Research on Evacuation of Hotel Staff Based on Pathfinder

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Abstract. In order to alleviate the serious congestion in the evacuation process of high-rise buildings in today's society when a fire occurs, a hotel building in Xi'an was used as the background in this research process, and the disaster escape software Pathfinder was used to conduct a fire on all personnel in the hotel. The subsequent evacuation simulation shows that different behaviors and different groups of people need to spend time in the process of escape and the actual situation of the stairs, walkways, safety exits and other locations in this situation. Combined with the comparative analysis of the required evacuation time and evacuation width of the building in the "Code for Fire Protection Design of Buildings", it is determined that the fastest evacuation of people can be carried out in 657s.

1.Introduction

In recent years, with the continuous growth of the world’s population, the limitation of land resources has gradually received attention, and high-rise residential buildings have accounted for a relatively high proportion of urban construction in recent years [1]. However, the dangers of high-rise building fires are particularly prominent. High-rise buildings are characterized by high height, large scale, large amounts of combustibles, densely populated people, complex functions, and difficult evacuation. Once a fire occurs, the fire spreads rapidly, making it difficult for people to evacuate quickly. Timely rescue is not easy to complete, and it is easy to cause irreparable damage to people's lives and property [2]. At the same time, personnel are prone to panic and other emotions under stress, and it is difficult to calmly analyze the situation and make decisions [3]. Therefore, optimizing the safe evacuation of high-rise residential buildings is of great significance [4, 5]. In this regard, scholars at home and abroad have carried out a series of studies. In 1974, Bazjiana et al. [6] put forward the issue of "another safe exit" for vertical evacuation; Kinsey [7] used a questionnaire to investigate the residential floors of people during the Xi'an fire. The higher the value, the more inclined to use the elevator for evacuation. Zhang Hunan [8] proposed that fire elevators should be installed on the refuge floor of super high-rise buildings for safe evacuation; Hu Chuaping [9] reviewed the current computer simulations and fire psychological behaviors involved in elevator evacuation. Ding Yuanchun [10] used Pathfinder evacuation software to carry out multiple comparative calculations to study the cooperative evacuation mode of elevator stairs. Tian Shucheng et al. [11] used Pathfinder to simulate different exit shapes, group composition ratios, and initial positions of personnel, and found that the shape of the exit has a significant impact on the evacuation efficiency, and the "V"-shaped exit has the shortest evacuation time. The main reason for the occurrence of serious casualties is that when the fire broke out, the evacuation distance was too long, the evacuated too many people caused confusion and special people (the disabled, the old, the weak, the young, etc.), and the evacuation to a safe location was impossible in time, Or confusion occurred during the evacuation process, unsafe
factors such as stampede incidents occurred, resulting in a large number of people being trapped, and eventually misfortune due to smog or fire. Therefore, after a fire occurs, the evacuation of personnel is the first issue that should be considered. The evacuation research of hotel personnel based on Pathfinder is particularly important. This paper takes a hotel in Xi’an as a simulation object, and uses FDS and Pathfinder to perform a full-scale simulation of the building. The results obtained are compared with the values, and the unsafe behavior of people and unsafe conditions of objects and different groups of people when high-rise buildings occur are analyzed. The safe evacuation is designed to design a reasonable evacuation design.

2. Numerical modeling

2.1 The basic situation of the entity model
This simulation takes a hotel building in Xi’an as the background. The main function of the hotel is office and catering. The length of the building is 59.7m, the width is 16.1m, the total height of the building is 32.8m, the total building area of the ground part is 9661.17, and the ground is 11 floors. The standard floor area is 3m. The design belongs to the second-class high-rise public building. The first floor is a lobby and exhibition hall, the second to tenth floors are for accommodation, and the eleventh floor is for office and conference rooms and restaurants. The fire resistance level is two, and there are two evacuation stairs inside the building, which adopts a frame-type overall structure.

2.2 Modeling basic parameters
Because the basement floor is the underground garage and equipment room in the hotel design, the evacuation problem of the underground part is not simulated, only the simulation simulation of the 1-11 floors above the ground is constructed, and the pedestrians are set according to the measurement of the actual walking speed of the pedestrians. The walking speed is as follows, the 2-10 floors are standard floors, the pedestrian's horizontal walking speed is set to 1.03m/s, and the stairway speed is set to 0.96 m/s; the 11th floor is for office and dining venues, and the pedestrian's horizontal walking speed is set to 1.1m/s, the speed of descending stairs is set to 0.73m/s; the pedestrian speed is set to 1.2m/s on the first floor. According to the "Human Body Dimensions of Chinese Adults", the shoulder width of men is set to 0.4m, the shoulder width of women is set to 0.36m, the door width of the accommodation room is 0.9m, the door width of the evacuation passage leading directly to the shared front room is 1.8m, and the smoke-proof staircase The width of the Class B fire door in the room is 1.5m, and the width of the door in the lobby on the first floor is 5m. The number of people on each floor in the model is set as shown in the table below.

| Floor | 1   | 2-10 | 11  |
|-------|-----|------|-----|
| Number of people | 50  | 80   | 274 |

The Pathfinder model is shown in Figure 1 below:
2.3 Time required for evacuation

The fire process is roughly divided into the process of starting a fire, increasing the fire, fully developing, weakening the fire, and extinguishing. Evacuation of people generally goes through the stages of fire detection, action preparation, evacuation action, and evacuation to a safe place. The following figure shows the relationship between fire development and evacuation time.

![Timeline diagram of fire development and evacuation](image)

The available safe evacuation time \( \text{ASET} \) refers to the time from the moment of fire to the dangerous transition of the fire to the safety of personnel. It mainly depends on the building structure and its materials, fire control and fire extinguishing equipment, etc. It is related to the spread of fire and the flow of smoke. It includes the time \( t_d \) from when a fire is started to when the fire is detected and an alarm is given and the time from when the alarm is issued to when the fire poses a threat to people th. \( \text{ASET} = t_d + t_{th} \)

The necessary safe evacuation time \( \text{RSET} \) refers to the time from the moment of fire to the evacuation of people to a safe area. It includes the time \( t_b \) from the fire to the indoor personnel perceiving the fire, the pre-action time \( t_c \) and the evacuation movement time \( t_s \). \( \text{RSET} = t_b + t_c + t_s \)

3. Evacuation simulation

Assuming a fire on the 8th floor, according to the basic evacuation process and related specifications, the evacuation procedures are as follows:

1) Evacuate the fire floor and its upper two floors and its lower floor, namely the 7, 8, 9, 10 floors;
2) Evacuate the unevacuated floors higher than the fire floor, that is, the 11th floor;
3) Evacuate the remaining floors, namely the 1st to 6th floors.

In order to minimize crowd congestion, the following delays were set in the simulation process: the evacuation time of the 11th floor was delayed by 60s, the evacuation time of the 7th to 10th floors was delayed by 0s, and the evacuation time of the 1st to 6th floors was delayed by 60s.
Figure 3. The evacuation plane at the beginning of the evacuation 45s

Figure 4. Three-dimensional situation of evacuation at the beginning of the evacuation 45s

Figure 5. The evacuation plane situation at the beginning of the evacuation 85s

Figure 6. Three-dimensional situation of evacuation at the beginning of the evacuation 85s

It can be seen from the situation in the figure that at 657s, the evacuation the hotel were evacuated from the hotel, and the simulated evacuation ended.
Figure 7. time line

The evacuation time of the entire floor, the first person in the hotel was evacuated at 65s. During the first 60s of the evacuation, the 1-6 and 11 floors were set with a 60s evacuation delay. In the first 60s, the personnel on the 1-6 and 11 floors do not move, and prioritize the evacuation of the 8th floor and the upper and lower floors assuming a fire. The number of people who have been evacuated at 321s will be equal to the number of people who have not been evacuated in the building. At 657s, the hotel will be the last person to evacuate and the simulated evacuation will end. The time used meets the requirements in the specification.

Table 2. Timetable of simulated evacuation

| Category       | Time (s) |
|----------------|----------|
| Average exit time | 327.5    |
| Start-up time   | 4.6      |
| CPU time        | 46.2     |

4. Conclusion

The use of Pathfinder software to simulate the evacuation of high-rise buildings is simple, convenient and easy to operate. The complete built-in mathematical model avoids tedious mathematical reasoning, which is very convenient for engineering applications and is useful for research on emergency evacuation of buildings. Design is of great significance. From this evacuation simulation, we have learned the following points:

1. The emergency evacuation of high-rise buildings needs to be simulated in the early design process;
2. The model should be established strictly according to the actual situation of the building during simulation;
3. Obstacles should be set up strictly in accordance with the room functions in the building to ensure the accuracy of the simulation results;
4. The advanced automatic fire alarm system should be selected to reduce the fire determination time and allow enough time for the subsequent evacuation of personnel;
5. During the evacuation process, it is necessary to ensure an orderly evacuation from the fire scene to avoid trampling, crowding and other phenomena.

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