METHODS FOR THE FORMATION OF ENERGY-EFFICIENT ARCHITECTURE OF SOCIAL OBJECTS IN WORLD DESIGN PRACTICE

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Abstract: *Today, people are increasingly drifting away from nature in an age of accelerated lives and information technology. Only the natural environment can create comfortable, ecological conditions for human life. It has become evident that the biological component of the domain has been noticeably reduced in the big cities, and the appeal to the global architectural community of the ecological and aesthetic aspects of design and construction, which contribute to the comfortable and sustainable development of urban space, has become particularly relevant over the past decades. In a big city, architecture is omnipresent. Hence, the architectural-spatial environment should be solved as much as possible in the context of the natural environment, embodying not only the material needs of a person but also spiritual ones. The current unfavorable environmental, energy, and economic situation in the world requires new methods for designing and building the architecture of new and reconstructed old buildings. The article discusses the issues surrounding the formation of modern energy-efficient architecture in the context of its relationship with the natural environment through the use of modern design solutions. The article is based on surveys of social facilities made by the authors from 2017 to 2021 in Eurasian and European cities. The article analyzes a new mechanism of architectural formation based on the shape formation of an architectural object, the content of the architectural shape, the aesthetics of perception, and the organization of eco-space.*

Keywords: *architecture, social facilities, energy efficiency, world experience.*

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Introduction

In the middle of the twentieth century, the world's major cities faced solutions to serious environmental problems, the prerequisites for which were economic growth, urbanization, and urban population growth. The city is a complex organism, representing the close interaction of objects created by humans for socio-cultural, domestic, and industrial purposes with the components of the natural environment. With the urban areas' expansion and development, this interaction assumes the form of the growing pressure of urban area development on the environment.

In today's world, urbanization issues have long been at the forefront of the fight against urban pollution. The problem stems from humanity's focus on boosting economic development, increasing yields, and increasing productive values. However, the protection of the environment in urban development, as well as in the development of infrastructure, is ignored [1].

The high concentration of various types of human activity, while creating several unconditional advantages, nevertheless led to a disturbance of the optimal balance between the natural and artificial components of the landscape. As we approach the tipping point where the deterioration of the biosphere becomes uncontrollable, cities face an urgent need to preserve and maximize the natural components of the environment [2].

Nevertheless, "only in the city, being a product of civilization, a person can satisfy his needs in labor and creative work, in spiritual and cultural spheres, in education and development of the intellect, in wide communication and social movements, in fascinating spectacles and pleasures, in sports and mass relaxation" [3].

As public awareness of the magnitude of the anthropogenic load on the environment grew in the 1960s and 1970s, the global architectural community investigated various approaches. New scientific developments in this direction are being developed. Several studies have been conducted on many aspects of urban ecological development. The issues of climate change due to human activity are revealed in A.I. Voyvekov's and M.I. Butko's research. In J.E. Aronin's research [4], special attention was paid to the influence of climate and its elements on architecture. Here, the author emphasizes that "the peculiarities of the regional climate and local weather conditions are the first basis for the formation of ecologically sustainable urban systems" [3].

In the concept of the city's ecologization, Tetior A.N. describes the importance of preserving and restoring the natural environment. Additionally, ecological buildings must address the challenges of self-sufficiency and recycling through innovative, architectural, and technological solutions. Moreover, "green" buildings should be able to restore nature [2].

Ecological and urban development of cities, their sustainable development in V.A. Kolesnikov's research. From the standpoint of philosophy, Ilvitskaya S.V. and Lobkova T.V. [5] investigate the relationship between housing architecture and the natural environment, whereas Belyaeva E.L. [6] investigates the problem of visual perception of the architectural environment. Karpov S.V., in his scientific article on the basis of modern foreign materials, considers problems of urban ecology in the context of the ethical and aesthetic aspects of architecture [7].

The work's novelty is to develop new methods for creating a modern architecture of social facilities based on human interaction with the environment, considering regional conditions. This study aims to scientifically substantiate the methods of energy-efficient solutions to the objects being studied in architecture and to propose them for use in designing buildings. Based on the goals set, the research objectives are defined as follows: study and analysis of foreign and domestic experiences in creating energy-efficient architecture; development of the method's structure for the formation of energy-efficient architecture.

Materials and Methods

The authors conducted a full-scale study of the architecture of social objects in Astana, Yerevan, Delft, Copenhagen, and Groningen. The research material was formed based on a scientific program and internships in the framework of improving the quality of education in the training of architects. From the list of studied buildings, the authors have selected objects where the subject of the work is most clearly expressed. These are modern buildings built in cities such as Astana, Yerevan, Delft, Groningen, and Copenhagen.

The analysis method and investigation of the objects under study allowed to identify four main aspects of the architecture's relationship with the natural environment, which, according to the authors, determined the principles of the formation of energy-efficient architecture and are the basics for solving the modern city's environmental problems.

Results and Discussion

Having studied architectural objects, the authors described the main methods of formation that contribute to reducing the ecological load on the urban environment, i.e., shape formation, principles of natural structures in architecture, mimicry of the architectural environment, and visual perception of architecture and the architectural environment. In turn, the methods should be separated into two primary categories: morphological (shape formation, principles of natural structures in architecture) and aesthetic (mimicry of the architectural environment, visual perception of architecture).

Shape formation

Over the past decades, a definite paradigm has developed in architectural theory and practice for understanding and developing the architectural shape formation of objects, which is based on natural processes. The problems of urban ecology and the relevance of natural factors predetermined the appeal of the natural forms of living organisms and their associative image in architecture. The volumetric and spatial possibilities of architecture, with the involvement of the morphological aspect, contribute to the formation of a harmonious, light, durable, ecological, comfortable, and energy-saving architectural environment.

Natural structure construction principles in architecture

Wildlife is not only the most beautiful form of life, but it is also a superb example of an architectural structure, combining many structural systems in a more effective way.

For example, spider threads, which have high strength, form the basis of cable-stayed structures. Twisted, spiraling structural forms (borrowed from the twisting shape of shells and the spiraling of the stem of a plant, etc.) are used in the architecture of high-rise buildings or spiral central staircases. The cereal plants' spindle-shaped stem is a prototype of the elastic hinge-damper device in buildings, which, in turn, can withstand strong wind flow. The prototype for structure formation in architecture was various perforated structures of deep-sea living organisms. For example, the basis of the artistic idea of a bike-pedestrian bridge in Astana is the form of a sturgeon fish.

A vivid example of nature symbolism is the sculptural composition of the Grand Cascade public space in Yerevan: Alexander Tamanian's sculptural composition and Derenik Danielyan's mosaic panel sculpture (unfortunately not preserved).

Mimicry of the architectural environment

Each single energy-efficient building cannot solve the ecological problems of the urban environment. The main task of architectural and urban mimicry is the "co-scale reappearance of natural objects", i.e. immersion of a person into the natural environment. Such objects become aesthetic "green" centers of attraction in a highly urban environment [8].

Planting green spaces in areas characterized by a strong breeze also creates a barrier to wind flows, forming a more comfortable zone - an "aerodynamic shadow".

Thus, the object becomes the center of gravity, where the reason for gravity is the person's simple needs: to breathe clean air, contemplate and walk, and immerse in the natural environment (Fig. 1).

Architectural objects: 1. Sculptural composition of the Grand Cascade and mosaic panel (Armenia, Yerevan) and archival photo of A. Danielyan's mosaic panel, 2. Dormitory (Copenhagen, Denmark), 3. The Bike and Pedestrian Bridge (Kazakhstan, Astana), 4. The central staircase in the Palace of Schoolchildren (Kazakhstan, Astana), 5. Interior of the academic building of the Groningen Technological University Hanse (Netherlands, Groningen), 6. Copenhagen International School (Copenhagen, Denmark), 7. A. Tamanyan's Grand Cascade (Armenia, Yerevan) - photo by A. Toyshiyeva, 8. Walden Dos School, Mexico City, 9. The interior of the mockup workshop of the *Faculty of Architecture* and the Built Environment at *TU Delft* (Netherlands, Delft) - photo by A. Toyshiyeva.

Fig. 1. *Methods of energy-efficient architecture: shape formation and mimicry of the architectural environment*

Visual perception

An essential point for understanding architecture is its visual perception of personification, which is based on various methods of aesthetic expression. To create an expressive, comfortable urban environment using compositional-aesthetic means and the texture of the materials used, such as metric organization and rhythm; the texture and color of the materials used; bright color accents of facade finishing elements; artistic techniques for using natural and artificial light (for example, for visual comfort, the use of light at night); preservation of the natural landscape, the use of natural materials and alternative energy sources, the use of green roofs, planting of greenery. For the reconstructed building color formation or site development in general, it is vital to make a decision in the context of the color image of the natural and architectural environment.

In light of criticizing the globalization of urbanism and urban development without considering the local peculiarities of the territory, the most logical approach is one based on the territory's traditional structures with new functionality and technological improvements. The identity of urban space lies not only in traditional architectural forms but also in geometric and human-scale configurations of space and aspects of the citizen's interaction with this space [9].

The peculiarities of natural structure construction and various means of aesthetic perception can be traced back to the implemented and studied objects of energy-efficient architecture (Fig. 2).

Architectural objects: 1. Smooth fishlike shape: a perforated structure in a bike-pedestrian bridge (Kazakhstan, Astana), 2. Principle of spiral: The central staircase in the Palace of Schoolchildren (Kazakhstan, Astana), 3. Grid principle: Copenhagen International School (Copenhagen, Denmark), 4. The principle of the web-supported cable-stayed structure in the Khan-Shatyr shopping center (Kazakhstan, Astana), 5. The principle of the leaf vein grid, interior of the academic building of *Hanze Institute* of Technology (Netherlands, Groningen), 6. Texture and color of finishing materials: Schoolchildren's Palace (Kazakhstan, Astana), 7. Artistic technique of using natural light: the central hall in the interior of the Schoolchildren's Palace (Kazakhstan, Astana), 8. Artistic technique of using artificial light: SEC Khan-Shatyr (Kazakhstan, Astana), 9. Walden Dos School, Mexico City, 10. Copenhagen International School (Copenhagen, Denmark), 11. The central staircase-tribune of the Faculty of Architecture of the Delft University of Technology (Netherlands, Delft).

Fig. 2. *Energy Efficient Architecture Methods: Natural Designs in Architecture, Visual Perception*

Conclusion

An analysis of the methods for forming an energy-efficient architecture, in addition to the basic principles and design standards, makes it possible to identify principles aimed at improving the quality of the environment.

The fundamental principles of the morphological method of formation are determined by an associative way of natural forms and processes in architecture:

- the personification of natural forms in architecture (the principle of a fish, a circle, a spiral, nature symbolism in public space details and facade decoration),
- the personification of natural structures in architecture (the principle of a spiral, cobweb, grid, perforated structures).

The fundamental principles of architecture and visual perception are the ideals of organizing life:

- the submission of the shape of building and the public spaces to the relief,
- spatial connection of the interior with the natural environment,
- access to light and clean air,
- means of expression through metric organization and rhythm, the color of materials, bright color accents of facade elements, artistic methods of using natural and artificial light, using natural materials, using green roofs.

Today, in a period of high technological development and increasing societal dynamics, new methods of architectural design are becoming increasingly relevant, where architecture promotes the establishment of harmonious relationships between humans and the external world and determines the organization of adaptive, comfortable space in relation to contradictory sociocultural processes occurring in society. As a result, architectural creativity in the twenty-first century is determined by a new vector toward the creation of comfortable surroundings, i.e., the symbiosis of architecture and nature, the symbiosis of various cultures, and the symbiosis of the historical past and the future.

References

[1]. R.A. Kazarian, The Development of Modern Cities from the Perspective of an Ecological Approach. Ekonomika stroitel'stva i prirodopol'zovaniya, 1(78), 2021, 28-34 (in Russian). Doi: https://doi.org/10.37279/2519-4453-2021-1-28-34

[2]. A.N. Tetior, Arkhitekturno-stroitel'naya ekologiya. Akademia, Moscow, 2008 (in Russian).

[3]. V.A. Blinov, Arkhitekturno-gradostroitel'naya ekologiya. Arkhitekton, Yekaterinburg, 2017 (in Russian).

[4]. J.E. Aronin. Klimat i arhitektura. Gosstroyizdat, Moscow, 1959 (in Russian).

[5]. S.V. Ilvitskaya, T.V. Lobkova, Philosophy of Environmental Friendliness of Architecture as Basis of Modern Design of the Dwelling. Bulletin of Belgorod State Technological University Named After. V.G. Shukhov, 3 (8), 2018, 69-74 (in Russian). Doi: https://doi.org/10.12737/article_5b6d585bcd1b55.50847042

[6]. E.L. Belyaeva, Arkhitekturno-prostranstvennaya sreda goroda kak ob"ekt zritel'nogo vospriyatiya. Stroiizdat, Moscow, 1977 (in Russian).

[7]. S.V. Karpov, Filosofiya arkhitektury kak etiko-esteticheskoe osnovanie arkhitekturnoi praktiki. Gumanitarnye vedomosti TGPU im. L.N.Tolstogo, 2 (38), 2021, 77-83 (in Russian). Doi: https://doi.org/10.22405/2304-4772-2021-1-2-77-83.

[8]. A.V. Popov, T.V., Sorokoumova, Yu.S., Belyaeva, K.G. Sukhanova, Application of the Principles of Mimicry in Shaping Architectural and Urban Development Environment. Ekologiya urbanizirovannykh territorii, 3, 2019, 88-94. (in Russian). Doi: https://doi.org/10.24411/1816-1863-2019-13088

[9]. V.A. Nefedov, Landshaftnyy dizayn i ustoychivost' sredy. Poligrafist, St. Petersburg, 2002 (in Russian).

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