International Core Journal of Engineering Volume 7 Issue 12, 2021
ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

Subway evacuation simulation based on Pathfinder

Chen Zhao
School of Shanghai, Shanghai Maritime University, Shanghai 201306, China
247408094@QQ.com

Abstract

The research on evacuation in China is later than that in developed countries. Since the beginning of the 21st century, as the country attaches more and more importance to security, the research on evacuation is developing faster and faster. A large number of domestic scholars have started to conduct evacuation studies, but the data of evacuation behavior characteristics in China are relatively insufficient, and only foreign data can be referred to, which will inevitably affect the research results. Therefore, in recent years, many scholars began to conduct investigations on evacuation behavior to obtain data.

Keywords

Pathfinder, Subway, Evacuation, Safety.

1. Introduction

1.1 Introduction to Pathfinder

Pathfinder simulation software is a simulation based on import, export and human movement developed by Thunderhead Engineering in the US. It provides simulation design and execution of graphical user interfaces, as well as analysis results of 3D visualization tools. Thunderhead Engineering also developed the widely used FDS based flue gas simulation software Pyrosim.

In Pathfinder simulation software, the movement mode of personnel mainly includes SFPE mode and Steering mode. The former uses the SFPE concept in the fire Protection design manual. Pedestrians in the mode do not affect each other, that is, they do not give way to each other and can penetrate each other. The walking speed of people is determined by the density of people in each room, the flow of people through the exit is determined by the width of the exit, and flow-based selection means that people automatically move to the nearest exit. In contrast, the Steering mode uses a combination of path planning, guiding mechanism and collision handling to control pedestrian movement. When the distance between people and the path of the nearest point exceed a certain limit value, the software algorithm will generate a new path to change the pedestrian's walking path. In this mode, the evacuation flow is not restricted by the door, and a certain distance is kept between the evacuees. Since the Steering mode is more consistent with the actual situation, the software simulation in this paper will adopt this mode to simulate.

Pathfinder emulators have the following features:

①The software can not only draw simulation model according to the relevant data of actual investigation, but also directly import FDS, DXF and other simulation models or architectural drawings, which saves a lot of time in modeling and is very convenient.

②For good simulation results, the software is presented to users in the form of 3D animation, which is clear at a glance. At the same time, a complete and specific record of each pedestrian evacuation time and each staircase, exit evacuation situation.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

③It can completely and accurately display everyone's evacuation path and evacuation situation, and restrict people in different areas according to different conditions set, so that the simulation results are more real and the simulation data has more reference significance.

1.2 Research status at home and abroad

Taking a subway station as the research object, Cheng simulated the evacuation process of subway station under the condition of different passenger flow and different width of evacuation stairs through Pathfinder evacuation simulation software, and put forward the concept of comprehensive factor. More influencing factors are reflected in the pedestrian evacuation speed qualitatively and quantitatively[1].Li use a subway station in Beijing as an example, using the subway field experiments, simulation model experiment and the simulation test method, three kinds of simulation software respectively from fire, subway trains and subway station, subway station platform fire four aspects carries on the analysis, found that there is blind in the process of evacuation behavior, unable to select the optimal safety evacuation exit[2].Jia use Anylogic simulation software to evacuation simulation of Harbin metro station, analyzes the subway station evacuation capacity, and puts forward the safety evacuation zone are installed in station method, based on the ant colony algorithm, to evacuate the shortest path as the main target, full consideration of various factors, location optimization for on-site safety evacuation areas [3].Some foreign countries carried out the evacuation research relatively early, and many foreign scholars carried out investigation and research on this, and obtained relatively rich data. Nirajan Shwakoti et al. from Australia collected and analyzed the influence of different angles in the design of passageways in buildings on pedestrian movement speed, and obtained the relationship between the Angle of passageways and pedestrian movement speed in fire evacuation [4].

1.3 Research significance

Subway station as a crowded place, but also has a certain degree of privacy. At the same time, the fire after the formation of smoke and toxic gases. Therefore, it is of great significance to study the characteristics of fire safety evacuation in subway stations and put forward reasonable and effective evacuation suggestions while carrying out fire prevention related work in subway stations, which is of great significance to the development of subway rail transit and guarantee the safe riding environment of personnel.

2. Physical mode

This paper will take Lingang Avenue subway station in Pudong New Area of Shanghai as a model to establish a simulation model for research. The subway station is divided into two floors. The upper floor is the station hall floor, which is set to be 80m long and 30m wide. The lower layer is the platform layer, and both sides and the middle of the platform layer are trains, and pedestrians are not allowed to walk. When building the model, it was dug out, so the platform layer was shown as two areas, both of which were set to be 80m long and 6m wide. The height difference between platform floor and station hall floor is 6m. The two floors are connected by stairs, using 4 3m wide stairs, divided into 10 meters away from both sides of the boundary. According to national safety regulations, the Angle between the stairs and the ground should be 30°, so the length of the stairs is 12m. Two are set up in each of the two areas of the platform floor, which are symmetrically distributed. Four safety exits are set up on the station hall floor with a width of 5m.

3. Staff attribute setting

Because of people's gender, age will directly lead to different pedestrian speed. Therefore, the age groups in the study were divided into juvenile (younger than 18 years old), young and middle-aged (between 18 and 60 years old), and old (older than 60 years old). Different passenger flow will also have an impact on pedestrian movement speed. Passenger flow can be divided into peak period, steady period and low peak period, and evacuation at peak period is mainly considered here. Since

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

the gender difference is not obvious in teenagers and the elderly, this study only considers the gender difference between middle-aged and young people. The specific data are shown in the following table.

Table 1. Movement speed of personnel

	The young	Middle-aged (male)	Middle-aged (female)	The old
Movement speed (m/s)	0.75	1.05	0.95	0.65

According to the investigation, due to the remote location of the subway station, the passenger flow is relatively small, and the total number of people in the station does not exceed 150 at peak hours. The number of people in this experiment was 150, including 23 teenagers, 58 young and middle-aged males, 48 young and middle-aged females and 21 old people. In the simulation, the targets were green for teenagers, blue for young men, red for young women, and black for old people. The effect is shown below

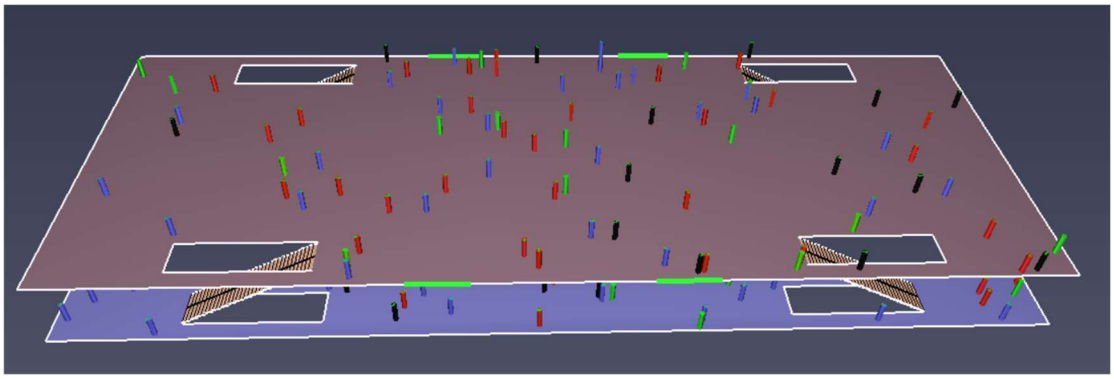

Figure 1. Overall effect diagram

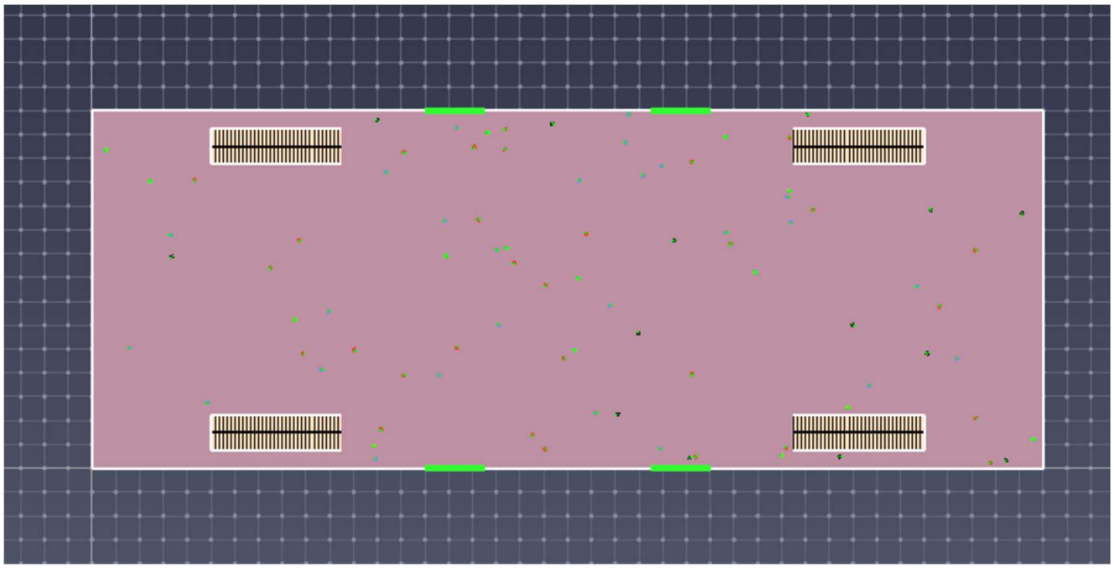

Figure 2. Top view

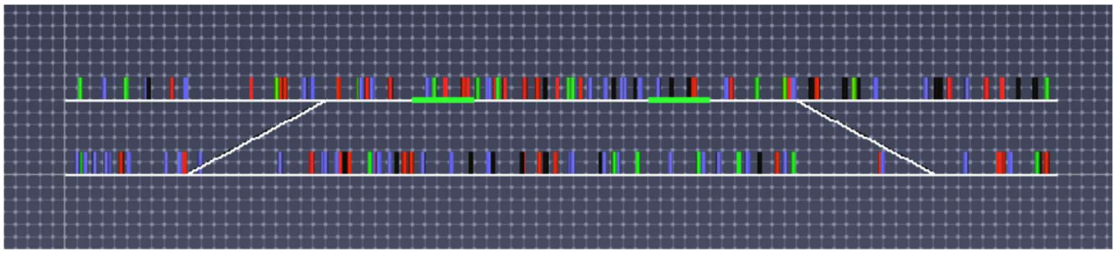

Figure 3. Front view

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

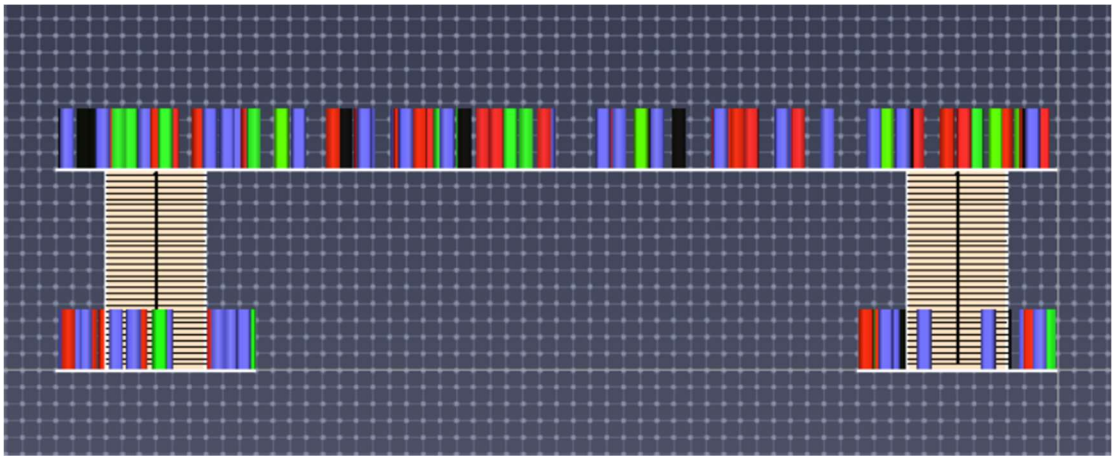

Figure 4. Side view

4. Simulation results and analysis

Through the simulation, we can get the movement of all the people randomly distributed in the subway station escaping from the safety exit and other parameters.

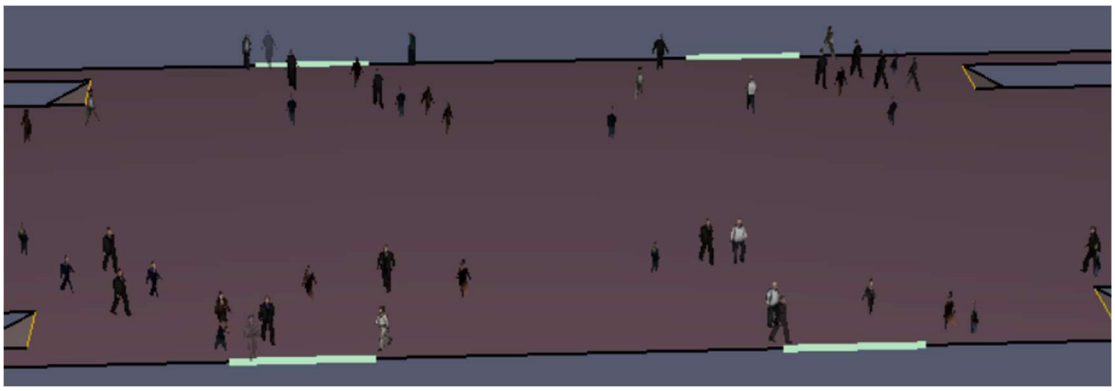

Figure 5. Simulation process diagram

4.1 Evacuation time

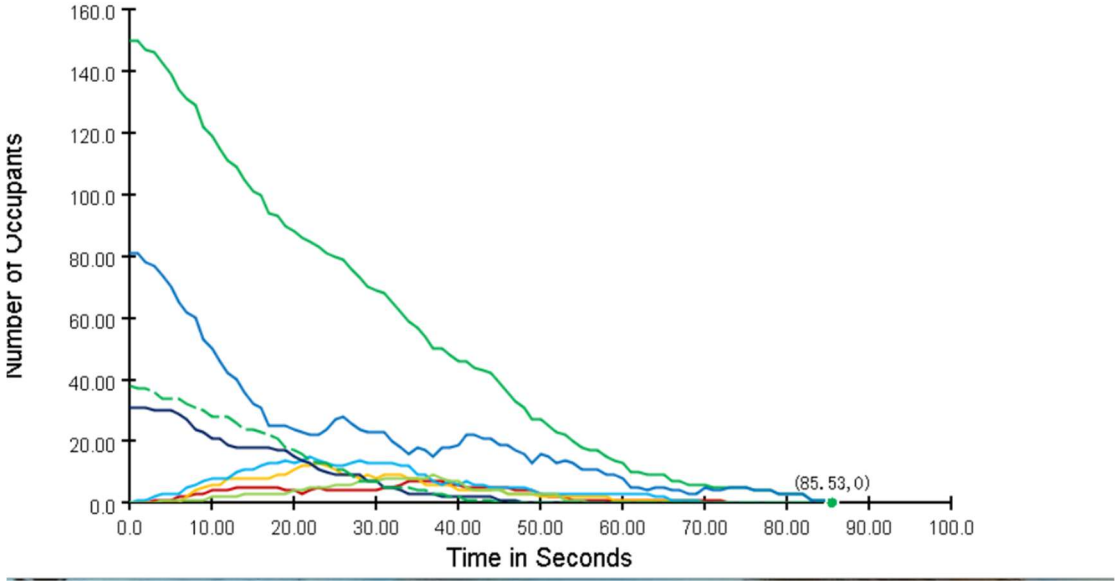

Figure 6. Simulation results

It can be seen from Figure. 6 that when the time goes to 85.53 seconds, all personnel complete evacuation, which is very abundant compared with the national security regulation of 6min. And in 73 seconds, everyone evacuated from the platform floor to the station floor. If there is a fire accident

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

on the platform floor, it takes only 73 seconds for all personnel to evacuate to the safety area, which is quite fast.

4.2 Traffic density

There is no doubt that the density of pedestrian flow affects the evacuation. Due to the high density of pedestrian flow, the space occupied by each pedestrian is small, making it difficult to walk normally, not to mention evacuation in case of fire. It is obvious that the density of the flow of people has a great influence on evacuation. Some scholars have studied the relationship between pedestrian flow density and pedestrian speed. They use ρ to represent pedestrian flow density, v to represent pedestrian speed, w to represent the width of safe passage and f to represent the size of passenger flow. Studies have found that the relationship between them can be expressed by the following formula:

$$f=\rho \cdot v \cdot w \tag{1}$$

From Equation 1, we can see that under the condition that the passenger flow and the width of the passage are the same, the pedestrian flow density is inversely proportional to the pedestrian speed. That is, the greater the pedestrian density, the slower the pedestrian speed. In the actual situation, we can find that since the total area of the subway station is constant, when the crowd density is large, the passenger flow will increase, and vice versa. Therefore, the walking speed of personnel in the low peak period is much faster than that in the peak period, and the number of personnel is small, so the evacuation time is naturally much shorter. In this simulation, the key positions are four stairs leading from platform floor to station floor and four safety exits, as shown in Figure 7

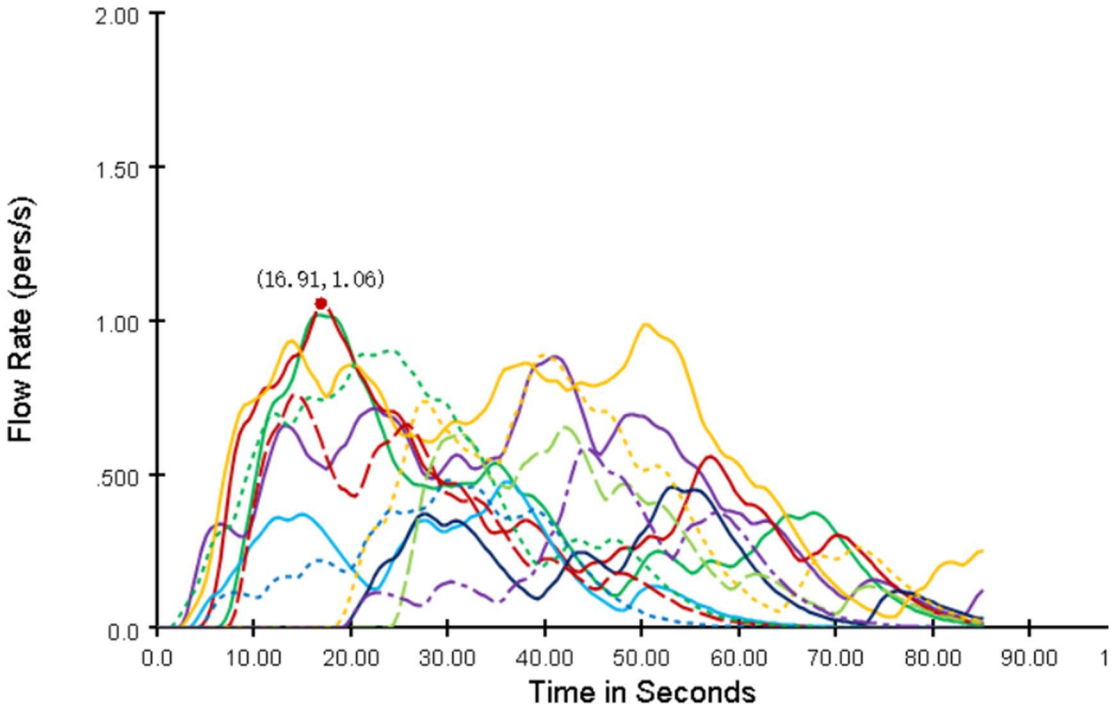

Figure 7. Pedestrian density

As can be seen from Figure 7, the highest point is at (16.91, 1.06) among the four stairs and four safety exits. When the time goes to 16.91 seconds, the density of human flow reaches the maximum value of 1.06, which is much smaller than the safety value. Therefore, it indicates that the width of the stairs and the width of the safety exit are very correct.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

5. Conclusion

5.1 The simulation results

According to the actual situation, the number of evacuees was set at 150 people, and four groups of people were set, corresponding to different age groups and different movement speeds. According to the simulation results, the evacuation time is about 85 seconds, which is in line with the national safety regulations of 6 minutes, and the flow density of 4 stairs and 4 safety exits is monitored, which are prone to dangerous accidents caused by crowding. However, according to the results, the highest density of human flow is 1.06, which is also within the safe range. It can be seen that the evacuation activities of the subway station can be carried out quickly, safely and effectively, and the safety of personnel can be well guaranteed in the event of an accident.

5.2 Deficiency

①Due to the current special situation, it is impossible to conduct a more detailed on-site survey and analysis of the subway station. If conditions permit, on-site shooting should be carried out again for comparative analysis with simulation results.

②Due to the limitations of the use of software, only evacuation simulation can be carried out at present, and then in the future work, join the fire situation, and limit some safety exits or stairs can not be used, analyze the evacuation simulation time and safety in these cases.

③Since people are subjective, the parameters set in this simulation may not be comprehensive enough, which can be improved in the future.

5.3 Recommendations and Measures

Through software simulation, we can find that the subway station can almost meet the national safety evacuation standards, but this is based on everyone can correctly choose the optimal evacuation path. In fact, not everyone can choose the best path, even most people are not familiar with the subway station, can not accurately find the exit, can only blindly follow the flow of people ahead. When we solve the evacuation problem, there are many factors that we cannot control, we focus more on management. The following are my suggestions for safe evacuation of subway station personnel in case of fire:

①Make full and reasonable use of radio and video for publicity

Subway station staff can broadcast radio and related videos to promote safe evacuation without affecting the normal life of pedestrians, and improve the awareness of safe evacuation of pedestrians. At the same time, in the event of a fire, related equipment can also be used to guide pedestrians to help them find the safety exit and improve the probability of successful evacuation.

②Pay attention to the Posting of safety signs

Subway stations must be posted in eye-catching places such as safety information and safety passage safety signs, so that passengers at a convenient time to pay attention to these information, improve safety awareness. At the same time, in the event of a fire, these safety signs can also play a good role in guiding and improving evacuation efficiency.

③Regular safety training for staff

Due to the uncertainty of passengers, it leads to uncontrollable passengers. When we cannot determine the relevant parameters of passengers, we can only ensure the safety common sense of staff first. Regular safety training and evacuation drills for the staff can improve the safety awareness of the staff, and help passengers choose a better evacuation path in the event of fire evacuation, and improve the success rate of evacuation.

④Equipped with professional guidance staff

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0043

When a fire breaks out, the evacuation of passengers requires the guidance of subway staff, and the professionalism of the guidance staff is irreplaceable. Professional guides can greatly improve the success rate of all personnel evacuation, which is irreplaceable in safe evacuation policy.

References

[1] LinNa. Cheng. Simulation of Subway Station Fire Emergency Evacuation based on Pathfinder [D]. Lanzhou: Lanzhou Jiaotong University, 2014

[2] ShengYang. Li. Study on fire Simulation and Evacuation of a Subway station [D]. Huainan: Anhui University of Science and Technology, 2018.

[3] Qi.Jia.Simulation of Emergency Evacuation in a Subway Station [D]. Harbin: Harbin Institute of Technology, 2018.

[4] Nirajan Shiwakoti, examing influence of merging architectural features on pedestrian crowd movement [J]. Safety Science. 2015,75:15-22