IOP Conference Series: Earth and Environmental Science

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IOP Conf. Series: Earth and Environmental Science **234** (2019) 012001 doi:10.1088/1755-1315/234/1/012001

Study on the Control Strategy of Urban Rail Transit Passenger Flow under the Condition of Large Passenger Flow

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Abstract. As urbanization accelerates, urban rail transit has become the backbone of urban public transportation due to its large volume, high efficiency and fast speed. In recent years, more and more new lines have been opened and gradually developed to the direction of network operation. With the increase of residents' demand for travel, the situation of large passenger flow exists in some stations, Because the situation of large passenger flow will bring hidden danger to the safety of road network, this paper puts forward the control strategy of passenger flow in the case of large passenger flow.

1. Introduction

With the expansion of residents in some megacities, passenger travel demands increase with an unprecedented speed and cause a series of transportation problems. Urban rail transit has more and more influences on urban development due to its characteristics of large capacity transportation capacity, relative independence, high speed operation, safety and comfort, it has become the main artery of urban public transportation, the operation of urban rail transit is tend to networks, Urban mass transit passenger flow refers to the situation when the passenger flow of a station or several stations exceeds the normal operation capacity of the station in a certain period of time. When the mass passenger flow occurs in urban rail transit, a large number of passenger flows gather at platforms, station halls and even station entrances and exits, the propagation scale of large passenger flow in urban rail transit network is larger and its evolution mechanism is more complex comparing with traffic congestion of urban ground vehicles. In order to ensure the safe operation of urban rail transit system in the case of large passenger flow, further research is needed on the emergency management strategy of urban rail transit system when large passenger flow occurs. This article Through analyzing the reasons for large passenger flow and the perspective of complex network research the spread rule of passenger flow in urban rail transit network, this article discusses the case of large passenger flow in urban rail transit passenger flow of emergency control strategy.

2. Characteristic Analysis of Large Passenger Flow

Urban rail transit passenger flow is the passenger flow formed by people using rail transit to reach the destination, including flow, flow direction, flow rate and other factors. Large passenger flow mainly refers to that due to the occurrence of an emergency, the passenger flow in a certain period of time of the station exceeds the maximum service capacity of the station in normal operation. The generation of large passenger flow is affected by many factors, among which, the capacity of station E, the capacity of train transport N, and the flow of large passenger flow U are the three most important factors.

Station is an important node in urban rail transit network that connects passengers, lines and trains. Passengers pass through the import and export channel, buy tickets at the station hall, enter the pay zone through the gate machine, wait at the platform to board the train. The rail trains run in accordance with the established operational plan to carry passengers. However, when the station encountered heavy passenger flow, a large number of passengers crowded into the station, the capacity of the station quickly reache saturation, the congestion of passengers on and off the platform reduces the flow speed of passengers, the delay of the train at the crowded station was extend. This effect is transmitted to the rear train step by step, causing the departure delay of the rear vehicle, thus affecting the transmission capacity of the whole train line. Meanwhile, passengers who didn't get on the train in time stopped at waiting area to become "waiting" passengers and subsequent arrivals to wait for the next train. The forming process of large passenger flow is shown in Fig.1.

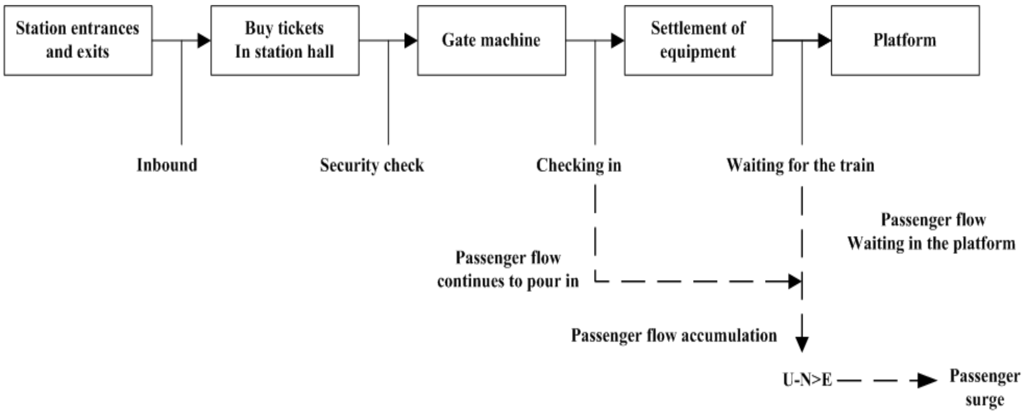

Figure 1. Large passenger flow formation process

3. The Propagation process of Large passenger Flow in Rail Transit Network

The superposition of the incoming passenger flow and the original passenger flow of the station will lead to the increase of passenger density of waiting area in the station. As time goes on, the capacity limit of the station will be reached. When the train arrives at the station, passengers on and off the train interact with each other, the passenger flow speed decreases, and the train stops for longer time. At this time, the large passenger flow will "infect" other stations with the running of the train, resulting in a second explosion of the large passenger flow. The specific propagation process is shown in Fig.2.

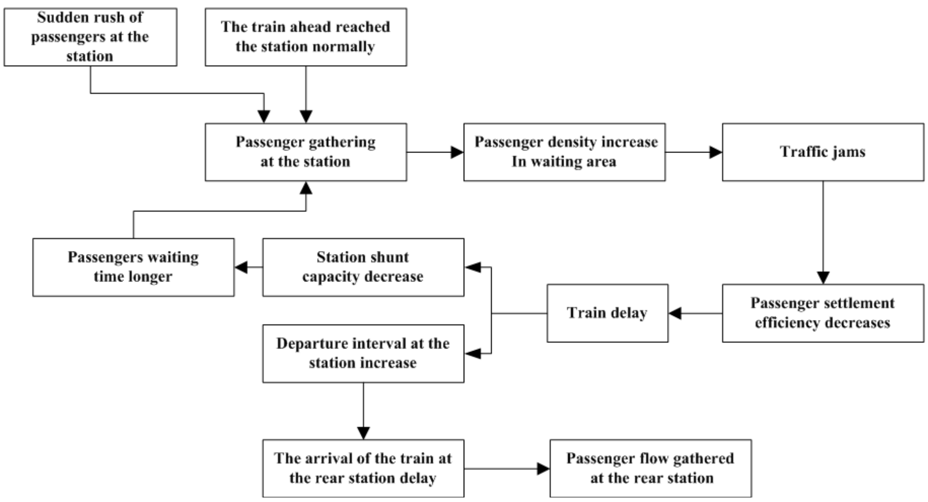

Figure 2. Propagation process when station occurs large passenger flow

Due to the departure delay of the mass transit train, the waiting time of passenger flow at the transfer station will increase, the passenger flow density will be further increased. When the train arrives at the transfer station, the interleaving of the passenger flow between the upstream and downstream will cause a second delay in the departure of the train. At this point, the large passenger flow will affect the operation of the entire network through the transfer station, the propagation process is shown in Fig. 3.

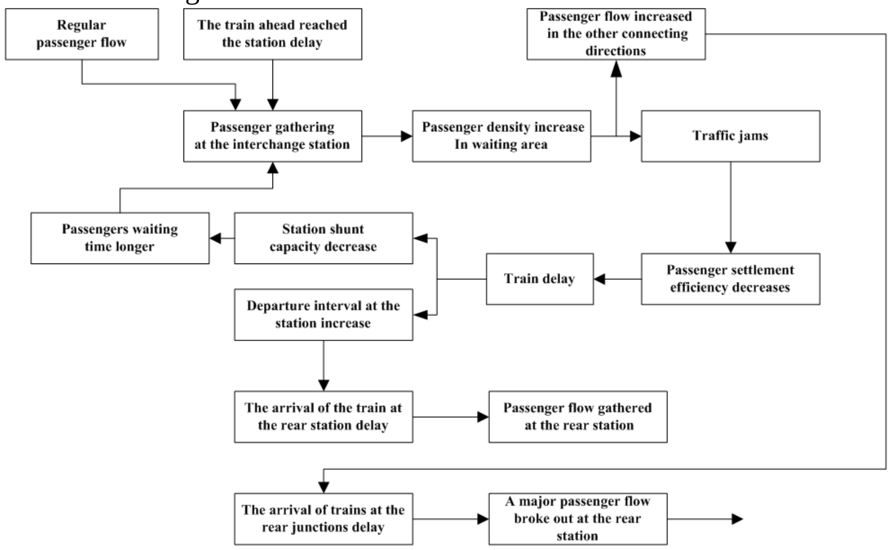

Figure 3. Propagation process when interchange station occurs large passenger flow

Standing among the transmission of large passenger flow process is similar to the transfer station, because of the influence of train delay ahead with, passengers waiting time waiting area raised passenger density rise over time, similar to the boarding passenger flow of mixed delays caused behind the departure and arrival of the train. However, the middle station has little influence on the whole network because of the single connection of the line.

4. Large Passenger Flow Control Measures

The emergency control strategy of urban rail transit network is under the premise of ensuring safety in case of heavy passenger flow, take the most reasonable measures to speed up the evacuation of large passenger flow and reduce the risk of operation accidents. Mainly from two aspects corresponding to the subway passenger flow situation, the train transportation organization optimization and the station passenger flow control.

4.1Transportation Organization Optimization

(1) Train Marshaling Plan. When making train marshalling plan, it is also necessary to take into account the factors such as the passing capacity of the station, the train departure interval and the marshalling vehicle type. The reduction of train departure interval can effectively improve the network capacity, the size of the departure interval is also related to the number of trains. Generally, the greater the number of train marshalling, the longer the departure interval is. The calculation formula of train marshalling M is as follows.

$$\mathrm{M} = \frac{p_{max}}{n * c_c} \tag{1}$$

In the formula, p_{max} represents passenger flow in a single section, n represents the maximum number of trains per hour across a single section, c_c is the maximum capacity of a vehicle.

When the vehicle type and traffic density are certain, the larger the passenger flow is, the more marshalling vehicles are required. Due to the short duration of the large passenger flow and the limited passenger flow crowded section, an appropriate size arrangement scheme can be determined according to the spatial and temporal characteristics of the large passenger flow, so as to improve the transport capacity and accelerate the passenger flow evacuation.

(2) Full Day Travel Plans. The main content of the whole day travel plan is the number of trains scheduled to start all day, which needs to take into account the factors such as passenger flow, train

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marshalling number, number of vehicle personnel and full capacity rate. The number of trains passing through a section in a single direction per unit timeN_i can be calculated from the following formula.

$$N_i = \frac{P_{max}}{M * c_c} \tag{2}$$

In the formula, M represents the number of trains in formation during heavy passenger flow.

Start interval to increase capacity. If the scheduling and organization work permits, the operation scheme with asymmetric upper and lower directions can be run to evacuate the passenger flow as soon as possible when the passenger flow of a certain section is particularly large. The investment of line spare train is also an effective way to improve the running speed of train.

(3) Train Interchange Program. There are two main types of rail transit train intersections: conventional intersections and special intersections. The conventional intersection means that the train does not return to other stations except the terminal. The special intersections mainly include connecting intersections, nested intersections, staggered intersections and combined intersections.

Bridging: trains run in sections of their respective traction lines and at each reentry station. When the propagation of large passenger flow in the network causes the uneven passenger flow in peak hours of some sections, the passenger flow can be effectively evacuated by using this intersection scheme when it is collected and stored in different sections. The scheme is beneficial to improve the service level of the crowded section, but it will increase the passenger transfer time.

Nested intersections: the same line is divided into different sections. Different intersections may have a common line. Nested intersections are suitable for the case of uneven distribution of passenger flow during peak hours and large passenger flow in overlapped sections. The operation of nested intersections needs to take into account the arrangement of line return-points.

Staggered intersections; Trains with different intersections operate independently in their respective independent traction sections, and some of them intersect. Suitable for suburban to urban passenger flow. The use of cross-roads can meet the travel needs of urban passengers and reduce the waiting time of crowded areas, but it may cause the increase of travel time of some passengers.

Combinatorial intersections: forms of intersections joining together. It is applicable to the case where the passenger flow in the section is particularly complex and the single crossing cannot meet the passenger flow demand. The advantage of combined crossing is that it can choose the crossing way flexibly according to the actual situation of passenger flow, while the disadvantage is that if too many choices are made, it will increase the difficulty of identification and affect the full capacity of the train.

In order to meet the transportation needs of passenger flow, the formulation of train interchange is also affected by train service level, passenger flow organization, return operation, train capacity and other factors.

(4) Train Stop Plan. There are two kinds of train stop schemes of urban rail transit, station stop and large station stop. Station parking means that the train stops at every station of the line. This scheme is characterized by simple train operation organization and suitable for running when the passenger flow of the line is evenly distributed. However, when the passenger flow distribution is uneven, the scheme can't meet the passenger's travel demand well.

There are three types of parking schemes for large stations: cross-station parking, section parking and fast and slow trains. The cross-station stop scheme can effectively reduce the number of stops of the train, improve the travel speed of the train, and reduce the travel time of long-distance passengers. However, cross-station parking will reduce the departure frequency of similar trains, increase the waiting time of passengers and increase passenger flow on the same line. It is recommended to adopt the section stopping scheme when the line is running on the size intersection. At this point, the whole operation completed jointly by multiple extents, small road train station parking at run time, big pay the train run time skip the small cross road section station parking outside of the small cross road section traffic assignment. It is helpful to reduce the cross road of the train operation time and operation train number, convenient for passengers traveling long distances, but reduces the O-D between direct sex, increased the different train departure intervals.

When the line is running on a large cross-road and the passenger flow scale is large, the fast and slow car scheme W can be adopted to evacuate the gathering passenger flow as soon as possible.

Express train scheme and cross-station stop scheme are similar. When the slow car runs, it stops at the station. The express train stops across multiple stations according to the actual situation of passenger flow. The aim is to evacuate crowded stations without considering other stations.

4.2Traffic Control

When the passenger flow control measures are adopted, the station generally adopts the three-level flow control method. According to the principle from the bottom to the top and from the inside to the outside, there are three levels: platform, payment area and non-payment area respectively to control passenger flow. The three-level flow control method is shown in the following **table 1**:

Table 1. Three levels passenger flow control of station

Control grade	Control content	Control position
Level 1	Platform passenger flow control	The platform channel
Level 2	Pay zone passenger flow control	Gate machine
Level 3	Entrance and exit passenger flow control	Station entrance

If the passenger flow density in the station platform area is high, the station shall adopt the first-level control measures, change the direction of the escalator by setting a separation strip in the platform channel. In addition to increasing the outflow speed of platform passenger flow, the speed of passenger flow into the platform area is reduced, and the passenger flow density in the platform area is controlled. When the first step is taken, the passenger flow density of the platform layer is controlled. If the passenger flow outside the station continues to flow into the charging area, it is likely to cause congestion in the paying area. At this time, the station can adopt secondary control measures, reducing the rate of passenger flow into the pay zone by stopping some of the locks and automatic ticket machines. After the secondary measures, paying the passenger flow density, the effective control for inbound traffic continues to flood, will eventually cause paralysis of the entire station, now need to take 3 curtains on measures, to passenger flow into the management of the station exit, serious when can take closed the station, not only into the passenger flow in order to ensure the orderly operation of the station.

5. Conclusion

In this paper, the urban rail transit network encountered large passenger flow as the background, the propagation mechanism of large passenger flow in the network is explored, the emergency control strategy and the propagation law of large passenger flow in the network are studied. It provides a control strategy for the passenger flow control of the station in the line network when large passenger flow occurs.

6.Acknowledgements

This work was supported by the key Project of BEIJING POLYTECHNIC. The Project number is 2018Z002-009-KXB. This support is gratefully acknowledged.

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