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Passenger Flow Organization and Countermeasures in the Large Passenger Flow Period of Guiyang City Rail Transit

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Abstract

Guiyang metro Line 1 was opened for trial operation in December 28, 2017. The massive construction and advantages of rail transit in Guiyang have attracted more and more passengers. Rapid growth of passenger flow has exerted great pressure on rail transit operation. In order to ensure transport safety and service quality in peak passenger flow or special conditions, passenger flow organization and control measures are needed. This paper studies the analysis and method of passenger flow control in rail transit station, which provides theoretical basis for formulating reasonable passenger flow control scheme. This ensures that the station and the whole road network can give full play to their ability to transport passengers safely.

Keywords

Rail Transit; Large Passenger Flow; Organization; Measures.

1. Introduction

At the end of 2018, Guiyang City opened urban rail transit operations, after spending a lot of public rides and passenger traffic, the passenger traffic of the subway tends to be stable. The peak motor vehicle traffic of the roads along Shaxi Road, Xincun Road, Qianling Mountain Road and Lincheng East Road along Metro Line 1 have been reduced to varying degrees. The corresponding road section saturation is reduced by 2.7%-12%, the vehicle speed is increased by 5%-27%, and the delay per kilometer is reduced by 5-36 seconds. Some citizens choose to take the track, which will alleviate the road congestion caused by the passing of motor vehicles in the past peak period, In particular, the traffic environment of the connecting roads between Shachong Road and Xincun Road connected to Nanming District and Yunyan Districts and Guanshan Lake District has been improved significantly.

With the increasingly complex orbital environment in Guiyang, sudden and large passenger flows have also occurred, which has also attracted the attention of rail transit workers and researchers. Many literatures have qualitatively analyzed the sudden large passenger flow from the perspectives of classification, formation, dissemination and diffusion of passenger flow. Some literatures also quantify the spatial and temporal distribution characteristics, network propagation and dissipation laws, and give a series of research results on the evolution law of sudden large passenger flow.

Zhang Xuebing and Yang Lin studied the current situation, causes and countermeasures of the big passenger flow [1-2]. Zhu Wei quantitative analysis of the formation and propagation mechanism of large passenger flow at the station, and expounds that the large passenger flow propagates its influence to the rail transit network through the “Ripples reaction” [3]. Assis, Milani analyzes the passenger flow structure and the characteristics of the line passenger flow dynamics with time[4]. Casteli uses the transfer station as a research node to predict the passenger flow and its spatio-temporal characteristics of each line, and draws a running time

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figure[5].Jia Wen-ting analyzed the impact of sudden large passenger flow on the service level of the station, constructed a model of the impact of sudden large passenger flow on the service level of the station, and proposed the operational management countermeasures in a targeted manner[6]. Peng Qi-yuan quantitatively studied the impact on the service level of the station and the train operation when the train carrying the sudden large passenger flow was delayed at the transfer station [7]. Xu Rui-hua selects the actual scene to simulate the train operation process, and believes that capacity utilization, number of spare vehicles, buffer time, number of auxiliary lines, etc. are strongly correlated with train delay and propagation [8]. Duan Li-wei comprehensively considers passenger flow density, train capacity, and boarding efficiency, and studies the passenger flow density and train delay time of the platform, and summarizes the network propagation mechanism of sudden large passenger flow [9].

2. Basic Situation of Large Passenger Flow in Rail Transit in Guiyang City

2.1. Large Passenger Flow Characteristics

The large passenger flow of Guiyang Metro is generally divided into two categories, one is the large passenger flow during peak hours, and the other is the large passenger flow with strong controllable. Peak hour passenger flow refers to the passenger flow corresponding to a certain period of time during which passengers travel most concentrated. Whether it is passenger traffic at the peak hour of the station or passenger traffic at the interval, when these passenger traffic exceeds the passenger traffic that the station's normal passenger transportation facilities or passenger transportation organizations can bear, there will be a large passenger flow during peak hours. At the same time, such passenger flow is easy to be crowded, slow in flow, mutual interference, and complicated organization work. The large passenger flow at the peak of Zhong-shan West Station is shown in Figure 1.

The other type is a strong and controllable large passenger flow, which refers to a passenger flow that exhibits strong controllability and organization. Generally speaking, the strong controllable large passenger flow has the characteristics of large intensive amount, concentrated travel time, and basically the same destination. At the same time, this type of passenger flow is highly tolerant to crowded environments and often occurs during large or extra-large periods of urban activity. The characteristics of this type of passenger flow have different characteristics from the morning and evening peaks and the large passenger flow in urban rail transit, it is a large passenger flow that exists for a period of time, with strong organizational and predictability. And Guiyang is a multi-ethnic city, More than 20 ethnic minorities, such as the Han, Buyi, Miao, Hui, Yi, and Dong, all have large-scale activities with their own national characteristics, and are prone to strong and controllable large passenger flows. The strong controllable passenger flow of the Zhong-shan West Station National Day is shown in Figure 2.

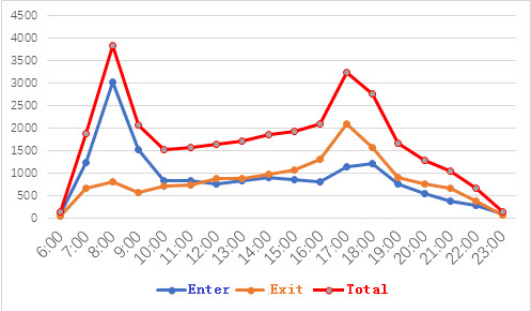

Figure 1: Zhong-shan West Station workday morning and evening peak passenger flow

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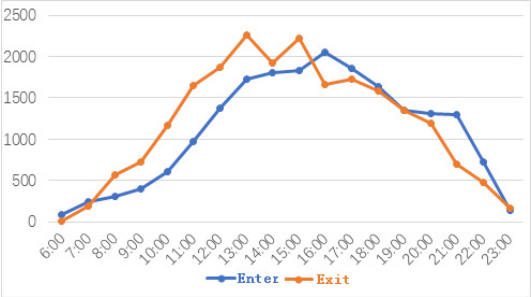

Figure 2: Zhong-shan West Station National Day strong and controllable large passenger flow

2.2. Factors that Cause Large Passenger Flows

The station hall of urban rail transit is a place for the formation of large-scale distribution of passenger flow. The basic streamline for passengers to travel is the entrance of the station, and is concentrated in the station hall through the entrance and exit channels, after security check and ticket purchase, the ticket will enter the paying area, and then arrive at the station waiting via the connecting channel, and finally take the subway to the destination. Whether it is a large passenger flow during peak hours or a strong controllable large passenger flow, in general, when there is congestion caused by large passenger flow, the passengers waiting on the platform will be crowded. However, due to the limited space capacity of the arriving train, some passengers are unable to get on the train, and passengers are stranded and congested on the platform. With the accumulation of detention, the accumulated passenger flow in the station will exceed the passenger flow allowed by the station, and a large passenger flow will be formed in a short time.

2.2.1. External Factor

There are many external factors that cause large passenger flow. Mainly, the geographical location of the station, the architectural planning around the station, and the economic development level are important factors affecting the rapid passenger flow. The concentration of the core functional areas of the city makes the passenger flow of commuting, business and tourism superimposed, and the passenger traffic grows rapidly, resulting in an increase in passenger traffic during peak hours.

2.2.2. Internal Factor

Relatively speaking, the internal factors that cause large passenger flows are single. Station capacity, such as station entrances and exits, station halls, station capacity; station facilities and equipment capabilities, such as station access, boarding equipment, ticketing system and other service capacity subway capacity.

3. The Propagation Mechanism of Sudden Large Passenger Flow

Sudden large passenger flow, firstly caused a surge in passenger traffic in the station, tens of thousands of passengers gathered in a short time, which will inevitably lead to different levels of congestion in the various areas of the station, and the average passenger flow density of the station will increase. The increase in passenger flow density at some of the capacity bottlenecks on the passenger flow line is particularly prominent. In the passenger traffic area, the speed of movement of passengers is significantly reduced, and even parking stops; in the intertwined areas of different passenger flow lines, conflicts are more prominent and the resistance between passengers increases; on the service facilities such as the floor escalator, the capacity is saturated, and a large number of passengers wait in line for service. The queue time is significantly larger than the daily queue time. Overall, the capacity of the key locations in the station is close to saturation, the passenger traffic efficiency is significantly reduced, and there are security risks.

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In the station, the end point of each passenger's movement is the platform, after the sudden large passenger flow occurs, the platform becomes the most serious position. A large number of passengers continued to enter the station and eventually concentrated in the waiting area, and the passenger flow density of the station continued to rise. When the train arrives at the station, the passengers' tension and urgency are strengthened. The passengers who were originally distributed in the form of multiple queues gather at the door, and the local crowding is intensified, which makes the passenger's boarding and dropping efficiency significantly lower. On the one hand, the number of people getting on and off the platform has become larger, which often directly leads to the delay of the stoppage time; on the other hand, crowded passengers lead to lower efficiency of getting on and off, which indirectly increases the passenger's total boarding time. Due to the impact of large passenger flow, the train could not safely close the carport and the shielding port according to the operation plan, and the train stayed at the station for a long time, which caused the train departure time to be delayed.

The spread of sudden large passenger flows is not only happening in the station, but also affecting other stations, the entire line or even the entire road network. In the occurrence of a station, once the passenger flow delays due to the large passenger flow, it is easy to cause the arrival time delay of the train to reach the front station and the arrival time delay of the subsequent train arriving at the station. Subsequent train arrival time delays, passengers on the next train need to wait longer, and during this time, there may be more passengers gathering at the station, further increase the passenger flow density of stations and stations. Arrive at the station ahead late, it will cause a backlog of passengers in front of the station. If there are a large number of passengers at a station to get off or transfer, large passenger flows spread to the station and even to other routes. If there are fewer passengers getting off at a station, the full load rate of the train will greatly limit the number of passengers on board, and some passengers will stay. As a result, the influence of large passenger flows gradually spread on the lines and networks. Figure 3 depicts the propagation process of sudden large passenger flows.

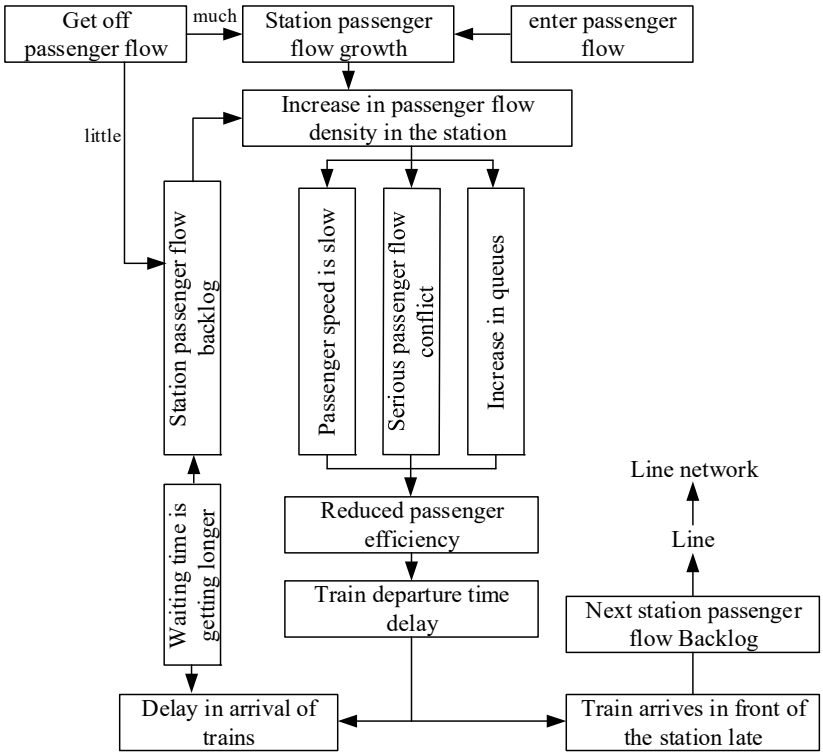

Figure 3: Dissemination process of sudden large-scale passenger

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4. Large Passenger Flow Response Measures

Whether it is a large passenger flow during peak hours or a strong controllable large passenger flow, it is a large passenger flow that is predictable. The main countermeasures are to alleviate the crowded transmission in advance, and to control the congestion and spread of passenger flow within a certain range through countermeasures. From the perspective of urban rail transit passenger transport organization, it is possible to adopt an adjustment method in advance.

4.1. Station Organization Management Measures

According to the main factors affecting the passenger flow organization of the station, combined with the actual operation organization experience of the large passenger flow in Guiyang West Zhongshan Station, the specific measures of large passenger flow organization are proposed from the following aspects.

4.1.1. Reasonable Design of Passenger Flow Lines

In particular passenger stream line in the transfer station, is provided to follow the principle of the shortest possible straight line. Strengthen the manual and broadcast guide passenger flow, speed up the passengers' entry and exit transfer convenience, speed up the evacuation of the passengers in the station, avoid the superposition of the influence of crowding of passengers, and limit the flow when the passenger flow is too large.

4.1.2. Do a Good Passenger Flow Forecast

For the predictable large passenger flow, the station must make a top passenger flow test in advance. According to the characteristics of the passenger flow of the station, the time of occurrence and the passenger flow, etc., a reasonable plan for the organization of large passenger flows is formulated. For the unpredictable large passenger flow caused by bad weather, major events, etc., the station should formulate emergency response plans for sudden large passenger flow according to experience and actual conditions and according to the plan, organize emergency rescue drills to increase the emergency response capacity of employees in the face of sudden large passenger flow, so as to quickly organize the evacuation of large passenger flows.

4.1.3. Improve the Connection between Conventional Public Transport and Urban Rail Transit

The two modes of transportation are synchronized during peak hours, and the distribution characteristics of passenger flow during peak hours are similar. The large passenger flow during the peak hours of urban rail transit will also bring about the increase in conventional bus demand, the close connection between the two can shorten the passenger stay time and ease the traffic situation near the station.

4.1.4. Adjust the Driving Schedule in a Timely Manner

When the passenger flow is crowded to a certain extent, the station should inform the control center in time, and the control center can reasonably organize the train operation, command the train to stop, avoid the trains arriving in different directions at the same time, and improve the evacuation efficiency of the large passenger flow. According to the forecast of large passenger flow, the operation map should be reasonably adjusted, the number of spare vehicles should be increased appropriately, and the trains should be added to increase the capacity during peak passenger hours. If the operation time of large holidays is extended by 2 hours from weekdays, the arrival time of trains in all directions will be “two or two staggered” to ensure passengers. Do not take the wrong direction and have enough transfer time.

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4.2. Passenger Flow Control Measures

According to the basic principle of passenger flow control, combined with the passenger flow organization of the advanced urban track, there are three common measures to control the strong controllable large passenger flow.

4.2.1. Physical Cutting

The physical cutting method can divide the passenger flow in and out of the station and the passenger flow in space, thereby reducing the conflict point, reducing the interference between the passenger flow and shortening the transfer time. The physical cutting method can isolate the passenger flow on the plane by means of mobile guardrails or other facilities, thereby rationalizing the walking order of the passenger flow in the station and solving the contradiction between the passenger walking habit and the station layout. In addition, the opening of new walkways can also be used as a form of physical cutting.

4.2.2. Increase Flow Rate

By guiding the passengers to select the shortest path to improve the passenger's running efficiency, the passenger's occupation time of the station facilities and equipment is relatively reduced, thereby improving the equipment utilization rate and the flow speed of the streamline. At the same time, it is also possible to call the station attendant and the station police officer to maintain the order of each platform and passage, so that no personnel in the passage stay for a long time, so as to keep the various areas unimpeded.

4.2.3. Source Control

The source control method is to control the flow of various stream lines to achieve the purpose of resolving streamline intersections, and reduce the possibility of passenger flow conflicts. The station coordinates the operation plan of each line, and determines the arrival point of the trains in each direction according to the passenger flow in each line, and tries to avoid the simultaneous arrival of trains in different directions to avoid the dense arrival of passengers and improve the comfort and safety of the ride.

5. Conclusion

Through the analysis of the large passenger flow organization of Guiyang rail transit, and according to the characteristics of Guiyang rail transit morning and evening peaks and National Day holiday crowds, the characteristics of peak passenger flow and strong controllable large passenger flow are summarized. Combined with the large passenger flow phenomenon that may occur in urban rail transit, several large passenger flow organization methods are proposed. Large passenger flow organizations are the top priority of rail transit passenger flow organizations. Drawing on the experience of Guiyang's existing light rail and large passenger flow organization, we hope to provide reference for the large passenger flow organization formed by large or extra large-scale activities in the future, and continue to improve and optimize it in the actual application process.

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