

Use of underground space in creating a comfortable environment of a modern city

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Abstract. The study is devoted to urgent problems of developing the underground space of cities. The article considers urban underground spaces as a reserve of additional area, due to which it is possible to increase comfort and improve the quality of life of people. The issues of lack of free urban land are studied, and the possibility of organizing multilevel, convenient and safe pedestrian-transport communications in the urban environment is also being considered. The innovative approach to solving this issue requires an integrated approach, taking into account the variety of factors affecting the formation of the underground structure of urban space. Based on the theoretical and practical experience in the design and construction of underground structures, the positive and negative sides of the development of the underground space were formulated. The use of underground space in cities demonstrates the possibility of a comprehensive solution to a wide range of urban, economic and environmental problems.

1. Introduction

Urban development is always interconnected with the processes of deformation taking place in society. Currently, we can observe the active growth of urban spaces. They are developing in all directions: peripheral areas are being actively developed, buildings are getting taller, the city is going underground [1]. The intensive development and growth of cities raises a number of social, transport and environmental problems.

The issues of active urban growth are gaining significant relevance throughout the world. This is due to the lack of urban areas for new construction, with rising land prices, high building density and many others. "Horizontal" urban sprawl leads to a separation of places of residence from socially significant cultural objects, an increase in the length of engineering communications, problems in the road transport infrastructure (an increase in the number of vehicles, traffic jams) and, as a result, environmental degradation. The deterioration of the environmental component of cities is directly related to the decrease in the number of green spaces. Usually landscaped urban areas are converted to the needs of vehicles. This fact confirms the relevance of research in the field of urban planning and underground urban studies, engaged in the study and organization of the underground environment[2].

One of the trends in the development of modern cities to improve the current situation is the intensive development of the underground space. The functional use of the underground space must meet a number of requirements: aesthetic, sanitary-hygienic, technical and economic [3]. Active development and integrated use of the underground space should be the "program" for the development of a modern city.



2. Materials and methods

The work uses materials from articles and dissertations to summarize information regarding the organization of underground urban spaces. The main trends and modern approaches to the organization of urban space with developed underground structures are studied. The study revealed that in the modern world the most common location of engineering and transport communications and structures are underground, but if you look at the history, you can find a large number of examples of placing "below ground level" objects for various functional purposes [4].

In ancient times, there were entire underground settlements, the structure of which included engineering communications systems, residential, public and industrial facilities. Examples are the underground cities of Cappadocia, Aydin-tepe and Derinkuyu in Turkey; cave city of Matmata in Tunisia.

During the analysis of historical experience in the design and construction of underground facilities, you can find examples of the use of underground spaces for household needs, such as the Yerebatan Cistern - an underground reservoir in Istanbul. Under the ground you can place not only what you want to hide, "remove from the eyes." Religious underground structures are also quite common. Examples include the underground churches of Lalibela, Ethiopia; a complex of cave temples in India - the caves of Ajanta and Ellora; the five caves of Dambulla that make up the Buddhist Golden Cave Temple, Sri Lanka.

The analysis of the design and construction experience of underground urban spaces revealed two main areas of their formation: horizontal and vertical. The first type implies the development of underground complexes as a horizontal base based on a single transport and communication network that unites aboveground urban spaces [5]. A key factor in the development of such spaces is the inclusion in the structure of multifunctional multilevel pedestrian-transport communications, including quite large ones (railway stations, subways, garages, parking lots, tunnels, expressways, etc.) [6].

As an example of the development of a modern multifunctional underground space, one can consider the PATH complex, Toronto, Canada (Figure 1).



Figure 1. PATH Underground Complex, Toronto, Canada.

This object meets all the trends that have formed in modern urbanism. It is a well-developed network of pedestrian tunnels at 12 levels, which are harmoniously combined with objects of transport infrastructure, including a railway station, metro stations, underground garages and parking lots. This entire developed network of pedestrian transport communications has 125 exits to the surface, it combines land-based residential and office buildings. It is enough to go down from the house or office, and you can move freely in this "city", receiving the necessary social and communal services.

Another interesting example of the active development of the underground space is the "city" La ville (Montreal, Canada). In addition to its developed network of pedestrian transport communications, its structure includes banks, museums, hotels, shopping centers and universities.

One of the leading countries in the development of underground spaces is Japan. The structure of the underground city of Yaesu includes about 250 restaurants, shops and other social services, united by a developed communications network. According to statistical studies, about 8-10 million people

visit Yaesu every month.

The second type is the development of underground space along the vertical axis - the creation of "underground skyscrapers" of various functional purposes, ensuring the autonomous existence of the underground object. The most famous concept of an underground multi-story building - a "scraper", was developed by the engineering bureau BNKR Arquitectura, Mexico (Figure 2). The building was designed in the form of an inverted pyramid with a height of about 300 meters. Of the 65 floors, 30 are planned to be allocated for residential function, and 35 for office premises. Recreational and socio-cultural public spaces are also planned in the building.

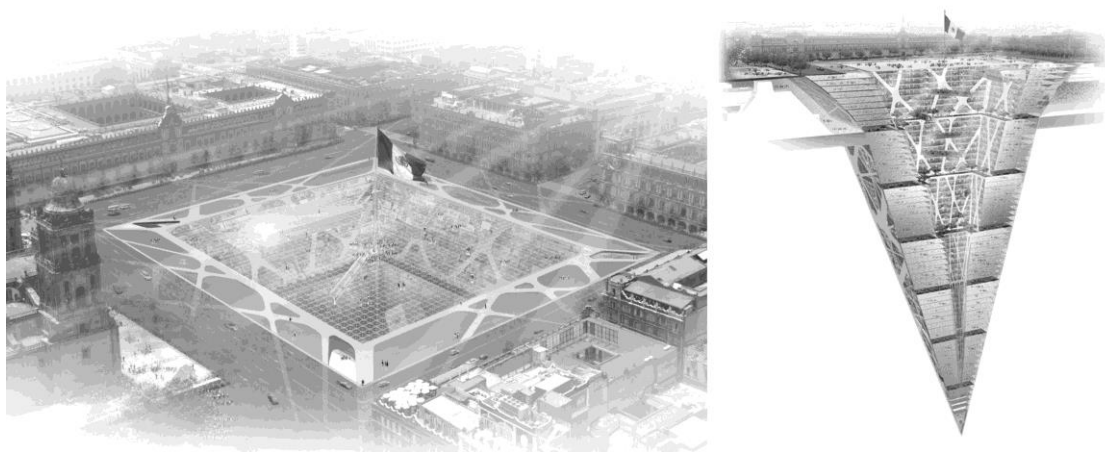


Figure 2. Concept of an underground multi-story building, Mexico

3. Resultse

Why is underground urbanism attractive? There are several aspects that explain the feasibility of developing underground space.

From an urban perspective, this will allow:

- spending urban areas more appropriate;
- compactly locating large objects in the building structure (including historical), without violating the existing nature of the environment;
- increasing the efficiency of utilization of engineering and transport infrastructure facilities (reducing the length of communications and the rational organization of the transport and pedestrian network);
- creating additional recreational areas, recreation places, etc. through the use of vacant spaces.

From an environmental point of view, underground urbanism allows:

- increasing the area of landscaping;
- improving the sanitary and hygienic condition of the city;
- reducing energy costs for the operation of facilities.

The economic effect is achieved:

- improving operational characteristics by providing the soil with natural protection against adverse weather conditions;
- minimizing expenses on facade finishing materials [7, 8].

In addition to the unconditional "advantages" in the development of the underground space, there are a number of significant drawbacks, mainly related to the cost of construction due to more complex architectural, structural and engineering solutions. With underground placement of objects, difficulties may arise with:

- drainage and waterproofing;
- organization of natural lighting of objects;

- ventilation and conditioning device;
- complication of fire extinguishing and evacuation systems [9].

Separately, one should consider the issue associated with the psychological discomfort that occurs in people who are underground. Psychologists noted a negative psychophysiological reaction of people to being underground [10]. At the moment, there are a number of developments that allow leveling the negative psycho-emotional impact, such as:

- competent architectural and planning organization of the internal environment;
- ensuring the maximum possible visual contact of a person with the surrounding terrestrial space (light courtyards, atriums, etc.);
- use of color effects;
- the most effective organization of natural lighting of spaces;
- organization of imitation of natural lighting (light ceilings, screens, etc.);
- the use of man-scaled articulations in space design;
- inclusion of natural elements (living plants, fountains, aquariums, etc.).

When there were negative psychoemotional reactions of people to being in underground structures, in all countries during the sociological research there was an interest in these objects of youth and the attractiveness of these structures for tourists [10].

Existing pros and cons dictate the need for further research in the development of underground space. A multidimensional approach to the study of this problem proves the impossibility of a single solution to the extent of using the underground space and dictates the individual approach to the formation of the underground environment for each settlement. This approach must be considered:

- natural and climatic characteristics of the territory;
- prospects for the growth and development of the city;
- historical and cultural potential;
- architectural and artistic value of the environment;
- existing transport infrastructure.

4. Conclusion

Nowadays in Russia there are no specialized regulatory documents for the design of underground complexes. Each object is unique, requiring special technical conditions for design and operation. There are no government programs that provide an integrated approach to the development of underground space. A serious systematic approach to the development of the underground space of cities is required. This may be a key point in creating a comfortable environment focused on the needs of residents.

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