

Evaluation of the Status Quo and Outlook of the Urban Underground Space Development and Utilization in China

Qian Qihu¹, Chen Xiaoqiang¹

¹University of Science & Technology, China

ABSTRACT

In this paper, evaluation of the Status Quo and outlook of the urban underground space development and utilization in China are described.

1. EVALUATION OF THE STATUS QUO OF THE URBAN UNDERGROUND SPACE DEVELOPMENT AND UTILIZATION IN CHINA.

With the advent of the 21st Century, China has experienced rapid development of urban underground space and constantly improves system of urban underground space that have earned it a leading role in mega cities in the world as regards the overall scale and development speed of the underground space. China has become a major country in the world with respect to the development and utilization of urban underground space which has attracted widespread attention of governments at all levels.

In terms of function, underground traffic plays a major part in the development and utilization of China's urban underground space. The construction rate of China's urban rail transportation ranks first in the world; the construction of urban underground expressways has already kicked off and will be speeding up; urban underground logistics systems are under study; special planning of the underground space is fully underway in the mega and large cities; many cities have compiled or been compiling detailed planning to be aligned with the reconstructing of central districts and the construction of new districts; the large-scale underground complexes have become the highlights in the development and utilization of the underground space in many large cities, and have come up to the internationally advanced level. However, the comprehensive utilization efficiency of the underground space has to be improved; the construction of municipal comprehensive pipeline (common tunnel) has just started; development and utilization of underground space at great depth hasn't yet begun; to some extent, there is still a gap between China and the developed countries in terms of legislation, policy, operation and management, underground construction equipment for which the nation has ownership in the core techniques.

Today, in China the development and utilization of urban underground space has become an important means to enlarge urban capacity, relieve urban traffic pressure and improve urban environment, and an important approach to the establishment of a resource-saving and environment-friendly city.

Take Beijing for example. At present, the city has 30 million m² underground spaces. The floor area of underground space in the city is going to increase 3 million m² annually, accounting for 10% of the total floor areas of city.

Currently, the construction speed of China's urban subway transportation is at the top of world. Statistically, China will develop 1200km urban subway transportation till 2010. From now on, China will averagely construct 180km every year.

Urban underground space planning is drawing general attention. So far, more than 20 cities, including Beijing, Shanghai, Chongqing, Nanjing, Hangzhou and Qindao, have compiled a special plan for their urban underground space, effectively standardizing its development and utilization. Many cities have

composed circumstantial plans for reconstructing the central districts and the construction of the new districts. For instance, Beijing CBD, Zhongguancun West District, Olympic Central Area, Beijing Financial Street, Wangfujing Business District, etc. effectively control and guide the development and utilization of the underground space along a scientific, reasonable and orderly route.

Underground complexes in large cities are characterized by their amazing number, large scale and high standard. By taking advantage of the construction of the underground railway, new districts and urban reconstructing, many cities have established huge-sized complexes that fulfill comprehensive functions and form a complete system of their own, such as Beijing Zhongguancun, Olympic Central Area, Shanghai World Expo Garden, the South Railway Station, Wujiaochang, Guangzhou Pearl River CBD, and the Wave Culture City of Qianjing CBD in Hangzhou. Each of the projects covers an area of above 100 thousand m² built up 3 to 4 storeys, serving simultaneously the purpose of transportation, municipal administration and commerce, providing a superior interior environment and bringing on good terms between the ground and underground.

Urban underground expressways have started. The finished structures include Xuanwu Lake Underground Expressway, Nanjing East City Underground Trunk Road, West Lake Underground Hubin Road in Hanzhou, Beijing Olympic Center, Zhongguancun, Financial Street Underground Road, the underground sections of Shanghai Middle Ring, the west corridor underground section in Shenzhen, etc. The projects under construction are, among others, the Shu Lake Underground Expressway, etc.

1.1 Construction rate of China's urban rail transportation ranks first in the world

In recent years, city's subway construction comes into a unprecedented developing period in China. Up to June.2006, subway had been constructed in 7 cities in mainland China: Beijing-113km; Tianjing-7.4km; Shanghai-123km; Guangzhou-36.6km; Shenzhen-21.8km; Nanjing-16.9km; Total line-318km. And three cities (Chongqing, Dalian, Wuhan) have urban rail transportation. Now 17 subway lines with total length 360km are constructed or ratified in 8 cities.

According to construction planning the Beijing's subway line net will compose of 19 lines, total length 561.51km. It will exceed New York's total subway length and will become the longest in the world. In Shanghai 13 subway lines will be finished till 2012, total length 510km could be used.

1.2 Underground complexes in large cities are characterized by their amazing number, large scale and high standard

Large underground complexes in many Chinese cities, which are combined with the subway, the old town reconstruction and the new area construction, are constructed. It can improve the level of comprehensive use of the land; solve the problems of traffic and environment, but also to create a new image for the city.

1. Beijing

The Western District of Zhongguancun in Beijing: Its underground floor area is 500,000m², and the number of motor vehicle parking is 10,000. This underground space is divided into three floors. It is the largest three-dimensional transportation network in China which is formed by underground space development, utility tunnel and underground round driveway.

The Wangfujing District in Beijing: It has 600,000m² available underground spaces in 1.65km² of this district. The main function is underground rail transportation, municipal facilities and public space and so on.

The Commercial Street Center in Beijing: The underground transport system in the area is the first large-scale underground transport system. The total floor area is about 30,000 m². Among them, the total length of underground driveway system is 2,426m; the length of underground pedestrian is approximately 195m.

2. Shanghai

Jing'an Temple Square in Shanghai: The Square is the exit & entrance of Jingan Temple station for No. 2 subway line. It is a complex consisting of sinking plaza, underground mall, opening theater and

grass land extended from Jingan Park.

Underground Complex of Shanghai South Railway Station: Its depth is 15m, total development area is 90,000m².

The Complex of the People's Square: It is a large underground complex which consists of two subway stations, two underground malls, an underground park and an underground substation, which is combined with the interchange station of No.1, No.2 subway line. Its total area is 50000m².

3. Shenzhen

The Luohu Port and the Railway Station in Shenzhen: The complex has three-storey ground and underground. It obtained super excellence award of Asia & Pacific area given by Urban Land Institute (ULI) in July 2006.

The large underground parking in Futian Centre District: It has more than 10,000 parking spaces.

Huaqiang North Commercial Street in Shenzhen: Its length is 930m and the width is 16m. Its commercial business area is 32,000 m².

4. Other Cities

Combining with the construction of No.1, No.2, Nanjing Xinjiekou interchange subway station is carried on the integration of more than 10 underground spaces such as Zhenghong Underground Commercial Street, Xinjiekou Department, Center Store and so on. It forms a network of underground space, with a total floor area of over 400,000m².

Combining with the construction of Gongbei Port Square, the underground space of Gongbei Port Square in Zhuhai is built, whose total underground floor area is 150,000m² with three-floor. It is a underground complex integrated with commerce, parking, bus stops, taxi stops and office.

Dalian Buye City (150000m²), Dalian Olympic Park (40,000m²); Xi'an ZhongGulou Square (50,000m²); Jingnan Quancheng Square(40,000m²); Nanjing Hexi underground complex (100,000m²); Harbin Hongbo Square (100,000m²).

According to incompletely statistics, the number of underground complexes in China which floor area is over 10,000m², is more than 200.

1.3 Tunnel construction in focus of world attention

With the acceleration of the reform and opening up in China, traffic congestion causes much inconvenience to people's life, and affects the economic development. Many cities need to cross river for expanding city, so many tunnels are constructed for improving the environmental quality, solving urban traffic congestion, reducing noise pollution etc. Not only there are the tunnels through CBD, but also the tunnels through the mountains. The traffic mileage of tunnel in China in 2002 is increased by 13 times than in 1979. China has become the country which tunnels are the most, the most complex and the fastest-growing in the world.

The first underwater Tunnel of Dapu Road in Shanghai was put into operation from the 1960s, and now the Cross Yangtze river tunnel of Waihuan in Shanghai, River-crossing Tunnel of Dalian Road, Fuxing East Road and Yan'an East Road, the Waitan Sightseeing Tunnel, Xuanwu Lake Tunnel in Nanjing, Yongjiang Tunnels in Ningbo have been constructed and operated.

Chinese first undersea tunnel -- Xiang'an Tunnel in Xiamen city: It was started in 2005, and its total length is 9km. The deepest point under the sea is about 70m.

Jiaozhou Bay Tunnel in Qingdao: Its length is 6.17km, and underground length is 5.55km, and the length of crossing sea is 3.95km The project will be finished by the end of 2009.

Yangtze River Tunnel in Nanjing: It was started on March 29, 2005, and the total investment is about 3 billion RMB, and it is also the longest tunnel of the Yangtze River.

The Yangtze River Tunnel and Bridge in Shanghai: This project was entirely started in September 2006. The project uses the "South Tunnel and North Bridge" program. "South tunnel" between Shanghai and Chongming is about 8.9km. Length: It is continuously excavated to 7.5km by shield. It is the longest continuous construction of the similar projects in the world. Large: The inner diameter of tunnel is about 13.7m, and the outer diameter is 15m. The diameter of shield machine is 15.43m. It is the largest shield tunneling in the world. Depth: The maximum depth below river is about 55m, it is the deepest tunnel under the river in the history of the world.

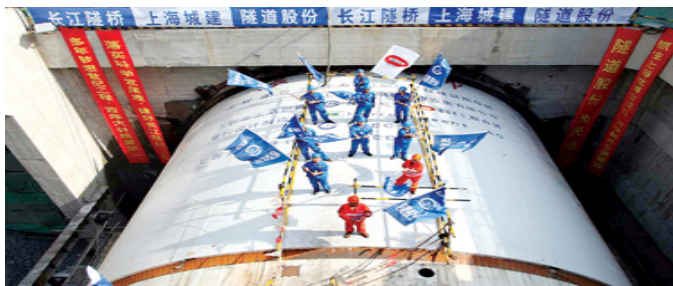


Fig. 1. The biggest shield in Yangtze tunnel with 15.43m diameter.



Fig. 2. Chongming island.

Cross Yangtze River in Wuhan: The east tunnel located at lower reaches of Yangtze River was firstly excavated in September 29, 2006. The length of Yangtze River Tunnel is 3630m .

1.4 Widespread attention to the planning and management of urban underground space

The Management Regulation of the Development and Utilization and of Urban Underground Space, issued on Oct. 27, 1997, provides a legal basis for the development of urban underground space. The legislations yet to be enacted include The Utilization Statute of the Underground Space in Shenzhen (under consideration) and The Regulation of the Development and Utilization of the Underground Space in Shanghai (draft); regulations that have been implemented include The Regulation of the Development and Exploitation of the Underground Space in Benxi (Oct. 10, 2002), and The Regulation of the Development and Exploitation of the Underground Space in Huludao (2002).

In June 2006, Shanghai municipal government has passed The Pilot Edition of the Regulation of the Ratification of Urban Underground Space Construction Land and the Registration of Real Estate in Shanghai (here in below the Pilot Regulation). Shanghai, Hunan, Shenzhen, Shenyang , etc. have specified the property right of underground space.

With regard to urban underground space, although so far there has been no uniform criterion of underground space in China, beneficial exploration has been made concerning the compilation of urban underground space planning in many cities.

Nearly 20 big cities including Beijing, Shanghai, Shenzhen, Nanjing, Hangzhou have finished the urban underground space planning (conceptual), laying out the scale, overall arrangement, function, depth and order for the future development of their underground space, specifying the guideline and the key development areas in its development, laying the foundation for further scientific and rational development and exploitation.

Beside, many cities have made regulatory detailed planning for the controllability of regional underground space by taking into account the ground plan, for example, Beijing Chaoyang CBD, the core of Qianjing CBD in Hangzhou, Wuhan Wangjidun Shopping Center, etc. They all nailed down particular programs for the development depth, intensity and scale of the underground space, putting forward its structure and conformation as well as the development strategy and investment model.

2. OUTLOOK OF THE URBAN UNDERGROUND SPACE DEVELOPMENT AND UTILIZATION IN CHINA

In the 21st century, China will realize sustainable and stable growth in economy, and continuous progress in urbanization. Currently, the Chinese government calls for the construction of a resource-saving and environment-friendly society, hence the increasing emphasis on the development and utilization of China's urban underground space. By the end of 2020, China will have become not only a major country but also a power country concerning the development and utilization of the urban underground space.

China's overall scale and area of urban underground space will rank first in the world. Take Beijing for

example. In the year 2020, the constructed underground space will amount to 90 million m², 5 m² per capita. According to the plan of underground space of Beijing' central urban districts, the underground space of such areas will account for 20%-30% of the total floor area in 2020. The updated design of Beijing Rail Traffic shows that in 2020 the total length of the city's rail line will exceed 1000 km. In the next decade, Beijing's rail transportation will increase 40 km per year; people within Ringroad Five can reach their destinations within 20 minutes by rail; within Ringroad Two they can reach a subway station no more than 5 minutes. Public transportation facilities will become the chief means of transportation for 80% of the citizens, half of whom will frequently take the rail.

The urban underground space will become a systematic network that develops in line with the ground space. Based on the Management Plan of the Development and Utilization of the Urban Underground Space issued by the Ministry of Construction, cities with a population over 1 million will have finished compiling their special plans for urban underground space, bringing systematically and progressively in progress the development and utilization of the underground space of large cities. Many cities will have a systemized and modernized urban underground space system, including the complete underground transportation system, the underground lifeline system, the underground air defense and anti-disaster system, and the underground public facility system in the key areas of those cities.

The urban underground expressways will also be systemized, so will the underground municipal comprehensive pipeline. Underground logistics systems will be constructed in many cities. Beijing will build a network of underground expressway, shaped in four latitudinal and two longitudinal lines. Shanghai municipal government has ratified the plan of the 井-shaped corridor which will extend 40km, 26 km of it being underground. Once completed, it will help the city form a 井-shaped underground express traffic network. The first session of the project (the south-north corridor) had gone through its design and bidding by the end of Oct. 2006, and the whole project will be completed in 2010. The city, at the same time, is studying the feasibility of an underground container transport system. Beijing is also instituting a feasibility plan for its underground system of logistics. Many cities are examining the laws and rules of building municipal comprehensive pipeline, exploring its system and mechanism. Now there has been various investment and financing modes of the pipeline. The capital city is launching on a vigorous construction of the municipal comprehensive pipeline in combination with the construction of the subway.

2.1 In terms of overall scale and size of urban underground space China will rank first in the world

According to statistics, China's urban underground rail line in operation will reach 1200km before 2010, 180km built per year. Beijing: the designed subway network is composed of 19 lines with a total length of 561.5km, Beijing will exceed New York and become the city with the longest subway. There will be 15 urban lines, 425.7km long, in which, M10 and M11 form the second ring subway.

Shanghai: according to Shanghai's "the Eleventh Five-Year" Comprehensive Traffic Development Plan, by 2010, 11 traffic lines with a total length of 400km will be constructed. (by 2010, the figures will increase to 13 and 510km respectively), forming a rail traffic network with "four latitudinal and three longitudinal lines".

There will be a rapid development of the exploitation and utilization of urban underground space based on urban underground rail traffic. Not only will the overall scale and size of underground space come out to the top of the world, many China's metropolis will also set the pace for its development and utilization.

2.2 A wide prospect for tunnel construction

According to statistics, tunnels about 6000km long will be built in the first two decades of the 21st Century, including the railroad and road tunnels in China's Western Campaign, subway projects, underground public facilities, mechanical pipe-lifting projects, West-East Gas Pipeline, hydropower plant, etc. about 300km annually.

In accordance with the plan of the Ministry of Communications, with 10 year, China will set up urban road tunnels over 155km. The Zhongnan Mountain Tunnel that is about to be completed has a total length of 18.4k, first in Asia, second in the world. Xuefeng Mountain, Hunan is 7km long. The three ultra-long tunnels of Xian's Hanzhou Expressway are 34km in total that run through Qinling Mountain, while the length of all the tunnels is 100km.

In the next 20-30 years, 5 cross-sea tunnels will be built. They are: Bohai Bay cross-harbor tunnel from Dalian to Yantai; Hanzhou gulf project from Shanghai to Ningbo; Lingdingyang cross-sea project connecting Hong Kong, Macao, Guangzhou, Shenzhen and Zhuhai; Qiongzhou Strait cross-sea project joining Guangdong and Hainan; Taiwan Strait cross-harbor project linking Fujian with Taiwan. The possible solution of the grand and arduous projects is to combine bridge and tunnel, a major part of which will be under the sea.

Table 1. A survey of the constructed or ratified subways in 15 cities.

City	Time of being open to traffic	Number of lines constructed / under construction (lines)	Total length (km)	Stations	Designed route	Total design length (km)	Designed stations
Beijing	1969	4	114			408(1000)	
Tianjin	1984	1	26.195		(8)9	227	
Shanghai	1995	3	123		(11)21	384/400(540)	259
Guangzhou	1999	2	36.6			640	350
Shenzhen	2004	2	21.866	19	5	120.7	65
Nanjing	2006	1	21.72	16	(6)10	365	
Wuhan	2004	1	10	10	(5)7	212	
Dalian							
Changchun	2001	1	14.6	17			
Chongqing	2005	1	32	13			
Chengdu	2004	1	50.65	26	7	274.5	146
Hangzhou	2003	1	50.68	31	(6)8	278	
Xian	2002	1	19.74	20	6	251.8	
Shenyang	2005	2	47.2		7	182.5	
Haerbin		1	14.41	16	7	143	115
Suzhou		1	16		3	360	

2.3 An underground network will be built to achieve a harmonious development of ground and underground space

Table 2. The estimated size and plan of underground space in some cities.

City	Planning Range (km ²)	Exist Development Quantity (10,000m ²)	The time (year)	Prediction Quantity (10,000m ²)	Planning Period
Beijing	1085	3000	2006	9000	2004-2020
Shanghai	600	1600	2006	-	-
Nanjing	258	280	2005	730	2002-2010
Shenzhen	2000	1900	2005	-	-
Qingdao	250	200	2004	2544	2004-2020
Wuxi	1662	200	2005	1500	2006-2020

Several underground towns will take shape: the underground construction area of the core of the Pearl River Newtown, Guangzhou is 600,000m²; the underground part of Shanghai World Expo Garden will occupy an area of 400,000m²; the underground town under Shanghai south railway station is about 200,000 m²; Wujiaochang underground town is about 300,000 m²; the underground town of the core,

Qianjing CBD in Hangzhou is 2 million m²; Wuhan Wangjidun Shopping Center is over 3 million m².

2.4 The forming of a system of urban underground expressway

Increasing attention has been paid to the underground expressway as a solution to urban traffic problems. Shanghai municipal government has ratified the plan of the 井-shaped corridor which will extend 40km, 26 km of it being underground. Once completed, it will help the city form a井-shaped underground express traffic network. The first session of the project (the south-north corridor) has gone through its design and bidding by the end of Oct. 2006, and the whole project will be completed in 2010. The city, at the same time, is studying the feasibility of an underground container transport system.

Beijing will build a network of underground expressway, shaped in four latitudinal and two longitudinal lines to alleviate the traffic jam in the second and third ring roads and Changan Road. Each line has 4-6 exits that do not interconnect but join the underground parking lots in some areas with high passenger flow. After 2020, the system will make the traffic easy for motor vehicles, reduce traffic congestion, promote the utilization rate of the parking lots and improve ground parking and traffic environment.

While constructing Hongkong-Shenzhen west corridor, Shenzhen built an underground expressway about 7km long to solve the traffic problems and improve ground environment of the city.

In the inner ring road of Nanjing, Xuanwu Lake underground expressway, east trunk line and north underground road account for one second of the ring, forming the underground traffic system in the city.

3. CONCLUSION

In the 21st century, China will realize sustainable and stable growth in economy, and continuous progress in urbanization. Currently, the Chinese government calls for the construction of a resource-saving and environment-friendly society, hence the increasing emphasis on the development and utilization of China's urban underground space.

Finally, in a word, by the end of 2020, China is not only a major country but also will become a power country concerning the development and utilization of the urban underground space.

REFERENCES

- Zhilong, C., 2004. Urban Underground Space Planning, South-east University Press.
Qihu. Q., November 2006. Presentation of IACUS 2006.