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UNDERGROUND AS AN INTEGRAL PART OF THE CONTEMPORARY CITY: FUNCTIONAL, SPATIAL AND VISUAL ASPECTS

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Abstract: The use of underground space creates new opportunities for contemporary cities. Underground becomes a promising location for specific technical and industrial facilities, as well as public buildings designated for recreational, commercial and cultural purposes. Due to the growing number of subterranean buildings and increasing human activity below the ground level, it is a challenge for many contemporary cities to integrate the newly emerging facilities with the existing urban structure. This paper presents review of planning and architectural approaches to an effective underground space design. The analysis of so far experience of various cities around the world shows that the functional, spatial or visual integration can contribute towards improving the quality of the urban environment as well as enhancing users' comfort. Among the factors determining the success of the contemporary underground facilities there are both the selection of the functional program and location in the urban structure as well as the detailed design solutions. During the design process the fundamental problems related to integration should be therefore addressed simultaneously at several dimensions – at the city dimension, at the district and close neighbourhood dimension, at a given facility, and sometimes even at individual space.

Keywords: integration, underground space, architecture, urban planning.

Introduction

The rapid urbanization and densification of the cities are among the major global problems. Today, almost 4 billion people live in the cities and by 2050 the number is expected to rise to nearly 7 billion [14]. The process of the global urbanization is developing rapidly and contemporary cities need to learn how to cope with this challenge. For many congested urban environments the underground space planning becomes a promising resource in this respect. Space below the ground level is perceived as an additional spatial and service layer of the contemporary city [1]. Increasingly, it also becomes a promising environment for situating public use buildings designated for transportation and commercial functions or recreational and cultural purposes. Due to the growing number of buildings and the increasing human activity, taking place underground, the integration of the subterranean level with the existing aboveground urban fabric is crucial for further and sustainable development of cities.

The aim of this study is to identify a set of potential solutions that affect the assimilation of the underground layer with the urban fabric. The research focuses on the review and the analysis of the existing planning and architectural approaches to the development of contemporary underground facilities. It provides an in-depth literature review and description of local visions of several underground buildings. First, the paper uncovers key aspects of physical characteristics of underground spaces pointing at the complexity of the discussed problem. Second, specific aspects of integration are described in detail.

Underground space design

Underground facilities that constitute the subterranean layer of contemporary cites can be divided into two fundamental groups that distinguish between the groups of uses they target: 1) product-oriented uses and 2) people-oriented uses [6].

Facilities designated for product-oriented uses include mainly infrastructural facilities, storage, parking or industrial buildings. These facilities are mostly physically and visually isolated from above ground urban tissue. From the functional point of view they, however, constitute an important part of the city, supporting the performance of the whole urban structure. Buildings such as rock caverns or road and waste water tunnels have a potential to improve urban development by reducing air pollution and facilitating mobility. Placing such structures underground has several advantages such as protection from noise or vibration, limited visual impact or preservation the land surface for uses requiring above ground environment.

The second category of underground facilities that refers to people-oriented buildings includes mostly buildings used for leisure and recreational purposes, exhibition, culture, commercial and public transport facilities. These buildings often constitute an important part of the urban public space. Some of these facilities, for example metro stations, attract hundreds of users every day and increasingly perform as an urban activity nodes [11]. Due to the high human activity, people-oriented buildings require special design. For them, in contrast to the product-oriented structures, spatial and visual isolation becomes a significant drawback. The most negative consequence of the use of underground facilities for non-service functions is probably the strong discomfort that the majority of the population expresses under the ground level. The isolation causes the loss of connection with the natural environment and separation from the external conditions, including weather and - most importantly - sunlight. The lack of a direct view of the outdoors causes a feeling of disorientation and sense of entrapment. Carmody and Sterling [6, 7] argue that the negative effects are all related to one of the three basic physical characteristics of the underground facilities: 1) lack of visibility from the exterior; 2) lack of windows; 3) being underground. They also claim that the degree of the integration can be one of the mitigating factors for reducing the negative reactions [7].

Thus, in the planning and design process of underground facilities it is especially important to pay attention to creating a pleasant and healthy environment, both underground and above the ground level. Well designed, integrated places can enhance human's well-being in the underground space. On the other hand, an effective planning of subterranean utilities can contribute to creating more sustainable and liveable cities. In the next sections, in order to illustrate specific planning and design strategies affecting the assimilation of the underground layer, the integration will be analysed by looking at its functional, spatial and visual aspects.

Functional integration

One of the key factors determining the development of the contemporary city is the effective planning of land utilization. During the planning process, all urban problems as well as the potential benefits and drawbacks of the new construction have to be considered and implemented into the long-term development strategy. Due to the increasing role of cities' underground layers in their further growth, there is, however, a need to rethink the traditional urban planning techniques [13, 17]. The traditional approach is based on two-dimensional space perspective that is limited to 1) the surface and 2) aboveground development. However, one should be aware that the contemporary urban space is three-dimensional, consisting of the ones mentioned above as well as the underground part. For the effective urban planning, it is therefore essential to arrange functional deployment integrating both, the surface and underground space.

A successful implementation of the three-dimensional perspective could be achieved by incorporating the master or sectorial plans focusing on the underground development into the ongoing urban planning policy. One of the best examples with this respect is the city of Helsinki in Finland, which is the first city in the world that has developed the Underground Master Plan for the whole municipal area. The plan provides the framework for managing and controlling city's underground construction work and allows for choosing suitable locations for underground facilities [15]. It also describes space allocation for long-term investments projects (such as traffic tunnels), the existing underground facilities as well as the reserved rock resources for unclassified future use (Fig. 1). The Underground Master and Sectorial Plans are also introduced in smaller cities such as Arnhem (Netherlands) as well as in the big metropolises like Hong Kong, Singapore, Shanghai or Beijing (China) [3, 8].

The three-dimensional approach allows for sustainable development of the city and enhances overall safety and economic efficiency. The underground space planning enables the vertical expansion of the urban structure and can become a powerful tool for preventing dangerous processes associated with high density, urban sprawl or stagnation in the development of city centres that contemporary cities have to deal with. The important obstacle on the way to an effective and integrated urban planning is, however, the diversity and mixing of space uses [12]. Underground corridor that contains commercial and industrial space unburdens the surface, which can be then used for housing, recreation and open space. On the other hand, existing densely built urban areas, containing above ground transport and technical facilities, can be diversified by underground buildings designated for social functions. The best illustration in that respect is the design of the *Lowline* in New York City. The aim of this project was to revitalize the old underground car depot located in the high density area in Manhattan. The abandoned facility is currently being changed to the first world's underground public garden (Fig. 2). Despite the fact that the project concerns the transformation of the already existing underground space, it perfectly illustrates the concept of an effective functional integration.

Spatial integration

To become an integral part of the city, underground layer requires not only functional relationship with the surface, but also physical connections with the above – on the ground – life. Physical connection of spaces is the most effective way of their integration, which similarly to the functional deployment, requires the decisions to be made at the very early stage of the design process [18]. The spatial integration is directly influenced by the location and the function of the facility. It is extremely important particularly for the people-oriented buildings.

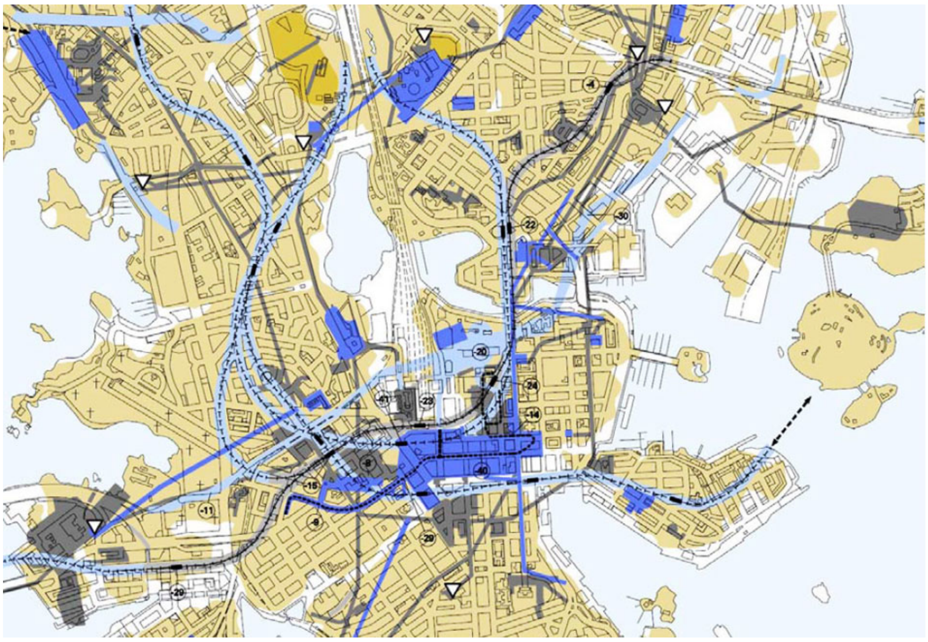

Fig. 1. Extract of the Helsinki Underground Master Plan. Light blue – routes reserved for new tunnels; dark blue – areas reserved for future investments; grey – existing tunnels and underground facilities; dark brown – areas reserved for future use (not designated); light brown – rock surface located in the distance of less than 10 m from the ground level (Source: Helsinki City Planning Department).

Fig. 2. The *Lowline* project: transformation of abandoned underground space in Manhattan, New York [19]

One of the design patterns, enhancing the integration, is to incorporate the underground space into the widely understood aboveground urban public space. As the underground encourages the creation of recessed areas, the public space can be formed directly in front of the entrance to the facility. Entrance zone can take a form of, for example, a sunken square or recessed green courtyard connected to the upper level by stairs and ramps. The former can be found in front of the metro station *Les Halles* in Paris (France) or the metro station *Centum* in Warsaw (Poland) (Fig. 3). The entrances designed in this way allow for easy, horizontal access to the facility, which can contribute towards reducing the negative feelings associated with being underground [7]. The public spaces created by the entrance zones, can also enhance the integration of the underground facility into the urban structure. They often perform as a representative part of the urban space, serve as meeting points and provide venues for outdoor cultural activities. As a result, this design strategy can literally 'open up' the underground for the social life. It is, however, associated with a substantial interference with the urban structure and therefore it is not always possible to implement.

Fig. 3. Sunken courtyard in front of the entrance to the metro station *Centrum*, Warsaw (Photo: Katarzyna Jasińska)

For the majority of the underground facilities direct and vertical entrance is primary, and sometimes the only place, where the connection with the surface can be made. The design strategy enhancing integration of the subterranean facility with the existing urban structure aims at combining the both layers through the common entrance zone inside the aboveground building. This type of design solution is mostly implemented in the densely built areas, which increases the efficiency and concentration of the urban space. In Montreal (Canada) for example, all access points to the underground are placed in the public area in office buildings, hotels or shops. Such an idea is meant to increase overall safety (the entrances are better controlled), facilitate maintenance (the entrance zone is a private property), and to a large extent reduce the negative psychological effects [9].

The combination of above and underground facilities can also contribute to the development of underground multifunctional large-size structures that are connected with urban surface in many places. In several cities, on the basis of metro network there are formed underground corridors that integrate stations with the remaining under- and above-ground buildings. This type of structure has particularly grown in Montreal's downtown area [5] or in Toronto, where the underground is formed by over 30 km of underpasses that together with the associated structures form the largest shopping mall in the world [2]. The *Downtown Toronto's Underground Pedestrian Walkway,* usually referred to as PATH, consists of nine metro stations connected by pedestrian network, which is located below the public use buildings (Fig. 4). The underground passages are surrounded by shops, restaurants and other types of services. The networks consist of nodes (lying under the buildings) and lines connecting the above and underground facilities. The system constitutes well-organized spatial structure, which links the main points around the city. Numerous connections between the surface and subterranean levels allow also for the use of both spaces. In consequence, the underground layer remains well integrated with the city fabric and aboveground facilities. The comprehensive underground systems work effectively especially in the countries with severe climate [16]. Nevertheless, such structures can be found in the downtown areas of several world's mega cities, e.g.: Atlanta, Chicago, New York, Philadelphia (USA); Edmonton (Canada); Tokyo (Japan); Beijing, Shanghai, Hong Kong (China) and Moscow (Russia). As for Europe, a good example of such structure is the Alexanderplatz, one of the largest communication hubs of Berlin (Germany). It consists of a railway station, and several metro and tram lines integrated to the commercial zone of the underground complex and numerous above ground public use buildings [4].

Visual integration

Apart from the direct communication links, the relationship between the urban environment and underground layer can be also established through the visual connectivity. It is mainly related to the provision of the exterior view and the introduction of daylight. The visual connectivity can reduce the sense of entrapment and sometimes can contribute to a better spatial orientation. To large extent, the integration depends on the shape and depth of individual facility. Similar to spatial integration, visual integration is essential for the people-oriented buildings.

In the case of shallow buildings, the visual integration can be achieved through spacious, well-illuminated entrance zone. For deeper buildings, such as for example metro stations[1], the design solution, which allows for visual integration includes large-size glass roofs that

[1] Metro stations can be situated even 50 m underground, in contrast to other people-oriented buildings, which usually are not located deeper that 10 m below the ground level [10].

bring in daylight to the lower floors of the facility. Excellent example is the metro station *Canary Wharf* in London (UK), designed by Foster & Partners, where concourse halls and parts of the platforms are illuminated through a giant glass dome created above the entrance to the station (Fig. 5). Less spectacular, but also notable design solution, which keeps visual relationship with the exterior world in the deeper parts of the building, is the creation of internal atriums or skylights. The glass panels in the roof of the platforms at the *Alameda* station in Valencia (Spain), designed by Santiago Calatrava, can serve as very good example (Fig. 6). The incoming daylight brings dynamics to the interior and contributes to the creation of interesting, and sometimes even spectacular architectural impression.

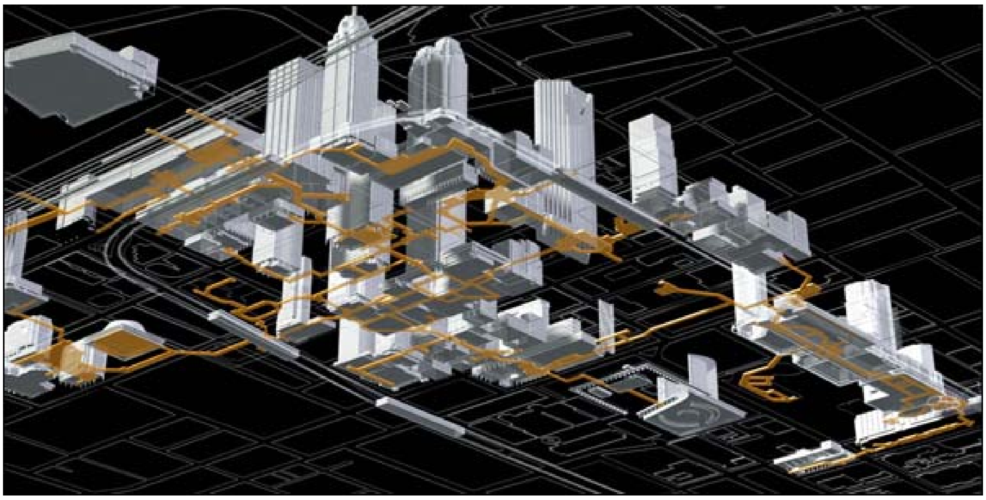

Fig. 4. System of underground paths and nodes, *PATH*, Toronto [20]

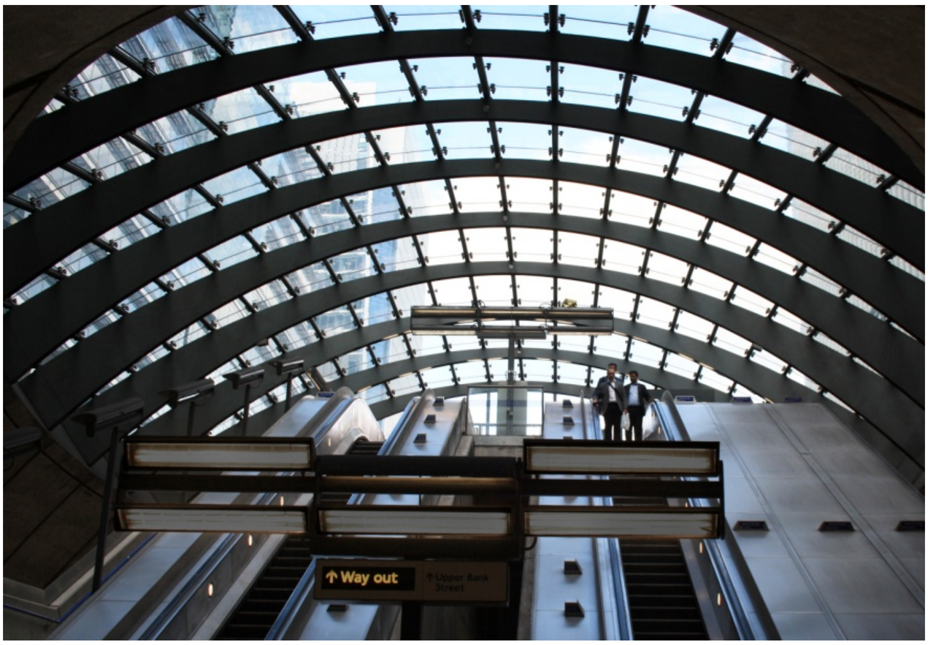

Fig. 5. The glass roof covering the entrance to the metro station *Canary Wharf*, London (Photo: Katarzyna Jasińska).

Fig. 6. Skylights in the roof of metro station *Alameda*, Valencia (Photo: Katarzyna Jasińska).

Conclusions

Urban underground space plays a crucial role in creating cities that are able to cope with today's global challenges. However, in order to use the potential of subterranean location there is a need to perceive and understand the underground not as an isolated layer, but as an integral part of the contemporary city. Functionally integrated underground space can contribute to cities' further sustainable development and lead to the creation of more liveable and friendly urban environment. On the other hand well designed, spatially and visually connected places can facilitate human's well-being below the ground level.

The successful assimilation of undergrounds with the urban structure depends heavily on the function, location, shape and depth as well as architectural solutions of the individual facility. In order to provide healthy and friendly environment all those factors should be taken into account during the design process. It is essential that during the design process the designers consider simultaneously several aspects: the city, the district and close neighbourhood, the given facility and sometimes even individual space.

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