation of a hierarchically organized functional and planning structure of the city, the very presence of which testified to the different nature and level of urban development of individual structural elements that falls from the center to the periphery [4].

At the same time, the structural and planning elements of the city differ in the representation of territories, historical, architectural and cultural potential, urban development density (including the density of functional content), management features (within city limits and beyond), the monetary value of land, etc. This fact allows authors to talk about the formation of an individual urban environment, which has various advantages and disadvantages in each structural element.

Imposing of the transport infrastructure on the functional-planning organization of the city helps to identify the most optimal sites for high-rise complexes today – the central core, urban nodes, subcenters, the buffer zone on the border of urban development and suburbs.

The systems approach considers the structural elements of the city as an external environment to new high-rise complexes. Said environment is formed as a supersystem in relation to them. Therefore, the systems approach, in turn, focuses on the relationship between MHC and the environment, based on structural and organizational features of the supersystem. This relationship contains contradictions caused primarily by the hierarchical level of structural elements of the city, which must be resolved out of turn [5].

In this case, if the external environment (the environment of the structural element of the city) acts as a “habitat” for the high-rise complex, then the internal environment of the object acts as the environment of its functioning. Essentially, the internal environment of the high-rise complex acts as its organism.

The internal environment of the high-rise complex, which is also understood as a complex system, covers all its elements. It is a part of the system of high-rise complex, determines its structure and includes two components. The first consists of elements, relationships and connections that affect the system of the high-rise complex and its subsystems. The second is the internal environment of individual elements that are part of a single system of high-rise complex, which determines their behavior [6].

The existing urban environment of a particular structural element is always marked by a different nature of its impact on the system of the high-rise complex – it can be neutral, passive or active, aggressive, favorable or unfavorable.

Thus, the environment of the historical core of the city is an urban formation formed over the centuries, which has its own architectural image, functional content, building density, nature of landscaping, etc. Therefore, it plays an active role in the placement of new buildings in general, not just high-rise, influencing the very possibility of their construction and inclusion in the existing architectural ensemble.

When choosing a town-planning hub or an existing urban development sub-center to house a new high-rise complex, the surrounding environment can be favorable or neutral in the case when the new building enriches it aesthetically, complements missing functions or provides new jobs.

The creation of a high-rise complex on the periphery in places where urban highways are transformed into highways of state importance, where urban subway lines end, forming interchanges, determines its active system-forming role in relation to the passive poorly developed urban environment.

According to the role of the environment in the existence of the system of high-rise complex, we distinguish systems based on internal sources of development (in cases when the high-rise object forms the environment), or on external sources (in cases when the authentic environment of the center determines the architecture of new complex).

In the case of placement of high-rise complexes in different structural elements of the city, both approaches are actively used. When it comes to the periphery, it is proposed to direct the vector of interaction from the system of the high-rise complex to the surrounding environment, in other cases - from the environment to the system.

Based on all of the above, the proposition is made on main approaches to the placement of multifunctional high-rise complexes in the urban environment of structural elements.

According to it, the formation of MHC in various structural elements of the city is seen, first of all, as the creation of a new subsystem of "influence", where individual objects act as carriers of housing function and major functions of the tertiary and quaternary sectors of the economy in post-industrial cities.

The formation of such a system should be based on the modern regulatory framework, which must be ahead of the construction industry, and not just following in its wake.

The architectural solution of MHC in all urban structural elements ranging from the central core to the outskirts of the city must be unique and not allow the replication of world-famous objects.

Authentic buildings dictate the number of storeys, composition, stylistic features, the combination of global and national architectural trends in the architecture of MHC in the historical core of the city.

It is possible to form MHC in the form of new sub-centers of the city center at a certain distance from its core or to supplement the existing urban nodes. In such cases, the architectural solution focuses on the nature of existing buildings, their height, scale and is aimed at creating dominants, accents, the urban skyline. The high-rise complex is formed as a new ensemble or complements the existing one. Functional orientation is determined by both urban needs and the specifics of the functional content of a particular structural element of the city.

The least number of restrictions accompanies the formation of the architecture of MHC on the periphery. Complex urban structures in the format of «city within a city» may be created there, combining residential, public and transport functions.

Placement of MHC in a sparsely urbanized environment is a prerequisite for the use of landscape spaces as system-forming elements. Green areas, water surfaces, folds of landscape not only create unique "land art" and platforms for demonstration of objects of contemporary art, the so-called "public art", but also permeate the internal environment of high-rise complexes, determining the composition of their stylobate part on the basis of the principles of landscape urbanism, as well as enabling the use of vertical gardens and green roofs.

The presence of certain natural resources opens the possibility of introducing the recreational function in MHC – namely, creating conditions for a “day-off” rest for inhabitants of both the city and the suburban zone. It promotes the formation of an urban node that combines internal urban and external suburban communications in a uniform infrastructure, provides transfers from one mode of transportation to another, organizes parking.

In terms of its composition, the high-rise complex fixes the entrance to the city, acting as a "gate" of sorts, while its functional versatility provides new jobs and helps in stopping suburban residents who travel to the city for household purposes (for goods and services).

In terms of innovation, multifunctional high-rise complexes have always been the reflection of industrial revolution and scientific and technological progress since their emergence in the USA in the mid-nineteenth century. Today, the formation of structures approaching the height of one kilometer is impossible without use of the latest technologies in the field of construction, building materials and engineering solutions. Energy efficiency and "smart" management are becoming important characteristics of high-rise complexes.

At the same time, the flexibility of strategies and the ability to quickly adjust goals in the creation and operation of skyscrapers must be integrated into the process of innovation, as the linear scheme of "action – result" does not work for introducing novelties to take root and turn into innovations. The innovation process is always accompanied by risk. And no one can predict its results. Innovations can be slowed down or even fail due to funding problems, lack of appropriate skills and abilities, inconsistency with urgent tasks and goals of the activity [2].

Nevertheless, despite all the risks, a certain movement towards the "information society" is observed nowadays, in which the decisive role shifts from industry to information. Meanwhile, the understanding of the city as a complex hierarchically organized open system capable of self-organization, enables the formation of its "Smart" subsystem, which serves as a "smart" basis for the formation of high-rise complexes [7].

In accordance with the fragility of complex systems, some attention is paid to ensuring the balance and stability of both the single multifunctional high-rise complex (which operates independently in a separate urban structural element) and the resulting subsystem, in which every high-rise complex is an exclusive object capable of interchange, mutual complementarity and self-renewal.

The sustainability of the multifunctional high-rise complex is due to the presence of a large number of various functions, which are determined by: characteristics of the structural element of the city; the presence of the "network" of more stable structural elements in the structure of the complex in relation to its environment; the presence of elements, which, if necessary, may be regarded as "attractors" of a kind; the presence of elements (functions, engineering, planning solutions, etc.) that can expand into the surrounding environment and, together with it, form new support structures.

The construction of the subsystem of MHC as an "object of influence" contributes to the creation and development of the image of individual structural elements of the city. It unfolds on the principle of the multiplier effect when the very fact of the formation of high-rise complexes becomes a starting point for finding and utilizing funds, technologies, materials, modern spatial, architectural and urban planning solutions, as well as the involvement of various functions for further development of image.

CONCLUSIONS

1. Multifunctional high-rise complexes are considered as complex systems in the complex system of a city. MHC and the surrounding urban environment mutually determine each other.

2. The structuredness of the modern urban system and the imposition of transport infrastructure on its functional and planning organization allows the identification of the most optimal sites for high-rise complexes – territories of structural elements with different levels of urban development.

3. The formation of MHC in different structural elements of the city is considered as the creation of a new subsystem of "influence" where individual objects act as carriers of housing function and the main functions of the tertiary and quaternary sectors of the economy in a post-industrial city.

4. The creation of separate multifunctional complexes and their subsystems is aimed at both the point effect in a particular structural element and the resonance (impact) at the level of the city system, which in post-industrial conditions can be considered as "development intervention". It provides:

- achievement of a balanced state of the system and the environment (equilibrium of the system with the environment) at different hierarchical levels (from the complex to the city), which is the main condition for the stability of the system, as the balance of the system is associated with such an important indicator as sustainability;

- formation of MHC in the context of "smart" subsystem of the city by increasing the innovative representation of new elements in the way of life and living environment;

- improvement of the structural-planning organization – formation of new nodes in the framework of the city; complicating the structure of the community center of the city as its most stable element (subsystem) in order to create new points of attraction for the placement of MHC.

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Implementation of the Principle of Environmental Compensation in Designing Modern Transport Buildings on the Example of Multi-storey Parking Garages and Helicourts

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Abstract. The need for creating a harmonious environment and solving diverse and complex issues related to its design and construction in line with the concept of sustainable development is a major and urgent task faced by modern architecture and construction science. This paper analyses and summarizes the application of the environmental compensation principle in designing modern transport infrastructure facilities for the storage of road and air transport in the largest cities – multi-storey parking garages and helicourts. It has been established that observance of this principle plays one of the key roles in the formation of ecologically balanced, safe, and aesthetical architecture of modern transport facilities for the storage of road and air transport, and creates a favourable, comfortable environment with minimal negative impacts on human existence. Based on the principle under consideration, the authors proposed modern approaches to the design of multi-storey parking garages and helicourts in the largest cities. Namely, these approaches include maintaining the ecological balance of the building with the environment. Such balance shall meet the design standards of ecologically determined, engineering and technical, sanitary, and hygienic arrangement of internal space of the multi-storey parking garages and helicourts, and provide for resource conservation during their operation. The paper describes examples of design and construction projects of ecologically balanced multi-storey parking garages and helicourts in the largest cities, which give a deeper insight into the types of these structures and modern approaches to their designing.

INTRODUCTION

The need for creating a harmonious environment and solving diverse and complex issues related to its design and construction in line with the concept of sustainable development of human settlements is a major and urgent task faced by modern architecture and construction science. Galloping urbanization, the rapid development of various technologies and technical means that form an artificial environment on the one hand, and natural disasters occurring in the world because of its depletion caused by the same development, on the other hand, create new requirements and conditions for modern architecture. The need to ensure an ecological balance – meet the modern needs of mankind and protect the interests of future generations, including their need for a safe and healthy environment - defines the current global construction trends, which indicate that the most promising direction is the development of urban environment based on energy-saving and eco-friendly technologies [1].

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In a rapidly developing world, the issue of improving the facilities for the temporary and permanent storage of both road and air transport, which according to analysts will flood the world's megacities in the nearest future as one of the types of public transport, is especially acute. The ecological aspect of creating a favourable environment for human existence with minimal negative impact plays one of the key roles in shaping the architecture of modern transport infrastructure facilities for the storing of urban road and air transport. These facilities primarily include underground and above-ground multi-storey parking garages and helicourts.

At the same time, during technical and flight operation of the parking garages and helicourts, cars, helicopters and other vehicles can directly pollute the air and soil in the area, generate noise, etc. In particular, the main threats are:

- Pollution of surface layers of the atmosphere (up to 900 m) by emissions of aircraft engines: CO, CnHm, NOx, SO_2.
- Impact of chemicals on the atmosphere, hydrosphere, and lithosphere, soils, wastewater, and groundwater, which is manifested in the contamination of the area of multi-storey parking garages and helicourts.
- Physical impact as a result of electromagnetic radiation primarily emitted by air facilities which feature high coherence (frequency and phase stability) and acoustic or noise exposition caused by automobile, aviation noise.
- Pollution of the lithosphere manifested in the destruction of natural landscapes – removal of the top layer of soil, and in the alienation of territories for controlled and illegal solid waste landfills.

Therefore, improvement of environmental approaches in the design of transport facilities for the storage of road transport and helicopters is becoming a topical issue today.

The purpose of this paper is to analyze the principle of environmental compensation in the designing modern transport facilities for the storage of road and air transport such as multi-storey parking garages and helicourts in the largest cities.

Analysis of current research and literature. Many domestic and foreign researchers and practitioners devoted their effort to the study of the importance of environmental aspects in the design of transport facilities. In particular, S. S. Kysil focused on the international experience in design, main ecological and aesthetic aspects, modern approaches to the use of natural and artificial shapes in the formation of the architectural environment of ecologically balanced multi-storey parking garages [2-4]. Humanization of the architectural environment of multi-storey parking garages has been discussed by S. Henley [5], S. McDonald [6] and Ye. O. Holubeva [7], respectively. N. G. Semyroz [8] addressed the issue of helicourts integration into the urban architectural environment, and N. E. Nikolaikina [9] described the main types of anthropogenic impact on the environment associated with operation of air vehicles.

The works by modern researchers discussing the design of multi-storey parking garages and helicourts are of great practical importance and will remain relevant in the future. However, most of them were descriptive and lacked the systematic approach in addressing the environmental compensation principle and ecological aspects of designing such buildings.

METHODS

In this paper, the following methods were used: analysis of modern domestic and foreign experience in the construction of parking garages for road and air transport in the structure of large cities, analysis of quantitative geoinformation data, photo fixation of places, analysis of regulatory data, graphic analytic method and environmental method.

The environmental assessment method determines the ecological condition of the natural environment and natural hazards associated with the operation of transport facilities – multi-storey parking garages and helicourts addressed in this study. Cars, helicopters, etc., during the operation of parking garages and helicourts have a direct impact on the environment and change the conditions thus affecting the principles of existence within ecosystems.

RESULTS AND DISCUSSION

The modern multi-storey parking garage is a complex facility intended for the storage of the largest possible number of vehicles at a given place. It includes premises designed for various engineering-technological and functional purposes. In relation to the earth's surface, multi-storey parking garages may be classified into underground, above/underground, and aboveground, Fig. 1.

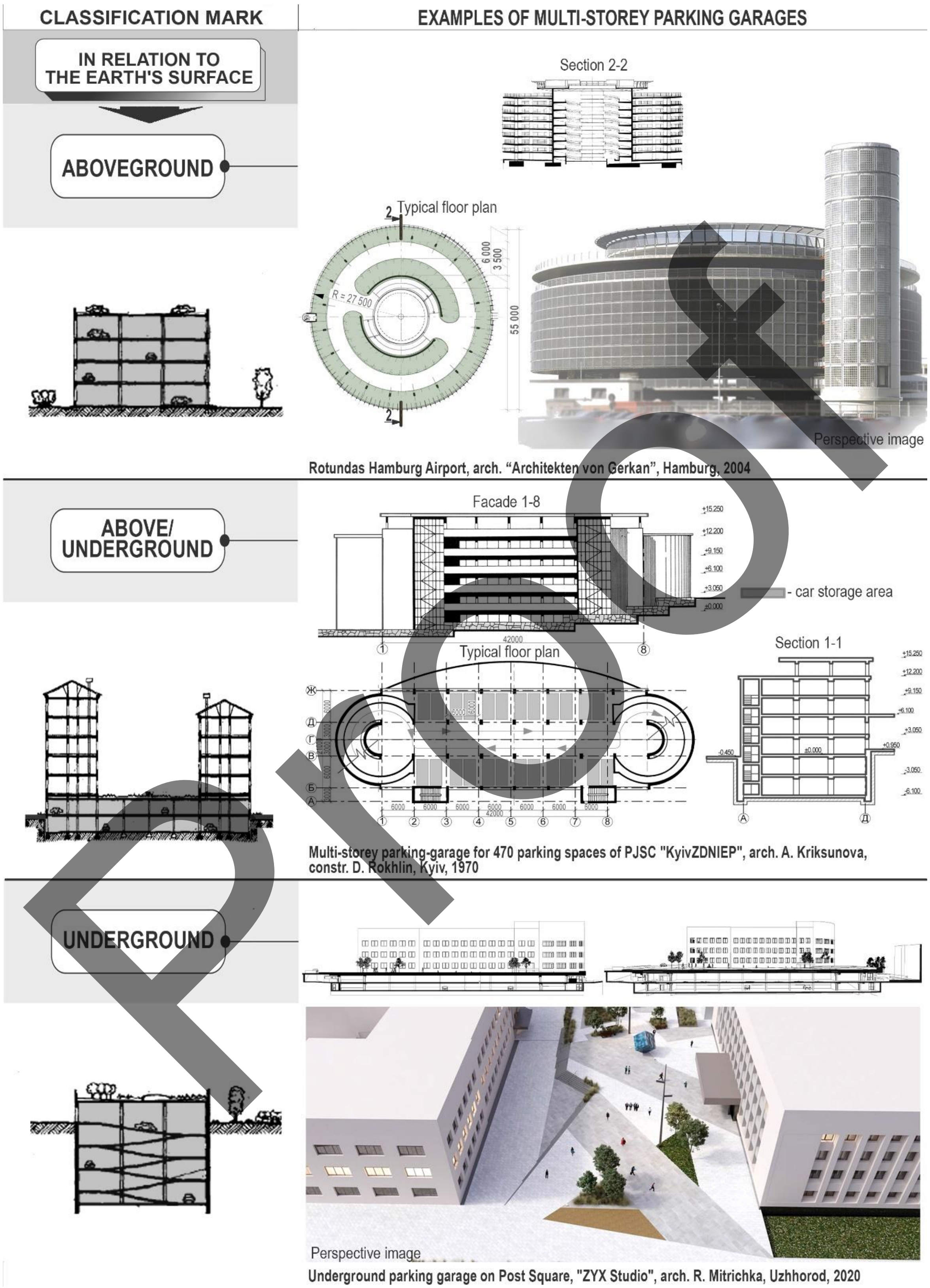

FIGURE 1. Classification of multi-storey parking garages in relation to the earth's surface [10]

Underground multi-storey parking garages require approximately 10 – 20 less land than above-ground multi-storey ramp-access parking garages featuring the same number of levels. However, the construction of underground multi-storey parking garages is feasible only in case of favorable hydrogeological conditions on the construction site (groundwater, karst formations, and communications). Underground multi-storey parking garages, in turn, require the installation of special ventilation, sewerage, etc. equipment. Ill-conseived construction of such structures may lead to the destruction of greenery and the damage of historic buildings in the area, which is unacceptable, especially in the central districts of the cities. According to O. Biutner [11], the construction and operation (excluding the cost of land) of a single parking lot in underground multi-storey parking garage is approximately 25-30% more expensive compared to the above-ground parking structures. However, due to environmental protection issues and the lack of expensive land for parking in highly urbanized areas, underground multi-storey parking garages are becoming much more popular today.

Helicourt – a complex of facilities servicing the air transport passengers, located at the top or on the roof of residential or public building only, or located on the platform of the transport unit, having a specially equipped court to ensure takeoff and landing of one or more helicopters [12].

The need to create a harmonious environment and address various complex issues related to its development and construction under the concept of sustainable development of settlements is an important and urgent task of modern architecture and urban planning. With the change of social conditions, the development of scientific progress, the emergence of various technical devices, and growing urbanization, new forms, and principles of planning and organization of urban transport facilities enter into the foreground, namely of multi-storey parking garages, helicourts for storing road and air transport, which according to analysts will flood the world's megacities in the nearest future as a public transport, similar to air medical service.

Modern above-ground, above/under-ground, underground multi-storey parking garages, and helicourts are artificially created architectural and structural closed systems. There is a direct linkage between the urban air environment and the hygiene of the premises for storing cars, air transport, etc. This is because cars, helicopters, and other vehicles can directly pollute the air, generate noise and vibration during their movement and operation of these structures. Therefore, the arrangement of multi-storey parking garages and helicourts should meet ecological requirements and provide a safe and comfortable architectural environment. This is possible with the implementation of environmental compensation principle in designing the multi-storey parking garages, helicourts, which includes:

- Establishing ecological balance between the building and the environment.
- Ecologically determined engineering and technical, sanitary and hygienic arrangement of the building's internal space.
- Resource conservation during building's operation.

The ecological balance between multi-storey parking garages and helicourts and the environment at the city planning level is ensured by:

- Rational placement of multi-storey parking garages and helicourts within the city structure.
- Planting greenery and landscape planning in the area of multi-storey parking garages and helicourts. Arrangement of noise protection green zones around multi-storey parking garages and helicourts.
- Cooperation with engineering and technical networks of the city.
- Use of eco-friendly and durable building materials for construction of multi-storey parking garages and helicourts.
- Minimized use of non-renewable natural resources.
- Minimization of pollutant emissions, vibration, noise from cars, helicopters during operation of parking garages and helicourts.
- Appropriate architectural solutions featuring rational spatial forms.
- Use of modern and efficient urban air cleaning systems.

The ecologically determined engineering and technical, sanitary and hygienic arrangement of the internal space of multi-storey parking garages and helicourts includes:

- Rational planning and functional zoning.
- Full-fledged implementation of all functional processes.
- Application of effective engineering and technical solutions with control systems: ventilation, water and air cleaning, smoke removal.

The resource conservation (rational use of natural resources) during operation of multi-storey parking garages and helicourts includes:

- Use of alternative energy sources – deriving energy, heat water, etc. from alternative sources: sun, wind, land.

- Control and optimization of engineering systems.

Since noise and vibration generated by moving cars and helicopters in multi-storey parking garages and helicourts have a great influence on the surrounding environment, to ensure their optimal impact, it is recommended, first of all, to rationally place such buildings within the structure of the city, Fig. 2, A.

The design and placement of both multi-storey parking garages and helicourts must provide for the use of protective measures, which maintain the permissible levels of noise penetrating into the surrounding buildings. To reduce the traffic noise in the settlements, the following construction and acoustic means may be recommended: zoning, landscaping, and development of the territory based on the use of the first row of buildings – multi-storey parking garages and helicourts – as a continuous noise protection screen, Fig. 2, B, C.

Rational placement of multi-storey parking garages and helicourts along motorways, highways, and other transport routes – sources of high noise, as well as on the outskirts of residential neighborhoods, etc., helps reduce ambient acoustic noise. In this case parking garages and helicourts serve as noise protection screens and may reduce the noise load by about 40 dBA, which is significantly higher compared to 5-6 dBA reduction by 40-50 m wide line of greenery, Fig. 2, C.

In the neighborhoods, it is recommended to place these transport facilities for the storage of road and air transport in groups separated from residential buildings by local streets. It is necessary to observe the required gaps between parking garages and helicourts and surrounding buildings. The transport facilities should be located as far as possible from preschool institutions, schools, health care facilities, nursing homes, etc.

There should be arranged sanitary protection green areas between multi-storey parking garages and helicourts and surrounding buildings, which will protect from noise and reduce vibration, Fig. 2, A, B.

The following methods remain effective at the urban planning level: distancing the feature from the source of the noise; use of natural terrain as screen or barrier to prevent the spread of noise; planting thick tree belts along roads; improving noise insulation of windows; orientation of windows of all quiet rooms in the opposite direction from the noise source. One of the solutions for densely built-up urban districts may be the installation of noise control screens along the roads, highways, and in places with significant noise load and high traffic.

To reduce the vibration generated by moving vehicles in multi-storey parking garages and helicourts it is necessary to arrange engineering and technical zones with high sound insulation, separate the foundations with technological equipment from the engineering structures of the building.

At the architectural and planning level, the means of achieving ecological balance with the environment include the organization of operated roofs and terraces with recreational areas; planting vertical façade gardens at multi-storey parking garages and helicourts; placement of parking garages and helicourts on the upper levels and rooftops of public and industrial buildings, Fig. 3.

Recreational areas with gardens and sports fields on the rooftops or terraces of multi-storey parking garages and helicourts help reduce noise from road and air transport. One such example is the project of a multi-storey car park, «Shinjuku Gardens» (Tokyo), which comprises 80 parking lots and was designed by Cheungvogl Architects in 2010. Its facade is made of tall grass-filter, which cleans the polluted air and transmits the sunlight, and there is a small park on the rooftop, where visitors may have a rest, Fig. 3, C. Another example is a students' project of a business center with rooftop helicourt, which features recreational areas with planted trees, shrubs, etc. on the roofs and terraces of the building, Fig. 4.

Vertical façade gardens allow to effectively reduce the transmission of noise and vibration generated by vehicles stored in open multi-storey parking garages and helicourts. This is especially relevant for densely built-up districts, where planting trees is limited by the lack of land. One such example is the project of an open multi-storey parking garage at Polzunova Street on Pryvokzalna Square in Kyiv, which facade is made of noise and gas absorbing vertical green walls, Fig. 3, B, C.

Placement of parking garages and helicourts on the upper floors and rooftops of public and industrial buildings becomes especially relevant in densely built-up urban districts. Optimal architectural and engineering solutions providing for vertical movement of vehicles are essential to the implementation of such projects. This may be illustrated by the project of the multifunctional shopping and entertainment center, «MIST-City», in Dnipropetrovsk, which features 1000 parking lots on the upper floor and the rooftop of the building, and a car lift to move the vehicles, Fig. 3, A.

To save natural resources, it is recommended to use non-conventional energy sources in the design projects of multi-storey parking garages and helicourts. In particular, wind turbines (installed on the rooftop, within the building structure, or in the adjacent territory) and solar panels (installed on the rooftop, facades).

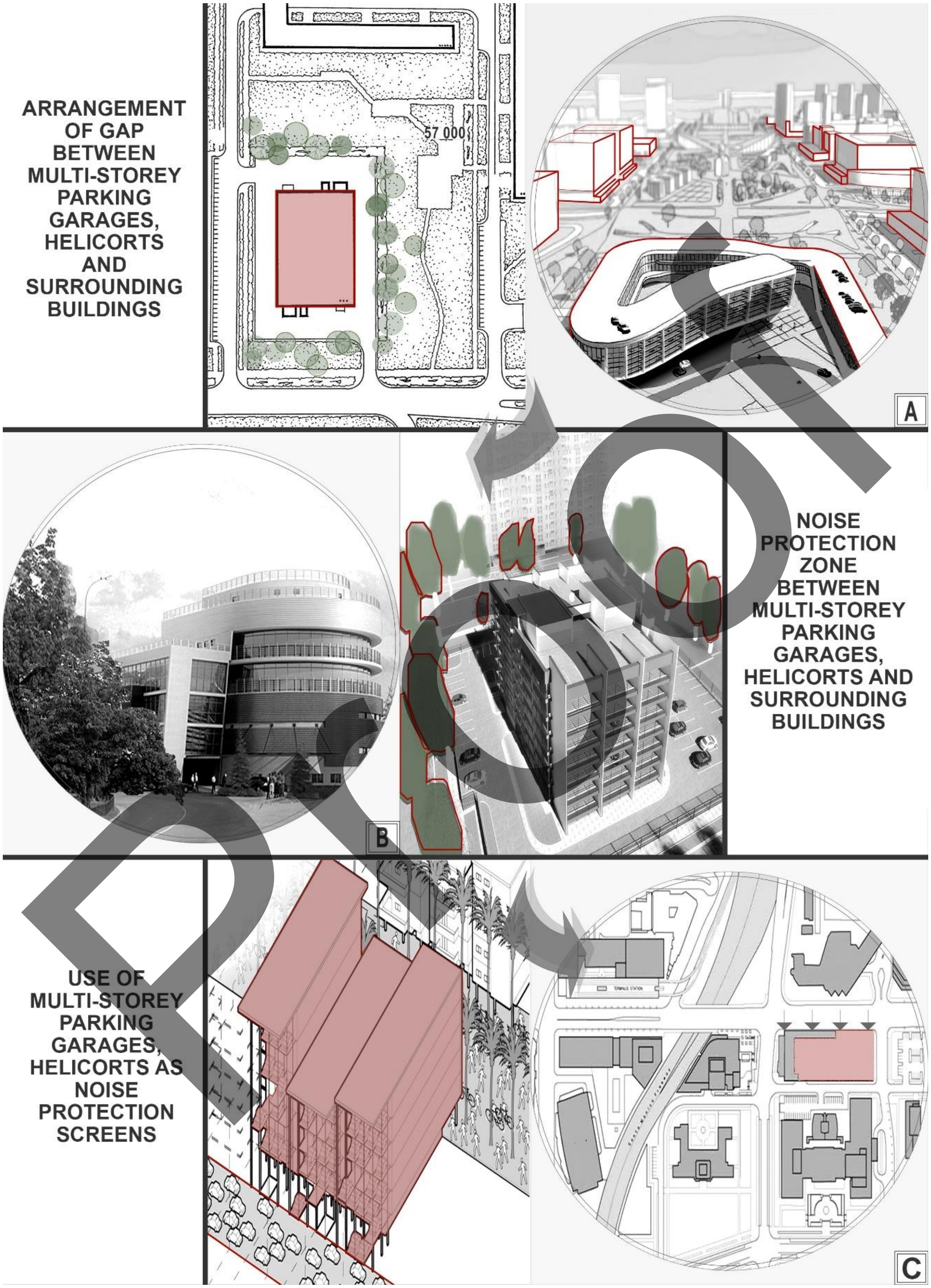

FIGURE 2. Examples of arrangement of ecologically balanced architectural environment of multi-storey parking garages and helicourts in the largest cities. City-planning level [10]

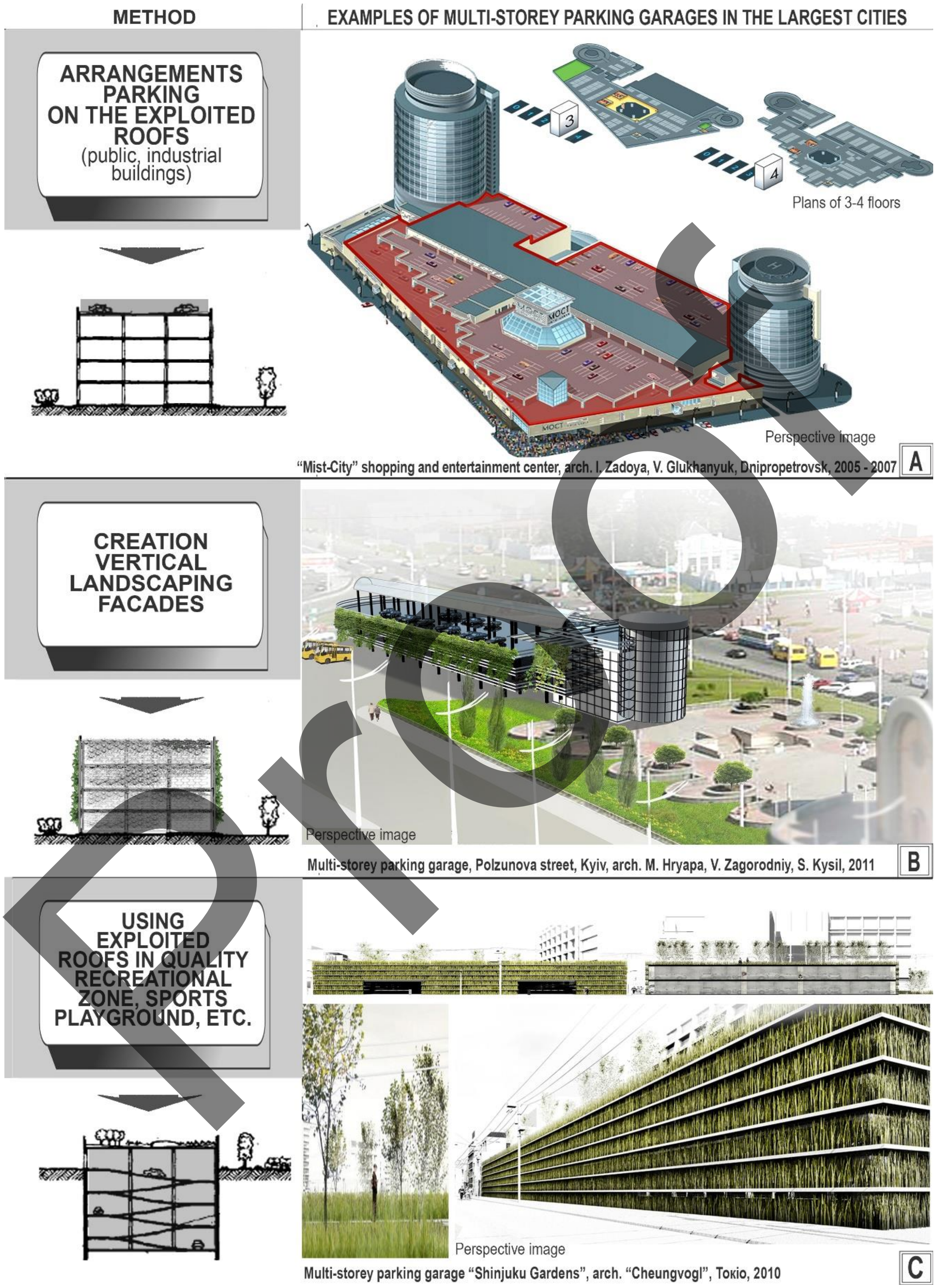

FIGURE 3. Examples of arrangement of ecologically balanced architectural environment of multi-storey parking garages and helicourts in the largest cities. Architectural and planning level [10]

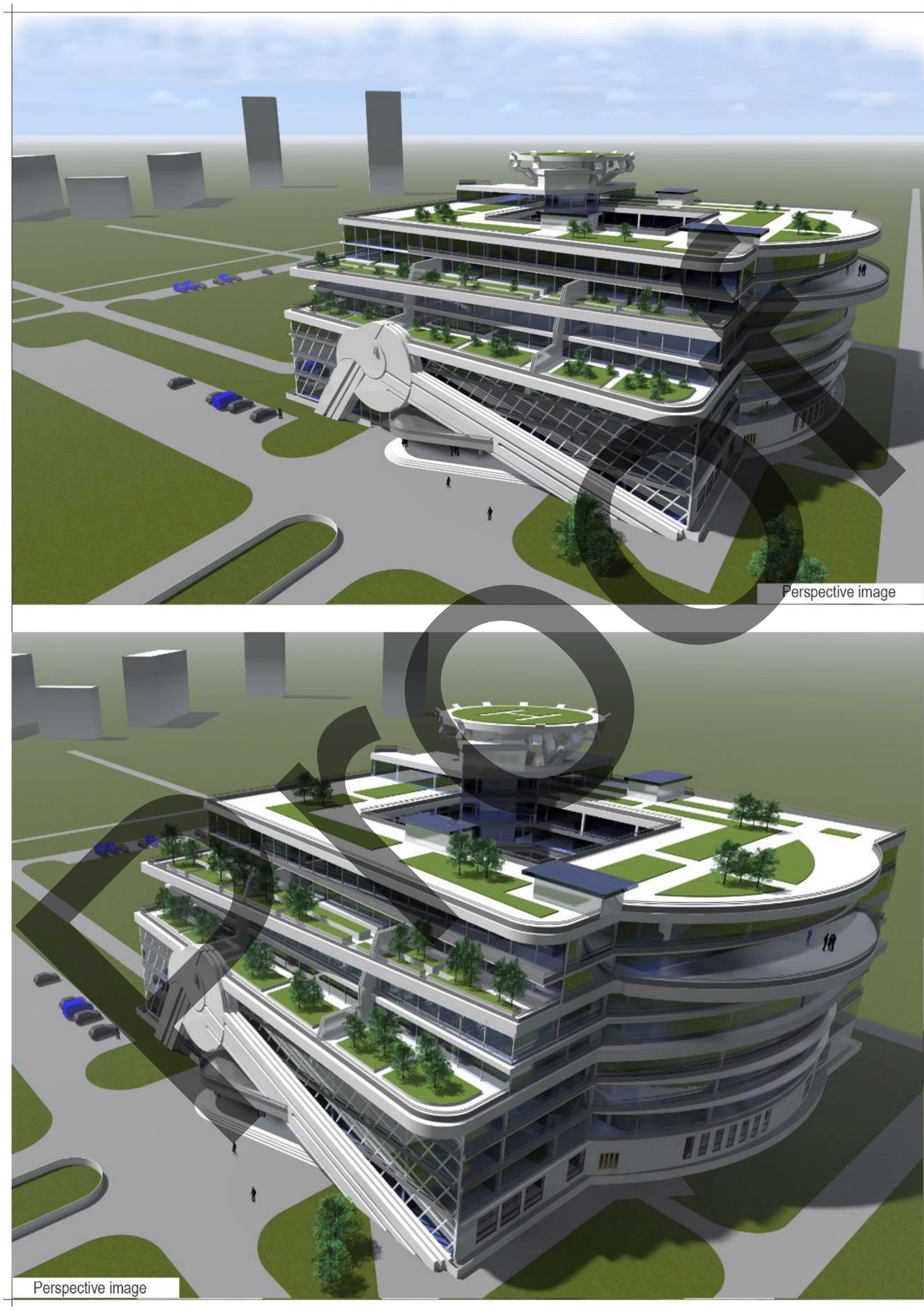

FIGURE 4. Suggested project of business center featuring helicourt by Semyroz N. G., Benchuk N., 2014 [12]

The architectural environment of transport facilities designed for the storage of road and air transport should comply with modern aesthetic and ecological requirements and contribute to the establishment of a comfortable living environment. During the design of multi-storey parking garages and helicourts, the main focus should be placed on reducing to a minimum the potential negative effects of their operation on the environment.

CONCLUSION

The analysis of international and domestic experience in designing the facilities for the storage of road and air transport has shown that adherence to the principle of environmental compensation will contribute to making up for negative man-made impact through rational functional planning and spatial arrangement of the building and optimized footprint, and to environmental protection of the territories adjacent to the parking garages and helicourts.

Application of the principle of environmental compensation during the design and operation of multi-storey above-ground, above/under-ground, and underground parking garages and helicourts will make it possible to reduce general negative impacts associated with their placement in the city structure, ensure observation of sanitation and hygiene standards during their efficient use and contribute to the creation of a harmonious urban environment.

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Ergative Properties in the Development of Urban Systems

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Abstract. The research is focused on improving the methodological tools of spatial structure and development of urban systems, taking into account the requirements and properties of the urban space organicity. The concepts of ergativity, self-organization and organicity in various subject areas are specified. Theoretical foundations of the research of ergativity in urban planning are specified. In particular, theses about natural order and natural longevity; modern theoretical doctrines of time; a broader combination of the determinism and metaphysics principles. The ergative model of spatial structure and development of urban systems is substantiated. The theses are proved on examples from the architectural and urban practice of Lviv.

INTRODUCTION

Fundamental science is aimed at cognition and explaining the laws of nature. Some patterns are revealed to researchers, and the task is to apply them to applied problems and the organization of simple things, including in urban activity and spatial structure of society. In urban planning, the understanding of laws and patterns operating in nature, issues of organicity and self-organization actualizes new requirements for spatial structure and urban development and according to the authors is concentrated around the concept of ergative systems. The research is focused on improving the methodological tools of spatial structure and development of urban systems, taking into account the requirements and properties of the urban space organicity (considered as ergativity).

METHOD

Modern urban planning in Ukraine is characterized by a certain "blurring" of the issue, as well as a lack of intersectoral research, while the science of other subject areas establishes and expands interdisciplinary links, considers properties and relationships that were not considered relevant decades ago. The study of urban problems requires deep knowledge of psychology, history, social relations, philosophical and world-view bases, widespread use of methodological tools related to urban areas [2; 11]. It should be emphasized that self-organization in a special way of using urbanization as the ability of a system to produce or change behavior according to situations. It is assumed that circumstances may change, and at the same time the participation of residents in urban development management will change: opportunities will be expanded, social cohesion will be stimulated, public confidence in the government will increase, responsibility for general social conditions in districts will increase; environmental sustainability increases not only in the short but also in the long terms, employment of residents is optimized. The issues asserted by the community have both a local and a general level – the elimination of misunderstandings, when projects are focused only on higher returns of investors; vision of urban policy, reform and development of urban networks, etc. [6].

Self-organization, self-development and organicity as the natural processes in urban planning and architecture is of high interest to specialists in this subject area [4–7]. The concept of a flexible plan and the dominance of procedure

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issues in the development and approval of urban planning documentation, expanding the possibilities of making adjustments. This practice began in the Netherlands in the mid-1960s and consisted of improving and directing unstructured residents' protest movements through parliament in a constructive way for the benefit of society. Citizens were empowered and encouraged to participate in administrative and communal responsibilities: first in the living environment, then in regional and national spatial planning agencies, and later in formal planning procedures. This approach and methods of community participation in urban planning are also criticized, in particular the excessive focus on the process, rather than on the content of planning and design [14]. However, these actions have led to new types of public-private partnerships and a new type of entrepreneurial planning style in which local, regional or even national governments have expanded cooperation of stakeholders and civil society to develop effective and realistic solutions where each party would share the responsibility. In Ukraine, this issue is considered by M. Habrel [6–7], M. Djomin [4], A. Pleshkanovska [10], O. Kucher [8], I. Shepelenko [11].

RESULTS AND DISCUSSION

Let's clarify the concepts: self-organization, organicity and ergativity. Most often, the concept of self-organization is considered within sociological research, as the term "sociological self-organization" meaning a spontaneous process in society or groups. It arises as a result of individual actions within broad social systems. In the *demographic sphere*, it is associated with the processes of population reproduction, marriage, migration; in the *economic sphere* - with labor relations, with a change of place of work, the impact of society's needs on production initiative; in the *socio-psychological sphere* – these are values, traditions, habits, attitudes to other public opinion, issues of leadership and prestige. Self-organization as a phenomenon can play a constructive or destructive role. On the one hand, it strengthens the purposefulness of actions of social groups on common interests, objectivates the decision choice, improves settlement as an alternative to erroneous actions; on the other hand, there is a danger of domination of short-term benefits over strategic needs - individual and group interests over public ones. *Self-organization* in urban planning is interpreted primarily as community participation in issues of spatial planning and urban development management.

Within the publication, it is advisable to clearly outline and better understand the *phenomenon of organicity*. The organicity is interpreted different in chemistry, physics and sociology. In the Ukrainian language it can be synonymous with naturalness, ie what happens in a natural way. The dictionary of foreign words provides a different interpretation of this concept [3: 484] as: inherent or similar to a living organism, ie one that is characterized by life processes inherent in living objects; direction in the sociology of the late XIX - early XX century, which identifies society with the body, and explains social life by biological laws.

Organic urbanism is the interpretation of the city as a living organism, identification and explanation of urban processes, forms of organization and mechanisms of development of urban systems by characteristics common for living organisms, as well as patterns of living system structure and functioning. Since human is the most perfect form of living matter, it includes in its structure and functioning the basic elements: body – mind – soul – spirit. These systems have connections and relationships: cyclicity; functional specialization; the need for active work to maintain the state; features of growth and procreation; reflexivity of actions, etc. Natural systems are characterized by proportional structure and relations, in particular the laws of the golden ratio. According to the authors, these theses and statements should be comprehended and applied in urban science as the concept of "healthy" city [6].

Ergativity is the ability of a system to respond to changing conditions, to produce and change behavior according to the situation. This concept is widely associated with self-organization, self-development and organicity of urban systems, but includes not only the human aspect, but also other characteristics of urban space. The ergativity of the systems is related to the following issues: behavior as reactions of the system to external influences; negentropy - the ability of the system to manage its uncertainty in case of accidental or adverse environmental influences and the ability to eliminate their consequences; as well as purposefulness, predictability, regulation, risk, disclosure of the uniqueness of the system, etc.

Theoretical Bases of Ergativity Research in Urban Planning

This is an attempt to generalize the philosophy of the systemic perception of the city as an organic phenomenon in the time and realities of today. The first thesis is that natural order and natural longevity are selective iterations (repetitions) that are deprived of the power of their own initiative is deeply rooted in science. This should negate the effective development of this platform. However, the ideas of the "rights" of nature, which exist in all cases and are considered the pinnacle of rationality, also remain popular. Determinism is considered as a concept that does not consider many characteristics of human and the intangible components of his activities. Therefore, in our opinion, it is expedient to more widely study and use the naturalness of processes and phenomenon of objective reality, particularly in urban systems.

The second thesis is that time and time characteristics have more effective impact on the development of systems than is usually thought – sometimes in time is more important than good. Theories of time are grouped into two opposing doctrines: the first states that time processes are quite real and irreversible; the second is that time is unreal according to the principles of the eternal existence. Ideas are developed and laws are formed, which state that in nature there are certain realities or quantities that are eternal and unchangeable, and therefore timeless [1]. Such immutable invariants are the smallest elements and fundamental laws, in particular energy accumulation. On this basis, the categories of stability, activity and dynamism of processes are considered important.

The third thesis is opposite to empirical science and metaphysics. The world remains alien and incomprehensible, perhaps even more so than in the past, when this understanding was given and interpreted through religion. And although many principles and concepts have changed the modern science of determinism in relation to certain doctrines of the past, the time of joint interpretation of the provisions of deterministic science and metaphysics was still a time of the most active development of science, art and culture. Probably, these methodological approaches should not be opposed today. The assumption that science is only interested in facts and logical conclusions is doubtable [13], since all research is based on ideas and hypotheses. And in architecture and urban planning, such concepts as spirituality, identity, aesthetics, political conditions, etc., are important in research, but metaphysical in nature.

The three theses are associated with the opposition of idea and matter, the definition of their role and primacy in the development of systems. On the one hand, scientists recognize and are convinced of the reality of human material actions, on the other hand, they argue that matter has never been able to create something significantly new.

The stated considerations seemed to us necessary for understanding the theoretical provisions of the "natural flow", self-organization and properties of ergativity of urbanized systems. An important theoretical issue in the study of self-organization in the conditions of increasing entropy of systems is "determining the direction of development", including answers whether there are objective relationships between the past and the future in urban planning [14]. Another aspect involves understanding the processes of change and development according to the methods of the natural sciences, which are associated with the emergence of life and its subsequent evolution. The next thing that needs to be understood is the concept of creating "something new" on a natural basis, including the concepts of birth, selection and expansion. L. Boellens points to the possibility of going beyond pre-defined systems and perceive urban development as a continuous formation process [1]. In this approach, special attention is paid to heterogeneities and self-organizing components, there is an opportunity to explain how such networks exist in the constant process of their formation and reform. That is, to understand the issue of ergativity in urban development, an attempt was made to understand the processes of their development, as well as the categories of variability, heredity and selection on the basis of plurality.

Based on the methodological platform of the systems approach and meaningful theses, we formulate the essence and structure of the ergative model of spatial structure and development of urban systems. This model is human-centered and is based on the position that human has the ability to think and create, to change conditions, followed by adaptation. The model outlines the specifics of human processes, needs, activities and behavior. It is related to the needs of the individual and the community and is aimed at meeting them. Meeting needs requires resources and produces waste. Priorities and directions of development are determined according to human needs. Accordingly, the ergative model of urban systems development also includes functional and ecological components. The functions of the system are the main for the functional component; the environmental component outlines the efficient use of resources (especially non-renewable) and the harmful effects. The ergative model of urban systems formation allows in each situation to correctly prioritize depending on the spatial characteristics and properties of the system, "open channels" to self-organization and effective use of the spatial potential of the city.

Ergative Properties in the Spatial Structure and Development of the City

Example of Lviv

Ergativity is a universal property of urban systems, and it should be based on the substantiation of design solutions and actions. There are urban tasks for which this property is crucial and more effective than managed development, in particular in the organization of the recreational process in a large city. However, the model is effective for all tasks, including protection, preservation and use of the historical environment of cities, substantiation of housing policy in the city, etc. One of the authors was the chief architect of the development of the Historical and Architectural Reference Plan of Lviv. The updated document has not been approved for more than two years. The reason is the city's lack of interest in having such a document. This blocks the mechanism of activation of important social processes in the city.

Currently, the town-planning documentation for the city is expected to be updated. The task is to "open the channels" of self-development. According to the ergative model, it is expedient to involve the spiritual potential of the city, the initiative of the residents not only in the form of public hearings, but also activities; remove obstacles that block initiatives, including use of historical potential; to demonopolize the activity of the city authorities, the chances of which appear in the conditions of administrative-territorial reform; wider use of process research methods and behavior analysis of the system.

We will illustrate the statements with a case study in Lviv. The first example is the self-organization of recreation in groups in which people with similar lifestyles and values are organized together. A significant part of recreational processes in the city and its surroundings takes place on the basis of self-organization (trips to nature, weekly rest, kayaking, cycling, hiking or skiing). For many years, self-organization has proved to be an effective way of cheap and attractive recreation, contributed to the formation of the way of life of certain communities. Such groups, as a rule, are not registered in organized institutions, and initiatives come from within. The reason for their success is relative freedom, which is sometimes regulated by instructors and senior groups.

The second example concerns the redevelopment of the recreational zone of Vynnykivsky Lake, located on the territory of Vynnykivsky Forest Park, on the outskirts of Lviv. Since the mid-1950s, the lake has been created as a recreational area and equipped with a boat station and beaches. However, in the 1970s, the recreational area degraded, and the lake was unsuccessfully "reconstructed" for more than twenty years. Recently, the Vynnyky community received information about the reconstruction of the lake. There were a number of questions that worried residents, including whether they would lose access to one of the few, albeit abandoned, reservoirs near Lviv, as the lake would become private property. An initiative group was formed, which, having studied the detailed plan of the territory, claims that the developed project violates a number of laws and norms, in particular construction near the lake violates the coastal protection strip, no clear boundaries, red lines, no status of adjacent streets. The Vynnyky general plan has been under correction for years, and the town council has supported the project.

Today Vynnykivsky Lake is being built up, two buildings have been erected on several floors, trees have been cut down, the lake dam has been concreted, turning the lake into a swimming pool. People are interested in: how many plots have been privatized, how many organizations have been registered at an address that does not yet physically exist; how the route from Lviv to Vynnyky will be reformed; how will engineering networks develop? At risk is also a source from which not only locals draw water. The boundaries of Vynnyky and Lviv are not shown on this fragment - the lands of the Lviv City Council and the lands subordinated to the regional administration; there is no strategic environmental assessment report.

The main reason for the conflict situation was the lack of a systematic approach and platform for communication between the government, investors and residents. This approach considers it important that any object, process or phenomenon can be considered as a system (the object stands out as a whole system). All issues raised by the community are addressed in the project, but there are antagonistic settings and contradictions. This large-scale example can be considered successful in terms of the ergatic approach – it "opens the channels" for quality development of this recreational area of the city, but all participants in the process remain dissatisfied.

Within the systematic methodological platform and ergative approach, it is possible to improve the activities taking into account the requirements of self-organization and the organicity of processes development solving other tasks in the city, including substantiation of housing policy.

The integral characteristics of the spatial situation in the city with the help of life problems include indices: socio-political state of the city; economic activity; quality of urban living environment; as well as the ratio of housing supply and demand; affordability of another's housing. Responding to the preparation of housing policy provides for the definition of the structure and forms of cooperation of housing of different types and different target groups of owners and users; the structure of cooperation of the ratio of "infill – expansion" of the territory of housing; restoration to special social groups defined for the artery of income, age, civil status, health status, origin; participation of the city in the development of public and engineering infrastructure; the size of housing of different categories in the city space; restoration to housing reconstruction and housing policy on the secondary market; forms of financing and investment in housing development by sharing responsibilities and effects.

Housing policy should provide specific requirements: 1) the ability to have housing for all residents, which is the primary condition for the effectiveness of urban and state policy; 2) the cost of housing purchase significantly exceeds the financial capabilities of individuals (especially those who start a family), so this area should be regulated by the state; 3) housing should change when the needs of the family change in accordance with the mechanisms of living conditions change in the human life cycle; 4) the rapidly changing factors affecting housing needs should consider housing supply and demand balance; 5) the real estate market should be diversified without managing different priorities and needs.

CONCLUSIONS

The theoretical bases of ergativity research in urban planning that are connected with the natural order and natural longevity are specified. The ergative model of spatial structure and development of large cities is substantiated. The requirement of ergativity in relation to the problems of spatial policy in large cities in the new geopolitical and socio-economic conditions is demonstrated and its new principles are substantiated. The role of urban-spatial factors in this policy is determined. Analysis of the defined factors for the recreational activities formation, redevelopment of recreational areas, placement of new facilities in the system and housing policy development allows to identify effective approaches and tools that can be applied in Ukraine to substantiate spatial policy in its large cities.

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Assessment of the Sustainability of the Culture of Housing Construction in Slobozhanshchina at Different Stages of Development

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Abstract. The objective of this work is to assess the possibility of developing the established tradition in the process of transition to green construction. The article examines the current state of green policy in Ukraine, including in the construction sector. When analyzing the cultural heritage of Slobozhanshchina in the field of construction, it was found that construction methods have changed during the transition from an agricultural to industrial type of economy. The transition to a Green economy should be considered the next phase of change. In the absence of verified information on the new construction technologies, people tend to rely on tried-and-true traditional methods, instinctively selecting the solutions closest to tradition from the innovations pool. Turning back to better local environmental solutions in the construction sector is only possible by changing the approach to land use.

INTRODUCTION

Today, the global community is extremely concerned over the impact of humanity on the environment. The issues of greenhouse gas emissions and global warming, water pollution, loss of biodiversity are affecting the entire planet, depending on the actions and choices of each person, but not every inhabitant of the planet ever thinks anything about it. The most important decision made by every inhabitant of the world is the arrangement of their own home. Each person strives to obtain the best option as they understand it. Often the choice of the majority in a certain region, during the construction of their own habitation, leads to a more or less optimal model, called "traditional dwelling". One would think that a traditional dwelling, the creation principles of which have been extensively polished, should leave us with an ecologically ideal living environment. However, if we turn to the construction heritage of the Kharkiv region (Slobozhanshchina), which began to be re-populated only in the middle of the 17th century, we will understand that during these 3.5 centuries the building materials from which traditional houses were created had been changed at least three times.

In the context of this study, the objective is to assess the possibility to rely on the established tradition in the process of transition to green construction. Deciding on the direction to focus on so that the housing construction sector of the Kharkiv region could steadily move towards ecological construction is an important component. The purpose of this study, referring to the cultural heritage of Slobozhanshchina, is to determine the reasons for changes in construction traditions.

THE POLICY OF GREEN BUILDING

Currently, the ecological approach is considered a new stage in the industry development, including the construction sector. The principles of Green building (also known as Green construction or Sustainable building) are formulated in various ways across different documents. In this study, we draw upon the Green building statements made by Dr. N. Kishnani from Singapore [1], which may be summarized as follows:

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1. determination of requirements for buildings (thermal conditions, ventilation, etc.) and and optimizing planning solutions;
2. Green building is based on local resources (construction materials, electricity, water, etc.) to reduce greenhouse gas emissions from transport and give the project a local flare;
3. the building should be liked by the people, thus, it will exist for a long time, which will have a positive effect on the environment;
4. possible modifications and changes in the building must be envisaged since it is to exist for a long time;
5. the environmental friendliness ('Greenness') is assessed both by using quantitative indicators (equipment efficiency, feasibility studies, etc.), and qualitative indicators measuring human well-being and satisfaction;
6. Green building minimizes the negative impact on the immediate surroundings and the entire planet, including the minimization of the environmental impact during the construction process and building life cycle.

In Ukraine, the first steps towards Green economy were reflected in the National Report to the Government "Sustainable Development Goals: Ukraine" and in the subsequent Presidential Decree. Based on the current state of Ukrainian social and economic development, the energy component has gained priority in terms of changes: the development of emission-free energy, energy conservation and energy efficiency. [2] In the eye of the Ukrainian society, efficient waste management and conservation of natural reserves are the key aspects of environmental preservation and, therefore, also are incorporated into state policy. Green building has not yet been developed in Ukraine as a separate political program, however, this aspect is a topical issue in the works of Ukrainian researchers and public organizations.

However, the fact that Ukraine has only embarked on the path of transition to Green construction makes it necessary to look into the experience of countries already enjoying a positive experience both in the implementation of individual projects and also in the formation of state policy supporting Green construction. In this study, we turned to the experience of the United Kingdom, which construction policy was studied in detail in the work by D. Gibbs and K. O'Neill [3]. From this study, it becomes clear that the UK relies on a wide variety of niche solutions provided by various local companies, consultants, and architects who offer the construction market a wide range of ready-made construction products and completed projects. The goal of state policy in the field of construction is to bring state standards to such indicators so that the niche products proposed are used by the key players in the construction industry.

The fact that local ideas and scientific developments are not implemented in sale-ready products on the market is an important issue on the Ukrainian construction market hindering the transition to new technologies (including the construction techniques). To begin with, legacy of the Soviet Union ensured that the construction market is represented by giant state institutions and factories with an outreach to scientific enterprises through the state apparatus, and small high-tech enterprises that could occupy narrow market niches with their products are virtually non-existent in the country. Following the gradual collapse of large state offices that had played important parts in the construction market of Ukraine, the connections established between scientific laboratories and enterprises were severed. Creating new connections among new market players has been an extremely difficult task. Secondly, the local small businesses that emerged in the 1990s - 2000s are more likely focused on importing finished products. It is much easier and cheaper to adapt a finished construction material or a product to the modern Ukrainian market requirements than to develop and implement a solution of your own. Unfortunately, such "adaptation" results in a quality degradation of such solutions. In addition, when it comes to green technologies implemented in ready-made industrial solutions, substitution of concepts occurs with their movement in space, since transportation comes in conflict with the idea of green building, not local source materials.

The most viable solutions in this basic premise are those relying on the improvement of technologies, products and materials already existing on the market. Certain principles of creating traditional housing and green building are similar, as cited in the study by L. Boginskaya and her colleagues [4]. The private low-rise housing construction sector, in which the end user also makes the decisions to build or upgrade, appears to be more open to Green building principles. This very sector, heavily represented in small historical towns and villages of the Kharkiv region, is the platform, which may produce consumers of niche green technologies. The solutions, which are commonly referred to as traditional construction, arise during the creation of private low-rise housing. In the current situation in the Kharkiv region, it is necessary to strive to ensure that the principles of the Green building become a part of the traditional building process.

RESEARCH MATERIALS AND METHODS

We have collected the material for this study from three different sources. Firstly, it includes the results of previous scientific research on the traditional construction of residential buildings in Ukraine. The consideration of the topic has begun in the late 19th - early 20th century by ethnographers. [5] In particular, the dwellings of Slobozhanshchina were first analyzed in the works by M. Sumtsov. [6] Kharkiv old houses were firstly measured and included in the heritage of the Ukrainian people in the 1920s, in line with the search for new Ukrainian architecture. This material has come down to us most fully in the book of the famous Ukrainian researcher of cultural heritage S. Taranushchenko. [7] In the 1970s a lot of Ukrainian researchers turned to the study of traditional Ukrainian dwellings, this extensive material made it possible for V. Samoilovich to trace the typology of the Ukrainian folk dwelling. [8] The influence of traditions on modern dwelling was considered in his works by N. Bozhinsky. [9] Secondly, this work is based on photographs of historical residential buildings (more than 500 facilities), collected by the author in the process of the survey of the historical towns of the Kharkiv region and certain historical villages. Thirdly, the materials are supplemented with several interviews with the owners of some of these houses, where they talk about how their dwellings were created or reconstructed.

The historical and genetic method is used to analyze the material collected. Two external factors that influenced the formation of a typical residential building in the Kharkiv region have been identified: natural conditions and historical developments. Various constructive types of housing have been identified, which analysis is carried out in accordance with the principles of Green building given at the beginning of the article. When describing the types of buildings, the following characteristics are highlighted: optimal planning solutions; conformity to lifestyle (mobility); durability; the locality of building materials; thermotechnical properties of the house; ease of use. Since the genesis of the traditional house planning solution has been studied in sufficient detail by other scientists, this aspect is not covered in this article extensively.

NATURAL CONDITIONS

The Kharkiv region is located in the north-east of Ukraine, within the watershed separating the basins of the Don and Dnieper rivers. The relief of the region is an undulating ravine plain divided by river valleys, gullies and hillside gullets with a prevailing slope of the surface to the south. In 1980, scientists recorded that the 98% of the region's surface of the Kharkiv region has been changed by man - most part of the territory is used for agricultural activities. By the 2010s, the number of protected natural areas has increased.

Climate observations in the Kharkiv region first begun in 1738, however, there were no systematic observations, which can be relied upon today, until 1891, and the network of meteorological stations in the region was formed only by 1892. At the end of the 19th century, the Kharkiv region has already embarked on the path of industrial development. We have insufficient information to draw any conclusions on the influence of industrialization on climate change. However, historical documents indicate a change in the number of forests on the territory of the Kharkiv region, which were practically destroyed by man, and then re-planted, that had an undisputed impact on the local climate.

The climate of the Kharkiv region is temperate continental with mild but unsteady winters and long stable, sometimes dry, hot summers. In winter, the average temperature can drop to -7°C, but sometimes can reach -35°C. In summer, the average temperature is + 26°C, but occasionally it rises to + 39°C. The average annual rainfall is 515 mm. Such a climate requires protection of the dwelling from the ambient temperature, that is, it must be heated in winter and kept cool in summer. Traditional houses most often being compact and of a rectangular shape is not surprising. The rooms are divided into warm premises - a kitchen and habitable room and into unheated premises - a mud room, storage rooms. Subsequently, verandas are added to the such houses, first open, then glazed. If there is a possibility, a “summer kitchen” is arranged separately - a small house with a stove used to cook food in the summer in order to keep the main house cool. An underground cellar for storing food is obligatory attribute of a residential building. If possible, it is built separately from the heated premises in order to maintain a cool temperature at all times.

HISTORICAL DEVELOPMENTS

The settlement of the Kharkiv region, which resulted in the towns and villages existing today, took place throughout the 17th century. For a long time, this territory was the Wild Field – a non-delineated, sparsely populated steppes, where the population led a predominantly nomadic lifestyle. However, as shown by archaeological excavations there were settlements that existed on this territory until the 14-15th century. However, as a result of the border disputes that occurred in the 16th century on this territory, only the remains of the former settlements were found at the beginning of the 17th century, with no inhabitants registered. The sedentary population lived mainly in “apiaries” - small settlements built in sheltered places, housing about 5-10 people. It was not possible to record the location of such settlements, which was the key to their survival.

New settlements, which were founded under the auspices of the Moscow state, accepted colonists, a small part of which were from the Moscow state. Basically, these were “service men” who founded and served in the newly created fortresses. The bulk of the colonists who went to Slobozhansk Ukraine, which included the modern Kharkiv region, originated from central Ukraine (Right Bank of the Dnieper). The heads of the settlers were mainly Ukrainian Cossacks, who gathered groups (families) of settlers and brought them to locations previously agreed with the Moscow government. In return for the development and defense of these lands, the Moscow state promised significant benefits (“freedom”) for 100 years. The settlers brought their belongings, skills and traditions with them, which included construction methods. The life of the first settlers was difficult and full of dangers, which was not surprising, as some settlements have been re-populated several times. Moreover, the new settlers occupied the farms of the previous ones. The previous owners could be either killed or taken prisoner, or simply left for new lands as a result of disagreements with local authorities. Under these conditions, the mobility of dwellings was important.

It is possible that during this period already there were 2 constructive types of houses: log houses and frame houses. The frame houses were cheaper and less durable. Frame houses of the 17-18th century have not survived, however, there are descriptions of the construction of frame houses, compiled in the 19th century. [5] In addition, some towns have dilapidated frame houses, but most often, the owners report that they were built in the first half of the 20th century. For example, the construction of an abandoned frame house is described in the town of Merefa, which was located on Severna street, 18 (former village of Artemivka). Neighbors reported that the house was built around 1930. Its later roof was dismantled, and the old wall frame could be inspected. The basis of the house is wooden pillars, which are located in the corners of the house and in the places where the inner walls of the house meet. The foundation of the house remained unknown because today it is covered with debris. In some places, a brick socle was visible, which most likely appeared during the later reconstruction. A loadbearing wooden beam was installed between the corner posts at the bottom and along the top of the wall. The lower one had a square section of about 20x20 cm, and the upper one was made up of the main square bar of about 12x12 cm, to which a rectangular bar of a smaller section with a height of about 6 cm was added. A bar of the worst quality was used for the upper strapping, some beams to one of the ends lost their square section and became round timber. Frame racks were inserted at the installation locations of future doors and windows into these lower and upper strapping beams. Boards were laid flat on the lower and upper strapping beams between these racks, additionally strengthening the racks in the locations of windows and doors. Planks 12 mm thick were attached with nails along the entire height of the frame racks perpendicular to the plane of the street, into which window and door frames are inserted. Thick sanded wooden branches with a diameter of about 6-8 cm were attached to this frame at an angle of 45° from the inside and outside, the longest elements are made of square bars of the same section. The branches on the side of the street are turned at an angle of 90° in relation to the branches on the inside. Inside the frame is clay mixed with straw. Clay without straw is smeared over the gaps from the outside and from the inside between the branches, and the surface is smoothly leveled. The house was whitewashed on the inside and outside with chalk, the wooden frames on the windows were painted blue. One of the inner walls was made from brick, and the remains of a chimney were visible. There was a stove next to it, which was then dismantled when the town was connected to gas supply in the 1970s. The house stood for about 80 years, having undergone at least one renovation. In 1930, most of the materials used for its construction were not purchased. Some of them were made in local workshops (bricks, beams, boards, nails), own materials were mainly used or those obtained locally (clay, straw, branches, trunks of young trees). The thermal engineering qualities of such a house were average - the thickness of the walls was about 30 cm, more than half was clay and straw, a material that is still considered one of the best local heaters today, despite the fact that its thermal conductivity (0.1 W / m°C) is on average 2 times worse than that of mineral wool (0.05 W / m°C), and almost 3 times worse than foam (0.037 W / m°C), not to mention more modern heaters.

Another type of house – a log house - is more expensive, and of higher quality. It is described in sufficient detail by S. Taranushchenko. Most often, the walls of such houses are made from oak beams of approximately 18x20 cm. Less commonly, these houses are made from coniferous wood. Buildings from other hardwoods are also mentioned in archival documents, but they were probably not durable and were eventually abandoned. Such log houses were mobile, as they could be disassembled and re-assembled in a new location. If necessary, the damaged parts of the log house could be replaced with new material. The material of these log houses could be reused in other structures or to make other things. Houses made of oak timber continue to be actively used today, despite the fact that this technology was almost completely forced out of construction at the beginning of the 20th century. The majority of these houses in Slobozhanshchina were initially lined with clay or clay and straw mix from both sides, and then whitewashed. Although houses built in the second part of the 19th century could have wooden exterior cladding and oil paint coating.

Clay-smeared walls are becoming a thing of the past today. Houses with these walls are most often owned by rather elderly people. These houses, if they have not become museums, are fated to be modified. The houses faced with clay must be constantly coated with clay and whitewashed. Such a need was even reflected in the folk tradition to whitewash the house before Easter (in spring) and the Intercession of the Theotokos (October 14). Today, this tradition has been preserved in the form of a general house cleaning with the obligatory washing of windows. The climate of Slobozhanshchina is rather humid, and the problems mostly arise with walls plastered with clay kept in the shade, which have no enough time to gain the required strength over the summer. Thus, often attempts are made to protect the open clay layer, it is sometimes done only from one or several sides. There are houses where different walls are lined with different materials and the building history of the house can be traced by such facing. The house is usually faced with bricks on the outside, but other finishing materials can also be used, for example, wooden boards, roofing felt or plastic lining. Log houses, faced with high-quality ceramic bricks, are still considered among the best houses even today. The advantage of such a house is its high thermal conductivity and its wall require no constant maintenance. Depending on humidity conditions, an oak bar 20 cm thick has a thermal conductivity coefficient from 0.19 W / m°C to 0.61 W / m°C. Then there is an air gap of about 5 cm, the thermal conductivity of which is about 0.025 W / m°C; and, finally, facing with ceramic bricks of 0.12 cm thick with a thermal conductivity of about 0.37 W / m°C. The disadvantage of such old houses is that they often have small rooms, small windows and low ceilings. Thus, the owners often put such houses on a high brick foundation, make the windows larger, and add additional rooms. With good care, such a house may stand for a least 200 years. A resident of Merefa assured us that, according to his family legend, one of the houses in the center of the town was owned by his ancestor, and assistant to the head of the Merefa settlers. The house was only reveted with ceramic bricks at the end of the 19th century and completed. In the documents drawn up in the 20th century, only the date of its reconstruction is given. If we assume that the local historian is right, the service life of such a house is more than 300 years.

A house with clay plastered walls and a thatched roof is a symbol of Ukraine in general, and Slobozhanshchina, on the territory of which the Kharkiv region is located, in particular. In the towns and villages surveyed at the beginning of the 21st century, thatched roofs were indeed rare. One could occasionally see reed roofs on small outbuildings. The only example is the house in Merefa, where a young owner considered such a roof as a way to broadcast his affiliation with the Ukrainian culture. Perhaps, it is the uniqueness of this house, which has become widely known in the town, that encourages its owner not to replace the coating with a more modern solution, although the condition of the house shows that attempts were made to arrange an additional protection against moisture and wind using plastic wraps. From a conversation with the owner of a farm in the village of Zamiskoje, Valkovsky district, Kharkiv region, we learned that a thatched roof, reinforced with liquid clay, can stand for 50 years without any repair. Unfortunately, the owner had to replace it as he was unable to carry out repairs. As a teenager, the owner himself was an assistant for his grandfather, a famous master roofer. He participated in the creation of the roof for his house and was knew much about its construction. According to him, a timber batten was attached onto rafters. Sheaves of threshed wheat began to be laid on it from the bottom edge. Sheaves were tied to the lathing. When the first tier of sheaves was laid, they had been combed with a rake and poured over with liquid clay. On this layer, they began to lay the next tier of sheaves, which were combed and poured with liquid clay again. The topmost row was made by the master himself, without his grandson, because there was no longer a place for the assistant. After the tiers were laid, the master took the scythe and began to cut off the top layer of the sheaves so that the roof turned out without ledges. Then he poured liquid clay on it again. The sheaves were also slightly trimmed from below so that they hung neatly. Thatched roof has a significant advantage in thermal conductivity over the metal or slate that replaced it. However, the owner of a house in the village of Zamiskoje noted in his interview that the roof on their house was the last one created by a master. The house was covered with thatch in 1946, when there was virtually no agricultural equipment in Ukraine left a result of World War II, and the crops were harvested in the old fashioned way - manually. At the same time, the heads were again tied into long even straw sheaves, which the roof was made from. Today, despite the fact that grain crops still are being grown in Slobozhanshchina, harvesting is carried out using by combines. In this case, the straw breaks and can no longer be used as a building roof material. Thus, in the best case scenario, the material has to be transported over a distance of several hundred kilometers in order to create a traditional thatched roof.

The situation with a wooden oak logs is similar. When the settlers came to Slobozhanshchina in the middle of the 17th century, mighty oak forests on the territory of the present Kharkiv region were wide-spread. An oak reaches its peak height (about 20-40 meters) in about 100-200 years, and then gradually gains thickness within 300-400 years.

These forests had been practically destroyed in the first 100 years of the sedentary population present on the territory of Slobozhanshchina. During the reign of Catherine II (late 18th century), a reforestation policy was carried out on the territory of Slobozhanshchina, however, at the turn of the 19th and 20th centuries, the volume of forests decreased again due to the development of industry, the growth of cities, and the laying of railways. Pine, a faster growing culture, became dominant in a small share of the local building timber materials market. Today, oak timber is not even offered on the construction market of the Kharkiv region as a common material. Coating with clay and straw continue has been used in private construction for quite a long time, however, there are no substantiated recommendations on the use of this material in combination with newer building materials that have taken their place on the building market. The modern owner does not understand which materials and designs can be used with this insulation, which combinations are ill-advised. Today, there is also no reliable source for disseminating this knowledge among the population.

The ceramic brick, which emerged on the construction market of Slobozhanshchina in the 19th century, opened a new industrial era in private construction. Today, it continues to dominate the construction materials market, sharing its position with silicate bricks, also local building materials. The creation of houses from ceramic and silicate bricks has become quite traditional knowledge. Optimal design solutions have already been worked out, the artistic expressiveness of the material had been also a part of the folk tradition. Traditionally, the thickness of the outer walls of a brick house in the Kharkiv region was 510 mm, with a thickening (decorative casing) around the windows and under the roof. The thermal conductivity coefficient of ceramic bricks is 0.37 W / m°C, and 0.4 W / m°C for silicate bricks. It is possible to combine brick walls with clay and straw plaster inside for additional insulation.

However, the policy of Ukraine, aimed at saving natural gas burned during the heating season on an annual basis, has led to the population actively insulating their traditional brick houses. In cities and villages, the owners take off decorative brick platbands down with their own hands in order to panel their houses with insulation. On the one hand, this is a movement towards the natural resources preservation, and on the other hand, towns and villages are losing their unique appearance, a whole layer of cultural information is being lost. At the same time, obsolete, short-lived, but familiar construction materials and equipment actively demand on the market. The newest materials are still being produced in single pieces in the scientific laboratories of universities.

CONCLUSION AND RESEARCH PERSPECTIVES

In conclusion, it can be noted that the process of transition to a Green economy in Ukraine has already begun. The transition from an agricultural economy to industrial has significantly affected the traditions of local construction in Slobozhanshchina, changing them. The transition to a Green economy should be considered the next phase of change. The absence of developed programs for the transition to a Green economy in the construction sector has led to many opportunities missed along the way. The lack of verified information on construction technologies makes people rely on time-proven traditional methods, instinctively selecting the solutions closest to tradition from the innovations pool. Turning back to better local environmental solutions in the construction sector is only possible by changing the approach to land use. As part of the strategic goals, the forestry policy must be revised. Crop harvesting must consider not only the nutritional value of a product, but also the possibility of using related materials in construction. The following short-term steps may be proposed to facilitate the transition to green building in the private housing sector.

1. To determine the indicators and criteria, which will make it possible to assess the degree of environmental friendliness of a building, as well as the process of its creation
2. To determine those principles of green building that may be implemented in the current conditions of the construction sector, and outline those principles, the movement towards which may be considered long-term strategic goals.
3. The new generation of architecture students must focus on green building principles.
4. As for the private construction segment, development of simple design solutions that are most environmentally friendly, based on local building materials, and accommodating local cultural traditions are required. At the same time, it is imperative to inform the consumer of the extent to which the solution complies with the Green building principles.
5. To create an effective promotion program on green building among the local population, informing them of the latest design solutions. This can take form of a locally available guide.
6. To establish monitoring of the local and global environmental impact of the construction process and building life cycle.

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Novel Approaches and Practices of Placemaking in the Architecture of Modern Shopping Centers

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Abstract. The beginning of the 21st century saw significant changes to preferred qualities of shopping centers, mostly due to the emergence of e-commerce and the accepted universality of shopping centers solutions often ignoring conditions of their surroundings. The article argues convergent goals of the latest shift in the development of shopping centers, as manifested in modern solutions of this type of buildings in the second half of the 2010s, and urban development, specifically the practices of placemaking. Furthermore, the article outlines methods and approaches relevant in this context, and highlights connection with tasks of cultural sustainability based on preferred qualities of modern shopping centers.

INTRODUCTION

The beginning of the 21st century is characterized by the shift of perspective in the design of shopping centers. This building type originated in the United States in the middle of the last century. The recent decline and closure of a number of shopping centers indicate a change in the preferences of their visitors. There were local reasons that played a role in this, such as errors in object placement, exaggerated size, etc. However, universal factors also played an important part in this development, in particular, the intensification of competition due to the saturation of the shopping centers' market, which led to the search for alternative means of obtaining competitive advantages, as well as the development of e-commerce, that especially affected utilitarian purchases. The latter has led to a greater role of a unique experience that accompanies shopping activity in urban shopping malls. As a result, new qualities of architectural and structural solutions of shopping centers come to the fore, while some old qualities become less important. Changes in the architectural and spatial solutions of shopping centers indicate the main directions of the ongoing search for qualities that would characterize new forms of this type of buildings, adequate for the challenges of their time. One of the notable trends is the increasing attention to the role of shopping centers as public buildings, the place of implementation of a particular form of urban life.

Shopping centers are large objects that have a significant impact on the city and urban life. The realization of their public role as important centers of human activity raises the issue of choosing the right qualities that can improve and humanize their environment. Therefore, it is considered useful to analyze a number of the world's newest shopping centers in order to identify new characteristics and features that gain new prominence in the design of this type of buildings.

MATERIALS AND METHODS

The article examines modern shopping centers constructed in the second half of the 2010s – among them newly built or reconstructed, notable examples of their type, most of which have received architectural awards. Data from the online mapping service "Google Maps" is used; in most cases, it describes the shopping centers in question from the standpoint of their location, physical size, appearance, internal construction and functional content in sufficient

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detail and quality. The analysis in the form it was undertaken falls under the category of fair use and complies with the rules of use of the service [1]. The study involves structural and functional analysis of available information – namely, plans, photographs, text descriptions. Verification of results is carried out via the analysis of newspaper articles, reviews by visitors, and comments by authors of shopping centers in question [2-17].

RESULTS

In the context of changing views on the design of shopping centers, 11 modern examples of this building type were analyzed, as well as the latest analytical works and practical recommendations for their design, able to provide a context for the observed changes [18-26].

Among these studies, authors consider it important to note the following. M. Beyard in the guidebook "10 ways for rethinking the mall" [18] suggests that the obsolescence of existing shopping centers lies with their outdated conceptual structure. In contrast, he points to the importance of integration with the context of a situation and the needs of the community, involving local population into decision making through participatory measures. He also argues in favor of increasing the role of mixed-use and social component of shopping centers. "Placemaking – Value and the Public Realm" [19] is devoted to the actualization of the role of "place" as a source of unique characteristics of the experience of a visit to the commercial and public spaces of shopping centers. "Restructuring the Commercial Strip: A Practical Guide for Planning the Revitalization of Deteriorating Strip Corridors" [20] highlights the shortcomings of existing shopping centers – standardization of their image and solutions, lack of connection with the needs of local communities and insufficient attention to social aspects of their existence. Among useful qualities mentioned by the study in this regard are the spontaneous order and self-regulation of transit-recreational spaces of shopping centers, the variety of their use and forms.

The study examined the following indicative examples of modern shopping centers and their features (Fig. 1).

Coal Drops Yard [2] in London, UK (architect T. Heatherwick, 2018; the object was awarded the Versailles Prize in the "World Winners - Shopping Centers" category in 2019) is an open shopping center of relatively small size, created on the basis of the reconstruction of two coal depots near King’s Cross railway station on the territory overlooking the Regent's Canal. Of note is the active mixed commercial and public use of the facility, open transit-recreational space, the integration of complex with the surrounding urban environment, as well as its impressive architecture aimed at creating an aesthetically pleasing place of urban life. The complex features a two-level public space that connects Lewis Cubitt Square and the waterfront. The two volumes flanking this transit space both have characteristic features of buildings on the basis of which they were built (the use of dark brown bricks, characteristic vaults), and expressive modern additions, such as the active shape of their roofs and the volume between the buildings where roofs meet. This approach clearly demonstrates the use of local semantic narratives and existing buildings in the design of new shopping centers and the selection of their thematic concept.

Victoria Gate [3] (architect firm ACME, architect F. Ludewig, 2016) was created in the central shopping area of Leeds, UK, surrounded by several other retail spaces, including historic ones. This complex is characterized by a common style of decoration of its store facades and the increased role of the general architectural concept of its transit-recreational space as an aesthetically articulated "place" with its own character. Structurally, it is an integrated shopping center, like the historical arcades that are typical for this area of the city. It has three separate entrances, which provide the possibility of transit traffic between three adjacent streets, integrating the interior of the quarter into the sequence of surrounding urban spaces. The formation of the own memorable visual character of the building was noted as an important part of the program of creating the complex. Particular attention is paid to the expressiveness of its facades with the use of visual references to local cultural narratives related to trade (the use of visual forms characteristic of Victorian arcades, as well as the "knitted" geometric motif, which aims to evoke association with the wool trade of Leeds). However, some reviews suggest that this link is not always perceived by visitors as a regional element of the appearance of the shopping center due to the abstractness of its implementation.

Eastland Shopping Center [4] in Melbourne (architect firms ACME, Universal Design Studios, Softroom, 2016; was awarded the Special Versailles Prize for Exterior in 2019) is one of the largest shopping centers in Australia that started its existence in 1967 as a traditional shopping center of introverted autonomous structure serving Ringwood, a suburb of Melbourne. But in 1995-2002 it was completely rebuilt in anticipation of a greater role of entertainment functions, which is consistent with the emergence and popularity of so-called “destination malls” in the period, large shopping centers with emphasis on entertainment in their functions. The next stage of transformation was the expansion in 2015-2016, during which the shopping and entertainment complex was complemented by several public functions and a public square, forming a full-fledged community center in the suburb of Ringwood following the wishes of the local community. Additional features include a public library, art gallery, hotel and an expanded range of entertainment and restaurants. The resulting complex is characterized by a mixed system of open and enclosed spaces of commercial and public use.

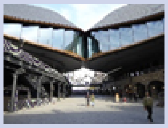
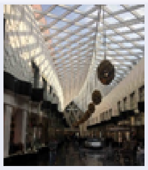
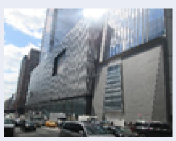
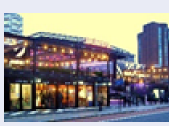
Shopping center		Author Country	Year	Novel approaches – specifics
	Coal Drops Yard	T. Heatherwick UK	2018	Use of local narratives (inclusion of existing structures) Open-air transit-recreational spaces
	Victoria Gate	F. Ludewig, ACME UK	2016	Use of local narratives (structural and visual references) Increased role of an aesthetic articulation of the place
	Eastland Shopping Center	ACME, Universal Design Studios, Softroom Commonwealth of Australia	1967; 1995; 2016	Mixed use with significant role of cultural establishments. Mixed structure with both open-air and enclosed spaces. Adding public functions per requests from local community.
	The Shops and Restaurants at Hudson Yards	Kohn Pedersen Fox, Elkus Manfredi Architects USA	2019	Reinforced visual and transit links with urban environment
	City Center Bishop Ranch	R. Piano, BAR Architects USA	2018	Open-air transit-recreational spaces of malls. Importance of facades both facing outwards and inwards.
	K11 Musea	Kohn Pedersen Fox, Ronald Lu & Partners People Republic of China	2019	Mixed use with significant role of cultural establishments. Reinforced visual and transit links with urban environment Increased role of aesthetic articulation of the place Use of green facades
	Suzhou Center Mall	Benoy People Republic of China	2017	Active use of buffer, transitional spaces Use of green facades
	Boxpark Croydon	R. Wade UK	2016	Use of containers highlights temporality, flexibility and modularity of solutions.

FIGURE 1. Novel qualities of shopping centers, manifested in the second half of the 2010s (images used: [27-34]; images were cropped to size)

The Shops and Restaurants at Hudson Yards [5] in New York, USA (architect firms Kohn Pedersen Fox and Elkus Manfredi Architects, 2019). Located in the city structure, it is part of a large-scale reconstruction of the surrounding neighborhood and is designed to be integrated into the urban environment. It provides communication with the surrounding public spaces created during the renovation process, such as the “Vessel” observation deck, which is visible from the atrium of the commercial building; its expressive architecture and proximity of location are often mentioned in reviews among the attractive qualities of the mall. On the upper levels, the shopping center also has a direct link to the High Line, an elevated city park on the site of a former railway viaduct passing through Manhattan. The complex is designed for both tourists and visitors from nearby office centers, as well as other New Yorkers. However, reviews indicate that visitors themselves perceive it as focused mainly on tourists by the choice of price category of its shops and services.

City Center Bishop Ranch [6] in the city of San Ramon, USA (architect R. Piano, architect firm BAR Architects, 2018) is a shopping center with open transit-recreational spaces. The famous architect tries to distance his work from its interpretation as a "mall", "something artificial", focusing instead on public functions and the connection of forms of the complex with the surrounding landscape in its positioning. The lack of significant existing buildings around, together with the nature of the proposed community center, presupposes the use of an introverted structure, but it still has a greater interaction with the surrounding environment than in traditional suburban shopping centers. The open courtyard is the main center of social activity of the complex. The transparent ground floor of the surrounding volumes opens onto this yard and the open "streets" leading to it from all sides, as well as to the outside area, including the adjacent spaces to the pedestrian traffic system of this shopping center.

K11 Musea [7] in Hong Kong, PRC (architect firms Kohn Pedersen Fox, Ronald Lu & Partners, James Corner Field Operations, LAAB Architects, 2019) is a ten-story shopping complex, positioned by the developer as a cultural and commercial center. In addition to its traditional commercial function and catering facilities, it also includes an art gallery, botanical exhibitions and a children's entertainment and educational center. The nodal solution with a distinctly decorated large atrium is typical of introverted complexes, but it has active connections with the surrounding streets, both transit and visual. Characteristic is the active use of green terraces and green facades in the architecture of the building, which complements and improves the surrounding urban environment. This, together with the articulated division of the floors, which form irregular horizontal ledges on the facade, allows architects to visually compensate for the usual oversized scale of the architecture of a large shopping center in an urban situation. The complex is characterized by increased attention to the means of aesthetic articulation of its environment, the application of measures in accordance with the concept of sustainable development (such as green facades, rainwater collection, energy-efficient ventilation, etc.), as well as the planned close integration of physical experience with an augmented reality providing new social and artistic forms of activity within the shopping center.

Suzhou Center Mall [8] in Suzhou, PRC (architect firm Benoy, 2017; awarded the MAPIC Award in the nomination of "Best New Shopping Center" in 2018) is one of the largest shopping centers built in recent years, illustrating the trend towards continued active development of large introverted shopping centers in East Asia while the pace of their construction is decreasing in the USA, Canada and Western Europe. The complex itself is characterized by its large size and introverted structure, as common for its type as an autonomous node for attracting visitors. However, it is also characterized by active buffer spaces of the entrance area and its green terraces, which to some extent blur the rigid boundaries that separate its self-sufficient internal structure from the environment. This softens the contrast between its size and the surrounding buildings and, in particular, the human scale of the adjacent public spaces.

Boxpark Shoreditch (2011) [9], Boxpark Croydon (2016) [10], Boxpark Wembley (2018) [11] represent the series of shopping centers from freight containers built in the UK. The first was planned as a temporary structure and was supposed to exist for 5 years, but it still works today. The second is also planned as a temporary structure until replaced by capital buildings. Despite their temporality, they have all the features of shopping centers structurally, forming around clearly defined transit and recreational spaces that combine the commercial function with catering establishments and other functions into a single complex. Another example of the necessitated use of such solutions is Re: START [12] in Christchurch, New Zealand, built to temporarily replace the shopping district damaged by an earthquake. This shopping center lasted from 2011 to 2018. In 2014 at the request of visitors and stakeholders, it was relocated instead of being closed. Container solutions illustrate how commercial and public buildings can be temporary, variable and flexible due to the modularity of solutions, which they emphasize, as well as easy to construct and accessible while maintaining their basic structural logic.

DISCUSSION

The analysis of examples, supplemented by a summary of information from analytical materials and design recommendations, shows that the latest approaches to the design of shopping centers focus on the following qualities:

- The active role of the program (semantic concept, narrative idea) of the center.
- The use of existing local resources, from material to semantic content.
- Mixed-use, which intensify activities and provide more complex meaning to the associated space.
- Creation of a system of open and enclosed spaces, integrated with the environment, as well as the use of buffer spaces.
- The use of so-called “triangulation” (selection of mutually stimulating activities, elements of architectural organization and design of space that can enhance and link different activities together).
- The use of methods of participation both in determining the type and nature of the future complex and during its further existence.
- Dynamism and flexibility of the structure, which enables adjustment of the content and logic of the center to the current needs and wishes of the local population.

Analysis of research papers and recommendations for the design of shopping centers points to rising attention to the practices of placemaking – a concept common in Western urban planning. It describes the categories of qualities and methods for the analysis and design of "place" as a full-fledged part of an urban environment via the means of direct participation and establishing feedback from urban population. Its general principles are covered by the "Project for Public Places" website [21]. Among the qualities used for the description of "place" in placemaking are its accessibility and convenience of connections with the environment, suitability for social activity, stimulation of mixed activities, creation of a visually expressive image of the place on the basis of its existing characteristic features. Recent research, in particular, the analytical work "Placemaking - Value and the Public Realm" [19], performed by CBRE together with "Jan Gehl Architects", indicates ways to apply the concept of "placemaking" to the practices of modern shopping centers design. "Protection" is the first of the proposed main categories for measuring the successful solution of public space. It describes the qualities characteristic of shopping centers since their earliest examples. The category of "Comfort" is formed by several qualities, including connectivity, visual openness, stimulation of activities, suitability for pedestrians, suitability for social interactions and suitability for active leisure. The category of "Enjoyment" consists of qualities described as "human scale", "identity" (history, sense of place, local identity) and "senses" (good design and detailing, quality materials, use of plants and water).

The set of new qualities manifested in modern shopping centers highlights the emphasis on the properties of their solutions that are similar to the qualities which placemaking practices aim to achieve in an urban environment (Fig. 2). This result indicates the similarity of the goals and tools of said practices and the design of shopping centers in the context of modern challenges to the development of this type of buildings. This development indicates a potential benefit in transferring a number of techniques for shaping and assessing the urban environment (specifically, the practices of placemaking) to develop solutions for shopping centers seen as public spaces that have their own specifics, while at the same time can still be integrated into urban life. Specific examples of the manifestation of studied qualities in shopping centers allow authors to identify specific features of the implementation of such practices in the construction of this type of buildings. In particular, it is important to highlight the new attention to flexibility and permeability of their structure, actualization of the role of accessibility in contrast to autonomy, as well as attempts to justify aesthetic and conceptual solutions in the architectural context of their surroundings.

Potentially useful in this light are practices of environmental behavior psychology and the use of a system of landmarks for the mental map of a shopping center that is akin to urban. For example, the method proposed by K. Lynch [22] for the analysis of the perception of cities was used for the analysis of shopping centers as early as 1985 by B. Maitland [23], while among the recent authors Z. Tan can be named [24]. The connection between the architecture and structure of the shopping center and the branding of the place, for which they can serve as important assets, receives a new interpretation (aspects of this issue were touched upon in the works of L. Källstrom [25] and C. Teller [26]).

Placemaking practices postulate that each project solution is unique, location-specific. Therefore, the issues of choice of the semantic concept of the shopping center and the use of existing cultural resources of the region gain new attention. Such resources may include existing buildings, the function of which can be changed without significant harm to them in the course of revitalization programs, architectural references, city-specific styles and approaches, information about monuments and historic sites, and more.

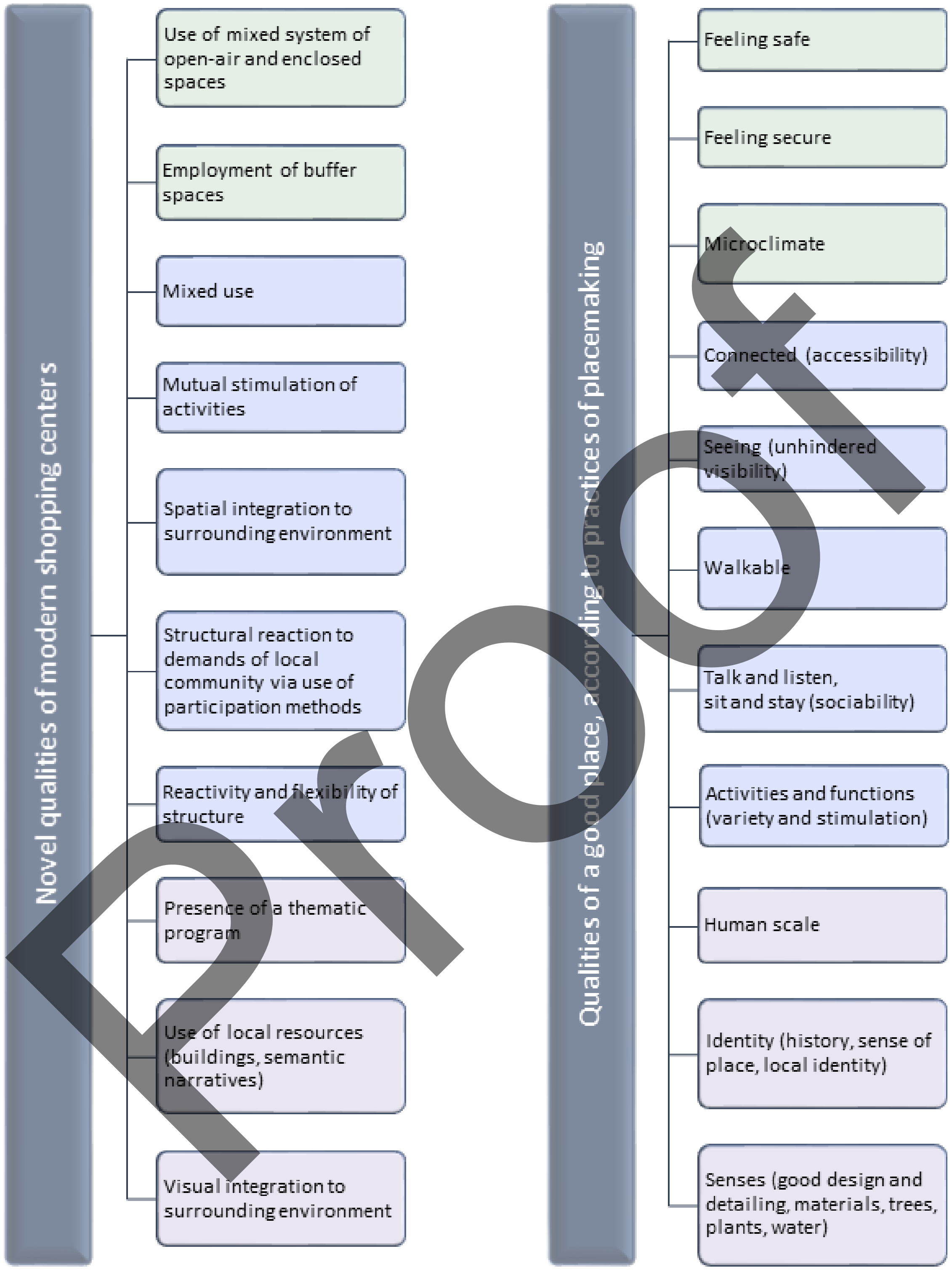


FIGURE 2. Comparison of novel approaches manifested in shopping centers of the second half of the 2010s with preferred qualities of the "place" (as stated by [19])

The principles of sustainable development require attention to local cultural resources and opportunities, such as the usual codes of perception, the characteristic atmosphere, the region's specific types and forms of activity, as well as the presence of existing structures and site-related semantic concepts that can be used to build a shopping center or define its idea, its program. This makes the choice of the semantic concept of a shopping center on the basis of local narrative and semantic resources especially relevant. Examples of such use of local cultural resources include Faneuil Hall Marketplace in Boston, Ghirardelli Square in Los Angeles and Coal Drops Yard in London, which used old buildings and local semantic narratives in their programs.

CONCLUSION

The beginning of the 21st century saw changes in views on the design of shopping centers. The main reasons for this were: the intensification of competition due to saturation of the shopping centers' market and the corresponding search for alternative means of obtaining competitive advantages; development of e-commerce, which covers an increasing part of utilitarian purchases; an increase of the role of a unique experience that accompanies commercial activity of the «brick and mortar» stores and shopping complexes. All this led to the change in priorities in the architectural and structural solutions of shopping centers.

The analysis of new approaches to their design reveals an emphasis on the following aspects: the active role of the program (semantic concept) of the center; use of existing local resources (from material to semantic content); "mixed-use" – multifunctionality with greater involvement of public and recreational functions, which intensify activities and provide more complex content to the associated space); application of methods of participation both for the definition of type and specifics of the future shopping center, and during its further functioning; dynamism and flexibility of the structure, which enables adjustment of the content and logic of the center to the current needs and wishes of the local community.

The analysis of new qualities manifested in modern examples of shopping centers shows them to be similar to the qualities that placemaking practices aim to achieve in an urban environment. This confirms the similarity of goals and tools of these practices and the design of shopping centers in the context of modern challenges to the development of this type of buildings. This development indicates a potential benefit in transferring a number of techniques for shaping and assessing the urban environment (specifically, the practices of placemaking) to develop solutions for urban shopping centers as public spaces. Among such methods are practices of studying the behavior of visitors via methods of environmental behavior psychology and the creation of a system of landmarks for the mental map of a shopping center that is akin to an urban environment. Specific examples of the manifestation of studied qualities in shopping centers allow authors to identify specific features of the implementation of placemaking practices in the construction of shopping centers – in particular, new attention to flexibility and permeability of their structure, actualization of the role of accessibility in contrast to autonomy, as well as justification of aesthetic and conceptual solutions in the architectural context of their surroundings.

The choice of the semantic concept of a shopping center with the related possibilities of creating centers integrated into the local context are beginning to occupy a prominent place in design. The principles of sustainable development require attention to local cultural resources and opportunities, such as codes of perception, the characteristic atmosphere, the regional specific types and forms of activity, as well as the presence of existing structures and site-related semantic narratives that can be used to build a shopping center or define its concept. Potential advantages of using local cultural and semantic features in the design of shopping center in this context are the appeal to the atmosphere and specifics of the place (via practices of placemaking), emphasizing the local-specific "experiential" retail, as well as the use of the socio-cultural potential of the region as required by the concept of sustainable development.

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Research of Community Noise Level in the Yards of the Designed Housing Development in "Lazurny" Neighbourhood of Poltava

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Abstract. Regulation of community noise level in residential areas, subject to noise pollution, to ensure comfortable conditions and acoustic safety of life, plays an important role in housing development planning. The article analyses sound pressure levels in the house complex of the designed housing development of "Lazurny" neighbourhood in Poltava and identifies the places, where the allowable noise level on the territory is exceeded. The authors have also analysed the possible measures to improve community noise level on the territory of the house complex and offered noise attenuations and noise protection devices.

INTRODUCTION

Acoustic air pollution affects a person's psychiatric and physiological health, disturbs normal rest, which, in turn, affects productivity. The level of noise pollution in the cities tends to increase from 0.5 to 1.0 dBA per year. When designing residential buildings, the protection of territories from noise is regulated by the following documents: DBN V.1.1-31:2013 "Protection of territories, buildings and structures from noise" [1], DSTU-N B V.1.1-33:2013 "Guidelines for the calculation and design of noise protection of rural areas" [2], DSTU-N B V.1.1-35:2013 "Guidelines for the calculation of noise indoors and on the territories" [3], DBN B.2.2-12: 2019 "Planning and building development" [4]. Noise protection of urban areas was studied in [5-6], for noise protection it is possible to use noise-protective greenspace expansion, noise screens, the characteristics and efficiency of noise protection devices were considered in the following research works [7-9]. The purpose of the work is to study the sound-pressure level on the territory of the designed housing development in "Lazurny" neighbourhood of Poltava.

ANALYSIS OF COMMUNITY NOISE LEVEL OF THE DESIGNED HOUSE COMPLEX IN "LAZURNY" NEIGHBOURHOOD

For long-term housing development of Poltava, the general concept for real estate development of "Lazurny" neighbourhood was built up and approved in 2010 [10], and a detailed territorial plan [11] was developed, approved by Poltava City Council. The considered area of "Lazurny" residential district (Fig. 1) provides for 14 house complexes and 11 detached residential buildings. Figure 1 also shows the location of the house complex, which was chosen for the analysis of community noise level of its yard space. This group was taken by the authors as the object of research because it has planning concept and the most unfavourable community noise level of the yard space.

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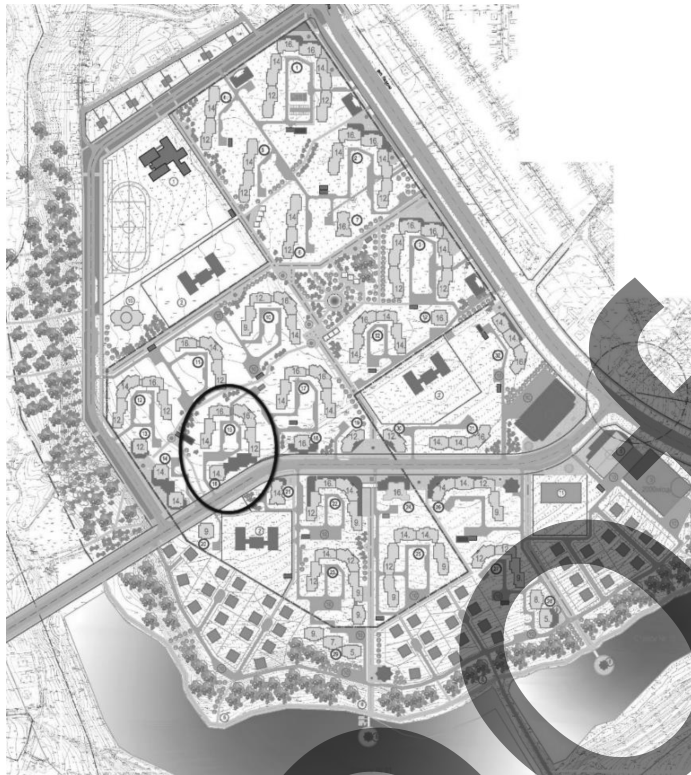
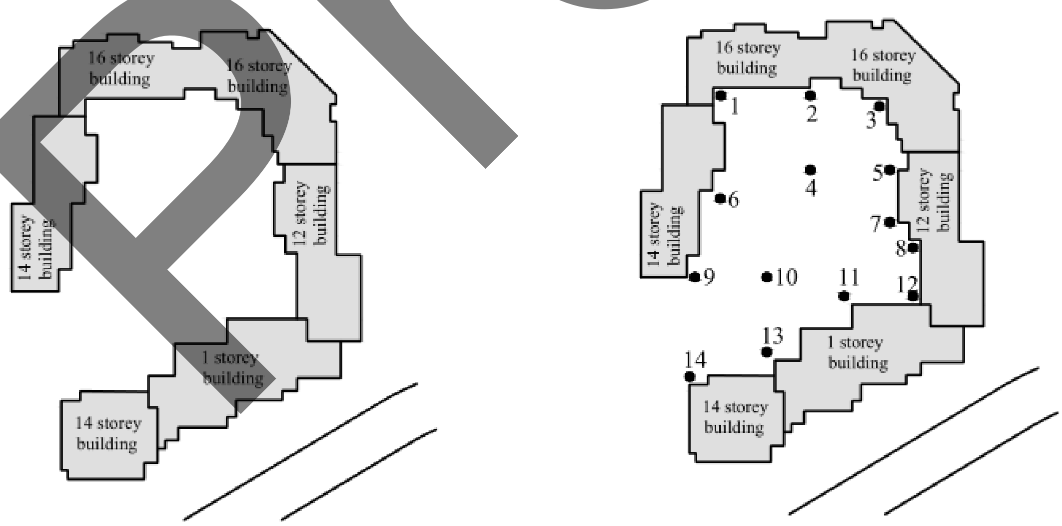


FIGURE 1. Detailed territorial plan of “Lazurny” neighbourhood with the encircled house complex, chosen for the analysis of community noise level of its yard space [11].

The planning concept of the house complex and the number of storeys of its separate parts, which was chosen for the analysis of community noise level, and the location of points on the territory of the house complex, where the noise level was measured, are shown in Fig. 2.



(a) (b)

FIGURE 2. The planning concept of the house complex selected for the analysis of community noise level (a) and the location of the points, where the noise level was measured (b).

The location of setting out points is taken in the most characteristic places of the house complex. Setting out points, located near the enclosing structures of the house, are taken at the distance of 2 m from them, according to DSTU-N B V.1.1-33: 2013.

Determination of the noise level at the setting out points was performed by the procedure, described in DSTU-N B V.1.1-33: 2013 “Guidelines for the calculation and design of noise protection of rural areas” [2].

The acoustic level at the setting out points on the territory of the house complex $L_{\mathrm{A}\,ter\,i}$, dBA, was determined from the formula:

$$L_{\mathrm{A}\,ter\,i} = L_{\mathrm{A}} - \Delta L_{\mathrm{A}\,dist} - \Delta L_{\mathrm{A}\,air} - \Delta L_{\mathrm{A}\,yard} - \Delta L_{\mathrm{A}\,scr} - \Delta L_{\mathrm{A}\,veg} - \Delta L_{\mathrm{A}\,lim} + \Delta L_{\mathrm{A}\,refl} \tag{1}$$

where L_{A} is the noise characteristic of the noise source in dBA, which was determined in accordance with Section 6 [2]; $\Delta L_{\mathrm{A\,dist}}$ is the recession of the acoustic level, dBA, depending on the distance between the noise source and the setting out point, was determined according to paragraph 7.7 [2]; $\Delta L_{\mathrm{A\,air}}$ is allowance in dBA, which takes into account the recession of the acoustic level due to sound damping in the air; is determined in accordance with paragraph 7.8 [2]; $\Delta L_{\mathrm{A\,yard}}$ is allowance in dBA, which takes into account the impact of the type of yard paving on the acoustic level at the setting out point; is determined in accordance with paragraph 7.9 [2]; $\Delta L_{\mathrm{A\,scr}}$ is allowance in dBA, which takes into account the recession of the acoustic level with the help of noise screens on the way of noise propagation, is determined in accordance with section 9 [2]; $\Delta L_{\mathrm{A\,veg}}$ is allowance in dBA, which takes into account the recession of the acoustic level by vegetation zones; is determined in accordance with section 10 [2]; $\Delta L_{\mathrm{A\,lim}}$ is allowance in dBA, which takes into account the recession of the acoustic level due to the limitation of viewing angle of the noise source at the setting out point; is determined in accordance with paragraph 7.10 [2]; $\Delta L_{\mathrm{A\,refl}}$ is allowance in dBA, which takes into account the rise of the sound level at the setting out point due to the imposition of sound, reflected from the enclosing structures of buildings; is determined in accordance with paragraph 7.11 [2].

The path of noise propagation from the road to the majority of setting out points was taken in three directions. Let us consider these directions for point 2 (Fig. 3). The first direction from the point is perpendicular to the road (Fig. 3, a), the second one is tangent to the higher part of the house (Fig. 3, b), the third one is in the direction, where there are no houses (Fig. 3, c).

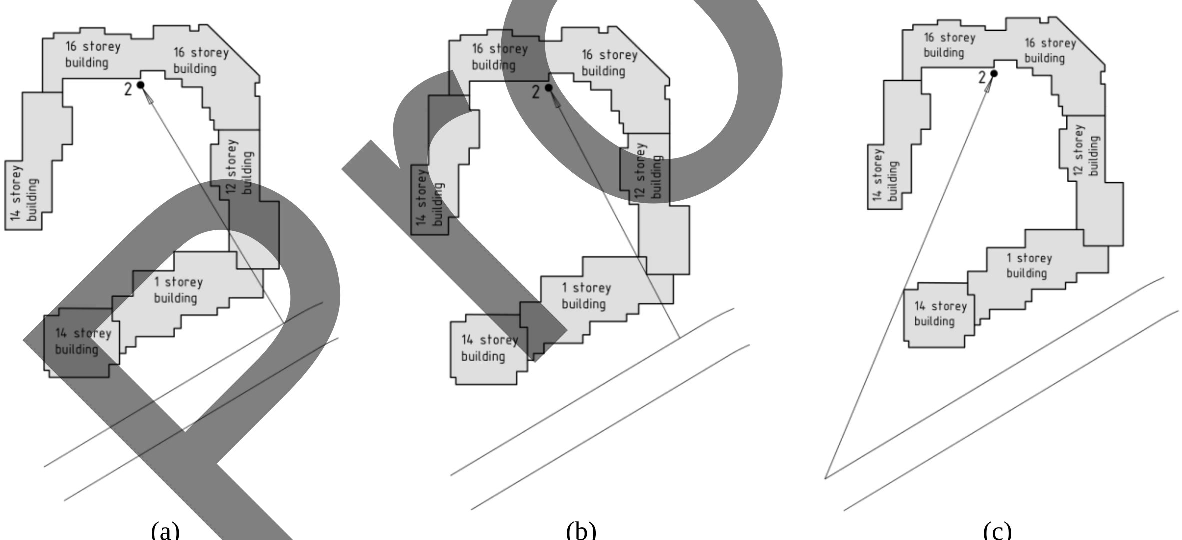


FIGURE 3. The path of noise propagation to point №2: perpendicular to the road (a), tangent to the higher part of the house (b), in the direction, where there are no houses (c).

The noise level was determined in all three directions. The highest level was taken for further analysis of the noise level in the house complex. Using the obtained noise levels at the setting out points, we constructed noise level isolines in the yard, which are presented in Fig. 4, a. According to the table 1 [1], the allowable noise level in the territory, immediately adjacent to the residential buildings during the daytime is $L_{\mathrm{A\,all}}$ = 55 dBA. Fig. 4, b shows the territory of the residential buildings, where these regulations are not met.

The measurement results of the noise level at the setting out points in the yard space of the residential building are given in table 1.

(a) (b)

FIGURE 4. Noise level isolines in the territory of the yard (a) and the yard space of the residential building, where these regulations are not met (b)

TABLE 1. Acoustic levels at the setting out points in the territory of the house complex.

Number of the setting out point	Acoustic level, dBA
1	53,9
2	53,8
3	55,0
4	52,6
5	55,0
6	**59,0**
7	51,6
8	53,8
9	**61,2**
10	**57,7**
11	43,0
12	45,0
13	44,0
14	**64,3**

Exceedances of the allowable noise level were registered at the setting out points №6, №9, №10, №14.

Based on the results of the analysis of community noise at the setting out points in the house complex, the following conclusions were made: the planning concept of the house complex does not ensure compliance with regulatory requirements for the level of noise in a large part of the yard space; in order to bring the noise level to the regulatory requirements, it is necessary to take additional measures for noise protection of the territory.

IMPROVING PROPOSALS FOR THE COMMUNITY NOISE LEVEL IN “LAZURNYY” NEIGHBOURHOOD HOUSE COMPLEX

We have analysed possible measures to improve the community noise level on the territory of the house complex of “Lazurny” designed neighbourhood. The first stage was the use of noise protection landscaping to improve the community noise level on the territory of the house complex in accordance with paragraph 10 of DSTU-N B V.1.1-33:2013 [2].

Fig. 5 shows the points, where the requirements to the noise level are not met, and the moving direction of noise from the road to these points, at which the noise level at these points is the highest.

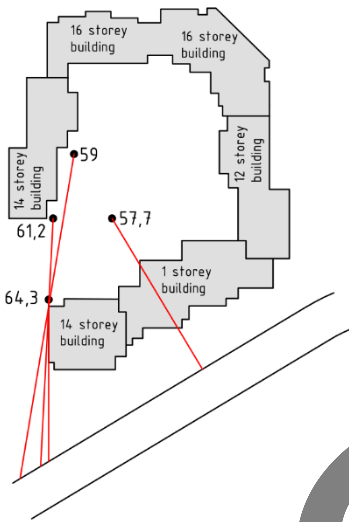
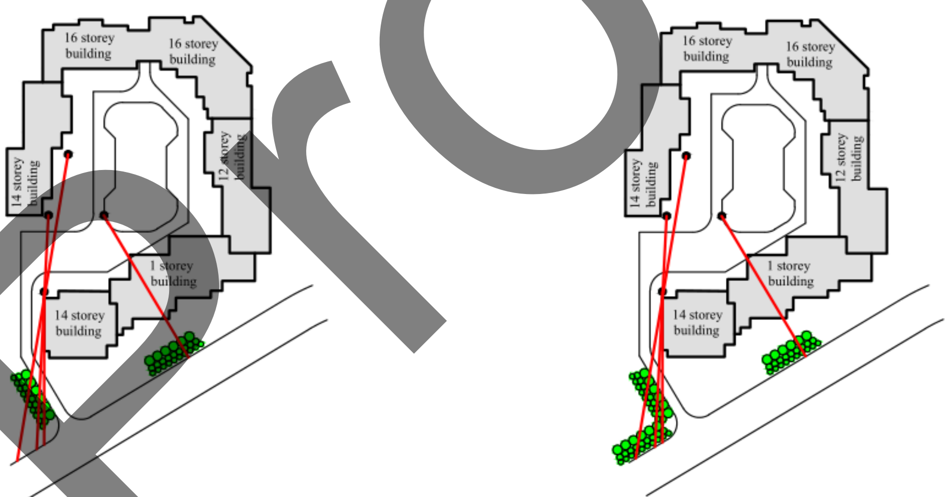


FIGURE 5. Location of the points, where the requirements to the noise level are not met, and the moving direction of noise from the road to these points, at which the noise level at these points is the highest.

Noise protection landscaping was adopted according to the scheme 2 fig. 7 DSTU-N B V.1.1-33:2013 [2]. Two variants of noise protection landscaping were considered (Fig. 6).



(a) (b)

FIGURE 6. Location of noise protection landscaping: option 1 (a) and option 2 (b).

Table 2 shows the sound pressure level at the setting out points №6, №9, №10, №14 after the application of noise protection landscaping.

As can be seen from the table, the use of noise protection landscaping did not have the desired effect on the recession of acoustic level at the setting out points.

The next step in improving the community noise level in the house complex was the use of noise screens in accordance with paragraph 9 of DSTU-N B V.1.1-33: 2013 [2]. The allocation scheme of noise screens is shown in Fig. 7.

TABLE 2. Acoustic levels at the setting out points on the territory of the house complex after the application of noise protection landscaping.

Number of the setting out point	Existing acoustic level, dBA	Acoustic level with allowances made for the use of noise protection landscaping, dBA	
		Option 1	Option 2
6	59,0	57,5	56,0
9	61,2	59,7	58,2
10	57,7	56,2	56,2
14	64,3	62,8	61,3

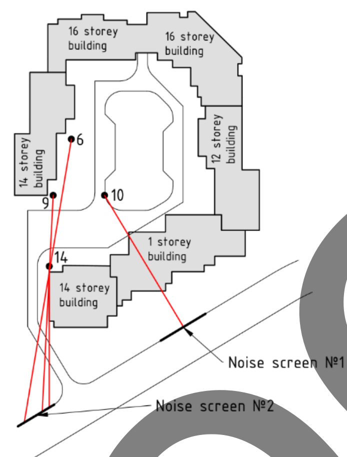


FIGURE 7. The allocation scheme of noise screens.

The use of a noise screen №1 with the height of 2 m allowed to reduce the noise level at the setting out point 1 to $L_{A\,ter} = 50{,}7\ dBA$, which is below the normalized level.

If we consider the community noise level at the points № 6, № 9 and №14, then the highest noise level is at the point №14. If at this point the norms of the community noise level are met, then they will also be met at all the other points. Studies have shown that the use of a noise screen №2 with the height of 3 m allowed to reduce the noise level at the setting out point №14 to $L_{A\,ter} = 54{,}1\ dBA$. That is, the noise protection norms at the points № 6, № 9 and №14 are also met.

The final allocation scheme of noise screens is shown in Fig. 8.

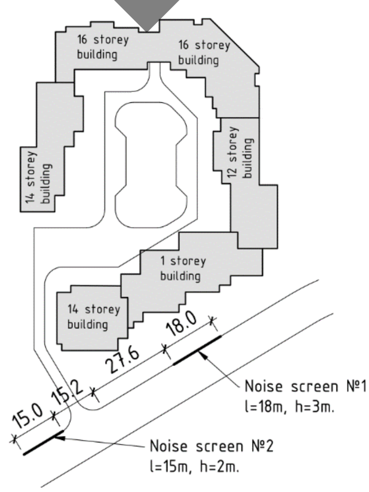


FIGURE 8. The final allocation scheme of noise screens.

CONCLUSION

The study of the community noise level of the house complex in “Lazurny” neighbourhood project in Poltava showed that the existing planning concept of the house complex does not ensure compliance with regulatory requirements for the noise level in the yard space. The considered additional measures for noise protection of the territory showed that the use of noise protection landscaping in this house complex will not provide the sufficient level of noise protection. Requirements of DSTU-N B V.1.1-33: 2013 for the considered house complex are fulfilled in the case of application of the screen №1, which is 2 m high, and the screen №2, which is 3 m high. Regulation of the community noise level in the residential areas, which are subject to noise pollution, is necessary for providing comfortable conditions and acoustic safety of human life and activities and plays an important role in the design of housing developments.

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Revitalization of Urban Public Spaces

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Abstract. The article considers the problems of urban public spaces revitalization. The functional direction of a certain urban area may change over time. Thus, when revitalizing the environment, a necessity of keeping the social and cultural processes to fit the times may arise. Revitalization may concern separate facilities or open urban spaces, as well as cover both types of locations. Examples and a brief overview of implemented projects for the renovation and modernization of urban public spaces are given. The process of revitalizing public areas includes the development of key planning solutions complying with the characteristics and characteristic parameters of a particular location. The revitalization process is considered as a promising program aimed at transforming, restoring and revitalizing sections of urban public spaces.

INTRODUCTION

Today, many territories in the cities are subject to modernization and radical restructuring. The process of renovation of public spaces and buildings is preceded by a thorough study of the urban planning situation and the general social and cultural activities in a given city. It is important that the revitalization of a certain location is carried out in close and active cooperation between local governments, local communities and architects.

At the present stage, the post-industrial society requires new creative approaches to organizing the urban environment, motivating architects to create spaces that will become active spaces for activities and recreation of the local population. The more diversity and places of creative expression offered to a citizen in a public space, the higher the coefficient of social and cultural activity in it.

With each passing year, the revitalization process is becoming increasingly relevant in cities around the world. As practice has shown, this process concerns not only the restoration of industrial territories, but also the territory of public and residential buildings. There are many examples of industrial facilities converted into public and residential buildings, however, they are not the only problem areas in the urban space. The formation of friendly public spaces and their identity is still relevant, especially for large cities with restrained urban conditions.

IDENTIFICATION OF THE PROBLEM

The uniformity of the urban environment, indifference and closedness of the surrounding buildings, streets, squares and green areas in the state of unrepair - all these are problems plaguing many cities and, unfortunately, the cities of Ukraine are no exception. The question of what can we do in a city to preserve its identity and create space for people living in it arises. What space will citizens feel comfortable in? The answer is simple – people feel comfortable in a place where there is "a human dimension" [1] and respect. Rethinking the organization of public areas of a city should become a priority for the local communities, i.e., all parties must take interest in creating a comfortable space for everyday needs, recreation, creativity, work. There are many spaces that we see every day when passing by, and some are even usually passed over, there are those that cause negative emotions in general. The presence of destroyed or dilapidated facilities within the historical areas of cities also cause dissonance in the overall structure of buildings.

Urban spaces pertaining to certain public buildings can also include creative and friendly spaces where people are able to feel comfortable: the territory of educational institutions, the inner quarters of the historical part of a city, the territory close to shopping, cultural and business centers, etc. As it become clear, revitalization applies not only to

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industrial areas, but also to our usual public spaces, also in need of renovation and revitalization, of a rethinking of approaches to design and an increase in the level of comfort.

Public spaces change over time, as they become obsolete or lose their functional purpose. This happens if the city sets its priorities wrong. There is also the problem of the territory limitation and its compaction, especially in the central parts, where a large number of the population is concentrated during daylight hours.

“The main goals of revitalization should be: leading the territory from a crisis state, tracking the results of the program implementation and ensuring a long-term development strategy. The effectiveness of the revitalization process depends on many factors such as: economic situation, spatial and cultural aspects of the territory, preservation of the location’s identity, etc.” [2]

Urban public spaces can be of a closed and open type nature. Closed spaces include isolated spaces and those part of a separate building. Open spaces include urban landscapes. Depending on the scale of the space requiring renovation, various approaches may be formed to the architectural and planning solutions and the selection of the most effective functional direction for the development of a specific territory or a separate facility. The specific character of the functional direction chosen for a certain urban area may change over time, therefore, in the process of environment revitalization, one should update the social and cultural processes in accordance with the requirements of the present.

“The urban environment is perceived by an observer as an area filling in the space between buildings and structures. Some types of these territories are perceived as independent spatial units (squares, parks, public gardens, etc.), others - as an integral part of an urban space (roads and sidewalks)” [3]. Revitalization can be of a local nature, i.e., be applied to a separate object, include open urban spaces: squares, public gardens, streets, parks, courtyards - in other words, all spaces outside buildings and structures, or a combination of both types of locations.

While exploring examples of renovating urban public spaces, several interesting projects should be highlighted:

1) Superkilen is a public park in the Nørrebro district of Copenhagen (Fig. 1). More than 60 nationalities live in this area. This feature of this area is reflected in the concept of the project. The park is divided into three sectors where you can find symbols of different countries of the world: the black sector features game tables, seating arrangements and the opportunity to have a barbecue with family and friends; the red sector focuses on sports, cultural events and trade; green is an open green space with various sports fields and artificial hills [4, 5].

FIGURE 1. Superkilen Park in Copenhagen, Denmark [11]

2) The Bicycle Snake (Fig. 2) is a public area taking the interests of pedestrians and cyclists into account: the first group can move along the embankment confidently and avoid dangerous situations, and the second group is able to overcome the usual distance quickly and enjoy the breathtaking view of the embankment [6].

FIGURE 2. The Bicycle Snake, Copenhagen, Denmark [12-14]

3) Hauser Plads is a public space within a historic square (Fig. 3). This is an example of an organization of a modern space for children and adults in the central part of the city, with playgrounds, recreation areas and green spaces. The lower tier of this location houses office premises, a canteen, parking spaces and auxiliary premises [7].

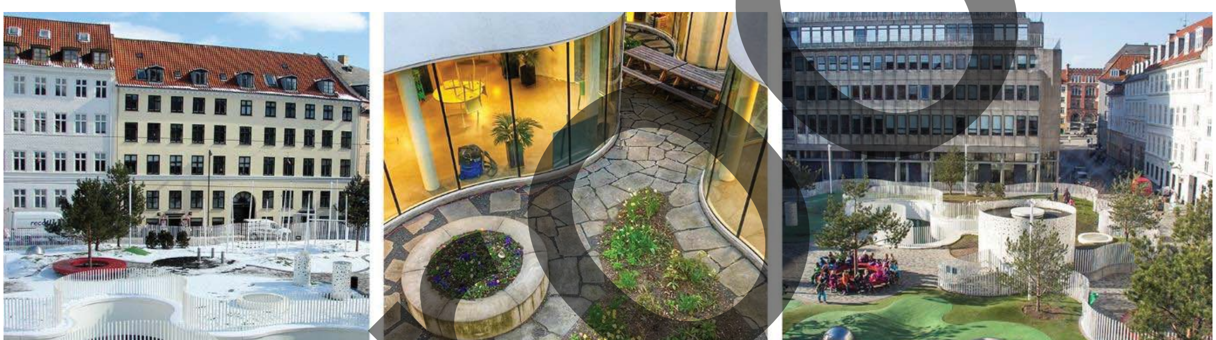


FIGURE 3. Hauser Plads, Copenhagen, Denmark [15,16]

4) Karen Blixens Plads Public Square a public space located between the University of Copenhagen and the Danish Royal Library buildings (Fig. 4,5). The space was inhospitable and unused by the local community, the bike parking space were the only structures that added a functional dynamic. Following the reconstruction, the square was given a multifunctional space and an expressive architectural solution. New parking spaces can accommodate 2,000 bicycles, and the entire square has become an active place for meetings, learning and relaxation [8, 9].

FIGURE 4. Karen Blixens Plads Public Square, Copenhagen, Denmark (Photo: Ielyzaveta Kormilets)

FIGURE 5. Karen Blixens Plads Public Square, Bicycle parking, Copenhagen, Denmark (Photo: Ielyzaveta Kormilets)

5) Tainan Spring is an example of the revitalization of a former shopping center into a public space (Fig. 6). The underground parking level has been converted into an urban swimming pool with green areas, playgrounds, and places for holding cultural events. The pool itself is designed in such a way that it collects water during the rainy season, and it can be used for fog sprayers in hot weather [10].

FIGURE 6. Tainan Spring, Tainan, Taiwan (Photo: Daria Scagliola) [17-20]

These examples clearly demonstrate the wide range of opportunities for improving public spaces in both the central and peripheral parts of a city. I.e., revitalization is, first of all, an integrated approach to solving problems that can improve the quality of life in a specific area of a settlement and revive the viability of a section of the urban environment. Urban areas subject to the revitalization program must undergo a detailed analysis, which will serve as the basis for a project to be developed.

RESULT

The revitalization of public spaces in an urban environment includes the development of fundamental planning solutions in line with the characteristics of a particular area.

Important parameters to consider in the process of revitalizing an urban space:

- development of a clear program structure (goal, analysis of the current situation, forecasts, architectural projects, etc.);
- involvement of various specialists and representatives of the public, taking into account the needs of residents;
- preservation of cultural and historical heritage and regional identity;
- prioritize pedestrian areas, traffic safety and a sense of security;
- multifunctionality of the design facility, a combination of social and cultural and commercial orientation;
- diversity of types of spaces, detail and scale of individual elements;
- ensuring equal access for all residents of the city to the public space
- safe use of space for children and adults;
- the need to provide places for holding cultural events (exhibitions, fairs, festivals, etc.);
- green areas as an element of landscape design and a method of ecological improvement. The use of green areas also increases the cost and quality of adjacent buildings;
- conceptuality of public space, introduction of the newest approaches and technologies in architectural and design activity (Fig. 7).

Criteria	Actions		
Friendly spaces	Increasing of safeness sense	Ecological approaches	Adding of play and sports areas
	Making a pedestrian priority	Adding of landscaping	Making of multifunctionality
Social activity and culture	Adding of recreational areas	Adding of public events places	Taking into account local culture and traditions
	Organizing an art space		
Visual, physical and psychological comfort	Creation of conceptual spaces	Small architectural forms placement	Formation of a quality design
	Landscapes creation	Ensuring a stay independent of weather conditions	Compliance with ergonomics

FIGURE 7. Criteria of organizing of a quality public space

The main indicators attracting residents to the public space must be determined based on the characteristics of the site under revitalization. These indicators include:

- convenient transport and pedestrian accessibility;
- location significance (uniqueness);
- visual effects and associations;
- meaningfulness of the environment;
- active and passive functions;
- functional variety.

Three main planning principles were identified during the research (Fig. 8, 9, 10).

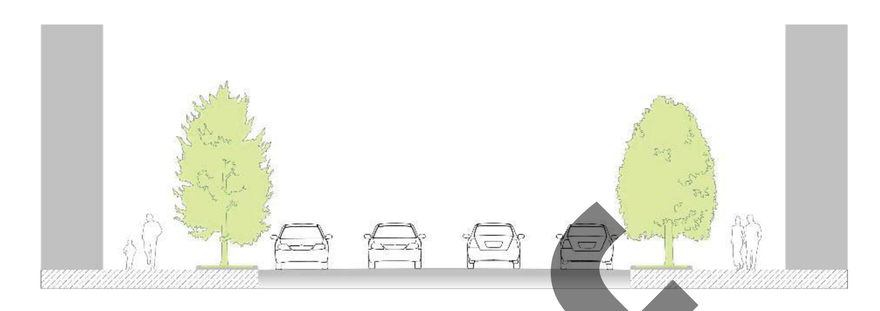
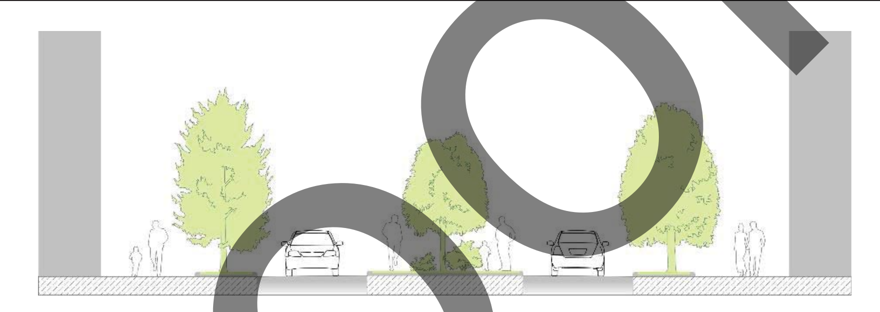
Respect for residents	Before
	
	Large crowding of city streets
	After
	
	Street priority for pedestrian traffic, traffic safety

FIGURE 8. Planning principle of public spaces revitalization «Respect for residents»

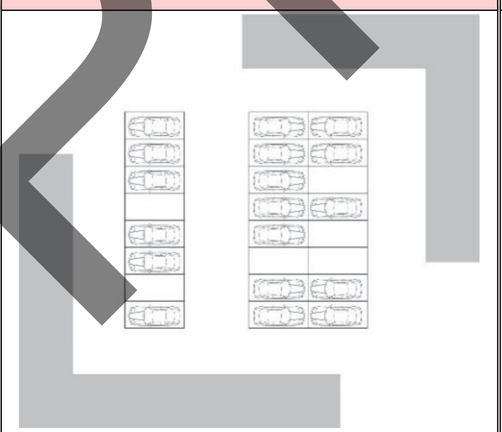
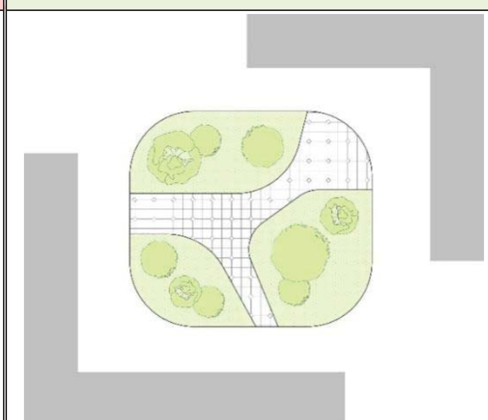
Attracting residents	Before	After
		
	Detachment and indifference of spaces, lack of courtyard space for a resident	Attractiveness of the location and actualization of necessary functions, creation of comfort

FIGURE 9. Planning principle of public spaces revitalization «Attracting residents»

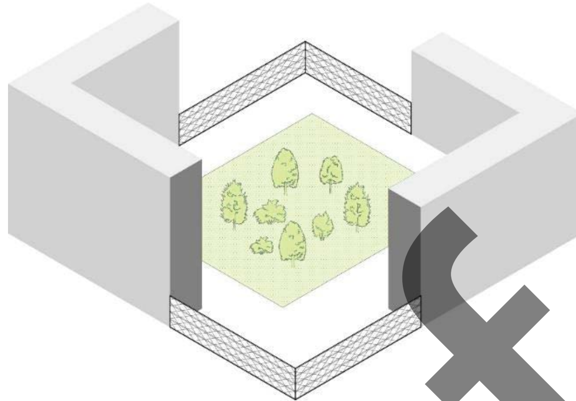
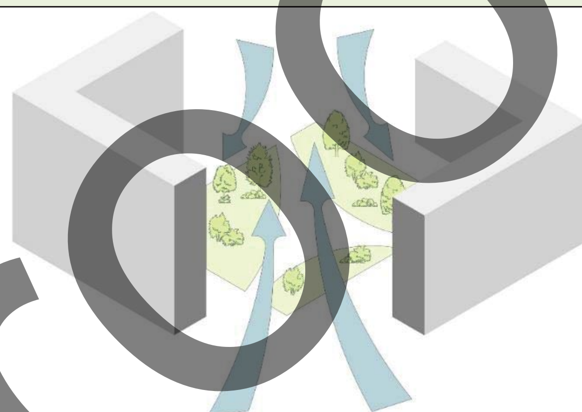
Hospitality of space	Before
	
	Isolation from the public, isolation of the spatial structure
	After
	
	Openness to citizens and interaction with adjacent territories

FIGURE 10. Planning principle of public spaces revitalization «Hospitality of space»

Each planning principle should be applied in the appropriate context based on the research conducted, the results of which showing its applicability. The considered principles are an universal foundation that is applicable to public space in any city as well.

CONCLUSION

It has been found out that certain areas of urban spaces require special approaches to the organization of the environment over time. The revitalization of urban spaces is a promising long-term program aimed at eliminating the problem and destructive areas in an urban environment.

The approaches to the revitalization of urban public spaces can include the following indicators:

- creation of a “friendly” urban space for all segments of the population;
- predominance of social and cultural functions and art spaces;
- creative recreational areas and ecological spaces;
- inclusion of commercial functions, job creation;
- change of the main functional purpose of the project area;
- encouragement to spend long periods of time in public spaces.

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Modeling the Processes of Determining the Hydromechanical Parameters of Particles of Impurities in Aqueous Solutions of Wastewater

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Abstract. Modern circulating water supply systems are the most common and reliable components of the country's industrial sector. The use of water in circulating and reusable systems requires the applying of advanced engineering solutions aimed at increasing the reliability level and its process reliability, technical excellence and environmental safety of circulating water supply systems. The solution of the specified problems and tasks is in a choice of hydraulically substantiated parameters and modes for systems of circulating water supply which can be defined by the correct calculation and economically expedient choice of a configuration of the circulating water supply systems. Achieving the reliability level and environmental safety of water bodies at industrial water supply systems can be determined at the design stage and, in particular, at the stage of modeling the processes that occur during the treatment of galvanic wastewater. Theoretical and experimental researches of parameters of impurity particles movement in water solutions are carried out in work. The analysis is carried out and recommendations concerning the choice of engineering and technical decisions at designing, choosing and operation of the technological equipment for circulating water supply systems at the industrial enterprises are developed.

INTRODUCTION

Circulating water supply systems are an important element of industrial water supply, which are characterized by constant hydraulic loads, this occurs under conditions of temperature difference (circulating heat and water supply systems), receiving loads with a wide range of wastewater, technical fluids, two- and three-component aqueous solutions. Therefore, the methods of controlling the hydrodynamic parameters and particles of impurities of aqueous solutions determine the general technical problem, which is solved due to a significant number of developed optomechanical systems, their use in a wide range of measurements of individual parameters and characteristics of transparent technical fluids (Fig. 1).

The study of a liquid medium using multifunctional optical-mechanical systems determines the relevance of the chosen direction of scientific research, which makes it possible to use optical methods based on laser Doppler interferometry for the country's water sector.

An effective lever for increasing the efficiency of work, reliability, efficiency for determining the previously indicated parameters and characteristics is the modeling of wastewater treatment processes and verification of the obtained research results [1].

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Mathematical modeling involves a mathematical description of the process model in the form of mathematical expressions and relationships [2, 3, 4, 5], which determine the adequacy and correctness of the model to the investigated process. Methods of mathematical modeling in combination with modern information technologies make it possible to study various options for the hardware and technological design of the process, to find the optimal parameters and characteristics in the conditions of one computational process.

The developed optical-mechanical systems for the study of two and three-component industrial wastewaters make it possible to determine individual hydromechanical parameters that characterize the circulating water supply systems.

The article presents developments on the intensification of the work of circulating water supply systems, which are solved through the use of methods of physical and mathematical modeling of the processes, purification and disinfection of wastewater from heavy metals in industrial water supply systems, optical methods of laser interferometry, numerical and analytical methods for optimizing the main parameters of work water treatment equipment [6].

The purpose of the work is to develop models of the processes for determining the hydromechanical parameters of particles of sewage impurities and verification of the obtained research results.

To achieve this goal, it is necessary to solve interrelated tasks:

1. Justification of the choice of parameters of impurities, for example, determination, calculation, and comparison of the values of the effective diameter.
2. Verification of the obtained research results according to a specific calculation algorithm.

MATERIAL AND METHODS

According to the theory of electrophoresis, developed by Smoluchowski and Gückel [7, 11], according to which the motion of a particle in an electric field is considered as a result of the effect of the Coulomb force on its surface charge from the electric fields and forces of viscosity in the horizontal plane Y in the vertical plane: forces of attraction, viscosity and Archimedes' forces. This arrangement of forces (1) and their action in the horizontal and vertical planes became the basis of the research carried out.

$$\begin{cases} \vec{F}_{\kappa} + \vec{F}_c = 0 \\ \vec{F}_m + \vec{F}_A + \vec{F}_c = 0 \end{cases} \tag{1}$$

The established mathematical relationship allows one to determine the individual parameters of the particles of aqueous solutions of vertical installations during electrochemical coagulation-flotation.

The differential equations that take into account the motion of particles of impurities of aqueous solutions in the spatial coordinate system form the following system of equations:

$$\begin{cases} D_{n_x} \cdot \frac{d\tau_{D_x}}{dt} + \Delta_{1-1}(\tau_1^x - \tau_1) = \Delta \cdot C_D^x \cdot (a + \alpha_1 \cdot \tau_1) \\ D_{n_y} \cdot \frac{d\tau_{D_y}}{dt} + \Delta_{1-2}(\tau_1^y - \tau_2) = \Delta \cdot C_D^y \cdot (b + \alpha_2 \cdot \tau_2) \\ D_{n_z} \cdot \frac{d\tau_{D_z}}{dt} + \Delta_{1-3}(\tau_1^z - \tau_3) = \Delta \cdot C_D^3 \cdot (c + \alpha_3 \cdot \tau_3) \end{cases} \tag{2}$$

where D_{n_x}, D_{n_y}, D_{n_z} is the number of particles of effective diameter, are within the measurable range (5…50 10^{-6} m), pieces in one of three spatial directions; τ_{D_x}, τ_{D_y}, τ_{D_3} is the quantitative change in the particles of impurities of aqueous solutions, the value of which (effective diameter) changes from the time of the course of the wastewater treatment process, pieces; Δ_{1-1}, Δ_{1-2}, Δ_{1-3} is the coefficient of increasing the efficiency of wastewater treatment of spatial coordinate systems, depending on the design of the water treatment equipment (number of treatment stages); τ_1^x, τ_1^y, τ_1^z is the initial concentration of impurities in wastewater entering treatment, mg/l; τ_1, τ_2, τ_3 is the final concentration of treated wastewater impurities, mg/l; Δ is delta function that takes into account a separate characteristic (parameter) of the particles of the water flow (in this case, the effective diameter of the particles of impurities in aqueous solutions); C_D^y, C_D^x, C_D^z is the concentration of pollutants in the spatial coordinate system *x, y, z*, mg/l; *u, v, w* is components of the speed of circulation of the water flow along the Cartesian axes *x, y, z*; *a, d* и *b* is coefficients taking into account the number of values of one group (for values of the effective diameter of one or several groups), taken in the range from 0 to 1.

For other hydromechanical parameters of particles of impurities in aqueous solutions, in addition to the effective diameter (*D*), hydromechanical parameters of particles of impurities in aqueous solutions *V*, *ζ*, *n* optical-mechanical systems are determined in a similarly and are determined in the studies carried out and the publications cited earlier [12].

Taking into account the conditions for the formation and course of processes in the operation of the components of industrial water supply systems, the following equations (2) make it possible to determine the hydromechanical parameters of particles *D*, *V*, *ζ*, *n* optical-mechanical systems and take the following form.

- for effective diameter:

$$\begin{cases} C_{D_x} \cdot \frac{d\tau_{D_x}}{dt} + \Delta_{1-1}(\tau_1^x - \tau_1) = \Delta C_D^1 \cdot (1 + \alpha_1 \cdot \tau_1) \\ C_{D_y} \cdot \frac{d\tau_{D_y}}{dt} + \Delta_{1-2}(\tau_1^y - \tau_2) = \Delta C_D^2 \cdot (1 + \alpha_2 \cdot \tau_2) \\ C_{D_з} \cdot \frac{d\tau_{D_з}}{dt} + \Delta_{1-3}(\tau_1^з - \tau_3) = \Delta C_D^3 \cdot (1 + \alpha_3 \cdot \tau_3) \end{cases} \tag{3}$$

We give the system of equations (2) to determine the concentration of particles of aqueous solutions ***D***, in three-dimensional coordinate system:

$$\begin{cases} C_{D_x} \cdot \frac{d\tau_{D_x}}{dt} + (\Delta_{1-1} - \Delta C_D^1) \cdot \tau_1 - \Delta_{1-1} \cdot \tau_1 = \Delta C_D^1 \\ C_{D_y} \cdot \frac{d\tau_{D_y}}{dt} + (\Delta_{1-2} - \Delta C_D^2 \cdot \alpha_2) \cdot \tau_2 - \Delta_{1-2} \cdot \tau_2 = \Delta C_D^2 \\ C_{D_z} \cdot \frac{d\tau_{D_Z}}{dt} - \Delta_{1-3} \cdot \tau_1^z - \Delta_{1-3} \cdot \tau_z + (\Delta_{1-1} + \Delta_{1-2} + \Delta_{1-3}) \cdot \tau_3 = \Delta C_D^3 \end{cases} \tag{4}$$

The equation (4) is a system of inhomogeneous linear differential equations. To obtain a general solution to an inhomogeneous system, it is necessary to add a general solution for its particular solutions, according to the homogeneous system and the decomposition theorem:

$$\begin{cases} \tau_1 = \tau_{1X} + \tau_{10X} \\ \tau_2 = \tau_{2Y} + \tau_{2OY} \\ \tau_3 = \tau_{3Z} + \tau_{3OZ} \end{cases} \tag{5}$$

where τ_{1X}, τ_{2y}, τ_{2Z} - particular solutions of a system of inhomogeneous linear differential equations; τ_{10X}, τ_{20y}, τ_{3OZ} - general solutions of the corresponding system of homogeneous linear differential equations.

A particular solution to system (5) is determined under the following conditions $t \to \infty$

$$\begin{cases} (\Delta\_(1-1) - \Delta C\_D\text{^}1) \cdot \tau\_1 - \Delta\_(1-1) \cdot \tau\_1) = \Delta C\_D\text{^}1 \\ (\Delta_{1-2} - \Delta C_D^2 \cdot \alpha_2) \cdot \tau_2 - \Delta_{1-2} \cdot \tau_2 = \Delta C_D^2 \\ -\Delta_{1-3} \cdot \tau_1^z - \Delta_{1-3} \cdot \tau_3 + (\Delta_{1-1} + \Delta_{1-2} + \Delta_{1-3}) \cdot \tau_3 = \Delta C_D^3 \end{cases} \tag{6}$$

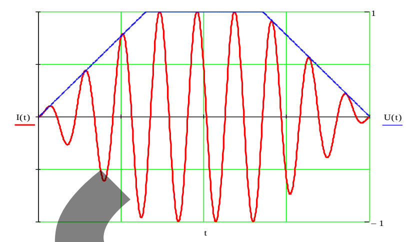
For generalization, we propose an algorithm (order) for obtaining research results, which connects the hydromechanical parameters and their functional relationship.

Solving problems with direct and reverse order allows you to significantly expand the functional conditions for the application of applied engineering problems and tasks. This formulation of the problem significantly expands the conditions for solving problems of an applied nature for a more accurate determination of hydrodynamic characteristics and parameters.

The results of experimental studies are shown in Fig. 1, in a concise form they give the main characteristics and parameters of modeling with direct and inverse problems.

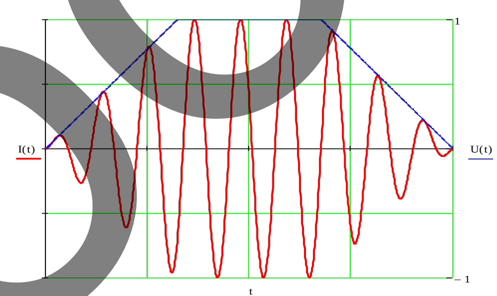
The results of measurements and mathematical processing of the values of the effective diameter in the study of the deposition process by optical-mechanical systems are given in table 1.

For certain values of the effective diameter, they are divided into corresponding groups, which only determine the mathematical closeness. The results of mathematical processing clearly indicate that the previous selection of values of the effective diameter for its effective size is the basis for further illustration. In this case, the corresponding characteristic of the optical-mechanical system is taken into account, which is determined by the design dimensions and the parameters of optical measurements.



PARAMETERS
INSTALLATIONS
diameter of laser beams — b= 50 micron
the angle between two beams in the measurement area, deg. — α= 6^0
electric field strength — E = 1000 V/m
PARTICLES
particle diameter — D= 8 micron
electrokinetic zeta potential — ζ = 0,8 V
PARAMETERS
particle motion — electrophoretic speed — υ = 0,38 mm/s
Doppler signal — Doppler frequency — ν = 84 Hz
Doppler period — T = 12 ms
Doppler signal rise time — t_1= 34 ms
offset from the horizontal axis — y = 0 mm

(a)



PARAMETERS
INSTALLATIONS
diameter of laser beams — b= 50 micron
the angle between two beams in the measurement area, deg. — α= 5-15^0
electric field strength — E = 1000 V/m
PARTICLES
particle diameter — D= (5-10) micron
electrokinetic zeta potential — ζ = (0,2-2) V

PARAMETERS
particle motion — electrophoretic speed — υ = 0,38 mm/s
particle diameter, micron — D = 8-50 micron
Doppler signal — Doppler frequency — ν = 38 Hz
Doppler period — T= 12 ms
Doppler signal rise time — t_1= 34 ms
offset from the horizontal axis — y = 0-0,5 mm

(b)

FIGURE 1. Results of experimental studies of the Doppler signal shape obtained as a result of theoretical calculation using a PC (maximum value): a – the installation angle parameters (α = 60) were at a fixed value; b - installation angle parameters (α= 5- 150) varied within a certain range

TABLE 1. The results of measurements and mathematical processing of the values of the effective diameter in the study of the deposition process by optical-mechanical systems

Rounded particle diameter, m	Diameter particles, D, micron				Arithmetic mean of effective diameter, micro	Average deviations, Δ	Variations, η	Standard deviation, σ
5	4,95	4,90	5,00	4,95	4,95	0,05	0,1	0,071
6	5,90	5,90	5,95	6,00	5,93	0,0625	0,023	0,0075
7	6,95	6,95	6,90	6,95	6,9375	0,0625		0,0058
8	8,00	7,95	8,10	7,90	8,225	0,225	0,2	0,0225
9	8,85	8,90	8,95	9,00	8,925	0,075		0,0183

When checking individual research results, it was taken into account that a characteristic feature of whether the emulsified impurities (particles) of aqueous solutions are too concentrated is the shape of particles (droplets) in the form of a sphere [13]. Therefore, the determination of the effective diameter most clearly illustrates the changes in the parameters of a particle during electrophoresis.

It is known that the sedimentation rate of a solid (thick) particle ($10^{1}…10^{-4}$ mm in size), the shape of which approaches the layer, and its volume does not change and is determined by the formula taking into account Stokes' law, which is used in sedimentation research [14]:

$$w = \frac{d^2}{18\cdot\mu} \cdot q \cdot (\gamma_\tau - \gamma_{ж}), \tag{7}$$

where w is the rate of sedimentation of particles suspended solids m / s; d - particle diameter, m; $\mu$is the fluid viscosity; γ_τ, $\gamma_{ж}$ is the density of suspended liquid particles, kg/ m^3.
In the case where the precipitated particle contains an adsorption hydrate shell, which is a complex of substances of different densities, the formula (7) takes the following form:

$$w = \frac{d^2}{18\cdot\mu} \cdot q \cdot \left(\frac{\gamma_1 \cdot W_{1_\tau} - \gamma_2 \cdot W_2}{W_1 - W_2}\right), \tag{8}$$

where W_1, W_2 - the relative volumes of the constituent particles of the substance, m^3.

Analysis of the dispersion values of suspended solids of the aqueous solution, obtained using fundamentally different physicochemical techniques, allows in some cases to characterize the structure of the particle and the state of the interfacial surface, which is important for assessing the aggregate stability of suspended solids [15].

The purpose of the analysis of the shape of the Doppler signal is to calculate the value of the deviation of the diameter from the size of the effective diameter, determined by optical methods of measurement and processing using computer programs (MathCAD, MathLAB).

One of the verification tasks is to minimize the values (functional) of the effective diameter, which is determined as a result of research, and its value is obtained by the formula:

$$J = \sum_{i=1}^{n} (D(t) - D_{експ.})^2 \tag{9}$$

where ***D***(t) is the calculated value of the effective diameter, which is determined using the developed mathematical model, m; D_{exp} - the experimental value of the effective diameter, which is determined according to known methods [16].

EXPERIMENTAL AND NUMERICAL DATABASE

To solve many problems and tasks that determine the level of intensification of circulating water supply systems, it is advisable to determine, calculate and further use the results obtained to make a further contribution to the development of water treatment technologies. First of all, it concerns transitional processes in stationary conditions, processes that determine their reliability and further use in the water management complex of the country.

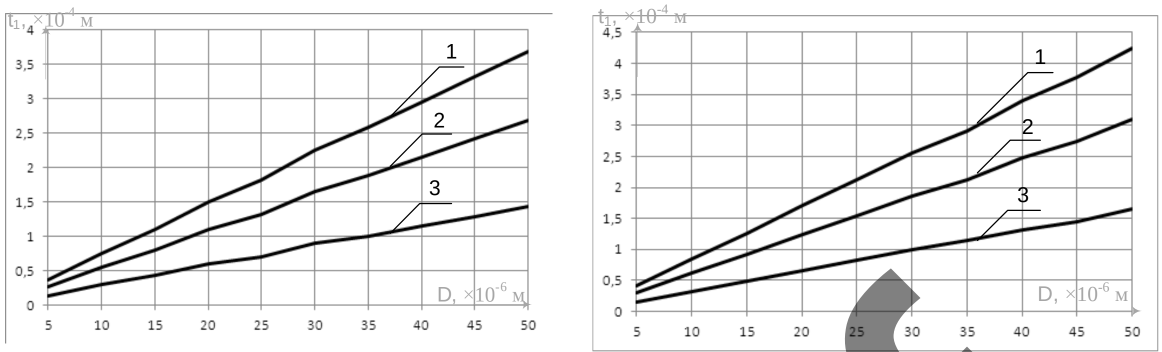
The equation (2) is a system of inhomogeneous linear differential equations. Taking into account the decomposition theorem, to obtain the general equation of an inhomogeneous system, it is sufficient for a partial solution of a homogeneous system, which determines the conditions of influence on the value of the effective diameter.

$$C_{D_{xyz}} \cdot \frac{d\tau_{D_x}}{dt} + \Delta_{1-1}(\tau_1^x - \tau_1) = \Delta C_D^1 \cdot (1 + \alpha_1 \cdot \tau_1), \tag{10}$$

which is determined by the conditions:

$$C_{D_{xyz}} = C_{D_{xyz}^{ijd!}}\ , \tag{11}$$

when the value of the effective diameter takes into account the molecular diffusion, the conditions of motion of the water flow and the linear (effective) diameter of the particle moving in the three-dimensional coordinate system (Fig. 2).



$cos\, 5^{\circ} = 0{,}996$ $cos\, 30^{\circ} = 0{,}8660$

FIGURE 2. The dependence of the amplitude of the increase in the speed of the Doppler signal ($t_1 \cdot 10^{-4}$ms) from the value of the effective diameter ($D \cdot 10^{-6}$m), in the case where the angle between the beams of the installation varies from 5^0 to 30^0, at different values of the velocity of the particles:
1 - $V = 0{,}35\ldots0{,}40$m/s; 2 - $V = 0{,}40\ldots0{,}45$ m/s; 3 - $V = 0{,}45\ldots0{,}50$ m/s

Angle of measuring optical scheme: 5^0, 10^0, 15^0, 20^0, 25^0 and 30^0 have the same form of dependencies.

For a particle of spherical shape in the criterion $C_{D_{xyz}^{ijd'}}$ use an equivalent diameter $D_{екв.}$. Given the volume of the particle V, mass m and density ρ_τ we have the following equation:

$$V = \frac{m}{\rho_\tau}. \qquad (12)$$

where the value of the equivalent diameter is determined by the formula:

$$D_{екв.} = \sqrt[3]{\frac{6 \cdot m}{\pi \cdot \rho_\tau}}. \qquad (13)$$

In the suspended state of the aquatic environment (water, wastewater), the particle has a spherical shape with a radius r (equivalent diameter $D_{екв.}$). It is believed that at any time $t = 0$ the concentration of particles in water is uniform and is determined by the ratio $n = n_0$.

By the developed technical solutions [1, 6] we have periods, the number of pulses and Doppler signals and determine the speed and concentration of particles, impurities before and after purification, respectively, according to the following equations:

$$\upsilon_1 = \frac{\lambda}{2 \cdot T_1 \cdot \sin \alpha_1} \qquad (14)$$

$$\upsilon_2 = \frac{\lambda}{2 \cdot T_2 \cdot \sin \alpha_2} \qquad (15)$$

where λ is the wavelength of helium radiation of the neon laser;

$$n_1 = \frac{k_1}{\upsilon_1} \qquad (16)$$

$$n_2 = \frac{k_2}{\upsilon_2} \qquad (17)$$

The indicators of the effectiveness of determining the quantitative composition of particles in water streams in three ranges of velocities (Table 2).

The degree of concentration C of the emulsion solution is determined by the concentration ratio n_1 at the beginning of wastewater treatment to concentration n_2 particles in solution after purification, which can be determined quite efficiently and accurately by optical methods. It is established that the use of the developed optical schemes creates conditions for measuring the period T_1 and T_2 Doppler signals and the number of Doppler pulses K_1 and K_2, thus determining the speed υ_1 and υ_2 and particle concentration n_1 and n_2 impurities before and after purification [12, 15].

TABLE 2. The efficiency of determining the quantitative composition of particles in water streams in three velocity ranges

The value of the effective particle diameter, micron	**Speed measurement range**								
	$V = 0,35\ldots0,40$ **m/s**			$V = 0,40\ldots0,45$ **m/s**			$V = 0,45\ldots0,50$ **m/s**		
	$n = n_0$	$n_1 = \frac{k_1}{v_1}$	$n_2 = \frac{k_2}{v_2}$	$n = n_0$	$n_1 = \frac{k_1}{v_1}$	$n_2 = \frac{k_2}{v_2}$	$n = n_0$	$n_1 = \frac{k_1}{v_1}$	$n_2 = \frac{k_2}{v_2}$
up to 5 μm	96-98%	94-97%	92-95%	95-96%	92-94%	91-93%	92-94%	91-93%	90-93%
up to 5-10 μm	95-97%	94-95%	91-93%	92-94%	91-93%	90-93%	91-94%	90-92%	90-91%
up to 10-15 μm	92-93%	91-93%	91-93%	92-94%	91-93%	90-93%	91-94%	90-92%	90-91%
up to 15-20 μm	90-91%	92-93%	91-93%	90-92%	90-93%	88-93%	88-90%	90-92%	89-90%
up to 20-25 μm	87-89%	90-91%	90-91%	89-91%	87-93%	86-93%	88-90%	89-92%	86-90%
up to 25-30 μm	85-89%	88-90%	90-91%	89-91%	87-93%	86-93%	88-90%	89-92%	86-90%
up to 30-35 μm	95-97%	94-95%	91-93%	92-94%	91-93%	90-93%	91-94%	90-92%	90-91%
up to 35-40 μm	92-93%	91-93%	91-93%	92-94%	91-93%	90-93%	91-94%	90-92%	90-91%
up to 40-45 μm	90-91%	92-93%	91-93%	90-92%	90-93%	88-93%	88-90%	90-92%	87-90%
up to 45-50 μm	87-89%	90-91%	90-91%	89-91%	87-93%	86-93%	88-90%	89-92%	86-89%

Note. The value of the effective diameter is chosen within 10-15 micron, 15-20 micron, 20-25 micron, 25-30 micron, 30-35 micron, 35-40 micron, 45-50 micron,

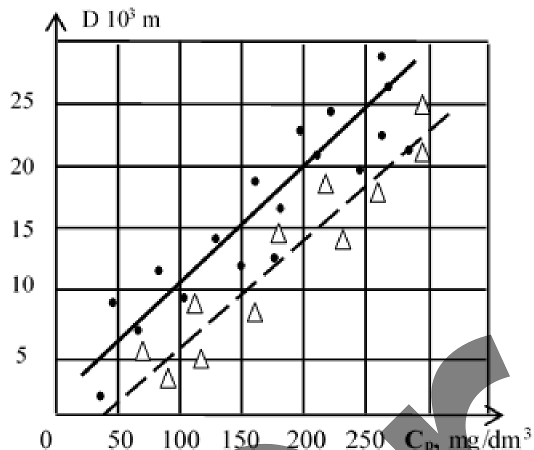


FIGURE 3. Dependence of the effective diameter ***D*, 10^{-3} m** from the concentration C_p, mg / dm^3 emulsion solution

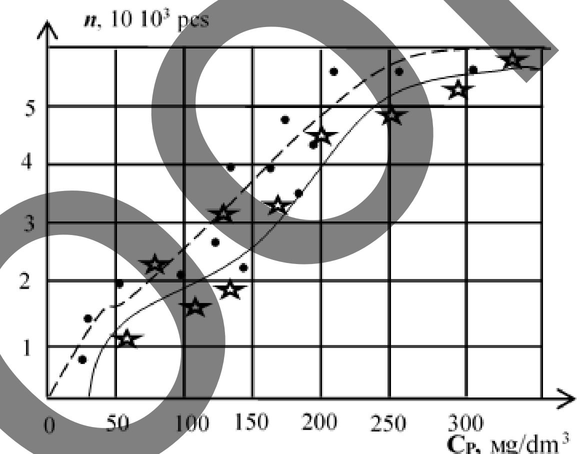


FIGURE 4. Dependence of the number of particles ***n*, 10 10^3** pcs. from the concentration of C, mg/dm^3 emulsion solution

The dependences of the effective diameter (Fig. 3 and Fig. 4) on the concentration are characterized by a directly proportional dependence.

The value of the effective diameter of a particle moving in a three-dimensional coordinate system depends on the diameter, which varies in shape and is determined by:

$$C_{D_y} = C_{D_x} = C_{D_z}. \tag{18}$$

DISCUSSION

The results of modeling of wastewater treatment processes and verification of the obtained research results, which are aimed at intensification of circulating water supply systems [1, 12, 15].

Determination of hydromechanical parameters of particles of aqueous solutions, which are considered on the example of effective diameter, is the basis for the development of a comprehensive system for modeling and verification (verification) of all other parameters (***D***, ***V***, ξ and *n*) by a similar method.

CONCLUSION

Thus, the creation of mathematical models of processes in the systems of circulating water supply systems allows to increase the automation of technological processes, to optimize the work of the components of the water supply system of an industrial enterprise.

Planning the experiment of circulating water supply systems allows to solve the following range of issues:

- increasing the efficiency of experimental research: reducing the time, money, and reliability of the results of wastewater treatment of industrial enterprises;
- obtaining preliminary information about the properties of the object for research and evaluation of the quality of wastewater treatment;
- study of the nature and determination of the mechanism of physical and chemical phenomena to ensure environmental safety in the disposal of sewage sludge of industrial enterprises;

The motion of aqueous solution particles by studying the effective particle diameter of aqueous solution impurities is investigated, graphical dependences of the amplitude of the Doppler signal rate increase are obtained ($t_1 \cdot 10^{-4}$ ms) depending on the value of the effective diameter ($D \cdot 10^{-6}$ m) and the angle between the beams of the installation, which is from 5^0 to 30^0 at different values of the velocity of particles (at velocities (1 - $V = 0{,}35 - 0{,}40$ m/s; 2 - $V = 0{,}40 - 0{,}45$ m/s; 3 - $V = 0{,}45 - 0{,}50$ m/s), changes in the angle of the measuring optical circuit: 5^0, 10^0, 15^0, 20^0, 25^0 and 30^0 indicate that the differences in the motion of the particles determined experimentally and theoretically do not exceed 5-6%, which is sufficient for making final engineering and technical decisions in the design, selection and operation of technological equipment for circulating water supply systems of industrial enterprises.

To increase the level of intensification of the circulating water supply system, the constituent units have been studied, which are as follows:

- in the rational use of chemicals in the treatment of wastewater using reagents [6] apparatus [1], methods [12, 15] and intensive methods [16];
- making waste of galvanic production with sulfuric or phosphoric acid, removal of excess moisture and using the quality of the reagent;
- determination of hydromechanical parameters of particles of impurities of aqueous solutions, wastewater, transparent technical liquids;
- treatment of liquid waste;
- industrial enterprises from previous processes of cleaning, treatment, neutralization and removal of pollution.

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Testing of Active Sludge to Ensure Stable Operation of Urban Treatment Facilities

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Abstract The stability of the operation of urban biological treatment facilities depends on the availability of operational methods for monitoring the state of activated sludge. However, to date, the problems of methodological development and practical application of tests of the state of activated sludge have not been completely solved. Physiological and biochemical analysis of activated sludge of urban wastewater treatment plants and laboratory nitrification biofilm formed during the processing of saline industrial wastewater was performed. The H_2 scavenging activity in the respiratory metabolism of the activated sludge microbiocenosis was calculated based on the values of the dehydrogenase activity of the sludge. The ratio of the rate of H_2 acceptance and the rate of consumption of O_2 by activated sludge approached the theoretical one, that is, the indicators objectively reflected the oxidizing capacity of the sludge. The ratio of the rate of CO_2 formation and the rate of O_2 consumption was 1.5, which indicated that the sludge in wastewater consumes substances more oxidized than carbohydrates. The activity of H_2 scavenging in the respiratory metabolism of nitrifying biofilms from a laboratory nitrifier was calculated based on the values of hydroxylamine oxidoreductase activity. And in this case, the ratio of the rate of H2 acceptance and the rate of consumption of O_2 by the biofilm approached 8, which indicates their objectivity in assessing the nitrifying capacity of the biofilm.

INTRODUCTION

The stability of municipal wastewater treatment plants (WWTP) is a guarantee of the stability of the city life support and its environmental safety [1, 2]. Largely, providing of stable high efficiency in operation of municipal biological wastewater treatment plants treatment plants depends on control of activated sludge condition, which is impossible without prompt and reliable methods of its control [3, 4], introduction of innovative technologies for utilization of stored, removed from the technology of treatment excess activated sludge [5]. Testing the sludge condition, i.e. a quantitative assessment of its quality and potential activity in the oxidation of pollutants – is the most important tool for both research and development, and the practice of operating wastewater treatment facilities, which is created with the involvement of various biological and technological disciplines, developments in fundamental sciences and the practice of wastewater treatment. However, until now, the problem of methodological development and practical application of activated sludge condition tests hasn't been fully solved, especially the assessment of the state of nitrifying sludge and its activity in the oxidation of ammonium ($N\text{-}NH_4$).

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UNRESOLVED ISSUE

Several convenient and reliable biological tests used in industrial wastewater treatment plants are designed to analyze the condition of sludge that oxidizes organic compounds. The most famous and widespread method is hydrobiological analysis, in which indicator microscopic organisms are used to assess of the sludge condition [3 – 8]. Unfortunately, this analysis is more likely not quantitative, but qualitative and characterizes the general condition of the biocenosis, and not its ability to oxidize specific contaminants.

Based on the leading role of the bacterial flora in the oxidation of pollution, the potential activity of the sludge, probably, can be most correctly and accurately estimated by the quantity of bacteria in it, specific ecological and trophic groups [9, 10]. The question is extremely difficult both theoretically and for practical implementation, because the activated sludge microbiocenosis includes many such groups and each requires quantitative accounting of its elective media and cultivation methods. The duration of incubation can be calculated for several days (to account for nitrifying bacteria – tens of days), which excludes the efficiency of testing [10]. Promising water treatment technology is the use of Anammox process [11]. Currently, fluorescence FISH microscopy using specific labeled probes is used to visually detect the presence of Anammox bacteria [12], which is realizable only in specialized microbiological laboratories of a high level. Due to the duration of traditional methods of analysis, the high cost of equipment and materials, as well as the need for highly qualified specialists, for modern methods of analysis, the use of microbiological methods for regular operational technological control of biological treatment processes in industrial plants is hardly advisable.

One of the most significant functional indicators of sludge is the specific oxidation rate of pollutants (organic or $N\text{-}NH_4$). This indicator (kinetic [13]) characterizes the physiological activity of biocenosis development, and for nitrifying bacteria, specifically, the intensity of the energy metabolism of ammonium-oxidizing bacteria (phase I nitrification).

The intensity of the process of oxidation by activated sludge of an organic substrate or ammonium nitrogen can be judged with equal reliability both by the decrease in the electron donor (organic substances, $N\text{-}NH_4$) and by the decrease in their acceptor – O_2 [14]. Therefore, another objective physiological method for assessing the oxidizing activity of sludge is based on the quantitative determination of the consumption of O_2 dissolved in wastewater (the final acceptor of electrons that are removed from organic compounds or NH_4^+) during the oxidation of organic and inorganic substrates.

The features of the of the energy metabolism of nitrifying bacteria determine the proportionality between the change in the rate of oxygen consumption and the change in the rate of removal of ammonium nitrogen by the biocenosis. In fact, NH_4^+ is the only donor, and oxygen is the only acceptor of electrons in the energy exchange of nitrifying bacteria of the first phase of nitrification. The ratio of consumption of $N\text{-}NH_4$ / O_2 is constant and, based on the reaction equations for the oxidation of $N\text{-}NH_4$ to $N\text{-}NO_2$, theoretically is 2.86, and for oxidation to N-NO3 – 4.0 [13, 14]. And for specialized sludge of nitrifying structures, in which fully saline wastewater with a high content of N-NH4 is processed, the choice of a controlled parameter when monitoring activated sludge depends only on the availability and efficiency of the analysis method.

Biochemical indicators have great potential in testing activated sludge - the activity of certain enzymes, mainly of the class of oxidoreductases (dehydrogenases, catalases, peroxidases, and also some other enzymes). The most widely used method for determining dehydrogenase activity (DHA) in the practice of scientific experiments and sludge control at industrial WWTP [15, 16]. It is based on biochemical dissimilation reactions, according to which, the main path of biological oxidation consists in the dehydrogenation of the substrate and the passage of active hydrogen (electrons) through the system of hydrogen transfer enzymes until it combines with the final acceptor (in aerobic processes, oxygen).

Currently, this method is used to assess the ability of sludge to oxidize organic substrates, to determine the completeness of wastewater treatment, the end of sludge regeneration or aerobic stabilization. In the metabolism of biocenoses of heterotrophic microorganisms, the proportionality between a change in the rate of oxygen consumption and oxidation of an organic substrate by dehydrogenation (DHA) is usually unstable, since organic substances in constantly changing proportions are a substrate for both energy and constructive metabolism. In addition, many organic substances are included in the metabolism of bacteria through the stage of sorption-accumulation. Therefore, oxygen consumption and consumption of organic substrate by biocenosis characterize the intensity of different metabolic pathways of chemoorganoheterotrophs.

For the operational control of the nitrifying activity of the sludge, a biochemical method for assessing the activity of the key enzyme of the 1st stage of nitrification has been developed – hydroxylamine oxidoreductase (HDOR) [17, 18]. In the case of deeply specialized nitrifying microbiocenoses, theoretically, there should be a certain proportionality between the rate of O_2 consumption by the microbiocenosis, the rate of deammonization of the medium by it, and HDOR activity (rate of NH_3 dehydrogenation).

The task of the research was to analyze the information content of various physiological and biochemical methods for the quantitative assessment of the state of sludge, including its nitrifying ability, for use in the technological control of the operation of treatment facilities.

MAIN PART

The object of research is activated sludge of municipal biological WWTP and a laboratory nitrifier biofilm formed during the treatment of wastewater containing only inorganic contaminants and ≥300 mg/l N-NH_4. The rate of oxygen consumption from the incubation medium was established using a portable oxygen meter (model YSI 55, Dissolved Oxygen Meter (USA). The rate of CO_2 formation was determined by the accumulation of this gas in the air of a hermetically sealed cultivator (1 L) with a certain volume of sludge liquid (100 cm^3) with a known concentration of activated sludge. The CO_2 concentration in the cultivator was measured using a cultivator placed in the air. The DHA and GDOR activity of the sludge was determined according to the method described in [18]. The N-NH_4 concentration was determined photometrically with the Nessler reagent [19]. The dry weight of the sludge was determined gravimetrically [19]. The duration of one determination of DHA, GDOR is 1-2 hours, the rate of O_2 consumption is 0.5-1.0 hours, the rate of CO_2 release is 1-2 hours.

As you know, there is a certain relationship and quantitative relationships between the biochemical and physiological indicators of the vital activity of microbiocenoses. Determination of DHA (measured in μg formazan / (g_{sludge} minimum)) using 2,3,5-triphenyltetrazolium chloride (TTC) (colorless substance) is based on the acceptance of hydrogen mobilized by dehydrogenase and reduction in an incubated medium in 2,3,5-triphenylformazan ($C_{19}H_{16}N_4$), a red substance) [16, 17] according to the reaction (1):

$$C_{19}H_{15}N_4Cl + H_2 \rightarrow C_{19}H_{16}N_4 + HCl \qquad (1)$$

Hence, through the molecular weights, we find that the amount of removed hydrogen is equal to the mass of formazan / 150. And the amount of oxygen consumed by the microbiocenosis for the binding of protons removed by dehydrogenases in the respiratory chain occurs according to the reaction (2):

$$H_2 + O_2 \rightarrow 2H^+ + O^{2-} = H_2O \qquad (2)$$

Using molecular weights, we calculate that this reaction uses oxygen (by weight) approximately eight times more than hydrogen.

Respiratory coefficient is the molar ratio of carbon dioxide released during respiration to the amount of absorbed oxygen (CO_2/O_2). In the case of classical respiration, when carbohydrates $C_n(H_2O)_n$ are oxidized and only CO_2 and H_2O are formed as end products, the respiratory coefficient is equal to unity. When using fats instead of carbohydrates, which are less oxidized than carbohydrates, their oxidation will be more oxygen is used – in this case, the respiratory coefficient will decrease (to a value of 0.6-0.7). If, during respiration, organic acids (substances that are more oxidized in comparison with carbohydrates) are oxidized, then less oxygen will be used than carbon dioxide is released, and the respiratory coefficient increases to a value greater than one. Like other physiological processes, the rate of respiration depends on a number of environmental factors.

To check these theoretical provisions, we performed physiological and biochemical analysis of activated sludge of municipal WWT plants and laboratory installations of nitrifiers (table 1). The H_2 acceptance activity in the respiratory metabolism of the microbiocenosis was calculated on the basis of DHA values, based on the mass ratios of the active compounds according to formula 1.

As can be seen, in the variant with activated sludge of municipal WWT plants, the H_2/O_2 ratio is approximately 10, which is slightly higher than the O_2/H_2 mass ratio according to the reaction equation (2). This is probably due to the loss of oxygen under the experimental conditions when mixing the sludge liquid.

TABLE 1. Indicators of biochemical and physiological studies of indicators of activated sludge, characterizing respiratory metabolism

Microbiocenosis	DHA, µg formazan / g minimum	Estimated acceptance activity of H_2, µg/g minimum	* Consumption rate of O_2, µg/g minimum
Active sludge of municipal WWTP	2500	17	180
Laboratory nitrification plant	20	0.13	5

* In the initial wastewater of municipal WWTP

The biofilm of a laboratory nitrifier, formed mainly by autotrophic nitrifying microorganisms, is practically incapable of oxidizing (dehydrating) organic compounds (DHA approaches 0). In the presence of organic compounds of wastewater, nitrifying microorganisms are practically unviable, hence the rate of consumption of O_2 in such an environment is very low.

The average rate of CO_2 accumulation (100 ml of sludge liquid with an activated sludge concentration of 2.1 g/l) in the gas-air space of the installation (fig. 1)' was 10 mg/(m^3·min) or about 50 µg/(g·min) (1.1 microMol/(g·min) or 24.6 µL/g·min). Taking into account the very high solubility of CO_2 in an aqueous medium (0.87 L/L), the volume of CO_2 released by the microbiocenosis is 189.2 µL/(g·min) or 8.4 µM/(g·min). The ratio of the rate of CO_2 formation and the rate of O_2 consumption (5.6 µMol/(g·min) is 1.5. This indicates that the wastewater is dominated by pollution close to the products of partial oxidation of carbohydrates.

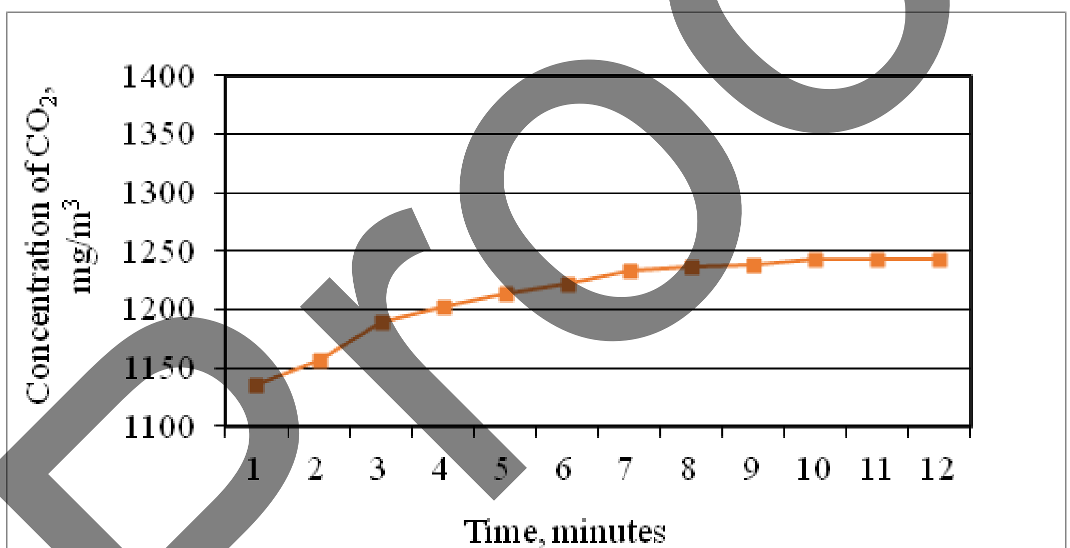

FIGURE 1. Dynamics of CO_2 accumulation in the gas-air space of the installation

Research results of the nitrifying biofilm of the laboratory installation are presented in table 2. The activity of H_2 acceptance in the respiratory metabolism of the microbiocenosis was calculated on the basis of the GDOR activity values.

TABLE 2. Indicators of biochemical and physiological studies of nitrifying biofilm, characterizing respiratory metabolism

Microbiocenosis	HDOR, µg formazan / g minimum	Estimated acceptance activity of H_2, µg/g minimum	*Consumption rate of O_2, µg/g minimum	Removal rate of N-NH_4, mg/(g·min)
Active sludge of municipal WWTP	90	0.6	18	0.003
Laboratory nitrification plant	4000	27	250	29

* In model saline wastewater with N-NH_4 concentration up to 1 g/l.

As can be seen from the data presented, the O_2/H_2 mass ratio obtained during the examination of the nitrifying microbiocenosis of the laboratory setup is close to 8. Moreover, the activity of accepting protons TTC is also confirmed by the removal rate of the proton donor N-NH_4 (absorbed by nitrifying bacteria in the form of NH_3). In the variant with activated sludge of municipal WWTP, such correspondences in the ratio of the masses of consumed O_2/H_2 have not been established. The rate of dehydrogenation in terms of HDOR activity (calculated activity of H_2 acceptance) is corresponds with the rate of proton removal in terms of the rate of N-NH_4 removal in terms of H-NH_3 (0.5 μg/(g·min)).

Based on the processing of indicators, determined in the study of various sludge, a relationship was established between the HDOR value and the ability of the microbiocenosis to remove N-NH_4 (fig. 2).

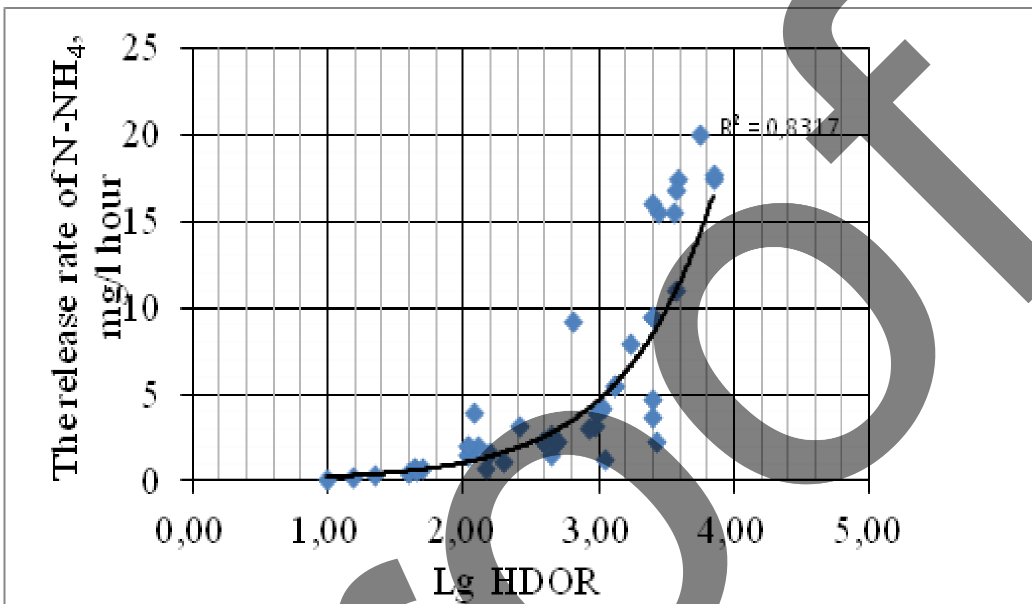

FIGURE 2. Impact of HDOR microbiocenosis for its activity in removing N-NH_4 from wastewater

CONCLUSIONS

For operational (no more than 2 hours) monitoring of the condition of sludge of municipal WWTP, indicators of DHA sludge (in the tested modification) and the rate of consumption of O_2 by it are recommended, between which stable correlations have been established that correspond to their biological nature.

To control the condition of microbiocenoses of nitrification plants, the indicators of HDOR activity of the biocenosis and the rate of consumption of O_2 by it are recommended, between which stable correlations have also been established that correspond to their biological nature.

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Using Historic and Architectural Facilities of Western Ukraine Towns within the Context of Sustainable Development

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Abstract. The article defines the relevance of using historic and architectural facilities of the towns of Western Ukraine as one of the main factors of successful implementation of Sustainable Development Goals. Theoretical analysis of factors influencing the formation of historic cities and towns is provided. The significance and features of using unique historic areas of towns as an implementation tool of sustainable development tasks were explored. The author stressed the necessity to integrate town-planning landmarks in downtown areas as the objects of the touristic proposal while developing a controlled urban environment in the future.

INTRODUCTION

Under constant social and political transformation at the current stage of development, the problem of the essence and relevance of developing sustainable development strategies became urgent in Ukraine. Formation of the programme for systematic governmental support of towns development and creation of favourable circumstances for its implementation is the subject of proactive study of scientific society. The particular interest arises to utilising the urban historic and architectural heritage within the framework of sustainable development. Rational approaches to the solution of this problem, including all the possible consequences, contribute to developing adequate social infrastructure of Ukrainian towns at the level of world requirements and standards.

The importance of the revival of social interest to historic and architectural components of the settlements and the following renaissance of historical memory results from the intensification of globalisation processes [3]. Understanding by every generation of the historical meaning and prospects for using urban architectural sites appears to be a potential part of ensuring the development of the controlled urban environment in the future. Consequently, this article aims to analyse Western Ukrainian towns' historical and architectural potential in the formation of sustainable development strategies.

RESULTS AND DISCUSSION

Domestic scientific circles frequently raise the issue of preservation, integration and popularisation of the Ukrainian urban architectural sites. The studies by M.V. Bevz [1], O. Lesyk [12], Zh.V. Myn [7], O. Mykhailyshyn [8], K.A. Polyvach [10], L. P. Skoryk [12] and others had a significant impact on justifying the uniqueness of the history of towns and the necessity of preserving the historic sites during modern urban transformations. Exploiting the historical and architectural potential of cities in the touristic area aiming at the revival of public interest to the protected objects in the urban area became the object for the works of O.V. Shershniova [16], P. Verbytska [3-4], M. R. Yasinskyi [17] and others. The analysis of scientific sources shows that not enough attention is paid to the issue of the historical and architectural heritage potential in the projection to the sustainable development goals, both at the level of the whole country and taking a region or settlement.

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The necessity of preserving and maintaining the cultural heritage as one of the goals of target development of towns and settlements on the global level was established in the final document of the UN Sustainable Development Summit “Transforming our World: the 2030 Agenda for Sustainable Development” of 2015 [10]. According to the officially adapted National Sustainable Development Goals for Ukraine [14], Ukraine’s Presidential Decree of 30.09.2019 “About sustainable development goals for Ukraine for the period up to 2030”, 17 sustainable development goals were established. The determined goals are considered fundamental for developing the future local developmental strategies of separate regions and territorial communities for the period defined by the local governments.

However, we examine the problem of updating the future use of historical and architectural urban facilities of towns within the formation of the rational environment to study social and cultural assets of historical areas as an effective tool for ensuring sustainable development.

The concept of “sustainable urban development” means stable urban space functioning, which provides rational upgrading of urban infrastructure for the current and next generations [16]. The formation of the future architectural image of the town is implemented by the gradual “accumulation” of style tendencies of a certain period, including the peculiarities of local traditions and external influence.

A historic town is a special place reflecting the connection between the self-identification of the ethnic population groups by forming authentic urban texture and the aspiration to implement new urban ideas, which often level down the value of historical architectural and town-planning structure as centuries-old heritage [3]. For many years, the insufficient consideration of towns specificity while conducting state administrative-territorial and social-economic reforms has made integrating the architectural heritage objects into modern urban systems more acute [1].

According to the State Programme of Towns Development [6], the planning and real estate development of town territories must consider landscape, historical, architectural, ecological, and other features and provide the preservation, restoration and renovation of the cultural heritage objects.

Among the established 2015 Sustainable Development Goals for Ukraine is a sustainable development of cities and territorial communities (Goal 11) [14]. The determining programme goals are as follows: the necessity to provide the cultural and natural heritage preservation attracting the private entities; development and implementation of urban development strategies directed at economic growth; employment creation; tourism, recreation and local culture development: local goods production. These are the components for ensuring sustainable development in certain territories. The historical and architectural facilities of towns serve the realisation of sustainable development strategies of the country. Their potential depends on such programme indicators as the number of cultural and natural heritage objects included in the UNESCO World Heritage List, the number of nationally important sites included in the State Register of Immovable Landmarks of Ukraine, and the number of touristic activity agents in Ukraine (Fig. 1). [14]

According to the Resolution of the Cabinet of Ministers of Ukraine, “Approval of the List of Historic Settlements of Ukraine”, 403 settlements have a “historic” status [11]. The term “historic settlement”, denoting a special status of cities and towns, is given to a settlement with wholly or partly preserved historic distribution area and cultural heritage objects, representing local traditions of planning and building form, common to particular cultures or the periods of development. The territorial distribution of the architectural heritage objects of the national and local value shows the most significant concentration of these landmarks precisely in the West of the country [10].

The historic and architectural facilities of the towns of Western Ukraine

The centuries-long history of the Western Ukraine lands (Volyn, Galychyna, Zakhidne Polissia, in particular), which not once appeared to be on the outskirts of different empires and states (Grand Duchy of Lithuania, Russian Empire, II Polish-Lithuanian Commonwealth), depicts diverse governing strategies concerning the development of the territories, taking place along with confrontation of a state and the ethical people, which inhabited it [8]. The experience of the previous generation, in some instances, reveals exceptional attention to the historic-architectural heritage of urban areas backed up by the national basis for further constructive social development of certain settlements, regions, and the state overall.

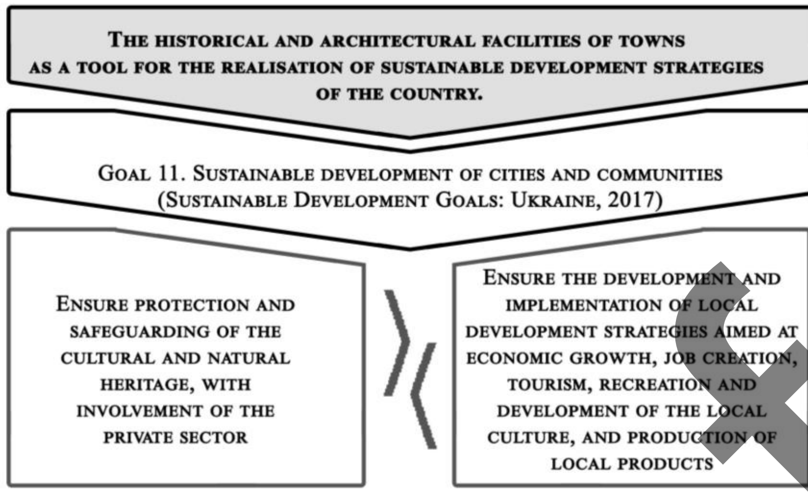

FIGURE 1. The historical and architectural facilities of towns as a tool for the realisation of sustainable development strategies of the country

The analysis of establishing a specific urban environment reveals the main influential factors for town development: ecological, economic, social-political, recreational, historical-cultural.

Any political-economical and social-cultural changes in the life of society manifest themselves in the integrational components of the state and quality of the processes of the territorial communities [2]. As a result, an authentic urban substance with familiar only for it town-planning ensemble in local landscape complex is formed.

On the territory of the Western Ukraine regions, we find 199 settlements with the "historic" status, which accounts for almost half of the nationwide number (Fig. 2) [17]. These are the towns with unique urban space (for example, cities of Kremenets, Vyshnivets, Dubno, Ostroh, Kovel, Chortkiv, Berezhany, etc.). They embody an inimitable combination of the natural environment and historic-architectural objects and represent certain epochs of urban development.

FIGURE 2. Location of small historic towns on the territory of the Western Ukraine region

FIGURE 3. The historic center of Kremenets (Ternopil region). Photo by the author, 2020

Keeping in mind the uniqueness of every place, it is essential to form the individual programmes of sustainable development, taking into account "the benefits, internal potential and attractiveness as the basis of locally-orientated strategies of steady development" [16].

The other development strategy of such settlements is fixed in the local development standards and master plan and is implemented according to the following criteria: restoration of historic planning spacial structure; renewal, renovation, adaptation and museumification of the cultural heritage objects; reconstruction and capital repairs of the objects of the coursed historic development [11]. In particular, to increase the region competitiveness, the Programme of Regional Development of Volyn suggests a range of projects aiming at repairing, restoration, and renovation building works at architectural monuments, monumental, parks and recreation art objects, tourism popularisation [13].

Paying close attention to the peculiarities of forming the sustainable development strategies of a particular town, we will consider the prospect of the historic-architectural usage of Kremenets Town (Ternopil Oblast) facilities (Fig. 3). The unique location of Kremenets on the hills of the Kremenets Mountains benefited the formation of the original planning structure of the town with an ancient history. The architectural and town-planning ensemble of the Volyn town has a chaotic nature of the streets' disposition compared to the sophisticated landscape complex. The main transport artery crosses the historic downtown area and the prominent Krements landmarks locate around it.

The goals and aims of the strategical development of Kremenets for the next few years in the area of town-planning, architecture and local environment design are to form a compact city model, "which is aimed at the creation of the high-quality local environment defined by the balance between historical values and functional opportunities, which is integrated by the infrastructure", promote the town as the historical and cultural centre of Kremenets Region [15]. Consequently, the programme anticipates the usage of the historic-architectural facilities for high-quality city infrastructure creation.

Complete implementation of the historic-architectural potential of the cities is possible within the context of the individual goals of regional development strategies, particularly the touristic industry development [13]. The objects of historic-cultural heritage (including architectural and town-planning landmarks) are the materialistic basis for the successful development of the tourism area as the components of region establishment [14].

The state programme of the town's development determines as reasonable to preserve cultural heritage within developing touristic trips to small cities [6]. The prospect of forming historic, historic-architectural, cultural and touristic centres in the towns benefits the preservation and possible economic use of landmarks, preserving buildings and facilities, the historic environment, limiting economic activity on the territory of historic areas of the towns [12].

Given the prospects of the touristic sphere during the global pandemic COVID-19, one should consider the possibility to use small cities in Western Ukraine as the objects of internal tourism. Consequently, the touristic proposal during the limited mobility of the population benefits the exploration of the touristic resources of the small town area.

Active globalisation raised the particular interest of the public community to level down the usual tourism forms to the benefit of diversity of leisure activities. Historic-cultural (cultural) tourism is developing. It aims to introduce the cultural environment of the visiting place, citizens' traditions and their lifestyle [4]. Historic-architectural facilities of the area become the basis for cultural tourism due to the regional practice of forming the viability environment with stylistic bounding to a certain age. The interest in the town history as the place of accumulation of the unique architectural, sculptural and park objects of previous periods benefits the popularisation of architectural tourism.

Since 2010, the implementation of the project "Touristic Volyn" has been in progress; the primary purpose is to form standard touristic products within the territory of historic Volyn (Rivne, Volyn, Zhytomyr, Khmelnytskyi and Ternopil Oblast). Within the project, the display of the historical areas of the Western Ukraine towns resulting from the existence here during the previous centuries of the unique cultural formation of the Eastern European Jews - "shtetls" is anticipated. Three touristic routes to the places of Jewish cultural heritage on the territory of borderlands are created: in Poland, Ukraine and Belarus [13]. Consequently, the potential of different towns historical-architectural environment is an indicator of the whole region development benefiting the popularisation of local landmarks outside one country as the resource for ethnographical-religious tourism.

The relevance of the consolidation of historic-architectural components of town spaces into the general system of the touristic area objects, which have strategical meaning, is connected with the possibility of drawing new investments for preserving and developing the social-cultural potential of the settlements [5].

At the current stage of human development, the crucial factor for successful sustainable development strategies implementation is the formation of the informational image of the region. [7]. Modern technologies and tools to inform about unique samples of historic-architectural heritage benefit society's increasing interest in national cultural heritage, popularisation landmarks on the state and international level.

CONCLUSION

Modern reality certifies sufficiently complex economic and political circumstances for Ukrainian society. Simultaneously, the discussion about the nature of sustainable development and the relevance of formation sustainable development strategies of our country is never-ending. The historical-architectural heritage as a part of the city infrastructure is one indicator of the successful implementation of sustainable development strategies. The architectural images and planning structure of small Ukrainian cities absorbed the features of historical ages, through which those urban entities passed in the process of their development. The life of poliethical local communities, the evolution of materialistic and spiritual culture with its regional specificity were to a certain extent displayed in them.

The successful usage of historical-architectural facilities of towns within sustainable development benefits the preservation and harmonic integration of historic areas into modern urban areas. It uses town-planning landmarks as indicators of regional development in the tourism area. Consequently, the unique town-planning ensembles of the downtown areas have a chance to exist and have a high-quality functioning in the future.

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The Use of Biological Activation of Microorganisms of Activated Sludge to Increase the Efficiency of Wastewater Treatment

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Abstract. Existing sewage treatment plants use technologies and treatment methods that do not always provide efficient and reliable wastewater treatment from organic contamination. Among the current methods and principles of wastewater treatment, biological methods, which are considered to be the most promising and environmentally sound, occupy a significant place, therefore, the intensification of biological wastewater treatment is an important task. In order to improve the efficiency of biological wastewater treatment processes, a method of biological activation the microorganisms of active sludge has been proposed, which has significant advantages over other methods. However, the lack of a sufficient scientific and technical base, the use of carboxylic acids to activate the active sludge causes the need for research on the effects of acids on wastewater treatment processes. Experimental studies of the effectiveness of biological stimulation of active sludge's bacteria with carboxylic acids are presented, theoretically and experimentally justifying the feasibility of consistent use for the treatment of active sludge by lemon and amber acids. The proposed method of intensification of biological wastewater treatment allows us to improve the efficiency of treatment in aeration tanks compared to biological cleansing without the addition of carboxylic acids. In addition, the use of carboxylic acids can have a comprehensive impact on cleaning processes: boost enzyme formation, suppress the development of filamentous bacteria, increase resistance to toxic pollution.

INTRODUCTION

Recently, the problem of rapid deterioration of water quality is becoming more and more urgent for Ukraine. The main causes of surface water pollution are the discharge of untreated and under-treated household and industrial wastewater.

Today there are changes in the nature of urban wastewater pollution, and a sharp increase in the composition of man-made communal drains contaminants, having a negative impact on the life of cleansing microorganisms. Additionally, the concentrations of nitrogen and phosphorus compounds are rapidly increasing in the original runoff.

Traditional technologies of biological treatment in modern conditions, which exist at most sewage treatment plants, do not allow for stable treatment cleaning during volley discharges of pollutants and do not provide effective and reliable wastewater treatment from organic contaminants and nitrogen and phosphorus compounds. The residual concentrations of which, have significantly increased in purified water.

This situation requires new technological and design solutions to effectively remove pollution with minimal operating costs and with environmental safety.

Therefore, in treatment plants where biological wastewater treatment is carried out in the traditional way, an important practical task is to intensify biological wastewater treatment and increase their efficiency.

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The study of methods of intensification and increasing the efficiency of biological wastewater treatment confirm [1–5] the environmental and economic benefits of the biological method of cleaning in aeration tanks with the help of active sludge microorganisms. However, the potential of the traditional process has actually been exhausted. The low efficiency of existing treatment plants leads to the deterioration of water systems.

An analytical review of modern ways to improve biological wastewater treatment from nitrogen and phosphate compounds has shown that the main areas of improvement - reducing energy costs, reducing the volume of facilities while ensuring high efficiency of nitrogen compounds removal [6, 7].

Several basic technological techniques have been developed to address the problem of deep wastewater treatment from organic substances and biogenic elements:

- SBR technology;
- technology of consecutive alternation of anaerobic, anaerobic and aerobic zones of biological cleaning;
- biomass concentration technology by combining biologically cleaned reactors of suspended and fixed form organisms or using special membranes.

SBR technology in general is a very cumbersomeresource and requires a fairly complex management system.

Among the methods proposed to improve the efficiency of household wastewater treatment, membrane technologies and nitrification - denitrification methods are considered common. The main disadvantages of the proposed solutions are the complex process of using chemical reagents to remove phosphates and energy dependence [8, 9].

In recent years, there has been an international search for simple but effective and cost-effective ways to intensify traditional methods of biological cleaning, including adding biologically active substances (BAS) in wastewater during treatment. One promising ways to improve the effectiveness of the biological wastewater treatment processes is the biological activation of microorganisms of active sludge, which has significant advantages over other methods [10, 5].

Analysis of the experience of using biologically active substances, namely carboxylic acids, indicates the lack of a sufficient scientific and technical basis for their use, which necessitates the need for integrated researchers to influence carboxylic acids on the wastewater treatment process.

MATERIALS AND METHODS

To increase the activity of enzymes and the selectivity of enzymatic oxidation in the microflora of active sludge, the method of biological activation of sludge is used, in which the sludge is treated with stimulating agents in the form of carboxylic acids. [11].

Studies on the treatment of the sludge field with carboxylic acids for biological stimulation of active sludge microorganisms have been performed in laboratory industrial conditions. Two acids, lemon and amber acids were used to treat active sludge [11].

All the solutions were prepared in distilled water and concentrated form, adding to the mixture the necessary calculated quantity. To avoid the possibility of undesirable changes in the biocenosis, a small part of active sludge,- 0.00001% of the total volume in working aeration tanks and regenerators, is processed [11].

In laboratory-industrial conditions, the effect of 2 fields of carboxylic acids on the processes of wastewater treatment was investigated during their introduction into a small fraction of active sludge treatment plants for further introduction of the obtained sludge solutions into aeration tank regenerators.

All the research was carried out on local material (wastewater and active sludge) in the laboratory of sewage treatment plants in Sumy.

Method of processing sludge by field of carboxylic *acids*

In practice, no more than 25 dm^3 of active sludge is processed in the laboratory. Processing sludge treatment was performed in the following sequence:

1. 20 - 25 dm^3 of active sludge is selected for processing, which is defended and thickened after settling to 10 dm^3 so that its concentration before processing was 4 - 6 g / dm^3. The condensed sludge mixture in any open vessel is placed in a cabinet with exhaust ventilation and aired continuously by an aquarium microcompressor. Active sludge is not fed before processing.

2. In parallel, a sample is taken for microscopic examination of the physiological state of active sludge microorganisms before treatment with carboxylic acid.

3. To eliminate the active action of carboxylic acid on cholera vibrio, which may be present in household wastewater, the pH of the sludge mixture is adjusted with a 1% solution of hydrochloric acid to 5.8 and aerated for 2 hours.

4. Then the pH is enhanced by an alkaline solution of potassium hydroxide (KOH) 2% to 7.5 with continuous aeration of the mixture.

5. Carboxylic acid of optimal concentration is added to the activated sludge: at stages 1 and 2 - 0.08% solution of citric acid in the sludge mixture (8 g of citric acid per 10 dm^3 of sludge mixture); in stage 3 - 0.08% solution of amber acid in the sludge mixture (8 g of amber acid per 10 dm^3 of sludge mixture). The mixture is aerated for 18 - 24 hours.

6. 200 cm^3 of clarified wastewater (top dressing) and 10 cm^3 of vitamin B solution (vitamin B1 - 3 ampoules, vitamin B6 - 3 ampoules, vitamin B12 - 4 ampoules) are added to the treated sludge. The mixture is aerated for 3 - 5 hours, but not more than 12 hours.

7. After the active sludge is grown, a sample is taken for microscopic examination of the physiological state of microorganisms.

8. According to the positive results of microscopy, the sludge mixture is processed in the regenerators of aeration tanks, directly in the supply zone of the reverse sludge feed area.

The resulting effect is achieved in 5–10 days to increase the cleaning effect on the main hydrochemical indicators and increase the microorganisms of active sludge.

Repeated processing (according to the same scheme) are mandatory, they should be 2-3 with an interval of 3-5 days.

Laboratory studies were performed in several stages, each of which solved the following tasks:

- At phase 1 comparative trials of the selected samples were carried out to determine the most effective and optimal variant of carboxylic acid concentration;
- At phase 2 extensive studies of the intensification of wastewater treatment processes with the selected option to increase the effect of combating filamentous swelling of active sludge and degradation of pollutants was carried out;
- At phase 3 studies were carried out to determine the rational parameters of the carboxylic acid regimen, as the peculiarity and benefit of the use of carboxylic acids is the possibility of gradually achieving the optimal dose value of sludge.

In addition, in phase 3 it was planned to study the effect of carboxylic acids on the increase in the species composition of microorganisms in active sludge.

Sampling for microscopic studies was carried out necessarily before and after biological activation of the active sludge field carboxylic acid. For hydrobiological control of active sludge, the dose of sludge, index and its dehydrogenase activity (DHA) were determined.

Samples for chemical tests were taken every day. During chemical analyses, appropriate measurement techniques were used for each indicator: NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, COD - photometric method, by color intensity; BOD_5 - tytrimetric method; weighted substances - gravimetric method [12, 13].

RESULTS AND DISCUSSIONS

At the treatment facilities in Sumy, the sequence processing of active sludge of activated sludge with carboxylic acids was determined: first citric acid and then amber acid.

In the processes of aerobic biological wastewater treatment, the most significant role is played by oxidative processes, the central position among which is dehydrogenation. Responsible for the dehydration reactions is dehydrogenases, the total activity of which is an indicator of the effectiveness of biological purification. Therefore, DHA (dehydrogenase activity) of microorganisms should be used as the main integral criterion for the oxidative ability of active sludge.

To confirm the effectiveness of the biological stimulation of active sludge's bacteria which were treated by carboxylic acids, the dehydrogenase activity of enzyme formation of active sludge was determined according to the method [14].

The toxicity of wastewater or the effectiveness of the biocleaning process is judged by the intensity of the coloration of the solutions obtained by oxidative recovery reactions. The more the enzyme dehydrogenase, the more intense the red colour of the studied water sample, the more destructive the contamination of sewage microorganisms, the more effective the clean-up.

The express method exists in various modifications, which is determined by the quality of the wastewater, specific conditions of the cleaning process, production technologies, the purpose of the study and so on.

Express method of definition of DHA allows qualitative assessment of the nature of the action of wastewater on the microorganisms of active sludge. The results of the completed study have been shown in **Fig. 1**.

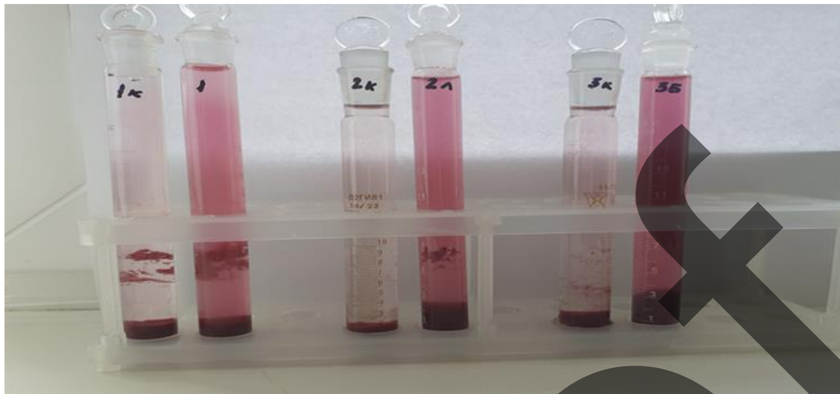

FIGURE 1. Definition of DHA – conducting 3 stages of treatment of biological method of active sludge:
1 – DHA after the first treatment with 0.08% citric acid solution of active sludge;
2l – DHA after the second treatment with 0.08% citric acid solution of active sludge;
3b – DHA after the third treatment with 0.08% amber acid solution of active sludge.

The lack of pink coloration or decrease in its intensity compared to control indicates the presence of toxic effects of wastewater on microorganisms and is a signal for immediate thorough analysis of wastewater entering the treatment plant. The following results were obtained during the study. It has been established that the total dehydrogenase activity of sludge after treatment with carboxylic acids increases without the introduction of additional substrate by 24%.The results of biological activation of active sludge microorganisms are presented in the Tab. 1 and Fig. 2 - 4.The results of the experiment show that the biological activation of active sludge provides a persistent effect of increasing the speed and depth of removal of pollutants and has a positive effect on the biocenosis of active sludge.

TABLE 1. Comparative table of concentrations of pollutants in the year of application of the method of biological activation of microorganisms of active sludge at the treatment facilities of Sumy

Indicators	The average concentration for 2018 mg/dm^3	Cleaning efficiency (2018), %	The average concentration for 2019, mg/dm^3	Cleaning Efficiency (2019), %	Allowable concentrations, mg / dm^3
Total suspended solids	24,3	92,1	19,8	93,8	15,0
Dry residue	915,6	6,8	827,4	15,8	1000
PH	8,0	-	8,0	-	6,5-8,5
Nitrogen ammonium	7,1	84,2	3,7	92,2	4,8
Nitrites	3,9	-	3,4	-	1,0
Nitrates	17,9	-	26,5	-	30,0
Chlorides	109,0	-	110,0	-	110,0
Sulphates	78,3	-	90,8	-	100
COD	44,1	90,5	36,3	95	37,0
BOD_5	16,9	90,9	15,0	95,1	15,0
BOD_{20}	22,1	90,3	19,1	95,5	-
Iron	0,23	86,0	0,22	87,2	0,3
Petroleum products	blc	-	blc	-	0,2
Surface-active compounds	blc	-	blc	-	0,05
Phosphates	6,5	39,3	6,0	42,0	5,7

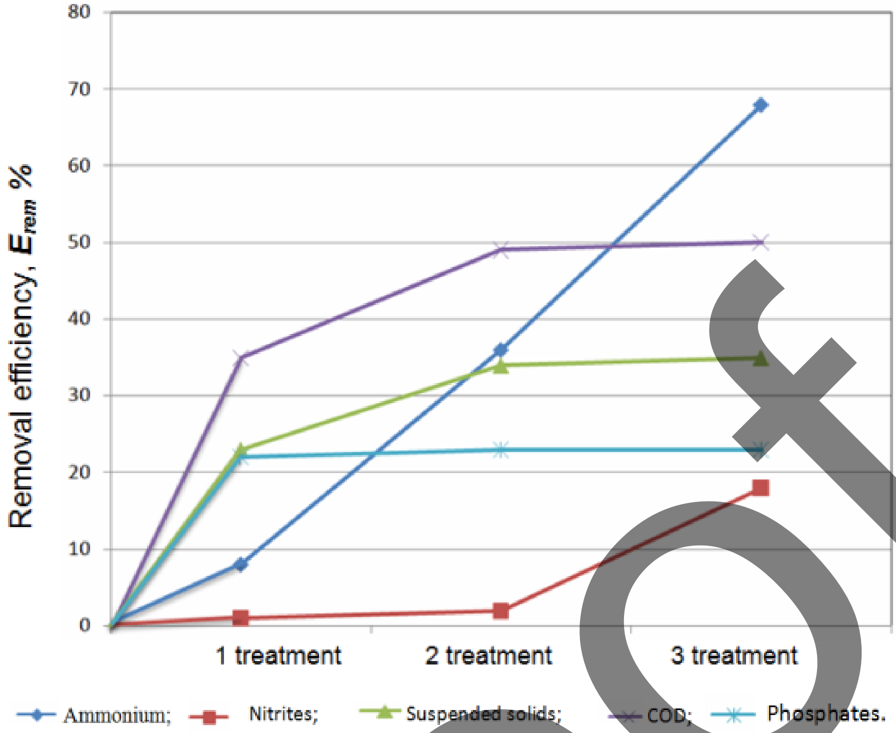

FIGURE 2. Dependence efficiency of pollutant removal from wastewater from successive treatments of fields with carboxylic acids:
1 treatment – 0,08% Citric acid; 2 treatment – 0,08% Citric acid; 3 treatment – 0,08% Succinic acid

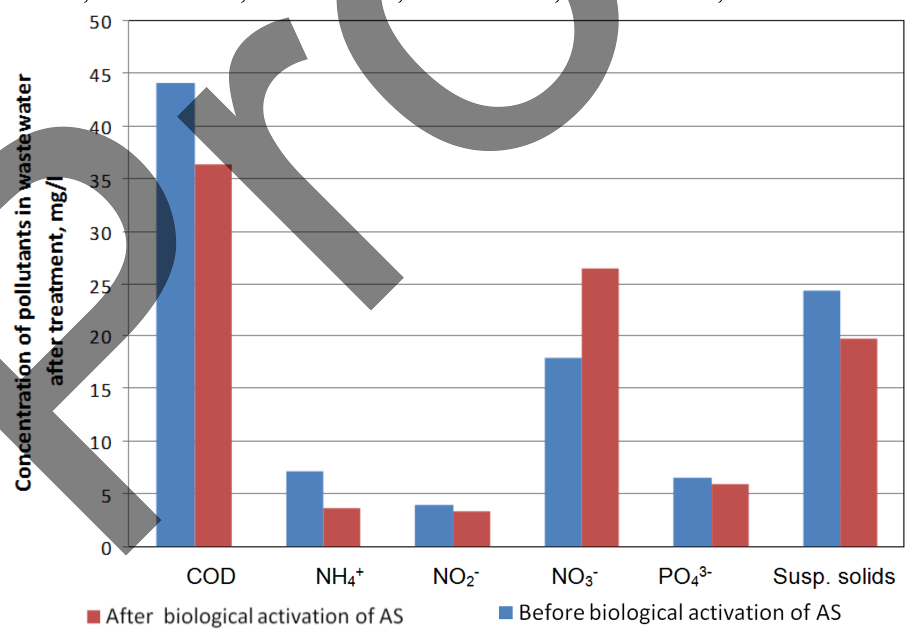

FIGURE 3. Changes in the concentration of pollutants in treated wastewater during the year of testing for the biological activation of carboxylic acid

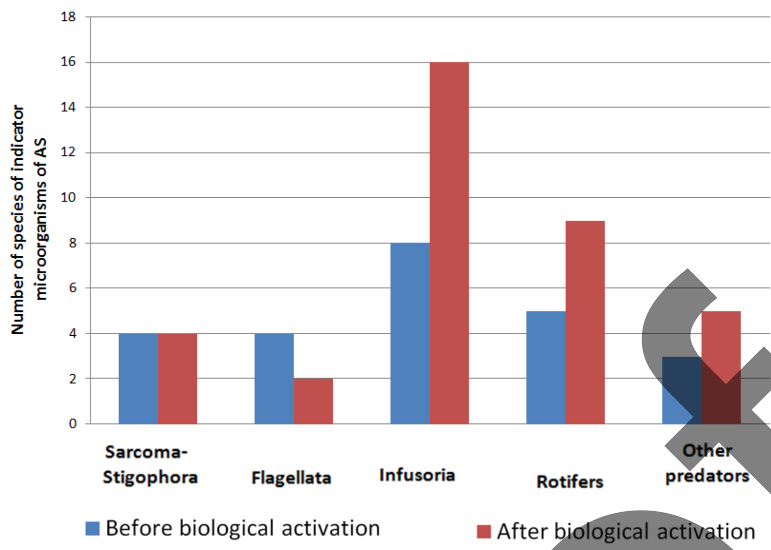

FIGURE 4. Influence of biological activation of microorganisms of active sludge on biocenosis of active sludge

As a result of the activation of active sludge (lemon and amber), according to the developed method, it has been established that populations of gel-forming saprophytic bacteria are formed in the active sludge, well adapted to the increased content of substrates and able to competitively inhibit the development of allochthonous, pathogenic and filamentous bacteria. In the biocenosis of active sludge a stable, and adapted to a given runoff microflora, is formed, which contains all the enzyme systems necessary for the degradation of the present pollutants. Active sludge after treatment improves its sedimentation properties.

DISCUSSION

As a result by experimental studies, biological activation of active sludge by carboxylic acids, provides a persistent effect of increasing the speed and depth of the extraction of pollutants and improving the properties of active sludge to give moisture. To theoretically explain this effect and understand the biochemical processes occurring in the bacterial cell under the influence of lemon and amber acids, the mechanisms of prokaryotic metabolism should be considered.

The Krebs cycle (tricarboxylic acid cycle (CTC)) is the central metabolic pathway of oxidation of organic molecules, which plays the role of "cellular fuel" [15]. CTC begins with the interaction (condensation) of a two-carbon molecule of acetyl - CoA (C2) with four-carbon (C4) oxaloacetic acid (oxaloacetate), which leads to the formation of a six-carbon (C6) molecule of citric acid (citrate), which is much lighter than acetate itself can dehydrogenated and decarboxylated, Fig. 5 [15].

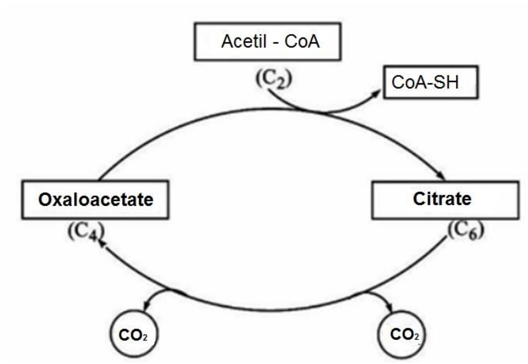

FIGURE 5. Scheme of the cycle of the citric acid

As a result of further multi-stage transformation of tri - and dicarboxylic acids (intermediates of CTC) there is a regeneration of oxaloacetate (C4) and two molecules of carbon dioxide are released.

In this cycle, under the action of specific enzymes, the processes of dehydrogenation of substrates take place, restorative equivalents of which (protons and electrons) enter the respiratory chain. The main way of biological oxidation is the dehydration of the substrate and the passage of active hydrogen (electrons) through the system of enzymes of hydrogen transporters to connect it with the final acceptor (in aerobic processes - oxygen). The number of hydrogen protons transmitted by the enzymes of the respiratory chain to O_2 is the total dehydrogenase activity of the microbial community. Dehydrogenation - the chipping of H_2 molecules from the acid cycle of Krebs occurs mainly by dehydrogenases. The addition of citric acid (a component of CTC) leads to an increase in the intensity of catabolic processes of the cell of the bacterium and increase the activity of dehydrogenases. Therefore, as a result of biological stimulation of active sludge, populations of resistant saprophytic bacteria are formed, which can inhibit the development of pathogenic and filamentous bacteria, and quickly adapt in wastewater and produce important enzymes.

CONCLUSION

Thus, an effective way to intensify biological wastewater treatment from various contaminants has been proposed. The use of carboxylic acids can have a comprehensive effect on cleaning processes: increase enzyme production, suppress the development of filamentous bacteria, increase resistance to toxic pollution. The advantages of the proposed method are:

- improving the efficiency of biological wastewater treatment in aeration tanks compared to biological treatment without the addition of carboxylic acids. Experimentally confirmed the feasibility of using citric and amber acids, which intensify the processes of biological cleaning (BOD_5 - by 5.2%, COD - by 4.5%, ammonium nitrogen - by 8%, orthophosphates - by 2.7%) and contribute to suppression of the development of filamentous bacteria.

- it has been established that with the introduction of carboxylic acids, the rate of oxidation of organic substances in aeration tanks increases 1.5 times in the final range of BOD_5 10-15 mgO / dm^3, the rate of decrease of ammonium nitrogen increases by 8% in the range of its final concentration 1 - 2 mg / dm^3 .

The proposed technology does not require reconstruction of facilities and does not lead to additional pollution of rivers, and is environmentally friendly. It is advisable that the introduction carboxylic acids is carried out with mandatory hydrobiological control and the re-introduction of the newly formed colonies of bacteria in the regenerators of aeration tanks.

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Environmental Risk Assessment of the Impact of Sewer Networks on the Environment in the Context of Sustainable Urban Development

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Abstract. The paper assesses the environmental risks of the impact of sewer networks on the whole of the environment components such as atmospheric air, soils and water environment as a prerequisite for sustainable urban development. An algorithmic support for the analysis of environmental risks that occur during operation or in case of emergencies in sewer networks has been developed. The risk assessment was performed for 11 sewer shafts in Kharkiv based on field measurements: for atmospheric air, according to four environmentally hazardous gaseous substances generated in sewer networks; for water environment and soils, according to 12 indicators and pollutants. A high level of environmental risk to atmospheric air has been found in three shafts. Environmental risks to the water environment and soils are imposed by phosphates and synthetic surfactants.

INTRODUCTION

Conducting research into the problems of sustainable urban development is an essential condition for ensuring the principles of environmental safety of the natural environment (NE) objects. It is cities that have a special role to play in achieving sustainable development because they are centers of significant environmental load. Sustainable urban development is understood as socially, economically and environmentally balanced changes in the social and territorial system of the city, which are aimed at fully implementing all the components of the city's potential and preventing the deterioration of the living standards [1], one of the elements of which is environmental safety. The sustainability of the city affects the possibility of implementing the principles of sustainable development of higher level systems and depends on the sustainability of all the components of the social and economic system of the city.

The concept of sustainable development has combined the three main components of society development such as economic, social and environment-oriented on a system level. From an environmental point of view, sustainable development is to ensure the integrity of biological and physical natural systems and their viability. Within the city, the viability of natural systems, primarily people, the city's population, depends on the environmental safety of living conditions. It is important for the practical implementation of the principles of sustainable development of the city not only to determine its resource endowment (resources, their structure, cost, potential), but also to analyze the

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situation in different activities, areas of economic activity and their interaction [2]. In the context of the above, one of the important aspects of sustainable urban development is the environmental safety of sewer networks. Risk assessment methods are used to determine the level of environmental hazard. In general terms, an environmental risk is understood as the probability of adverse consequences for the environment from any changes occurring in natural objects [3]. Management decision-making to reduce the level of environmental risk is associated with the probability of occurrence of man-made accidents that cause significant damage to the environment and human health [4]. An environmental risk is defined as a probabilistic characteristic of the implementation of the occurrence or absence of negative impact of man-made factors on the components of the environment.

The purpose of assessing the environmental risks of accidental emissions and discharges that may enter the natural environment (NE) due to accidents in sewer networks is to identify hazardous factors of impact, obtain and summarize information on the levels and consequences of their action and determine the likelihood of consequences to prevent the development of adverse effects in order to justify management decisions to reduce the level of risk. The procedure for assessing the environmental risks of impact on NE objects is arranged in three stages: hazard identification, risk assessment and risk characterization (figure 1) [5].

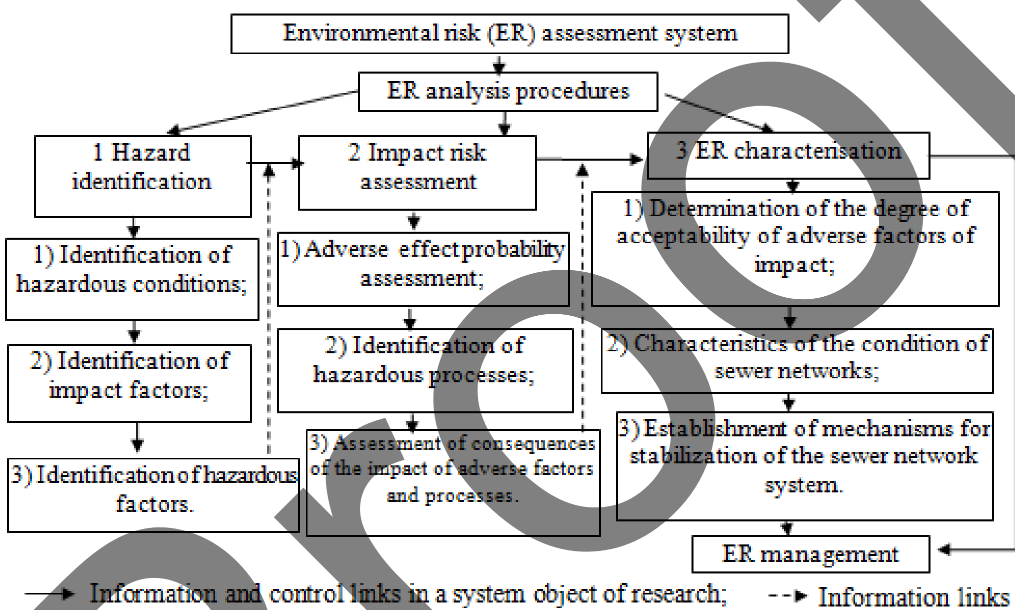

FIGURE 1. A flow diagram for the environmental risk assessment procedure

Hazard identification is the initial stage of the risk assessment procedure, which involves establishing the ability of a hazardous factor to cause adverse effects or consequences in the components of NE. The main task of this stage is to assess the completeness and reliability of existing data, collect and analyze information on quantitative indicators of hazardous factors of impact (concentration, dose, intensity of damage), determine priority data, for instance, based on preliminary cluster analysis. The initial data obtained at the hazard identification stage are then used to assess the risk of impact of hazardous factors on NE objects.

At the second stage of the risk assessment procedure, impact risk assessment, causal links between the impact of a potentially hazardous factor and the development of adverse effects and consequences of the object of impact are identified, a quantitative risk assessment is performed in the form of the probability of occurrence of a threat to the condition of the NE components (atmospheric air, soils, water bodies).

The third stage involves risk assessment according to different categories and types. Based on the generalization of the obtained data, recommendations are proposed that are necessary for the development of risk management measures [6].

Environmental risk assessment is a generalized characteristic of the impact of sewer networks on the NE and the consequences of their operation [7].

The assessment of the overall level of environmental risk on the basis of process flow indices in the research system is carried out on a verbal-point scale of levels of environmental risk (table 1) [8].

TABLE 1. Scale for determining the overall level of environmental risk

Item No.	Value	Risk assessment
1	0-1	No risk
2	1-1.5	Low risk
3	1.5-3.0	Moderate risk
4	3-4	High risk
5	>4	Maximum risk

The environmental risk assessment according to load factors is interpreted on a scale (table 2).

TABLE 2. Scale for determining environmental risks with reference to the processes in the research system

Item No.	Value	Risk assessment
1	$0–10^{-8}$	No risk
2	$10^{-8}–10^{-6}$	Low risk
3	$10^{-6}–10^{-4}$	Moderate risk
4	$>10^{-4}$	High risk

After reviewing the reduction in the operating life of sewer tunnels, the main groups of consequences caused by emergencies have been categorized; in particular, the following groups have been identified: ecological; economic; technical; social; innovative.

The ecological group of consequences of impact includes impacts on atmospheric air, soils, water environment (table 3) [9].

TABLE 3. Scale for determining environmental risks with reference to the processes in the research system

Area of impact	Value	Risk assessment
Atmosphere	Emissions of hydrogen sulfide, mercaptan, sulfur dioxide, carbon dioxide, methane, etc.	Intense man-caused load on the natural environment, which is a source of significant environmental hazards for urban regions, especially if the maximum permissible concentrations of substances of the second hazard class are exceeded
Hydrosphere	Entry into groundwater	Changes in the chemical composition of water and the appearance of other undesirable components that threaten environmental safety
	Entry into surface water sources	Dangerous increase in concentrations of substances and pollution of the main sources of water supply
Lithosphere	Flooding of territories and disturbances of water exchange	Increase in the level of groundwater and their corrosion activity owing to contamination with fecal water causes the activation of karst processes, which leads to the formation of karst dips, which threatens structures; destruction of the body of foundations; corrosion of reinforcement and concrete; deterioration of mechanical properties of soils (shear resistance decreases)
	Soil degradation	Deterioration of useful properties and soil fertility
	Suppression of the plant complex	Decreased seed germination, slow plant growth, abnormal development of root systems, chlorosis, wilting, plant death
	Contamination of the top layer of soil with heavy metals	Toxic heavy metals, even in minimal quantities, are not subject to decomposition processes, but can only be redistributed between natural environments, so they are concentrated in living organisms, causing various pathologies

OBJECTS AND RESEARCH METHODS

The purpose of the research is to calculate the assessment of environmental risks of impact on the NE components, which can be created by the shafts of sewer networks during their operation.

The object of the research is 11 sewer shafts located in different districts in Kharkiv. The subject of the research is the methodological support for assessing the environmental risks of impact on NE objects. To achieve the goal, the research needs to complete the tasks as follows:

1) To build a mathematical model of probabilistic risk assessment of the level of environmental safety for NE objects to identify and prevent emergencies in sewer networks to ensure sustainable development of urban communities;

2) To develop an algorithmic support for environmental risk analysis based on probabilistic characteristics;

3) To practically test the algorithmic support for environmental risk assessment of hazardous impact on NE objects so as to ensure the objectivity of management decisions.

RESULTS AND DISCUSSION

Input information for assessing the environmental risks of impact on atmospheric air, water environment and soil was provided by the chemical laboratory of Public Utility Company Kharkivvodokanal. The annual average monitoring data (2015 to 2019) of instrumental measurements of environmentally hazardous gaseous compounds contained in the sub-vault space of the sewers for eleven shafts, which are located in different areas in Kharkiv are given in table 4 [10].

TABLE 4. The annual average monitoring data (2015 to 2019) for concentrations of pollutants contained in the sub-vault space of the sewers

Shaft/Indicator	SO_2, mg/m^3	H_2S, mg/m^3	CO_2, wt%	CH_4, wt%
Maximum allowable concentrations (MAC) of the working area	10	10		50 (SRLI)
Hazard class	2	2		
Shaft at the intersection of Novo-Bavarskyi prospekt and Dzyuby prospekt	28.94	1.08	0.53	0.50
Shaft No.5 of KhTZ tunnel	30.2	1.45	0.66	0.69
Shaft No.4 of KhTZ tunnel	14.3	0.195	0.57	0.52
Shaft No. 3 of the tunnel of Avtozapchastyna Plant	1.12	0.068	0.52	0.33
Shaft No. 1 of the Osnovianskyi sewer tunnel	4.38	0.06	0.2	0.3
Shaft No. 5 on Zubareva street	4.38	0.06	0.2	0.3
Shaft No. 10 of the KhTZ tunnel	22.6	0.9	0.56	0.6
Shaft No. 12 of the KhTZ tunnel	33.8	1.5	1.8	2.2
Shaft No. 3 of the Main tunnel	11	0.15	0.51	0.42
Shaft No. 4 of the tunnel of the Northern group of plants	13	0.13	0.9	0.85
Shaft No. 4a of the tunnel of the Northern group of plants	16.7	0.49	1.2	1.2

The annual average data (2018 to 2019) for concentrations of pollutants contained in wastewater that is transported to municipal sewage treatment plants (MSTP) No.1 (referred to as Dykanivski treatment facilities) and No. 2 (referred to as Bezlyudivski treatment facilities) are given in table 5.

The calculation of the environmental risk assessment of the hazardous impact on the environment components is proposed to be performed based on the probability of occurrence of adverse effects from the identified violations in the NE systems during the period of negative impact of all sources of pollution. Load factors on the natural component of the NE are determined according to the results of the safety assessment of atmospheric air, water environment and soils. (figure 2) [11, 12].

TABLE 5. The annual average monitoring data (2015 to 2019) for concentrations of pollutants contained in the sub-vault space of the sewers

Indicators	MAC, mg/L	Hazard class	Value for MSTP1, mg/L	Value for MSTP2, mg/L
BOD5	300	2	185.51	239.61
Petroleum products	5	4	5.93	1.66
Nitrates	45	3	0.73	1.13
Nitrites	3.3	2	0.34	0.20
Chlorides	350	4	126.00	140.46
Sulfates	400	4	240.58	230.92
Hexavalent chromium	0.13	3	0.03	0.02
Nickel	0.2	3	0.13	0.05
Zinc	0.5	3	0.35	0.05
Phosphates	6	3	23.80	13.09
Copper	1	3	0.01	0.04
SS	0.5	3	1.69	1.56

According to the algorithm shown in Fig. 2, and according to the environmental risk identification scale with reference to the processes in the system of research (sewer networks) (table 2), an environmental assessment of the condition of man-made objects is obtained based on the monitoring of 11 sewer tunnels with determination of hazardous impact indicators. The developed algorithmic support of risk assessment of a man-made object takes into account the origin of the adverse impact factors, the consequences of an adverse factor for the NE components. Table 6 shows the results of the general and factor-by-factor assessment of the environmental risk impact of sewer tunnel shafts on atmospheric air.

TABLE 6. Results of the general and factor-by-factor assessment of the environmental risk of the impact of the sewer tunnel shafts on atmospheric air

Substance	Shaft at the intersection of Novo-Bavarskyi prospekt and Dzyuby prospekt	Shaft No.5 of KhTZ tunnel	Shaft No.4 of KhTZ tunnel	Shaft No. 3 of the tunnel of Avtozapchastyna Plant	Shaft No. 1 of the Osnovianskyi sewer tunnel	Shaft No. 5 on Zubareva street	Shaft No. 10 of the KhTZ tunnel	Shaft No. 12 of the KhTZ tunnel	Shaft No. 3 of the Main tunnel	Shaft No. 4 of the tunnel of the Northern group of plants	Shaft No. 4a of the tunnel of the Northern group of plants
SO_2, mg/m^3	1.09×10^{-5}	10^{-5}	1.12×10^{-5}	8.47×10^{-6}	7.08×10^{-6}	7.37×10^{-6}	9.72×10^{-6}	1.21×10^{-5}	8.06×10^{-5}	8.3×10^{-6}	8.8×10^{-6}
H_2S, mg/m^3	10^{-3}	5.16×10^{-3}	3.18×10^{-3}	1.28×10^{-5}	8.27×10^{-6}	8.09×10^{-6}	5.16×10^{-3}	3.51×10^{-3}	1.08×10^{-5}	10^{-5}	5.66×10^{-5}
CO_2, wt%	7.72×10^{-6}	7.63×10^{-6}	7.93×10^{-6}	7.79×10^{-6}	7.71×10^{-6}	7.24×10^{-6}	7.77×10^{-6}	1.05×10^{-5}	7.69×10^{-6}	8.37×10^{-6}	8.98×10^{-6}
CH_4, wt%	7.14×10^{-6}	7.13×10^{-6}	7.2×10^{-6}	7.15×10^{-6}	7.09×10^{-6}	7.08×10^{-6}	7.18×10^{-6}	7.75×10^{-6}	7.12×10^{-6}	7.26×10^{-6}	7.38×10^{-6}
General risk	3.08	2.99	3.10	0.54	0.45	0.48	2.79	2.07	0.51	0.27	0.85

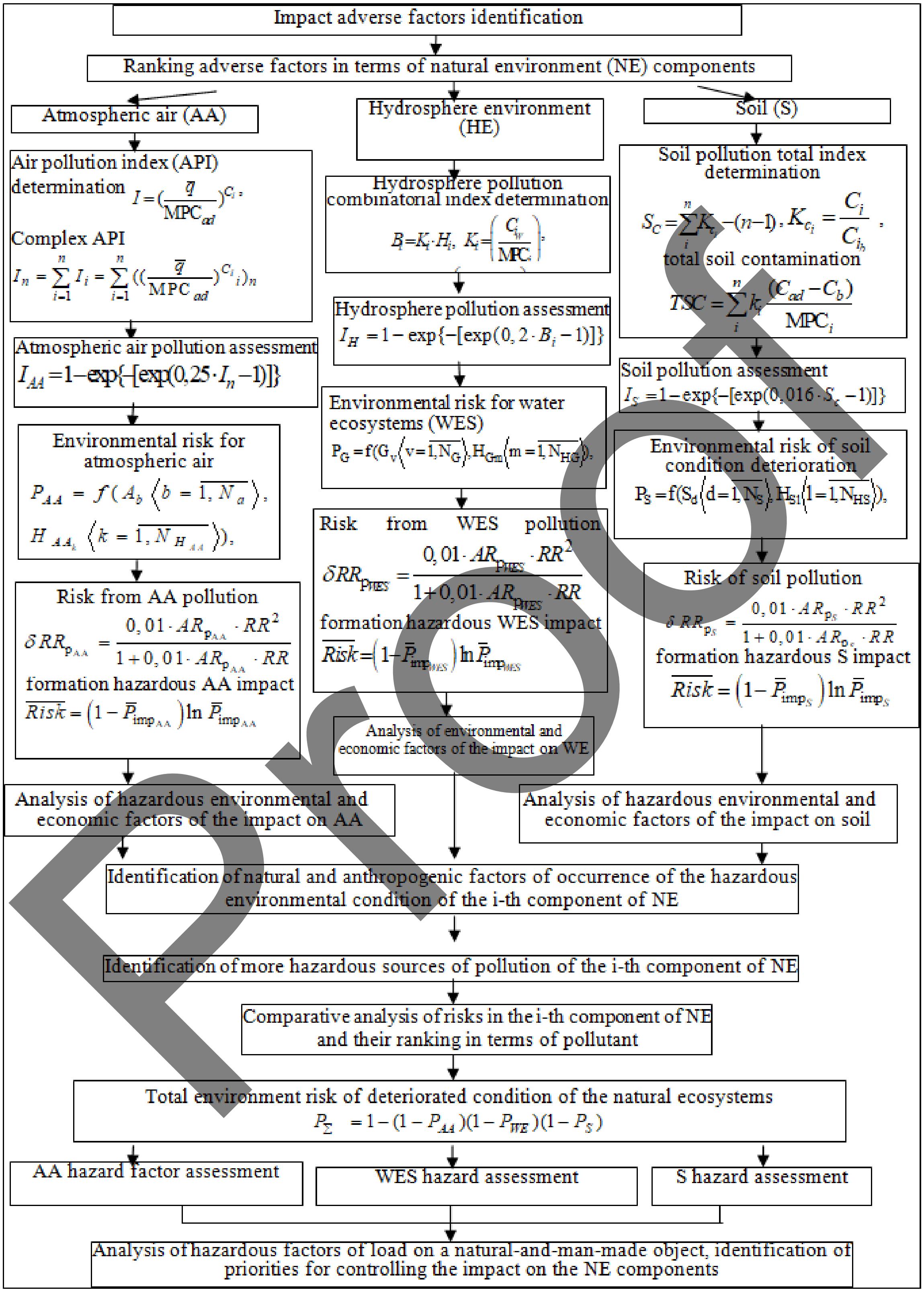

FIGURE 2. A flow diagram for the algorithmic support for the environmental risk analysis

As can be seen from table 4, Shaft No. 3 of the tunnel of Avtozapchastyna Plant, Shaft No. 1 of the Osnovianskyi sewer tunnel, Shaft No. 5 on Zubareva street, Shaft No. 3 of the Main tunnel, Shaft No. 4 of the tunnel of the Northern group of plants and Shaft No. 4a of the tunnel of the Northern group of plants have a low level of risk; Shaft No. 10 of the KhTZ tunnel, Shaft No. 12 of the KhTZ tunnel have a moderate level of risk; Shaft at the intersection of Novo-Bavarskyi prospekt and Dzyuby prospekt, Shaft No. 5 of the KhTZ tunnel, Shaft No. 4 of the KhTZ tunnel have a high level of risk. According to the results of the general and factor-by-factor assessment of the environmental risk of the impact of the sewer tunnel shafts on atmospheric air, hydrogen sulfide and sulfur dioxide are found to be the most important load and hazard factors. Figures 3 and 4 show the diagrams of environmental risks of the impact of sulfur dioxide and hydrogen sulfide on atmospheric air.

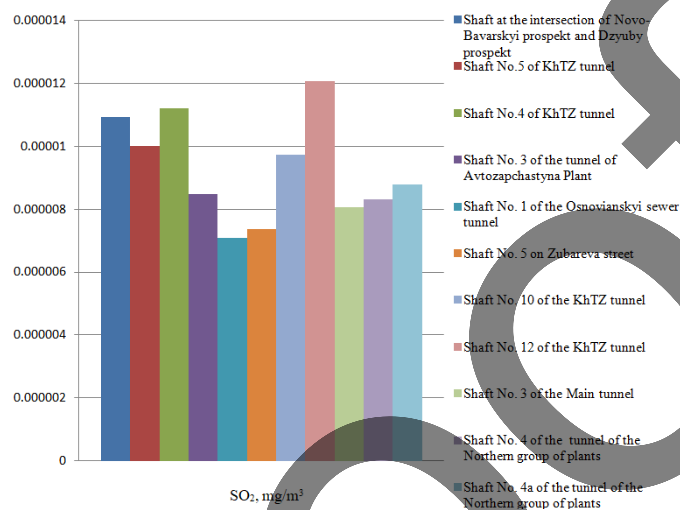

FIGURE 3. Significance of environmental risks of the impact of sulfur dioxide on atmospheric air

Table 7 shows the results of risk assessment of the impact of sewer tunnel shafts on water bodies and soils. The risk may arise owing to an accidental discharge of wastewater transported through sewer networks to the surface and its entry into surface waters, groundwater aquifers and soil. The qualitative composition of wastewater is monitored according to 21 indicators. The concentrations of the following pollutants and values are measured: ammonium nitrogen, total BOD, BOD5, suspended solids, petroleum products, dry residue, nitrates, nitrites, chlorides, sulfates, total iron, trivalent chromium, hexavalent chromium, nickel, zinc, phosphates, copper, synthetic surfactants (SS), phenols, COD, dissolved oxygen.

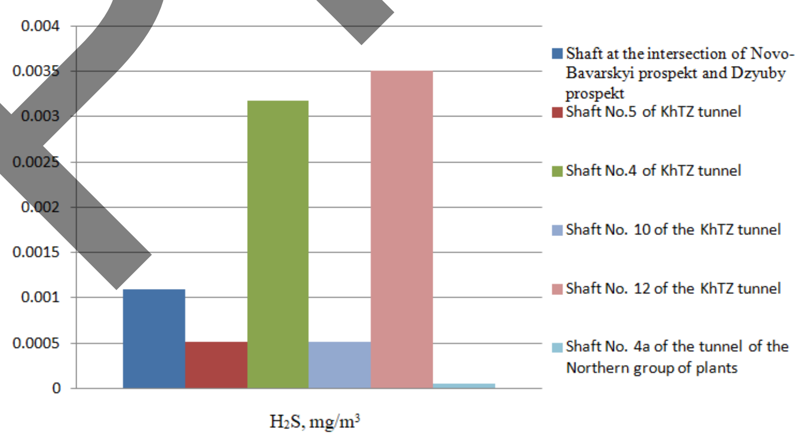

FIGURE 4. Significance of environmental risks of the impact of hydrogen sulfide on atmospheric air

The risk assessment took into account the 12 most environmentally hazardous substances, for which the maximum allowable concentrations are exceeded. Shaft at the intersection of Novo-Bavarskyi prospekt and Dzyuby prospekt, shaft No. 1 of the Osnovianskyi sewer tunnel, shaft No. 5 on Zubareva street, shaft No. 10 of the KhTZ tunnel, shaft No. 12 of the KhTZ tunnel are located in the sewers that transport wastewater to municipal sewage treatment plant No. 1 “Dykanivski treatment facilities” (MSTP1).

Shaft No. 5 of the KhTZ tunnel, shaft No. 4 of the KhTZ tunnel, shaft No. 3 of the tunnel of Avtozapchastyna Plant, shaft No. 3 of the Main tunnel, shaft No. 4 of the tunnel of the Northern group of plants, shaft No.4a of the tunnel of the Northern group of plants are located in the sewers that transport wastewater to municipal sewage treatment plant No. 2 “Bezlyudivski treatment facilities” (MSTP2).

Table 7 shows the results of the risk assessment of the impact of the shafts on water bodies and soils that may occur in case of an emergency situation in sewer tunnels.

TABLE 7. Results of the risk assessment of the impact of the sewer tunnel shafts on water bodies and soils

	BOD5	**Petroleum products**	**Nitrates**	**Nitrites**	**Chlorides**	**Sulfates**	**Hexavalent chromium**	**Nickel**	**Zinc**	**Phosphates**	**Copper**	**SS**
MSTP1	9.6×10^{-5}	9.5×10^{-5}	8.1×10^{-5}	8.3×10^{-5}	8.5×10^{-5}	8.8×10^{-5}	8.4×10^{-5}	9.1×10^{-5}	9.2×10^{-5}	1.9×10^{-3}	8.1×10^{-5}	1.6×10^{-3}
MSTP2	10^{-3}	8.4×10^{-5}	8.1×10^{-5}	8.2×10^{-5}	8.5×10^{-5}	8.7×10^{-5}	8.2×10^{-5}	8.4×10^{-5}	8.2×10^{-5}	1.2×10^{-3}	8.1×10^{-5}	1.5×10^{-3}

As can be seen from table 7, phosphates and SS are found to be the most significant factors in terms of load and hazard to the water environment and soils.

Figure 5 shows the significance of the environmental risks of the impact of phosphates and SS on the water environment and soils.

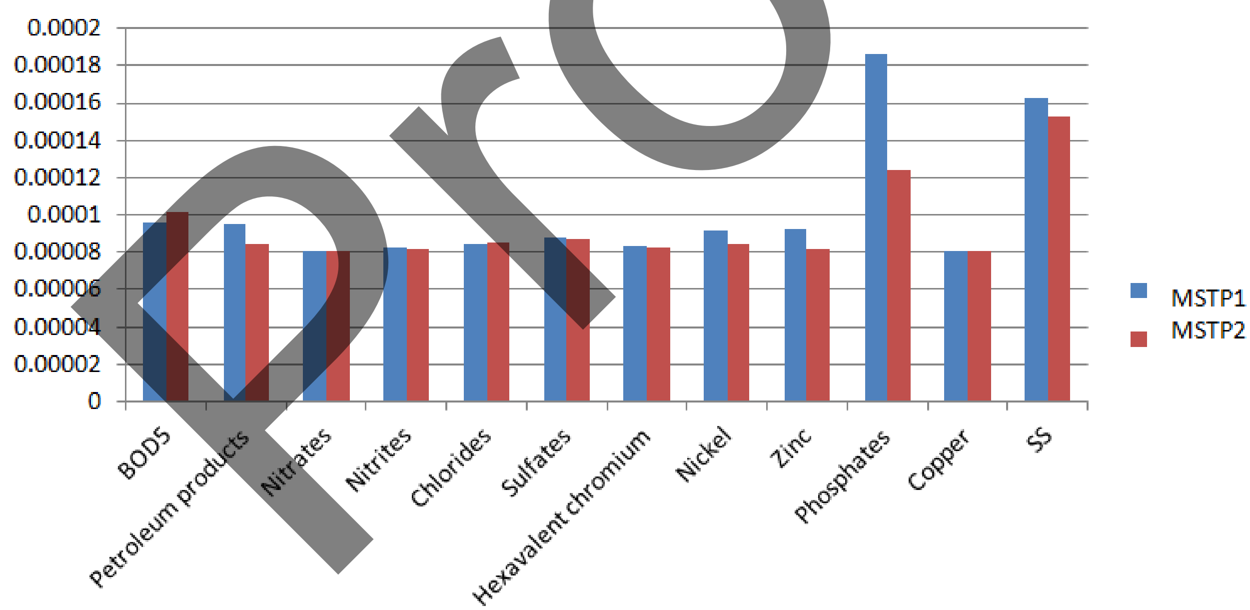

FIGURE 5. Significance of the environmental risks of the impact of phosphates and SS on the water environment and soils

CONCLUSIONS

One of the most important factors in ensuring the sustainable development of cities is the admissible condition of atmospheric air, water environment and soil. Sewer network shafts are one of the important sources of load on the NE components.

The impact of sewer tunnel shafts on atmospheric air, water bodies and soils has been studied based on the developed mathematical model of probabilistic risk assessment of the level of environmental safety for NE objects to identify and prevent emergencies in sewer networks to ensure sustainable development of urban communities.

The developed algorithmic support for the environmental risk analysis has been field-tested in 11 sewer shafts in Kharkiv. A high level of environmental risk of the impact on atmospheric air in teerms of hydrogen sulfide and sulfur dioxide contents has been found in three shafts, particularly, Shaft at the intersection of Novo-Bavarskyi prospekt and Dzyuby prospekt, Shaft No. 5 of the KhTZ tunnel, Shaft No. 4 of the KhTZ tunnel. A high level of environmental risk of of the impact on the water environment and soils in terms of phosphates and SS contents has been been found in six shafts being part of MSTP2

The application of the algorithmic support proposed by the paper for the environmental risk analysis will allow making objective management decisions to identify at early stages and prevent emergencies occurring in sewer networks.

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To the Point of Attribution of the Architectural Ensemble in Stariy Merchyk - Object of Urban and Architectural Cultural Heritage of National Value

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Abstract. A significant amount of lost monuments over the years of independence in Ukraine characterize the current situation as critical, first of all, in relation to the complex monuments. Based on the engaging of new materials and documents, the article analyzes the current state of study of the Stariy Merchik, manor and park ensemble in the Kharkiv region, as a justification for a modern assessment of its historical, cultural and urban planning value. The sources of the study of the monument are systematized in accordance with the historical periodization, the main stages of the creation, research and operation of the monument. Based on the historical and genetic analysis, the degree of losses and risks is analyzed, the historical values, town-forming significance in the spatial structure of the residential landscape are revealed, the completeness of the embodiment of the architectural concept and artistic features are specified. The article analyzes historical and new materials confirming the information about the authorship of the palace in Merchik by the famous architect of classicism V.I. Bazhenov. The compositional features of the spatial structure of the estate ensemble and the semantics of the architecture of the palace building were traced. Conclusions were made about the completeness of preliminary research and the need to draw up a program for the preservation, recreation and museumification of the monument, as it is one of the most significant objects of early classicism on the territory of the former Sloboda Ukraine.

INTRODUCTION

The methodology for preserving architectural monuments and urban planning is formed in the process of preliminary research of cultural heritage objects, in connection with the need to study it, preserve and authenticate its elements of the material and spatial structure, determine the historical and cultural values of the elements of the spatial ensemble and their territories. Significant socio-economic transformations in Ukraine that were associated with a change in the forms of ownership of real estate, a change in the use of the functions of historical monuments, forced the need to search and justify an adequate modern use of the new time. A significant amount of lost monuments over the years of independence in Ukraine characterize the current situation as critical, first of all, in relation to the considered monument complexes. The current situation has greatly aggravated the preservation of immovable cultural heritage included in the residential and industrial landscapes of villages and historical cities. Such objects include suburban palace and park ensembles and complexes, which at one time gained great fame, recognized in the period after the Second World War as objects of architectural and urban planning heritage of national importance, significant in terms of historical and cultural value.

RESEARCH MATERIALS AND METHODS

The ensemble of a country estate in Stariy Merchik in the Kharkiv region is considered one of the most significant architectural monuments of early classicism in Ukraine. The territory of the former Sloboda Ukraine until 1917, geographically, occupied a vast region of the Russian-Ukrainian border. A significant layer of the heritage of this

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typological group of monuments that has survived to date is of interest as a phenomenon in the history of architecture of Ukraine, which developed during the last quarter of the 18th - first half of the 19th centuries. The Stariy Merchik ensemble was created at the first stage of the development of classicism, which retained the features of the early period of the style formation. Ideologically, the architecture of palace and park ensembles developed as a vast cultural phenomenon that embraced the countries of Central and Eastern Europe, capital cities and deep provinces. The sources for the study of the Stariy Merchik palace and park ensemble are systematized in accordance with the historical periodization, the main stages of the creation and operation of the monument. Based on the historical and genetic analysis, the degree of its historical and cultural value, the completeness of the embodiment of the architectural concept, and artistic features are confirmed.

Historical Features of the Formation of the Estate Ensemble

The foundation of the Stariy Merchik settlement dates back to the period of the existence of the Kharkiv Sloboda Cossack Regiment. The estate in Stariy Merchik during this period was part of the land holdings of F.V. Shidlovsky (? -1677 - 1719) - the Colonel of Izyum and Kharkov regiments, later transferred to Colonel L.I. Shidlovsky (1687-1739), the founder of the Shidlovsky family of elders in Slobozhanshchina. F.V.Shidlovsky since 1707 was appointed as a head of all Sloboda Cossack regiments, in 1711 he was accused of exceeding official powers, deprived of all officials and titles. Last living years in Moscow and Kharkov. On the site of a wooden manor house, a descendant of the founder of the estate G.R. Shidlovsky in 1776-1778 built a new stone palace with a complex of manor buildings that formed an ensemble. [1]. The breakdown of the park and the construction of park structures belong to this time. On the site of the old church in 1778, a new stone church was built in the style of the main manor buildings. [2]. G.R. Shydlovsky (1752-1820) was a real state councilor, a state official of the Russian Empire, in the period from 1796 to 1800 - the vice-governor of the Slobodsko-Ukrainian province. He belonged to the most prosperous group of the Kharkiv nobility, was engaged in educational activities, was a member of the educational circle "Popov Academy", formed by A.A. Palitsin in 1767 [3].

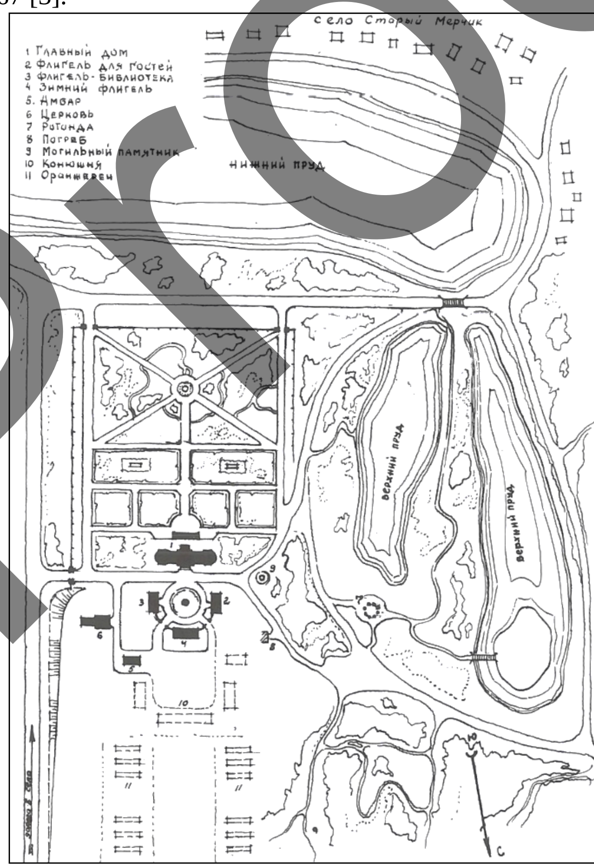

FIGURE 1. The plan of the Stariy Merchik estate. 1956–1957. Prepared by architect V. Nesterov

In the 1830s, after the death of G.R. Shidlovsky, the estate was bought by Count V.V. Orlov - Denisov, hero of the Patriotic War of 1812. After the serf reform, the estate of Stariy Merchik passed into the possession of N.A. Luzhina, and from 1871 to 1918, railway engineer E.M. Dukhovskoy. In the middle of the 19th century, the village of Stariy Merchik was the center of the volost. According to information from 1859, 1898 inhabitants lived there. The landowner's estate employed 329 people.

Urban Planning Significance and Spatial Solution of the Architectural Ensemble of the Estate

The village, formed in the upper reaches of the Mokriy Merchik River, had a street planning system. The estate occupied a central position in the structure of the village. The complex of the palace estate was located on the slope of the southern exposure, perceived from remote areas of the residential landscape against the background of the surrounding park. At the base of the valley of the Mokriy Merchik River, a developed system of ponds was arranged; on the slopes of a deep gully, a landscape park was formed on the basis of existing vegetation, which occupied an area of about 70 hectares. In addition to stone buildings in the ensemble of the estate, a horse yard (not preserved), a church with a bell tower, an almshouse and buildings of the volost government were built. The village housed a saltpeter and brick factories [4], a distillery and a parquet factory [5]. In the second half of the 19th century, a distillery and a horse factory were built on the estate. The capitalization of enterprises led to an increase in trade turnover, the revitalization of the activity of the parquet plant, which had fame in Russia at the end of the 18th century.

The spatial composition of the manor ensemble is formed by the example of the ceremonial palace and park ensembles according to a scheme that takes into account the orientation of the palace building to the surrounding residential landscape and the natural environment of the landscape park, as seen in Fig. 1. The front yard of the estate is formed by a two-story palace on a high base and a two-story building of services. Symmetrically located one-story wings closed the front space of the courtyard. A terrace was arranged along the main axis of the ensemble in front of the southern garden facade of the palace, from which a regular park began. This park provided visual and planning connections with the green surroundings of the estate. The northern facade of the palace was oriented towards the space of the front courtyard. All stone structures were made in the same architectural style. The household yard was formed by two symmetrically located stone barns and a coach house.

The manor palace is a huge two-story house on a high plinth, oblong in plan, with an easily outlined curved ends, with oval and semi-oval rooms inscribed in it. In the planning of the premises of the palace, the traditional enfilade was used. The double-height oval hall, due to the placement of window openings on the convex end wall of the house, had a wide view of the entire adjacent territory of the estate. The composition of the front courtyard had a compact character, in contrast to the palace ensembles of the Palladian type of the early 19th century. The pavilion type of composition became widespread in other estates of Slobozhanshchina. It is based on a comparison of a detached palace and service buildings, united by a low stone fence. The importance of the manor palace as the center of the composition was emphasized by architectural planning and decorative means. The rich plasticity of the facades of the palace in Merchik, perceived from the courtyard and entrances against the background of the park, is contrasted with simple and restrained service buildings. All these features created a harmonious image of the general estate composition.

The State and Degree of Study of the Monument at the Beginning of the Twentieth Century

In the pre-revolutionary period, for the first time, the estate of the Stariy Merchik settlement was studied in detail by the architect t G.K. Lukomsky based on the results of a survey of Kharkov estates carried out in 1910. At the same time, the first photographs of the manor buildings were published. Based on the materials of the country estates study of the Kharkiv province of the period of classicism in 1918 G.K. Lukomsky published a well-known monograph. The author of the monograph named the manor in Merchik among the first brilliant examples of manor construction in the second half of the 18th century. He wrote: “The architecture of Merchik, the entire plan of the estate, meaning all of its services, outbuildings, barns in connection with the park, flower beds, parterres, vegetable gardens, orchards is something so independent and exemplary that Merchik cannot go into a general overview with other estates ”[6]. G.K. Lukomsky considered the estate of Stariy Merchik one of the first estates of early classicism not only in Ukraine, but also in Russia. The park in Merchik, with a regular parterre in front of the southern facade of the courtyard, stood out for its splendor, an abundance of sculpture and park structures. V. I. Yaroslavsky, nephew of the Kharkov provincial architect P.A. Yaroslavsky writes in his memoirs that the idea of creating the Merchik estate belonged to A.A. Palitsin. “With his participation ... the estate of Grigory Romanovich (Shidlovsky) was landscaped ... In Stariy Merchik he

(Shidlovsky) built a huge stone two-story house on a high basement, below there were stoves and they heated the living room halls in two lights with choirs for musicians. Opposite was a stone two-story wing for the kitchen and servants' quarters, two more stone wings, one for the guests, the other for the butler. In the backyard there are stone stables and barns. In the garden there is a stone arena, a gazebo, a reservoir, a rotunda in the form of a round temple on two floors with vaults. All these buildings were built according to the designs of A.A. Palicin."[7]. In Merchik, he also builds a stone church, the drawings for the project of which were made by the architect V.I. Yaroslavsky. The palace in Stariy Merchik was one of the most famous and visited by art and nature lovers of the country estates of the Kharkiv region of the pre-revolutionary period. The interiors of the palace were decorated with works of art by the artist V.L. Borovikovsky. In the summer of 1848, the famous landscape painter, founder of the watercolor portrait, academician of the Imperial Academy of Arts P.F. Sokolov (1787-1848) [8].

FIELD SURVEY AND ANALYTICAL STUDIES ON THE ATTRIBUTION OF THE MANSION IN MERCHIK IN THE TWENTIETH CENTURY

Officially, the author-creator of the palace in Merchik is considered to be the Kharkov provincial architect Pyotr Antonovich Yaroslavsky [1]. Many researchers have dealt with the attribution of the palace in Merchik. G.K. Lukomsky pointed out that "during its construction the best Catherine's architect could have been the master - creator of the Merchik estate, but the architecture of the palace does not resemble anyone's hand. Only there is something in common in the details (and maybe in common in the master-molder) with the church in Babai. And if it is known for certain that it was built by P.A. Yaroslavsky, is it possible to ascribe to him the construction of the palace in Merchik "[6]. This hypothesis, expressed at the beginning of the twentieth century, did not receive further confirmation. The nephew of the Kharkov provincial architect, also an architect, V.I. Yaroslavsky, among the many works of his uncle, does not name the palace in Merchik. In his notes, placed in the first issue of "Kharkov Collection", he recalls that while living with AA. Palitsin, often visited G.R. Shydlovsky, for whom he made drawings - "to enlarge the stone church and to arrange a new iconostasis in it." He writes that once in Merchik "... I found uncle Pyotr Antonovich with him (G. R Shidlovsky) and plans." [7]. This fact does not confirm the authorship of the project of the palace building in Merchik. For the first time, the hypothesis on the attribution of the palace building in Merchik was expressed in a well-known monograph by a group of authors led by the artist, restorer, art critic, art theorist I.E. Grabar, dedicated to the study of the work of the architect V.I.Bazhenov. "On the territory of the USSR there is a building in which, as in focus, all Bazhenov's signs are collected, that were scattered separately in its various buildings. This is a wonderful house in the Merchik estate in the Kharkiv region ... "[9]. The information provided in the monograph about the artistic features of the creative method of V.I. Bazhenov, embodied in the architecture of the manor palace in Merchik, became the main hypothesis for establishing the authorship of the famous monument.

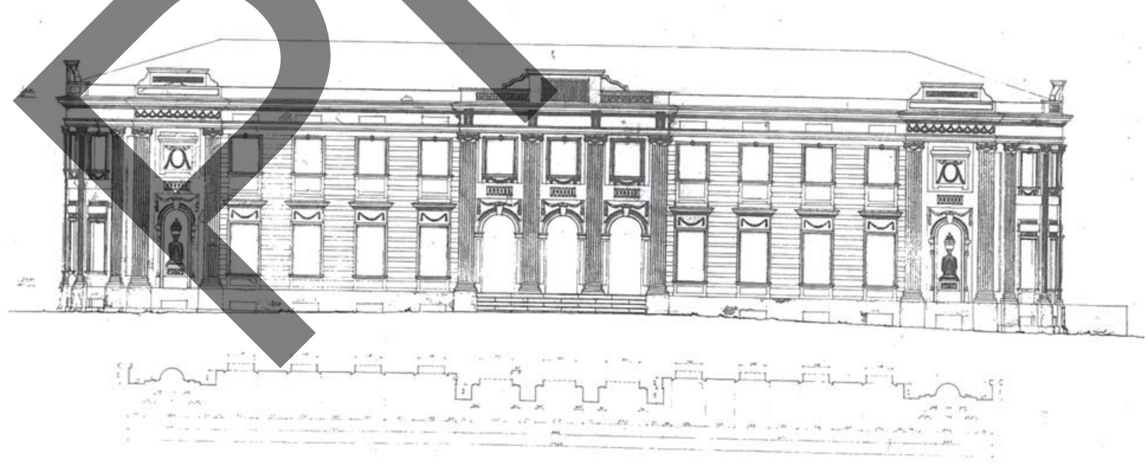

FIGURE 2. Measurement drawing of the northern façade.1956-1957 Prepared by A.V. Ryabushin, I.N. Lavrentiev, V.V. Nesterov

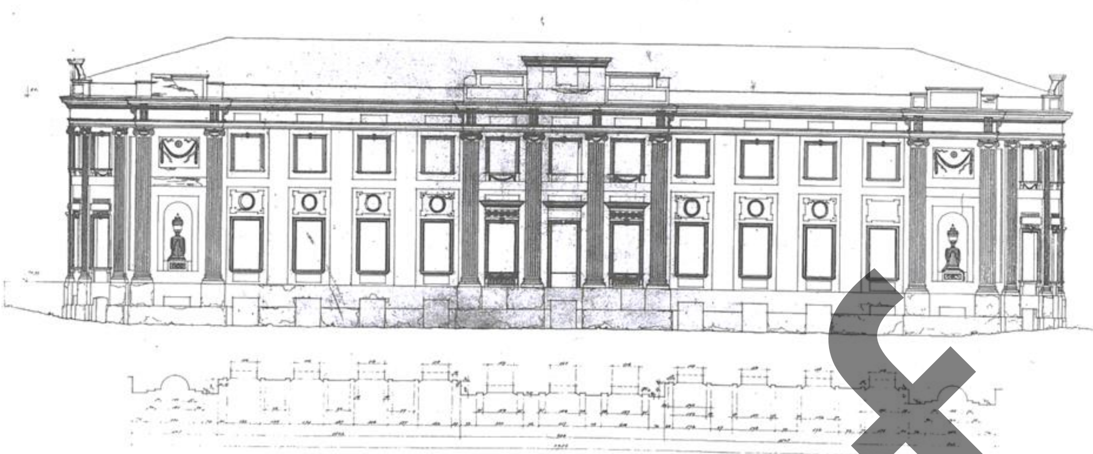

FIGURE 3. Measurement drawing of the southern façade. Prepared by A.V. Ryabushin, I.N. Lavrentiev, V.V. Nesterov

"Like none of the Russian architects of the 18th century," wrote IE Grabar, " Bazhenov designed niches for statues wherever he could, inserted stone bas-reliefs into the walls, cut vases into them, and provided special places for staging figures. Already one such abundance of sculptural decor outside and inside the building makes one look at it wary and search for other true signs of Bazhenov's hand in his plan." [9]. To date, this point of view is shared by many researchers involved in the study of the architectural ensemble during the second half of the twentieth century. Materials from historical sources established that V.I. Bazhenov has not visited Kharkov. Most likely, Shidlovsky, on one of his trips to Moscow, obtained from Bazhenov a project for a house and services, which were built for him by P.A. Yaroslavsky. The role of V.I.Bazhenov in the creation of the palace in Merchik has not been documented. However, we can confidently attribute it to the works of the Bazhenov school. This is confirmed by the archival information about the stay of P.A. Yaroslavsky in Moscow, where from December 1773 to February 1775 he studied at the school of the Kremlin expedition under the leadership of V.I. Bazhenov. P.A. Yaroslavsky stated "... learning and adapting to the buildings under construction and constructed, some of the rules outlined in perspective at the direction of the architect Mr. Bazhenov ..." [10]. According to L.D. Sokolyuk, who researched the development of art education in Ukraine, P.A. Yaroslavsky, upon his return from Moscow, became a provincial architect and at the same time a teacher of the architectural class at the Kharkos Collegium, organized in the 1770s [11]. He is rightfully considered one of the founders of the Kharkov architectural school of the 18th century.

Comprehensive Studies of the Ensemble of a Country Estate in the Second Half of the Twentieth Century

After the end of the Second World War in 1946-1947, on the instructions of the Office of Architecture under the Council of Ministers of the Ukrainian SSR, the first measurements of the palace building of the estate were carried out, stored in the funds of the State Construction Committee of the Ukrainian SSR. This work was carried out by Kharkiv architects V. Kostenko, B. Miroshnichenko and Y. Moskaltsev. [12].

The first measurements and detailed studies of the estate palace in Stariy Merchik were carried out in 1956-1957 by a group of Kharkov architects, graduates of the architectural faculty of the Kharkov Civil Engineering Institute (KhISI), including A.V. Ryabushin, I.N. Lavrentiev, V.V. Nesterov (Fig. 2, 3). The purpose of this work was documentary, on the basis of the measurements performed, confirmation of the authorship of the monument and proof of its involvement in the work of the architect V.I. Bazhenov. Dimensional drawings were presented at exhibitions in Kiev and Kharkov, after which they were transferred to the department of protection of architectural monuments of the Union of Architects in Kharkov. According to the architect I.N. Lavrentiev, these materials have long been lost. In the report of V.V. Nesterov on the results of an analytical study, a detailed analysis of the palace in Merchik is presented: its planned structure, constructive solution, architectural study of facades and interiors as of the period of measurement work. The study of the architectural and stylistic features of the famous Bazhenov buildings allowed the authors to prove the indisputable belonging of the monument to the work of the genius master of classicism Vasily Ivanovich Bazhenov. This is confirmed by the information of the old Merchik resident M. Pilyashenko about the authorship of the palace. He refers to the testimony of the former footman Yakov Kotelevets, who worked for the last owner of the estate, E.M. Dukhovsky, that the palace was built by the architect, the author of the design of the Grand Kremlin Palace in Moscow. J. Kotelevets also testified that the estate had a large archive of documents that occupied 11 bookcases, and the owner of the estate, E.M. Dukhovskoy probably knew the name of the author of the palace project. Y. Kotelevets, who entered the service of the landowner as a boy, was always with him and therefore could receive this information from the owner of the estate. M. Pilyashenko's information received from J. Kotelevts confirms the authorship of V.I. Bazhenov. V. Nesterov in his memoirs writes that the contents of 11 bookcases, including the archive, utensils, the decoration of the palace in the revolutionary and early post-revolutionary years, everything was plundered and disappeared without a trace. “The same sad fate befell all the noble estates and churches. It was an outrage on a much larger scale and cruelty than during the Pugachev revolt.

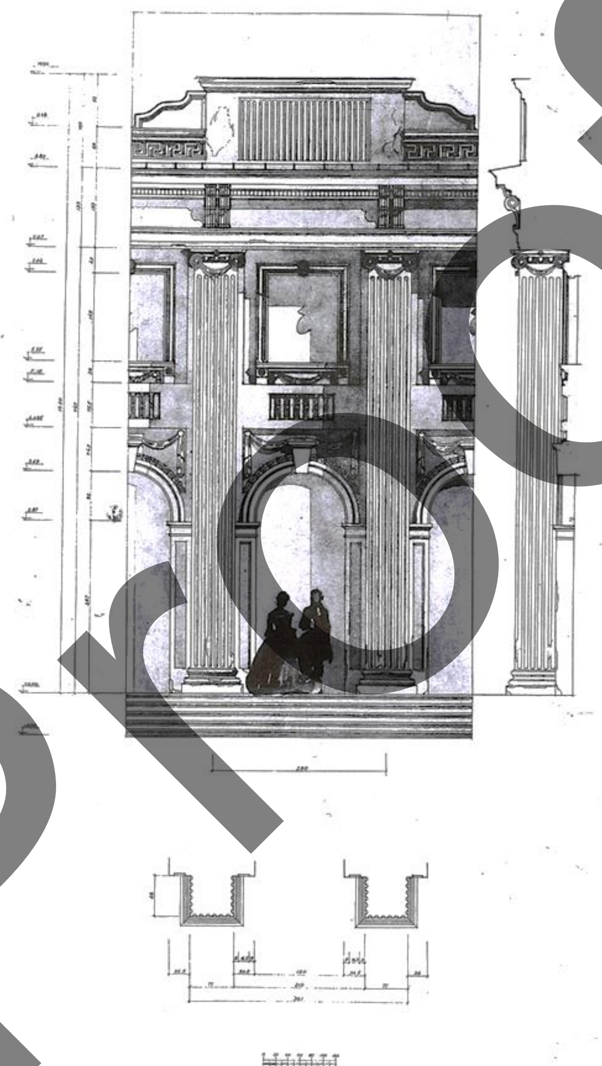

FIGURE 4. A fragment of the central portico. Northern façade. Measurement drawing. 1956-1957 Prepared by A.V. Ryabushin, I.N. Lavrentiev, V.V. Nesterov

In 1968 A.V. Ryabushin for the first time published the measurements of the estate palace in Stariy Merchik in the magazine “Construction and Architecture” [13]. From 1968 to 1979, detailed studies and measurements of the estate ensemble were carried out by students and employees of the architectural department of the Kharkiv V.V. Dokuchaev Agricultural Institute under the guidance of the candidate of architecture Marchenko T.L. Dimensional drawings and research materials were used as the basis for the development of project proposals for the preservation of the monument, reconstruction of its architectural and spatial structure. The preserved landscape and spatial composition of the landscape park have been studied in detail. In the 1980s, comprehensive studies of the state of the palace estate ensemble, its compositional features in the context of the development of the estate culture of the northeastern region of Ukraine, were continued by the author of this article [14.]. In the post-war period, the territory and buildings of the country estate were used as an educational institution. The palace housed the main educational and administrative building of the veterinary college. During the period of independence of Ukraine, the technical school was closed. The complex of manor buildings has not been used since 1997, which provoked active destruction and looting, primarily of the palace building itself. Due to the fact that counter-emergency work planned for the beginning of the 2000s did not take place, in 2018 a fire occurred in the palace building, as a result of which the structures of the ceiling and attic were significantly damaged. The current state of the manor buildings requires urgent rescue work, conservation of preserved structures, isolation of the internal space to preserve the remains of the interiors, including the organization of a security system for the preserved buildings throughout the upland part of the manor.

Features of the Architectural and Spatial Composition of the Ensemble of the Merchik Estate Based on the Materials of Field Research

The authors' skill of the estate in Stariy Merchik can be traced in the integrity of the compositional solution based on three levels of large-scale spatial connections:

- the traditional classicism allocation of the main volume and its silhouette in the spatial environment of the estate, against the background of the park, in the residential landscape;
- the monumentality of the volume with large articulations of the form, the fixation of the main axis by the large order columnar portico, that is presented on Fig. 4;
- stylistic commonality of methods of decorative solutions for the facades of the palace and manor buildings.

Ways of decorative solutions for facades meet the conditions for the orientation of the building and its perception according to the main specific disclosures. The main and garden facades are made using similar details, but they give a different impression. The northern orientation of the main facade of the palace required the use of expressive plastic, therefore, details of more strict forms are placed on the facade, the wall is richer in decoration, and the facade is more sculpturesque. The garden facade is richly decorated with floral ornaments: wreaths, garlands in the tympanes of window and door openings, entablatures intertwining on the frieze, hanging from volutes on pilaster capitals, there is a use of rustication, flat niches and cylindrical niches with vases. The axes of the lateral facades, which have a rounded shape, are revealed by risalits with semicircular niches, richly covered with decor. Various options for flower garlands prevail. Metrically repeating decorative motifs - garlands on the frieze, elements on the cornices correspond to the clear lines of rustication.

The proportions of the facades are strongly elongated. The ratio of the height of the facade to the length of the longitudinal wall is 1:4. The impression of monumentality is achieved by the use of large-scale plasticity, reduction of vertical divisions, large proportions of decorative elements. The planning solution, the methods of decorative design of the facades, the methods of creating the green surroundings of the estate inherent in the park's space, express the connection between architecture and the natural environment and are distinguished by their picturesqueness and skill in building a composition.

The solution of the interiors in the premises at the main floor of the palace: a double-height oval hall, a semicircular living room, an office with niches, was distinguished by special sophistication, subtlety and skill in working out details. In the decoration of the premises, painting, gilding, and stucco molding were used. The nature of the decoration of the interiors with motives of floral ornamentation was close to the facades of the building. Based on the analysis of the layout, architectural and spatial composition and stylistic solution of the buildings facades, general techniques were established that were characteristic of the palace in Merchik and a number of manor houses that definitely belonged to V.I. Bazhenov. The solution to the plans of Bazhenov's buildings is characterized by the presence of oval and semi-oval rooms, the placement of the main rooms at the intersection of the compositional axes. Many premises of the palace in Merchik are similar in configuration to other buildings (Rumyantsev's house on Moroseyka, the plan of Bazhenov's own house). In solving the facades of the palace in Merchik, Bazhenov's favorite techniques were used: opposing large monumental forms to finely and gracefully traced details, the use of a "large" order in combination with the technique of deepening decorative details into the plane of the wall. Common methods of decorative design of facades and interiors of buildings can be traced in many buildings of V.I. Bazhenov. Thus, the garlands of the frieze on the risalits of the palace in Merchik are identical to the garlands of the Razumovsky house and the Hermitage in Kuskovo.

CONCLUSIONS

The current state and the preservation degree of the buildings of the country estate ensemble testify to the significant historical and cultural value of the complex monument, despite the losses and destruction that have occurred in the palace building over the past decades. The integrity of the spatial structure and architectural and planning composition of the buildings ensemble is expressed in the territorial integrity, the preservation of the boundaries of the ensemble and the adjacent landscape park. The surrounding residential landscape with renovated residential and public buildings, at the location of the estate, has preserved the historical network of streets, and from the side of the main entrance - the historically formed one-floor building in the classicism style.

The estate has preserved the typological diversity of buildings and structures, with the exception of a horse yard near the western border of the landscape park, outbuildings, a greenhouse, which were lost in the pre-revolutionary period. The destruction of the manor church building (central volume with a dome, refectory, bell tower fragments), which occurred in the first half of the 20th century, were partially restored in the 1980s, but without observing the original volume, volumetric-spatial solution and style. The surviving dimensional drawings and photographic illustrations of the main elements of the architectural ensemble (a palace, 2 stone outbuildings, a service building, barns, a fence around the front yard of the estate) can be used for field examination and drawing up a program for the regeneration of the classicist ensemble.

The preference for museification and the regeneration of the territory of the complex monument is justified by the historical and cultural significance of the palace and park ensemble, which in the culture of romanticism occupied the value of a center for the development of enlightenment, architecture and garden and park art. Prominent architects of the late 18th - early 19th centuries contributed to the creation of the manor ensemble. The attribution of the palace building in Merchik and its involvement in the legacy of the famous classicist architect V.I.Bazhenov, puts the ensemble of the estate in Stariy Merchik among the works of architecture of a high artistic level. The preservation of this object among the monuments of national importance is an important professional, organizational and managerial task of the current stage of development of the modern cultural policy of the state.

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A Low-productivity Plant for Cleaning Domestic Wastewater in Non-canalized Areas

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Abstract. The relevance of deep treatment of domestic wastewater from objects in non-sewer areas is considered. The analysis of existing treatment technologies and structures is given. A three-stage aerobic bioreactor with preliminary anaerobic wastewater treatment, which ensures a decrease in the content of various forms of nitrogen, BOD and suspended solids in the wastewater during the life of the bacteria attached to the brim and free-floating microorganisms is proposed. A methodology has been developed for calculating and designing a low-capacity installation for deep wastewater treatment, taking into account the laws of nitrification, denitrification and oxidation of organic pollutants according to the stages of treatment, taking into account the quality requirements for treated wastewater at the level of standards for discharge of effluents into fishery ponds.

INTRODUCTION

The widespread environmental degradation has led to an aggravation of the problem of domestic wastewater treatment in non-canalized territories, caused by the need to bring the quality of treated wastewater to the regulatory requirements for their discharge into fishery ponds.

In connection with the growth in the construction of cottages, small production facilities, recreation centers in non-canalized areas, which are remoted from cities and other settlements, the problem of domestic wastewater treatment at such facilities has become very important. The need for creating scientifically-based, reliable, compact, highly efficient and energy-saving technological schemes and designs of low-capacity plants for deep wastewater treatment has increased.

ANALYSIS OF RECENT PUBLICATION

As an example in work [1], biological treatment plants for small amounts of wastewater are presented − biocontactors (disk, drum or rotary, with fillers, tubular, etc.) that operate, as a rule, according to a multi-stage scheme. Biocontactors are compact, have low energy consumption, simple and reliable in operation, withstand salvo inflow of wastewater, during breaks in operation, the possibility of drying of the biofilm is excluded. One of the main disadvantages of such plants is the lack of technical ability to control and maintain the required amount of dissolved oxygen, since the rotor speed is constant. Biocontactors are not designed to achieve modern requirements for the degree of wastewater treatment, so they can only be recommended for seasonal facilities.

Combined structures (CS) [2], consisting of two main technological units − biofilters and aeration tanks located under them were developed. To ensure the biological process of biodegradation of organic and biotransformation of inorganic oxygen contaminants and to support the sludge in the aeration zone of the aeration tank-sump in suspension, water-jet aeration is used, which makes the construction work reliable and economical in comparison with the use of compressor equipment or mechanical aerators. Thus, the design feature of the CS sediment aeration tank allows

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maintaining the sludge concentration in the aeration zone of more than 4-6 g/dm^3 at its high age, which is typical for aeration tanks of conventional classical designs.

The possibilities for intensifying the operation of biological treatment facilities lie in the implementation of the "bioconveyor", which provides direct-flow passage of wastewater through treatment plants in combination with the use of polymer-free and microbial organisms attached to polymer fillers [3-6].

In work [7], a plant which provides a direct-flow passage of wastewater through anaerobic-aerobic bioreactors with a fibrous filler and a contact clarification filter (CCF) with a foam plastic filtering filler was presented. A detailed study of wastewater treatment in (CCF) was made. The results of the wastewater treatment quality as a whole for the plant, which do not correspond to the parameters of discharge into reservoirs of fishery designation according to BOD_{20} and nutrients are proposed.

The company Vestar (Rivne) [8] proposes a technology for wastewater treatment using three-stage bioreactors - filters with floating polystyrene filling. Hydro automatic mode of washing the filler is provided. High efficiency of suspended solids removal was noted − 97%, BOD_5 − 94.5%. The issue of removing nutrients is not being addressed.

A critical analysis of treatment plants design showed that they all have certain advantages and disadvantages, operation parameters are not clearly defined, the boundary conditions at different stages of wastewater treatment are necessary for the calculation and design of plants, and, as a rule, the quality of wastewater treatment is not ensured to requirements for discharge into reservoirs of fishery for concentration of various forms of nitrogen, BOD_{20}, suspended solids.

The proposed of the low-productivity plant (LPP) "ECOSTAR 1" is based on the use of direct-flow wastewater through three-stage aerobic bioreactors attached to a fibrous filler and free-floating microorganisms. Pre-treatment of wastewater in a septic tank is envisaged. Synthetic ruffs are used as a fibrous filler [9, 10]. The use of spatial succession of attached microorganisms-destructors and the trophic chain of zooplankton allows the complete utilization of organic pollutants and the treatment of wastewater at the level of modern requirements for discharge into fishery ponds [9].

As a result of preliminary anaerobic treatment of wastewater in the septic tank, the accumulation and averaging of runoff, dilution of salvo discharges of highly concentrated wastewater, their destruction, lowering the concentration of Synthetic surfactants to non-foam-forming values occurs. Ammonification takes place in the septic tank, deep restoration of the medium, the formation of easily oxidized compounds, which contributes to the further process of denitrification [11].

Technological diagram of the low-productivity plant "ECOSTAR 1". In accordance with the technological scheme,

the wastewater after anaerobic treatment in a septic tank is introduced into stage 1 of the bioreactor (denitrifier), mixed with air supplied by a bubbler and with return activated sludge coming from a secondary vertical settling tank. The flow of the mixture of return activated sludge and wastewater from the septic tank, rising up the stage 1, is in contact with ruffs fixed at the height of the stage. The steps of the bioreactor 1, 2 and 3 are equipped with a ruff filler [9].

From stage 1, the sludge mixture flows to stage 2 (nitrifier), and then enters the sludge separation into a vertical secondary sump. The clarified wastewater enters stage 3 (post-treatment bioreactor). Stage 3 is supplied with airlift of circulation of the treated sewage water. At the bottom of stage 3 a bubbler of regeneration of ruffs is placed. Remove of regenerated water and excess activated sludge are drained from the secondary sump into the first septic tank.

From stage 3, the treated wastewater flows to stage 4 − a disinfection filter filled with a granular catalyst filler, which is continuously blown with air and therefore not silted. Disinfected water enters a technical well, from where it is pumped into a reservoir.

The stages of the bioreactor are distinguished by air supply systems. The concentration of oxygen dissolved in water in stage 1 is not more than 1…2 mg O_2/dm^3, in stage 2 − not less than 3-4 mg O_2/dm^3 important [12]. In stage 1, the main source of oxygen is nitrates from the flow of return activated sludge and treated wastewater; in stage 2, only air from the fine-bubble aeration system. In stage 1, air is rather a means of creating mass transfer between the liquid and the biocenosis of attached microorganisms, in stage 2, both functions of air (oxygen source and mass transfer means), which is extremely.

THE PURPOSE OF THE WORK

The purpose of this work is to develop a methodology for calculating and designing a low-capacity plant for deep wastewater treatment taking into account the regularity of the processes of nitrification, denitrification and oxidation of organic pollutants by stages of treatment, considering the requirements for the quality of treated wastewater at the level of standards of discharge into reservoirs of fishery designation.

To achieve this purpose, the following basic tasks were solved:

- analyze the obtained research results;
- analyze the equations of kinetic dependences of nitrification processes, denitrification and oxidation of organic pollutants at the stages of wastewater treatment;
- develop recommendations for calculating the required amount of attached and free-floating biomass of microorganisms for wastewater treatment, the required number of ruff filler, working volumes and duration of wastewater treatment at the stages.

MATERIAL AND METHODS

As a result of experimental studies of wastewater treatment in the proposed LPP [11, 12], residual concentrations were obtained: ammonium nitrogen not more than 0.5 mg [NH_4^+]/dm^3, nitrite nitrogen, not more than 0.02 mg [N-NO_2^-]/dm^3 and nitrogen nitrates not more than 9.1 mg [N-NO_3^-]/dm^3, BOD_{20} − 3-4 mg O_2/dm^3, suspended solids − 2-3 mg/dm^3, which corresponds to the standards of discharge into reservoirs of fishery designation.

Technological dependencies and basic parameters of the wastewater treatment stages were obtained.

Calculation technique and design of the LPP "ECOSTAR 1". The technological scheme of wastewater treatment in LPP includes wastewater filtering, anaerobic treatment in a septic tank, aerobic treatment in a three-stage bioreactor with attached biomass, secondary sedimentation between the second and third stages of the bioreactor, and disinfection.

Initial data are: the number of inhabitants, the rate of water disposal, wastewater consumption, ammonium nitrogen concentration, pollution according to BOD_{20}, the average winter and average annual temperature of wastewater.

Sewage screening. All wastewater taken to the treatment plant is filtered to isolate large mechanical impurities in a special yard well through a basket with 2-3 mm openings. The basket should have a volume sufficient to accumulate garbage during the month.

Septic tank. The volume of the septic tank and the number of chambers is taken depending on the flow rate and the average winter temperature of the wastewater. The last chamber of the septic tank serves as a receiving tank for collecting wastewater for aerobic biological treatment with a three-silt system.

The first stage of aerobic bioreactor (denitrifier). The volume of the first sludge system depends solely on the limited amount of BOD_{20} in the anaerobically treated wastewater, so it is necessary to carry out the denitrification process immediately, using both the restored mineral compounds of wastewater and organic impurities. According to studies, the denitrification process has a kinetics described by equation (1), which relates the specific rate of denitrification $\rho_{[N-NO_3^-]}$, mg [N-NO_3^-]/(g·h), with the concentration of nitrates in wastewater according to the formula:

$$\rho_{[N-NO_3^-]} = 31{,}28\frac{C_{[N-NO_3^-]}}{12{,}85 + C_{[N-NO_3^-]}}, \qquad (1)$$

where $C_{[N-NO_3^-]}$ − the concentration of nitrogen nitrates, mg [N-NO_3^-]/dm^3.

Simultaneously with denitrification, a decrease in the BOD_{20} value occurs according to the kinetic dependence equation:

$$\rho_{BOD} = 112\frac{L_1}{33 + 1{,}3125L_1}\cdot\frac{1}{1+\varphi a_{tds}}, \qquad (2)$$

where ρ_{BOD} − specific oxidation rate of organic substances, mg O_2/(g·h); L_1 − concentration of BOD_{20} at the outlet of the denitrifier, mg O_2/dm^3; φ − the coefficient of inhibition by the decay products of activated sludge, dm^3/g, taken φ = 0.07 dm^3/g; a_{tds} − the dose of sludge, free-floating and attached biocenoses, g/dm^3, is taken a_{tds}=1 g/dm^3.

The concentration of nitrogen nitrates should not exceed 7 mg [N-NO_3^-]/dm^3, because the maximum allowed concentration is 9.1 mg [N-NO_3^-]/dm^3, but a reserve of possible increases in the amount of nitrogen in wastewater is needed, and the calculation must be carried out by an amount less than the standard.

At a concentration of nitrogen nitrates of 7 mg [N-NO_3^-]/dm^3 according to the formula (1), the specific denitrification rate is 11 mg [N-NO_3^-]/(g·h).

In this case, the value of BOD_{20} is consumed at a specific rate ρ_{BOD} not less than 40 mg O_2/(g·h). This value of the specific rate of decrease in BOD_{20} is observed at a value of BOD_{20} at the exit from the L_1 denitrifier of at least 25 mg O_2/dm^3.

Therefore, when solving the problem of nitrate removal, it is necessary to coordinate the reduction in BOD_{20} and the consumption of ammonium nitrogen for denitrification biomass growth in a ratio of 100: 5: 1 simultaneously (BOD_{20}: ammonium nitrogen: phosphorus).

Given the content of ammonium nitrogen in wastewater treated in septic tanks, within $C^{en}_{[NH_4^+]} = 20 - 50\ mg[NH_4^+]/dm^3$, the ratio q_{ras}/q may vary from 1-3.

Return flow of activated sludge q_{ras} (under the condition of the need to dilute the initial runoff due to the high initial concentration of ammonium nitrogen) is not less than 3 times greater than the flow rate of the initial runoff, accepted $q_{ras} = 3q$, dm^3/h. This is due to the requirement to obtain residual concentrations in the process of aerobic biological treatment: ammonium nitrogen not more than 0.5 mg [NH_4^+]/dm^3, nitrite nitrogen, not more than 0.02 mg [N-NO_2^-]/dm^3 and nitrogen nitrates not more than 9.1 mg [N-NO_3^-]/dm^3, which meets the standards for discharge into fishery reservoirs.

The biomass of attached microorganisms required for conducting the denitrification process using the ashless substance P_1, g, is determined by the formula:

$$P_1 = \frac{q\left(C^{en}_{\left[N-NH_4^+\right]} - C^{gr}_{\left[N-NH_4^+\right]} - N\right)K}{\rho_{\left[N-NO_3^-\right]}}, \tag{3}$$

where $\left(C^{en}_{\left[N-NH_4^+\right]} - C^{gr}_{\left[N-NH_4^+\right]} - N\right)K$ − the amount of nitrogen nitrates in purified water to be removed during denitrification, mg [N-NO_3^-]/dm^3; q − consumption of wastewater from a septic tank, dm^3/h; $C^{en}_{\left[N-NH_4^+\right]}$ − the concentration of nitrogen of the ammonia feed wastewater at the inlet of the denitrifier, mg [N-NH_4^+]/dm^3; $C^{gr}_{\left[N-NH_4^+\right]}$ − the concentration of ammonium nitrogen used to increase the biomass of attached microorganisms, mg [N-NH_4^+]/dm^3; N − recommended residual concentration of ammonium nitrogen during biological treatment − 0.39 mg [N-NH_4^+]/dm^3; K≈1.

The concentration of ammonia nitrogen in the stock $C^{gr}_{\left[N-NH_4^+\right]}$ used for the growth of biomass of attached microorganisms is determined by the ratio of 100: 5: 1.

The growth of sludge will take (L_{en}-L_1), mg O_2/dm^3 in the initial runoff.

The concentration of L_1 is taken at least 25 mg O_2/dm^3 − specified BOD_{20} at the exit of the denitrifier.

The amount of ammonia nitrogen will decrease by:

$$C^{gr}_{\left[NH_4^+\right]} = (L_{en} - L_1) \cdot 5/100. \tag{4}$$

Biomass P_1 provides a decrease in the value of BOD_{20} by ΔL_1, mg BOD_{20}/h, according to the formula:

$$\Delta L_1 = \rho_{BOD} P_1. \tag{5}$$

The concentration of contaminants according to BOD_{20}, L_1, mg O_2/dm^3, wastewater going to the second stage of the aerobic bioreactor (nitrifier) is specified by the formula:

$$L_1 = \frac{qL_{en} + q_{ras}L_{ras} - \Delta L_1}{q + q_{ras}}, \tag{6}$$

where L_{en} − concentration of BOD_{20} of wastewater at the inlet of the denitrifier after the septic tank, mg O_2/dm^3; L_{ras} − concentration of BOD_{20} of the return sludge mixture, mg O_2/dm^3, is accepted L_{ras}= 13 mg O_2/dm^3; q_{ras} − flow rate of return activated sludge for diluting the initial waste fluid from a septic tank, dm^3/h; is accepted $q_{ras} = 3q$.

The second stage of the aerobic bioreactor (nitrifier). The second stage of the aerobic bioreactor provides nitrification of ammonium nitrogen in the sludge mixture and the oxidation of organic wastewater impurities to a residual value L_2=10-15 mg O_2/ dm^3.

Varying the volume of the second stage of the bioreactor (nitrifier), the amount of biomass of attached and freely floating nitrification microorganisms, the number of ruff carrier, and the constructive placement of the carrier, the actual volume of the second stage is determined W_2, load A according to BOD_{20} to the biomass of activated sludge in the second sludge system (should be no more than 150 mg BOD_{20}/(g·day)) and the length of time the wastewater stays in the nitrifier.

The daily load of BOD_{20} on the biomass of activated sludge in the second sludge system A, mg BOD_{20}/(g·day), is determined by the formula:

$$A = \frac{(L_1 - L_2)Q}{a_i W_2}, \tag{7}$$

where L_2 − residual concentration of organic impurities according to BOD_{20} after oxidation in the second stage of the bioreactor (nitrifier), mg O_2/dm^3; Q − daily wastewater consumption, dm^3/day; a_i − dose of activated sludge, g/dm^3, is taken a_i=1.0 g/dm^3; W_2 − the volume of the second stage of the bioreactor, m^3, is taken approximately.

Amount of free-floating activated sludge biomass P_{as}, g, in the second stage is determined by the formula:

$$P_{as} = a_i W_2. \tag{8}$$

If A> 150 mg BOD_{20} /(g·day), free-floating activated sludge biomass is not enough, the biocenosis of attached nitrifying microorganisms is additionally required.

The necessary biomass of attached and free-floating nitrifying microorganisms P_2, g, is determined by the formula:

$$P_2 = \frac{\left(C^{input}_{[NH_4^+]} - C^{exit}_{[NH_4^+]}\right)(q + q_{ras})}{\rho_{[NH_4^+]}}, \tag{9}$$

where $C^{input}_{[NH_4^+]}$ − the concentration of ammonium nitrogen in the wastewater entering the second stage of the bioreactor (nitrifier), mg $[NH_4^+]/dm^3$, determined by the formula:

$$C^{input}_{[NH_4^+]} = \frac{\left(C^{en}_{[NH_4^+]} - C^{gr}_{[NH_4^+]}\right)q + C^{ras}_{[NH_4^+]} \cdot q_{ras}}{q + q_{ras}}, \tag{10}$$

where $C^{ras}_{[NH_4^+]}$ − the concentration of ammonium nitrogen in the treated wastewater supplied with return activated sludge, mg $[NH_4^+]/dm^3$, accepted $C^{ras}_{[NH_4^+]}$ = 0.9 mg $[NH_4^+]/dm^3$; $C^{exit}_{[NH_4^+]}$ − the concentration of ammonium nitrogen in the diluted wastewater at the outlet of the nitrification agent, mg $[NH_4^+]/dm^3$, determined by the formula:

$$C^{exit}_{[NH_4^+]} = \frac{qC_{[NH_4^+]}}{q+q_{ras}}, \tag{11}$$

where $C_{[NH_4^+]}$ − the concentration of ammonium nitrogen at the outlet of the nitrification agent, mg $[NH_4^+]/dm^3$, is accepted $C_{[NH_4^+]}$ = 3-5 mg $[NH_4^+]/dm^3$.

Specific nitrification rate $\rho_{[NH_4^+]}$, mg $[NH_4^+]$/(g·h), the community of attached and free-floating biocenosis will be:

− attached biocenosis:

$$\rho^{attch}_{[NH_4^+]} = 12{,}92\frac{C_{[NH_4^+]}}{4{,}99 + C_{[NH_4^+]}} \tag{12}$$

− free-floating activated sludge:

$$\rho^{free}_{[NH_4^+]} = 9{,}73\frac{C_{[NH_4^+]}}{5{,}45 + C_{[NH_4^+]}}. \tag{13}$$

By average $\rho_{[NH_4^+]}$ (formulas (12), (13)), which should be at least 2 mg $[NH_4^+]$/(g·h), at concentration $C_{[NH_4^+]}$ =3-5 mg $[NH_4^+]/dm^3$ is determined by P_2.

The amount of biomass of attached microorganisms−nitrification is determined by the formula:

$$P_{attch} = P_2 - P_{as}. \tag{14}$$

Based on the recommended amount of biomass attached denitrifying microorganisms a_1=0.1 kg/m and attached nitrification a_2=0.07 kg/m determines the required number of hard ruffs.

The working height and dimensions in terms of denitrifier and nitrifier are taken based on the structural placement of ruffs (diameter of ruffs d=120 mm, step 1.1d, porosity 98.8%). Taking into account the diameter and porosity of the ruffs, the working volume and the actual value of the daily load according to BOD_{20} − A, and the duration of wastewater treatment in the nitrifier are determined. If A>150 mg BOD_{20}/(g·day), recalculation is performed.

Secondary sedimentation tank. When designing a vertical secondary sump, the sludge mixture flow rate and allowed speeds in the central pipe V=20-25 mm/s and in the upward flow of purified water $V \leq 0.5$ mm/s are taken into account.

With a central pipe height of 1 m, an uptake layer ensures water sedimentation for 0.5 h, which, with a silt index in the range of 60-90 mg/dm^3, is sufficient to obtain a residual suspension concentration of no more than 15 mg/dm^3 at the outlet of the secondary sump.

The third stage of the aerobic bioreactor. The post-treatment bioreactor is designed for an hour-long stay of treated wastewater with airlift circulation of purified water at a speed of V=20-30 mm/s.

In the bioreactor, a filler of hard ruffs with 20% undercoat of chemical fiber is installed. The weight of the biomass of ruff microorganisms, kg per 1 m^3 of bioreactor volume b=3-4 kg/m^3. The amount of biomass of attached microorganisms in g per ash less substance per 1 m ruff is taken a_3=100 g/m.

Catalytic filter. Disinfection of the treated wastewater is carried out in a filtration column with a catalytic charge layer h=1 m at a filtration rate of V=3-5 m/h and continuous air supply $I \geq 2$ m^3 per 1 m^2 of filter load per hour.

CONCLUSION

A methodology for the engineering calculation of low-productivity plants is proposed, recommendations for their design are developed.

The technology of multistage anaerobic-aerobic wastewater treatment proposed in the LPP using the free-floating microorganisms attached to a ruff filler allows to obtain a deep degree of wastewater treatment by concentrations of various forms of nitrogen, BOD_{20}, and suspended solids without additional facilities.

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Compositional Role of Spatial Boundaries in the Organization of Orderly Urban Space

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Abstract. The compositional role of spatial boundaries in the organization of structured order and its violation is considered in the article. Furthermore, the semantic importance of violation of a clear geometrically formed structure in terms of aesthetic perception of urban space is elicited. Working with space and understanding it as an artistic phenomenon is the most important component of architecture poetics. The main quality of space is the boundary. Boundaries are the determining organizing factor of space. They are an integral part of the image that is formed in the human mind. The function of boundaries is only delimitation, while its image has many interpretations such as partition, ligament, transition, threshold, etc. Architecture appears just on the border of external and internal, so the purpose of this study is to identify the morphological and semantic qualities of architectural and spatial boundaries in the architectural environment. The main methods of forming spatial boundaries will provide an opportunity to solve important problems of organizing the structure of urban spaces.

INTRODUCTION

The main task of architecture is the organization of an ordered space created for human life and activity. And for humans it is natural to perceive an organized space that has a geometrically clear and understandable form. Considering the issue is relevant as the spatial structure of the urban environment is a complex framework formed by many objects and systems. Most of the modern city spaces merge, intersect and form a continuous chain of various inhomogeneous spaces and impressions of their perception. Nowadays, the spatial structure of the city is getting more complicated due to many factors in the development of functional and planning structures. While the spatial boundaries in the urban environment are either not clearly identified or absent, it may complicate the orientation of man in space.

Thus, the purpose of the study is to substantiate the compositional role of spatial boundaries in the organization of ordered space and to identify the significance of violation-disorder of geometrically clear structure in terms of aesthetic perception of urban space.

Man evaluates the world visually, comparing its properties: flatness, volume, depth and its position in relation to part of this world from the outside or inside. First of all the size and the form of limited space are perceived. The impression of isolation is created psychologically by observing objects that limit the space. The nature of space affects the behavior and feelings of the person in it. In a space with clear or closed boundaries, without a visual connection with the external environment, a person feels inside, within a certain space. In the absence of clearly defined boundaries, a person can feel a visual connection with the outside world.

So, the main feature of space is the boundary. To feel space means to have a sense of distance and boundaries. The boundary is more than just a solid barrier, it is more of a "seam" along which two spaces are firmly connected. Boundaries serve as an organizing factor of space. Continuity of boundaries, proximity of parts to each other, repetition of rhythmic intervals, similarity, homogeneity or harmonious order - these qualities facilitate the perception of complex space. The study of the organization of ordered space and the compositional role of spatial boundaries in

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architecture is relevant because boundaries are an essential organizing factor of space, they are an integral part of the image that is formed in the human mind.

MATERIALS AND METHODS

Scientific research includes the following methods: analysis and systematization of scientific literature on the topic of research, natural and graphic research of architectural and urban planning ensembles, study and systematization of factual materials, analysis of primary sources, comparative analysis of architectural and general scientific concepts to identify the main provisions that correspond to the direction of research. Methods of analysis, synthesis and abstraction are used. Also, the research methodology includes comparative, functional, morphological, compositional and semiotic analyzes of the urban planning structure of historical ensembles.

COMPARATIVE ANALYSIS OF SPATIAL BOUNDARIES

The results of the study

To determine the idea of the semantic structure of the spatial composition, it is needed to rely on the provisions of Gestalt psychology, which is based on the following: any effective structure should be the simplest [1]. Thus, the following principles can be formulated:

– a person is psychologically focused on an ordered space, he is looking for it in the environment, often imagining an unfinished fragment of space.

– a person perceives a geometrically shaped space, such as a sphere, cube, parallelepiped and the like, as ordered one. It is more difficult to perceive an oval, a triangle, spaces in which the center is more difficult to determine. It is no coincidence that the Renaissance often operated with circular shapes, while the Baroque used the shapes of ovals, paraboloids, and trapezoids.

It is necessary to pay attention to the fact that there is a real space and the space which is felt through visual and dynamic contact. They are significantly different. A person evaluates space when he perceives it. Forms and properties of architectural spaces greatly affect human life and behavior [2]. The concept of positive (structured) and negative (amorphous) space is used in architectural composition. A space is considered positive if it has a certain shape or border that is clearly felt. Positive spaces are spaces that are geometrically and psychologically adequate, they are easily determined as organized. If it is impossible or difficult to determine the shape of space, it is called negative. The formation of a sense of positive space, organized by freely located volumes, is also possible due to the "guessing" of the spatial form. The feeling of space organization is formed due to the imaginary continuation of the limiting surfaces. The main direction of continuation is a visually more active plane (more significant and massive, having a larger size). This surface serves as a source of information about the potential order inherent in this space (Figure 1,2).

FIGURE 1. Examples of complex spaces of the historical part of Lviv. Figures by student M. Maistrenko [13].

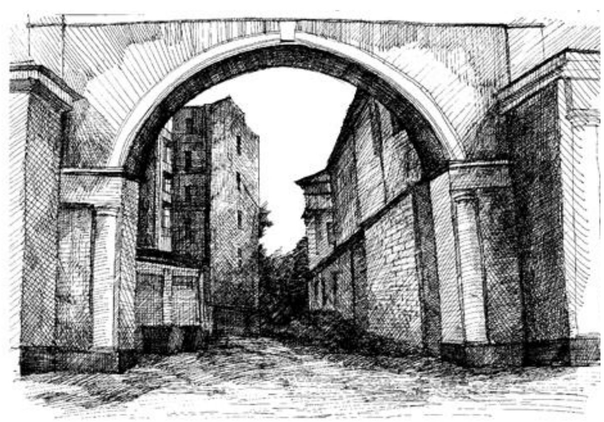

FIGURE 2. Examples of complex spaces of the historical part of Lviv. Figures by student N. Uspenskaya [13].

R. Arnheim puts forward the laws of "simplicity" of the ratio of parts and whole, the rules of "grouping" the figures on the principle of similarity, and others. He notes that any visual model strives for simplification and simplicity [3].

Geometric "Platonic bodies" (circle, sphere) are the key to the structure of space. These forms are endowed with a deep symbolic meaning. Thus, the shape of the circle has been sacred for a long time, it is the basis of the universe, the basis of the human body proportions, etc. [4]. Using universal geometric shapes in compositional and structural solutions makes architecture and architectural – urban space in general more acceptable to man on an emotional level. The symbolism of these forms is substantiated by their aestheticization as absolutely ordered forms (ideal). The geometry of simple forms can be quite easily guessed in more complex forms and thus be perceived as the most acceptable in general. This form can be perceived as a prototype for forms with more complex configuration. Thus, a triangle, a square and a circle are signs of the architectural alphabet, pure geometric shapes, understood as a universal code by which the environment is formed [5].

At the same time, the aspect of art that is obligatory for architecture requires a setback from the simplicity and ease of perception to more complex structures. "Complications", "alienation", "catharsis", according to L.S. Vygotsky, Y.M. Lotman, are mandatory components of a work of art. According to Y.M. Lotman, an artistic text is a text with increased signs of order. But no less important, in the artistic structure, is the fact that along with the levels of coincidence, there are necessarily levels of differences. In any system, two trends can be identified – the establishment of structured order and its violation [6, 7]. Speaking about the nature of art, the famous literary critic V. Shklovsky wrote about the semantic importance of violating a literary text. Artistic text with a well-formed order does not follow the geometry to the end. It always has some violations. There is an order in art, and at the same time, there is not a single column in the Greek temple that is repeated exactly [8]. These concepts can be immediately transferred to works of architecture.

As can be seen from the above, it is necessary to prove the importance of violations of a simple geometric shape. It is essential that the ideal geometry is violated as society is humanized. And the circle (sky), clear in ancient times, turns into a baroque oval or dissolves in other forms. The world order becomes transformed as humanity develops and sometimes begins to deny itself in search of something new. Rational epochs change the irrational worldview with a new form of order – order in chaos. So, although man tries to level complex shapes to simple geometric ones, at the same time he always seeks how to move away from them. Therefore, violations of elementary geometric laws are required to achieve the compositional and artistic integrity of an architectural work [9].

On the example of world masterpieces of architecture the sacred symbolism that underlies the geometric constructions can be noticed. For example, Versailles Park – a French regular park – has a geometrically proper layout with a pronounced symmetry and regularity of composition (Figure 3).

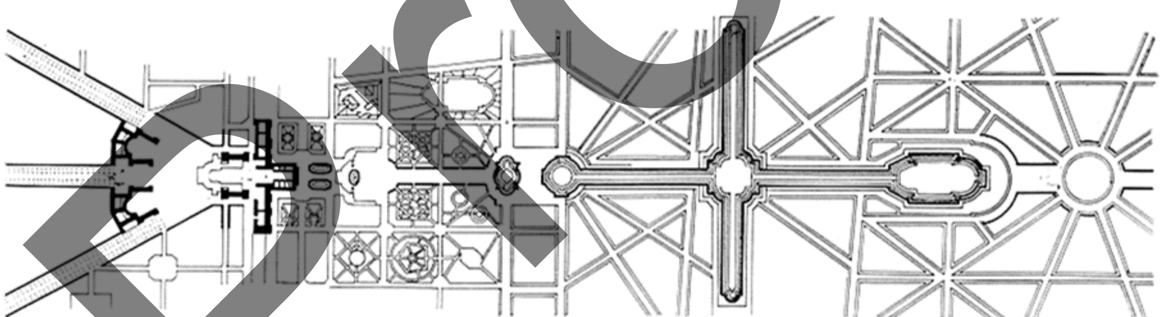

FIGURE 3. Palace and Park Ensemble of Versailles, Andre Lenotre, 1789.

The axes of the park are the axes of symmetry, all the elements of the park have the regular geometric shape. Versailles, like other regular parks, symbolizes the obedience of nature to the laws of mind. This is evidenced by its logic, symmetry, order. Its planning was subordinated to three radial arterials, which diverged from the central part of the palace in three directions: So, Saint-Clu, Paris. The main alley is crossed by transverse alleys, which form rectangular or square sections of bosquets. The toponymy of Versailles Park was reproduced by figurative means of the theological interpretation of the semantic essence of the garden and park space. According to it the creation of the first garden - Eden is interpreted as an act of will of God-creator, who creates a hierarchical order of world harmony. Versailles, with its geometry, embodied a new model of the universe, constructed in the spirit of French rationalism, where the Sun King rules, conquering both the earthly world and the heavens [10].

Another example is the architectural ensemble of Kiev-Pechersk Lavra, which was built in the eighteenth century. in an effort to support the idea of "Heavenly Hail", heaven on Earth. It was based on a geometric-axial system. But the system of architectural spaces of the complex which is formed to almost proper geometric forms is broken due to the complex relief of the Lavra territory (Figure 4).

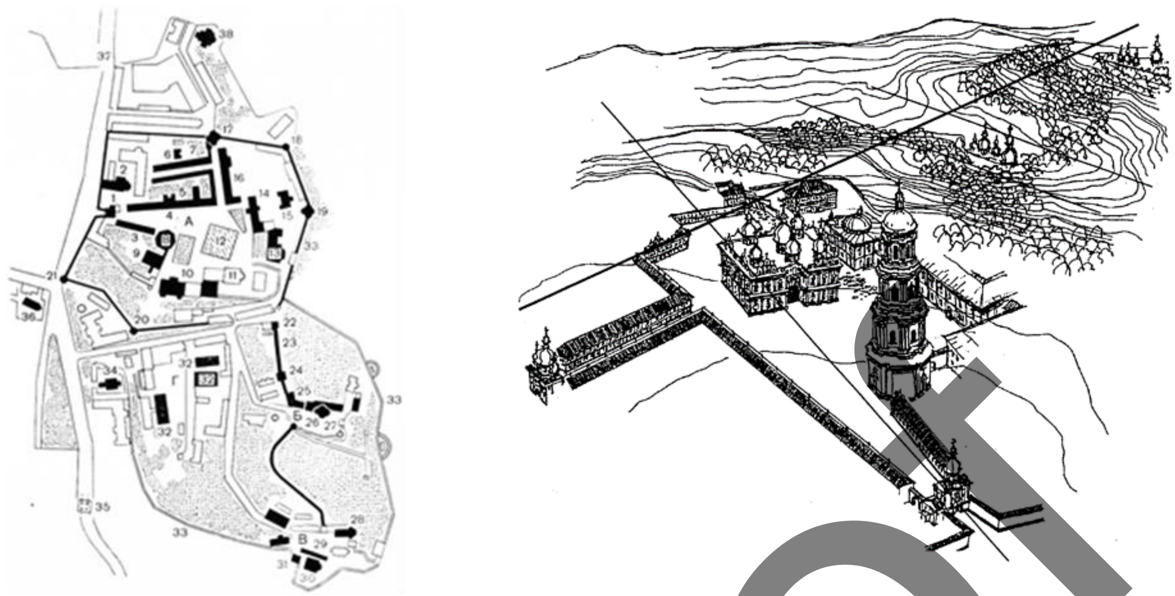

FIGURE 4. Scheme of the general plan of the Kiev-Pechersk Lavra.
Compositional and axial structure of the Kiev-Pechersk Lavra.

The ensemble of the Lavra characterizes the harmonious combination of the complex structure of buildings and landscape, individual components and the whole formed by them. The sacredness of the Lavra space is expressed in the peculiarities of the ensemble construction. Order was thought as a compromise between simple geometry and the complexity of a particular situation – the Dnieper hills. The whole combines order, geometry and picturesque naturalness. Making the necessary violations in the clear geometry of the spaces enhances the artistic value of the ensemble of the Kiev-Pechersk Lavra [11]. The construction of the main building in the center is connected with the idea of the center of the world, its central axis embodies the image of the world mountain. The vertical axis of the cathedral, which expresses the opposition "top-bottom", symbolizes the meditative connection between external and internal.

For many years, the monastery became a model of architectural and spatial organization of monasteries and church construction. Nowadays, the architectural ensemble of the Kiev-Pechersk Lavra is a model of high architecture, for which there is no time limit. Its compositional and figurative unity, versatility, complex semantic integrity is still impressive and requires great professional attention [12].

The difference between understandable spaces acceptable to man, which have a clear logic, and others that do not fit into such a concept, is, in fact, decisive. A straight street, a wide square, a clearly defined yard, etc. are understandable. Rotation or narrowing of space, immersion in a shadow or a difference in height immediately transfers the space into the category of incomprehensible - strange, endowed with negative semantics. Strange are the spaces of the city, which for one reason or another do not fit into the existing structure, do not have its logical continuation [13]. More often, such spaces are found in historical parts of the city. But not in all, only in those which general structure is read quite clearly. As S. Ya. Senderovich notes, this is a combination of what cannot be combined, existence on the edge of rationality [14]. Their kinship is perceived through the general contrast of the clear and the light to the shadows and chaos. Accordingly, without the presence of a strangely shaded complex illogical space, the logical meaning of urban spaces would not have received the necessary sharpness, tension and discharge, riddles and clues, and in general went to the profane routine.

Thus, complex spaces, different from the easy to understand basic architectural and urban structures, give these structures a deeper meaning by stimulating a tense perception of their ambiguous nature. Ambiguity is the path to art. Spatial-light pulsation, which is felt by a person moving in an illogical space and overcoming a chain of tension, causes at the level of the subconscious the final clear culmination – a light output. The freer and more acceptable the picture that opens, the clearer the exit-portal that opens it, the more emotional the finale and the deeper the impression is. The expectation that took place gives a feeling of satisfaction, filling with new meaning, the environment is perceived as a holistic architectural ensemble. The lack of expected completion leaves the environment mundane and makes a person indifferent to it. A new being that appears because of the tension experienced will always be perceived as something more significant, higher than the ordinary obvious.

Methods of forming the spatial boundaries of architectural and urban complexes

In the urban structure, an important aspect of space perception is the need to fix spatial boundaries, beginning and end, which is embedded in man at the level of archaic consciousness, as an architectural expression of the collision of qualitatively heterogeneous spaces in the form of binary oppositions. The impression of isolation is created psychologically by observing objects that limit space. The main feature of space is the limit, "the limit of life and death, the limit of honor and dishonor" [15]. According to Y. Lotman, “space is probably the oldest archaic language. And this is not only what we now realize as "space", but it is a universal, through which ethical concepts are revealed.

The concept of "spatial boundaries" was considered in the works of such architectural theorists as K. Lynch, A. Gutnov, V. Glazychev, S. Shubovich, B. Uspensky, O. Yavein [16-19]. A. Gutnov identifies two fundamentally different methods of organizing an open architectural space. The first is the creation of a closed space with the help of architectural structures located along the perimeter, the other way is the erection of a monumental building, which creates a specific spatial field around itself, a zone of active influence of the boundary.

FIGURE 5. Place Vendôme in Paris. Architect Jules Arduin-Mansard, 1699.

As, Place Vendôme in Paris, created in 1699 by architect Jules Arduin-Mansard in honor of Louis XIV, which is framed on all sides by buildings, has clear and rigid spatial boundaries. Thus, a contrasting ratio of external and internal, despite the large size of the area, a person feels "inside" in a closed static space (Figure 5).

Clearly limited architectural and urban spaces are often found on different scales: city squares, courtyards and individual rooms [20]. Limitation on four sides is often found in historical works of architecture, which were used for visual and spatial selection of a sacred or very significant place, inside which was placed a memorial or sacred building.

FIGURE 6. Place de la Concorde in Paris. Architect Ange Jacques Gabriel, 1755.

Place de la Concorde in Paris, designed by architect Gabriel in 1755, is not built around the perimeter of the buildings. This gives a person the opportunity to admire the beauty of the city, echoing it. The Luxor obelisk of Ramses

II from the Egyptian temple is installed on the square. For the visual organization of space, the architect needs visual accents right in the middle on each side of the square. In the east, the focus is on the exit of the Tuileries Garden, decorated with two equestrian statues, in the south - the bridge over the Seine (the palace on the opposite bank appeared later), and in the west - the view of the Champs Elysees (Figure 6).

There are no clearly defined boundaries, but there is a monument that defines the boundaries of this area. The Luxor obelisk can be seen from many positions, it is a landmark at long distances, but as it is approached, it acquires a characteristic meaning that organizes the space of the square around, creates boundaries that are visually formed in the human mind. This type of spatial boundaries is felt the weakest. Such an element can form boundaries around itself only if it is visible from many positions and angles [21].

Blurring of spatial boundaries in the absence of rigid limits on either side, due to the nature of the slots or by dotted elements of architecture creates around a specific spatial field, the area of active influence of the boundary. For the visual organization of space, the architect needs visual accents that fix the visual boundaries. The space loses the essence of a sacred or very significant place, but its boundaries give a softer and more picturesque character to the environment. A person can feel a visual connection with the outside world.

Anything differs from others both spatially and qualitatively. Highlighting a thing from another world is to differ it from everything else. B. Uspensky notes that the boundaries allow us to distinguish a work of art from everyday life. Destroying boundaries makes a work of art more accessible and reduces its image. "In order to see the world as iconic, it is necessary first note the boundaries, namely the boundaries create the images" [22]. Therefore, the boundaries determine the artistic space, which is opposed to the everyday world. Violation of the border allows to bring together artistic and everyday spaces, but also leads to a loss of artistic value.

In The Problem of Spatial Boundaries, as a subject of research, OI Yavein considers the properties of spatial boundaries as an architectural expression of the collision of inhomogeneous spaces in the form of binary oppositions. Accordingly, he distinguishes "boundary-relationship" and "boundary-object" as spatial elements that act as architectural means of organizing the boundaries between climatically, functionally and symbolically heterogeneous spaces. In analyzing spatial boundaries, O. Yavein takes into account, on the one hand, the utilitarian functions of boundaries, and on the other hand, considers spatial boundaries as oppositions, such as "organized-unorganized", "public-private", "center-periphery" and etc. [23]. Lynch also notes the ambivalence of the spatial boundary, that is, he points out that it is not only a barrier, but rather connects parts of the city. He also identifies paths, areas, nodes and landmarks, the other meaning of which is to be boundaries [24]. Thus, the boundary in architecture determines the unevenness of space, which simulates the situation of collision of semantically inhomogeneous spaces [25].

The spatial structure of the urban environment is a "framework" formed by the street network, natural landscape, architectural structures and other environmental objects that create a system of various chaotic inhomogeneous spaces and impressions of their perception. This poses a special task for designers:

– be able to "divide" by means of architecture adjacent spaces that merge together;

– know the techniques of "connection", harmonization not only of functional processes, but also impressions from different parts of the city, adjacent to each other.

FIGURE 7. Kharkiv. Arch of the house on the Kharkiv embankment, arch. V.S. Donskoy. Figures by student V. Kulibaba [13]

FIGURE 8. Kharkiv. Hromadyans'ka Str. Figures by student V. Kulibaba [13]

Boundaries serve as an organizing factor of space. Continuity of boundaries, proximity of parts to each other, repetition of rhythmic intervals, homogeneity or harmonious order – these qualities facilitate the perception of complex space. Spatial boundaries can be: urban development, linear park, boulevard, fence, terrain differences, environmental boundaries, small architectural forms - these elements contribute to "reading" a person subconsciously the nature of the boundaries and identify spaces on an intuitive level (Figure 7,8).

The basic methods of forming spatial boundaries will provide an opportunity to solve important for modern architecture problems to organize the structure of urban spaces.

CONCLUSION

Man is psychologically focused on ordered space, he seeks it in the environment, often imagining an unfinished fragment of space. The feeling of organization of space is formed due to the imaginary continuation of the limiting surfaces. The main direction of continuation is a visually more active plane, which is the source of information embedded in this space.

A person perceives an orderly space similar to simple geometric shapes – a sphere, a cube, a parallelepiped, etc. These three-dimensional shapes are derived from the simplest planar shapes – a triangle, a square and a circle. These are the basic elements of the architectural alphabet. They have been used to depict the structure of space. At the same time, the aspect of art that is obligatory for architecture requires a setback from the simplicity and ease of perception to more complex structures.

Violations of elementary geometric laws are necessary to achieve the compositional and artistic integrity of an architectural work. Violations in order is an aspect of a work of art.

Complex spaces, different from the easy to understand basic architectural and urban structures, give these structures a deeper meaning by stimulating a tense perception of their ambiguous nature. Ambiguity is the path to art.

Boundaries serve as an organizing factor of space. Architectural and spatial boundaries have semantic qualities:

– semantic boundary. The function of the boundary is only demarcation, while its image has many interpretations – a barrier, a partition, a connection, a transition, a threshold, etc .;

– psychological boundary. Boundaries are perceived by a person, depending on the qualities – the nature of space affects the behavior and feelings of the person in it. In a space with clear or closed boundaries, without a visual connection with the external environment, a person feels inside, within a certain space. In the absence of clearly defined boundaries, a person can feel a visual connection with the outside world.

Continuity of boundaries, proximity of parts to each other, repetition of rhythmic intervals, homogeneity or harmonious order - these qualities facilitate the perception of complex space. Violation of the boundary allows to bring together artistic and everyday space, but also leads to the loss of artistic value.

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Ecological Transformation of Industrial Regions: Recreation System by the Example of the Emscher Landscape Park

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Abstract. The revitalization practice of degraded industrial and economic territories, as well as the renaturalization of waterways of the Ruhr industrial region is considered in the article. A model of a regional tourism and recreation system based not only on natural and recreational, but also on historical and cultural facilities, dated back to industrialization period, is proposed. The functional planning structure of the park is analyzed, the methods and principles of its development are considered. In addition, some industrial districts of Ukraine are compared to the Ruhr region. Based on the analysis of industrial area redevelopment practice, a model of transformation of historical industrial areas of Ukraine into the tourism and recreation systems is considered.

INTRODUCTION

In modern urbanism, the issue how to make urban environment eco-friendly is increasingly urgent. It depends on a number of factors. The most important one is the person's "quality of life", taking into account not only the current generation, but also future generations. This idea substantiates the environmental aspects of global transformations in all spheres of social existence: from science, production and consumption to everyday tasks. In terms of architecture, sustainable construction is the desire to express green values whereas in terms of urbanism environmental aspects require systemic transformations.

The ecological scheme of the region could be formed in accordance with the level of regional planning and natural landscape characteristics of the area. Depending on the regional scale, it can take into account transnational, state and local ecological corridors, 'ecological plume' of urbanized territories, the system of tourism and recreation, land characteristics, and many other factors. The purpose of this scheme is to account, forecast and create a long-term strategy for the development of the territory as a single system based on the settlement system, natural and recreational fund, infrastructure and economic resources.

The increasing role of environmental issues in the regional planning process set out new requirements for earlier urbanized territories, including areas of critical urban development (industrial areas, storage facilities, transport corridors and hubs). Due to economic changes, a lot of them are stagnant, abandoned or not used effectively.

PROBLEM STATEMENT

The problem of rational use of regional territories with established industrial and functional planning structure is urgent, especially at the current stage of the post-industrial economy of Ukraine as well as conditions of sustainable development of existing recreation and tourist potential. Today, many areas of urban development need a conceptual

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rethinking, since they are not only industrial and economic centers of the country but also technological, scientific, historical, cultural or recreational ones.

PURPOSE OF ARTICLE

The Purpose of the article is to analyze the experience and practice of the ecological transformation of the Ruhr industrial region. It is a good example of the regional concept that provided this region with environmental improvement and ensured a significant socio-economic effect.

MATERIALS AND METHODS

The ecologization process in regional planning is based on a number of European programs, 'European Green infrastructure' and 'NATURA-2000' in particular, as well as on the provisions of environmental conventions: Maastricht (1993), Sofia (1995), Aarhus (1998), Kyiv (2003) and Belgrade (2007), which set out the main environmental provisions and identified the ways to integrate environmental policies into the others (Fig. 1) [1-5].

However, a key example of the transformation of an industrial area, which is an analytical basis for this study, was the reorganization experience of the Ruhr industrial area in 1989-1999. This reorganization was held as a part of the program of the Emscher Park International Architectural Exhibition. As a result, the region became an example of a comprehensive industrial reform: as of 2018, 2 out of 141 mines (record of 1956) remained in operation, and stopped its production in 2019 [6, 7].

In the light of these transformations, the Ruhr region has become a notable example of practical rehabilitation of the territory with its significant industrial and urban development. 'Environmentally-oriented approach' and 'landscape planning' were the main transformation principles. Unsatisfactory condition of the main waterways in the region was considerably improved, due to the 'renaturalization' of the Emscher River in part, the dirtiest of the rivers, and the creation of the Emscher Park.

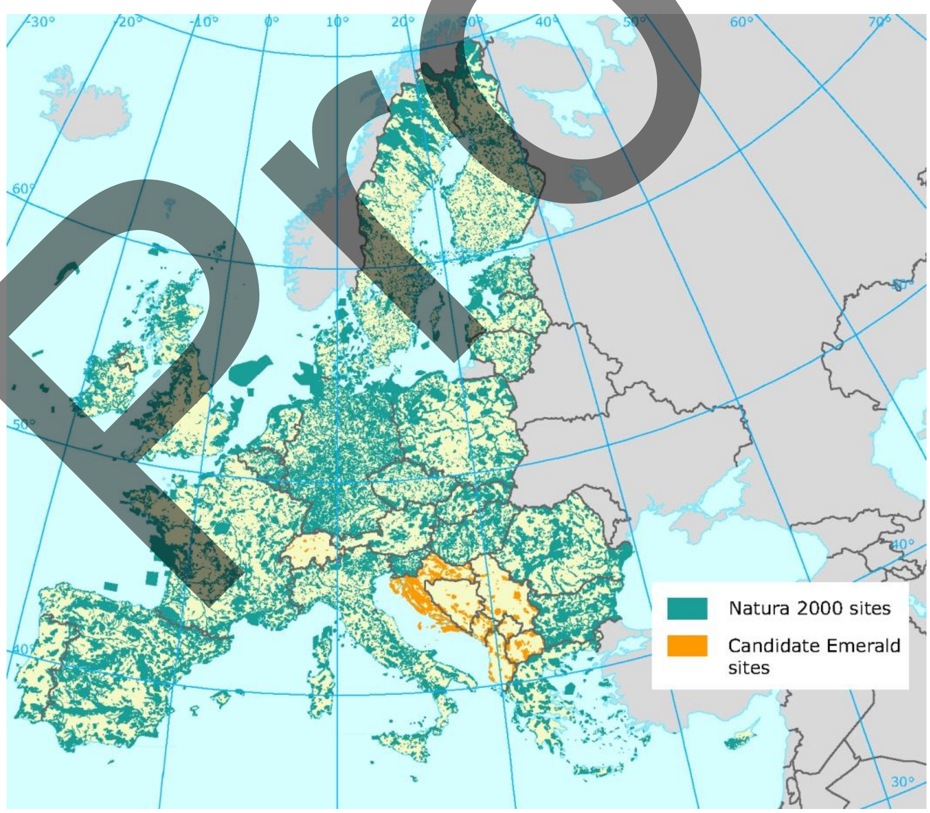

FIGURE 1. The 'Natura-2000' and the 'Emerald network'

THEORY

The Ruhr Industrial Region (German: Ruhrgebiet, North Rhine-Westphalia, Germany) is an urban agglomeration with the area of 443.5 thousand hectares and is a metropolis with population of about 5.3 mln. people. The agglomeration is one of the largest in area and level of urbanization in Germany (Fig. 2, Fig. 3).

When the production was reduced onsite of the industrial areas, the Emscher Landscape Park (Emscher Landscape Park, North Rhine-Westphalia, Germany) was established with the area of 460 km2, linking 17 cities with total population of 2.5 mln. people. This park is programmed and created as a ‘green connection’ between the settlements of the district. Its structure consists of ‘regenerated’ mining areas, forest and recreational areas. A set of environmental measures was carried out: construction of dams and reservoirs, reforestation (by 35%). Technological, scientific, museum and cultural sites have been formed on the site of industrial facilities, which are connected by seven green ‘corridors’ and the entire landscaped area of the Emsher Park. This project of German scientists Karl Ganser and Christoph Zöpel (German Karl Ganser, Christoph Zöpel) for the rehabilitation of industrial areas was implemented in its real life size and the landscape park itself is the largest in Europe. The concept of the park provided for re-planning of the region, delimitation of industrial and residential areas, creation of park strips as green corridors of the region [8, 9].

The analysis of ecological factors of this region made possible to evaluate positive changes in environmental management, i.e. the increase in forest area (by 35%), pastures, natural zones and the reduction in agricultural land area (Fig. 4, 5, 6) [10, 11].

The unique industrial and cultural resources of the Ruhr region became the basis for the development of a powerful network of ‘industrial parks’, which included a total of 45 museums (natural, technical, industrial and scientific), 17 observation decks, 13 large industrial settlements. It was a great starting point to build a network of social and cultural facilities – ‘Way of industrial culture of the Ruhr region’ was created as a historical and industrial tourist route, which not connect important places of industrial development, but also is the most prominent network of industrial tourism in the world (Fig. 6) and a part of the European route of industrial heritage [12-15].

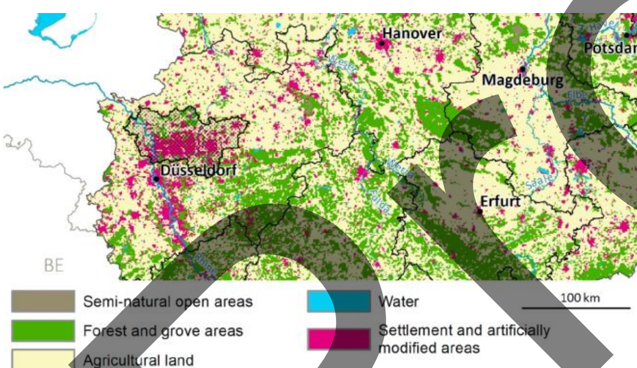

FIGURE 2. Main ecosystem types in Germany, 2015.

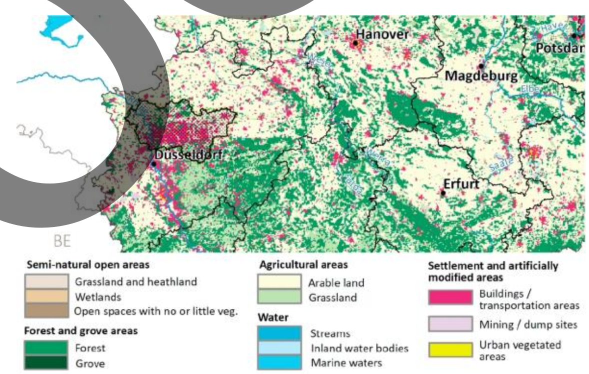

FIGURE 3. Sub ecosystem types in Germany, 2015.

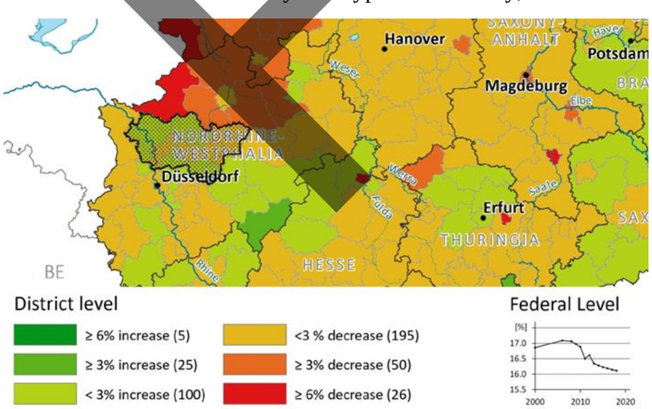

FIGURE 4. Proportion change of grazing areas in Germany, 2000-2018.

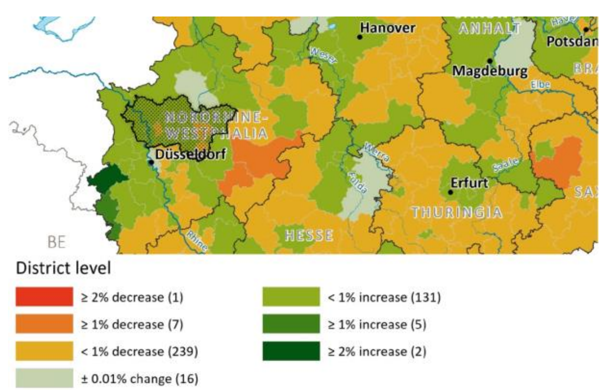

FIGURE 5. Proportion change of nature-accentuated areas in Germany, 2000-2018.

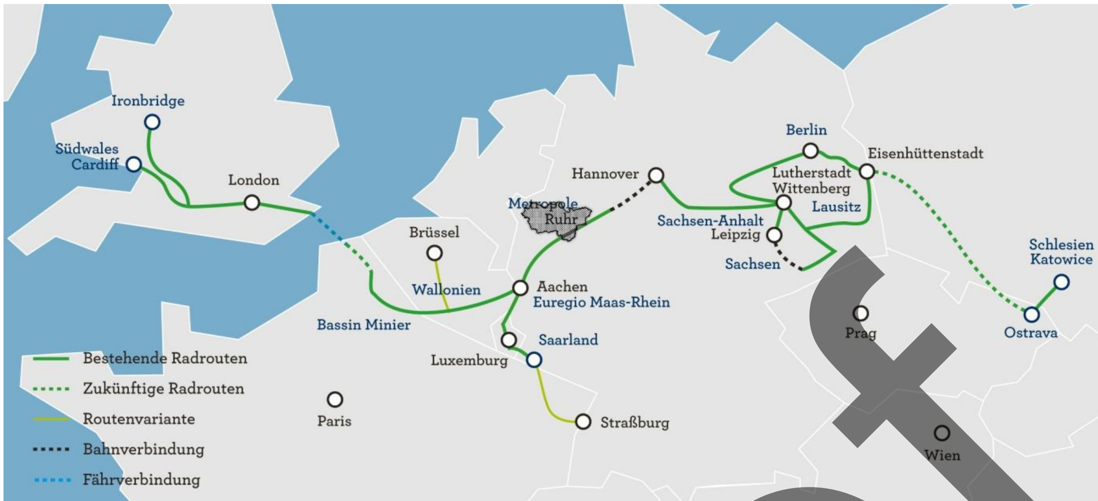

FIGURE 6. The European bicycle routes 'Coal and Steel' and industrial facilities [16].

The level of tourist and recreational infrastructure development of the Ruhr region (the tourist route is 400 km of motorway, 700 km of bicycle paths and separate routes for visitors with special needs) was an essential factor that influenced the self-identification of the region with a great tourist potential, due to its significant historical and cultural heritage (Fig. 7).

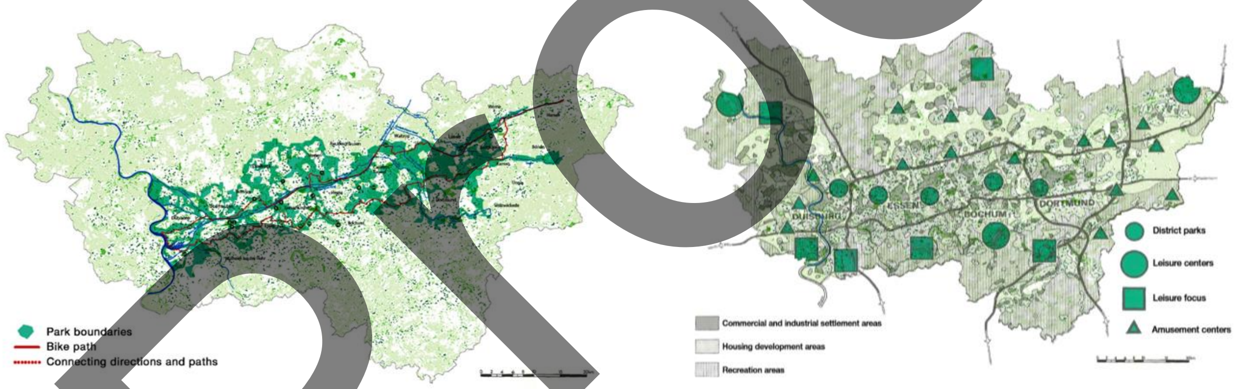

FIGURE 7. Ruhr Industrial Region and the Structure of the Emscher Landscape Park

The result of the urban transformation of the region was a completely new ecological and recreational system, based on not so much available natural resources as mostly historical and cultural ones [16-20].

RESULTS

As a result of the literary and cartographic analysis of the Emscher Landscape Park development, its functional and planning principles, concept, natural resource, historical, cultural and infrastructural base, a number of conclusions were drawn:

1. The park was developed by renaturalization of degraded industrial economic territories and polluted waterways.
2. The structure of the park is a cluster-corridor network of restored woodland in the buffer zones of the agglomeration. Woodland is used to clean contaminated soil from heavy metals.
3. In conditions of high urbanization of the territory, a number of historical and cultural objects of the industrialization period, not natural ones, became the basis for the tourism and recreation system of interstate level.

4. The rapid growth of the tourism and recreation system was possible due to the developed infrastructure of the industrial region expanded by tourist walking and cycling routes.

CONCLUSION

It was found out and concluded that the experience of the Emscher Landscape Park development could be put into practice for further ecological transformation of historical industrial areas to create tourism and recreation systems of interstate level.

In conditions of current transition to postindustrial and information society, deindustrialization the practice and experience gained are of high value and importance. They could be applied, first of all, to urbanized regions focused on mining and processing industries, metallurgy and mechanical engineering, which include large agglomerations.

Taking Ukraine into consideration, these regions are the Dnipropetrovsk region with Dnipro and Kryvyi Rih agglomerations (mining, heavy metallurgy and mechanical engineering) (Fig. 8); Donetsk region with Donetsk-Makeevskaya, Gorlovsko-Enakievskaya and Mariupol agglomerations (coal, coke-chemical industry, metallurgy), Luhansk region with Luhansk, Alchevsko-Kadievskaya, Khrustalnenskaya and Lisichansko-Severodonetsk agglomerations (coal industry, metallurgy and mechanical engineering).

FIGURE 8. Industrial heritage route concept (Dnipro and Kryvyi Rih agglomerations)

The territories of the indicated regions have rich industrial heritage, however, today they are depressed, have high urbanization of the territory and a developed infrastructure. Depending on the current policy and programs of socio-economic development, the territories of these regions are appropriate for the potential reorganization of their structure. The tourism and recreation system, by the example of the Emscher Landscape Park, can become one of the main directions apart from intensifying the industrial qualities and establishing a ‘technopark’.

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Strategic Management of Innovation Activity of Railway Enterprises within Digital Changes in the Industry

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Abstract. The paper reveals the world trends of railways innovative activity development and on this basis establishes the gap between tendencies of innovative growth of the railway transport enterprises of Ukraine and preservation of the closed format of the implementation of their innovative activity. Given the scale of digitization processes and the fragmentary nature of the implementation of innovative changes in the railway industry, the feasibility of using such flexible strategic tools for managing innovation activities of railway transport enterprises as customization and models of open innovation has been proved. The evolution of customization in the process of ensuring the innovative development of railway enterprises and the transformation of the organization principles of their innovative activities is reflected. This is taken as the basis of the approach to strategic management of railway enterprises innovation in the implementation of digital changes in the railway industry. Scientific approaches to evaluating the effectiveness of the implementation of innovative solutions in railway transport enterprises are revealed. It is proposed to evaluate the effectiveness of innovative tools in railway transport enterprises by calculating the economic effect obtained by optimizing costs, increasing the profitability of business segments of railway enterprises and increasing the value of their business due to the implementation of innovative solutions.

STATEMENT OF THE PROBLEM

The dominance of the global trend of digitalization and acceleration of the processes of digital modernization of business lead to a radical transformation of the principles of organizing innovation activity at railway transport enterprises. Global trends in the development of innovative activities of railways indicate the total digitalization of the life cycle of innovative products, increasing the technological complexity of production and the transition from mass standardized production to the development of customized products and services, deepening global innovation partnership and cooperation based on digital ecosystems, open innovation systems development, strengthening cross-functionality and convergence of their elements.

Besides, the current situation of domestic railway transport companies reflects the disregard for global innovation trends in the development of railway companies and the preservation of the closed format for the innovation activities implementation in the railway industry of Ukraine. The tactical nature of the tools to ensure the innovative development of home railway enterprises indicates the feasibility of using strategic management tools of their innovation, taking into account the world practice of intensifying the innovative development of the railway industry entities.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

At present, scientists are highlighting the study of innovative activities management of enterprises, in particular railway systems. Among the scientific achievements devoted to the solution of the outlined problem, special attention should be paid to the publications of such scientists as L. Glinenko, V. Dykan, O. Gassmann, E. Enkel, M. Zelenkov, N. Kalicheva, J.-N. Kapferer, O. Kirdina, V. Kompaniets, M. Korin, M. Mishchenko, O. Nikiforuk,

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O. Polyakova, H. Chesbrough, O. Shramenko, V. Shulmeister, and others. [1-15] In particular, V. Dykan, N. Kalycheva, O. Kirdina, M. Korin, O. Nikiforuk, O. Polyakova, O. Shramenko, V. Shulmeister conducted a comprehensive investigation on modern problems of railway transport development and determining further prospects for its development. The issue of encouraging the innovative activity of railway transport enterprises at the current stage of their development is revealed in detail as well. L. Glinenko, O. Gassmann, E. Enkel, J.-N. Kapferer, H. Chesbrough considered the content, features of customization and the characteristics of its application in various areas, as well as highlighted the peculiarities of the open systems of producing innovations. M. Zelenkov, M. Mishchenko, A. Ozerska, O. Selina considered the issue of evaluating the effectiveness of innovative projects in railway systems. Along with this, the issue of strategic management of innovation activity of railway transport enterprises under the conditions of total digitalization of business processes and radical restructuring of the global transport and logistics space remained insufficiently considered which led to the choice of the subject of this research.

STRATEGIC TOOLS OF INNOVATIVE ACTIVITY MANAGEMENT OF RAILWAY ENTERPRISES

According to the world experience of transport companies, ensuring a high level of adaptability of innovation systems of railway transport enterprises at the current stage becomes possible due to the introduction of such strategic tools as the model of open innovations and customization of innovative products of the industry. In view of this, it is necessary to consider the listed tools and features of their application in innovative activity of the railway enterprises in more detail.

Nowadays scientists pay considerable attention to the study of the essential content, features of the development of customization and the characteristics of its application in various areas. Thus, several approaches to understanding the category of "customization" have been formed: firstly, as marketing trends, which are formed on the basis of market segmentation research and are the result of marketing focus of the enterprise on a specific group of consumers; secondly, as a marketing tactic that involves the formation of consumer demand for products and motivation to purchase them; thirdly, as a strategy of innovative development of the enterprise, which provides the formation of additional value for both producers and consumers in the process of development and commercialization of innovations by improving the communication interaction of these entities; fourthly, as a business philosophy and innovative development of the enterprise. The latter approach expands the scope of the customization tool: it focuses not only on the company's relationships with consumers, but also with suppliers, partners and other stakeholders.

The most common of the modern definitions of customization is its understanding as a process of individualization of products from the demands of specific consumers by making appropriate changes in the process of product development or production. The main task of customization is to create a feeling around the consumer that the work is done personally for him and aimed at meeting only his personal needs. A number of experts consider customization to be practically an ideal of interaction between enterprises and consumers. Because the latter are active partners of business entities in creating value. Therefore, customization attracts not only by ethical orientation, but also by the opportunity to obtain financial benefits. After all, due to the higher value of the customized solution, the customer gains a competitive advantage. The corresponding concept of joint value creation is based on the idea of open innovations and marketing interaction. Its use allows the company and the consumer to consolidate resources and create added value by participating in each other's innovative programs.

Given the wide range of definitions of the essence of customization in the scientific literature also different approaches to the classification of its types have been formed. Therefore, the classification based on production is the most generalized. It involves the allocation of horizontal (product modification using standard components) and vertical customization (production of an individual product from unique components created directly for a particular customer). In turn, in paper [7] the author identified such types of customization as cosmetic (standard product; standard price; external product change), expert (creation of a new type of product), modular (addition to existing parts; standard price; short performance time), adaptive (standard product; universal options). L. Glinenko significantly expands the list of customization types, supplementing them with such types as [3]:

- “pure” standardization (production of a standardized set of goods according to pre-defined requirements of a certain segment of consumers);
- “segmented” standardization/limited adaptive customization (customization at the stage of distribution and sale by adapting the product to the customer’s needs by changing the packaging, method of delivery, completeness, etc.);

- “customized” standardization (consumer micro segmentation, personalization of proposals and offering a large set of proposals with shifted characteristics to meet the requirements of different microsegments);

- “limited” customization (the ability to customize or personalize is laid down in the production, for example: Benetton clothes are painted in the colour chosen by the consumer after choosing the product in the store);

- “pure (transparent)” customization (creation of a completely unique product for individual consumers without informing consumers about customization);

- “compatible” customization (the company communicates with individual consumers, participates in the formation of their requirements and offers customized products for these requirements with the establishment of appropriate flexible production);

- partial personalization (consumer ideas are taken into account in the development of goods; the consumer is given the opportunity to change parts of the product properties for which the requirements are highly individualized) or “mass compatible customization" (consumers massively participate in designing value proposals “for themselves”);

- full (“pure”) personalization (the product is created so that the consumer can completely change the product and adapt it to specific conditions) or “mass cross-customization” (the consumer participates in the development of the concept of the product “for himself” and generates ideas for improvement goods for others).

The classification of customization types in the B2B segment arouses interest as well. Mass customization is the most common. It involves the production of mass products and making minor adjustments, often in its appearance, in order to form a unique offer for the customer. In turn, customization in the premium segment entails the formation of unique products that differ not only in appearance but also often in functional properties. Customization for the market segment involves the modernization of products in accordance with the needs of a particular consumer segment. Another unusual way to customize products is the so-called “private label”, which focuses on the production of products without a label and its design in accordance with the company logo or company name.

Thus, today customization has undergone a significant transformation in the process of evolution of both the management concepts of production activities of enterprises in general, and directly the innovation and marketing activities of economic entities (Fig. 1). Thus, the concept of lean production came to replace the concept of mass and large-scale production, characterized by the creation of standardized products that are in common homogeneous demand, and the implementation of which allows to achieve cost savings due to economies of scale. This concept involves the systematic elimination of losses in production activities, optimization of production processes, increasing the flexibility of production depending on changes in demand for products. The level of product customization at this stage is low.

The next stage in the transformation of the management system of production process is the concept of rapid production response, which is characterized by a focus on accelerating production that meets the needs of the buyer (customer), who can easily assess the benefits of other manufacturers or carriers within the development of Internet technologies. The products at this stage are characterized by an average level of customization.

Nowadays the dominant concept is active production, which focuses on ensuring its instantaneous adaptation to changes in the environment, in particular by predicting probable risks, rapid adaptation to individual quickly changing market demand and creating opportunities for enterprise operation in the integration of online and offline formats. The concept of active production is characterized by a high level of robotization of production activities and customization of products. It should be noted that at this stage the phenomenon of customization becomes mass and systemic, gradually transforming into customization, which involves the consumer not only in the production process of innovative products, but also in the management of processes for its implementation.

The type of consumer's behaviour and its role in the production process of innovative products is dramatically changing as well. Thus, if in mass and large-scale production, the consumer had not participated in the innovative activities of the enterprise, and demand for products was determined on the basis of analysis of the general market situation, then in the period of active application of the principles of lean production the consumer played the role of "evaluator" of the product consumption value. Therefore, the gradual segmentation of the market took place depending on the needs of target groups of consumers. Under the conditions of fast-reacting production, the consumer takes an active part in innovative activity of the enterprise, in particular in creation and production of innovations. In turn, the digitalization of the processes of interaction between business and society has led to a convergence of the role of producers and consumers of innovative products. Currently, the consumer acts as a co-creator and joint party in the production and implementation of innovations and on this basis an interactive digital space of interaction between producers and consumers is formed.

Thereby, the importance of customization in the process of ensuring the innovative development of enterprises is growing. If at the stage of mass and large-scale production customization had been perceived exclusively as a marketing trend, which was not properly taken into account in the process of innovative development of enterprises, then it is considered as a marketing tactic and a tool to improve demand for innovative products. In the context of the concept of fast-response production, customization was a strategy of innovative development of enterprises, and today it is perceived as a philosophy of innovative growth of business entities in the long-term run.

Evolution of concepts of enterprises production management	*Evolution of the type of consumer behaviour and its role in the innovation process of enterprises*	*Evolution of the phenomenon of customization in the process of ensuring the enterprises innovative activity*	*Features of application of the customization tool in innovative activity of the railway enterprises*	*Stages of innovative development of railway enterprises*
Mass and large-scale production. Production of standardized products that are in general homogeneous demand, and the implementation of which allows to achieve cost savings due to the effect of scale. Products are not customized, produced under conditions of constant demand	The consumer does not participate in the innovative activity of the enterprise, and the demand for products was determined on the basis of the general market situation analysis	***Customization as a marketing trend that has not been properly taken into account in the process of enterprises innovative development***	Standardized production cycle and low susceptibility to innovation. Acceptability of innovations and market demand are studied in general or after the launch of innovation in production. Attitude to the market only as a consumer of the results of production technological activity of railway enterprises	***Development of transport and logistics infrastructure in accordance with the world's dominant principles of railway development***
Lean production. Systematic elimination of losses in production activities, optimization of production processes, increasing the flexibility of production depending on changes in demand for products. Low level of product customization.	The consumer plays the role of "evaluator" of the product consumption value, the gradual segmentation of the market takes place depending on the needs of target groups of consumers	***Customization as a marketing tactic and a tool to improve the demand for innovative products of enterprises, correspondingly***	The analysis of consumers' needs of innovative production is carried out at early stages of innovations development. Respectively, the organization of innovation activities at railway enterprises is carried out taking into account the demand for products	***Intensification of innovative development processes of railway enterprises*** *aimed at optimal use of resources. Automation of transportation management processes*
Rapid response production. Concentration on accelerating the production of products that meet the needs of the buyer/customer, who has the opportunity to easily assess the benefits of using the services of other manufacturers or carriers within the development of Internet technologies. Average level of product customization.	The consumer takes an active part in the innovative activities of the enterprise, in particular in the processes of creating and producing innovations	***Customization as a strategy of enterprises innovative development***	Research of consumers' needs of innovative production is carried out from fundamental researches to after-sales service of finished goods. Prospective demand is analysed, and at the last stages of the innovation process, market demand is formed on the basis of the forecast done	***Intensive nature of innovative activity of railway enterprises***. *Formation of an integrated intelligent environment of railway transport. Development of intermodal transport systems*
Active production. Ensuring instantaneous adaptation of production to changes in the external environment, in particular by predicting probable risks, rapid adaptation to individual quickly changing market demand and creating opportunities for enterprise operation in the integration of online and offline formats. High level of robotization of production activities and customization of products. The phenomenon of customization acquires a mass character, gradually transforming into customization	The consumer acts as a joint party and co-creator of the production and sales of innovative products, forming an interactive digital space of interaction between producers and consumers	***Customization as a philosophy of enterprises innovative development***	Based on the digital platform and using digital marketing tools, the consumer is directly involved in the creation of innovative products, from the stage of fundamental research to after-sales service. The use of digital marketing technologies provides not only the formation of demand for products, but also the development and promotion of innovative products, customized to the maximum extent to the needs of each customer	***Innovative renaissance of railway enterprises***. *Formation of a digital environment for the generation of innovative ideas and the production of personalized innovative products. Maximum integration between consumers of transport and logistics services, infrastructure management system and transportation process*

FIGURE 1. The evolution of customization in the process of ensuring innovative development of railway enterprises

Given the scale of digitalization processes, it should be noted the importance of the application of the tool of customization in the innovative activities of railway transport enterprises. Customization as a flexible adaptive technology for organizing innovation processes will allow railway companies to adapt instantly to individual customer requirements by ensuring the continuity of processes of engineering, technical, technological, design and other changes. The advantages of customization in the innovation activities of railway enterprises are: integration of business processes within a single digital environment, which allows monitoring and control of product compliance with consumer requirements in real time at all stages of the innovation life cycle; possibility of virtual modelling and testing of innovative products with the participation of the consumer; real-time production system optimization; the opportunity to perform component technological operations by enterprises of the industry, regardless of their territorial location, etc. Based on the digital platform and using digital marketing tools, the consumer is directly involved in the creation of innovative products, from the stage of fundamental research to after-sales service. The use of digital marketing technologies provides not only the formation of demand for products, but also the development and promotion of innovative products, customized to the maximum extent to the needs of each customer. Thus, the use of the customization tool in the innovation activities of railway enterprises will allow to achieve their innovative renaissance due to the use of digital environment for generating innovative ideas and production of personalized innovative products, maximum integration between consumers of transport and logistics services, infrastructure management system and railway systems.

The conducted investigation of the evolution of the theory of customization and the features of its application in the innovation of railway enterprises allows us to conclude as follows: along with the transformation of local innovation systems into open models of design and production of innovations in the industry, the application of customization tool digital platforms and the use of digital marketing technologies to attract stakeholders in the process of creating innovative products is getting great significance. These provisions are proposed to be the basis for an approach to strategic management of innovation activities of railway enterprises in the context of large-scale digital changes in the railway industry (Fig. 2).

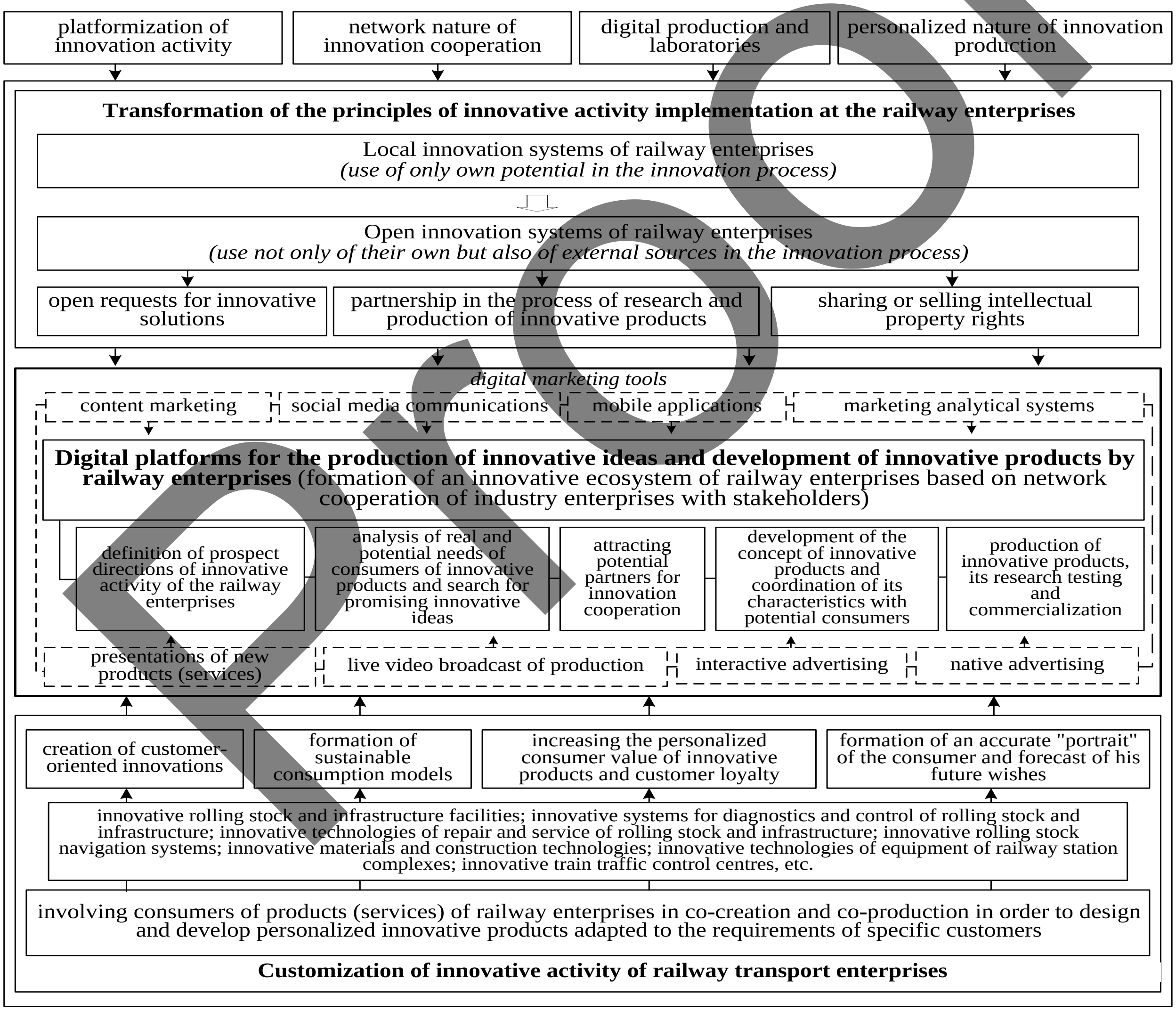

FIGURE 2. Approach to strategic innovation activity management of railway enterprises under the conditions of digital changes implementation in the railway industry

The application of the above tools to enhance innovation processes in railway enterprises in a digital economy will allow:

- to use reasonably resources during innovative activity or exchange them, reducing the load on the environment;
- to develop its own system of quality control of transport and logistics services, based on horizontal connections and trust of users (user feedback, rating system);
- to obtain additional economic results by customizing innovation activities;
- to provide effective network cooperation with stakeholders;
- to combine financial and economic resources for joint use in the innovation process;
- improve the rules for participants in the open model of innovation, ensuring that users comply with all legal requirements (this refers to all aspects of activities from informing the performers of innovation on the mandatory obtaining of permits to quality control of innovative transport and logistics services), etc.

EVALUATING EFFICIENCY OF INNOVATIVE SOLUTIONS IMPLEMENTATION AT THE RAILWAY ENTERPRISES

In prospect, as for planning innovation and technological support for the development of railway transport enterprises, it should be kept in mind that customized innovations are the basis for not only meeting the needs of passengers and cargo owners, but also for obtaining additional technical, economic, social and other results. Because now cargo owners and passengers want to receive the necessary, timely and reliable amount of data on the process and quality of providing them transport and logistics services. Their needs can be met primarily through innovation and technological renewal of rolling stock and railway station services. For example, mass equipping freight railway cars with special sensors (forming so-called “smart” freight cars) will allow the railway company and its customers to monitor the location of cars and goods transported in them. This innovation is necessary to ensure efficient logistics that meets the needs of customers and allows at any time to obtain data on the location of cars and, accordingly, the goods of customers. Thus, the enterprises of the industry can transfer data not only about a location of a rolling stock, but also about its run, temperature, and display all movements on the passed segments of a track as well. In addition, all devices will have an autonomous power supply system.

However, this is not a limited list of benefits, which become possible in the context of digitalization. In addition, it should be noted the increase of railway cars availability for use, regulation and quotas, optimization of the calculation of transportation. In addition, along with receiving information while the train is moving in real time, the capabilities of new services and increasing the efficiency of the railway cars use, the overall efficiency of rolling stock management to maintain it in a technically suitable condition rises as well.

Furthermore, one of the promising innovations in railway transport is the system of train driving and the formation of a complex system of "smart locomotive". Combining data on the current location of the locomotive and its technical characteristics on a digital electronic map with track profile and infrastructure objects, the auto-guidance system, using the algorithms for calculating the energy-optimal pathway of the train, provides commands to peripheral microcontrollers to control traction and all types of breaking in real time by means of digital communication channels. The automatic train guidance system ensures their energy-optimal operation in compliance with all safety standards, transmitting the necessary information about the processes taking place, both directly to the driver's console and secure wireless communication channels to a remote server for all interested services. In this case, the top management, receiving data on the movement of trains at the test site, can automatically generate options for changes in the schedule and send the locomotive updated on board schedule to perform.

Modern innovative locomotives have solved complex problems of adaptation and joint work of two artificial intelligences - auto-guidance system and microprocessor on-board control system of locomotive peripheral equipment. This task is implemented programmatically, so its successful solution also depends on the interaction of electronic systems and software of different manufacturers.

Modern requirements of customers dictate new features of cargo delivery. Thus, a tendency to arising services for fast and superfast delivery of goods is being formed in the world. On these trains, the percentage of automated container train management can reach 80%, ensuring the safe execution of the speed regime, taking into account the current speed limits. The built-in options of the recorder in the auto-driving system, which registers up to 45 parameters of the locomotive with reference to the plan-profile of the path and astronomical travel time, allow conducting objective analytical studies for feasibility proof and objectively setting fares for transportation of highly profitable by the cargo delivery speed, such as electronics, medicines, etc.

Thus, the system of innovation and technological support for the development of railway enterprises in terms of their adaptation to digital challenges should be supported by a number of local innovation projects that will ensure timely implementation of global technological solutions aimed at forming a "smart railway" (locomotive driver; registrars of locomotive operation parameters, fuel and electricity metering; driver information systems; "smart" railway car; smart railway stations; intelligent system of automated control of distributed traction trains, etc.), and on this basis the gradual digitization of business segments of enterprises industry.

The introduction of such innovative measures is important for railway transport companies, as their implementation will reduce energy consumption, reduce operating costs, create fundamentally new working conditions for workers in the industry, increase productivity and improve the quality of rolling stock, and therefore they must be subjected to evaluation and effective management influence. In view of the above, it is necessary to focus on the study of approaches to evaluating the efficiency of the implementation of innovative solutions in the railway industry.

There are several main approaches to assessing the effectiveness of technological and technical solutions in enterprises:

- definition of the overall efficiency as the ratio of the results obtained from the implementation of the innovation, and the costs spent in the process of its implementation;
- application of methods for assessing the effectiveness of investment costs, based on the method of discounting, which provide the calculation of net discounted income, profitability index, internal rate of return, etc.;
- calculation of the total or average annual profit from the project, return on investment, payback period;
- real options method;
- method of venture capital, etc.

Let us consider the main approaches to evaluating the effectiveness of innovation, which are designed directly for use in railway transport enterprises in more detail. Thus, paper [13] reveals an approach to assessing the economic efficiency of rolling stock modernization in terms of obtaining an integrated effect, which includes evaluation criteria in terms of effects of two levels:

- the effect of the first level is determined by the direct economic benefit from the project and includes the financial and economic effect and the effect of accelerating the modernization of rolling stock;
- the effects of the second level (technical, technological, innovative, social, environmental, educational, managerial, scientific, generalized transport effect and forestall economic damage) involve obtaining an indirect economic effect. For example, the managerial effect is proposed to be assessed by the indicator of time reduction for organizational decision-making.

An interesting approach to evaluating the effectiveness of innovative projects was proposed by A. Ozerska. The author presents the sequence of evaluation of innovation proposals and their ranking: the first stage is the selection and formation of the indicators structure for evaluating the efficiency of innovation projects by groups; the second is the development of methods for transition of indicators into a comparable form; the third is the formation of methods for calculating the generalized efficiency of the innovation project; the fourth is the development of methods for choosing the best project. In addition, scientists provide a list of indicators for evaluating the effectiveness of innovative projects, which are grouped as follows: indicators of economic, innovation-economic, socio-economic and environmental-economic efficiency and indicators of the impact of innovative projects on economic development [12].

In turn, M. Korin proposed the choice of alternative investment strategies within the investment management model of railway infrastructure projects based on the calculation of the coefficient of integrated efficiency of infrastructure investments ($K_{II}^{\text{int.}eff.}$), which reveals the ratio of infrastructure risks (G_{IR}) and the volume of infrastructure investments (G_{II}) [10]:

$$K_{II}^{int.eff.} = \frac{G_{IR}}{G_{II}} \qquad (1)$$

The methodology for assessing the effectiveness of digitalization of transport and logistics systems management, which is based on the assessment of operational, technical and economic efficiency, is of interest as well. In particular, it is proposed to understand operational efficiency as a set of indicators that characterize in quantitative terms the ability of the digital control system of the transport and logistics system to solve planned and force majeure tasks in a timely and high-quality manner. The general indicator of its evaluation is the ability of such a system to ensure minimum costs when changing the conditions under which the management decision was made. Quantitatively, this criterion is proposed to be defined as a function of the time spent on the organization of the logistics process and the time dictated by the nature of the conditions of its implementation. Local criteria for characterizing certain aspects of operational efficiency can be the criteria of continuity, stability, carrying capacity, mobility, accuracy and flexibility of digital control systems [5].

In turn, technical efficiency is assessed on the basis of calculating a set of indicators that quantitatively reflect the technical side of the digitalization of transport and logistics system management. This refers to the technical and software capabilities of the digital management system, as well as the convenience of its use by employees. When assessing the technical efficiency of the digital control system it should be analysed its design and technical (productivity and operational reliability of technical means, weight, temperature and other characteristics of system elements, the degree of unification and standardization of technical controls and software products), and technical and operational indicators (energy and material consumption, number of personnel servicing the control system, weight, area and volume of digital equipment and other technical devices). Furthermore, it is necessary to assess the prospects and feasibility of technical means of digitalization [5].

Indicators that quantitatively reflect the material and financial costs of the project to digitize the management of the transport and logistics system and the possibility of their compensation, in turn, characterize economic efficiency. In this case, according to the author, it is advisable to assess such indicators as economic costs of digital control system, direct (real) and indirect economic effects, payback periods, which are compensated by these effects. In addition, it is important to use comprehensive indicators to assess the implementation of digital change, including general (rational implementation of digital control system, the amount of the allowable level of increase in its value) and specific, taking into account the company's activities (probability of timely transportation, amount of transit stock in storage, costs for transportation of material and technical means, the cost of transport and forwarding documentation, etc.) [5].

Significant attention of scientists is focused on applying the methods that involve the formation of a balanced scorecard that reflects all aspects of the enterprise (finance, customers, staff, business processes), and within which strategic guidelines and criteria for achieving them are defined. The peculiar feature of this method is the definition and calculation of indicators that allow a comprehensive assessment of the effectiveness of business processes, including specific business projects. For each stage of project implementation, indicators are determined that allow to assess the degree of the goal achievement and compliance of the obtained result with the planned level, including to determine the extent and causes of the detected deviations. The use of such practices in the activities of enterprises allows increasing the efficiency and flexibility of the management system as a project in particular and the enterprise as a whole.

An effective methodology for assessing the effectiveness of innovative solutions in the railway industry is also the formation and calculation of a system of key performance indicators (KPI), which generally allow assessing the achievement of goals or success in implementing an innovative project in railway transport enterprises. Many railway companies around the world use this approach.

Thus, in summary, it should be noted that in general in the scientific literature and directly in the practice of railway transport enterprises a significant number of methods for evaluating the implementation of innovative solutions have been formed. They take into account the specifics of enterprises and promising areas for sustainable growth. Most of them focus on assessing the impact of implemented innovative projects on the change of general performance indicators of railway transport enterprises, including in terms of economic, technological, social and environmental efficiency. In our opinion, the approach that involves the definition of key performance indicators in terms of areas of development of railway enterprises is noteworthy. Because this technique is successfully used by railway companies in other countries, which assess the effectiveness of activities in regards to calculation of economic, technical and social indicators, safety indicators, efficiency of rolling stock and infrastructure, quality of service, environment, etc. Key indicators of efficiency are recognized as an effective tool for obtaining relevant and reliable results of evaluating the effectiveness of management, business processes, personnel, production and innovation activity of railway enterprises, the application of which allows identifying bottlenecks and determining the success factors of innovative measures at the enterprises of the industry.

Given the above, the efficiency of innovative tools in railway enterprises can be assessed by calculating the economic effect obtained by optimizing costs (ΔC^{opt}), increasing the profitability of business segments of railway enterprises ($\Delta B^{ad.v}$) and increasing the value of their business from the implementation of innovative solutions (ΔP^{bs}):

$$E^{in} = \Delta C^{opt} + \Delta B^{ad.v} + \Delta P^{bs}, \tag{2}$$

CONCLUSIONS

Thus, it should be noted that the introduction of this approach to strategic management of innovation of railway enterprises will contribute to the rational use of resources by enterprises in the process of innovation, development of its own quality control system for transport and logistics services based on horizontal connections and users' trust, obtaining additional economic results by customizing innovation activity, ensuring effective networking with stakeholders, combining their financial and economic resources for joint use in the innovation process, improving the rules for participants in the open model of innovation, ensuring that users comply with all legal requirements.

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Modern Problems of the Development of Wedge-shaped Urban Greening Systems (on the Example of Poznan and Kharkiv)

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Abstract. The formation of an integrated continuous greening system is one of the criteria for sustainable urban development. But intensive development and urbanization have significantly affected their condition, which makes the study of existing green areas of cities relevant. Aim of the article is a study of current state and identification of problems in wedge-shaped system development of urban greening on the example of Poznan and Kharkiv. Cartographic analysis based on GIS, field research, comparative analysis are used. Statistical data processing is carried out using the STATISTICA program. The classification of the existing greening system of Kharkiv, which remained, is accomplished by area, size of the minimum and maximum diameter. Urban planning scenarios of degradation of green wedges is revealed. The problems of UGS development are determined, actions and measures aimed at solving the problem of resuming the development of UGS are proposed.

INTRODUCTION

Human being, as a part of nature, cannot exist without a natural environment. For millennia, nature has provided food, protection, building materials, influenced the environment, and so on. With cities development, the theory of nature inclusion in the urban environment was also developed. In the Soviet theory, it has a definition - “*urban greening system*” (UGS) formation. The key ideas of urban greening have become "Parkway" by F. L. Olmsted (1868) and "Garden City" by E. Howard (1898), who are still considered to be the founders of green infrastructure [1]. The development of European theory was influenced by the work of Joseph Stubben (1907), who first introduced the rules of urban greening and T. H. Mawson, who first formulated the definition of urban greening system and noted the need for the formation of urban greening continuity and links with suburban greening and rural areas [2]. In 1910, a wedge-shaped greening system was presented in a Berlin project by R. Eberstadt, B. Moring, and R. Petersen, which fully met these requirements [3]. The idea of a wedge-shaped UGS was used in the planning of Copenhagen, Helsinki, Tallinn, Stockholm, Melbourne, Poznan, Wroclaw, Kharkiv and many other cities. Thus, powerful wedge-shaped system of Kharkiv has become the embodiment of the modernist paradigm of urban planning in Ukraine, forming a stable, continuous greening system, which still has been forming ecological framework of the city. T. Beatley draws attention to the high achievements of European theory in the field of urban landscaping, multifactorial and interdisciplinary approaches to the formation of integrated sustainable landscaping systems that have become exemplary for the whole world [4].

However, intensive development and urbanization in recent decades have significantly affected the state of UGS and ecosystems in cities [5,6]. The greening systems of most cities have undergone significant degradation.

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After the adoption of the sustainable concept by the world community, general vector of human development was changed towards harmonization of human-nature relations [7]. For the first time, the preservation of natural biodiversity was put on the same level with social and economic development. This has also updated research in the field of urban greening.

But the current state of wedge-shaped greening systems of Ukrainian cities formed in the Soviet period remains out of researchers' attention. Thus, the relevance of this study is determined by:

- growing role of green spaces to mitigate climate change in cities;
- importance of wedge-shaped urban greening systems in ensuring sustainable urban development;
- lack of a comprehensive analysis of changes in the state of wedge-shaped urban greening systems due to the intensification of urbanization processes.

Theoretical reflection also requires the principles of urban greening systems formation in the transition from "aggressive" urban planning of the modern era to "green" urban planning of the early XXI century.

Aim of the article is a study of current state and identification of problems in wedge-shaped systems development of urban greening on the example of Poznan and Kharkiv.

The time limits of the study are determined by the beginning of wedge-shaped systems formation in the studied cities from the 1930s to the present. Territorial boundaries of the study are concentrated in Kharkiv, for comparative analysis existing studies on the UGS of Poznan (Poland) are used.

Research methodology includes the following algorithm: retrospective analysis of wedge-shaped greening systems creation in cities, comparative analysis of the current state of UGS, identification of common problems and specifics of UGS. Methods of analysis, synthesis and abstraction are used. Cartographic analysis of Kharkiv using GIS programs is combined with field research of elements of Kharkiv greening system. Statistical data processing is carried out using the STATISTICA program.

Analysis of literature sources and recent publications. The general stages in the development of the theory of the urban greening systems formation are investigated in the article by H. Osychenko, V. Hryshyna [8]. Works of evolution and current state of the greening system of the studied cities are empirical basis of the study. Greening Poznan was studied by P. Urbanski [9,10,11], B. Szpakowska, E. Raszeja [9], M. Krzyzaniak. [10,11], A. Rydzewska [10], D. Swierk, M. Szczepanska [11]. Stages of Kharkiv city formation were investigated by V. Antonov [12], E. Cherkasova [13], including its greening A. Kolesnykov [14], A. Antonov, A. Paramonov [15], T. Kolesnyk [16], the stages of Kharkiv greening system formation are highlighted by H. Osychenko, V. Hryshyna [17]. The principles of UGS formation of the modernism epoch are presented in researches of domestic scientists of 1950-1990 such as L.B. Lunts [18], Y.V. Rodychkyn [19], V. F. Hostev, N.N. Yuskevych [20], V.A. Horokhov [21]. Their works are devoted to the practice of creating a natural environment in the structure of cities, planning patterns of UGS formation, stages of formation and urban levels of their design. Modern theories and principles of formation are presented in the works: G. Austin (2012) [22], A. Kaplan (2012) [23], E. Anderson (2014) [24] and others. In particular, E. Honeck (2020) presented a method of identifying green infrastructure in cities for its preservation and development in the future [25]. Wedge-shaped greening systems is considered in the works of F.L. De Oliveira (2017) [26], H.W. Frey (2000) [27], who recognized their effectiveness in comparison with other systems, and N. Xiu, M. Ignatieva, C.K. VandenBosch (2016) determined that existing greening systems should be transformed into green networks [28]. The method of forming green infrastructure on the basis of landscape-functional units, including green wedges, is presented in the work of I. Filipiak, J. Rubaszek, J. Potyrala and P. Filipiak (2018) [29]. However, urban planning and planning problems that led to the degradation of green wedges and the entire system of green areas of cities, the formation of directions for the restoration of UGS to ensure sustainable urban development remained insufficiently studied.

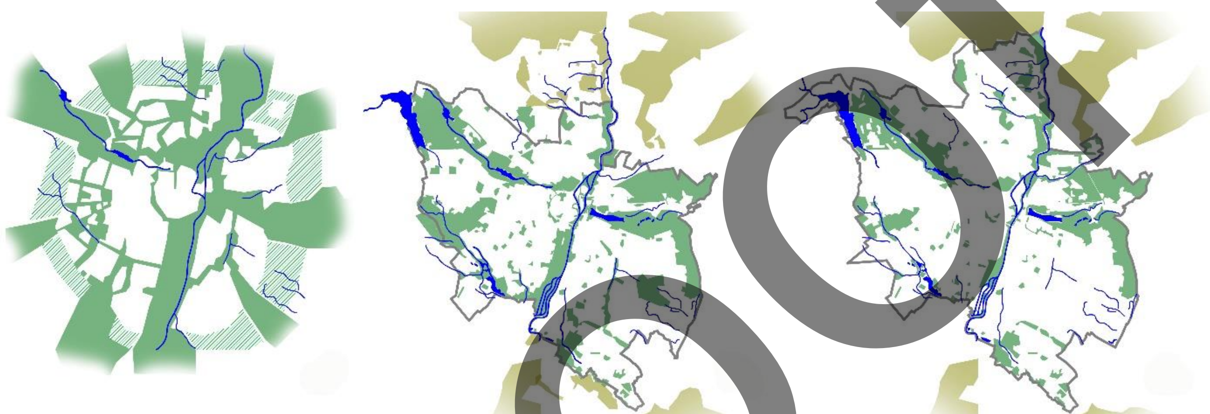
COMPARATIVE ANALYSIS OF GREEN WEDGES' DEVELOPMENT IN POZNAN AND KHARKIV

Formation of green wedges of Poznan and Kharkiv

Formation of green wedges of Poznan

Wedge-shaped UGS of Poznan was formed in the early 20th century under the influence of European trends in urban greening, but had its own unique structure. The first vision of the Poznan UGS was presented by J. Stuben in the plans of 1903 and 1914 in form of two green rings. The first attempt to UGS form with a combination of wedges and rings was presented in "Master plan of buildings in Poznan" by S. Paiserski in 1929. The plan provided for the creation of four green wedges that penetrate into the urban territory: the northern and southern wedges were located along the Warta River, the western one was in Bogdanka River Valley, and the eastern one was in Kibina Valley. Creation of green wedges in river valleys was aimed at preserving water resources and unique natural areas with rich biodiversity, such as the Debin Forest, as well as creating recreation areas for citizens.

Final formation of Poznan UGS was approved in the master plan of 1934 (Prof. V. Charnetsky, Prof. A. Vodzichko) (Fig. 1a). It provided for the creation of an inseparable green ring around the city in combination with a powerful green wedges system. Two inner green rings were formed on the site of former fortress fortifications, the largest outer ring was to reach 1000-1300 meters [9]. Also, to the 4 main wedges were to be added 6 smaller ones. Thus, all areas of the city were divided by greening. In addition to its ecological and recreational function, the green wedges were designed as a full-fledged pedestrian and bicycle infrastructure, horseback riding trails that formed routes and connections with suburban recreation areas. Formation of wedge-shaped UGS of Poznan was completed in the 1980’s. It was not possible to fully implement V. Charnetsky's plans, however, the existing system of green wedges in combination with the remnants of the greening of rings still withstands the ecological load and forms good accessibility to recreational areas.



(a) (b) (c)

FIGURE 1. Retrospective of green wedges development in Poznan: (a) project of 1934; (b) condition of green wedges in 1958; (c) condition of green wedges at present.
(Figures by V. Hryshyna based on P. Urbanski schemes and analysis of Poznan city plan 1958 [9, 30])

Formation of wedge-shaped greening system of Kharkiv

For the first time project of a wedge-shaped greening system of Kharkiv was offered in master plan of the city in 1934 (architect A.M. Kasyanov, end. A.L. Eingorn), where formation of 6 wedges, 3 big (northern, southern, east) and 3 smalls along the rivers Kharkiv, Lopan, Udy was provided. Powerful northern green wedge was created on the basis of Pomirky and Sokolnyky settlements. For this purpose, planned resettlement of people and greening of these areas was carried out to create a single forest park (Lisopark), which stretched from the north to Nikolaev Park (now M. Gorky park) [13]. Uniformity of recreational facilities during this period was also ensured by division of large parks with an area of 60-100 hectares surrounded by industrial or residential buildings.

Final formation of wedge-shaped UGS of Kharkiv took place in postwar years. In master plan of the city of 1964-1966 (architect V L Antonov, engineer V.M. Pogorelov) the northern forest park wedge occupied a significant part of the plateau, had a width of 2.5–4.5 km and was part of the city structure for 8 km, the southern - 7 km, the western wedge was formed by a forest, which was partially within the city limits. Meadow parks and hydro parks were created along small green wedges of the rivers (Fig. 2.a).

Also, in general plan of 1964 the need to create an external green belt with a width of 5-10 km was recognized to ensure the sustainability of environmental indicators and limit territorial development of the city, but these intentions were not realized [12,28]. Thus, the UGS of Kharkiv was formed in a combination of green wedges and green spots, as well as numerous green connections (boulevards, embankments, street greening), creating the integrity, continuity and uniformity of greening.

(a) (b) (c)

FIGURE 2. Retrospective of green wedges development in Kharkiv: (a) Master plan project of 1964 [31]; (b) condition of green wedges in 1985 [32]; (c) condition of green wedges in 2020-2021 [34]. (Figures by V. Hryshyna)

Analysis of the current state of UGS in the studied cities

Current state of Poznan UGS. At the present stage, Poznan UGS development is presented by 3.47 thousand hectares of public green spaces, which is 13.26% of the city area, 64 m^2 per 1 resident [11]. It should be noted that with the city and its infrastructure development in Poznan it is still managed to preserve most of the green areas. However, in recent years, there has been an active attack on greening, which is associated with lobbying by the city authorities for private investment plans contrary to state interests. As a result, the definition of "green zone" was changed, where according to the new interpretation it is allowed to build not only single-family housing, but also multi-family housing, which leads to development of green areas. Another problem is that most often unorganized green areas are assigned for the development of the city, which is a potential for the urban greening system development. P. Urbański also raises the issue of too high density of new buildings, which leads to decrease in the area of biologically active surface in the city, resulting in the destruction of system continuity [9]. However, the residents of Poznan are active in preserving green wedges and undeveloped natural areas as recreational facilities, as evidenced by numerous protests against the construction of green areas.

Due to urbanization in Poznan the number of green areas reduce, there is a degradation of green wedges (Fig. 1. b, c). Thus, in the central part of the city, due to compaction of buildings, they cover only the coastal strip of the Warta River, while the outskirts of the city are about 1 km wide. Also, small green wedges that divided areas of the city disappeared. The only one left among the small wedges is a green wedge in the valley of the Yunikovsky stream, which is about 3 km long. Nevertheless, Poznan preserves a large number of forest areas, which include the reserves Luvinets (1.47 ha) and Morasko (54.54 ha), 20 natural monuments, 9 ecological sites, 3 protected landscape complexes and 146 forest objects adapted to the needs of tourism and recreation [10]. As a result, the city has preserved many undeveloped or underdeveloped areas, which are areas for biodiversity development.

Currently, the recreational system of green areas of Poznan has 42 parks with a total area of 505.12 hectares, 134 hectares of gardens and 111 small green areas (748.3 hectares) with buildings which also perform recreational functions, which is a total of 24.1 m^2 per person. The main problem is the insufficient level of greening and equipment of some parks, which reduces their recreational attractiveness [9].

Current state of Kharkiv UGS. The recreational greening system of Kharkiv has 2.8 thousand hectares of public greenery, which is 19.0 m2 per 1 person. It includes: 1 forest park “Lisopark” (1860 ha), 3 hydro parks: Zhuravlivsky, Udyansky, Osnovyansky (371.5 ha), 2 meadow parks: Oleksiyivsky and Petrenkivsky (175.1 ha), 19 parks (330.1 ha), 4 gardens (42.4 hectares), 37 public gardens (63 hectares), 1 zoo (22 hectares), 3 botanical gardens (65.2 hectares). Also, in Kharkiv, there are 9 territorial objects of the nature reserve fund with a total area of 1580.5 hectares, 87% of which are occupied by the regional landscape park and natural monuments Sokolnyky-Pomirky (Lisopark) [34]. Currently, 89 out of 133 green objects in Kharkiv are small and medium-sized, 86 are local facilities that do not have natural connections (Tab. 1). Of course, current situation does not correspond to ideology of sustainable development and requires its scientific understanding and determination of directions for correction.

TABLE 1. Classification of existing green areas of Kharkiv city by size

		Area (ha)	min Ø (km)	max Ø (km)	Length (km)	Number of objects	Total area (ha)
LINEAR OBJECTS	**Small with short length**	≤ 4.5	≤ 0.11	≤ 0.45	≤0.5	20	**38.0**
	Small with long length	4.6-25.0	≤ 0.3	≤ 0.5	0.51-3.0	26	**347.0**
	Medium	25.1-100.0	≤ 0.45	≤ 0.7	1.1-4.0	21	**919.0**
	Large	100.1-500	0.3-1.1	0.6-2.2	1.4-4.0	4	**861.0**
	Huge	> 500.0	≥ 0.9	≥2.2	≥4.0	2	**2177.0**
COMPACT OBJECTS	**Tiny**	≤ 3.0	≤0.15	≤0.22		22	**26.0**
	Small	3.1-25.0	0.16-0.4	0.23-0.63		23	**209.0**
	Medium	25.1-100.0	0.41-0.7	0.64-1.1		12	**628.0**
	Large	> 100.0	≥0.7	≥1.2		3	**460.0**

TABLE 2. Comparative analysis of the state of green wedges of Kharkiv city in 1985, 2020-2021.

Wedge's Name	Wedge's elements in 1985	The size of the wedge's element in 1985 (ha)	Wedge's elements in 2020-2021	The size of the wedge's element in 2020-2021 (ha)
NORTHERN WEDGE	N 1	1940.0	N 1	1660.0
			N 2.1	84.7
	N 2	356.0	N 2.2	89.0
			N 2.3	28.6
	N 3	73.0	N 3	37.5
	N 4	278.0	N 4.1	78.2
			N 4.2	71.2
	N 5	25.0	-	-
		2672.0		**1978.0**
WESTERN WEDGE	W 1	172.4	W 1	172.4
	W 2	175.5	W 2	95.0
	W 3	496.0	W 3	417.0
	W 4	238.5	W 4	210.7
	W 5	61.0	W 5.1	18.4
			W 5.2	9.5
		1143.4		**895.1**
SOUTHERN WEDGE	S 1	455.0	S 1	450.3
			S 2.1	121.0
	S 2	465.0	S 2.2	146.5
			S 2.3	102.5
	S 3	142.0	S 3	131.5
	S 4	45.7	S 4	45.7
		1107.7		**997.5**
NORTH EAST WEDGE			NE 1.1	39.8
	NE 1	210.0	NE 1.2	36.6
			NE 1.3	14.0
	NE 2	103.8	NE 2.1	36.9
			NE 2.2	20.0
			NE 3.1	73.6
	NE 3	310.1	NE 3.2	31.3
			NE 3.3	18.4
	NE 4	457.5	NE 4	181.3
		1081.4		**451.9**
EAST RIVER WEDGE	E 1	45.0	E 1	43.8
	E 2	93.0	E 2	73.5
	E 3	53.5	E 3	36.4
	E 4	14.0	E 4	10.2
		451.9		**163.9**
Total wedges' area		**6210.0**		**3968.3**

As a result of analysis, authors found that compared to the period of greatest development of UGS, total territory of Kharkiv greening areas (excluding territory of private estates) decreased by 38% and it is 5.6 thousand hectares, 37.3 m^2 per 1 resident (Fig. 2.b, c, Tab. 2) [17]. The northern wedge, which was divided into 5 parts, was destroyed, about 380 hectares were given for manor development, which penetrates deep into the forest. Nevertheless, such most acceptable neighborhood without regulation of development and greening there is almost total felling of trees, complete change of vegetation with lawn, the dominance of introduced species, which has a negative impact on the ecosystem. The area of biologically active surfaces also decreases, noise pollution increases. The southern and western green wedges, which are at a greater distance from the center, are less popular with developers, but they degrade due to negative human activities. The analysis showed that the depth of wedges penetration into city body also decreased. Numerous connections between green wedges to each other and to green areas along river systems have been destroyed (Fig. 3).

Most urban greening is concentrated in 4 districts (Kholodnohirsky, Shevchenkivsky, Kyivsky and Slobidsky). This increases the load on small existing facilities that are surrounded by residential buildings. Field studies have shown that the functional equipment of parks is uneven. Parks and squares of the central part of the city have a high level of order, design, equipment and functional diversity. On outskirts of the city, only small facilities of up to 5 hectares are equipped and other greening are gradually returning to the state of wildlife. Thus, the largest landscape and recreational facilities: Lisopark, meadow parks and hydro parks do not have a recreational infrastructure at all.

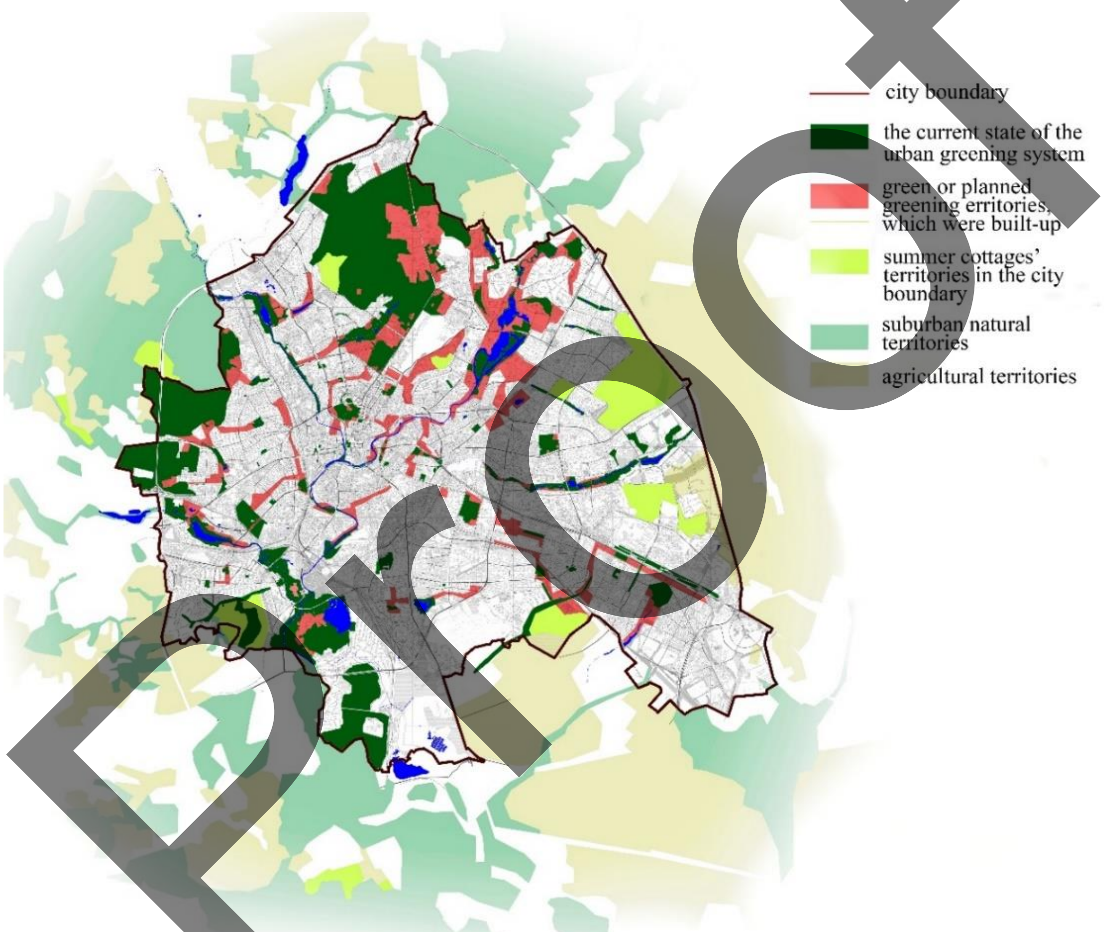


FIGURE 3. Kharkiv urban greening system degradation to 2021 (Figure by V. Hryshyna, H. Osychenko)

PROBLEMS OF CITY WEDGE-SHAPED SYSTEMS DEVELOPMENT

The study revealed the same processes of reducing the total territory of green areas in cities, deformation of UGS and increasing the anthropogenic load on natural green areas.

The study identified common urban planning problems in current state of UGS in the studied cities:

1) spatially integral green areas are replaced by objects of three types in cities:

- separate small areas of green open spaces (<10 ha) surrounded by dense buildings;
- some areas of greening are located in difficult natural conditions (thalwegs, beams, steep slopes, swamps, etc.);

- integral, large green areas (> 100 ha) associated with the suburban green belt, which are preserved only in the peripheral zone of the city;
2) a significant increase in unregulated anthropogenic load on the "remnants" of green areas - large elements of landscape-ecological framework, and small, surrounded by new buildings;
3) general deterioration of existing green areas as a result of partial destruction of biogeocenosis;
4) landscaping of cities green areas on the basis of a fragmentary approach.

The main factors causing changes in greening systems are growing processes of urbanization, migration to cities and population growth in suburbs. As a result, there is a territorial growth of the city due to construction of suburban green belt, and attack on greening inside the city. These processes are common in cities, but differ in the degree of wedge-shaped systems transformation. In Europe, where the process of deindustrialization began in the 80s of last century, urban greening systems began to actively expand through creation of parks on territories of former industrial facilities. These processes have not yet affected Ukrainian cities.

A comparative analysis of these processes of UGS reducing in Poznan and Kharkiv showed that "destruction" of each of "green wedges" occurs in several identical scenarios (Fig. 4):

1. narrowing of green wedge diameter due to buildings penetration along its border;
2 planning rupture of green wedge into separate "green spots" due to a wide strip of building (width from 150 m);
3 fragmentation of green wedge due to laying of urban highways through its territory;
4 reducing the depth of green wedge penetration into city structure;
5 "corrosion" of green wedge - gradual introduction of some large buildings into depths of green wedge;
6 loss of green wedge connection with the suburban green belt due to suburban zone development
7 destruction of small green wedge due to its complete development;
8 narrowing to the critical level of green corridors along the rivers, which formed connection between wedges;
9 cemeteries, vegetable gardens, summer cottages placement in the existing green areas of wedges, which have much lower rates of greening and alter the natural landscape;
10 combination of scenarios.

In addition to the described common scenarios of UGS degradation in Kharkiv, the following is also observed:
11 destruction of green wedges connections with the central part of the city;
12 significant narrowing of green wedges of river systems;
13 limiting the development of greening territories with large industrial areas.

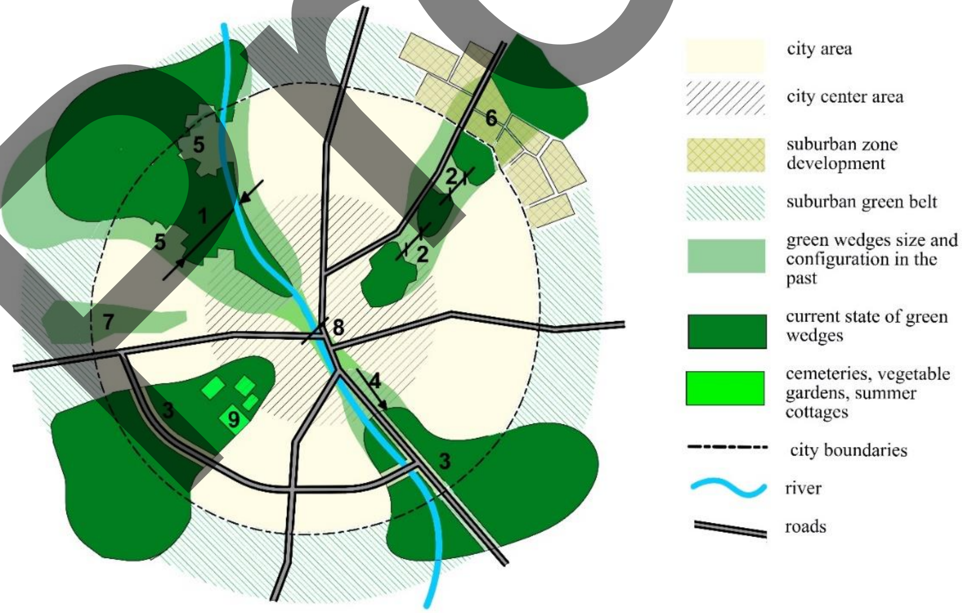


FIGURE 4. Scenarios of green wedges' destruction: 1) diameter's narrowing; 2) planning rupture and transforming into separate "green spots"; 3) fragmentation by roads; 4) reducing the depth penetration into city structure; 5) "corrosion"; 6) loss connection with the suburban green belt; 7) full destruction of small green wedges; 8) critical narrowing of green corridors; 9) changes of green area function. (Figure by H. Osychenko)

Development of Ukrainian cities is planned taking into account needs of economic development and business requirements instead of long-term sustainable urban development, and the problems of green areas development of cities are not actualized in the master plans. Thus, in Kharkiv master plan 2003, changes to master plan 2011 and 2019, it was determined that the number of urban greening is fully in line with the norm and should continue the policy of greening preservation and arrangement. So, the main town-planning document does not provide any proposals for Kharkiv UGS development in the future. In practice, in recent years, areas important for UGS functioning have been actively transferred for construction: green corridors, meadows, riverside areas, parks, etc. Political activity and a high level of environmental awareness of Polish population allow to successfully protect the existing greening system from similar problems. This emphasizes the importance of socio-economic and political factors in addressing the development of urban greening systems.

So far, the area of landscaping per person in Kharkiv remains within domestic norms, but the real situation of the green area degradation indicates the need for additional research to provide the population with recreational services.

CONCLUSION

It is defined that in the last 30 years, wedge-shaped greening systems of the studied cities has been gradually degraded and there is a risk of complete transformation of green wedges into individual green spots, which will have negative consequences for both urban biodiversity and population. This critical situation is especially developed in Kharkiv city.

To solve the urban landscaping development issue, it is necessary to develop an algorithm of legal, organizational and urban planning actions aimed at improving the transformed areas of urban space, based on a holistic and integrated approach:

- assessment of preserved green areas condition and search for new areas to development;
- study of the citizens needs in recreational activities and level of its satisfaction in modern conditions;
- assessment of existing and prospective anthropogenic load on green areas.

Substantive components of this concept should be:

- political decisions to ensure sustainable development of green areas, the creation of environmental programs and programs for biodiversity development, the formation of new urban planning solutions for the development of UGS, which would be based on these programs;
- legal decisions of territorial communities on the UGS formation, enshrining in the standards of urban planning documentation the scheme for the analysis and development of the UGS;
- compensation for losses green areas by greening of former industrial territories and on an artificial basis with involvement of the latest technologies;
- redistribution of anthropogenic load on green areas by creating even location of recreational facilities and their equipment;
- development of settlement territories on the basis of estimating of provided recreational services for population, implementation of eco-quarters with an intensive form of gardening in town-planning practice;
- comprehensive solution of functional, planning, compositional and environmental problems of cities in the design of UGS. This requires the development of special architectural and town-planning, landscape techniques and their further implementation.

Thus, the next stage of research is a multifactor analysis of Kharkiv territories to determine potential and search for concepts of UGS sustainable development in the context of growing urbanization and formation of basic strategies for UGS development in large cities.

The study is performed within the direction of research work of O.M. Beketov National University of Municipal Economy in Kharkiv on the scientific topic: "Study of the urban infrastructure development in the context of sustainable development of the city".

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The Impact of Epidemics on the Urban Space Transformation in the Russian Empire at the Beginning of the XX Century

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Abstract. The authors analyzed the role of epidemics in the urban space transformation in Kharkiv during the typhoid epidemic at the beginning of the 20th century. The epidemics of infectious diseases, which regularly occurred in conditions of rapid urbanization, had high mortality rates and negatively affected the socio-economic development of cities. The search for ways to survive in densely populated cities in the context of epidemics has positively influenced the change in the urban environment by creating centralized water supply systems, sewerage systems, garbage disposal in cities, organizing sanitary and epidemiological services to monitor the quality of water, food, and the implementation of sanitarian standards at enterprises and institutions. The city press played a crucial role in the urban environment transformation by forming the civic position of the townspeople, who have been involved tremendously in cities metamorphosis due to sanitary standards, the ideas of a comfortable and safe city.

INTRODUCTION

Epidemics have played a leading role in the development of the urban space, city facilities improvement, and the formation of the urban culture. The need to survive in the conditions of the lightning-fast spread of the infections with a high level of virulence and mortality rates necessitated the formation of the "city health improvement" concept.

The necessity of the urban space transformation under sanitary and hygienic standards related directly to regular epidemics of various infectious diseases broke out in cities in the early 1900s. The lack of traditions of hygiene in the culture of the urban population had disastrous consequences. At the beginning of the XX century, mortality in the cities of the Russian Empire significantly exceeded the mortality of the rural population. The high overcrowding of living in unsanitary conditions, the severity of working conditions at industrial enterprises, the harmfulness of many urban professions affected the health of the townspeople tremendously, making them more vulnerable to infectious diseases with high contagiousness. Moreover, pauperism, crime, alcoholism, prostitution, begging, homelessness were also prevalent in cities. These factors also contributed to the rapid spread of epidemics among the townspeople.

The purpose of this article is analysis the role of epidemics in urban space transformation. Since the outbreak of typhoid fever in 1909 in Kharkiv influenced changes in urban space and urban culture, its example of changes in metropolises of the Russian Empire in the early 1900s due to epidemics is interesting for research. This investigation bases on the materials of the press published in Kharkiv during that period.

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PRESENTING MAIN MATERIALS

The search for ways to survive for densely populated cities encouraged the central government and city authorities in the Russian Empire in the late 19th - early 20th centuries to promote the creation of a centralized water supply system, sewerage, the organization of sanitary and epidemiological services to monitor the quality of water, food, sanitarian conditions at enterprises and institutions. Furthermore, to think about the need for centralized waste disposal, expanding the network of medical institutions. These ideas radically influenced the traditional life of city dwellers and changed their habits and opinions about the safety and comfort of living in the city. It was especially true for the first generation of urban dwellers who moved from the countryside under the influence of urbanization processes and forced to "retrain" to live in the city, acquire knowledge about sanitation, cleanliness, hygiene, which did not play a crucial role in the culture of the peasants.

This was especially true for the first generation urban dwellers who moved from the countryside under the influence of urbanization processes and were forced to "retrain" to live in the city, acquire knowledge about sanitation, cleanliness, hygiene, which did not play an important role in the culture of the peasants.

The beginning of the twentieth century for Kharkiv, as a large industrial, commercial, scientific center with a population of more than 250,000 people, was quite hard in terms of annual epidemics: cholera, smallpox, diphtheria, scarlet fever, typhus, and other infectious diseases claimed the lives of a significant number of townspeople and struck economic development of the city.

The epidemics of the beginning largely influenced the formation of the urban environment of Kharkiv: the analysis of the causes of the spread of infectious diseases forced the city authorities, doctors, and townspeople to look for productive solutions to improve the amenities under sanitary and epidemiological requirements. A characteristic feature of this process, we consider the initiative of Kharkiv's residents themselves in the fight against epidemics and the formation of public opinion on the need for the authorities to implement measures to improve the epidemiological situation in Kharkiv.

The city press played a leading role in informing Kharkiv citizens about the causes and course of epidemics, characterizing the measures taken by the authorities in the fight against the spread of diseases, and popularizing the culture of health of citizens in the conditions of the extend of infections.

The largest epidemic in the period under study can be considered the outbreak of typhoid fever in the spring and summer of 1909, which surpassed others in the number of cases and high mortality rates.

This epidemic actualized some issues of the improvement of Kharkiv, for instance, the problem of expanding the water supply network, organizing its work by sanitary standards, organizing constant monitoring of the operation of the water supply system.

The members of the Kharkiv City Council and epidemiologists joined the commission to investigate the origin of the spreading of the typhus epidemic. They suspected the water from the city water supply since the outbreak of the epidemic fell on an atypical period for this disease in spring. Typically, typhoid fever occurred in August-September and was associated with swimming in the rivers and lakes, eating unwashed vegetables and fruits. According to epidemiologists, fecal contamination of water supply sources might have caused the beginning of the typhoid fever epidemic in the spring months.

Examining Kharkiv's water supply system identified several shortcomings that could cause typhoid rods to enter the water through the urine and feces of infected patients. (Due to scientific studies, 1 g of human feces contained up to two hundred million bacteria of typhoid fever). The water in the water supply was a mixture of water from Pavlovsky and Bogomilivsky springs and artesian water. The commission found out the contamination of tap water could have occurred from the Bogomilivsky springs. Its water intake galleries passed through the territory of the public garden, where thousands of pilgrims came to take water from the well, which was considered healing. Since this garden was a popular urban public space of outdoor leisure and entertainment, many townspeople spent their evenings and weekends there. The lack of toilets in this area forced plenty of people to use bushes instead of water closets contaminated soil could lead to an epidemic. [2].

The clay pipe with sewage waste from the prison department also passed through the Bogomilivsky spring without effective disinfection of the contents of latrines. Pipe cracks caused impurities from the prison's sewerage pipe might have entered the soil and infected the water in the wellspring of the water supply system [1]. The clay pipes, easily cracked, could not have protected the water from contamination.

The commission also discovered the facts of using water from the Lopan River to cool the engines of the water supply system, which could have caused typhoid bacteria to enter the water supply pipes, as the locals drained sewage in the absence of a centralized sewage system in Kharkiv into the rivers.

Violations of sanitary standards at the city water supply company could have caused an epidemic in Kharkiv. During the inspections, the commission revealed the lack of medical control over the health of the workers of the water supply system.

The inspection found the cases of typhoid infection among workers that might have contributed to the penetration of infection into water pipes. Moreover, the company employees did not obey the demand to work in a clean uniform; they wore dirty clothes and shoes. Only a few workers put on robes. The territory of the enterprise, especially the area with the installed filters, was not cleaned and was heavily littered.

To identify the causes of the onset of the typhus epidemic, Ivan Schmidt, an assistant to the chief sanitary doctor of the Russian Empire, was sent to Kharkiv. Arriving from St. Petersburg, the inspector conducted a thorough epidemiological investigation and stated that it is impossible to unequivocally blame the water from the water supply system for the massive spread of the disease. As the result of checking the sanitary condition of Kharkiv, Schmidt revealed numerous violations of sanitarian and hygienic standards on the streets of the city, in the houses of residents, in markets, in shops, at *food* and beverage *companies*. According to the inspector, one of the crucial causes of the epidemic could be considered the absence of a centralized sewage system in the city, which led to the uncontrolled disposal of waste in the city's rivers. Soil pollution by sewage water led to water pollution in wells, and Kharkivs used polluted water for consumption.

The commission published results of their investigation in the newspapers, and the Kharkiv city government, under the influence of the public, made the following decisions: a bacteriological station was opened, which daily took and analyzed water from the water supply system and other water sources in Kharkiv (rivers, wells). The epidemiologists intensified control over the implementation of sanitary safety rules on the water supply station, such as counteracting water pollution at the filtration station, examining the worker's health, and monitoring their work. The City Counci1 had planned to replace the clay water pipelines with cast iron ones, build new water pipelines and create spare reservoirs [2].

The Kharkiv Medical Society had played the leading role in shaping the public opinion of Kharkiv citizens about the conditions for countering the epidemic. Its members regularly delivered lectures to residents of the city, gave interviews to the press, published educational brochures and leaflets with information about the disease and ways to prevent infection; these materials spread among townspeople regularly [1].,

The members of the medical society published the article with the appeal to the city leadership in the popular Kharkiv newspaper "The morning" (in June 1909). They required to protect the sections of the water supply system during the repair and replacement of pipes, emphasized the inadmissibility of using the dug holes by the Kharkiv residents to dispose of garbage, and asked authorities to notify the townspeople about the beginning of repair work during which it was dangerous to use tap water for consumption. Doctors said about the threat of contamination with dirty water while bathing, using it for washing vegetables, fruits, berries, and herbs. Disregard for sanitary standards in food preparation also posed a threat to life and health.

The highly respected opinion of the doctors in the society caused the activity of locals in fighting against breaking the sanitarian rules, so the city newspapers began to receive complaints from Kharkiv residents about the violation of epidemiological procedures in the city.

The editorial office received numerous letters about cases when the residents poured slop and sewage into the ditch during the repair of water pipes on Meshchanskaya Street. It led to the formation of a fetid river in the street, in which the water pipe directly lay. Also, the awful aromas from this dirty river “may have poisoned anyone” [6]. Kharkiv residents warned about the high threat of tap water contamination due to such behavior of the locals of this street.

The conscientious Kharkiv citizens were upset by the irresponsible attitude of the locals to the anti-epidemic rules. Thus, the newspaper "The morning" published a report about the opening of the bathing season by irresponsible citizens, despite the ban on bathing in rivers by the authorities and warning sanitary doctors about the high likelihood of contracting various diseases while bathing. The authors of the letters were outraged that, ignoring the orders of the authorities, Kharkiv residents swam in the city rivers.

Since the beginning of the epidemic in Kharkiv, the city sanitary department and the newspaper's editorial office had received dozens of letters from locals about the unsanitary conditions in the city. The workers of bakery and meat-sausage enterprises sent many complaints describing the unacceptable working conditions. All letters ended with a request for anonymity.

Even though Kharkiv residents strongly believed that all business owners pay a special tax (bribe) to the police to prevent sanitary control, sanitarian inspections reacted to complaints. So, on May 29, 1909, the policeman Ilyashenko and the doctor Tsilvansky examined the bakery that belonged to the Turkey citizen Harutyun oglu Kaskante (Zhuravlivska Street, 79). It turned out that the bakery's slops poured directly into the courtyard, so they fell into the well, and employees took the water from it for baking bread. The inspectors found that the entire yard was flooded with sewage and the water in the well was unusable. The bakery was also dirty: the floor littered, the walls and windows covered with cobwebs. The bakers worked in dirty clothes and poured the bread dough directly onto the grimy floor. The owner received a protocol to pay a fine.

On May 20, Mayor of Kharkiv A. Pogorelko personally inspected the city markets, noting the high level of unsanitary conditions in their work. His discontent caused the pollution of fish rows at the Blagovishchensky market. The Mayor also discovered the dirty and fetid water discharge into the river near the Rogatinsky bridge from the Bormann sweet factory [5].

Unfortunately, the authority deprived sanitary doctors of the control under the work of enterprises and institutions. Members of the medical society appealed to the Kharkiv City Council with a demand to organize a sanitary commission in the city, whose members should be representatives of the authorities, epidemiologists, and the police. The epidemiologists demanded to expand their rights, first of all, to allow writing out protocols for the untidy maintenance of courtyards, residential and commercial premises, and send these protocols to the police.

The medical society drew attention to the fact that sanitary doctors (there were only two in the city with a quarter of a million population) wrote out protocols and sent them to the council, where they usually got lost. This procedure discredited the sanitary doctor in the eyes of the population and could not overcome the unsanitary conditions in the city. The activists asked city authorities to increase the staff of sanitarian doctors from two to six [7].

The crucial component of counteracting the spread of epidemics, especially typhoid fever (with the oral-fecal route of transmission of pathogens), was the introduction of city sewers. Unfortunately, the lack of central sewage in 1909 in Kharkiv could have also been the probable cause of the outbreak of the epidemic. The members of the Kharkiv medical society appealed to the city authorities to start the building of the central sewage immediately to stop the "sanitarian catastrophe of the city" and infectious diseases spread.

According to experts, the lack of a centralized city sewage system caused total soil pollution in Kharkiv with feces, sewage from cesspools. Due to the data of the sanitary commission, only 1/20 of all sewage was taken out in Kharkiv to mud dumps, while the bulk of them was absorbed by the soil, which led to water pollution in rivers, wells, and reservoirs. The townspeople explained the break the rules for waste disposal by the expansive cost of sewage removal. The commission noted that since the private companies owned the sewage business, they increased their prices enormously [2]. The Kharkiv's doctor Igumnov, in his speech at the meeting of the Kharkiv Medical Society in June 1909, said that Kharkovites very often refused to take a shower, as the water disposal was tremendously expensive.

The violation of the rules for waste disposal caused the seep of polluted water into the soil. Soil contamination caused pollution of the underground water. Since only 1,770 households from 13,200 in Kharkiv used water from the water supply system, the majority of locals took water from the wells located in the city next to cesspools. Analysis of the well's water showed its unacceptable quality; it influenced the spread of the disease, which quickly turned into epidemics in the scales of the overcrowding city [Ibid.].

Doctors demanded from the authorities to liquidate cesspools in the city, which worked in violation of sanitary standards, transfer the garbage dumps from the center to the outskirts, strictly persecute the persons, poured polluted water and sewage on the street and into rivers. Furthermore, epidemiologists asked to supervise the street trade of beverage, ice cream, and other products, thrift stores.

The epidemic increased the social activity of townspeople, who started to ask the local authorities to improve the city facilities. For instance, the sellers of the Blagovishchensky market wrote a letter to the Kharkiv newspaper, in which they complained about the lack of repairs to the road dug for years.

After the article in the newspaper, the City Council organized the commission to check the sanitarian conditions of the city markets. The commission included the members of the city government, epidemiologists, and the chief of police who examined the Blagovishchensky, Horse, and Fish markets on June 7-8, 1909. To put in order the Blagovishchensky market, the commission determined several measures. They discovered a lack of drain for dirty water, a small number of water taps, toilets, and urinals. The commission asked the market managers to open a refrigerator for storing food since the sale of meat and fish during the hot weather without it might have caused the epidemy. There were demands to build a gallery for trading dairy and meat products, ban to sell the vegetables and fruit from the ground. Special requirements were about regular cleaning of the market area.

The Horse and Fish Market management received similar recommendations [9].

Residents of Lysa Gora region turned to the city council with a request to open an outdoor water pump to get water from city water pipes. They emphasized that authorities had ignored their request for five years, and the lack of clear water forced them to take it from the single well in the street. However, there was not enough water for everyone, and residents even had no opportunity to buy it.

There was only well in Zhuravlivka region with high-quality water. The locals of this area complained that because of high demand and the shortage of water well's owner prescribed a fee for using it.

Even though the usage fee was cheap, the poor people were not able to get water. They had to drink substandard water from free wells and put themselves in danger of getting sick.

Kharkiv residents also complained about the lack of cleaning in the city. The newspapers received a myriad of messages about garbage on the streets. Locals asked Kharkiv City Council to build roads, pavement and clean them constantly. They demanded to have the opportunity to go on the sidewalk comfortably.

CONCLUSION

Thus, the typhoid epidemic in Kharkiv in the spring and summer of 1909 brought up many issues of urban space improvement. The search for ways to overcome the spread of the disease brought together representatives of city authorities, doctors, citizens in the process of developing sanitary standards, changing the culture of everyday life. The city authorities defined the extension of the water supply network as a crucial task in fighting the epidemy. According to scientists and members of Kharkiv City Council, access for all city residents to high-quality water had to prevent the spread of infectious diseases. A crucial role in preventing epidemics was given to the plans to build a centralized sewerage system in Kharkiv. An important task was to disseminate knowledge about the epidemic among the inhabitants of Kharkiv to change their cultural ideas about hygiene and sanitation.

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The Phenomenon of Spontaneity in the Formation of New Urban Centres during the Industrial Revolution (on the Example of Khreshchatyk Street, Kyiv, Ukraine)

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Abstract. The research analyzing the phenomenon of spontaneity in the formation of new urban centers in historical cities during Industrial Revolution at the end of the 18th – the beginning of 20th centuries. The conclusions are made based on the example of Khreshchatyk Street urban center formation that took place in Kyiv, Ukraine at the time of industrial revolution. The proses of new urban center formation had in Kyiv remarkably spontaneous character although by the plans of urban development elaborated by city authorities at the middle of 19th century its location envisaged in completely deferent place. The results of the research showing that in reality the process of Khreshchatyk Street formation as new urban center of Kyiv had hidden reasons and was determined by many implicit patterns sourcing from global historical and socio-political conditions of that time as well as from initial unique historical, topographic and urban circumstances of Kyiv. Thus, the same mechanism could be considered valid to other historical cities of the world that spontaneously formatted new urban centers at the time of industrial revolution. It also make possible to assume that ancient cities could poses some kind of historical mentality permanently influencing on its development and transformation in time.

INTRODUCTION

During the Industrial Revolution (19th – early 20th centuries) many historic cities have formed new urban centres. The change in the position of urban centres at that time was caused by a change in socio-political relations, the development of technological progress, the growth of industry and the relocation of large numbers of new habitants to the cities to serve it. Examples of such formation can be observed in almost all European countries, as well as in America and Japan. In particular, this process is extremely characteristic for Vienna [1], Berlin [2], Warsaw and Krakow [3], Lviv [4], etc., as well as for the historical cities of Japan [5-6]. The so-called Meiji Revolution (1868-1889), was the time when Japan after the centuries of limited communication with the world, was extremely active in catching up with European and American technological progress. In previous studies, we focused on the urban development of such Japanese historic cities as Tokyo, Kanazawa, Hagi, Onomichi and Omi-Hachiman pointing that in their development process could be noticed some aspect of historical “modus operandi” – a remarkable stable way of acting that depends from the initial character of city’s authority system formed at very early time [7-9]. In other worlds, it can be assumed that every historical city poses some kind of unique historical mentality of cultural space [10] that influence on its transformation process and sometimes not corresponding with official plans of urban development. It is also possible to notice that the formation of urban centres during the Industrial Revolution could have a significant element of spontaneity. “The spontaneity” in this case is understood lake a possibility of fixing the position of the new city centre in different place then the city authorities or city development projects provided to do. This specific point became the hypothesis of this research.

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In this regard, an extremely interesting example is the spontaneity of a new urban centre formation at the area of Khreshchatyk Street in Kyiv (Ukraine). Khreshchatyk Street is a newly formed from the end of 18th century suburb district, which during the Industrial revolution spontaneously gained role of the main street of the city [11]. The history of the formation of Khreshchatyk is relatively short, but extremely interesting. During the Industrial Revolution, this small suburb street developed unexpectedly rapidly and became central within a few years. The purpose of this work is to analyse the phenomenon of spontaneity in the formation of Khreshchatyk Street in Kyiv to identify there the elements of possible hidden patterns or flukes.

HISTORICAL PERIODS OF KHRESHCHATYK STREET DEVELOPMENT

Khreshchatyk Street runs along the bottom of a deep ravine (Khreshchata Valley) between high hills, which housed two ancient historical centres of Kiev – Starokyivska Kniazha Hora (urban centre of Kyivan Rus period) and the fortified fortress of Pechersk (military centre of the city formed in 16th-18th centuries). From the river Dnieper side, the third ancient trade centre of the city, Podil, adjoined the Khreshchata Valley. Khreshchatyk ravine gradually began to turn into a street only at the end of 18th century. Therefore, first, we have to define the historical periods of street development.

Based on the study of various urban plans of Kyiv and other historical and archival documents [12] as well as literary sources [13], the entire development of Khreshchatyk as a street can be mainly divided into three periods. The first period run about from 1790 to1860. During this period, the first houses with mansions appear here, the street itself is planned. However, by the end of the 18th century Khreshchatyk was still considered a city road, not a street [14]. Therefore, this road at the bottom of the Khreshchata Valley, not yet being an urban street, both in its position and functional purpose, for several centuries gained, preserved and gradually increased its potentiality of the future main avenue of the city. During the 17th century, the ravine of Khreshchatyk was empty yet, but from the 18th century, local people began to settle there. By the end of the 18th century, the section of the road on the bottom of Khreshchata Valley at a distance from Tsarska Square to Prorizna Street was the first to turn into a one-sided urban development, mostly on the right side of the ravine. All the buildings on Khreshchatyk at that time were residential buildings, except for one estate – the first theatre in Kyiv.

Areas of the slopes from Tsarska Square to Prorizna Street and on the opposite side until 1805-1806 were distributed for construction. There were one-story wooden houses, which made the area look like an ordinary provincial district. Construction of the street was very slow at first. Only the fire in Podil riverbank district in 1811 accelerated it a little bit. Some of the victims of the fire in Podil settled on Khreshchatyk (in this time the street was yet called Teatralna Street, because of the single Kyiv Theatre situated there). Here there were small handicraft enterprises and shops. In the 1830's Khreshchatyk's development was revived due to the expansion of the Pechersk Fortress and the eviction of its inhabitants. From the plan of Kyiv in 1830, it can be seen that the right side of Khreshchatyk went beyond the section between Tsarska Square and Prorizna Street and extended to the line of Bibikovsky Boulevard [12]. 1830-1860s is the time of continuous construction of the street. The second draft of the regular city development plan, drawn up by architects V. Beretti and L. Stanzani and engineer L. Shmegelsky, was approved in 1837. In the draft city plan of 1837, the street acquired its final contours, which are largely preserved to this day, and was already called Khreshchatyk Street [13].

Khreshchatyk, according to the projects of 1837, began near Tsarska Square and ended near Bessarabka Square. The analysis of the project of 1837 shows that Khreshchatyk was given an important place in the development of Kyiv, but not the main one: the creation of a new city centre at that time was planned at the area of Volodymyrska Street. Khreshchatyk Street on the plan of 1837 was narrowed, in broken contours [12]. Thus, Khreshchatyk did not yet receive the significance it had later. In the lines of this project, Khreshchatyk, its squares and adjacent streets were quickly developed. The rich entrepreneurs from old city trade centre Podil quickly noticed the business chances of capital transfer to Khreshchatyk area. Following the settlers from Pechersk, quite prosperous trade companies moved there from Spaska and Oleksandrivska streets, Kontraktova and Zhytna squares of Podil [15]. Later, two- and three-story masonry houses appeared in various places in the Khreshchatyk area. Therefore, in 1860 there were many more estates with small houses on Khreshchatyk and the surrounding streets. Only from Khreschatytska Square to Tsarska Street and at the approach to Lutheran Street, the freestanding buildings were replaced by two- and three-story dense development at that time.

The second period of Khreshchatyk Street development took place from the 1870s to 1941. It is advisable to distinguish two stages within this period: from 1870 to 1917 and from 1917 to 1941. During the first stage of the second period, the character of the street changed dramatically: it was rebuilt, the size of the buildings increased up to five-six storeys, and the dense development appeared everywhere. To obtain a large front of street development, the neighbouring quarters with large green-plant areas inside, were replanned and divided into a number of smaller blocks (for example, the redevelopment of the quarter of Professor Mering's estate with creation of Mykolaevska, Meringivska, Olhinska and Nova new streets instead). The status of Khreshchatyk as the centre of the city was officially established. At the turn of the 19th and 20th centuries, Khreshchatyk experienced an unprecedented flowering. Due to the growing economic importance of the city, the centre of administration, trade, industry and business life of Kyiv in the second half of the 19th century moved to Khreshchatyk. The City Council (City Duma) also moved from Podil to specially erected in 1874-1878 building at Khreshchatyk Square, and Podil became an industrial suburb of the city. This reincarnation of Khreshchatyk took place gradually, starting from the area from Tsarska Square to Khreschatyk Square, where were transferred the most of business activities of Podil being before for the long time the trade centre of Kyiv.

In the 1860s, there were still many houses on Khreshchatyk that did not have a single shop and were intended only for the residence of their owners. Ten years later, it became impossible to see here. During this period, mostly combined buildings were built (housing, shops, and offices). Shops occupied almost all the lower floors. Five- to seven-story buildings alternated with low-rise buildings that have survived here since the beginning of the street. After 1878, when the City Duma office building was erected at Khreshchatyk Square, administrative buildings no longer appeared at Khreshchatyk, because there was no more city land fund for this purpose. In the 1890s-1910s, Khreshchatyk Street entered a new phase of development as the central part of the capitalist city. The street was formed as a pronounced centre of business, commercial and industrial life, but not as a centre of administrative and economic management. Due to all this, the demand for construction sites has increased. Land rent became unprecedented high. The street and neighbourhoods were built up by a solid bulk of high-rise masonry buildings along the perimeter of the blocks. The green trees flourished here before disappeared, the slopes around also were covered with buildings. The high land rent on Khreshchatyk led to the construction of multi-storey (five- or seven-story) masonry buildings also at internal parts of the neighbouring blocks. The density of buildings in some Khreshchatyk neighbourhoods reached 70-75% at 1914 [16]. The development and importance of Khreshchatyk Street as a trade and business centre of Kiev grew until 1914. By this time, the street was already oversaturated with buildings and congested with transport and communications. The First World War of 1914 almost stopped construction activities in Kyiv.

The second stage of the second period of street development covers the period between the First and Second World Wars (1914-1941). This stage became the most tragic for Khreshchatyk. The development of the street stopped. During the revolution and the civil war, Khreshchatyk suffered significant damage, but still remained a city centre. From the 1920s until the beginning of the Second World War, the street was restored and cosmetically rebuilt. Some improvement and landscaping work also was carried out. In some places, old houses were demolished and new ones were built in their place. During the most intensive reconstruction of the street in the pre-war period (1936-1941), a significant number of Khreshchatyk buildings got new superstructures and reconstructions. Most of the facades, according to Soviet ideology, were greatly simplified, many elements of the decor were lost, due to which the general impression of the street changed significantly. During the Second World War, Khreshchatyk was almost completely destroyed.

The last period of the street's development covers the period from the end of the Second World War to the present day. First, it is marked by the post-war reconstruction and expansion of Khreshchatyk and subsequent changes of its image. The width of the street was significantly increased; technical equipment and landscaping were modernized. Despite the fact that the nature of the building has changed radically due to the widening of the street and the replacement of destroyed buildings with new and larger architectural complexes, some affinity of today's ensemble Khreshchatyk with the old building of the street takes place. The preserved monuments of the old street have taken a certain place in the new structure of Khreshchatyk. Throughout the last period of development, street buildings have undergone constant changes due to new constructions, superstructures, reconstructions or demolition of some buildings. And although we can say that at present the general structure of the street is relatively formed, the process of constant slow changes in the architecture of Khreshchatyk continues now, which has become especially relevant against the background of bright political changes and revolutionary events of late 20th – early 21th century.

THE CHARACTER OF KHRESHCHATYK STREET DEVELOPMENT AND THE FACTORS INFLUENCED TO IT

From the analysis of the historical destiny of the street follows the statement about two qualitative turning points in its development [11]. The first turning point had place in the 1870s, when the character of Khreshchatyk Street transformed dramatically due to the total change of the type of buildings and growing of their height. The second qualitative turning point occurred during the Second World War, when almost all old buildings were destroyed, and later Khreshchatyk was completely rebuilt. Thus, during the existence of Khreshchatyk Street it is possible to state the existence of two chronologically and qualitative different architectural formations. At the same time, it is obvious that the pre-revolutionary ensemble of buildings reached its development peak in 1914. The second development peak can be observed in present time, although now it can be considered that the ensemble of the street is not yet completely shaped (figure 1).

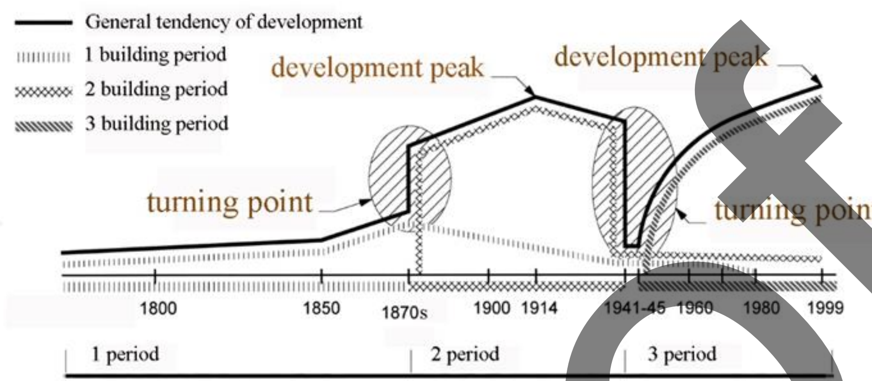

FIGURE 1. Khreshchatyk Street historic development character (by authors).

Based on the circumstances noted above, it is possible to identify various situational, historical, urban and socio-political factors that during the Industrial Revolution led to the formation of Khreshchatyk Street as a multifunctional city centre [11]. Among such factors, it is expedient to allocate two main groups. The first includes global factors that had place in almost all major cities of Europe, America or Japan in the 19th century. The second group includes specific factors unique to Kyiv. Among the global factors of the formation of urban centres in the 19th century, the development of Khreshchatyk was determined by:

- Rapid development of capitalism, which during the Industrial Revolution caused major changes in the land tenure system, a sharp increase in industrial development and the movement of large masses of people in cities, which in turn led to significant changes of historical European cities urban environment. Due to the development of new social and economic relations, as well as technical progress, cities need fundamentally new types of administrative and residential buildings (banks, exchanges, hotels, apartment profitable houses, clubs, cinemas, shops, etc.). The place for them often was not enough on the old streets of the cities centres.
- Emergence of railways and railway stations, which usually led to the formation of new transport links and the total shift of emphasis on the importance of city roads. In the case of Kyiv, the construction of a new railway station in 1870 caused the strengthening of the Khreshchatyk-Vasylkiv transport axis.

Specific factors of city centre on Khreshchatyk formation in the 19th century were:

- Ancient important transport significance of the Khreshchatyk road, which was geographically very suitable for the role of the main avenue of the city.
- Unique Kyiv's relief and subsequently historical peculiarities of the topography of Kyiv, and in particular Khreshchatyk Street (a deep valley clamped on both sides by high slopes), quite clearly fixed the position of the street. Despite some technical problems caused by this topography, the location of the street between three scattered ancient parts of Kyiv was extremely convenient when it came time to expand and merge the city.
- Big fire in Podil old trade district in 1811, which forced many Podil residents to move and build on Khreshchatyk area accelerating its formation as a street.
- Big Khreshchatyk redevelopment, caused by the expansion in 1830s of Pechersk Fortress, which led to a large eviction of residents from this area and the relocation of most of the Pechersk merchants to Khreshchatyk. This dramatically accelerated the formation of the Khreshchatyk Street and actually decided its role as future city centre.
- With the transformation of the street into a place of very profitable business, there was a huge increase in the price of land for construction on Khreshchatyk area. In this regard, the construction of the street has extremely

condensed, both on the front and in the middle of the quarters. Neighbouring blocks also were re-planned with a breakdown into smaller ones and the creation of new streets flowing into Khreshchatyk.

Along with the factors that conditioned and accelerated the formation of the city centre on Khreshchatyk, there also existed specific reasons that delayed the development of the street [11]. Among these reasons are:

- The topographic position of the street as a deep ravine, which caused recurring flooding by rainwater and required powerful drainage.
- Inconvenience of building the street due to natural potholes.
- Excessively steep rises of cross streets and the absence of duplicate routes of transit traffic.
- In some cases closing by buildings of convenient transport directions.
- Private ownership of land on Khreshchatyk with landowners often considering only their personal profits, which did not always contribute to the development of the street.

RESULTS AND DISCUSSION

Thus, we can say that Khreshchatyk, which was formed as a street at the end of 18th century, turned into the city centre gradually and unplanned, spontaneously. The city developing plans of that time envisaged the city centre in the area of the newly planned Volodymyrska Street [13], that is, in a completely different place. Nevertheless, based on the historical circumstances described above, it can be stated that the formation of the city centre in the area of Khreshchatyk was inevitable and subjected to a number of implicit patterns. The rapid formation of the street as a city centre stemmed from its convenient geographical and topographical location as a link between three ancient parts of Kiev. Thus, we can say that the socio-economic circumstances of the Industrial Revolution only led to the action of this mechanism laid down by the topographic, historical and cultural preconditions of the city's existence.

It should be noted that the further destiny of the street described above can also be considered as somewhat natural. In particular, the reconstructions and simplifications of the architectural image of Khreshchatyk took place during the 1930s, directly stem from the new functional needs and socio-political situation of the time (revolution, civil war and the ideology of Soviet rule). The destruction of the street during the Second World War could be considered a coincidence if Khreshchatyk was not located in the very centre of Kyiv. After all, during the war, architectural monuments always suffer, especially those located in the central areas of the city. At the same time, the destruction of most of the old street buildings cleared the way for the new needs of the main street of the big city. Reconstruction of Khreshchatyk at the turn of the 1940s and 1950s went by widening the street, enlarging its scale and the height of buildings. All these latest architectural and urban planning solutions directly stemmed from the new economic, social and political needs of the city. Today, Khreshchatyk is also not a stable system; the architecture of the street exists in constant motion, style interpretation and image transformation [17], which, due to a rapid change in socio-political circumstances during Independence of Ukraine, became especially noticeable in the first decades of the 21th century.

CONCLUSION

From the preliminary analysis, it can be concluded that the specifics of the spontaneous formation during the Industrial Revolution of the main street of Kiev – Khreshchatyk, in fact, was subject to a number of implicit patterns. In general, it was due to the peculiarities of its geographical and historical situation as a part of an ancient city of unique history and specific hilly topography developing in surprisingly rapid, rich in events and tragedies time of 19th-20th centuries. Undoubtedly, a certain fluke, in particular, the human factor also was present. The architectural image of the street was formed under the influence of creative personalities of architects, tastes and desires of landowners and various officials. However, these aspects influenced mostly the superficial (architectural details) rather than the basic (urban, compositional and stylistic) characteristics of Khreshchatyk formation. Thus, in cases of spontaneous formation during the Industrial Revolution of new urban centres of other historical cities of the world, it is also possible to predict the existence of implicit patterns of influence. These patterns arising from the global historical and socio-political conditions of that time as well as from specific historical, topographic, urban, cultural end others circumstances of each city in particular.

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Investment and Innovation Policy of Railway Transport: Features of Formation, Implementation and Evaluation of its Efficiency

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Abstract. The study substantiates the key role of railway transport in ensuring sustainable growth of the transport system and encouraging the processes of Ukraine's economic revival. The current state and development trends of domestic railway transport have been analysed and allowed defining its crisis situation and limited investment and innovation potential for encouraging progressive changes in the railway industry. The main provisions and features of the formation and implementation of investment and innovation policy in railway transport are revealed. A method for assessing the priority of implementation of investment and innovation projects in railway transport has been proposed. There has been outlined an example of the application peculiarities of the method of determining the price, which will provide a realistic assessment of the investment opportunities of railway transport for the purchase of a certain type of rolling stock and ground the management position on the choice of its manufacturer.

STATEMENT OF THE PROBLEM

At present, the focus of the country's economic policy is on overcoming the negative consequences of the socioeconomic crisis caused by the dominance of the coronavirus pandemic crisis and the disruption of established relations between countries and businesses, and the transition to sustainable economic growth in Ukraine. This is possible with the availability of the main drivers that are able to create a basis for further economic growth in the transition phase. One of such drivers of stimulating the country's economic growth is the transport sector, which plays a key role in creating conditions for its innovative modernization, facilitates the country's transition to the concept of sustainable development and creates a basis for its international competitiveness.

A special place in the transport system of Ukraine belongs to railway transport, the efficient operation of which creates the basis for further sustainable development of the country. The importance of the railway complex in the economic development of Ukraine is determined by: firstly, the impact on the efficiency of economic entities; secondly, creating preconditions for increasing the transit potential of Ukraine; thirdly, the role of the catalyst of the innovation process in industry and one of the largest consumers of the results of the production and innovation process of enterprises of other activities; fourthly, the impact on solving environmental problems; fifthly, the role in the social sphere of the economy; sixthly, compatibility with other means of transport. This gives grounds to claim that railway transport is an integration element of the efficient functioning of the transport system.

However, despite the strategic role of railway transport in ensuring the sustainable development of both the transport system and the national economy as a whole, nowadays its effective functioning is limited by a number of unresolved issues. These issues include extremely critical condition of rolling stock and infrastructure, low carriage and traffic capacity, outflow of highly qualified personnel and gradual loss of intellectual potential of the industry, inefficient organization of operational processes in railway transport and in general the decline in the quality of management of the railway company. The total destructive impact of these factors leads to the loss of

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competitiveness of railway transport and the decrease in its investment and innovation potential needed to implement progressive changes in the industry. Taking into account the above, it is very important to consider the issue of formation and implementation of effective investment and innovation policy in the railway transport of Ukraine and providing its sustainable competitive development on this basis in the long-term run.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Scientific works of such scientists as Dykan V., Kalicheva N., Korin M., Ovchinnikova V., Tokmakova I., Yanovska V., Nash C., Matthews B. and Smith A., Gkoumas K., van Balen M., Ortega Hortelano A., Tsakalidis A., Grosso M., Haq G., Pekar F. and others [1-9] are devoted to theoretical, methodological and practical problems of improving the efficiency of the railway complex, in particular innovation and investment principles of its development. However, noting the significant scientific and practical contribution of these scientists in research and solving problems of railway transport development, it should be stated that currently no research has been conducted that would comprehensively solve the problem of investment and innovation development of railway transport as a component of the national economy and its interaction with other elements of the country's economic system. The significance of this issue becomes obvious taking into account deepening processes of globalization of the world economic system and their impact on the path of the national economy development, the key components of which are powerful research and production interindustry complexes. The need for them is felt considering the necessity to implement large investment and innovation projects of national scale, which requires the accumulation of scientific, industrial, intellectual and other potentials of entities belonging to different spheres of economic activity. The solution of the outlined problem is accompanied by the need to substantiate the priority areas of investment and innovation activities in railway transport and the formation of an effective investment and innovation policy to ensure its sustainable development.

CURRENT STATE AND PROBLEMS OF RAILWAY TRANSPORT DEVELOPMENT

Despite the exceptional role of railway transport in stimulating the processes of socioeconomic growth of Ukraine, its condition remains quite difficult today. The railway infrastructure, the fleet of locomotives, railway cars and other special equipment are under catastrophic conditions, the deterioration level of which reaches a critical level. Thus, the deterioration level of locomotives reaches the mark of almost 100.0%, in particular diesel locomotives are worn out by 98.3%, electric locomotives - by 94.4%. The situation with the carriage fleet of JSC Ukrzaliznytsia is no less difficult, the deterioration level of which reaches 90.0%. The situation is complicated by the fact that in recent years the reduction of the fleet of freight wagons of JSC "Ukrzaliznytsia" occurred simultaneously with its increase by private owners. Therefore, it is getting a threatening impact on the railway monopolist activity under the conditions of opening of the rail market for private operators. Thus, today the fleet of freight cars of Ukraine is almost 173.0 thousand units, of which 84.9 thousand units are cars of the state monopolist, and 88.1 thousand units are cars of private owners (51.0% of their total number). Along with this, the catastrophic state of railway infrastructure should be noted. Currently, about 6.4 thousand km of railways need major repairs, and 2.7 thousand km should be reconstructed. In turn, the rail equipment is worn out by 78%, the catenary - by 71%, and the devices of railway automation and communication - by 68%.

Outdated rolling stock, critically worn-out infrastructure, low capacity of the railway network and generally inefficient organization of operational processes on railway transport have led to the reduction in freight and passenger flows and reduced profitability of the railway company. In 2020, 305.5 million tons of cargos were transported by rail, which is 97.6% compared to 2019. In January-February 2021, 43.8 million tons of cargo were transported by rail, which is 7.4% less than a similar indicator in 2020. Reduction of cargo flow was recorded for such types of cargo as grain (transported by 35.4% less than in January-February 2020), cement (by 26.8%), ferrous metals (by 5.6%)), iron and manganese ore (by 4.7%), construction materials (by 3.6%), oil and oil products (by 2.1%), other cargo (by 8.1%). The growth of traffic volumes was recorded only in terms of such types of cargo as ferrous scrap (growth rate 33.6%), chemical and mineral fertilizers (17.2%), coke and coal (4.1 and 3.3%, respectively). Regarding the volume of passenger traffic by rail, it should be noted that the passenger traffic has halved in January-February 2021 from 22.0 to 11.2 million people [10].

The reduction of freight and passenger flows has been reflected in the dynamics of financial results of JSC "Ukrzaliznytsia". Therefore, if in 2019 the financial result of JSC Ukrzaliznytsia had been a profit of UAH 2.9 billion, in 2020 the company generated a loss of UAH 11.9 billion. In addition to the above factors, this situation is caused at great extent by ineffective fiscal policy. As the company has increased its debt in recent years (by the end of 2020, its total amount reached UAH 58.3 billion). At the same time, credit resources are attracted not for the implementation of infrastructure projects for the development of railway transport, but, first of all, to cover existing financial obligations. In particular, in 2020 the company attracted UAH 23.5 billion of credit resources. In turn, the company spent UAH 28 billion to repay current liabilities, UAH 3.4 billion of which were interest on loans [11]. The implementation of such a policy leads to a reduction in investment in the renewal of capital assets and causes to further immersion of the company in the systemic crisis.

This is reflected in the systematic non-fulfilment of capital investment plans for rail transport. Thus, the level of implementation of the investment plan has not exceed 50-60% in recent years, in particular, in 2019 the investment plan of JSC "Ukrzaliznytsia" was fulfilled by 51% (UAH 9.3 billion). In turn, in 2020 the company assimilated investments to the extent of UAH 10.7 billion, which amount, on the one hand, corresponds to 85% of the plan, and on the other hand - meets the investment needs of the industry only by 20%. Currently, railway transport is in a very complicated situation and the amount of investment required to stabilize the activities of JSC "Ukrzaliznytsia" is steadily growing every year.

However, despite the difficult situation of JSC "Ukrzaliznytsia" and the dynamics of investment activity in recent years, in 2021 the company has planned to implement a capital investment plan for UAH 27 billion. Most of the investment is planned to upgrade rolling stock (purchase of the new, modernization and complete overhaul of the existing fleet, including the purchase of 80 passenger cars, renewal of about 23.5 thousand freight and 451 passenger cars, as well as 318 units of locomotives, etc.), increasing capacity and eliminating bottlenecks in the infrastructure, as well as repair and modernization of roads. In particular, it is planned to launch an initiative to electrify the Dolynska-Mykolayiv and Izov-Derzhkordon sections [12]. Admittedly, the implementation of such projects is extremely important for JSC "Ukrzaliznytsia" at the present stage. However, full implementation of the planned indicators is a rather difficult task for the company, taking into account that the highest level of investment in the development of railway transport in recent years was recorded in 2018, when their volume reached UAH 16.9 billion.

Thus, today in Ukraine's railway transport, innovative changes are generally focused on the renewal of rolling stock and the gradual reconstruction of the railway network. Among the innovative projects in the field of freight and passenger transportation, which have been implemented in recent years, it should be noted the improvement of information and communication interaction with customers, in particular through ticket sales and registration of freight documents through digital service channels; gradual transition to the electronic fleet management system of JSC "Ukrzaliznytsia", which is currently operating in test mode, and covers a small proportion of rolling stock; expanding the scope of coverage of railway transport activities by automated control systems, in particular, for the last year and a half an automated wheelset accounting system has been in operation, etc.

Despite some changes, the practice of implementing innovative solutions in railway transport is currently fragmentary. Assessing generally the results of the implementation of measures declared in the concepts and programs of railway transport development as innovative, on the whole, it should be noted that they did not contribute to the creation of an effective innovative railway transport system with sufficient managerial, production, scientific, resource and other potentials to strengthen the role of science, technology and innovation in the economic development of the industry and suspended negative trends in science and technology. In particular, despite the adoption of a strategy for the development of railway transport, there is a further systematic non-fulfilment by the railway company of plans to invest and ignore the innovative modernization of railway transport, which only deepens the crisis in the industry.

Thus, taking into account the considered investment and innovation trends in the development of railway transport, it should be noted that today JSC "Ukrzaliznytsia" needs a radical overhaul of investment and innovation policy and the management system of the railway industry overall. The formation of an effective investment and innovation strategy for railway transport has significant potential in this direction. This strategy is aimed at optimizing and diversifying the portfolio of business assets and minimizing investment risks of JSC "Ukrzaliznytsia", and the use of modern forms and tools of investment cooperation in infrastructure projects. Primarily, this refers to expanding the mechanisms and forms of cooperation of the railway company with the state and business, in particular through the intensification of state and private partnerships and the use of new investment mechanisms for cooperation with stakeholders (IPO, crowdfunding, etc.).

FEATURES OF INVESTMENT AND INNOVATION POLICY FORMATION OF RAILWAY TRANSPORT

Today it is generally accepted that overcoming the economic crisis is due to the introduction of new technologies that create new production opportunities, mastering of which provides a breakthrough in increasing the efficiency of the economy, its transition to a new stage of development. Sectoral innovation policy is meant to determine the main goals of innovation activity of the railway complex and the main ways to achieve them. On the one hand, it is based on state innovation policy and takes into account national economic development trends, economic growth dynamics and business environment. On the other hand, it has regard in intra-industry needs in general.

In view of the above, innovation policy should be considered as: strategic in nature, formed using a systematic approach, characterized by continuity of innovation activity in all industry members. The directions and goals of the industry are determined by the market situation and inseparability with scientific and technological progress. Therefore, the strategic goal of the innovative policy of railway transport is ensuring the qualitative transformation of production of the technical and technological level and overcoming the significant gap in the level of technical and technological development of domestic railway transport and world railways in order to successfully integrate it into the world transport system and increase amount of international passenger and cargo flows by national railway company.

Implementation of the strategic vision of the innovative policy of railway transport determines the feasibility of solving the tasks, as follows: determining the priorities of innovative development of railway transport; formation of an efficient mechanism for selecting priority projects for implementation of innovative projects; forecasting scientific and technological progress and creating innovative programs; formation of demand for new high-tech products and services; development of new progressive financing schemes for innovative projects; development of organizational schemes of scientific support of innovative programs; formation of measures and expansion of educational development programs for scientific personnel of the research sector of the railway complex; improvement of resource provision schemes for research and innovation activities; organization of research and innovation activities; ensuring the development of the existing innovation infrastructure and the formation of its new progressive types; organization of schemes of coordination of market - science - production - market interests and their interaction within promotion of new production and services on the market; development and implementation of encouraging measures of innovative activity of the railway complex subjects (of organizational, material, moral, managerial nature); organization of coordination schemes of interests and interaction of external and internal subjects of research and innovation activity in issues of the strategic purpose realization; formation of a unified information system in the field of railway transport on existing and promising innovative developments; promotion of ideas of the innovative railway complex development among employees; promoting the intensification of inventive and innovative activities; promoting the formation of innovative culture of the railway complex.

The innovation infrastructure is one of the key objects of the innovation policy of railway transport, taking into account the tasks facing it. The innovation infrastructure provides development of a favourable environment for the interaction of innovation objects, which includes a system of necessary social, legal, economic, informational, financial and other institutions that support both innovation activity and innovators themselves. Such elements of innovation infrastructure are state innovative financial and credit institutions, venture companies and funds, areas of intensive scientific and technical development (technopolises), technology parks (Hi-Tech parks), innovation centres (technological, regional, industrial), incubators (innovative, technological, business innovative), consulting (consultant) companies, etc. The tasks of information supply and production and technological support of innovation are solved with the help of its elements. Certification, standardization and intellectual protection of innovative products are carried out; there is a promotion of effective development and implementation of innovative projects; exhibitions of innovative projects and products are organized; training, retraining and advanced training of personnel for innovative activity is carried out, etc.

Despite the exclusive role of innovation infrastructure, the latter is functionally incomplete, underdeveloped in Ukraine. It does not cover all parts of the innovation process. In the innovation environment, there are almost no venture funds and technology transfer centres, the activities of inventors, innovators, scientists are not properly supported, educational and scientific potential is not fully used, especially in higher education, in the field of information and communication, high technology, and information resources of the system of scientific, technical and economic information.

Railway transport is challenged with needs for developing and monitoring the efficiency of innovation infrastructure. Currently, the railway industry does not have an index system that would characterize the level of organization and innovation results in railway transport, which is connected to its inefficient management. Because today the innovative infrastructure in railway transport is represented by scientific-research and design research institutes, which are under the management of the Ministry of Infrastructure of Ukraine and (or) are subordinated to Ukrzaliznytsia. Given the capabilities of the above infrastructure, it is necessary to identify such shortcomings that need to be solved immediately as low technical and technological level of innovation infrastructure; low level of employers' salary in the research sector, i.e. reducing the prestige of intellectual labour; lack of progressive organizational forms of innovation infrastructure.

A promising way to further development of the innovation infrastructure of the industry is the creation of science and technology parks that implement new forms of cycle "science - technology - production" management and are aimed at creating the most favourable environment for the development of small and medium science-intensive innovation firms. The structure of the science and technology park usually includes innovation and technology, training, consulting, information, marketing, legal, financial, economic centres and the industrial zone. Each of them provides a specialized set of services, such as retraining services, search and provision of information on a particular technology, legal, financial, economic advice, etc. Creation of scientific and technical parks in the transport industry will ensure integration of scientific potential of universities, research and design institutes, design and testing centres, industrial laboratories into a single innovation system. Within this system, it is possible to solve complex scientific and technical problems of innovative development; focus of investment sources on targeted financing of innovation processes; scientifically substantiated decisions on determination of priorities of innovative development of objects of priority restoration and development, distribution of investments and organization of financing projects. The activity of science and technology parks can influence the innovative renewal and development of capital assets of railway transport enterprises and implement a full innovation cycle from the development of the idea to the implementation of developments in production.

Another object of innovation infrastructure is sectoral venture funds, which are institutional investors that carry out exclusively venture investment activities related to attracting funds from venture investors in order to profit from investing these funds in assets. The latter can be represented by the assets of innovative enterprises; joint ventures created to implement technology parks projects; science parks; enterprises of innovation infrastructure. Venture funds invest in innovative programs and projects, new knowledge and intellectual products, production equipment and processes, production infrastructure and entrepreneurship.

A promising form of innovation infrastructure in the industry is the technology transfer centre as well. Its activities are related to the transfer of know-how, new technologies, technological equipment and scientific and technical knowledge from owner to customer. Technology transfer can be carried out, in particular, by signing the following contracts: on the supply of industrial technology; technical-industrial cooperation; on the provision of technical services; engineering; on the establishment of joint ventures; on rent or leasing of component technologies, equipment; commercial concession (franchising).

Another important element of innovation policy in railway transport is the innovation process. Assessing the world practice of innovation processes, it can be concluded the availability of only their second or third generation in railway transport. Today there is limited marketing and information support of the innovation process, removal of structural units from direct involvement in the innovation process; insufficient connection of recovery processes with scientific and technological progress. This leads to the replication of obsolete equipment and technology; delayed implementation of best practices; low integration with suppliers, consumers, partners in the organization of the innovation process; insufficient development of the base of experimental research. All the above complicates the process of testing new technology and correcting the shortcomings of the new design; unsatisfactory financial support for innovation, which nullifies the prospects for improving the innovation process; low technological condition of enterprises in the research sector, etc.

Every year the problem of funds lack for the implementation of the innovation process increasingly complicates the possibility of innovative development of railway transport. It is known that innovative developments are associated with sufficient funding, significant implementation periods and risks. It is possible to reduce the financial burden and risks, but this requires changes in the innovation process. That is, it is proposed to introduce a practice that combines the efforts of railway transport and other businesses in the innovative development of the railway industry. This is possible when the parties have common interests, produce the same products, outline the same prospects for product improvement, and want to get permanent partners, expand markets. For example, today there is a problem of insufficient orders of Ukrzaliznytsia for the products of car-building plants (even the enterprises that are part of it and have transferred to the production of cars remain without the possibility of selling products and are forced to look for markets). Under such conditions, it is important to implement measures aimed at reducing prices and increasing product quality. Just at this time, it is necessary to carry out innovative activities actively while reducing the cost of its implementation. This will be facilitated by the organization of the innovation process, which feature is the coherence of actions of the parties to the innovation process at all stages - from marketing research to the introduction and commercialization of innovations (Fig. 1). As a result, railway transport will have: the opportunity to reduce costs for research and development, marketing research, development of an experimental model; the ability to obtain products that in terms of parameters and quality meet the established needs; access to the scientific and technical database of partners; the possibility of providing orders for the research sector of the industry (these are design and engineering technological bureaus, design bureaus, design and survey institutes, research centres of the industry); the possibility of increasing scientific potential.

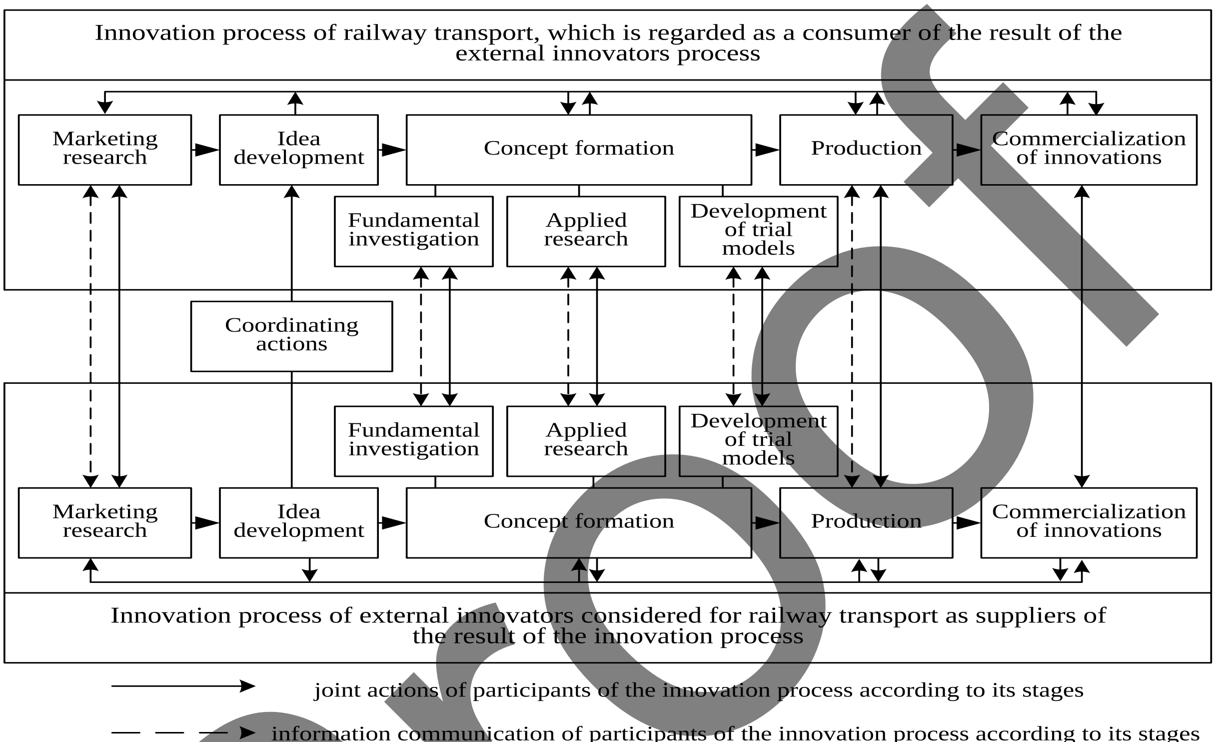

Figure 1. Joint innovation process of railway transport and external innovators

Other participants of the innovation process, in addition to reducing the cost of innovative developments and gaining access to a wide scientific base of railway transport, get the main result in the form of increased guaranteed orders from the main customer in the domestic market – Ukrzaliznytsia. Furthermore, joint actions in the innovation process of railway entities and external innovators should be in case when innovative transformations in railway transport lead to the beginning of a new life cycle of investment and innovation project in related industries.

In this sense, the formation of a permanent investment committee on investment activities of railway transport acquires practical value, which considers the inclusion of all railway enterprises, representatives of scientific schools, research institutes in the processes of investment and innovation development. They are the subjects of the innovation policy of the railway complex. The main tasks of the investment committee on investment activities of railway transport of Ukraine are, as follows: determination of priorities of investment activity in accordance with the approved programs of railway transport development; coordination of investment projects and programs in accordance with the identified priorities for the development of the industry; assessment of technical and economic efficiency, as well as the feasibility of inclusion in long-term, medium-term and annual plans of capital construction, modernization and acquisition of capital assets; consideration of proposals on the mechanism of attracting investments for the implementation of projects and programs; consideration and decision-making on proposals submitted by potential investors; analysis of directions of investment activity on railway transport of the CIS member states; promoting cooperation with the authorities on attracting investment resources; coordination of draft regulations aimed at improving the investment climate in Ukraine, taking into account the interests of the industry; elaboration of recommendations of business forums, international experts on investment development.

Since modern positive transformations are associated with the interaction of the three components of education-science-innovation, it is necessary to point out the exclusive role of intellectual capital as an object of innovation policy in railway transport. These components in the system of intellectual capital formation largely depend on the educational, scientific achievements of past periods, on the stability of community development, reasonable borrowing of innovations, stopping the "brain drain" and so on. The ability to regulate training skilled workers, to encourage solving transformational problems through education, science and innovation, the development of the knowledge economy are the necessary ways to promote the intellectual rise of the railway industry in the system of forming an innovative model of its development.

IMPLEMENTATION AND ASSESSMENT FEATURES OF INVESTMENT AND INNOVATION PROJECTS OF RAILWAY TRANSPORT

Provided the limited financial resources of railway transport, the efficient development of railway transport requires reducing the financial costs of enterprises and rational investment of own funds and credit resources, that substantiates the importance of defining prioritizing investment and innovation activities and forming a methodology for assessing the priority of investment and innovation projects. This technique can be presented in the form of the following stages (Fig. 2):

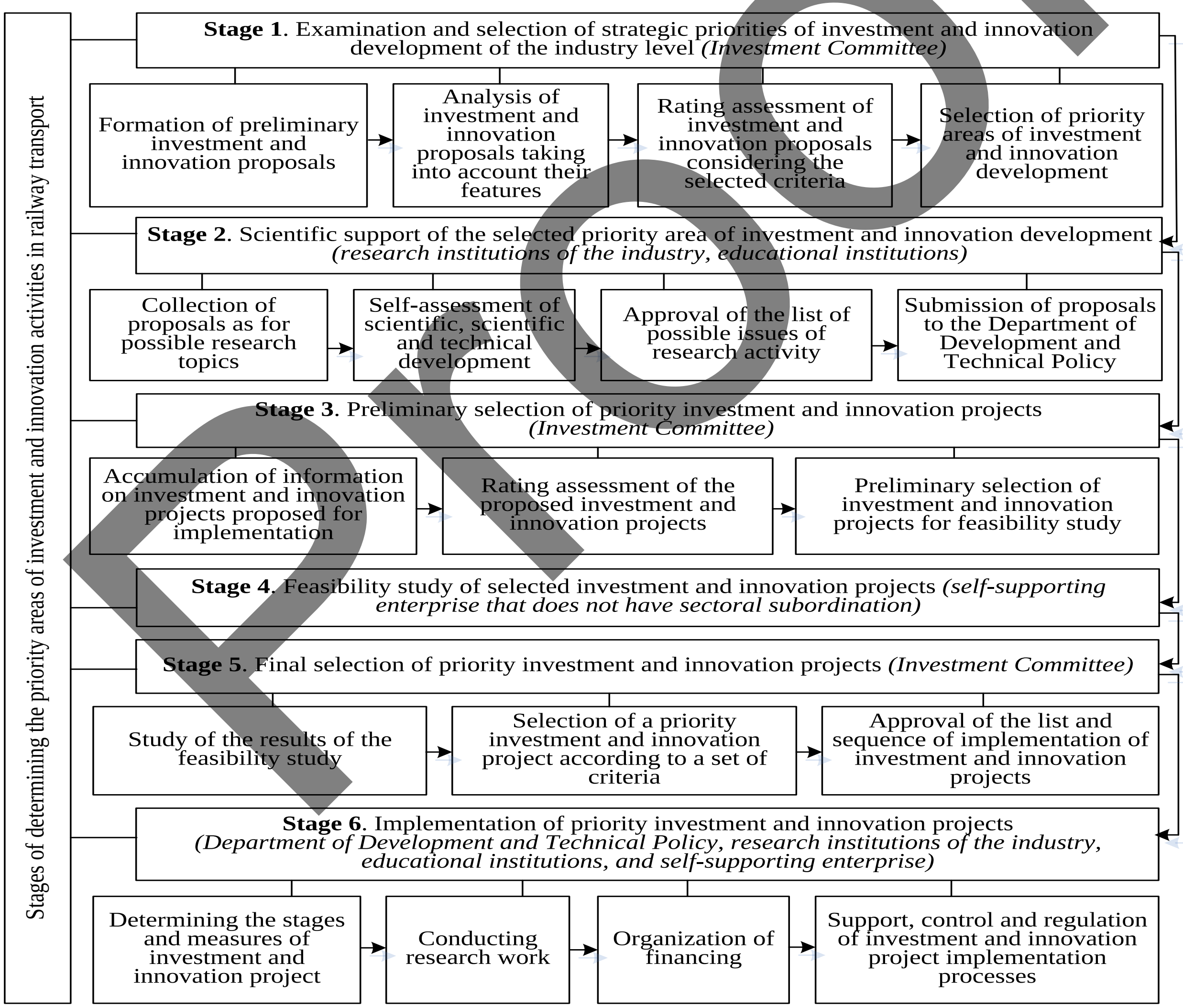

Figure 2. Selection stages of investment and innovation projects

The first stage is the examination and selection of strategic priorities for investment and innovation development at the industry level.

The second stage is scientific support of the priority direction of investment and innovation development of railway transport.

The third stage is the preliminary selection of priority for the implementation of investment and innovation projects for the development of railway transport.

The fourth stage is the feasibility study of pre-selected investment and innovation projects.

The fifth stage is the final selection of priority investment and innovation projects for the development of railway transport.

The final sixth stage is the implementation of priority investment and innovation projects.

Let us consider in more detail the fifth and sixth stages, which are related to the selection and direct implementation of investment and innovation projects in railway transport on a specific example. Thus, for example, one of the negative aspects of the implementation of investment and innovation policy in railway transport is the inconsistency of the management position of the railway company and rolling stock manufacturers as for the pricing of rolling stock. As the issue of the price determining method remains unresolved, the method will provide a realistic assessment of the investment opportunities of railway transport for the purchase of certain types of rolling stock and will ground the position of management concerning the choice of manufacturer.

The basis for determining the purchase price of rolling stock may be the calculation of its marginal level, which differs in determining the useful effect that the consumer receives during the operation period of new rolling stock compared to the base model in terms of operating and associated one-time costs. This price calculation takes into account the life cycle of the new and basic model of rolling stock and, in contrast to similar approaches, characterizes its cost, which exceeding does not allow to obtain even the slightest effect from the use of new rolling stock.

The life cycle of rolling stock comprises three main stages:

1) the preparatory stage, which includes the selection of possible suppliers, assessment of compliance of technical requirements of rolling stock with those stated by the consumer; conducting tenders; signing contracts for the construction and supply of rolling stock; preparation of structural divisions of the company for operation of rolling stock, its service and maintenance;

2) the operational stage, which is related to the operation of rolling stock and determines the costs of factory repairs, maintenance, roundhouse servicing, modernization of rolling stock, preparation for operation, etc.;

3) the liquidation stage, which involves the decommissioning of rolling stock and its disposal.

In view of this, the cost of the rolling stock life cycle includes the costs of its acquisition, commissioning, operation, maintenance, compensation for downtime, decommissioning and disposal.

The marginal price is set in the following sequence: first, the choice of comparison objects (new and basic model of rolling stock); secondly, the comparison of these models of rolling stock on the set of certain technical and economic parameters; thirdly, determining the annual operating costs when using the basic and new rolling stock and additional capital investments associated with the acquisition of new one; fourthly, the calculation of the beneficial effect from the use of new rolling stock; fifthly, the calculation of the marginal price of new rolling stock.

The basis of the feasibility study of the investment measure determines the economic effect for the calculation period:

$$E = R - M, \tag{1}$$

where E - economic effect; R - cost assessment of the results of measures; M - costs of measures.

In turn, the integrated effect of the production of new rolling stock should be considered as the excess of results over costs in terms of total output of new equipment for the calculation period. The costs of investment measures are divided into two components: the cost of production and sale of new rolling stock (total cost) and the cost of using rolling stock, which allows transforming formula (1) into the following form:

$$E = (P - C^{p}) + (R - C^{fr} - C^{ma} - C^{pl} - C^{wc} - C^{pf} - C^{rs} - C^{m} - P), \tag{2}$$

where P - unit price of new rolling stock; C^{p} - costs of production and sale of new rolling stock (total cost); C^{fr} - factory repair costs; C^{ma} - maintenance costs; C^{pl} - costs of preparing rail cars for loading; C^{wc} - costs of washing covered rail cars; C^{pf} - costs for preparing rail cars for filling; C^{rs} - costs for roundhouse servicing of freight rail cars; C^{m} - modernization costs.

The economic effect of railway transport from the use of new rolling stock is determined by the savings of capital and current costs without taking into account the liquidation value:

$$E^e = (C_c^b + C_o^b - D^b \cdot \alpha) - (C_c^n + C_o^n - D^n \cdot \alpha) = (P^b + C^{frb} + C^{mab} + C^{plb} + C^{wcb} + C^{pfb} + \\ + C^{rsb} + C^{mb} - D^b \cdot \alpha - P^n - C^{frn} - C^{man} - C^{pln^{wcn}} - C^{pfn} - C^{rsn} - C^{mn} + D^n \cdot \alpha, \quad (3)$$

where C_c^b, C_c^n - capital costs for the acquisition of rolling stock (basic and new); C_o^b, C_o^n - operating costs of rolling stock (basic and new); D^b, D^n - disposal value of rolling stock (basic and new); α - discount rate.

Alignment of interests of the manufacturer and the user is most likely provided equal distribution effect. For the manufacturer, its amount is determined by the difference between the selling price and the total cost of production. This equality of effects is represented by the equation:

$$P^n - C^p = (C_c^b + C_o^b - D^b \cdot \alpha) - (C_c^n + C_o^n - D^n \cdot \alpha) = P^b + C^{frb} + C^{mab} + C^{plb} + C^{wcb} + C^{pfb} + \\ + C^{rsb} + C^{mb} - D^b \cdot \alpha - P^n - C^{frn} - C^{man} - C^{pln^{wcn}} - C^{pfn} - C^{rsn} - C^{mn} + D^n \cdot \alpha. \quad (4)$$

In case of equality, $P = C^p$ the manufacturer's effect is zero, and such a price is the lowest limit of the marginal price. The upper price of rolling stock is equal:

$$P^n = P^b + C^{frb} + C^{mab} + C^{plb} + C^{wcb} + C^{pfb} + C^{rsb} + C^{mb} - D^b \cdot \alpha - C^{frn} - C^{man} - C^{pln^{wcn}} \\ - C^{pfn} - C^{rsn} - C^{mn} + D^n \cdot \alpha. \quad (5)$$

Given the equality of producer and consumer effects, formula (4) takes the form:

$$P^n = {}^1/_2 \cdot (P^b + C^{frb} + C^{mab} + C^{plb} + C^{wcb} + C^{pfb} + C^{rsb} + C^{mb} - D^b \cdot \alpha + C^p - C^{frn} - C^{man} - C^{pln^{wcn}} \\ - C^{pfn} - C^{rsn} - C^{mn} + D^n \cdot \alpha). \quad (6)$$

CONCLUSIONS

Thus, the current state and trends in the development of domestic railway transport have been analysed, which allowed to define its crisis situation and limited investment and innovation potential to stimulate progressive changes in the railway industry. The main provisions and features of the formation and implementation of investment and innovation policy in railway transport are revealed. The method of assessing the priority of implementation of investment and innovation projects in railway transport is developed. Acceleration of investment and innovation progress in the activity of railway transport has been considered on the example of coordination of its interests with the interests of rolling stock manufacturers regarding finding the marginal price for their products. The production is characterized by the useful economic effect, which the consumer obtains during operation of new rolling stock instead of the basic model within operation and associated one-time costs.

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