Research on the integration of rail transit and conventional public transport -- Taking Chongqing as an example

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Abstract. In order to achieve the urban development pattern led by rail transit and give full play to the role of rail transit, it must rely on the connection of conventional public transport. In this paper, the integration of urban rail transit in Chongqing is discussed from six aspects: bus stop, bus terminal, bus line network, transfer passenger flow, stop and go point and convenient service facilities. Based on the in-depth analysis of the current problems, combined with the requirements of existing integration standards and actual conditions, the improvement plan, implementation plan and construction mechanism are proposed.

1. Introduction
The concept of integrated connection of transportation was put forward in 2010. In the construction of rail transit, all major cities in China aim to establish integrated connection of public transportation. At present, Beijing, Guangzhou, Chongqing and other cities with rail transit have successively issued local management methods or regulations, but it is difficult to test the results after construction. At the same time, due to the late "seamless" put forward, the effective "seamless" connection evaluation system for rail transit and conventional public transport has not been established, which leads to the poor adaptation of rail transit and conventional public transport to urban sustainable development[1].

With the development of the conventional public transport network in the main urban area of Chongqing, and the rail transit is gradually becoming a network, under the background of the integration of public transport, it is necessary to study the connection between the rail transit in the main urban area and the integration of conventional public transport.

2. General situation
The integration of rail transit and conventional public transport will complement each other, shorten the transfer distance and better solve the problem of "the last kilometer" of citizens, and further improve the share rate of public transport. Therefore, to solve the integration of rail transit and conventional public transport has become the most important problem to solve urban traffic congestion[1].

In 2018, Chongqing proposed to lead the urban development pattern with rail transit and build the urban transport travel structure dominated by public transport. It is planned that in 2035, the green transport in the main urban area will account for more than 80% of the travel, and the public transport will account for more than 70% of the motorized travel. However, according to the sampling survey on the experience of transit and public transit transfer, only 33% of the citizens are very satisfied with the
transit transfer, while 40% are not satisfied with the transit transfer, which shows that the integration of transit and public transit can not meet the needs of the citizens at this stage.

The research content of this chapter is to evaluate the connection ability of rail transit based on the bus connection system, and consider its convenience and humanization. This paper analyzes the problems existing in the integration of rail transit in the main urban area of Chongqing from five perspectives of bus stop, bus terminal, bus network, passenger transfer and convenience facilities, and deeply analyzes the main causes of the problems.

2.1. Connection analysis with bus stops
The transfer distance between the entrance and exit of rail transit and the surrounding public transport is one of the important indexes to evaluate whether the connection between rail transit and conventional public transport is good. According to the guidelines for the connection of Chongqing rail station in 2019, the distance between the bus stop and the entrance and exit of rail transit station should be controlled within 15-50m, and it should not be more than 100m under difficult circumstances[2].

As of November 2019, Chongqing has opened 172 rail stations, 498 rail entrances and exits, and 361 bus stops connected to the rail. It can be concluded that the average transfer distance from the entrances and exits of the metro station in the main urban area of Chongqing to the adjacent bus stops is about 80m, which is still a certain gap from the 15-50m specified in the guidelines. Moreover, the data does not include "no bus stop connection" and "no two-way connection" rail stations.

2.2. Connection analysis with bus terminal
The initial and terminal bus stations play an important role in the network optimization of the urban functional core area and the network layout of the expansion area[3]. However, according to the survey, there are only 14 bus hubs and terminals (9 hubs + 5 terminals) within 300 meters from the rail transit in the main urban area, far from meeting the travel needs of more than 8 million permanent residents and a large number of floating population in the main urban area.

2.3. Public transportation network
According to the survey, there are about 70 bus lines within 300m in the main urban area, which are mainly connected with the rail function, accounting for about 10% compared with the total number of
bus lines. Most residents can't reach the rail station all the way, so they need to change buses for many times.

Among them, 26% of the lines with the length of 1-5km, 38% of the lines with the length of 5-10km and 36% of the lines with the length of more than 10km are bus connecting lines within 300m of the rail station. From the distribution location of the connecting lines, the bus lines with the length of 1-5km are mostly distributed in Yuzhong District, Jiangbei District, Yubei district and Shapingba District. It can be seen from this that Liangjiang New Area and Shapingba new town, represented by Jiangbei District and Yubei District, are gradually developing a transit network dominated by rail[5]; bus lines with a length of more than 15km are mostly distributed at the end of the line, showing a trend of "arrow through the heart" in Yuzhong Peninsula.

![Figure 3 Distribution diagram of bus connecting line length within 300m of rail station](image)

2.4. Changing passenger flow

The average daily passenger flow of Chongqing Rail Transit "eight lines and one ring" is about 5.8 million times, and the transfer passenger flow ratio is about 22%. According to the daily average transfer rail passenger flow data of public transportation IC card at the rail station, the distribution characteristics of public rail transfer volume show that the points with large transfer volume are mainly distributed in:

1. Rail line intersection station;
2. Group center station;
3. Jiangqiaotou station;
4. Rail line end area station;
5. Stations with low station density, large regional service population.

![Figure 4 Distribution of transit transfer](image)
2.5. Convenient service facilities
The convenient service facilities of the track mainly refer to the canopy facilities of the pedestrian passageway in the entrance and exit area of the track and the information guidance instructions of the rail transit transfer set at the station hall level. There are mainly two aspects to be improved as follows:

(1) In terms of information connection: the information guidance from rail to bus station is insufficient and the intelligence is not high.

(2) In terms of convenience facilities: the connectivity of convenient and humanized service facilities such as canopy and barrier free between rail access and bus parking port is insufficient.

3. Analysis of current problems

3.1. The integrated network structure of rail transit has not been formed
The layout of the public transportation network in the main urban area can not meet the demand of the public transportation dominated by rail. It is mainly reflected in the low coverage and small number of connecting bus lines; bus lines are still mainly long lines, which are affected by traffic congestion and other factors, with poor punctuality; at the same time, the development of community connecting bus lines is still in its infancy, and the characteristics of large communities lead to the long travel time of residents. Finally, the travel time at both ends of residents is too long, and the willingness of citizens to choose public travel is decreasing.

The public rail transfer rate is relatively low and the transfer coverage rate needs to be improved. According to IC card data, the current public rail transfer volume is about 450000 times a month, and the transfer rate is about 22%. There is a big gap between 40% of Beijing and Shanghai. The results of big data analysis show that the coverage rate of transit area within the radius of 1.5km is only 45.7% of the ideal value; the coverage rate of pedestrian area within the radius of 800m is only 69.4% of the ideal value; the coverage rate of the area within the inner ring is slightly higher than that outside the inner ring, and the coverage rate of 1.5km is much higher than that within the inner ring Outside the ring.

Figure 5 Relationship between public transport connection service and population distribution in the main urban area

3.2. Deficiencies in integrated layout and construction implementation mechanism of stops
At present, many cities in our country neglect the connection between rail transit and conventional public transport in the stage of rail planning, design and construction, resulting in the passenger flow is far lower than expected. At present, about 8% of the rail stations in the main urban area have no public transportation connection, which is often caused by the following three reasons:

(1) Due to the influence of the location of rail station, the conditions for setting up a port are limited, so it is impossible to set up a bus station.

(2) The integrated layout of rail entrances and bus stops in the planning and design stage is not enough.

(3) The construction sequence of track station and surrounding road facilities is inconsistent.
3.3. The construction of initial and terminal stations is insufficient, the planning layout and humanized design need to be improved

The first and terminal bus stations in the main urban area mainly form a batch of transit hub stations for rail transfer in combination with long-distance passenger transport and other functions. Most of the first and terminal bus stations have a serious shortage of floor space, no parking space, and the phenomenon of parking is relatively serious. A small number of maintenance sites undertake far more maintenance tasks than the design and maintenance capacity[4].

From the point of view of the operation of the connecting public transportation network, the rail stations in Xiyong, Caijia, Dadukou, Banan and other regions have obvious demand for the first and terminal stations. However, there are only 8 bus terminals under construction, and 60 planned ones that are not yet built, which are always in the state of making up the arrears.

Because the independent initial and terminal stations are small, it is difficult to open up during construction. Part of the plots are affected by the terrain factors, which lead to poor land use conditions, irregular plots, weak land economy and efficiency, and difficult construction.

4. Planning strategy

4.1. Basic principle of connection distance adjustment

For the stops with the connection distance of 50-100m, the harbor type generally does not consider the transformation, and the straight-line type generally takes the form of shortening the connection distance or transforming it into a harbor for transformation; for the stops with the connection distance of more than 100m, the way of adding and retaining the original port can be adopted, combining with the line network organization to form the sub master station operation mode; for the stops that are difficult to optimize, the improvement can be adopted in the way of pedestrian facilities, optimize the connection distance and improve the accessibility of bus stops; in the case of bus stop form optimization, it is recommended to adopt the harbor type when the useful ground conditions are available, the straight-line type when the useless ground conditions are available, and maximize the possibility of station setting.

4.2. Key construction points of initial and terminal bus stations

In view of the shortage of initial and terminal bus stations, scattered land and rail supporting land can be used to set up initial and terminal bus stations in a short period of time to solve the problem of lack of ground for community bus connection. At the same time, combining with the analysis of transit transfer volume and OD distribution, current population distribution and service relationship of rail station, the paper puts forward the future construction stations of connecting the initial and terminal stations, which are mainly distributed in:

(1) Urban peripheral central area station;
(2) Urban peripheral service area station;
(3) Stations with poor accessibility such as the riverside area within the inner ring road.

4.3. Connection line optimization method

This paper believes that using big data to guide line planning and change the traditional single line network layout structure can respond to the daily travel needs of the people along the line flexibly, make the line planning more scientific and reach the users more[6]. In the subsequent optimization of public transport network, the use of big data platform analysis, the implementation of public participation system and other support mechanisms to improve the coverage of public transport network and better serve the travel of surrounding residents. At the same time, big data platform is used to realize data analysis visualization, form scheme operation feedback mechanism, open public platform and establish public participation mechanism.
4.4. **Key points for improvement of convenient service facilities**

The optimization of service facilities for the convenience of the people must implement the standard requirements of information intelligence and quality improvement, and guide and promote the implementation according to the requirements of unified planning, synchronous design and division of labor construction.

1. Information connection: strengthen the two-way connection between rail station and bus station, and strengthen the intelligent information display;

2. In terms of convenient service: further study the rainshed, barrier free and other convenient and humanized service facilities within the scope of rail integration to form corresponding standard requirements.

5. **Summary**

The integration and connection of rail transit is an important part of the integration of urban public transport. It solves the travel demand of "the last kilometer" in the process of rail travel, so as to form a complete rail travel process of "door station door" and improve the management level and operation efficiency of urban transport.

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