Research on Delayed Evacuation Strategies of University Teaching Buildings Under Epidemic

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Abstract. In order to study the impact of delayed evacuation strategies on the evacuation of university teaching buildings under the epidemic situation, this paper selects a university teaching building F area to carry out personnel evacuation experiments and uses software to build an evacuation simulation simulation scene. This paper is based on the evacuation experiment to study the effect of delayed evacuation strategy on the instantaneous density of evacuation personnel in university teaching buildings; compare the evacuation process and evacuation density simulated by MassMotion software with the experiment to verify the rationality of the model; use the software to explore the effect of different delay time intervals on the instantaneous density and the influence of evacuation time, explore the best response time interval to keep the evacuation density of university teaching buildings below 1 people/m^2 under the epidemic situation. Studies have shown that when the interval is 85s, the instantaneous evacuation density of personnel achieves a higher rate of 85.05%, and the total evacuation time is less than 541 s, which provides a reference for the evacuation of college personnel under the epidemic.

Keywords: Universities · Delayed evacuation · MassMotion · Epidemic

1 Introduction

At the beginning of the 20th century, foreign scholars had made certain studies on the phenomenon of evacuation delay. Sekizawa verified the evacuation delay phenomenon [1]; Sherman analyzed the factors affecting evacuation delay for more than 1,000 survivors of the "9.11" incident [2, 3]. Domestic scholars such as Zhen Dong have improved the evacuation efficiency by delaying the evacuation of some office buildings [4]; Jinzhao Guo, Xin Shen and others have shortened the evacuation time by delaying the evacuation of the people in the middle of the university dormitory building [5]. However, most

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researchers are committed to reducing the evacuation time in emergencies. In the 2019 novel coronavirus, reducing the gathering of people and reducing the evacuation density are the keys to the management and control of the epidemic in universities. This paper uses experiments to study the impact of delayed evacuation strategies on instantaneous density, uses simulation software to delay processing on different floors, and explores the optimal delay time interval to keep the instantaneous density below 1 person/m^2 in an epidemic situation.

2 Experiments on Evacuation of People Under the Epidemic Situation in University Teaching Buildings

2.1 Experimental Scenario

Figure 1 shows the experimental scene on the first floor of the F area of a university teaching building. The teaching building has 4 floors, each with a height of about 4m; each floor has 7 classrooms, and each classroom can accommodate up to 80 people; each floor has two east and west exits. The area of the intersection of the east and west stairs is 5×2.6 m, 6.5×19 m, and the area of the east and west exit platforms is 2.6×8.2 m, 6.5×19 m.

Two experimental scenarios are set up in this experiment, and the specific conditions are shown in Table 1. Cameras were used to capture the number of students passing through the staircase intersection and east-west exit platforms. The cameras were set up on the first, second, and third floors of the east-west stairs. The east and west shooting areas were numbered as areas 1–6 from lowest to highest.

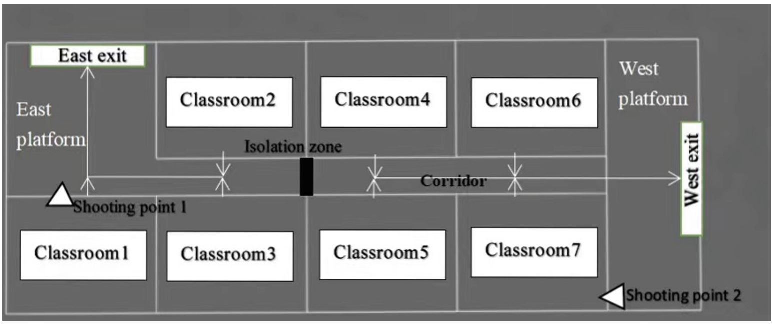


Fig. 1. Schematic diagram of the evacuation experiment scene

Table 1. The specific situation of the experimental scene

Experimental scene	Evacuation time			Number of experimenters
		East	West	
Free evacuation	Level one	11:45:00		1322
	Level two			
	Level three			
	Level four			
Delayed evacuation	Level one	11:45:00		1319
	Level two	11:46:53	11:49:00	
	Level three	11:46:30	11:45:35	
	Level four	11:46:44	11:46:30	

2.2 Instantaneous Density Analysis

It can be seen from Fig. 2 that the appearance time of the instantaneous density peak in each area is delayed. Areas 1, 3, and 5 are delayed by 100 s, 50 s, and 25 s respectively. The lower the floor, the later the instantaneous density peak appears. On the whole, in the delayed evacuation, the peak value of instantaneous density decreased by 24.88%, but there are still some cases in the area that do not meet the standard (the rate of reaching the standard = the number/total number of people meeting the standard of instantaneous density for evacuation under the epidemic situation). See Fig. 3 and Fig. 4 for details.

The congestion time and local density here respectively refer to the time period during which each area did not meet the instantaneous evacuation density standard for people under the epidemic situation during evacuation, and the average evacuation density of people in the area during the congestion time. Compared with free evacuation, the congestion time in areas 1, 3, and 5 has been reduced by 35.38%, 35.79%, and 28.33%, respectively, and the local density has been reduced by 20.59%, 14.85%, and 12.20%. The delayed evacuation strategy can effectively reduce the evacuation congestion time and local density.

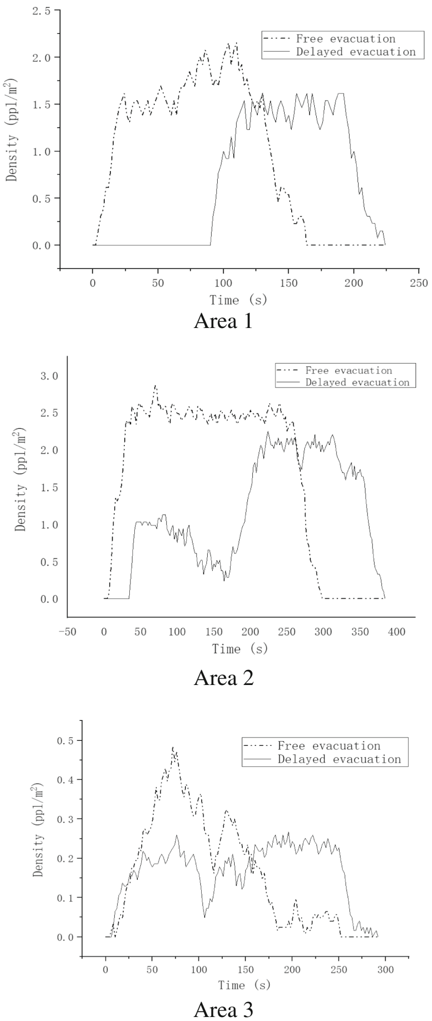
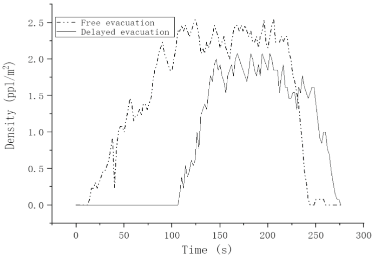
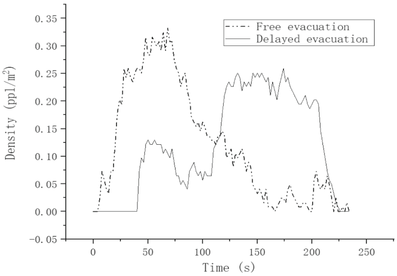


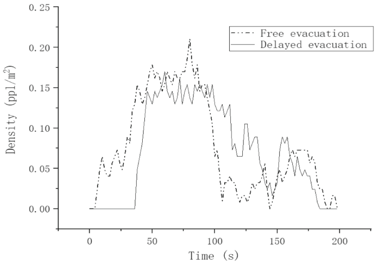
Fig. 2. The instantaneous density of evacuation in each area



Area 4



Area 5



Area 6

Fig. 2. (*continued*)

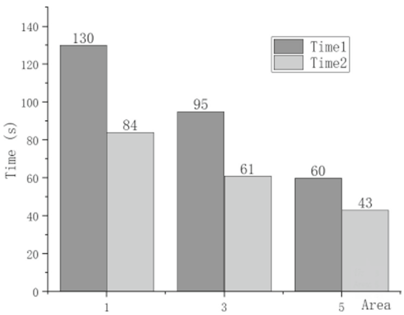


Fig. 3. Regional congestion time

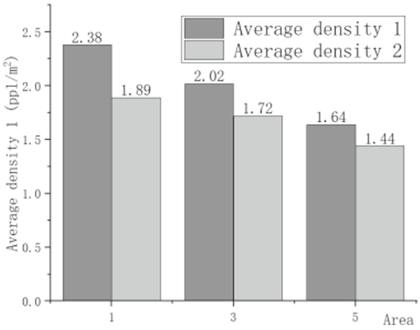


Fig. 4. Regional local density

3 Simulation Simulation of Evacuation of People Under Epidemic Situation in University Teaching Buildings

3.1 Simulation Scenario Design

In order to verify the rationality of the MassMotion social force model, the evacuation experiment was simulated. The specific settings are shown in Fig. 5. The evacuation simulation model of the teaching building is shown in Fig. 6.

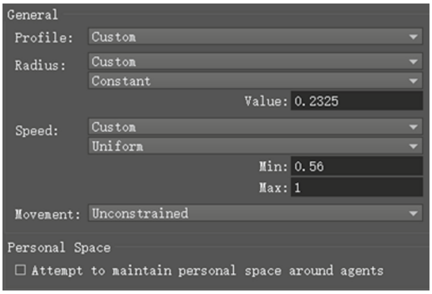


Fig. 5. Personnel evacuation speed and shoulder width setting

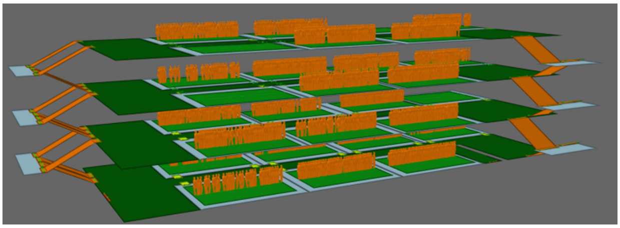


Fig. 6. Simulation model of evacuation in teaching building

3.2 Analysis of Simulation Results

1) Evacuation Density Simulation

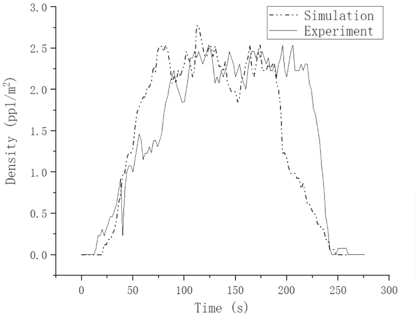
In order to further verify whether the simulation model can be used for follow-up research, the personnel density in the free evacuation simulation scenario is compared with the experimental data. According to the experimental results, the evacuation of people on the west side of the teaching building is in full compliance with the evacuation standards under the epidemic, so now take the areas 1, 3, and 5 as examples for verification, as shown in Fig. 7.

The results showed that in the free evacuation experiment, 83.91% of the people in area 1 had an evacuation density of 1.5–2.5 people/m^2, the initial evacuation time was 6 s, and the last person was safely evacuation in 298 s; in the simulation, 80.53% of the people in area 1 have an evacuation density of 1.5–2.5 people/m^2, the initial evacuation time is 8 s, and the last person is safely evacuated and shared 316 s; the evacuation density of 58.48% of the people in area 3 is 1.5–2.5 persons/m^2, the evacuation time is 14s, and the last person was safely evacuation in 258 s; in the simulation, 57.57% of the people in area 3 had an evacuation density of 1.5–2.5 people/m^2, the initial evacuation time is 20 s, and the last person to evacuate safely takes 248 s; the evacuation density of 46.32% of the people in area 5 is 1.5–2.5 persons/m^2, and the initial evacuation time is 4s, and the last person evacuates safely in 164s; in the simulation, 42.19% of the people in area 5 have an evacuation density of 1.5–2.5 persons/m^2, the initial evacuation time is 6s, and the last person evacuates safely in 164 s. Comparing the experimental and simulated evacuation density curves, it is found that the two are in good agreement, indicating that the social force model and parameter settings of MassMotion are more reasonable and can be used for follow-up research.

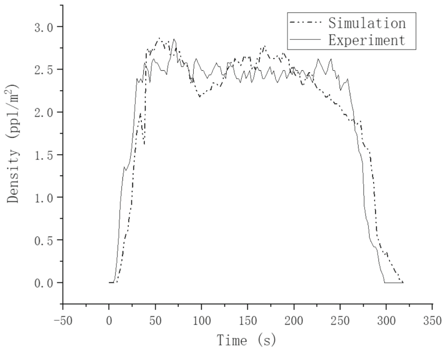
2) Optimal Delay Time Interval

In this paper, only one case of delayed evacuation experiment of teaching building is carried out, so the evacuation efficiency cannot be guaranteed. By adjusting the different delay time interval $\triangle$t of each floor in the simulation, the best delay time interval is explored (for example, when $\triangle t = 5$ s, the evacuation time from the first floor to the fourth floor is 0 s, 5 s, 10 s and 15 s respectively), so as to improve the evacuation efficiency. Figure 8 shows the compliance rate and total evacuation time of density under different delay time intervals, taking area 1 as an example.

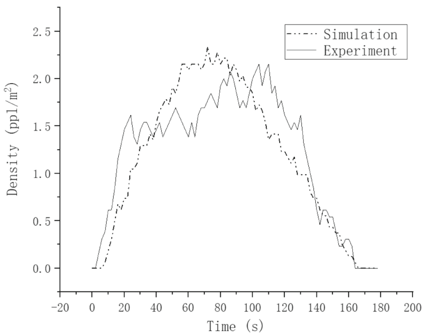
The results show that the total evacuation time and compliance rate increase with the increase of the delay time interval, and the two curves show an overall upward trend. This is because as the time interval between people going downstairs is prolonged, the confluence time of each floor is relatively prolonged, which provides sufficient time for the evacuation of the people on the next floor, resulting in an increase in the overall evacuation time and the evacuation of people in the simulated area. Instantaneous density reduction. The best time interval should ensure the evacuation time on the basis of a high rate of compliance. Taking into account that the students' off-get out of class time should be controlled within 10 min, the best time interval for the evacuation of the teaching building is 85 s, and the total evacuation time is 541 s, which is up to the standard. The rate is 85.05%.



(A) Area 1



(b) Area 3



(c) Area 5

Fig. 7. Comparison of instantaneous density of evacuation between experiment and simulation

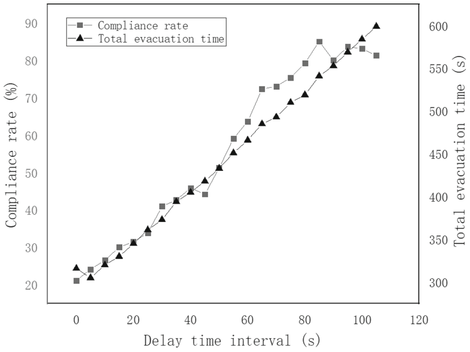


Fig. 8. Density compliance rate and total evacuation time under different delay time intervals

4 Conclusion

(1) According to the experimental results, the delayed evacuation strategy reduces the highest instantaneous density in areas 1, 3, and 5, and the lower the floor, the later the instantaneous density peak appears. The peak value of instantaneous density decreased by 24.88%. Compared with free evacuation, the congestion time in this area has been reduced by 35.38%, 35.79%, and 28.33%, respectively. The local density dropped by 20.59%, 14.85%, and 12.20%.

(2) The simulation results of MassMotion are in good agreement with the experimental results, which shows that the parameters of the software are reasonable and can be used in the follow-up study of delayed evacuation.

(3) The simulation results show that when the delay time interval of the teaching building is 85 s, the evacuation efficiency is the highest, that is, the instantaneous density compliance rate is 85.05%, and the total evacuation time is less 541 s. Therefore, under the epidemic situation, it is recommended that colleges and universities refer to the results of the experiments and simulations in this article, formulate delayed evacuation strategies, reasonably arrange get out of class time, effectively reduce the instantaneous density of evacuation of teaching buildings under epidemic conditions, and protect the personal safety of students in the epidemic.

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