WAYS OF DEVELOPMENT OF MODERN URBAN ENVIRONMENT IN THE CONTEXT OF APPROPRIATION OF UNDERGROUND SPACES

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Abstract: *Today, in many countries of the world, the appropriation of underground areas is directly related to urban planning and development. If, until now, the subsoil was considered a technical area through which the engineering and technical infrastructures passed, a new task is presented: to develop the principles of functional zoning of the given areas by the master plan of the city, which is considered in the article. The purpose of this article is to develop a method of systematic appropriation of underground areas, which will contribute to the solution of socio-economic problems in the context of urban development. During the research, a study of local and international experience was carried out, on the basis of which an analysis of the situation of underground and above-ground areas was developed in the context of the urban environment, on the example of Yerevan. A methodology was formed based on the principle of effectiveness of the interconnection of the discussed underground and above-ground areas and the application of new volume-spatial approaches.*

Keywords: *Underground spaces, environment, above-ground space, principles of cooperation.*

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Introduction

The congestion of the modern urban environment, especially the center, has led to the fact that in many cities of the world, underground areas have been used. It provides the opportunity to have spaces where infrastructure that serves the population can be located without disrupting the appearance of the above-ground part of the city. By developing the city vertically in several levels underground, these spaces can include transportation networks, tunnels, industrial structures, and various other infrastructures. The use of underground spaces can lead to a series of positive processes, one of which is the reduction of the load on above-ground spaces, as well as the improvement of the local environment and the preservation of green areas. One of the purposes was also to create a method for establishing a connection between public utilities and the transportation system. The experience of underground construction has left behind a controversial legacy of irregular intervention, creating a demand for mastering the interconnectedness of underground and aboveground spaces [1]. It is also necessary to mention the relocation of structures of public significance from aboveground urban spaces to underground areas, which will lead to the replacement of freed spaces with green areas, thereby improving the urban environment.

The specialization of underground spaces has become not just a goal but a necessity and a problem in modern major cities. This is explained by both the growth of urbanization and also by the negative effects of the intense expansion of cities, which leads to inadequate maintenance of infrastructure. Underground spaces require various means for construction, but for the urban environment, they represent the most rational solutions.

Studies show that if the service life of above-ground structures is 100 years, then the service life of underground structures is longer, for example, for tunnels it is 500 years. As it is known, the first underground power plants were built in Germany in 1907, and then in 1910 they were built in Sweden. Moreover, an underground factory was built in Germany in 1917, serving as both an environment and structure for underground structures [2]. During the Second World War, in order to ensure safety, factories, power plants, food, equipment and fuel warehouses, as well as vaults for the preservation of cultural values, etc., were located

in the underground areas. Already in the 50s, underground industrial organizations were operating in 50 countries of the world. In the 70s, there were almost 450 underground facilities in NATO countries alone. In the 80s, their number increased 3 times [3]. Studies related to the field were carried out by J.Carmody, R.Sterling, which were based on the systematic observation of urban surface and underground areas, taking into account their interconnections, the transport system, possible risks and environmental impact limits [4]. These areas serve as environments for underground structures and, at the same time, essential parts of urban territory. According to some studies, in the case of certain underground structures, depending on the depth of the structure, the construction materials and energy can be saved [5]. Special attention is being paid to energy efficiency worldwide. The experience of developing underground spaces shows successful economic utilization of energy and heat. Studies show that this activity is highlighted as a main prerequisite for using underground space.

Urbanists and architects in their still theoretical research are inclined towards underground cities. For example, researchers M.E. Bazilevich and N.E. Kozyrenko at the twelfth international scientific conference of the Faculty of Architecture and Design of the Pacific State University in Khabarovsk said literally the following: "The image of the underground in the minds of people gradually transformed, following the changes that took place in science and culture in different historical eras. Previously, the underworld, perceived as the kingdom of death and the underworld, today has practically lost its sacred meaning and acts as a field for the development of new computer and construction technologies. The most current and promising direction in this area is the construction of underground cities. The image of the underground city has clearly formed in the public consciousness and reflects the socio-cultural, scientific and technical levels of development of modern society. The conducted comparative analysis shows the similarity of most of the components and properties of the images of the above-ground and underground cities. The identified inconsistencies are due only to differences in planning schemes and the specifics of underground construction" [6]. Thus, research by specialists confirms that in the minds of people (consumers, users) the readiness to perceive the benefits of underground space has matured.

The experience of utilizing underground construction shows that there are three fields in the use of underground spaces: technical, legal, and psychological [7]. According to conducted analyses, the technical issue includes solutions related to underground water drainage, ventilation, water supply, and air exchange systems. The legal issue is particularly relevant to the United States and those countries where, historically, land ownership also includes the rights to the underground space. The psychological issue refers to people's subjective opinion that the conditions in underground spaces cannot match the specific environmental conditions of above-ground spaces.

Materials and Methods

It is known that the exploration and utilization of underground spaces are conditioned by the following factors:

- Preservation and restoration of historically formed urban structures,
- Supplementing urban vacant spaces with underground spaces,
- Relief and division of urban transport flows,
- Future development of cultural, residential, and communal service systems,
- Improvement of transport routes of different social significance,
- Development of the city's engineering, communal, and warehouse economy [8].

The research methodology includes a complex approach to the discussed problem, a study of professional literature, as well as a comparative and situational analysis of underground and surface areas. As is known, the functional zoning of a space is determined by the main development strategy of the city. Indeed, the functional zones of above-ground spaces can include various categories such as social, commercial, residential, recreational, industrial, and communal, as well as engineering, transportation infrastructure, agricultural, and other types of functional zones. These diverse zones are integral to the overall development and functioning

of the city. The functional zoning of underground spaces is based on the typologies of underground zoning. For this reason, to implement the functional zoning of underground spaces, it is necessary to develop a typology that will correspond to the city's above-ground zones in the future. The decision to place this or that underground structure is made depending on the conditions and type of the service network's development, the functional zoning of the living area, and the structure of the transportation network, taking into account the types of streets and roads, also including geological and ecological conditions [9].

It is also proposed to place shelters for self-defense in underground areas, vehicle and rear tunnels, metro stations, and train stations. The mentioned objects can be significant by their purpose:

- monofunctional, multifunctional,
- placed separately or attached,
- shallow and deeply embedded (-15m) or below (-15m) [10].

The proposed method can become an essential factor in the formation of main outlines during the phase of urban planning document development. Aboveground spaces, relieved of transportation means, can become green zones, expanding into circular parks and connecting the green segments of the city with each other. The proposed methodology has a unique significance for the city of Yerevan, as until today, this issue has not received the appropriate attention. From the experience studied in many countries, it can be concluded that when constructing underground spaces, it is necessary to maintain the sequence of functional zones, ensuring the connection between aboveground and underground spaces.

Results and Discussion

As a result of the analysis, a method for the integrated ownership of the city's underground and aboveground areas has been formulated, which includes the following types: engineering and transportation structures, commercial and public food places, administrative, entertainment, and sports facilities, engineering equipment objects and networks. There are the following concepts: "functional zoning" and "territorial zoning", which are the main elements in the urban planning process [11]. As is known, functional zoning is defined by the master plan, providing the future development plan of the city, and territorial zoning is defined by development and land use legislation. In practice, to this day, functional and territorial zoning in RA has not been specified, because the appropriate toolkits for exploitation and complex appropriation of underground areas have not been developed.

The main processes, which are used in developed countries, are regional zoning according to functional significance, presented in the following classification:

- Special purpose (defense objects),
- Engineering – communications,
- Infrastructures, transport,
- Multifunctional public facilities,
- Recreational [12].

The principle of interconnectivity formed based on the typology methodology of underground and aboveground areas allows the implementing of urban environment improvement programs in a multifaceted and integrated manner, which are based on the application of the main functions of urban management. The developed methodology will allow for the efficient implementation of functional management processes of underground and aboveground structures, ensuring convenient integration with the transportation system and effective resolution of existing socio-economic issues in the city, thereby improving the surrounding environment.

The schematic below (Fig.) presents the method of typology of underground zones of the city, based on the results of comparative analysis and generalization of the theoretical foundations of underground construction. Their connection with the existing functional zoning of the above-ground part will also be ensured.

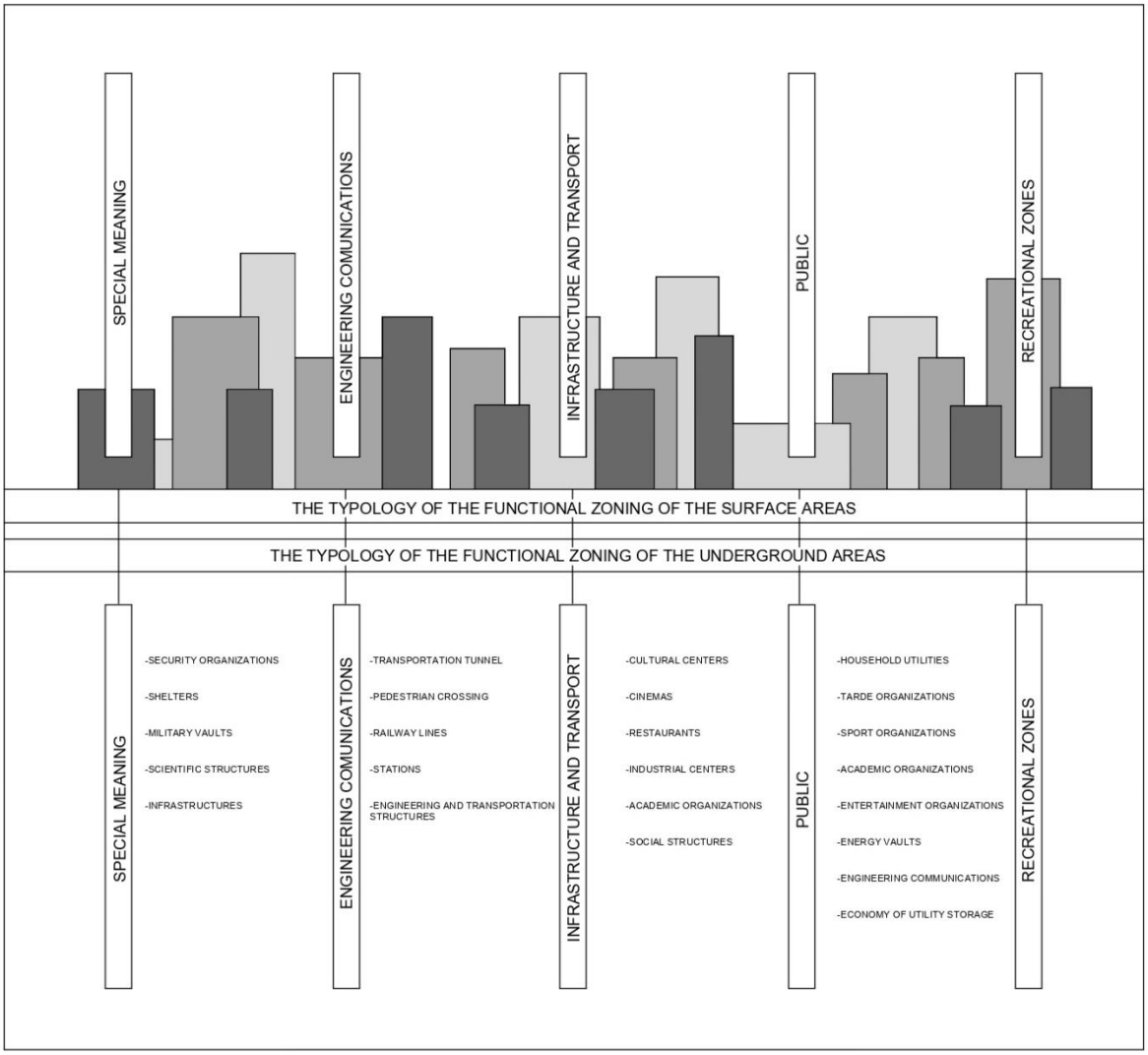

Fig. *Schematic of the integrated ownership method for underground and aboveground spaces*

The typology has been formulated following the functional purpose of the underground space. It should be applied in the development of urban planning documents in the phase of forming the main outlines for the development of cities. The above-described methodology of spatial planning is proposed for application in the development of multifunctional public underground areas of Yerevan city as part of the functional zoning of underground spaces. The suggested problem for the city of Yerevan has a significant meaning, however, until today, there was very little consideration of that issue.

From the experience of various countries, it can be inferred that every city, with its unique characteristics, can undertake the construction of underground spaces and implement the construction of functional zones in a necessary sequence [13]. The primary issue for Yerevan city is the creation of transportation and rear paths in underground spaces, connecting them with the aboveground transportation network. The next phase may involve the development of structures around them, such as commercial, administrative, communal, industrial, and engineering-technical function buildings.

Conclusion

For the construction, erection, and organization of underground spaces, certain principles are distinguished, including that all structures must present themselves as part of a unified spatial-temporal system, which will have a more complex zoning in conjunction with aboveground buildings. Their interrelations within the space must be carried out by identifying existing obstacles, taking into account geographical and geological conditions.

Including underground spaces in urban spatial planning creates a new system of complex utilization and usage opportunities, allowing the city's development in a vertical direction, limiting extensive expansion horizontally.

Placing transportation means in underground spaces will relieve the population from transportation noise and many other inconveniences.

An analysis of methodological developments in the theory of underground urban planning shows the absence of a unified systematic approach; existing studies are of a private nature. To achieve the greatest total (social, urban planning and economic) effect from the development of urban underground space, it is necessary to summarize theoretical developments, agree on the typology of underground and above-ground space objects, and also implement further work on the development of the proposed methodology with the identification of functional zones of the urban environment. The effectiveness of solutions for the development of underground space contained in urban planning documentation directly depends on the development of the theory of underground urbanism. Consequently, at present in Armenia there is an acute issue of the formation of scientific methods for planning the underground territory of cities.

Based on the methodology, the functional zoning of the underground areas was carried out, based on the proposed typology, which will be interconnected with the above-ground zones of the city of Yerevan. The presented study can serve as a basis for the present and future of the city of Yerevan, providing a reliable and safe environment for the population, making the city more comfortable and profitable.

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