

Comprehensive Development and Utilization of Underground Space and Underground Rail Transit

Xiao Xing^{1,*}

¹China Railway First Survey and Design Institute Group Co. Ltd., Xi'an, Shaanxi 710043, China

*Corresponding author. Email: 343307763@qq.com

ABSTRACT

Research purposes: Based on the analysis of the development trend of urban underground space, this paper briefly describes the necessity of underground space development, and focuses on the necessity of joint development and utilization of underground space and urban rail transit. From using the master planning of underground space and rail transit conditions, traffic conditions, metro stations, metro stations and underground space development through the research, in the form of respectively expounds the regional use of underground space, block type, site ontology model, the integration model, and analyzed the underground space metro stations as the core, puts forward the components of three-dimensional traffic, the design concept of connectivity and the surrounding projects.

Research conclusions: The comprehensive development and utilization of underground space and underground rail transit is an important subject facing our country at the present stage. The inevitable demand and product of urban development play an extremely important role in intensive land use and rational and effective development of underground space. The integration of aboveground and underground space, transportation organization and service is the inevitable trend of urban rail transit construction and development in the future.

Keywords: *underground space development, urban rail transit, urban area underground space utilization, block type underground space utilization, underground space traffic organization*

I. INTRODUCTION

Recent years, with rapid development of cities, the scale of town is expanding. Huge change happen to the city space and configuration. The ground space of the city is bearing great pressure like transit, population and so on. It is imperative to look for other space for the transit and business. As the massive construction of the urban rail transit, the concept of comprehensive utilization of underground space emerges, and become one of the effective ways to alleviate the pressure on the ground in the city. The development and utilization of the underground space linked with the underground rail transit has become a trend in urban design.

II. BACKGROUND

A. Necessity

1) *Demands of the city development:* Exploitation and utilization of the underground space is a necessary demand for the city development. The above ground for the human survive is lessen with the development of the society and the city environment is destroy with the

exploitation of the business. The living environment has become crowded, the traffic conditions have gone from bad to worse, and the cost of development is putting new demands on urban design.

Construction of the urban rail transit has improved the transit, shortened the distance between people's work, life and business activities, and then organized well three-dimensional traffic cycle interaction in the underground space. The urban rail transit and the underground space become the new urban design concept, these two parts are independent and inseparable.

2) *Inevitable product of the underground rail transit:* The underground rail transit (subway) bear the huge traffic volume of each city and make people travel easily (Chu Dongzhu, 2018). For one thing the basic function of the subway is take the passenger get the destination fast and on time, for another thing the subway can relieve the ground traffic pressure. As the renew of the metro station design, subway is not only a traffic tool but also a carrier and linker of the underground space exploitation in order to meet the

economic benefits of society and rational use of planned plots ("Fig. 1").

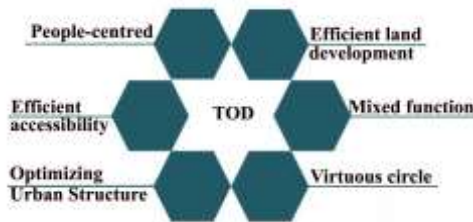


Fig. 1. Schematic diagram of urban space development trend.

B. Research status

Nowadays, countries all over the world are studying the development and utilization of subways and underground space. The London Underground is undergoing underground renovation of the old station. As a result, the underground museums, art galleries, etc. were derived. The Berlin Central Railway Station in Germany has been transformed into underground space, which combines the three modes of transportation: railway, urban fast track and subway. Montreal, Canada, had built a 36km² underground city as early as the 1990s, greatly increasing the base of public space activities. This civil underground space is mostly connected to rail transit sites, and it is usually taking the rail transit site as a starting point, radiating development to the surrounding area (Fan Wenli, 2007). Jing'an Temple Station of Shanghai Metro connects the sinking squares, urban complexes and shopping centers through the interconnection of underground spaces, and secondary planning the underground space to be developed around, planning to form a regional integrated underground space system. The speed and the increment of the Chinese rail transit has become the first in the world and the construction of large underground complexes in cities has become the focus of underground space development and utilization (Cheng Zhilong, 2016). Therefore, the utilization of underground space is a worldwide trend, and it is one of the effective ways to expand public space and enhance social and economic benefits.

III. PRECONDITIONS

A. Planning precondition

The city control planning and the detailed planning are the most important conditions for the urban rail transit station and the urban ground and underground development. The plot planning of the area within 500m around the metro station is the precondition that determining the station service ability. Study for the utilization of the underground space combined with the metro station, it usually needs regional analysis in the range of 2-2.5km. At the same time, it should pay

attention to the regional transit, the development and utilization in the area, land ownership and the reserve. Analysis the development intensity based on the distance grades in the area in order to direct the specific location and scale for the metro station and development of the underground space.

B. External plot conditions of metro station

1) *External plot conditions surrounding of metro station:* In the development of underground space of Metro station, first of all, the planning situation of surrounding land should be analyzed, and generally, it is important to plan sites for commercial and residential areas as a priority, and then the analyze the potential plots and reserve plots in commercial and residential plots so as to determine the development intention.

2) *Status conditions of the space above station:* In order to better develop and utilize the underground space, it is necessary to investigate the current development situation of the upper space of the surrounding land, analyze the development intensity and density around the site, and finally determine the arrange utilization of the underground space.

3) *Urban road and transit:* Metro stations are generally located on urban main roads with large traffic flow. At present, urban design requires metro stations to take into account underground crossing, to form a diversion of passengers and vehicles, and to alleviate traffic pressure. Thinking of the utilization of the underground space, we should consider the traffic condition of the station area, analysis the relationship between the entrance and exit passage of the site and the plots, and enhance the accessibility of site and surrounding land by using the connection of underground space

4) *Traffic connection condition:* The convenience of the underground space development and the conveyance should be analyzed in order to increasing the service value of developed land since there are parking lot, bus stop, taxi stop and bicycle stop around the stations. For the design of the metro station which is connected to the railway station and the long-distance bus station, the designer should take the precondition as the integration of underground space, and study on the traffic line relations of transport transfer hubs.

C. Metro station internal space conditions

The form of the metro station is difference according to the wire network, the line and the traffic organization conditions. There usually have certain development conditions, such as space above the wiring, sporadic space in public area, subsidiary soil space, all of which can be used. The development of

station ontology and the utilization of underground space in surrounding areas can form an organic whole.

IV. FORMS

A. Development and utilization of regional underground space

1) *Basis and main contents:* The basis of urban regional underground space development is the district. The conditions for the study are the location and planning nature of the region in the city. The developing available scope is the region in 10-15km. The design should be based on the comprehensive planning of the area to do the development and utilization from planning structure and the functional zoning, which conclude the underground space, subway, comprehensive corridor, underground parking and traffic space, pedestrian system connection, urban landscape and so on.

2) *Regional forms:* In the comprehensive utilization of regional underground space in underground rail transit, we need to considering peripheral upper planning first, and then study on the location of metro lines laid from this area, and finally, combine with site layout and distribution of potential plots for planning to finish the design. The site location should be adjusted according to the available underground space, and the underground space should be interconnected with the site location.

First, the available underground space around the station is classified according to the planning nature (commerce, public places, underground landscape, etc.). Through the pedestrian system to connect with the station, and according to the urban traffic organization, a certain number of underground parking lots are set up to meet the service needs of large passenger flow. Next, after the scale of the above large space utilization is formed, it can continue the whole urban landscape in the underground, organize the internal landscape belt, and build the underground space ecosystem. Meanwhile, attention should be paid to the effective connection and rational co-ordination with the municipal facilities around the site, mainly to the design of the connection with the underground municipal street crossing system and the integrated design of the sponge city comprehensive corridor.

Taking the development of underground space in Xi'an as an example, the comprehensive development of underground space in Xixianfengdong New Town Central Business District relies on the integration of rail transit stations. This area has created a comprehensive development mode of regional underground space in all directions, such as subway, underground commerce, pedestrian system, three-dimensional transportation, landscape design, etc., in order to create the concept of

three-dimensional city in Xixian New Area, to create a brand-new urban underground landscape environment, and to promote the new development of regional economy in the future ("Fig. 2").



Fig. 2. Regional development schematic map of Fengdong New Town.

B. Development and utilization of block-type underground space

For the study of the block-type underground space, its research scope is usually 5km, its research basis is the long-term planning and renovation intention of whole block, and its research form is several blocks in series, generally, the layout of space is narrow and long. Since the developing region of the block-type underground space is limited, the overall consideration of rail transit stations becomes even more important. Gathering passenger flow in metro station enhances the accessibility of scattered underground space in the block and increases the flow of people. The introduction of metro stations is an important auxiliary means for the development of block-type underground space. The vertical relationship of station, development layer and landscape layer can be considered in space utilization, and the layout and development mode of station can be combined.

The main problems to be solved in the development of block-type underground space are to take the community as the center, improve the service level of the city, improve the working, production and living environment of the old blocks, and enhance the community ecosystem environment.

Taking the comprehensive reconstruction project of Xi'an Happy Forest Belt as an example, "Happy Forest Belt" is located in the Eastern Military Industrial Zone of Xi'an city. Its origin can be traced back to 1953, when it was designed by urban planning experts of the former Soviet Union, and its main function is to act as a protective isolation zone between industrial and residential areas, with a total length of 5.4 kilometers and a width of 140 meters. The underground space planning of the project includes business, pedestrian corridor, subway hall floor, sunken square and other crowds gathering space, which are mainly located on the ground floor. The garage and subway platform layers are mainly located on the second floor of the underground, and the comprehensive pipe corridor is mainly located on both sides of the forest belt, which is located on the 2-3 floor of the underground. This renovation project is a measure to build "forest city" and "sponge city" and improve the ecological status of the city. After the completion of the project, the living environment of the old industrial zone will be improved, and the construction of "Happy Forest Belt" will be taken as the starting point to achieve the goal of promoting economic development and regional industrial transformation ("Fig. 3").



Fig. 3. Diagram of underground space development in Xi'an "Happy Forest Belt".

C. Traffic organization connection

1) *Connection of station passage and surrounding underground space:* Generally, the station has a main entrance and exit in the surrounding areas, while the other auxiliary entrances and exits increase or decrease according to the passenger flow. With the improvement of urban design requirements, the accessibility between station entrance and exit corridors and surrounding areas is more demanding. The entrance and exit corridors are no longer solely used as passenger entrances and exits, but are gradually transformed into pedestrian access for citizens to cross the street and travel. When there are large commercial complexes, sunken squares and underground parking lots around the station, the subway entrance and exit corridor can be connected with its underground space, and passengers can reach it without leaving the station,

which not only achieves the effect of diverting ground traffic, but also increases the convenience of service. For example, the underground passageway design of East Tsim Sha Tsui and Tsim Sha Tsui Transfer Station of Hong Kong Metro, which connects more than ten blocks of commercial underground space, and sets up about 12 ground entrances and exits in each plot, effectively utilizes the continuous pedestrian system of underground space organization and improves the land use rate.

2) *Underground connection of station with high-speed railway, passenger station and airport:* The terminal station of a metro station often transfers with other modes of transportation, such as high-speed railway station, long-distance passenger station and airport. The transfer passenger flow organization should maximize to achieve "zero-distance transfer". That is, in the overall underground space layout, the transfer between the exit hall of a metro station and the entry hall of a high-speed railway station, long-distance passenger station and airport terminal hall should be considered. When the station is limited by the buried depth, it cannot reach the same level transfer. It should consider setting up a shared transfer hall underground to organize vertical traffic transfer, so as to shorten the walking distance as far as possible.

There are two types of transfer organization forms, parallel zero distance transfer organization and vertical space traffic transfer organization.

Parallel zero distance transfer organization, taking textile city station of Xi'an Metro Line 1 as an example. It is located in the New Business Circle of Textile City in eastern of Xi'an City, it is the transfer station of line one, line six and line nine. In 2038, the early peak passenger flow of Line 1 will be 21,420 people per hour. After the completion and operation of Line 6 and Lintong, the long-term early peak passenger flow will reach more than 50,000 passengers per hour, and the third-line passenger flow will reach 15,870 people per hour. The gathering and distributing passenger flow will be very large. The hall of the station is connected with the ticket-selling and waiting hall on the ground floor of Chengdong Long-distance Passenger Station. Metro passengers can transfer to long-distance buses directly only in the basement, thus realizing the seamless connection and zero transfer between the public area of the subway station and the waiting hall of the passenger station ("Fig. 4").

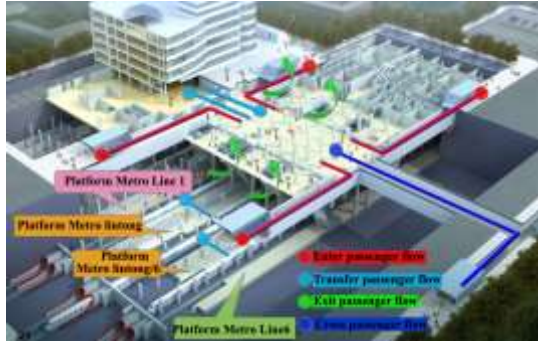


Fig. 4. Schematic map of underground floor of long-distance passenger transfer at Textile City Station.

3) Vertical space traffic transfer organization, taking North Passenger Station of Xi'an Metro line 2 as an example: North Passenger Station of Xi'an is a modern super-large transport hub which integrates railway, urban rail and urban road traffic transfer functions. The north-south corridor with large scale and the middle and lower part of the railway station yard is more than 460m long, the transportation transfer and connection organization system is complex. Because the railway station is more than 460m long from north



Fig. 5. Transfer schematic map of Xi'an North Railway Station.

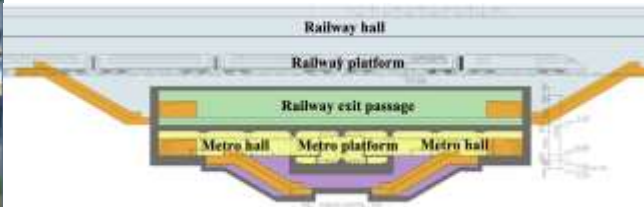
D. Other forms of development and utilization

In addition to the development and utilization of large-scale underground space such as the areas, blocks and so on, for the metro station body of the new urban traffic artery, it also contains a variety of internal development and utilization.

1) Utilization of internal space of metro station: Metro stations generally use the edge space of the non-paid area in the public area of the station to set up a number of scattered shops, each with an area of about 20-30m². They can also use the entrance and exit passages to set up development space, so as to make full use of the soil space.

According to the conditions of metro distribution, a large area of station development space can be integrated in the station distribution area, so as to improve the utilization rate of the spare area of the station.

to south, both sides of the station are equipped with station buildings and squares in front of the station. Through full research, analysis and demonstration of various lines and stations, the station scheme of the metro station positioned directly below the passenger station yard is adopted, which is the most convenient for transfer and better links up with the traffic facilities of the squares on both sides. In combination with the passenger dedicated station building, a 96-metre-wide comprehensive transportation hall is set up in the metro station hall combined with the passenger dedicated exit passage, which is divided into three distinct functional zones along the longitudinal direction: the outermost two sides of the national railway exit passage, the middle two sides of the municipal passage connecting the north and south square, the middle of which is the metro payment area, and the parties. The zoning of passenger flow is clear, forming a three-dimensional vertical traffic connection mode of high-speed railway station on the top and metro station hall and platform on the bottom ("Fig. 5").



According to the buried depth condition of Metro station, the station can be developed by using other layers and interlayer space besides hall, platform and equipment layer.

2) Reserved combination conditions for metro stations: Starting from the overall planning of the city, when there are existing vacancies around the metro station and commercial land is reserved, the connecting conditions between the metro station and the long-term commercial and underground space should be reserved at the appropriate location of the entrance and exit passages.

For the development of the whole floor of the Metro station, the connecting conditions between the reserved development floor and the long-term surrounding underground space can be considered.

V. CONCLUSION

With development of the underground rail transit, exploration of the underground space has become the hot spot in urban design. Taking the metro station as the core, the components are three-dimensional traffic, interconnected with surrounding projects has become a new concept of comprehensive utilization of rail transit and underground space. The development of the underground space comprehensive utilization will certainly comprehensive development with subway construction as the core turn into the comprehensive planning based on urban design. This model will realize the integration of urban over-ground and underground space, transportation organization, underground service space and urban landscape ecosystem, and it will consider the cohesion of all parts in an overall way but single function model, so as to improving the comprehensive benefits.

References

- [1] Chu Dongzhu, Gu Zhengrong. Analysis on the Formation and Development of Underground Space between Urban Rail Transit Stations. *South Architecture*, 2018,05.
- [2] Fan Wenli. The Trend of Underground Space of Modern City: Integrating Subordinate Underground Space into City Space [J]. *International Urban Planning*, 2007(6): 53-57.
- [3] Chen Zhilong. Blue paper on Urban Underground Space Development in China. Press of Tongji University, 2016.
- [4] Zhang Jianjun, Li Tingrui, Guo Yuan, Han Peng, Xu Xiaoni. Elementary analysis on the land use of urban underground space [J]. *China Highway*, 2018, 35(10).
- [5] Ma Zhongzheng, Guo Sicheng. Development and utilization of underground space in Shanghai rail transit line 14 project [J]. *China Highway*, 2018, 20.
- [6] Wang Yang, Zhao Jingwei, Peng Fangle. Urban rail station underground space development control [J]. *Planners*, 2014, 70-75.