Research on the Optimization of external traffic organization of urban passenger station Based on VISSIM Simulation

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Abstract—In order to ensure the normal operation of the bus terminal, the external traffic organization of the bus terminal is studied. This article takes Xi’an Chengnan passenger station as an example, analyzes its external traffic organization in detail, and finds out the problems in the traffic organization of the passenger station based on the survey results. Then, according to the requirements of the external transportation organization, a scheme for optimizing the external transportation organization was proposed, which was carried out using VISSIM simulation software, and the feasibility of the optimization scheme was verified.

1. Introduction
With the rapid development of urban motorization, road traffic has increased dramatically, and the problem of urban congestion has become more and more serious. Many urban passenger stations are located in the bustling sections of the city, and multiple passenger cars entering and leaving the station at the same time will inevitably occupy the roads outside the station, resulting in abnormal traffic congestion around the passenger station, which directly causes the city’s already congested traffic conditions to be even worse. At the same time, vehicles interfere with pedestrians at the entrance and exit, which seriously affects residents’ travel and daily life. Whether the passenger station can operate effectively, the transportation organization has a very important role. Optimizing the external traffic organization of the urban passenger station can reduce the impact of the bus terminal on the surrounding urban traffic, and it is very helpful to reduce the congestion of urban traffic.

Foreign countries, especially developed countries in Europe and the United States, pay special attention to the construction and research of highway passenger transport hubs. Regarding the transportation organization of passenger hubs, Avishaiceder (2004) proposed that effective channeling of passenger flow is the key to achieving a reasonable transfer, which can be studied and analyzed from mode sharing, connection layout, traffic flow organization, etc. [1]. Anderson Ribeiro Correia’s (2008) research on comprehensive passenger hubs mainly used simulation evaluation methods to identify bottlenecks affecting traffic and design traffic organizations [2]. In China, Starting from the external traffic of the bus terminal, Li Jing defined the external transport organization of the bus terminal and explained its influencing factors. Then, based on the problems of the external transport organization, he
proposed the purpose and requirements of the design of the external transport organization of the passenger terminal [3].

2. The current situation and existing problems of external traffic at chengnan passenger station

2.1. Study area
The research object of this article is Xi’an Chengnan Passenger Station. Xi’an Chengnan Passenger Station, a demonstration project of the Shaanxi Comprehensive Hub, has very favorable geographical conditions. It is close to the South Third Ring Road in the north, the middle section of Yanhuan Road in the south, the south section of Zhuque Street in the east, and Changyi Road in the west. The project closely connects the four highways of Beijing-Kunming, Baomao, Fuyin, Shanghai and Shaanxi, which is convenient for people from Xi’an to Hanzhong, Ankang, Shangluo in the province, as well as the surrounding southwest and south-central provinces. On the other hand, the project integrates road passenger transportation, tourist lines, subways, city buses, taxis, social transportation, etc., which facilitates the transfer of passengers.

2.2. Current status of external traffic
The following picture shows the basic situation of the roads around Chengnan passenger station. It can be seen that the south third ring road to the north of Chengnan passenger station is an urban expressway, the south section of Zhuque Street in the east and the middle section of Yanhuan Road in the south are all main roads, and the traffic volume is very large. In particular, the traffic pressure on the south section of the South Third Ring Road-Zhuque Street is very heavy.

![Figure 1. Roads around Chengnan passenger station](image)

The problems of traffic organization at the intersection of the South Third Ring Road and Zhuque Avenue South and the southern section of Zhuque Avenue are more prominent, so this paper mainly studies this area. According to the results of field investigations, the current road traffic organization form around the Chengnan passenger station is: the South Third Ring Road organizes eastward one-way traffic, and the west entrance is divided into left, right, and straight directions. Due to one-way traffic, the east entrance does not go straight, the north entrance does not turn right, and the south entrance does not turn left. The channelization scheme is shown in the figure.

According to on-site traffic observations, the traffic volume at the intersection of South Third Ring Road and Zhuque Avenue South is shown in the table below.

|       | Peak hour traffic | Capacity | Straight traffic | Turn-left traffic | Turn-right traffic |
|-------|-------------------|----------|------------------|------------------|-------------------|
| East  | 400               | 1632     | 400              | 220              | 720               |
| West  | 1984              | 3900     | 132              | 132              | 132               |
| South | 1392              | 3840     | 635              | 350              | 350               |
| North | 985               | 3840     | 672              | 350              | 350               |
The signal of the intersection is divided into three phases. The first stage is the west entrance straight and left turn, right turn is not a signal control. The second stage is from east to left. The third stage is straight-forward north-south, left turn at the north entrance, and right turn at the south entrance for continuous passage. The current signal timing is shown in the figure below.

Figure 2. Intersection signal timing

There are four bus stops within 500 meters in the Chengnan passenger station. And there are 21 bus lines: 203, 408, 219, 401, 166, 106, 270, 173, 46, 278, 210, 18, 258, 229, 321, 312, 525, 920, 928, and 929 sections.

Among them, Chengnan Bus Junction Station prohibits passengers from getting on and off, only stops at the starting and ending points of the bus; Chengnan passenger station (inside the station) is for passengers to get on and off inside the passenger terminal. The bus stations that have a greater impact on the surrounding roads are the Chengnan passenger station, which has stations on both the east and west sides of Zhuque Street. This study will temporarily study these two bus stations. The two stations of the Chengnan passenger station are roadside stops. The innermost lane on the west side has a dedicated bus lane for the use of buses alone; there is no dedicated bus lane on the east side, and vehicles are mixed.

2.3. Analysis of external traffic organization issues
Combined with the field survey results of Xi'an Chengnan passenger station, the problems of its external traffic organization were analyzed.

2.3.1. The connection between bus terminal and city bus
The bus stops at Chengnan passenger station are scattered, and some bus stops are far from the ticket hall. Although the decentralized arrangement of bus stops is beneficial for bus stops, it is easy to cause the transfer distance to be too long, and it is not easy to find the correct stop. Moreover, the principle of "bus priority" has not been embodied, no bus lanes are set up, and buses are mixed with other vehicles.

2.3.2. The connection between the passenger station and taxis and social vehicles
The main reason for the current chaotic traffic organization at passenger stations is the chaotic management of taxis and social vehicles, which is an intractable problem. Although certain parking areas are set up, there is still a phenomenon that vehicles stop at random to board and disembark and disturb other traffic.

2.3.3. Traffic jam around
In order to facilitate passenger transfer, urban passenger station is generally located in a more prosperous area. The traffic volume of the surrounding roads is relatively large. The role of the traffic node of the passenger terminal attracts a large number of people and vehicles, which makes the original road conditions worse. The road is more congested.
3. Optimization of external traffic organization

The optimization of the external transportation organization is to connect the bus terminal with the city's comprehensive transportation network, so as to realize the rapid distribution of the traffic flow in the passenger station. The requirements for the optimization of external transportation organizations include: rapid distribution of traffic flow; equalization of the traffic load around the road network and intersections of passenger stations; traffic at automobile passenger stations has little disturbance to the main road; convenient passengers can easily transfer, and the transfer distance is short.

According to the problems in the transportation organization in the previous chapter, the following external transportation organization optimization plan is proposed.

3.1. Set up the bus lane

To achieve rapid distribution of passengers and reduce road burden, the bus station should vigorously develop the bus priority. There are two bus stops on the east side of the Chengnan bus station, and the bus stop on the west side is set up for bus use alone, reducing the queue and frequent lane changes of vehicles. There is no bus lane at the station on the east side. The bus station on the east side is parking on the roadside. All the buses are going straight and there is no left or right turn. The rightmost lane is the right turn lane. The traffic volume of the right turn vehicle is also large, accounting for about 50%. Therefore, the bus stops in the rightmost lane to get on and off, and the bus changes lanes after leaving the station, and there is more conflict with the right-turning vehicle.

According to the setting of the current bus station, the following optimization is carried out: the rightmost lane is set as a dedicated bus lane, and a special right-turn lane is opened on the entrance road of South Third Ring Road-Zhuque Avenue using a non-motorized lane, and a borrow area is provided on the entrance lane for the right turn the vehicle to the right lane. Its type is shown below.

![Figure 3. Type of the bus lane](image)

3.2. Intersection optimization

Optimize the intersection of South Third Ring Road and Zhuque Main Street, rationalize the channelization of lanes, and scientifically time the signal lights of the intersection.

A bus-only lane for right-turning vehicles will be added to the south entrance. According to the calculation, the flow ratios are \( Y_w = 0.51, Y_e = 0.2, Y_s = 0.36, Y_n = 0.25 \), the intersection is a three-phase, the total flow ratio is \( Y = 0.51 + 0.36 + 0.2 = 1.07 > 0.9 \), need to redesign the intersection inlet or signal phase scheme.

According to the actual situation, the left-turn phase of the east entrance is cancelled. The left-turn vehicle of the east entrance detours to the north entrance of Zhuque Avenue through the right-turn lane, and then goes straight to the south passenger station. Recalculate the signal timing scheme. At this time \( Y_n = 0.36 \), the total flow ratio \( Y = 0.51 + 0.36 = 0.87 < 0.9 \). Meet the requirements. The new timing scheme is shown below.

![Figure 4. Optimized signal timing scheme](image)
4. Simulation evaluation of optimization scheme
Use VISSIM simulation software to simulate the road sections and intersections around Chengnan passenger station.

4.1. VISSIM simulation
VISSIM is a microscopic traffic simulation software based on time intervals and driving behavior. It is used to model and analyze the traffic operation conditions under various traffic conditions. It is an effective tool for evaluating traffic engineering design and urban planning schemes. It is widely used in highways and cities. Optimal design of roads and intersections [4] and traffic impact assessment analysis [5].

4.2. Evaluation index
The VISSIM simulation is from point to plane, the point is the evaluation of key intersections, and the side is the evaluation of the surrounding road network. The following table is its evaluation index.

| Evaluation index | Intersection evaluation | Road network evaluation |
|------------------|-------------------------|-------------------------|
| Average number of parking | The indicator reflects the number of vehicles stopped at the intersection due to signals. | Total parking delay | The indicator refers the comprehensive delay time of all vehicles on the road network. |
| Delay time | The indicator refers to the difference between the time required for the vehicle to travel without the signal and waiting for the obstacles and the actual travel time. | Number of parking | The indicator refers the number of times the vehicle stopped due to obstruction in the entire road network. |
| Average queue length | The indicator is used to evaluate the congestion of vehicles at the entrance of the intersection. | Cars delayed | The indicator refers to how much time the vehicle spends on the road network due to obstruction. This indicator includes vehicle parking delays at intersections. |
| Maximum queue length | The indicator is used to evaluate the degree of congestion caused by congestion at a certain entrance of an intersection. | Average speed | This indicator reflects the smooth running of the vehicle on a certain road section, and it includes the passing time of the vehicle at the intersection. |

4.3. Evaluation of optimization scheme
After the simulation model is established, VISSIM simulation is carried out on the model of the current situation and optimization scheme of the Chengnan passenger station. The statistics of the evaluation indicators obtained by the simulation are shown in the table.
Table 3. Intersection data before Optimized

| Direction         | Average number of parking | Delay time | Average queue length | Cars delayed | Maximum queue length |
|-------------------|---------------------------|------------|----------------------|--------------|---------------------|
| South-North       | 0.78                      | 38.9       | 44.3                 | 47.6         | 151.4               |
| East-South        | 0.68                      | 46.8       | 11.7                 | 52.4         | 36.1                |
| West-East         | 0.66                      | 23.6       | 108.9                | 32.4         | 221                 |
| South-West        | 0.41                      | 14         | 0                    | 19.8         | 0                   |
| North-South       | 0.47                      | 35.6       | 54.3                 | 40.5         | 100.6               |
| North-East        | 0.6                       | 30         | 40                   | 30           | 91.4                |
| West-North        | 1.04                      | 31.6       | 31.2                 | 43.9         | 70.8                |
| South-East        | 0                         | 0          | 0                    | 0.1          | 0                   |
| Total             | 0.63                      | 29.9       | 37.6                 | 37.1         | 221                 |

Table 4. Optimized intersection data

| Direction         | Average number of parking | Delay time | Average queue length | Cars delayed | Maximum queue length |
|-------------------|---------------------------|------------|----------------------|--------------|---------------------|
| South-North       | 0.56                      | 30.9       | 21.5                 | 36.8         | 76                  |
| East-South        | 0.6                       | 21.6       | 106                  | 30.2         | 215                 |
| West-East         | 0.4                       | 12.7       | 0                    | 18.8         | 0                   |
| South-West        | 0.45                      | 33.9       | 52.3                 | 37.7         | 100.7               |
| North-South       | 0.58                      | 29.1       | 27.2                 | 28.6         | 52.4                |
| North-East        | 0.99                      | 30.5       | 30.1                 | 42.5         | 70                  |
| West-North        | 0                         | 0          | 0                    | 0.1          | 0                   |
| South-East        | 0.59                      | 25.1       | 29.9                 | 33.2         | 215                 |
| Total             | 0.56                      | 30.9       | 21.5                 | 36.8         | 76                  |
Comparing the intersection data before and after optimization, it can be seen that the average vehicle parking delay, average vehicle parking times, and queue length of the simulated intersection have been reduced to a certain extent.

Table 5. Road network performance before and after optimization

|                  | Total parking delay | Number of parking | Cars parking delayed | Average number of parking | Cars delayed | Average speed |
|------------------|----------------------|-------------------|----------------------|---------------------------|--------------|---------------|
| Before           | 55.464               | 5766              | 32.593               | 0.941                     | 45.85        | 20.583        |
| After            | 40.89                | 4998              | 24.34                | 0.826                     | 35.77        | 24.332        |

Comparing the road network performance data before and after optimization, it can be seen that the total parking delay is reduced by 14.574h, the parking number is reduced by 768, the average parking delay is reduced by 8.253, and the average parking number is Reduced by 0.115, the average vehicle delay is reduced by 10.08s, and the average speed is increased by 3.749. The performance of the road network has been significantly improved. In summary, the external optimization program is effective.

5. Conclusion
This article takes Xi’an Chengnan passenger station as an example to analyze its external traffic organization. Aiming at the existing problems, a transportation organization optimization plan is proposed. Through VISSIM, the traffic organization before and after optimization is simulated to obtain the intersection and road network performance data. The comparison shows that the optimization scheme is effective.

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