Research on the Evacuation of Passenger Flow at Commercial Block Stations under Emergencies Based on Pathfinder

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Abstract. Metro stations are small and closed. In the event of an emergency, it is easy to cause casualties and property damage. Pathfinder simulation software is used to simulate the evacuation of passenger flows under different operating conditions. Study the impact of factors such as exits, business districts, and train entry on evacuation times. This is of great significance for improving evacuation capacity and ensuring the safety of people's lives and property.

Keywords: Passenger Evacuation, Simulation Models, Pathfinder.

1. Introduction

Operational safety plays an important role in traffic safety [1]. In the study of passenger evacuation at subway stations under emergencies, after setting the simulation parameters of personnel and the internal environment of the subway station, the pathfinder software was applied to model the subway station [2]. Starting from the two aspects of personnel and internal facilities of the station, the impact on the evacuation of passengers under emergencies is studied [3]. It can be found that most studies have focused on non-interchange stations [4-7], with stations being simpler and a few tending to consider interchange stations in special environments. In addition to considering the factors of internal facilities and the change of the number of personnel in the station, this paper analyzes the evacuation situation of the shopping mall interchange station, that is, the flow of people with non-transfer purposes in the station during the evacuation process. It is of great significance to ensure the safety of people's lives and property [8-9].

2. Set up a simulation environment

2.1. The process of evacuation of personnel in the event of an emergency

The evacuation process is shown in Figure 1, with the initial state (P1) of people waiting for the train in an orderly manner at the station. At this time, a disaster occurs, and the personnel perceive the disaster and go to confirm (T1). If the person confirms that no disaster has occurred, return to the waiting position (T2). If the personnel confirm that a disaster has occurred, they begin to respond (T3) and enter an evacuation state (P3). People at the station hall level are evacuated to the exit (T4). Personnel at the platform level are evacuated by stairs to the exit (T5). The evacuation of persons in the train starts from inside the train to the exit of the station hall floor (T6). Affected by the factors of the mall, some people went retrograde to the exit (T7). Finally entered the state of evacuation (P4).

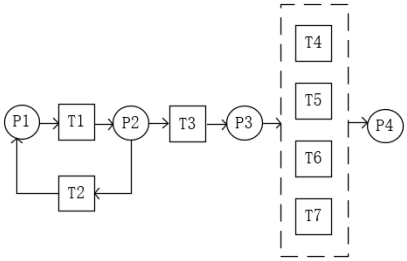


Figure 1. Evacuation flowchart

2.2. Build a built environment for subway stations

As shown in Figure 2, a simulated station based on the Shijiazhuang Metro Xinbai Square Station is constructed. There are passengers at the station who are engaged in commercial purposes.

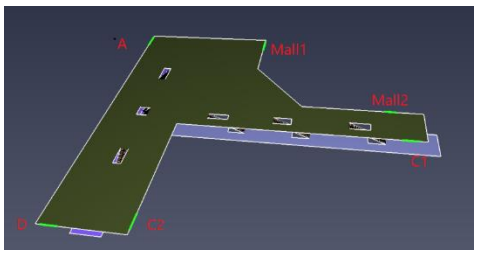


Figure 2. A simulated subway station diagram based on Pathfinder

2.3. Set up a subway station personnel environment

The total number of people in the station is 3150 people, 1300 people on the hall level, 1300 people on the platform level of Line 1, and 550 people on the platform level of Line 3. The personnel attributes are shown in Table 1.

Table 1. Personnel speed and shoulder width parameters

Pedestrian type	Proportion	Pace (m/s)	Shoulder width (cm)	Represents a color
child	6%	0.85	37.5	green
adult male	45%	1.27	41.0	blue
adult female	40%	1.20	39.0	pink
old man	9%	0.95	40.0	yellow

3. Results

3.1. Initial state

A total of 3,150 people were evacuated. Total elapsed time 220.5s. The results met the safe evacuation time standard from the hazardous area to the safe area within 6 minutes. The evacuation data for each exit is shown in Table 2. Each outlet flow is shown in Figure 3.

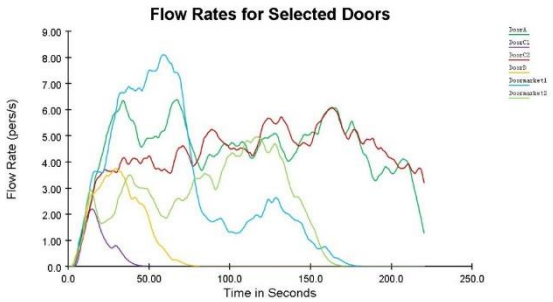


Figure 3. Changes in the flow of people at each exit

Table 2. Simulation results

Exit	The first evacuees pass through time/s	The last evacuees pass through time/s	Number of people evacuated/per	Average traffic (pers/s)	Peak traffic (pers/s)
A	1.5	220.5	988	4.51	6.37
C1	2.2	26.6	36	1.48	2.20
C2	2.4	219.2	965	4.45	6.08
D	0.8	63.4	137	2.19	3.75
market1	2.1	163.8	562	3.48	8.09
market2	1.7	149.9	462	3.12	4.97

3.2. Export impact

The influence of the width of the entrance and exit on the evacuation time of personnel is mainly considered. The results of Figure 4 show that increasing the width of the exit within a reasonable range can effectively shorten the evacuation time of personnel. However, when the width of the outlet is increased excessively, the effect on reducing the evacuation time is not obvious.

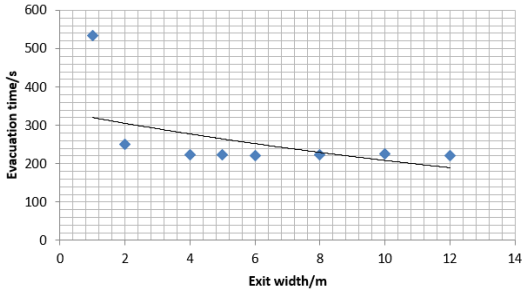


Figure 4. The effect of different exit widths on evacuation times

3.3. Mall area impact

Suppose there are 100 people on Exit A leading to a commercial block and 100 people on a commercial block leading to Exit A. The 200 people appeared inside the subway station in order to cross the street through the subway station. 20% of such pedestrians choose to continue to walk forward to the corresponding exit in front to escape, and 80% choose to turn back and evacuate in the direction of the exit into the station hall.

As shown in Figure 5, the time it takes to select a person to evacuate from Exit A, regardless of the influence of the business circle, the time it takes for the selected person to escape through Exit A is 55.4s. As shown in Figure 6, considering the business circle factor, the evacuation time of the selected personnel is 65.5s, which is 10.1s more than the scene 1. The return behavior of people for commercial travel purposes in the passage may cause convection of personnel in the evacuation process, hinder the normal evacuation of individual personnel, and increase the evacuation time of individual personnel.

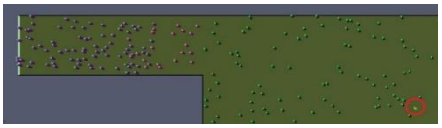


Figure 5. Initial state of the single individual evacuation process

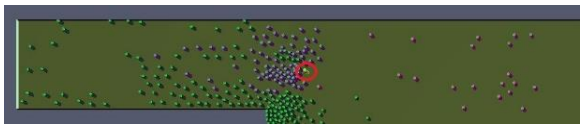


Figure 6. The business district affects the evacuation process of a single individual

3.4. One-sided trains stop

As shown in Figure 7, there is a one-sided train stopping on the platform level of Line 3 of the simulation station, and the third car of the train suddenly catches fire, and the carriage door cannot be opened normally. Suppose there are 500 people in the train randomly distributed in each carriage. The total evacuation time is 222.0s, which meets the time standard of 6 minutes of safe evacuation. When a train stops at the line 3 platform, the evacuation time on this floor increases by 58.3s compared to the initial state.

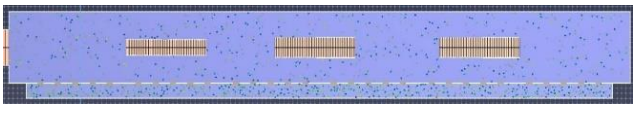


Figure 7. One-sided trains stop

4. Conclusion

Using pathfinder to simulate the evacuation of people at subway stations, it can be seen that:

(1) The width of the exit of the subway station has a certain impact on the evacuation time. Constantly increasing the width of the exit does not reduce the evacuation time indefinitely. Therefore, in the early stage of the construction of the subway station, it is necessary to determine a reasonable exit width.

(2) Exit C2 and Exit A have a large number of people evacuated during the evacuation process, and priority should be given to ensuring their normal use.

(3) The presence of people at stations for non-travel purposes has a negative impact on the evacuation effect. By tracking a single person, it was learned that the evacuation time of that person increased by 10.1s. Under the emergency, the focus is on the on-site relief of such personnel. Set up special crossings for people who are not for transfer purposes.

Acknowledgements

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