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Evacuation Simulation Analysis of Fires in Subway Junction Station

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ABSTRACT: Prompt and effective evacuation is very important to guard against emergencies in the city's Metro system to ensure the safe operation of the subway. With regard to a certain subway junction station in Shanghai, this paper carried out evacuation simulation analysis of fires. Base upon the field observation of passenger number and the software of Simulex, four evacuation scenarios were simulated in the discussion. Obviously the relevant suggestions are helpful to enhance the safety precautions of subway junction station.

1 INTRODUCTION

Subway transit is an important part of modern urban transport system, which endowed with high speed and great carrying capacity. The increasing problems brought about by high density of people in subway system have created an urgent need to strengthen safety management level. Although urban subway transit is well served with relevant operation system, it is prone to be very difficult during rush hour because all train passengers should be promptly evacuated in an emergency situation. Fire accident is the most serious disaster in subway station. Poison smoke and radiant heat resulted from fire is fatal to human being. Hence, it is necessary to further develop more perfect evacuation technology in case of fire accident for urban subway station. With regard to a certain subway junction station in Shanghai, this paper carried out evacuation simulation analysis of fires. Base upon the field observation of passenger number and the software of Simulex, four evacuation scenarios were considered in the simulation. In connection with each simulation scenario, the total evacuation time were calculated during the discussion. Apparently the relevant suggestions are helpful to enhance the safety precautions of subway junction station.

2 SCENARIO OF EVACUATION SIMULATION

2.1 Brief Introduction of a Certain Subway Junction Station in Shanghai

The total building area of this subway junction station is 17487 m^2, including station hall, station platform, station lane, equipment and management rooms, ground passageway (number: 5, total width: 24.56m) and so on. The station is 12.5m deep. The hall is on the 1st floor underground with 6649 square meters, 165.3m long, 21.6m wide and 4.2m high, consist of passenger distributing area, equipment and management rooms, inlets and outlets etc. The platform is on the 2nd floor underground with 4017 square meters, 183.7m long, 14m wide and 4.8m high. The corresponding management rooms are located on both sides of the platform. A louver opens through the ground in the middle part of the platform. There are four stairs in the central section. Each stair is about 3.5m wide with 31 steps (height of each step:0.135m), and there is an escalate beside it. Each escalate is 1.1m wide. There are five gateways on the ground. The total width of the gateway is 24.56m. The planes of the station hall and platform were shown in Fig.1 and Fig.2.

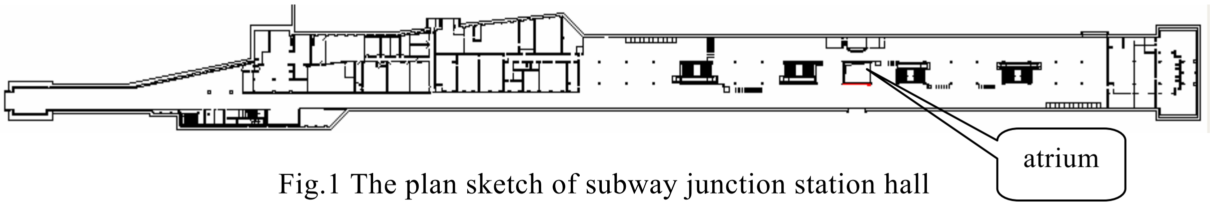

Fig.1 The plan sketch of subway junction station hall

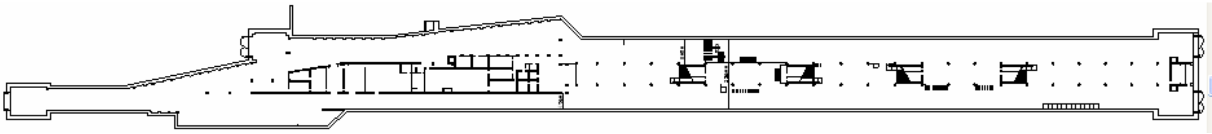

Fig.2 The plan sketch of subway junction station platform

2.2 Evacuation Simulation Scenario of the Subway Junction Station

In connection with evacuation simulation scenario of fire in subway junction station, the fires were supposed to take place at different locations of subway station platform. Therefore, relevant gateways (such as fireproof doors, transfer passage and outlets) of the subway station affected by fires should be closed on accordance with fire situation. In this paper, considering different conditions of baggage fires and train fire, four evacuation simulation scenarios were constructed, including: (1) scenario 1: only DOOR 1 was closed; (2) scenario 2: only DOOR 3 was closed; (3) scenario 3: only DOOR 6 was closed; (4) scenario 4: only DOOR 7 was closed. The locations and basic feature of these gateways were shown in Fig.3, Fig.4 and Table 1 respectively.

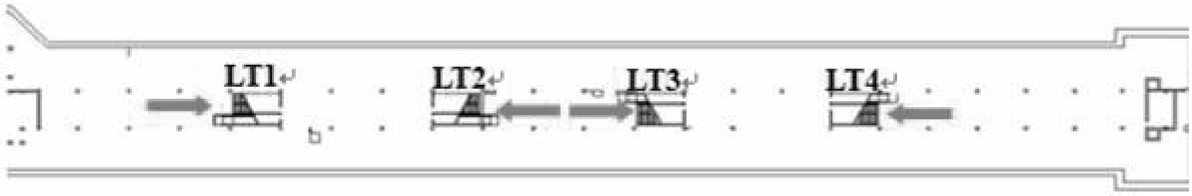

Fig.3 The plan sketch of evacuation simulation scenario in subway junction station platform

Fig.4 The plan sketch of evacuation simulation scenario in subway junction station hall

Table 1 Basic feature of gateways (to be closed) in evacuation simulation scenario

Serial number	Type	Quantity	Effective width (m)	Remarks
DOOR1	stair	1	6.00	leading to outdoors
DOOR3	exit	1	4.00	
DOOR6	stair	1	5.00	
DOOR7	exit	1	7.50	

Once a fire happened, the fire resisting shutter would be closed within 30s. Passengers in the subway junction station should not escape via transfer passage which connected Line 1 of the subway junction station to that of Line 2. Other outlets could be used except the gateway to be closed due to fire.

3 ANALYSIS OF EVACUATION SIMULATION RESULTS

3.1 Observation of Passengers in the Subway Junction Station

In order to carry out evacuation simulation of fire, the field observation of passengers were completed in the subway junction station. The observation period was from Monday to Sunday in a certain week. The collected data included the number of passengers walking out from Line 1 as well as Line 2 of the subway junction station and that transfer from these two stations, etc. Partial observation results were shown in Fig.5 and Fig.6.

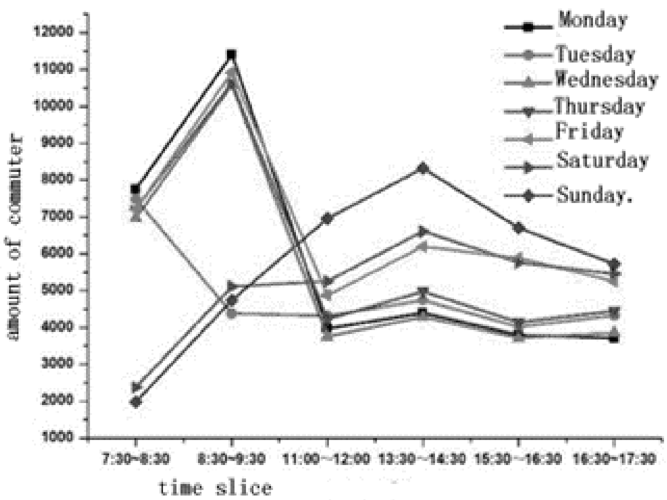

Fig.5 The number of passengers walking out from Line 1 of the subway junction station

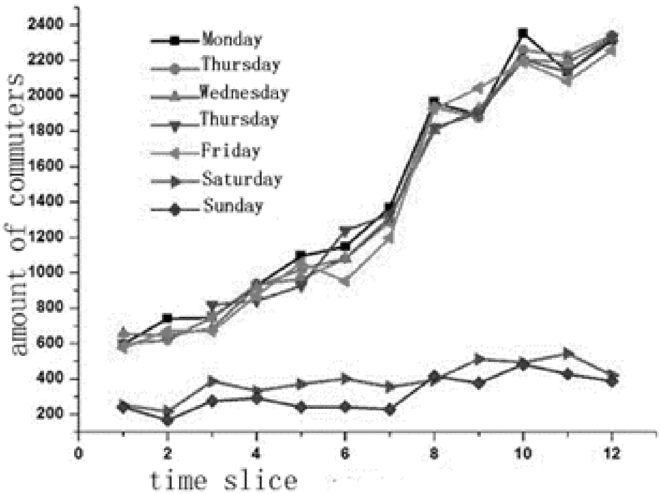

Fig.6 The number of passengers transferring from Line 1 to Line 2 of the subway junction station

3.2 Number of Passengers in Evacuation Simulation

The passengers in evacuation simulation mainly consisted of three parts: (1) passengers in the subway train P_1; (2) passengers in the platform and hall of the station P_2; (3) passengers transferring from two lines P_3. The subway train was usually composed of 6 carriages. According to the observation of rush hour, the average number of passengers in each carriage was 410 people. Supposing there were two subway trains parking in the station platform. Hence, $P_1=410\times12=4920$. The corresponding $P_2=1159$ and $P_3=1796$. The total number of passengers was 7875. As for comparison of analysis, the passenger number of 2500 and 4500 were also adopted in the evacuation simulation.

3.3 Evacuation Simulation Results of the Subway Junction Station

The software of Simulex was used to simulate the evacuation of fires in subway junction station. The total evacuation time included three parts: (1) Cue time; (2) Response time; (3) Travel time. In accordance with the actual situation of the subway junction station, the cue time of passengers in subway station platform was chosen as 112s and that in subway station hall was 120s. The response time of passengers was chosen as 120s. The travel time should be simulated by Simulex. The evacuation simulation results were illustrated in Table 2, Fig.7 and Fig.8 separately.

Table 2 Evacuation simulation results of the subway junction station

Evacuation simulation scenario	Number of passenger	Number of gateway	Total evacuation time (s)
	2500		338.9
Door 1 closed	4500	3	635.8
	7875		1350
	2500		359.7
Door 3 closed	4500	3	710.5
	7875		1300.6
	2500		505.0
Door 6 closed	4500	3	851.3
	7875		1405.3
	2500		418.3
Door 7 closed	4500	3	847.0
	7875		1570.2

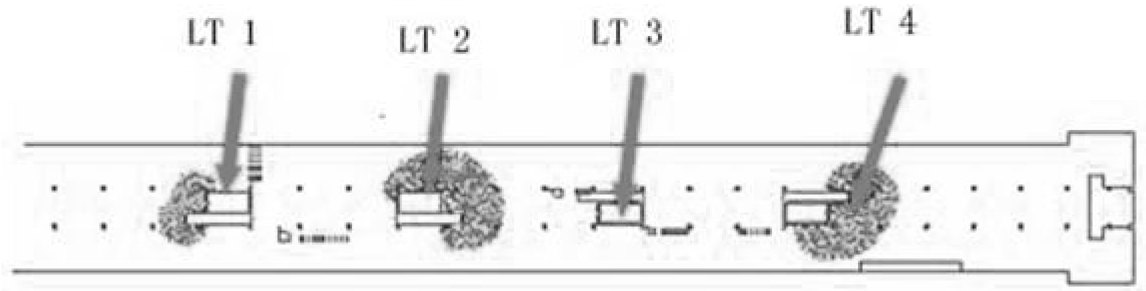

Fig.7 The sketch map of evacuation simulation in subway junction station platform

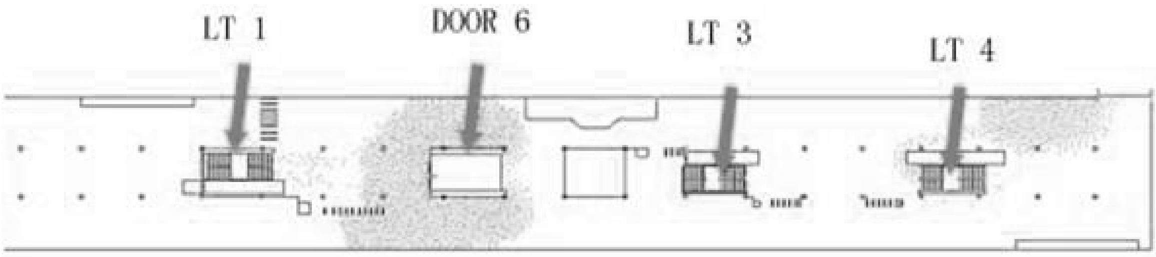

Fig.8 The sketch map of evacuation simulation in subway junction station hall

3.4 Brief Analysis of Evacuation Simulation Results for the Subway Junction Station

(1) The simulation results demonstrated that travel time was related closely with number of passengers as well as the width and location of gateways. If there were a large number of passengers in the subway junction station, travel time would be depended on the width of gateways. If there were few passengers, travel time would lie on both of the location and width of gateways.

(2) In connection with evacuation simulation results, gateways of Door 6 and Door 7 had comparatively large influence on the total evacuation time than those of gateways of Door 1 and

Door 3. Therefore, gateways of Door 6 and Door 7 were very crucial to safe egress of passengers in the subway junction station.

(3) Door 6 was located at the central area of the subway station hall. Thus it could be easily found. The width of Door 7 was quite large and was adjacent to Door 6. These two gateways could evacuate passengers directly outdoors. As a consequence, in case of fires in the subway junction station, most passengers would choose gateways of Door 6 and Door 7 to evacuate.

(4) Door 1 and Door 3 were on the side of the subway station hall. It was such a long distance for passenger to evacuate out of the subway station. Meanwhile, passengers should also go through a narrow passage to reach these two gateways. Consequently, passengers would not like to choose them for evacuation. In view of the simulation results, the evacuation signs had to be properly set. Only in this way passengers could be correctly guided to evacuate quickly.

(5) The basic simulating principle of Simulex is to choose the shortest way for passengers to evacuate. Consequently, if Door 1 be closed, no passenger would choose stair 3 and the stair 2 was excessively congested. It could be found in all simulation scenarios. Since stair 2 was easily neglected, the corresponding signs should be clearly indicated to ensure passengers evacuate within safe egress time.

4 CONCLUSION

Prompt and effective evacuation is very important to guard against emergencies in the city's Metro system to guarantee the safe operation of the subway station. In order to provide comfortable and safe environment for passengers, all materials used for subway carriages, stations and cables must be non-flammable. The monitoring, control and alarm systems would be armed with advanced techniques. Once smoke or a fire was detected, the automatic control system should be triggered to rapidly extinguish it. In addition, a well-trained squad should also ensure that all passengers be evacuated within safe egress time in an emergency.

ACKNOWLEDGMENTS

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