

RELATION BETWEEN THE MRT BUILDING AND UNDERGROUND SPACE EXPLOITATION —A Case in Guangzhou City

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ABSTRACT: On the basis of analyzing the history and characteristics of the underground space exploitation and the urban space development in Guangzhou, and making a thorough study on the underground space exploitation based on the subway building, this paper points out some main problems in the exploitation of underground space in Guangzhou, and emphasizes that Guangzhou must develop the underground space on a large scale with the aid of the subway building, and puts forward a proposal on the urban space coordinate development between on-ground and underground in Guangzhou City.

KEY WORDS: Metro Rail Transit (MRT); underground space; Guangzhou City

CLC number: TU984.191

Document code: A

Article ID:1002-0063(2003)04-0364-06

The human developmental history reveals that man has never neglected exploiting the underground space, from the primitive 'cave living' to the 'underground village' in Maternata of Tunis, from the subsided 'cave dwelling' in the northwest of China to the present 'underground city'. The underground space has been exploited widely and deeply.

The widespread utilization of the urban underground space took place after the beginning of industrial revolutions and urbanization. Due to series of problems on urban development resulted from the over concentration of population and industry, cities have to seek a wider space for further new development. The exploitation of the urban underground space provides man with a new living space, and meets the space requirement that cannot be realized on the ground.

In Guangzhou, the superiority of speed of the MRT (Metro Rail Transit) makes people feel the great glamour of the underground world. And therefore, how to exploit the underground space in Guangzhou has become a heated subject.

The urban underground exploitation roughly includes traffic space, commerce and recreation space, business space, logistics space, manufacture space and storehouse space, etc. In this paper, we regard the traffic space, commerce and recreation space as the main object of study.

1 PROCESS AND FUNCTIONAL CHARACTERISTICS OF UNDERGROUND SPACE EXPLOITATION IN GUANGZHOU

1.1 Background of Underground Space Exploitation

1.1.1 Requirement of the urban space development

Many experts hold that the space scale of a city is closely related to the developmental level of the communication. The best radius of a city equals a distance that man can reach within an hour (TREFIL, 2000). In the recent twenty years, the built-up area in Guangzhou has been enlarging rapidly. Before 1966, it was only 54km² (including four districts: Liwan, Yuexiu, Haizhu and Dongshan). It had increased to 136km² by 1987

Received date: 2003-01-23

Foundation item: Under the auspices of the National Natural Science Foundation of China (No. 40071034) and Natural Science Fund of Guangdong Province (No. 980268)

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(with three more districts: Fangcun, Tianhe and Huangpu Economic Development Zone). After the 1990s, the urban area has covered Baiyun District and the whole Huangpu District. And in 1995, the built-up area reached 259km². At the end of 2000, Panyu and Huadu two cities acceded to Guangzhou City, becoming two districts of Guangzhou. As a result, the built-up area has extended to 3718km² (Guangzhou Statistical Bureau, 1987–2000). The expanding city space requires an improved communication to shorten the traffic time.

Meanwhile, the space characteristic of zonal clusters makes a huge pressure of traffic in the center cluster, and causes a serious block on the town roads. Therefore, it is far from enough to strengthen the functional ties among groups of the city just by a few main lines. But, the densely exploitation of the town land in the center area makes it almost impossible to extend traffic land. So, other ways have to be found. Only by tapping the latent road capacity, improving the traffic structure and developing the underground public communication with large capacity and fast speed can it be possible to reduce the traffic block on the ground, and help to develop the external space in city.

1.1.2 Motive force of development of urban economy

It requires large funds as the motive force for developing the urban underground space. According to preliminary statistics, in 2000, Guangzhou's gross domestic product (GDP) per person was about 34.5×10^3 yuan (RMB), being US\$4175 by the national average exchange rate (Guangzhou Statistical Bureau, 2001). According to the experiences of developed countries, a subway times begins when the GDP per person amounts to US\$1000 (WANG, 2000). So Guangzhou is economically qualified for developing underground space on a large scale. The way of raising funds with various channels including financial allocation, overseas loans and the combined development along the subway lines, which has succeeded in No.1 subway and No.2 subway building, has rendered rich experience and effective model for further MRT development.

1.1.3 Drive force of MRT development

Whether the urban underground space building will become a network or not depends on the MRT (WANG, 2000). It is clear that, the MRT is the most active factor in the underground space. The road building in Guangzhou in the future will give the first place to the exploitation of the underground space. It has planned to build 99 tunnels and 7 metro lines by 2010. And we can foresee that Guangzhou will come into a new development age of underground space ex-

ploitation.

In the urban underground space planning, MRT is not only functional, but also plays an important role in shaping the space. For example, No.2 subway, No.3 subway and No.4 subway have changed the line's run in order to adapt the new planning of the urban development, thereby guide the city to extend to the east and the south. Therefore, Guangzhou must timely and rationally plan the exploitation of underground space with the aid of developing subway, so as to create an underground network with the subway as a framework, commercial town as a joint, and city plaza as a region.

1.2 Process and Functional Characteristics of Urban Underground Space Exploitation

1.2.1 Process of underground space exploitation

The early utilization of underground space in Guangzhou was mainly in form of civil air defense works on a small scale. After 1978, with the development of transportation, traffic tunnels began to come into being. For example, Ouzhuang Bridge with four stories, the first subsided grade separation bridge in China was built in 1983; later, many grade separation bridges and tunnels were built one after another. Over 5 pedestrian tunnels had been built by the end of 1987. In addition, the underground piping began to be constructed. Besides water supply and drainage pipelines, the communication lines, gas pipelines and optical cables etc., were built too. The building of basements—a structural characteristic of high buildings forms a new upsurge in underground space developing. But the underground exploitation is not paid enough attention to. More than 100 overpasses and 15 overhead roads were built in the 1990s, and only 1 pedestrian tunnel and 2 traffic tunnels were built in the same time. The underground space did not put into large-scale exploitation until the MRT was opened to traffic. No.1 subway in Guangzhou was put into use on June 28, 1999. The No. 2 subway began to be built in 2000. And the really upsurge in underground space developing set in till then. Only in 2001, 9 pedestrian tunnels and 6 traffic tunnels were built, and the No. 3 and 4 subways were planned. Up to now, all these convert the developing model in underground space from spot and small-scale linear construction into axis construction.

1.2.2 Functional distribution of underground space exploitation

The early civil air defense works were built for dis-

persing the people in the war. After the 1980s, underground projects were made not only for piping and pedestrian tunnels, but also for parking area, storehouses and markets under the buildings. In recent years, most basements were built underground to content with the increasing requirement of business, parking and other public installation. But, the underground spaces opened up in different periods were arranged in a decentralized way, without communication with each other.

The construction of urban subway, not only integrates the new area with the old ones between the east and the west of the city, but also links the south with the north of the Zhujiang(Pearl) River. So, the underground space is not a narrow and small area. When the network spreads in the underground, it builds up the connection within the city and among cities, even countries, showing the charm of the underground space.

2 PROBLEMS IN EXPLOITATION OF UNDERGROUND SPACE IN GUANGZHOU

At present, the exploitation of the underground space in Guangzhou lays particular emphasis on running business. It fails in exerting the modernized comprehensive function under the town, such as traffic, public installation, storehouse and waste material disposal etc. In an all-round way, Guangzhou still has a long way to go in exploiting the underground space when compared with the advanced areas in the world. The main reasons are as follows:

2.1 Unclear Dominant Ideas

Since there is not a department to unify the management of the exploitation of the underground space, it is common practice that whoever undertakes the exploitation will benefit from it, and thus manage it. As a result, there exists a phenomenon that the underground space exploiting did not go with the urban development. Firstly, neither the importance of the underground space exploiting, nor the large bearing capacity of the underground space for the crowded city has been fully recognized. Secondly, the underground space has been exploited blindly. For example, while the exploitation of underground space is widespread now, the basements built by different property traders are not uniform, neither in structure nor in number of floors. This will create a large problem in building a tunnel to link up every basement in the future.

2.2 Lagged Planning

The other problems existing in underground space exploitation are lack of scientific planning and absonant with the urban construction. The town function of the underground space should be realized by means of unified planning, which combines transport system, public installation system, anti-calamity system, goods reserving system and resources recycling system etc. Among these, the transport system under the ground will be the most active factor in the underground space. Now, although the Construction Committee of Guangzhou City has put the planning of 'The Underground Exploitation in Guangzhou' on the order of the day; the No. 1 subway has been built; the No. 2 subway will be finished soon; and the No. 3 subway is being explored, the planning of the 'Underground City' in Guangzhou has not designed yet. In that case, the exploiting of the underground space in Guangzhou will encounter disorder and reconstruction.

2.3 Isolated Exploitation and Single Function

With the rapid increasing of tall buildings, basements have appeared in plenty. At present, the underground space in Guangzhou is utilized mainly for business, but there is neither commercial street nor public plaza to link them together. Such isolated exploitation cannot bring a scale effect but cause the usable space to decrease enormously under ground; finally, great waste of the space resources and serious destruction of the environment will be brought about. Nowadays, another two subways—Huangpu motor vehicle tunnel and the Zhujiang River tunnel have been built, but they do not contact with each other, hence a network cannot be formed and the underground space cannot be exploited comprehensively by joints, which leads to single and less effective utilization.

2.4 No Network among the Transportations on the Ground and Under the Ground

On the one hand, the overlapping of the No.1 subway and the road on the ground is very great. The overlapping coefficient of the whole course of Zhongshan Road is 16.72, of which the coefficient of the patial course from Nonglinxia Road to Dongchuan Road is 34.00 in 1999(ZHANG, 2000). There are at least 54 bus lines overlapping over three parts with the No. 1 subway. This results in serious waste of the traffic resources and difficulties in the communication organi-

zation. On the other hand, some subway stations hardly have any bus lines above, or the distance between the subway station and bus station is too far, or the parking area is insufficient, which has prevented people from taking the subway. According to calculation, 66% of the people went to take the subway on foot, 16% by bus, 7% by taxi, and 1% by bike (ZHANG, 2000). This shows that most subway passengers are the residents nearby. Because there is not a network to link up the communication on the ground and under the ground, further traffic jam and heavy losses in the subway revenue are caused.

3 UNDERGROUND SPACE EXPLOITATION BASED ON SUBWAY BUILDING

3.1 Relations of the Formation Distribution between the Underground Space and On-ground Space

As an important part of underground space exploitation, the subway construction must be synchronized with the urban development. Following the building and running of the No.1 subway and the No.2 subway in Guangzhou, the urban area has extended easterly as planned. It is outstandingly shown in the abrupt rise-up of real estate market in Tianhe District and the eastern Haizhu District. Moreover, in order to adapt to the development of the city, the No.3 subway planned to run from the east to the west has been adjusted to run from the south to the north, and the No. 4 subway has been planned to be situated in the eastern part running from the south to the north, so as to guide the urban area to extend to the southern part rapidly.

3.2 Planning of the Underground Space Exploitation

The urban underground space exploitation must be closely integrated with the urban buildings and the civil air defense works, so as to exploit the city joint zones comprehensively, and form an underground synthesis. It would become an underground space network with the node building, range building, axis and network building.

3.2.1 Building by node

The dotted formation is a basic factor that forms the shape of the underground space. It bodies the urban function that extends to the underground, and is the most complicated part of the underground space functions. The building of the subways provides Guangzhou with a great opportunity to exploit its underground space. Taking advantage of the arrangement of

the traffic stations, a large number of markets, entertainment installations and parking areas are built in the station building or linked with the stations by verandas. In this way, while they can benefit from the stream of the subway passengers, they can provide the subway with stream of passengers and convenient transition. For instance, great majority of the stations of the No.1 subway has succeeded in a comprehensive utilization of the underground space, which forms a hub of public transport, subway station, underground business streets, civil air defense works and estate development. It is clear that, the city's underground space must be planned and exploited along the subway line. But, such dotted exploiting under ground can only supply subsidiary function for the city; but not affect the shape or character of the city.

3.2.2 Range building

The range of the underground space is a sign that the formation of town underground space is getting ripe and perfect, is the inevitable outcome when the underground space has developed to a certain stage, and is the objective law of urban land use and development (WANG, 2000). But in Guangzhou, the range development under the ground is still a weak link. So, it must be planned as quickly as possible.

The range building under the ground is mainly referred to the urban subsidence plaza, which can not only avoid the traffic disturbance on the ground and introduce a new function to the city, but also strengthen the connection of the space onground and underground and improve the urban environment. Viewing on the present conditions in Guangzhou, the following kinds of the subsidence plaza may be given priority to be developed.

(1) A plaza of historical and cultural legacies. Legacies of history and culture can fully represent the process of history development, and it is an area under protection in the city rebuilding. Taking Beijing Road as an example, it had been a busy commercial street that amassed vast businessmen and stores since the Sui and Tang dynasties and a developmental axis of the ancient city of Guangzhou. Even nowadays, it remains a hub of public transport either on the ground or underground. So, Beijing Road can use the experience of the Jing'an underground space exploitation in Shanghai City for reference, and it may be planned to be a urban space plaza with a multifunction of central business district (CBD), communication, tourism, and relaxation, etc.

(2) An urban center plaza. The urban center is an area where underground space as a range can form easily. As an assistant center and a developing area in

Guangzhou, Tianhe District amasses tens of units with high population density, such as large-scale commercial district, residential district, study and entertainment center and superior offices etc. In addition, with the No. 1 subway and the No. 3 subway passing through, Tianhe District has the advantage of both the dense exploitation of land and subway building. Therefore, when the Tianhe underground plaza is built, it will gain a broader developmental space and represent its function as a new city center.

(3) A commercial and touring plaza. The commercial and touring district in the city is mostly located in the 'Three High' area (high population density, high building density, high traffic density). For example, Shangjiu Road and Xiajiu Road in Liwan District are famous commercial streets, which are closed to vehicular traffic, and the major protection areas of historical relics in Guangzhou, because of the nearby buildings with arcades and Xiguan big houses that have the features of South China of the Five Ridges architecture. So, if the commerce and traffic can be introduced to the underground, tourist attractions and buildings on the ground can be linked up through the underground streets, a commercial and touring plaza would be formed. In this side, the underground Bell-drum Tower in Xi'an would be the example for the exploitation.

(4) A key traffic square. A key traffic zone is always thrown into chaos because the traffic lines are level crossing. For example, Haizhu Square is traffic intersect which mixed functions of water communication, land communication, underground communication, and a walking street. So, Haizhu Square should be exploited three-dimensionally based on the underground traffic construction, so as to reduce the block to the rate and safety of traffic caused by the forks. At the same time, an afforested square embellished with various gates to the underground, which is naturally distributed and featured with South China view, can be built near the Pearl River.

(5) A comprehensively developing plaza. For some areas being planned, overall consideration should be given to the comprehensive exploitation of its space. For example, Pazhou, where the Conference and Exhibition Center is under construction, and where the starting station of the No. 2 subway and one of the stations of the No. 4 subway are located. With ditches and canals crisscrossing, it is an area suitable for three-dimensional development. So, if it can be planned and built into a urban plaza in a stereoscopic way which combines the peripheral ground with un-

derground space development, it will be able to hold and attract passengers better, and will be developed to be a recreational business district (RBD) and ecotype new city center that have both high quality living function and leading function of meeting and exhibition, international business, information exchange, high and new technique, touring service.

3.2.3 Axis and network building

An urban plaza can only attract passengers to underground temporarily. Once the passengers have fulfilled their purposes of going underground, they will return to the ground and make a jam again. But if the movement can be realized under ground, the comprehensive benefit of the underground space will be really reflected. The subways built in Guangzhou make it possible to exploit the underground space in the way of forming an axis and a network. The subway realizes the purpose that a large number of people move underground. The No. 1 subway attracts more than 200×10^3 persons per day, makes 5% of the public traffic passengers move underground (ZHANG, 2000). In addition, the distribution and network effect of the No. 2 and No. 3 subways will attract much more passengers. Therefore, the condition of traffic-jams on the ground will be released tremendously.

Secondly, the basement streets, which play the linking role in large-scale city plaza development, are the important part in the network construction. The commercial streets, the exhibition aisles and the open space in the basement along the line, not only act as a tunnel passage connecting the buildings, but also reflect the characteristics of city streets. Thus, the basement becomes a place for social communication, which strengthens its attraction to the passengers and becomes an essential part of the underground space network.

It is thus clear that the formation of the underground space network is based on the setting up of the subway traffic system. So, the construction of the underground city in Guangzhou must closely rely on the subway, thus to establish an underground stereoscopic network on the basis of the subway as an axis, the built and building subways as a framework, the urban space plaza as a joint, the basement street as a vein.

4 PROBLEMS WARRANTING NOTICE IN THE UNDERGROUND SPACE DEVELOPMENT

The exploitation of the urban underground space by means of building the subway, urban plaza, commercial street, parking area and setting up municipal facili-

ties will lead to the strengthening of an accessible and convenient regional communication. In the key traffic areas, it not only enhances the gathering of the person flow, goods flow, finance and commerce, but also speeds up the forming and development of the city center area, and increases the efficiency and quality of the whole city. But owing to the long planning and construction circle, the huge investment, and the irreversibility of the construction, the exploitation of underground city must be planned over a long-term view. The concrete developmental strategies are as following.

(1) Multi-pattern exploitation. The underground space building generally includes transportation system, public building system, municipal facilities system and anti-calamity system. According to the environmental characteristics of Guangzhou, the underground space exploitation can be divided into several patterns: station squares, city plazas, CBDs, commercial streets, road crossings, scenic spots, protected buildings, high buildings, residential quarters, discarded space, etc. The underground space should be exploited according to the different characteristics of the patterns, thus obtaining the best utilization.

(2) Determination of exploitable system and region with priority. When exploiting the underground space, priority should be given to the systems and regions with more problems or in large demand. The city center, having great problem caused by the contradiction between land supply and demand is a priority in recent underground space exploitation and an area of great attraction for development. So, to fulfill the requirement of its ground function, the underground exploitation in city center should be focused on solving the traffic problem and opening up the spaces of commerce, entertainment, parking etc., protecting the city of historical and cultural features, improving the environment of the central area.

As for each large cluster outside the city center of Guangzhou, the development in the eastern cluster is guided with the high-tech industry, together with industry, port transportation, store housing, recreation and tourism, featured agriculture, etc. Since it is of lower population density, it does not require a large-scale exploitation of underground space recently. The building of large storehouses may be planned. The southern cluster taking the advantage of the No. 3 subway, the No. 4 subway and the city expressway, will be exploited to be a multifunctional central area and external trade processing area with the residential quarters, rest and vacation spots, tourism and business sections, new industry districts. So, it may open up directly the park-

ing area and entertainment quarter under the ground while the large buildings are built on the ground. At the same time, it may adequately build some storehouses and markets, and build up communicative stations in the buildings along the subway line, so as to improve the housing environment. For the northern cluster, its major task is to strengthen the key traffic and the ecological protective function. So, apart from building a subway to link the new international airport with the railway station, the underground space exploitation should be aimed at protecting the ecological environment and perfecting the traffic facilities.

(3) Coordinated development of urban space underground and on-ground. In the past, man recognized the urban space on a two-dimensional level. The land exploitation was only on the ground, which brought about unfavorable influences on the underground space building. Nowadays, many cities have put forward the idea to open up the underground space and build up an underground city, but they itch to move the whole city to the underground space all at once because of lack of knowledge about the relation between the underground space and on-ground space. So, in order to coordinate the development of the on-ground and underground space, we must first unite our recognition and renew the idea. On the one hand, we must be fully aware of the crisis which the city space are facing, realize that the stereoscopic development of the urban space is the only way to resolve the city problems and assure the city to develop in a sustainable way. On the other hand, we must fully recognize that, as a complemented and extended part of the land space, the underground space is the base of the development of the land space. The on-ground and underground space is an organic entirety. They cannot be developed independently.

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