Urban Underground Road and Urban CBD Traffic -
Underground #-shaped Corridor in CBD Core Area of Shanghai

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ABSTRACT

This paper analyzes the general situation of the urban underground traffic development and points out, that underground roads are an important way to improve urban CBD traffic and environment. Taking Shanghai CBD as example, it analyzes the present status, requirements in future and existing problems of the traffic in Shanghai CBD core area, and defines planning object and function orientation of the traffic in Shanghai CBD core area. Moreover it puts forward the overall layout and corridor scheme of underground #-shaped corridor, which provides the useful reference for the development of underground road system of other cities.

1. INTRODUCTION

Traffic is the most active factor in urban function. It is the most important key for a sustainable development of a city. Since entering 21st century, the population of China is rushing to cities rapidly, and economic and cultural activities of city residents are more active. Under the guiding of the state industrial policy and the enhancement of city residents’ life level, the number of private vehicles and the number of travel are greatly increasing. It requires that the modern cities must have enough traffic space for development. Being limited by conditions of land resource, environment protection, etc., the ground traffic of city is faced with the extremity of development. The contradiction of vehicles and roads, especially in urban CBD areas, is the major problem almost puzzling the traffic development of all modern cities. Therefore, to find underground space is one of the important models for the future urban traffic development.

As for the development of underground space, underground traffic is one of the core functions for the development of urban underground space. The development utilization of the underground space mainly by the functional level of underground traffic and the functional level of underground environment will be the core to construct the urban underground space in 21st century.

2. URBAN UNDERGROUND TRAFFIC DEVELOPMENT STATUS

2.1 Concept of urban underground traffic

So called urban underground traffic space is the space of underground traffic system and net formed by underground construction in series of traffic facilities in the city. Its function has following 3 aspects:
Underground pavement space - It is built for public walk. Many pavements are constructed to be a walk system. It has 2 forms: underground pedestrian walk and underground pedestrian crosswalk. Generally speaking, underground pedestrian walk is an underground shopping street, and the crosswalk is the simple function of underground traffic facilities for pedestrians. Underground railway traffic system space - facilities of metro, urban railway, light railway, etc. Since the first metro in the world was built in the sixties of 19th century, it solved the problem of large amount of pedestrian flow. The metro has a large transportation capacity. The single way passenger flow that the metro can transport is 30-60 thousand persons / times at a peak hour. Even a light railway can transport a single way passenger flow 10-30 thousand persons / times at peak hour. Underground vehicle traffic system space - including underground road and parking lots, etc. In the development of underground traffic, the underground road system and railway system play a very important roll in a comprehensive urban underground traffic system, because of their systemization and great effect.

2.2 Metro

A metro is an underground railway, meaning the underground railway traffic system shuttling between a city and the suburb. Generally speaking, development and utilization of modern metro began after the industrial revolution. The symbol is the construction of the first metro in London in 1863 in the world. In the later 140 years, metros were built all over the world. Up to now, metros have been built in approximately 100 cities in the world. They are all under operation. The metro construction and development greatly influence on modern cities. The speed of this railway traffic facility is 2-3 times than that of bus, and the capacity is 3-4 time of the bus. It has advantages of large capacity, high speed, low pollution, low energy cost, good safety, being punctual, etc. It is one of most important measures to solve traffic problems for large cities. Metro also has many advantages, such as little or less ground area occupation, land saving, environment protection, disaster protection, vertical separation from ground traffic system. It forms an urban traffic system of solid and multi-layer. It increases greatly the efficiency of various modern traffic tools. Nowadays, many metropolises have successful railway traffic designing experiences. Therefore, the research of railway traffic design has many references.

2.3 Urban underground road

Although rail traffic facility can meet most public traffic demand and attract passengers from private cars and decrease car flow, the time efficiency, the flexibility and easiness of private car are better than that of rail traffic tools. Therefore, it is unable to satisfy all individual demand of vehicle running. Because urban ground resource is limited and viaducts may produce many environment problems, the underground road, as a rapid traffic tool, is demonstrating more and more advantages. For this reason, underground road had become a hot topic of study and practice since 20th century. People pay more and more attention to underground road system. The CA/T project in Boston, USA, Cross City Tunnel (CCT) in Sidney, Australia, etc are built to release traffic jam and to protect environment. Generally speaking, underground road has 2 types - single line and multi-line system. Single line underground road has 2 ends, one entrance and one exit. This type is popularly applied, such as crossing river tunnels in Shanghai, Nanjing Xuanwu Tunnel, etc. The multi-line underground road system is studied very well, but less practiced, such as SERS in Singapore, Laser, Muse plan in France, etc. Shanghai Municipal Engineering Design General Institute has undertaken this study and research. Considering traffic jam in core area of Shanghai CBD and environment, it presents #-shaped corridor scheme and has put it into practice. Taking this scheme as example, this paper explains the underground road function to solve urban traffic and environmental problems.
3. EVALUATION OF SHANGHAI CBD TRAFFIC STATUS

Shanghai CBD area is in the center of the city, at the cross of Huangpu River and Suzhou River. Waitan, a traditional finance and trade area, is in its southwest. Lujiazui, the newly built finance and trade area, is in its south. North Waitan, which is gradually changing its function, is in the north. These 3 strong economic areas form the golden delta of Shanghai CBD core area. These 3 areas are separated by Huangpu River and Suzhou River. This river confluence demonstrates a beautiful metropolis scene and makes a charming CBD sight. But, it influences the communication among these areas, and makes it difficult to have an area arrangement, to realize function cooperation and mutual support. It is a key to harmonize the relationship between traffic demand and function development, and the relationship between the traffic construction and the area environment for realizing a sustainable development of a core area. The main problems are as follows:

(1) The net structure of trunk road in the core area is not complete. The Pudong section of Inner Ring Elevated Road fails to act its ring function. The Yanan Road Elevated Road ends at Pudong and Puxi core areas. There are not enough north-south direction trunks, especially in east area in the city. The trunks in Pudong and Puxi have not formed a complete system.

(2) Large amount of passing vehicles crosses the core area. The passing vehicles in Waitan occupy 70% of the vehicle quantity on the road, while that in Yanan Road Tunnel occupies 50%, and that in North Waitan occupies 50～65%. For this reason, the destination vehicles and local vehicles are greatly affected and the local environment is therefore influenced.

(3) The layout of road net in the core area is not reasonable. The Yanan Road Tunnel, connecting Century Avenue, crosses the Pudong road net, and the all south-north direction roads in North Waitan end at the mouth of Suzhou River and Waitan. This produces a bottle neck traffic pressure. The roads of east-west directions concentrate like a horn to the west. It makes problems in this area.

(4) The capacity of river crossing facility is not enough. Up to now, there is only one tunnel, Yanan Road Tunnel, crossing the river. It is a double direction 4-lane tunnel. It should bare the pressure of traffic from Yanan Road elevated Road and Waitan to connect the Pudong area. It fails to meet the requirement of communication between Pudong and Puxi. The communication between 2 banks of Suzhou River depends on Wusong Road Gate Bridge and Waibaidu Bridge. The passing vehicles occupy as more as 70%, and the local traffic is heavily influenced.

4. SHANGHAI CBD UNDERGROUND ROAD SYSTEM SCHEME

4.1 Scheme object

The traffic system in the core area is very complicated, and the land and space resource are limited. So the city sight and environment requirement is very high. To improve the traffic conditions of the core area, it is to deal with the following problems: (1) relationship between traffic attraction and function development; (2) relationship among traffic construction, space resource and environment sight protection; (3) relationship among various CBD traffic structures; (4) connection between river crossing traffic and core area traffic construction; (5) relationship among traffic corridors, supporting roads and traffic management model.

The scheme object is as follows:

(1) To construct an integrated traffic facility system in core area:
The 3 areas of Waitan, Lujiazui and North Waitan have mutual support and link action possibility in function development. They have different features of buildings and space environment, and are connected closely in location. It is an integration of tripartite confrontation, which is to be the most active area in Shanghai.
The communication of trade, travel and culture among areas of Waitan, Lujiazui and North Waitan is to be closer and closer. The traffic improvement in this core area should consider these 3 areas as a whole. Basing on the whole road net, it is to plan the traffic layout and organization as a whole, to construct an integrated traffic system.
(2) To separate the passing vehicle flow from the central area. The CBD core area composed of Waitan, Lujiazui and North Waitan is in the centre of Shanghai. These 3 function areas are greatly influenced by the passing vehicle flow. The passing vehicles in Waitan occupy 70% of the vehicle quantity on the road, while that in Yananlu Tunnel occupies 50%, and that in North Waitan occupies 50-65%. Therefore, the destination vehicles and local vehicles are greatly affected and the local environment is therefore influenced.

To improve the traffic and environment conditions and environmental quality of the core area, the passing vehicle flow should be separated from the ground of the core area.

(3) To improve the destination traffic condition in the core area. As the advancing of the core area function, the effect of gathering and radiating of the core area is getting more powerful. The relationship between the core area and the road trunks should be improved to upgrade its local traffic advantage, to enlarge the function radiation scope, and to accelerate city function development.

4.2 Plan Scheme

In accordance with the plan object, after scheme selection and optimization, considering the area development and function development factors, the #-shaped corridor scheme is recommended to construct an integrated traffic system in the core area. It is summarized as a “4+2+2” scheme, as shown by Figure 1 and Table 1.

“4” means 4 completely closed or half closed corridors, serving for the destination traffic flow of core area and the passing vehicle flow, namely: east-west corridor, south-north corridor, Waitan corridor and north horizontal corridor. The first “2” means 2 river crossing tunnels to connect the core area, namely: Renmin Road Tunnel and Xinjia Road Tunnel. The second “2” mean to improve the traffic organization and relative supporting facilities of 2 core areas in Pudong and Puxi.

![Fig. 1. Overall Layout of #-shaped Road Network.](image-url)
<table>
<thead>
<tr>
<th>Road</th>
<th>Length (km)</th>
<th>Scope</th>
<th>Construction proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>West-east Corridor</td>
<td>5.6</td>
<td>4 lanes</td>
<td>To implement to the inner ring before 2010</td>
</tr>
<tr>
<td>South-north corridor</td>
<td>16.6</td>
<td>4~6 lanes</td>
<td>Under study</td>
</tr>
<tr>
<td>Waitan Corridor</td>
<td>3.3</td>
<td>4~6 lanes</td>
<td>To be completed before 2010</td>
</tr>
<tr>
<td>North horizontal corridor</td>
<td>14.0</td>
<td>4~6 lanes</td>
<td>Ground capacity is enlarged for short term, prepared for long term implement</td>
</tr>
<tr>
<td>Xinjian Road Tunnel</td>
<td>1.9</td>
<td>4 lanes</td>
<td>To be completed in end of 2008</td>
</tr>
<tr>
<td>Renmin Road Tunnel</td>
<td>2.35</td>
<td>4 lanes</td>
<td>To be completed in end of 2008</td>
</tr>
</tbody>
</table>

5. CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the analysis of Shanghai #-shaped corridor example, it is obvious that the underground road is an important way to solve problems of urban traffic jam and environment. It may optimize urban road net and improve city function. The underground corridor in CBD core area is like a bridge in city heart. It is helpful to realize function updating of CBD, to keep the lasting energy of core area’, to realize a continuous development of society, economy and environment. The detailed effect is as follows:

(1) It is to optimize and complete road net of urban core area, to reinforce traffic capacity, to increase traffic corridors, to balance the traffic load of trunks, thus to insure the city traffic reliability.
(2) It is to enhance communication in urban core areas, to provide a multi-layer communication service, to realize traffic integration.
(3) It is to follow the urban CBD development. The newly added traffic capacity may satisfy traffic requirement newly increased by area function development, and may assure CBD function updating. It is helpful to separate most of passing vehicle flow from ground to underground. It is to help a city to renew its function and sight and to assure a continuous development of the urban core area.

4.2 Suggestion

Shanghai #-shaped corridor provides a good reference and experience for other cities in solving problems of city traffic and environment by accepting underground road system. Owing to that there are not enough practices of underground road system, many problems as follows are waiting for further study:

(1) Advanced research should be made in features of underground road traffic flow. Now there is only single line corridor traffic flow feature for reference. So the special subject research in the traffic flow feature of underground road is needed.
(2) Advanced research should be made from the view of a driver, to analyze the influence of the width, headroom and side width of a lane to the vehicle velocity and capacity, and to optimize the design of the width, headroom and side width of a lane.
(3) Advanced research should be made in subjects of the interior disaster protection, and tail gas collection of the underground road needs more study.

REFERENCES

Shanghai Municipal Engineering Design General Institute, 2006. #-shaped Corridor Study Report of CBD.