

## PRINCIPLES OF GREEN ARCHITECTURE FOR THE HISTORICAL PART OF SAINT-PETERSBURG

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**Abstract.** The main provisions of the concept of "green architecture" for the historical part of megacities require scientific and practical justification due to the fact that buildings in historical part have restrictions on the use of landscaping as well as there are restrictions for energy-autonomous buildings on the use of equipment based on renewable energy sources. Reconstruction, restoration, repair and other activities can be carried out as architectural and construction activities in the historical part of the city. This requires the clarifications in the strategy of development of the concept of "green architecture" for the historical part of large cities. The main directions of development of the concept of "green architecture" for the cold climatic conditions of Saint-Petersburg with a small number of sunny days in average of 60-65 sunny days per year are developed in the paper.

**Key words:** historical part of the city, megacity, architectural monument, restoration, urban ecology.

### 1.Introduction

The term "green architecture" includes not only architecture with integrated natural component but also energy and resource efficient, economical, ergonomic

architecture (Masood *et al.*, 2017; Girot, 2019; Magliocco and Perini, 2015). Accordingly, the "green" architecture" should be considered in the interaction of engineering, landscape and architectural solutions.

The principles of "green architecture" are implemented through the inclusion of a natural component in the structure of the building (Magliocco and Perini, 2015), the use of energy-saving systems (Masood *et al.*, 2017) as well as the compositional, planning and spatial solutions of building in plan and in volume (Qiao *et al.*, 2016; Attia, 2018).

The following principles should be highlighted:

- the principle of energy conservation. It is design and construction in which the energy consumption for heating and cooling is minimized;
- the principle of cooperation with the sun. It involves the use of solar energy as the main source of light and heat;
- the principle of respect for a person. The building is designed as a habitat for people, i.e. the environment where they can live, work and study.
- the principle of respect for a place. The architecture of the building should not contradict the surrounding nature or environment as well as harmoniously fit into it.
- the principle of integrality. It suggests that all of the above principles should be interlinked.

"Green architecture" implies the creation of houses that are a natural extension of nature without contradicting it (Benghida, 2016; Kayan, 2015; Kumawat and Singh, 2019). In its further development it aims to create eco-houses namely energy-efficient and comfortable facilities with autonomous life support systems. The design of such a house involves a complex of autonomous engineering equipment. Environmentally friendly materials and building structures are used in construction (Kharitonov *et al.*, 2017a, 2017b). Nowadays, "green architecture" acquires a kind of addition

through the use of modern materials and technologies (Smirnova, 2018; Belentsov and Smirnova, 2018) that can be produced on the basis of by-products of industry and at the same time be environmentally friendly, i.e. do not have a harmful influence on the environment (Kazanskaya, 2019). Scientists, architects and designers make an important contribution solving environmental problems.

Urban ecology is one of the directions in "green architecture". A man in the urban environment and the diverse human relationships with this environment taking into account the fact that the man is a biological and social being (Gaston, 2010; Lai *et al.*, 2015) is the object of study of urban ecology. The main goal of urban ecology is to find and develop solutions within the framework of urban planning and organization of territories, aimed at ensuring good living conditions of the population and rationalization of environmental management within the boundaries of the territory. Basically, the following methods are proposed to create an ecological balance and an environment close to the original nature by researchers: to reduce the area of anthropogenically altered and built-up lands, to return a significant part of the contaminated areas to their natural state. However, it is difficult to implement it in the dense historical buildings of the city.

The growth of urban areas in large cities is continuing, the number of urban residents is increasing. Particularly active anthropogenic impacts cover the central parts of the city that are attractive in terms of infrastructure and investment. As a rule the dense historical buildings are located in the central areas of city (Fig. 1).

Unique ancient materials and structures are exposed to anthropogenic impacts from the industrial environment (Kharitonov *et al.*, 2016; Ryabova *et al.*, 2017). Thus, the development of the principles of "green architecture" for the historical part of megacities is required.



Fig. 1. The historical buildings of the center of St. Petersburg.

With the development of the principles of "green architecture" in the historical part of such megacity as St. Petersburg (situated on the north-west of Russia) it is necessary to separate a number of architectural and construction activities. For example, activities those are acceptable for the reconstruction of historical buildings and activities for the restoration of cultural heritages.

The aim of the paper is to develop the principles of "green architecture" for the historical part of St. Petersburg taking into account the type of architectural and construction works associated with the reconstruction of the historic building or the restoration of the architectural monument.

## 2. Classification of architectural and construction activities in historical buildings

In the historical part of city it is necessary to separate a number of activities as shown in Fig. 2.

The main definitions of architectural and construction activities for historical

buildings, which may be historical buildings or cultural heritage sites (architectural monuments), should be clarified:

1. Reconstruction of objects is a change of parameters of the object, their parts (height, number of floors, area, volume) including the expansion of the object as well as the replacement and (or) restoration of bearing structures, except for the replacement or restoration of individual elements of such structures.
2. Conservation of cultural heritage is research, survey, design and production works carried out in order to prevent deterioration of the cultural heritage without changing the extant appearance of the object including emergency works.

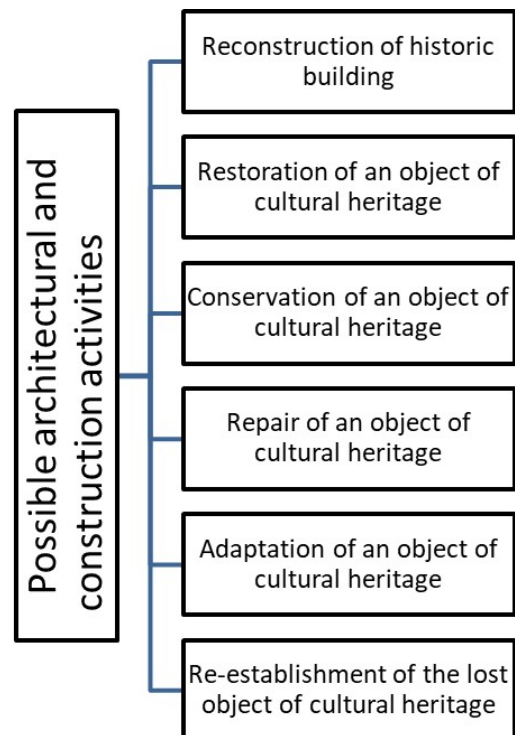


Fig. 2. Possible architectural and construction activities in the historically built-up city centre.

Objects of cultural heritage (monuments of architecture) are objects of real estate with associated works of painting, sculpture and other objects of material culture, which are valuable in terms of history, archeology, architecture, urban planning, art, science and technology and

are evidence of eras and civilizations, the original sources of information about the origin and development of culture.

3. Restoration of a cultural heritage site is a research, survey, design and production works carried out in order to identify and preserve the historical and cultural value of the cultural heritage site.

4. Repair of a cultural heritage site is a research, survey, design and production works carried out in order to maintain the operational condition of the monument without changing its features that are the subject of protection.

5. Adaptation of the object of cultural heritage for modern use is research, design and production works carried out in order to create conditions for the modern use of the object of cultural heritage without changing its features that make up the subject of protection, including the restoration of historical and cultural value of the elements of the object of cultural heritage.

6. Re-establishment of the lost object of cultural heritage is research, survey, design and production works carried out in order to restore the lost object of cultural heritage. The reconstruction is carried out by means of restoration of the architectural monument in exceptional cases with special historical, architectural, scientific, artistic, urban planning, aesthetic or other significance of the specified object and in the presence of sufficient scientific data that is necessary for its reconstruction.

### **3. The main objectives of development of principles of green architecture for the historically built-up city centre**

It is possible to formulate the following tasks within the framework of development of the principles of "green architecture" for the historically built-up city centre taking into account the above-considered activities:

1. Study of the interaction between the environment and places of settlement including all human activities in places of settlement as well as development of ways of this interaction.

2. Maintenance of ecological balance between places of settlement and environment as well as development of places of settlement by architectural and town-planning means. The use of eco-friendly buildings as well as architectural and urban planning, structural, technological solutions that help the existence and development of the natural environment in dense historical buildings.

3. Improving the quality of life in places of settlement and residential buildings by approaching the natural environment, creating an attractive image of the city, the interaction of the city and nature. Architectural, town-planning, constructive and technological solutions should exclude negative impact on the environment.

4. Saving all resources, their sustainable consumption, use of renewable resources as well as reduction of waste from construction and from the operation of buildings. The use of natural eco-friendly materials as well as environmentally acceptable by-products in the manufacture of building materials and structures.

5. Predicting and evaluating the possible negative effects of construction and operation of new and upgraded areas of settlement, buildings and structures to the environment. Timely detection of objects causing damage to the environment.

6. Environmental certification of materials, products, buildings in order to state the level of their impact on environmental situation in the city.

All the above mentioned tasks should be solved within the framework of the

concept of "green architecture". It is necessary to carry out the correct and thoughtful formation of new public spaces or reconstruction of existing ones, to build environmentally friendly and resource-efficient buildings in which the consumption of energy and the release of carbon dioxide into the environment are minimized.

The principles of resource efficiency of the building should be fulfilled at the design stage of new construction, reconstruction of buildings and restoration of architectural monuments. Objects of cultural heritage, ancient buildings without the status of cultural heritage and new buildings that are built on the spots of the earth or on the demolition of dilapidated buildings can be in the historic part of the city. It is necessary to design eco-friendly and resource-efficient buildings and structures in the case of new construction. Energy-efficient facade systems can be used in the case of reconstruction of buildings in the historical part of the city (Petrichenko *et al.*, 2018a, 2018b; Vieira *et al.*, 2018; Statsenko *et al.*, 2018). Eco-friendly facade materials similar to the original materials should be used in the case of restoration of cultural heritage (Kharitonov and Smirnova, 2015).

Eco-friendly and resource-efficient engineering systems are used for energy-autonomous buildings: wind turbines, solar panels. However, the use of solar panels has limitations for the climatic conditions of St. Petersburg with a small number of sunny days in average 60-65 sunny days per year. It is necessary to choose eco-friendly and resource-efficient building materials, namely materials of natural origin (natural stone, wood, etc.); artificially produced materials (concrete and reinforced concrete, metal alloys,

fiberglass, etc.); building materials based on industrial by-products such as microsilica, ash, slag and based on secondary raw materials, for example waste concrete, ground glass (Ma *et al.*, 2019; Tan *et al.*, 2018; Zhang *et al.*, 2018; Liu *et al.*, 2019). The principle of resource efficiency must be observed in the construction of building structures, for example, in the fulfilment of concrete works.

Masters of antiquity at creating a building have large-scale inscribed it in the surrounding architectural environment. Hence the principle of urban planning approach to the reconstruction and restoration of historical centres of cities appears. The amount of restoration needs to be addressed for entire historic streets. Modern anthropogenic impacts affect primarily the central urban areas, where the historical buildings of the city are. Ancient materials and structures are destroyed. The principles of scientific restoration should be observed when choosing materials and technologies for the restoration of architectural monuments.

#### 4. Features of restoration of historical environment

Restoration of architectural monuments has the following features:

1. The implementation of research and design works (historical and archival, field surveys, measurements, laboratory studies of building materials, etc.).
2. The veracity of the confirmation of original architectural elements based on solid archival and field research.
3. The integrity namely restoration of the architectural composition of the building and its image.
4. The preservation of originally created architectural elements and building structures.

5. The emphasis on the importance of historical heritage, visual disclosure of the creative achievements of ancient masters.

Architectural monuments and historical buildings require special attention as they are in the industrial environment. Among the main factors affecting the building in a modern city can be noted:

1. Polluted atmosphere.
2. Thermal effects.
3. Contaminated groundwater, changing the level of groundwater that leads to the destruction of the foundations of buildings.
4. Dense buildings, accordingly there is insufficient insolation.
5. High noise and vibration from urban land and underground transport, lack of parking spaces.
6. Incorrect reconstruction of the building and as a result – the use of a building with an uncharacteristic function.

These problems should be solved by developing the principles of "green architecture" and by ecological reconstructing historical buildings or restoring architectural monuments. To do this it is necessary to comply with the above principles. There are more restrictions for architectural monuments.

It is possible to preserve the appearance of the architectural monument and at the same time make the building energy efficient by using durable thermal insulation plasters with preservation of decorative elements of the facade. Lightweight thermal insulation architectural mortar of increased durability is developed in paper (Kharitonov and Shangina, 2016).

The roofs of historical buildings are mostly sloping roofs. However, in the

historical part of St. Petersburg there are roofs that can be used for landscaping and recreation areas (Fig. 3).

The roof space is used as a recreation area for excursions on the roofs. Beautiful views from the roofs to the city centre allow relieving emotional fatigue and enjoying the views of St. Petersburg. This is also included in the tasks of urban ecology as a direction of "green architecture". However, the cold climate does not allow doing it in large volumes.



**Fig. 3.** Roofs of historical buildings of St. Petersburg. The view on St. Isaac's Cathedral.

### **5. Analysis of the principles of green architecture acceptable for the conditions of St. Petersburg**

The following main principles can be identified as a result of the analysis of the principles of "green architecture" acceptable for the conditions of St. Petersburg city:

- integration of architecture and landscape;
- landscape design of territories of the contact zone;
- aestheticization of environmentally friendly technologies, structures, materials;
- principles of self-sufficiency;
- environmental design;
- conceptual design.

Ancient architects widely used the principle of "integration of architecture and landscape, introduction of an

architectural object in the landscape and historical buildings" in the construction of architectural monuments of St. Petersburg (Fig. 4).

Another characteristic technique in the principle of "Integration of architecture and landscape" is the use of elements of land and greenings in such a way that they seem to be a constructive part of the three-dimensional composition. This technique is difficult to perform for architectural monuments, and it is difficult to implement for other historical buildings due to the harsh climatic conditions.



**Fig. 4.** View of monuments from the Neva river embankment.

Landscape design of territories of contact zones is creation of the internal gardens isolated from external environment and designed as microcosms of real or assumed environments (Fig. 5). The term of contact zone is understood as the interface area of urban development and landscapes of artificial origin. The development of natural and artificial landscapes in the structure of the city will contribute to both the protection of the environment and the maintenance of mental and physical health of citizens.

Environmental design combines ideas about environmental protection and construction methods of environmental

design as part of the inclusion of an architectural object with the environment.



**Fig. 5.** Inner courtyard in the city center.

Conceptual design is adapted to the conditions of real life. For example, the use of functional planning solutions at the object and urban planning levels can be aimed at reducing the quantity of private cars and promoting public means of transportation. Changing the laws of zoning and pedestrian zones is used in urban planning practice and involves the reconstruction of streets for pedestrian zones to reduce car use and support pedestrian activity (Fig. 6).



**Fig. 6.** Pedestrian zone. Malaya Konyushennaya street.

The principles of self-sufficiency imply autonomy and renewability of life-supporting functions and environmental

safety of the architectural object. Efficient use of energy resources, thermal zoning of architectural objects, expanded use of alternative energy sources (passive solar energy, wind and water energy) as well as the optimization of structural and functional solutions of architecture for local natural, climatic and man-made conditions are techniques that can constitute the principle of self-sufficiency. Solar orientation is the most efficient use of energy, which implies the optimal design and functional structure of the architectural object to capture solar energy and natural sunlight.

Considering the possibility of applying these principles in the construction (including reconstruction or restoration) and improvement of the historical part of the urban areas one can recommend a closed model of the inclusion of the architectural object into historical environment.

The closed model of inclusion of an architectural object in the urban landscape is characterized by increased attention to providing protection from external adverse effects of the urban environment of large cities with high density of buildings. It is characterized by significant isolation of the building from the environment: protection from noise, regulation of microclimatic characteristics of the architectural object (ionization and air temperature, humidity conditions), saturation of the architectural object with elements of artificial nature (recreational areas with internal gardens, fountains and sports grounds). Functional saturation of an individual architectural object or complex is aimed at maximum satisfaction of the needs of the inhabitants and saturation of the object with services. The principle of comfort of

life is achieved in the aspects of infrastructure convenience, psychological relief, aesthetic and environmental well-being.

## 6. Conclusions

The development of the principles of "green architecture" in the historical part of a large city located in harsh climatic conditions such as St. Petersburg is considered in the paper. It is proposed to separate a number of architectural and construction activities, for example, activities acceptable for the reconstruction of historical buildings and activities for the restoration of cultural heritages. The principles of "green architecture" for the historical part of St. Petersburg taking into account the type of architectural and construction works associated with the reconstruction of the historic building or the restoration of the monument of architecture were clarified. Classification of architectural and construction activities in historical buildings was considered.

Thus, as a result of the study conducted in this paper the general approaches of harmonious inclusion of an architectural object in the historical environment taking into account the provisions of the concept of "green architecture" can be formulated as follows: optimization of structural and functional architectural and construction solutions for local natural, climatic and man-made conditions; the use of environmentally friendly building and finishing materials; changing the laws of zoning and pedestrian zones for the reconstruction of streets in pedestrian zones in order to reduce the use of the car and support pedestrian activity; the development of natural and artificial landscapes in the structure of the city to protect the



environment and maintain mental and physical health of citizens.

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**Received:** 15 August 2019 • **Revised:** 9 September 2019 • **Accepted:** 27 September 2019

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