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Present state, problems and development trends of urban underground space in China[☆]

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ABSTRACT

The status, problems and trends of China's underground space development are presented in this paper. In association with the features of use of China's underground space, such as the large scale, rapid development, high speed subway, various forms are summarized. Five problems in the use of underground space in China are put forward, including the uncoordinated solutions, unintegrated management system, incomplete regulations, incomplete planning, and unclear policy. Four use trends of underground space are also presented, together with (1) the integrated planning, construction and management relating to the development of underground space in central business district (CBD) of Beijing, after World Expo in Shanghai and the business district in south Ningbo; (2) introducing the urban underground complex with an integrated transport hub as its center relating to the cases of Hongqiao Transport Hub and Beijing South Railway Station; (3) the development of underground subway, road and logistic system; (4) the scientific utilization of underground water storage space and aeration of "sponge city". In this study, some institutional perspective on the use of underground space is also given.

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1. Present state of urban underground space development in China

Since the establishment of the strategy of "building a resource-saving and environment-friendly society", urban underground space has shown its advantages in providing resources to solve urban problems and has been developed rapidly (Qian, 2006). Chinese underground space development presents the following distinguishing features.

1.1. Large scale

The total building floor area constructed in the last decade has been more than 3 times that over the past 46 years. An area of nearly 100 million m² has been developed and more than 2000 large-scale underground complexes have been constructed in the period 2011–2015.

In Beijing, 50 million m² of underground space has been developed in 2008. In Shanghai, more than 34,000 underground projects have been completed with a total built area of 68.75 million m² by the end of 2013 (CMEA, 2014).

1.2. Rapid development

By 2020, 90 million m² underground space is expected to be developed in Beijing, with an annual increment of 3 million m² (Shi, 2006). The total underground construction area will reach 50 million m² in Shenyang (Yu et al., 2014), 20 million m² underground space is planned to be constructed in the main city of Wuhan (Sun, 2005), in Ningbo, the total underground space constructed will be 40 million m² in the urban area and 60 million m² across the whole city (Shen, 2011).

1.3. Unprecedented construction speed of subway

By the end of 2014, the urban rail transport systems (including subway) were in operated in 22 cities, with a total length of 2933 km. A rail transport network of 527 km has been built in Beijing and the total length of subway lines in service has reached 548 km by the end of 2014 (CAM, 2015). By 2020, the total length of the network in Beijing and Shanghai will be more than 1000 km and 800 km respectively.

1.4. Various forms of underground space development

Underground space has been developed in various forms in many cities: underground transportation facilities (underground

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footpaths, subways, underground roads, and underground car parks), underground complexes (integrated transportation, municipal, commercial and entertainment facilities) and underground municipal facilities (public ditches, waste disposal systems, rain-water storage systems) have been developed rapidly.

2. Problems in developing underground space in China

The use of underground space in China has seen great achievements but there remain many problems that need solving. These are discussed in the sections below.

2.1. Coordinated solutions needed

Although the development scale and speed of urban underground space and the level of individual development projects in China is top-ranked in the world, its quality in terms of providing integrated solutions to urban problems is still not high (Qian, 2007). So far, integrated planning, coordinated construction and regulated usage of underground space have not been realized. The development is concentrated on underground space at shallow or intermediate depth. Most built underground space is unconnected and single-functioned. The development of underground and aboveground space is not coordinated (Wang, 2013). Hence, an integrated and highly efficient underground network has not been formed. The management of the use of underground space does not match the development demand of urban underground space.

2.2. The management system is not integrated

The use of urban underground space involves a number of administrative departments. No clear management department has been appointed for integrated management and the appropriate coordination mechanisms have not been established (Zheng, 2012).

2.3. The regulations are incomplete

The National People's Congress and the State Council have not issued any regulation or law on development and utilization of urban underground space yet. Only the document "Regulations for development and utilization of urban underground space", a department regulation issued by the Ministry of Construction, is available, which lacks authority and operability (Liu et al., 2005). The concept and relevant regulations of property rights for underground space are not defined in the existing laws. The most fundamental civil right for underground space is not confirmed by law yet (Liu et al., 2006).

2.4. The planning is incomplete

Planning of underground space is not included in the master plan of most cities. The available underground space plans are specific plans and there is a lack of coordination between underground and surface spaces and the overall arrangement for future deeper underground space development (Li et al., 2005). No unified rules are available for the content, depth and method of the standards of underground space development.

2.5. The policy is unclear

The procurement manner, price, property registration and transfer, mortgage loan and financing, leasing and sale, taxation and other relevant policies for underground space are not clearly

defined yet in China (Shi, 2005). Currently, local governments or relevant departments manage underground space in their own ways.

3. Development trends for urban underground space

3.1. Integrated planning, construction and management of urban underground space

3.1.1. Background

Documents issued in recent years by national authorities require:

- "To enhance integrated planning, construction and management in cities, to promote orderly development and utilization of urban underground space, and to improve scientific management level of municipal construction."
- "Integrated design of aboveground and underground space and comprehensive planning of underground pipelines below main roads", "planning conditions and licensed content shall be clearly specified".
- "To develop integrated management system and mechanism", "to establish supervision mechanism for safe utilization of underground space".

3.1.2. Some practical examples

3.1.2.1. *The largest underground space developed in Beijing (CBD).* The central business district (CBD) of Beijing is divided into 18 pieces of land. The planned total land area is about 4.0 km², among which the core area is about 30 ha.

The total surface land and underground area is 4.1 million m², the aboveground floor area is about 2.7 million m² and the underground floor area is about 0.52 million m².

Underground space is divided into five storeys to separate pedestrians and vehicles, and accommodate underground transport system, commercial streets, public buildings, infrastructures, storage space and civil defense space, etc.

A resource-sharing underground parking system will be built. Underground car parks below adjacent construction land shall be connected as much as possible. Basement 2 of the CBD core area is the level for connecting car parks. An underground vehicle distribution ring can be built by using the space below urban roads, so as to ease surface traffic congestion.

A passageway is being constructed to directly connect the Subway Line 10 station and the underground mall of the World Trade Center, which greatly reduces the walking distance for staff working in the World Trade Center.

Basements 3–5 are designed for car parks, machinery rooms, heat and electricity lines, and to provide 100,000 m² of civil defense and disaster relief space.

3.1.2.2. *Development of underground space after World Expo in Shanghai.* Integrated planning, design, construction and management mode has been adopted for the development of underground space in the Shanghai Expo Park (Fig. 1), which is also a part of Expo site development.

Integrated planning, design and construction have been implemented in developing underground space in Zones A and B, and integrated management is under discussion (Xi, 2014).

The underground space provided for the headquarter base for China State-Owned Enterprises (SOEs) in Zone B is about 450,000 m².

The single-block commercial building development mode will not be adopted in Zone B. Instead, integrated development is emphasized. Thirteen SOEs will share a distributed energy center

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