

# Study on the Transfer and Connection System Design of Urban Rail Transit

Ze-Song WEI <sup>1,a,\*</sup>, Li ZHANG <sup>2,b</sup> and Xi-Ran JI <sup>3,c</sup>

<sup>1</sup>Beijing Jiaotong University, Beijing, China

<sup>2</sup>CRRC TANGSHAN CO., LTD, China

<sup>3</sup>Beijing Jiaotong University, Beijing, China

<sup>a</sup>76934311@qq.com, <sup>b</sup>sjc-zhangli1@tangche.com, <sup>c</sup>1965197208@qq.com

**Keywords:** Urban rail transit, External transport, Transfer connection.

**Abstract.** The main research of this paper is that there are three modes between urban rail transit and other means of transportation. The paper combines a large amount of practical research and data to analyze at different levels: the first one is the transfer connection between urban rail transit and urban external passenger transport, including railway, highway, aviation and water transportation, which connects urban inbound and outbound traffic; the second is the transfer between urban rail transits which can improve the rail transit coverage and convenience; and the third is the transfer connection between rail transit and other city transportation means, connect rail transit with private and conventional public transportation. The conclusion aims to give full play to the role of public and private transportation, expand the rail transit service area and service capacity, attract people, and provide "door-to-door" service for municipal transportation. Its innovation lies in the comprehensive design of transfer space to improve transfer efficiency, realize zero transfer of rail transit lines, and promote the sustainable development of rail transit system.

## The Transfer Connection between Urban Rail Transit and External Transport

The main urban external transportation means are highway, railway, airport, dock and so on. The transfer connection between urban rail transit and external transport includes connections between rail transit hub and highway station, railway station, airport terminals, docks and so on, introduce as follows.

### Connection with Railway Traffics

As the linking point for city traffic in and out, the railway station is the crucial urban transfer hub, and it's also a transfer station among urban all kinds of transportation. There is a huge flow of people transferring in railway station. It is essential to integrated underground space development and use, connect multi-floor station yards, in order to have a convenient transfer and guide the rational dispersion of people flow. There are some large transfer hubs around the world, such as Lyon station in Paris in France, Tokyo railway station, Shinjuku Station in Japan. They are all the transfer between railway station and urban rail transit through multi-floor connections. Similarly, Beijing West Railway Station in China was the first to use multi-floor transfer connection mode.

### Connection with Highway Passenger Transport Hubs

The connection between rail transit hub and bus station should ensure the accessibility. Besides, it should avoid the rail transit station and the bus station located on both sides of city main roads or expressways, otherwise it should set up special transfer channel cross the main road to ensure the safety of personnel transfer.

### Connection with Aviation Hubs

With the rapidly development of aviation transport, aviation hub also becomes a multi modes of transportation transfer node. In the completion of China's city rail transit network planning, cities like Hangzhou, Shenzhen, Qingdao, Chongqing, Chengdu planned to connect airport with urban rail

transit system, some large cities would put rail transits leading to aviation hubs as the primary consideration of city rail transit construction, in order to realize the efficient of logistics transportation. Hong Kong Airport Express line was put into operation in 1998, which is the first airport express line in China. As well as Shanghai Pudong International Airport Maglev lines, Beijing Airport Express and Guangzhou Airport Express line are all playing an important role on transporting passengers and materials.

### **Connection with Ports and Docks**

The connection between docks and rail transits is based on city main road networks and railways. Railway lines connect to the railway station, in order to be convenient to land-and-water coordinated transport. When the arrival passenger volume gets large, the rail transit and port station can be set up; when the passenger volume gets small, the rail transit station and port passenger station can be built on the same plane, connected each other with pedestrian channel.

In some coastal cities, some cities are separated by rivers, which lead to interruption of urban rail transit. In the case of unsuitable construction of bridge tunnels, ferries can be used to connect urban traffic on both sides of the rivers. Under the conditions permitting, the urban rail transit station can be built near the ferry terminal to promote the continuity of urban traffic. In Hong Kong, for example, the connection between the metro line and ferry is mainly concentrated in the vicinity of Wan Chai ferry, North Point ferry and Central ferry.

## **Transfer Modes between Urban Rail Transits**

### **Transfer Station Design Principles of Urban Rail Transit**

According to the operation characteristics of urban rail transit, urban rail transit stations can be divided into several modes which are terminal stations, intermediate stations and transfer stations. The transfer station is to ensure passengers transference from one line to another line, and it should also provide passengers with convenient facilities from one line's platform to another line's platform besides escalators. The transfer time depends on the horizontal and vertical distance between the two platforms, and the distance depends on the spatial layout of the transfer hub. Based on this, the design of transfer station should follow the following principles.

- (1) Be explicit about transfer routes, shorten the transfer distance, make it convenient for passengers' fast transfer.
- (2) Avoiding height loss, and reducing transfer height.
- (3) Separating entering and leaving passengers flow from transfer passengers flow, avoiding disturbing each other.
- (4) The transfer facilities should be in accordance with the needs of the transfer passengers, and some open space should be reserved which would be convenient to be modified and extended.
- (5) The transfer modes and forms should be carefully considered, meanwhile, the location of transfer channels and reserved space should be determined reasonably.
- (6) The transfer channels length shouldn't exceed 100 meters; otherwise, excessive ones should be equipped with automatic walkways.
- (7) Try best to save the project cost and be avoiding excessive expenses.

### **The Internal Transfer modes of Urban Rail Transit Hubs**

The transfer station is the interwoven node of each line in the urban rail transit network. It provides channel facilities for the passengers in the station to complete the connection between the two stations and achieve the purpose of transfer. The basic internal transfer modes of urban rail transit hubs include platform transfer; hall transfer, node transfer, channel transfer, outside station transfer and multi-mode transfer.

#### ***Platform Transfer***

Platform transfer is an ideal transfer mode which has shortest transfer distance, no transfer height loss, convenient and efficient for passengers' transfer. There are several types: one is the transfer on the

same platform which passengers on the same platform can complete the transfer line, passengers only need to walk to the other side of the station platform to complete the transfer of another train line. It is the best solution for passengers when the passenger volume is large. Another type is passengers on one station platform moving to other platforms by escalators or underground passages which needs spacious enough space on transfer escalators in order to avoid passengers piled up and threaten the safety of passengers.

### ***Hall Transfer***

The hall transfer refers to passengers go to target station hall or shared hall of the two stations by escalators, and then go to the target platform. The station hall is the necessary place of exiting and transferring. When passengers get the station hall, they can find out the exit or go to another platform to take trains according to the station hall's guide signs. At the same time, because that passenger got off the train walk in on direction, the platform cross flow decreases, the time passengers stay on the platform becomes short. Based on this, the effective usable area of platform can be increased, and it's better to control the width of platform scale.

### ***Node Transfer***

At the intersection of the two lines, the overlap part of the two lines tunnel constitutes the whole node, connecting the two station platforms through the stairs, which is convenient for passengers to pass through the escalator, and the height difference of the transfer is generally 5-6 meters. Therefore, it is also easy to transfer. According to the location of crossing points between two lines, there are three kinds of layout shapes: "T" shape, "L" shape and "ten" shape.

### ***Channel Transfer***

The channel transfer refers to one walkway set up between two stations which used for passengers' transfer. When two stations at the node of two routes is separated, and a long distance between two station platforms thus platform-to-station hall transfer is useless, channels transfer can be considered to serve on passenger transferring. The connection channel can be set up between the two station halls, or set on the platform directly. In the process of design, attention should be paid to the organization of passenger flow, so as to avoid the two-way intersection of transfer passengers, resulting in disorder

### ***Outside Station Transfer***

Outside station transfer is common used in the situation of not doing perfect road network planning. It is also inconvenient for passengers that might lead to add one more arrival and departure procedures lengthen the passengers' walking distance and mix people outside the station. In the rail transit system, outside station transfer is a systematic defect, so the road network planning should avoid it as far as possible.

### ***Multi-mode Transfer***

In the practice of transfer modes, apply only one transfer mode may not solve the practical problem, two or two more transfer modes mixed may apply to the transfer condition completely. It is not only convenient for passengers' transfer, but also save the construction cost. For example, mixing the platform transfer, channels with hall transfer which can form multi-direction transfer. In the island platform, the node transfer should also cooperate with the connecting channel or the station hall to meet the transfer capacity; the station hall transfer mode supplemented by the connecting channel can reduce the project reserve. The combination of different transfer modes aims at stronger connection and transfer layout, which not only ensures sufficient transfer capacity, but also makes engineering implementation and passengers convenient to use.

## **The Connection Analysis between Urban Rail Transit and Other Means of Transportation**

### **Connection with the Urban Conventional Public Transportation**

The conventional public transportation has the advantage of easy to change the routes and stations, with a big capacity of transporting, which is the best feeder transportation for rail transit. There are 4 modes of connection between rail transit station and conventional bus station.

Mode 1: The bus stopped on the side of the road directly, connects to the rail transit station by pedestrian facilities which is suitable for the parallel situation of rail transit routes and roads, but the interferences between bus accessing the stop and other road traffics would be easy to occur commonly in China. Shanghai metro line 3 and Beijing subway line 1 are all using this mode.

Mode 2: Bus and rail transit located on the same plane use the same platform facilities, and the underground passage connects two side-type platforms. This model ensures that the transfer condition in one direction is very good and a short walking distance, which is suitable for the unbalanced coefficient of passenger flow direction between rail transit and bus transfer.

Mode 3: Bus and rail transit located on the same plane, buses arrive at one platform side where rail transits leave from, and buses leave from another platform side where rail transits arrive at. Rail transits and buses share one platform which has a good transfer condition for two directions.

Mode 4: If bus routes have many connections with urban rail transit station, above three modes would have problems of traffic congestion caused by unenough platform space which would influence surrounding traffic. At this time, the mode of centralized layout can be chose, make platforms get together outside the road.

In the above modes, mode three has the shortest walk distance which shows a traffic concept of "cars leave but people stay". It is good for the organization of bus routes and the distribution of other traffic streamlines. Moreover, mode three is also widely used in foreign countries, it is not only suitable for the connection between ground urban rail transit stations and buses, but also can be used in rail transit complexes, railway stations, elevated stations and so on. The basic application condition is to provide the roads or overpasses around the station, and ensure the distribution area of the people flow in the station.

### **Connection with the Social Vehicle**

With the improvement of the living standards, the development of the city layouts, the car has become an essential mean of transport for household travels. Vehicles increased not only caused great pressure on road traffic, but also led to parking problems. However, the use of rail transit provides an opportunity to relieve traffic pressure, and whether it can provide excellent transfer services for passenger has become a crucial issue. Better connection between rail transit and social vehicle is the significant mean to promote the change from personal travel to public travel. There are some connection design principles between rail transit and social vehicle.

(1) Control the traffic flow which takes advantage of rail transit to control the cars number driving into central urban area.

(2) Rail transit stations located on the edge of residential area, built-up area edge or inside and outside urban traffic transfer node should be selected as connection stations to social vehicles. About stations in other areas, it is difficult for them to set the appropriate amount of parking lots, and the vehicles traffic would bring more pressure to the road traffic flow, so it is not suitable to adopt.

(3) Stations connected with social vehicles can be equipped with some feeder parking lots on the basis of the surrounding buildings.

(4) Feeder parking lots should be close to the entrances and exits of the stations as far as possible, and the special transfer channels towards stations can be set up.

(5) The parking lots' entrances and exits should be set on the branches or secondary roads, and the special roads should be connected to the main roads to reduce the vehicles in and out which disturb the road traffic.

(6) Take appropriate management fees policy, low fares, encourage passengers to actively change to urban rail transit mean.

(7) Organize and design the feeder vehicles traffic organization, set up clear guiding signs.

(8) Aimed at surrounding crossroads and bottleneck roads, the capacity increase measures should be adopted to minimize the delay time.

### **Connection with the Pedestrian Traffic**

The construction of urban rail transit hubs would change the utilization nature of pedestrian area land, and improve the intensity of land development especially the transportation hubs located in central urban area where surrounded business center, entertainment center, office building and other public buildings. In the area with high development intensity and high pedestrian flow, constructing an urban traffic system centered by traffic hubs and pedestrian roads as main roads according to the “people-oriented” guidance ideology. Forming a harmonious and safety urban public space with good guidance signs.

The “human-oriented” urban traffic system does not simply provide overpasses or underground passages for pedestrians, it would form a connection between hubs and surrounding buildings through the approaches of parallel connection and series connection. It also would form a convenient, smart three-dimensional space network to connect hubs with pedestrian traffic. In addition, in order to ensure the safety of pedestrians, the crosswalk line, safety island, separation facilities of people and vehicles and guidance signs around the transit hubs should be included in the design of integrated transportation system.

### **Conclusions**

Although there are still many problems in the transfer mode of rail transit hub in China, the development prospect of the transfer mode is considerable. In order to reduce these problems, it is necessary to consider the integrated design of transfer space in order to improve transfer efficiency, realize zero transfer of rail transit line, and promote the sustainable development of rail transit system. For the constructed hubs, the transfer space should be reconstructed and repaired so as to maximize the transport capacity of urban rail transit, so as to solve the urban traffic problems better.

### **Acknowledgement**

This research was financially supported by the Ministry of Education Planning Fund Project (ProjectNr. 15YJA760041)

### **References**

- [1] Cheng Bin 2007 Transfer study of urban rail transit hub Chang’an University 2007
- [2] Wang Zhiyuan 2013 Connection between urban rail stations and other modes of transportation Chongqing Jiaotong University 2013.
- [3] Ye Xiafei, Tan Fuxing 1998 Transfer and connection of urban public transport Urban Rail Transit Research 1998 1
- [4] Feng Guangdong 2014 Analysis of the status quo of rail transit and airport convergence in China Theoretical Research on Urban Construction: Electronic Version, 2014 18
- [5] Sha bin, Yuan Zhengzhou, Miao Jiang Hua, et al. Comparative analysis of transfer modes of urban rail transit Urban Traffic, 2006 4