Research on Evacuation Simulation of University Teaching Building Based on Pathfinder

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Abstract: There are many people in the teaching building of colleges and universities, and the population density is large, so it is easy to cause casualties when an emergency occurs. In order to master the rule of crowd evacuation in the teaching building, this paper uses Pathfinder software to conduct a full scale numerical simulation analysis of the typical teaching building fire and personnel evacuation in the teaching building of a university. According to the results and data of the simulation experiment, the emergency evacuation movement of the teaching building and the required safe evacuation time are analyzed. The research results can provide reference for the fire safety design of similar buildings and set up evacuation emergency plans.

Keywords: Academic Building; Evacuation simulation; Pathfinder

1. Introduction

With the development of society and the increase of attention and investment in education, more and more children have been able to receive school education. When the number of people receiving education is increasing, the safety problem in schools has become more and more important. In particular, the teaching building of the school is a place where people are very concentrated, and has a large fire load and many fire factors. Once a fire occurs, the fire and its smoke spread quickly, which is easy to cause serious casualties. When the school encounters some emergencies, such as earthquake and fire, it often happens that students squeeze and trample on each other due to improper evacuation. Once it happens, it will lead to mass casualties [1]. For example, on March 26, 2001, the dormitory of a public school in the capital of Kenya, an African country, caught fire; On June 5, 2001, Jiangsu Radio and Television Art Kindergarten caught fire; On November 24, 2003, a fire broke out in the dormitory of the People's Friendship University in Moscow, Russia; On November 14, 2008, a fire broke out in the dormitory of the People's Friendship University in Moscow, Russia. Watching live lives die, all of these accidents remind us to be alert to potential threats in personnel evacuation.

In China, the research on crowd dynamics and evacuation started in the late 1990s, which is later than that abroad. Northeastern University [2] has made certain achievements in introducing foreign advanced research achievements. Yuan Qimeng [3] and others studied the evacuation behavior of Skyscraper fire by investigating survivors of fires. Professor Fang Zheng of

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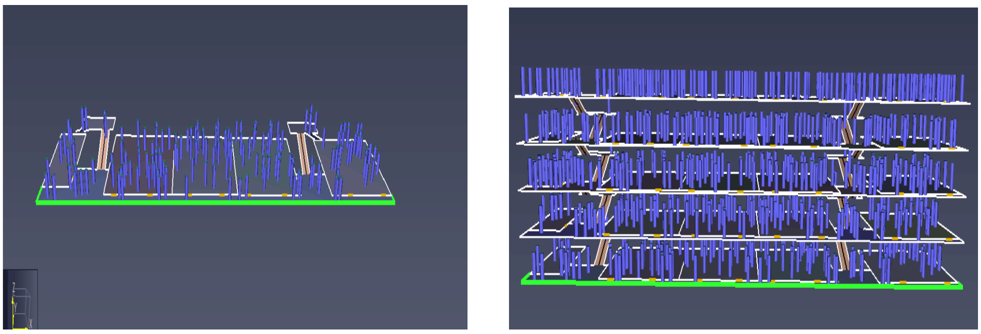
Wuhan University and other personnel have also made some achievements in the quantitative research on evacuation using FDS and "grid model"[4] and other technologies. In addition, the University of Science and Technology of China has also achieved good results in simulating human evacuation movement under emergency environment through FDS, cellular automata and other technologies. Wang Kun [5] used Pathfinder software to simulate the evacuation of the exit personnel of the teaching building, and studied and analyzed the influence of the different classroom arrangement on the evacuation efficiency. Zhijian Chen et al [6] studied the effect of seating arrangement and single and double doors on pedestrian evacuation in a three-dimensional stepped classroom. Yan Weidong, Chen Baozhi, Zhu Wei and so on have studied the evacuation route choice and the evacuation process psychological factor and the evacuation influence in the fire [7,8]. At present, the software is used for evacuation simulation research, mostly using Pathfinder [9]. Therefore, this paper takes the teaching building of a university as an example and uses Pathfinder to establish a software model [10] for research. By analyzing the evacuation and escape situation and the required evacuation and escape time of a school fire at a certain time between classes, we can study the congestion rules and solutions of the teaching building, and hope that this case can provide reference suggestions for more people to avoid stampedes and the loss of innocent lives when disasters occur.

2. Model parameter setting

This model takes the teaching building of a school as the sample, and builds the model according to the actual situation. The teaching building has four classrooms, two staircases and a toilet on each floor. Each classroom is 10m long and 9m wide; The toilet is 4m long and 8m wide; There are 1m wide corridors in front of the classrooms on the second, third, fourth and fifth floors. Therefore, we input the length of 54m and the width of 10m in modeling step 1. The height of each floor is 3m. As there are tables and chairs in the classroom, it is estimated that there are about 40 people in each classroom, 160 people in each floor, and 800 people in the teaching building. The escape speed of people is 1.19m/s according to the national standard. Considering the large number of personnel in the teaching building, the time is set as 300s. The model is shown in Figure 1.



(a) Single layer model diagram (b) Schematic diagram of overall model of teaching building

Fig. 1 Model Diagram

3. Simulation results and analysis

The purpose of studying the safe evacuation of people in the process of fire is to analyze whether people have enough escape time to evacuate to a safe area before the fire threatens the safety of people. In order to ensure the safe evacuation of personnel, it is necessary to allow sufficient time for personnel to evacuate to a safe area before the fire develops to a danger to personnel. That is, the required safe evacuation time (including detection alarm time, personnel response time and evacuation movement time) is less than the available safe evacuation time. The simulation evacuation result obtained by running the software is: the total evacuation time is 297.8s. Figure 2 shows the evacuation of the teaching building in 30s.

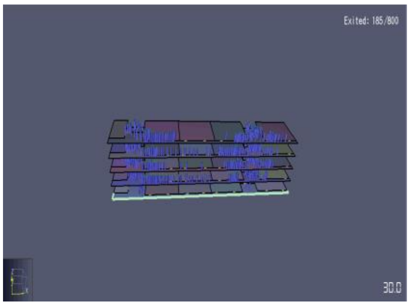


Fig. 2 Evacuation at 30s

It can be seen from the figure that the number of evacuees has reached 185 in 30s, and most of the 185 people who have successfully evacuated are people from the first floor and the second floor. People from the third floor, the fourth floor and the fifth floor generally arrive at the second floor, the third floor and the fourth floor in 30s, and there are still people stranded on the fifth floor, so the evacuation has not been successful. Figure 3 shows the change of evacuees with time in the whole process. From the figure, the whole evacuation process is mainly divided into two parts, the first 20 seconds and the later 20 seconds. According to the evacuation process, the first 20s represents the evacuation of the first floor. At this time, people are close to the exit, the evacuation efficiency is high, and the evacuation time is short. The last 20s is mainly the evacuation of high-level people, and the evacuation efficiency is lower than that of the first floor.

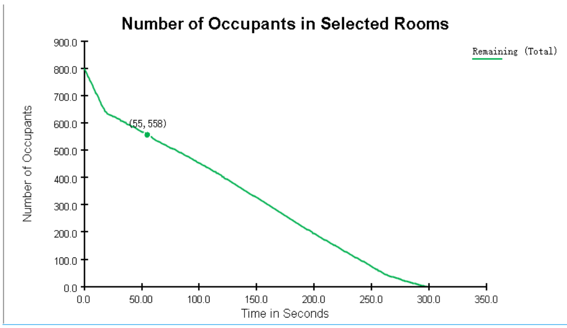


Fig. 3 Diagram of the number of evacuees changing with time

Figure 4 shows the relationship between the flow rate and time. From the figure, the flow rate gradually rises from 0 seconds to 15 seconds, corresponding to the evacuation of people near the first and second floors. At 15 seconds, the flow rate reaches 0.54 (pers/s). From 15 seconds to 22 seconds, the flow rate began to decline, indicating that the gradual evacuation of people near the exit ended. From 22 seconds to 24 seconds, the flow rate began to rise again, and then began to decline to 27 seconds, representing the evacuation process of people on the second floor. Then it began to rise, and the flow rate reached the maximum value of 0.6 at 37 seconds, then began to slowly decline, and gradually returned to 0 after 70 seconds, representing a process from the beginning to the end of high-level personnel evacuation. It can be seen that the flow rate between 15 seconds and 37 seconds is the fastest evacuation time in the whole evacuation time.

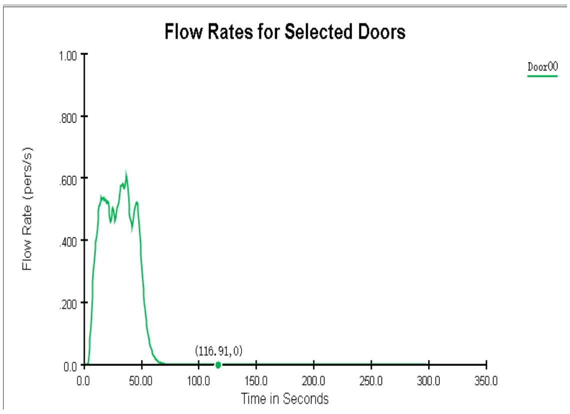


Fig.4 Figure of change of passenger flow rate with time

4. Conclusion

The factors influencing the evacuation of the teaching building through simulation judgment include: (1) there are too few escape stairs in the teaching building. When disasters such as fire occur, people cannot escape in time, and stampedes are easy to occur in the escape process; (2) The insufficient traffic capacity of stairs leads to evacuation queuing; (3) The number of people is unreasonable. The number of high-level personnel in the classroom should be reasonably arranged because they are far away from the escape route and need more evacuation time.

In view of the above negative influence factors, several suggestions for improvement are proposed: (1) appropriately add other escape routes and methods to enable them to respond quickly and effectively when emergencies come; (2) Increase the number of escape drills for students, so that they can calmly respond to real accidents without panic, which can greatly reduce the occurrence of stampedes. (3) Keep the traffic capacity of the stairs at all times. Do not pile sundries at the entrance of the stairs. It is strictly forbidden for students to block the classroom near the stairs.

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