Eco-sustainable architecture and comfortable living environment

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Abstract. Eco-sustainable architecture strives to achieve the integration of the human habitat with natural ecosystem. It gives a rise for the harmonious development of all the components in this direction, allows to apply the methods of structures' entire complex optimal design, taking into account the natural features of the area and the comfort of people living in this urban space. The problems associated with the peculiarities of the eco-houses’ construction are considered. The article focuses on the relationship of architectural, engineering, economic, socio-cultural and environmental aspects of modern structures’ design.

1. Introduction
The sustainable architecture’s goal is to achieve a balance of the surrounding urban environment and humans from the ecological point of view [1]. These issues have been considered by the UN Commission on the Environment since 1987. The directions of sustainable architecture are manifested in the concept of “green” construction, energy saving, the use of alternative energy sources, for example, wind turbines and solar panels (Figure 1,2). Six wind farms will be built in the Rostov region, some have already been built.

Figure 1. Wind power plants.  Figure 2. Solar power plant.

Attention should be paid to the development of innovative methods of using resources, for example, energy [1-3]. Alternative energy sources are wind, sun, ebb and flow, biomass, geothermal sources. Recently, much attention has been paid to the first two components. Geothermal energy in Russia is developing in Kamchatka, at a very slow pace, though. For example, a house in Hamburg, Germany is covered with transparent panels with water which is inhabited by algae. These algae convert the energy from the sun into biogas. Due to this, energy and heat energy is saved. Such panels have thermal insulation properties. But being carried away by energy saving, the architects did not take into account the aesthetic component of this project. It is unlikely that the residents of this building are comfortable.
in it. But in this respect the secondary use of materials should not be ignored, but getting too carried away with this direction might cause some problems as well.

Some architects offer domed structures with translucent cover, which cover vast territories, entire cities. The development of new technologies in the future will make it possible to do this, but is it advisable? Of course not. This or that project should be assessed from the point of view of the construction possibility and from the point of view of its necessity. And it is quite possible to use shell, cable-stayed and other large-span coatings, for example, for the construction of sports facilities, for shopping, entertainment and exhibition complexes. Such structures were used in the construction of stadiums in Russia in preparation for the football championship [2].

It is necessary to use the methods of optimal design of buildings and structures, it is possible to apply the principles of architectural bionics when creating building structures, as well as to introduce and use new materials and technologies [3-5]. It is these issues that should be considered from the point of view of a person’s comfortable living in harmony with the surrounding nature. Modern designers can consider a variety of options using mathematical modeling methods using BIM technologies.

2. Ways of developing a modern urban environment in harmony with nature and human comfort

The modern urban environment is determined by the peculiarities of architecture, heritage of the past and the natural environment. When an architect takes on a project, he should take into account all these features, not forgetting about the architectural value of adjacent buildings and their strength. And sometimes after the new modern structures’ construction, it is necessary to deal with the reconstruction and strengthening the old buildings. It is very important to build not a stand-alone facility, but an architectural ensemble that harmoniously fit into the environment. At present, much attention is paid to the combination of urban objects and nature, which contributes to the comfortable coexistence of humans, flora and fauna. Of course, speaking about the urban environment, we focus on plants [1, 6]. Since the space for construction is limited, plants can be located both near the object and on the structure itself. This makes the building unique and human-friendly.

![Figure 3. View of a modern city, London, UK.](image)

Nature, urban environment, people - all this makes up our world, and it should be harmonious and comfortable for humans [1]. The beauty of nature, architecture has a beneficial effect on a person, giving
the opportunity to work, live, create. “Green” architecture concept is not only structures, but also progressive technologies that make it possible to create a structure that meets modern requirements; these are the structures that make it possible to combine human needs and vivid natural beauty without destroying it.

![Image 1](image1.png)

**Figure 4.** Combination of modern building architecture and plant objects

Architects realize that the relief effect of buildings can be completely arbitrary, but nature prompts them for optimal solutions [6-8]. To do this, it is necessary to study the structural laws of natural objects and use the design ideas of both structural elements and the entire structure. Often, in the construction of buildings, the properties of symmetry, asymmetry and similarity are used in architectural elements, for example, the arrangement of columns, windows, domes. Since rod and glass structures are very often used in modern architecture, the properties of symmetry, asymmetry and similarity can be successfully used in the structures design. [9].

![Image 2](image2.png)

**Figure 5.** The interior space of uniquely shaped buildings.

In architectural bionics, it is possible to search for new, functionally justified architectural forms and create new rational structures in harmony with nature and architecture. Many works of the architect G. Boehm also use the architectural style, where the structural elements are the block structures of the most diverse forms and spatial composition.

To enhance the impact of architectural structures on the emotional state of a person, illumination is currently actively used. Designers create interesting designs for city streets and facades using light. This is especially beautiful on New Year and Christmas holidays. But luminous fluxes can also be used to create unique structures, using the structural features of a building, glass structures and reflective coatings on the buildings’ surface. The direction of light flux can be changed with the help of awnings, cornices, balconies, making it possible to enjoy the beauty of nature and the building itself.
During the construction of the quarter of mixed development in the city of Lyon (France)
“International City” (architect R. Piano), the natural environment was taken into account: the park and
the Rhone river. The solution to the arrangement of the streets of this complex was interesting. This is
the glazing of the inner streets of the complex. There are also other options for street decoration using a
wide variety of glass structures. (Figure 7) [9].

Glass structures are widely used in the construction of skyscrapers (Figures 8.9). R. Piano was one
of the first architects to use these trends. His most famous skyscraper is the Shard in London (UK). The
skyscraper got its name “The Shard” because of the architectural elements on the top of the building in
the form of fragments.

**Figure 6.** Glass structures of awnings and galleries of modern buildings.

**Figure 7.** Glass structures in the streets’ improvement of the city blocks with unique shape.

**Figure 8.** Modern skyscrapers.

**Figure 9.** Skyscraper “The Shard”, London, UK.
For the further use of various materials during construction, it is necessary to take into account the variety of architectural solutions [10, 11]. Bionics makes it possible to find the most unusual in shape and structure optimal for the design of a wide variety of structures. The development of architectural bionics has led to the emergence of buildings in architecture using a wide variety of lines and surfaces. This makes the building unique in its shape [1,3-5]. But modern architects are not limited to this. They use a combination of the most interesting in terms of structure and layer properties as structural elements when decorating the building both inside and outside. In this case, a wide variety of materials are used: polymer composites, metals, glass, wood.

Buildings built using the bionic principles are resilient, able to withstand the adverse natural events and natural disasters. The Coral Reef project by architect Vincent Callebaut is an example of such structures’ design (Figure 10). He tried to solve the problem of resistance of structures to earthquakes. Two thousand modular houses are combined into a wave-like structure built on anti-seismic piles. Houses work on the energy of waves, and inside there are all the amenities. This architect also works on projects where people not only live in buildings, but also grow plants.

![Figure 10. Coral Reef Project (architect Vincent Callebaut).](image)

Currently, there are many natural manifestations in the world. Architects design buildings to withstand this. Using the achievements of architectural bionics and using modern materials, they create structures that can withstand the elements. They study the laws of nature, use them to model the structural elements of building structures and to model the very impact of natural manifestations. For example, they build earthquake resistant houses using anti-seismic piles and undulating building structures. For the last years some architects have been designing structures resistant to wind loads due to their spherical dome shape.

A very interesting hurricane-resistant dome building in Florida (Figure 11). The idea for its construction belongs to Mark and Valerie Sigler. They started building safe houses after the destruction of the old house by the hurricane. The homeowners used new technologies and improved cement and steel structures during the construction, which will have to withstand the hurricane.

Figure 12 shows a house in Singapore. It is an example of a sustainable architecture. This structure is adapted to the effects of volcanoes and hurricanes.

![Figure 11. Dome of the House Building, Pensacola Beach, Florida.](image) ![Figure 12. House in Singapore.](image)
A disaster can happen in any part of the world, and architects are concerned about the building structures resistant to such phenomena. As a result of the negative impact, buildings do not remain intact and people are at risk. Architects try to design the structures that could protect against this.

Eco-sustainable architecture is a set of design solutions of architects and engineers that allow balancing the quality of a comfortable human life and maintaining the environmental sustainability of the surrounding nature.

Summary

“Green” architecture is one of the sustainable architecture directions, which, when designing structures, tries to solve the problems of harmonious development of the territory with the rational use of material resources, energy, taking into account the ecology, with the reduction of waste, with the improvement of people’s lives with the aim of minimizing negative impact on nature [1, 10, 11]. But it is necessary to take into account both the physical and psychological comfort of a person living in an urban space, not forgetting about the climate situation on the planet and the aesthetic component of architecture.

Sustainable architecture tends to take into account such conditions as the use of sustainable materials; reduction of waste during construction and operation, their processing; environmental pollution; energy efficiency and water saving; healthy living environment and comfortable area around the complex of structures. It would be worth noting the social, cultural and economic components in the buildings design. This factor should be taken into account. Currently, the interest in sustainable architecture is increasing in the world. When designing, it is necessary to take into account two sides of harmonious development: a comfortable living environment for a person and a minimum impact on the nature around him.

To develop a sustainable architecture, it is necessary to apply optimal design methods; be able to change the project if not previously taken into account negative conditions arose; apply modern methods of mathematical modeling and conduct sociological research to improve the functional, microclimatic and aesthetic parameters of the human environment. It is necessary to look for the new ways, developing architectural bionics, which this direction includes.

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