ВАЖНОСТЬ ИСПОЛЬЗОВАНИЯ ПОДЗЕМНЫХ ПРОСТРАНСТВ В СОЗДАНИИ КОМФОРТНОЙ СРЕДЫ СОВРЕМЕННОГО ГОРОДА

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Аннотация: Растущая тенденция урбанизации во всем мире создает одни и те же проблемы для расширяющихся и вновь развивающихся городов. Рост населения приводит к увеличению спроса на удобную инфраструктуру. Данная статья посвящена актуальным проблемам развития подземного пространства городов, а городские подземные пространства рассматриваются как резерв дополнительного пространства. Инновационный подход к решению этой проблемы требует комплексного подхода, учитывающего многообразие факторов, влияющих на формирование подземной структуры городского пространства. На основе теоретического и практического опыта проектирования и строительства подземных сооружений сформированы положительные и отрицательные стороны развития подземного пространства. Использование подземного пространства в городах показывает возможность комплексного решения широкого спектра градостроительных, экономических и экологических проблем.

Ключевые слова: рациональное использование городских земель, планомерное и комплексное использование подземного пространства, горизонтальных и вертикальных подземных сооружений, инфраструктуры, подземных небоскребов

The importance of using underground spaces in creating a comfortable environment of a modern city

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Annotation. The increasing trend of urbanization throughout the world creates the same problems for expanding and newly developing cities. The increase in population leads to an increase in the demand for convenient infrastructure. This article is devoted to the current problems of the development of the underground space of cities, and urban underground spaces are considered as a reserve of additional space. An innovative approach to solving this problem requires a comprehensive approach, taking into account the diversity of factors affecting the formation of the underground structure of the urban space. Based on the theoretical and practical experience in the design and construction of underground structures, the positive and negative aspects of the development of the underground space were formed. The use of underground space in cities shows the possibility of a comprehensive solution to a wide range of urban planning, economic and environmental problems.

Key words*:* rational use of urban land, systematic and complex use of underground space, horizontal and vertical underground structures, infrastructure, underground skyscrapers.

Urban planning and city construction are always interconnected with the processes of deformation occurring in society. Currently, we can observe the active growth of urban areas. They are developing in all directions: suburbs are actively developing, buildings are growing, the city is going underground [1]. The rapid development and growth of cities gives rise to a number of social, transport and environmental problems.

The issue of urban growth is becoming increasingly important around the world. This is due to the lack of urban space for new construction, rising land prices, high building density, etc. The “horizontal” expansion of the city leads to the separation of residential areas from socially significant cultural objects, an increase in the length of engineering communications, and problems in the road transport infrastructure (increasing the number of vehicles, traffic jams). The

deterioration of the ecological structure of cities is directly related to the decrease in the amount of green space. Typically, developed urban areas are converted for automobile use. This fact confirms the relevance of research in the field of urban planning and underground urbanism, which deals with the study and organization of the underground environment [2]. To improve the current situation, one of the trends in the development of modern cities is the rapid development of underground space. The functional use of underground space must meet a number of requirements: aesthetic, sanitary and hygienic, technical and economic [3]. Active development and integrated use of underground space should become a "program" for the development of a modern city.

Many large urban environments are faced with a lack of infrastructure for transit, distribution of resources, goods and services. In combination with the requirements listed above, the following problems may arise: traffic jams; poor environmental conditions due to noise and air pollution; lack of safety, security and protection from natural disasters and floods; lack of space for work and rest; restrictions on the preservation of the aesthetic qualities and (cultural) heritage of the urban environment; resource distribution, transportation and wastewater treatment, and aging communications infrastructure.

Highway noise and toxic vehicle emissions are recognized as pressing urban problems. Sound barriers can be installed to reduce noise pollution, but the visual impact of such measures is significant. Often, the value of residential real estate near highways decreases due to increased noise levels and vehicle exhaust fumes. There are also health and safety concerns about living next to a freeway. Again, shifting passenger travel from cars to public transport systems can reduce the impact of noise and pollution locally, but using underground environments can also save energy on a larger scale, since public transport systems can generally be more energy efficient . achieved. Alternatively, over the past few decades, many cities have built bypasses and road tunnels to improve traffic conditions and adapt the road network to projected demand. Examples are double-decker tunnels on the

A86 motorway in Paris, large-diameter tunnels on the M30 motorway in Madrid or split-close tunnels on the A10 motorway in Amsterdam (Samuel, 2006; Arnaiz and Bueno , 2009; ZuidAs , 2015). During the 1950s and 1960s, elevated highways were built primarily in a number of US cities such as Boston, Seattle and San Francisco.

Huge high-rise buildings like these that run through downtown areas are now considered unsightly, noisy and possibly dangerous, and provide only limited access to areas adjacent to the freeway. Many developed cities are considering replacing overpasses with urban road tunnels.

An example is the Alaska Highway in Seattle, which once completed will be the largest diameter tunnel in the world (Gatti et al ., 2013). Transitioning from surface roads to underground solutions is often difficult and costly. While the initial decision to build these roads from scratch is often based solely on direct construction costs, decision makers believe that real estate must consider glazing, system life, and long-term stability when making this choice. This will help avoid such unpleasant situations and reduce the cost of urban transport.

Research has shown that the most common location of engineering and transport communications and structures in the modern world is underground, but if we look at history, we can find many examples of the placement of “underground” objects for various functional purposes. [4] In ancient times, there were underground settlements, which included utility systems, residential, public and industrial facilities. For example, the underground cities of Cappadocia, Aydintepe and Derinkuyu in Turkey; Cave city of Matmata in Tunisia. In the process of analyzing historical experience in the design and construction of underground structures, one can find examples of the use of underground spaces for domestic purposes, for example, the Yerebatan cistern - an underground reservoir in Istanbul. Religious underground structures are also very common. Examples include the underground churches of Lalibela , Ethiopia; Complex of cave temples in India - Ajanta and Ellora caves ; Five caves of Dambulla , Sri

Lanka that make up the Buddhist Golden Cave Temple. Analysis of experience in the design and construction of underground urban areas revealed two main directions of their formation: horizontal and vertical. The first type involves the development of underground complexes as a horizontal foundation based on a single transport and communication network connecting above-ground urban spaces [6]. The main factor in the development of such territories is the inclusion of multifunctional multi-level pedestrian and transport communications, including very large ones (stations, subways, garages, parking lots, tunnels, expressways, etc.).

An example of the development of a modern multifunctional underground space can be considered the PATH complex, Toronto, Canada (Fig. 1).

Figure 1. PATH Underground Complex, Toronto, Canada

This object meets all the trends of modern urbanism. This is a developed network of 12-level pedestrian tunnels combined with transport facilities. Infrastructure including train station, metro stations, underground garages and parking lots. This entire developed network of pedestrian and transport communications connects above-ground residential and administrative buildings with 125 exits to the surface.

The second type is the development of underground space along a vertical axis - the creation ensures the autonomous existence of “underground skyscrapers” for various functional purposes. The most famous concept of a multi-story underground building, the “scraper,” was developed by the engineering bureau BNKR Arquitectura , Mexico (Fig. 2). The building is designed in the form of an inverted pyramid about 300 meters high. 30 of the 65 floors are planned to be

allocated for residential buildings, and 35 for office buildings. The building also includes recreational and socio-cultural public spaces.

Rice. 2. Underground high-rise building concept, Mexico

Why is it important to use underground media? There are several aspects that explain the feasibility of developing underground space. From the city's point of view, this embodies and allows:

• rational use of urban areas;

• compact placement of large objects (including historical ones) inside the building without disturbing the existing nature of the environment;

• increase the efficiency of using engineering and transport infrastructure (reducing the length of communications and rational organization of the transport and pedestrian network);

• creation of additional recreation areas, recreation areas, etc. through the use of free space.

From an environmental point of view, underground urbanism allows:

• increase the improvement area;

• improving the sanitary and hygienic condition of the city;

• reduction of energy costs for existing facilities.

Economic efficiency is achieved:

• improvement of operational properties by natural protection of the soil from adverse weather conditions;

• minimizing costs for façade finishing materials [7], [8].

In addition to the obvious “advantages” in the development of underground space, there are a number of important disadvantages, mainly associated with

construction costs due to more complex architectural, structural and engineering solutions. When placing objects underground, the following difficulties may arise:

• drainage and waterproofing;

• organization of natural lighting of objects;

• ventilation and air conditioning device;

• increasing complexity of fire extinguishing and evacuation systems [9].

Separately, we should consider the issue of psychological discomfort that occurs among people underground. Psychologists note a negative psychophysiological reaction of people to being underground [10]. Currently, there are a number of changes that make it possible to neutralize the negative psycho-emotional impact, for example:

• competent architectural and planning organization of the internal environment;

• ensure the maximum possible visual connection between a person and the surrounding above-ground space (light courtyards, atriums, etc.);

• use of color effects;

• the most efficient organization of natural lighting in places;

• the use of human-scale articulations in space design;

• introduction of natural elements (live plants, fountains, aquariums, etc.).

If people experience negative psycho-emotional reactions to staying in underground structures, sociological studies in all countries show interest in these youth facilities and the attractiveness of these structures for tourists [10]. The existing positive and negative aspects require further research in the field of development of underground space. A multifaceted approach to the study of this problem proves the impossibility of a single solution at the level of using underground space and requires an individual approach to the formation of the underground environment for each settlement. This approach should be considered:

• natural and climatic features of the area;

• prospects for growth and development of the city;

• historical and cultural potential;

• architectural and artistic value of the environment;

• existing transport infrastructure.

Currently, in Uzbekistan there are no special regulatory documents on the design of underground complexes. Each facility is unique and requires 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 underground space in cities is required. This can be the main goal in creating a comfortable environment focused on the needs of the population.

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