

Development Strategy for Urban Underground Space Planning in China

Zhu Hehua¹, Luo Xiao^{2,3}, Peng Fangle¹, Li Xiaojun¹, Liu Chunyan⁴

1. College of Civil Engineering, Tongji University, Shanghai 200092, China
2. College of Transportation Engineering, Tongji University, Shanghai 201804, China
3. Shanghai Tongji Urban Planning & Design Institute, Shanghai 200092, China
4. Law School of Tongji University, Shanghai 200092, China

Abstract: This paper reviews history and events related to urban underground space (UUS) exploitation in the world, while focusing on its status, achievements, and utilization in China. Further, development strategies are proposed for UUS issues that need to be resolved urgently, including: ① coordinating UUS and urban planning, and realizing synergetic planning between surface space and UUS; ② refining policies and laws based on Chinas national conditions, and completing both the management mechanism and legal system for UUS utilization; and ③ formulating an information platform for UUS, improving the efficiency of using big data, and eliminating the information isolation phenomenon. Finally, with the development of urbanization and information technologies, UUS utilization is poised for an exciting future.

Keywords: urban underground space planning; development and utilization; development strategy; space resources; legislation

Rapid economic growth and accelerated urbanization as the “reform and opening-up” has increased the number and scale of Chinese cities in a very short time. This has introduced multiple “urban malaise,” including: over-saturation of urban populations, traffic congestion, crowded spaces, reduced green areas, air and water pollution, inferior urban environment quality, and reduced ability to cope with disaster situations. Efficient utilization of urban underground space is one method of solving “urban malaise,” and also plays a critical role in sustainable urban development.

1 Significance, current situation, and problems of underground space development

1.1 Significance of underground space development

Underground transport systems are an integral component of

urban underground space (USS). Developing urban railway systems could facilitate green transport, lower transport energy consumption, improve urban form, and improve land use efficiency. Underground transport and parking systems could increase the capacity of urban transport systems, therefore ensuring efficient operation without occupying ground space. Underground corridors could save space by integrating facilities, thereby reducing the operation, maintenance, and renewal costs of urban pipeline facilities. This would further improve the urban environment and quality of life for residents. Moreover, developing urban underground space complexes would expand living space, and upgrade urban development from two-dimensions to three-dimensions.

Urban underground space development could follow the 13th Five-Year Plan of China: appropriately develop urban underground spaces to optimize urban spatial structure, enhance its

Received date: November 18, 2017; **Revised date:** December 20, 2017

Corresponding author: Luo Xiao, Tongji University, Associate Professor. Major research field is application of big data technology in urban planning and traffic planning. E-mail: luo.xiao@tongji.edu.cn

Funding program: CAE Advisory Project “Development Strategy for Urban Underground Space Planning in China” (2015-XZ-16); National Natural Science Foundation of China (Youth Program) “Quality Assessment of Participatory Living Environment Driven by Big Data Based on Residents’ Life Perception” (51708414); Shanghai Youth Sailing Talent Program “Research on Urban Built-up Environment Evaluation Based on Mobile Phone Signaling Data” (16YF1410900)

Chinese version: Strategic Study of CAE 2017, 19(6): 012–017

Cited item: Zhu Hehua et al. Development Strategy on Urban Underground Space Planning in China. *Strategic Study of CAE*, <https://doi.org/10.15302/J-SSCAE-2017.06.003>

relationship with ground space, and promote co-development with the entire city. Underground space development could help realize the internal promotion of a city, improve urban environments, build livable cities, and raise urban comprehensive carrying capacity.

1.2 Current situation of underground space development

According to the demand of different urban development stages, urban underground space could be divided into three need periods: municipal functional (focusing on municipal fundamental pipeline construction), transport functional (focusing on underground transport, municipal and disaster-prevention facilities, and highlighting the concept of an underground complex), and environmental and deepening (focusing on integrating underground and ground spaces, and improving environment quality). Thus far most of mid- and small-sized Chinese cities have advanced their exploitation of underground space into the period of municipal infrastructure functional need. Some large- and mid-sized cities have reached the period of railway-transport functional need. Further, several mega cities have entered the period of environmental and deepening need, to seek harmony between humans and nature.

1.3 Problems in underground space development

The size and speed of developing urban underground space in China are among the top in the world. However, we are still noticeably falling behind developed countries in underground space planning, specific policy, regulations, technical standards, and informatization.

Urban underground space planning lacks comprehensive and integrated methods to realize holistic planning, coordinated construction, and standardization. The design and planning of underground space fails to attract sufficient attention from government, and it is not included in the overall master plan of many cities. Furthermore, the planning of underground space in many places remains at the conceptual stage, and rarely materializes into practical application. Only several cities have included city-wide underground space planning, but there is no consistent understanding or standards in planning content, depth, and methods. Therefore, the situation “construction first and coordination later” is often complained about in practice.

Regarding the regulations: first, there are no authoritative national laws; second, the basis of ownership issues remains unsolved; third, there are no specific technical standards; fourth, there is no provision of a specific beneficial policy for underground space development [1]. Among all the major cities in China, there are few specific policies designed for underground space development. For existing policies, some governmental regulations only highlight principles, but with poor feasibility.

Informatization also appears to be weak: first, there is no in-

formation management administration, and underground space information data (and resources) only serve their own businesses and services. There is no integrated information; second, there is no consistency in standard information systems. Each professional division has their own understanding of underground space development range, exploitation form, and standardization of construction; third, the information resources are not shared. Overall the collection of underground space information involves multiple divisions, various complex data formats, and different standards and technologies. These difficulties have obstructed the practical sharing of underground space information.

2 History of underground space planning at home and abroad

2.1 Development journey of underground space abroad

In general terms, the development of underground spaces abroad was accompanied by the process of urbanization. Underground space construction evolved from single large buildings to underground complexes. This further developed into underground cities or other advanced underground space forms, which play a significant role in urban renewal. Moreover, underground municipal facilities have evolved from single water supply and drainage schemes to more advanced installations, with underground water supply systems, underground energy supply systems, and underground corridors. Regardless of the space environment quality, municipal service levels or the management and operation level of the underground building has reached a high level.

2.2 Underground space planning and management abroad

2.2.1 Current situation of underground space planning abroad

Developed countries in the western world do not usually have any comprehensive underground space development plan, and the development of urban underground spaces relies on specific planning or urban design.

(1) The utilization of underground spaces in Japan started with metros and underground streets. Public underground spaces in Japan (commercial and pedestrian streets) consistently apply ground architectural elements such as microcirculation, lighting design, and landscaping. Furthermore, municipal underground spaces (parking, shared ditches, underground water, and underground steam power plants) play a significant role in healthy urban metabolism.

(2) European exploration of underground space planning started in the north in the 1970s. Sweden proposed that underground space planning needed to consider various economic, technical, and management factors [2]. Britain, France, Germany, and some other countries were all engaged in efficient utilization of underground space resources, in an attempt to protect the urban environment and solve the issues of urban traffic and

disaster prevention. In the early 1990s, Paris had a conceptual plan for the development of a ring road in urban underground space, and Finland completed the Helsinki underground space master plan in 2010 [3].

(3) Early cases of underground space development in the U.S. were in Kansas, Louisville, and Minneapolis. The underground space in these cities is mainly focused on the re-utilization of mining space [4]. Montreal and Toronto (Canada) organically built underground streets and metro stations. These are connected via an underground network to the basements of neighboring buildings, allowing pedestrians to overcome bad weather and create comfortable living environments [5].

2.2.2 Current situation of underground space management abroad

Though developed countries are ruled by different legal systems and traditions, for management they are gradually making and improving related administrative regulations and technical standards. This is based on experience of how to improve the utilization of underground space resources, and the correct and efficient allocation of limited resources. They have thereby built up a legal system with distinct characteristics of urban underground space utilization.

(1) The Japanese national congress and governmental institutes (of all parties) play an important role in the development of underground space. They consulted all the social power networks, including professional committees and scientific research institutes. The organizational structure is strongly professional, with specific work distribution and a clear decision-making flow. This forms an underground decision-making system consisting of the National Congress, government, and the general public [6].

(2) In the major cities of Europe and America, railway transport planning and construction is a key aspect of the comprehensive and integrated underground space development program. Further, the construction and operation of transport management systems facilitate the formation of urban underground space development management systems [7]. In the U.S. the urban public underground space facilities (and planning construction management) are under the administration of the Federal Transport Department; In Britain urban public underground space facilities and planning construction management are administered by the British Ministry. The public underground space facilities and planning construction in Germany are under an “entrusted contract” between local governments. In France, the urban underground space utilization and update of city centers is handled by the société d’économie mixte (SEM).

2.3 Evolution process of urban underground space in China

2.3.1 History of domestic underground space

Urban underground space development and planning has experienced the following periods [8]:

(1) Civil air defense project development period (1950–1977): Because of the global situation, the movement of “deep digging, large hoarding” swept through China. However, the construction quality was poor and the effect was disappointing due to the lack of sufficient standards and technologies.

(2) Peace and wartime combination period (1978–1987): the third national defense meeting was held in 1978, and proposed the idea of “peace and wartime combination.” This idea was the guideline for underground space development in this period.

(3) Combination with urban construction period (1987–1997): After the “National Defense Construction and Urban Construction Conference,” the main direction for the underground space development was to be further deepened “to improve the comprehensive benefit of urban development.”

(4) Orderly development period (1998–present day): With the publication of the *Urban Underground Space Development and Utilization Management Regulations* in 1997, urban underground space planning has been recognized as an important aspect of urban planning. Specific planning should be based on two themes: the importance of urban development, and research on the preparation of urban underground space development and utilization plans. To meet the needs of new-type urbanization and social development in modern cities, the construction of underground utility tunnels has been an important aspect of improving urban infrastructure in recent years. The government has actively promoted the construction of underground utility tunnels. By the end of 2016, a total of 43 cities had been approved by the National Development and Reform Commission for the construction of metro system. In 2016 the government successively introduced policies related to the development and utilization of underground space, such as the *Note from Ministry of Housing and Urban-Rural Development on the Development and Utilization of Urban Underground Space Based on 13th Five-Year Plan*, and the *State Council Guidelines for Promoting the Construction of Sponge City* [8].

2.3.2 Relevant cases

Many cities in China, such as Beijing, Shenzhen, Xiamen, Shenyang, Bengbu, Qingdao, Tongren, and Luoyang have already produced master plans for the utilization of underground spaces. Moreover, they have integrated these underground space plans into a master plan for the whole city. Excepting a master plan of the whole city, some cities have conducted special studies on underground space planning, such as the Guiyang Urban Underground Space Development Planning Study (2008), and the Hangzhou Urban Underground Space Utilization Special Planning Study (2012).

3 Problems in (and Prospects of) planning and development of underground space in China

With the rapid development of social economy and the ac-

celeration of urbanization, more people are gathering in cities. Therefore population aggregation is rapidly increasing, together with the demand for mobility. For these reasons the planning and development of underground space resources in China is experiencing rapid development. Underground space planning and development is already proceeding at an accelerated rate particularly with the burgeoning populations of mega cities. In addition, with the technology development of big data, social development demands infrastructural connections and integrated management. Consequently, how to effectively improve the level of comprehensive development and management of underground space in China has become an urgent issue.

From the perspective of the direction taken by underground space use, construction of civil air defenses were the main focus in the initial stages, and then gradually integrated with urban renewal and urban construction [9]. With regard to the use and management of existing underground space, there are the following problems:

First, the property rights of underground space is confused [10]. The determination of underground space rights are without any basis, and cannot be guaranteed by law. This is because current laws have no clear provisions on either the ownership and tenure of underground space, or the ownership of underground buildings and structures. Second, the development of underground space resources has no unified plan, and all units and departments are constructing underground buildings for their own development needs. From the whole city prospective this results in a lack of unified planning and construction, which in turn leads to a disharmony between departments and produces many contradictions. Therefore the comprehensive benefits of city life are not obvious. Finally, there exists multiple and unmanned management structures. This kind of multiple management has introduced disorder and confusion, and there are also unseen areas with no management [11].

Second, there are safety problems associated with the use of underground space. Urban underground space usage is diverse and multi-faceted. Many cities in China use underground space to serve commercial and transportation activities (even entertainment activities), and safety has become increasingly important. With urban economic development in recent years, economic activities of cities have expanded from the ground to underground space. Municipal pipelines have crisscrossed underground space, and underground railways, commercial streets, and other buildings have been constructed. Major municipal facilities have also been sited underground. All of this leads to geological instability for surface buildings and facilities, and directly increases the possibility of man-made disasters.

Finally, the big data era brings new opportunities and challenges. Big data represents the recognition of data, and the ability of human beings to extract and process immense, complex, heterogeneous, and real-time data. Based on this, big data can improve information services and facilitate predictive measures.

It can also use the results of data extraction for urban monitoring, urban evaluation, and sympathetic management. In the era of big data urban construction can develop, integrate, and utilize many urban resources. This will perfect infrastructure construction, and build an advanced urban system.

4 Corresponding policy and law in underground space development

4.1 National policy

In national level policy, *Views on Further Strengthening the Management of Urban Planning and Construction*, *Opinions on Strengthening Urban Infrastructure Construction*, *Guidance Opinions on Strengthening the Management of Urban Underground Pipeline Construction*, and *Guiding Opinions on Promoting the Construction of Urban Underground Comprehensive Pipe Corridor* have corresponding provisions for the development of underground space, which mainly refers to layout requirements of urban underground pipelines, infrastructure, and utility tunnels.

4.2 Basic law

Basic civil laws regulating space rights include the *General Provisions of the Civil Law* (implemented on October 1, 2017), the *Property Law* (implemented on October 1, 2007), or the *Land Administration Law* (implemented in 1999 and amended in 2004). It is clear that land in the city belongs to the state, and that ownership and the right to use the land are treated separately. This lays the foundation of a legal principle for the establishment of space rights, and determines the basic meaning and content of space rights.

4.3 Comprehensive law

In China, comprehensive laws on the development and utilization of urban underground space (at the national level) have been preliminarily available, but they are not yet perfect. There are few individual laws for the development and utilization of urban underground space. Comprehensive regulations related to the development and utilization of urban underground space is the *Regulations on the Management of the Development and Utilization of Urban Underground Space*. This law has detailed provisions on the legislative purpose, the significance of urban underground space planning, engineering construction requirements, underground space engineering management, and penalties.

4.4 Special law

The special laws related to urban underground space planning are mainly *Measures for the Management of Urban rail Transit*

Operation and management. According to *Views on Further Strengthening the Management of Urban Planning and Construction* of the Central Party Committee and the State Council, *Opinions on Strengthening Urban Infrastructure Construction* of the State Council, *Guidance Opinions on Strengthening the Management of Urban Underground Pipeline Construction* and the *Guiding Opinions on Promoting the Construction of Urban Underground Comprehensive Pipe Corridor* of General Office, we should sum up the experience and formulate *Management Measures of Utility Tunnel Construction* as soon as possible.

4.5 Supporting laws and local legislation

The supporting laws and regulations for the management of urban underground space development and utilization shall include: ① the policy of governmental financial support, reduction of related expenses, preferential tax policy, and a financing policy for development and use; ② the technical standards and specifications for the construction of underground projects. Supporting laws include: *Circular on Issues Related to the Promotion of the Cooperation Model between Government and Social Capital*, *Operational Guide for Cooperation Model between Government and Social Capital*, *Management Methods for Franchising of Infrastructure and Utilities*, and *Technical Standard and Technical Specification for Underground Engineering Construction*.

The exploration of local legislation reveals a confusing scenario, involving all aspects of the development and utilization of urban underground space. The *Regulations on the Management of Underground Space Planning of Tianjin* (2009) is the first local underground space planning regulation in China. Similarly, there is *The Regulations on the Planning and Construction of Underground Space of Shanghai*. According to incomplete statistics, many cities in China have formulated comprehensive laws for the development and utilization of urban underground space. For example, the *Regulations on the Development and Utilization of Underground Space in Benxi* (2002), the *Regulations on the Development and Utilization of Underground Space in Liaoyuan* (2008), *Interim Measures for the Development and Utilization of Underground Space of Shenzhen* (2008), the *Measures for the Management of Underground Space in Shaoshan* (2009), the *Measures for the Management of Underground Space in Taiyuan* (2009), the *Measures for the Management of Underground Space in Pengzhou* (for trial implementation, 2010), the *Measures for the Management of Underground Information in Tianjin* (December 1, 2011), *Interim Measures for the Administration of the Development and Utilization of Public Land Underground Space in Haikou* (September, 2012), *Interim Provisions on the Management of the Development and Utilization of Underground Space in Wuhan* (July, 2013), *Interim Measures for the Development and Utilization of Underground Space in Changsha* (June, 2014), and *Interim Measures for the Development and Utilization of Underground Space in Mianyang* (Sep-

tember, 2014). Local legislations give more detailed and targeted measures and regulations for the development and construction of urban underground space, each with its own characteristics.

5 Conclusions and recommendations

5.1 Underground space development and utilization is of great significance to urban life

The utilization of urban underground space effectively develops and utilizes urban land resources, and promotes the coordination and unity of urban ground (and underground) development and construction. Further, the defense and security of the city are improved. It is an important method of building ecological and sustainably developed cities.

5.2 Utilization of urban underground space in China and problems

Presently there are both achievements and problems in the development and utilization of urban underground space in China. The overall scale and speed of their development and utilization in China are leading in the world, but the development and utilization lacks comprehensive, large-scale, integrated measures. Moreover, after planning approval the overall planning generally falls behind the actual urban construction, therefore losing timeliness and guidance; the related laws, regulations, and management systems of underground space are not perfect, although China has issued some relevant laws and regulations. Further, it has formed authoritative national legislation, though the management system is not unified. There is no clear regulation on the unified management responsibility of construction departments, and how to coordinate with land management, planning, civil air defense, and other departments. Finally, the urban underground space information platform construction and informationization application are obviously insufficient; although basic data has been provided, in urban underground space planning there has been little guidance or supervision regarding engineering construction, safety, disaster prevention, and other aspects.

5.3 Prospect of urban underground space in China

Throughout the development of underground space around the world, its utilization in China has broad potential. The discovery of underground space in China has developed from the natural extension of large buildings, to underground complexes, and to underground cities. Underground municipal facilities have been expanded from water supply and drainage networks to including large-scale water supply systems, large-scale energy supply facilities, and large-scale sewage facilities. With the promulgation of *Regulations on the Development and Utilization of Urban Underground Space*, the status of underground

space planning in urban master planning has been improved, and brought within the scope of statutory planning. It has promoted the development and utilization of urban underground space resources in China. In recent years there have been many cases of excellent underground space planning.

In summary, it can be predicted that in the near future the development of underground space in China will have broad development prospects. However, there are still some institutional and technical obstacles in the development and utilization of underground space resources. In addition to breakthroughs in technical methods, further effort is required in planning coordination. Additionally, we need to formulate implementation policies, laws, and regulations corresponding and relevant to the actual situation of China.

References

- [1] Chen X Q, Qian Q H. Study on the integrated management of urban underground space in China [J]. *Chinese Journal of Underground Space and Engineering*, 2010, 6(4): 666–671. Chinese.
- [2] Jansson B. City Planning and the urban underground [J]. *Underground Space*, 1978, 3(3): 99–115.
- [3] Vähäaho I. An introduction to the development for urban underground space in Helsinki [J]. *Tunnelling & Underground Space Technology*, 2016, 55(3): 324–328.
- [4] Vitt J E, Kjelshus B. Developing Kansas city's underground space [J]. *Underground Space (United States)*, 1980(4): 5.
- [5] Besner J. A Master plan or a regulatory approach for the urban underground space development: The Montreal case [J]. *Urban Planning International*, 2007, 22(6): 16–20.
- [6] Liu C Y. The study of Japan underground space development and utilization law [J]. *Civil Defense Garden*, 2006(s1): 128–131. Chinese.
- [7] Lu H P, Su Y. Study of Shanghai underground space and management system and mechanism [J]. *Shanghai Construction Science & Technology*, 2007(1): 6–9. Chinese.
- [8] Su Y, Peng F L, Wang X, et al. Study and practice of urban underground space planning in China [J]. *Chinese Journal of Underground Space and Engineering*, 2006, 2 (s1): 1125–1129. Chinese.
- [9] Liu J K, Pang Y S, Yi H L. Research on development and use of underground space in big cities in China—A case about Guangzhou city [J]. *Building Science*, 2009, 25(4): 72–75, 89. Chinese.
- [10] Wu F. Study on the management of urban underground space in China [J]. *Journal of Chongqing University of Science and Technology: Social Sciences Edition*, 2011(16): 82–83. Chinese.
- [11] Zheng H D. Subterranean space development and management system reform [J]. *Planners*, 2012, 28(3): 69–73. Chinese.