International Journal of Advanced Smart Convergence Vol.13 No.3 328-334 (2024)
http://dx.doi.org/10.7236/IJASC.2024.13.3.328

IJASC 24-3-39

Study on the Safety Evacuation of University Dormitory Occupants Based on Pathfinder

Zechen Zhang and Hasung Kong[1]*

Graduate student, 55338 Dept. of Fire and Safety Engineering, Woosuk Univ, 443 Samnye-ro, Samnye-eup, Wanju-gun, Jeollabuk-do, Korea

*****Professor, 55338 Dept. of Fire Protection and Disaster Prevention, Woosuk Univ, 443 Samnye-ro, Samnye-eup, Wanju-gun, Jeollabuk-do, Korea*

Corresponding Author E-mail: zack@stu.woosuk.ac.kr, 119wsu@naver.com

Abstract

This study uses Pathfinder software to simulate and analyze the safe evacuation of university dormitory occupants. Fire safety issues in densely populated dormitory buildings are gaining increasing attention, and improving emergency evacuation efficiency is crucial for reducing the harm caused by fire incidents. The study focuses on a student dormitory building in a university, simulating different evacuation scenarios and analyzing the impact of factors such as evacuation routes, personnel distribution, exit width, and stair width on evacuation time. Based on the actual dormitory conditions, parameters such as gender ratio, height range, shoulder width, and walking speed of the occupants were set, and evacuation times in various scenarios were compared.The simulation results show that proper planning of evacuation routes and increasing stair width significantly reduced evacuation times. The study recommends that universities establish systematic emergency response plans, conduct regular evacuation drills, optimize student dormitory layouts, and consider increasing stair width in dormitory building designs to improve evacuation efficiency and safety.

Key Words: *University Dormitory , Pathfinder Simulation, Emergency Management, Fire Safety*

1. INTRODUCTION

With the rapid development of modern education, university fire safety is gaining increasing attention. Universities have high population density and tightly arranged rooms, especially in dormitories, making safe evacuation in buildings challenging. To reduce the harm caused by fire accidents to university personnel, it is crucial to enhance routine fire monitoring and inspection as well as to improve emergency evacuation efficiency. Therefore, research on the safe evacuation of students in university dormitories is highly necessary. This study has significant implications for effectively conducting fire safety operations in university dormitories under new circumstances.

Nuria Pelechanon et al. demonstrated the importance of including psychological and physiological factors

Manuscript Received: August. 11. 2024 / Revised: August. 16. 2024 / Accepted: August. 21. 2024
Corresponding Author: 119wsu@naver.com
Tel:+82-063-290-1686, Fax: +82-063-290-1478
55338 Dept. of Fire Protection and Disaster Prevention, Woosuk Univ, 443 Samnye-ro, Samnye-eup, Wanju-gun, Jeollabuk-do, Korea

of humans in the model [1]. Chen Baozhi et al. proposed an evacuation route optimization algorithm and a genetic algorithm after predicting the consequences of toxic gas leakage accidents [2]. Xie Mingfeng et al. applied numerical simulation to the study of personnel evacuation, analyzing congestion issues in the evacuation process and improving four aspects: the number of open states of safety exits, the width, and the evacuation route [3]. Zou Xinjie et al. analyzed and explained the impact of whether the windows of the fire-affected rooms in university dormitories are open and whether the automatic sprinkler system is effective on the safe evacuation time of on-site personnel [4]. Zhan Lianxiang et al. studied the impact of fires on different floors on student evacuation and optimized the most unfavorable floor scenario to meet safe evacuation requirements [5]. Zhang Peihong et al. analyzed and predicted the flow laws of evacuation exits, considering the polymorphic phenomenon and waiting phenomenon of evacuation behavior in confined spaces, and conducted comprehensive evaluations [6].

This paper uses Pathfinder to select a story student dormitory building of a specific university as the research object and constructs evacuation simulation scenes to perform emergency evacuation simulations. Based on the objective conditions of the students living in the dormitory building, parameters such as the gender ratio, height range, shoulder width, and walking speed of the evacuating personnel are set, and the evacuation times in various scenarios are compared. The impact of relevant factors such as evacuation routes, evacuation personnel distribution, exit width, and stair width on safe evacuation time is analyzed to provide reference data for the design structure of university dormitory buildings and the formulation of emergency evacuation plans.

2. MAIN TEXT

2.1 Research model

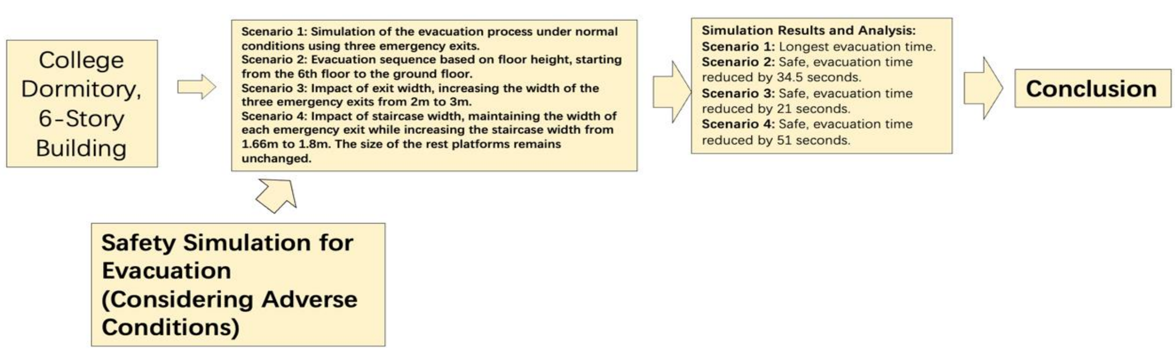

Figure 1: Research Model

2.2 Building Overview

The student dormitory building of this university has a total of six floors, with 55 rooms on the first floor and 61 rooms on each of the second to sixth floors. The entire dormitory building has a total of 360 rooms. Each room measures 8m×4m, and the door width is 1m. The height of each floor is 3m. Three evacuation stairs (east, west, and central) are constructed for personnel evacuation, with a stair width of 1.66m. There are rest platforms on each half-floor, measuring 4m×1.5m. Three safety exits (east, west, and central) are installed, with a width of 4m each. There are no obstacles in the evacuation passage (Figure 2).

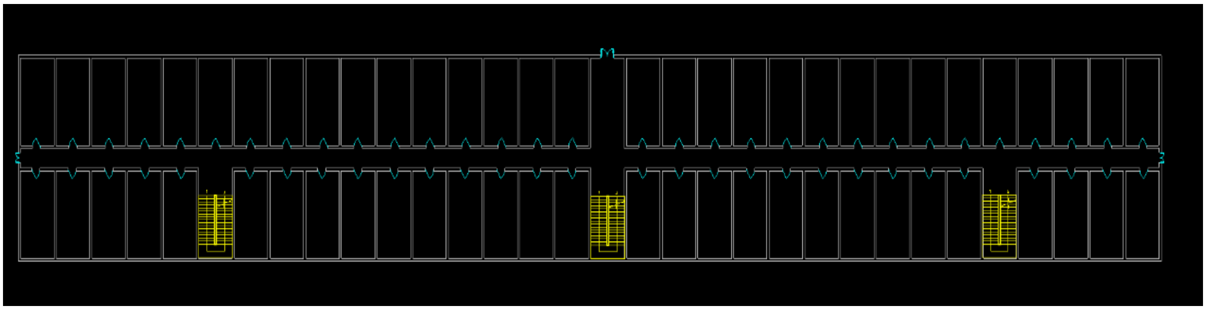

Figure 2: Building

3. SETTING OF EVACUATION SIMULATION PARAMETERS

3.1 Evacuation Personnel

Each room on the first to fifth floors of this dormitory building can accommodate six people, all of whom are male students. Each room on the sixth floor can accommodate three people. The maximum occupancy is set at 1200 people. Since all residents are young adults, there is no need to consider the impact of the elderly and children. Male students use the Bman0104 model with a shoulder width set to 40cm. Based on the actual situation of this dormitory building, the height of male students is set between 170-185cm. All personnel in the dormitory building are familiar with the structure and have normal behavioral abilities. The walking speed of male students is set to 1.3m/s (Table 1).

Table 1: Factor Settings

Item	Description
Evacuation Personnel	1200
Personnel Assignment	Male Students
Height	170 ~ 185cm
Shoulder Width	40cm
Average Walking Speed	1.3m/s
Behavior Model	Bman0104

3.2 Pathfinder Evacuation Model Construction

Based on the actual situation of this dormitory building, a simulation model is constructed using Pathfinder. The figure below shows the personnel evacuation simulation model of a six-story student dormitory building of a specific university (Figure 3).

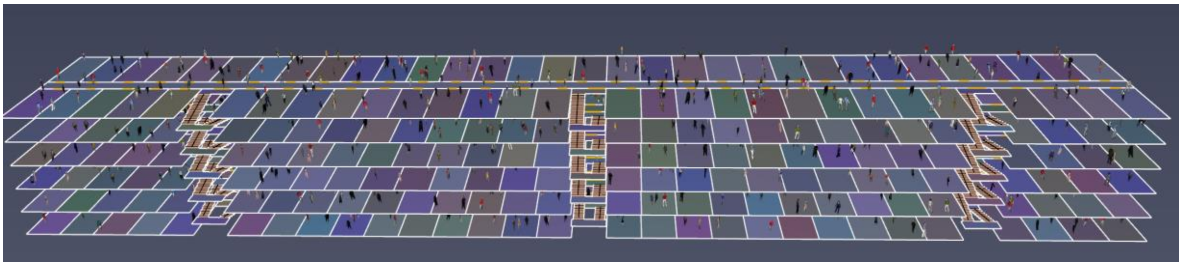

Figure 3: 3D Model

3.3 Setting of Evacuation Simulation Scenes

Based on the actual situation of this dormitory building, four evacuation scenes are set to discuss the impact of evacuation routes, evacuation personnel distribution, safety exit width, and stair width on safe evacuation time. The specific scene settings are as follows:

Scene 1: Basic Situation

Simulate the process of all personnel (1200 people) in this university's student dormitory building evacuating through the three safety exits under normal conditions.

Scene 2: Planned Evacuation Route

Evacuate in order from the 6th floor to the 1st floor based on floor height.

Scene 3: Impact of Exit Width

Increase the width of the three safety exits from 2m to 3m.

Scene 4: Impact of Stair Width

Expand the stair width from 1.66m to 1.8m while keeping the exit width unchanged. The size of the rest platform is not adjusted. The scenario settings are shown in the table below (Table 2).

Table 2: Scenario

Scenario	Door Width	Exit Width
Scenario 1	2m	1.66m
Scenario 2	3m	1.66m
Scenario 3	2m	1.8m
Scenario 4	3m	1.8m

4. ANALYSIS

4.1 Student Dormitory Evacuation Time and Safety Evacuation Evaluation Criteria

Whether personnel can evacuate safely in the event of a fire in the building is determined by two-time parameters: the Required Safety Egress Time (RSET) and the Available Safety Egress Time (ASET). ASET > RSET is used as the criterion for safe evacuation. If this criterion is met, it means that all personnel in the building can evacuate safely. Conversely, if this criterion is not met, it means that the evacuation design of the building does not meet the safety design requirements [7]. According to the relevant regulations of "Code for Fire Protection Design of Buildings" GB 50016-2014 (2018 Edition)[8], the available safety evacuation time for students in dormitories is 5-7 minutes.

4.2 Safe Evacuation Time in Various Scenes

The simulation results using Pathfinder show the student safety evacuation time and safety evaluation in the four scenes as follows. The change in the number of personnel during the evacuation process is shown in Table 3.

Table 3: Evaluation of student safety evacuation time and safety in each scene

Scenario	Evacuation Time	Safety Evaluation
Scenario 1	478	Unsafe
Scenario 2	412	Safe
Scenario 3	419	Safe
Scenario 4	403	Safe

From the analysis of the table, it can be seen that the safe evacuation time in Scenario 1 is the longest. In this scene, the time for personnel to complete evacuation at the two safety exits is much shorter than the total evacuation time. Therefore, it is necessary to scientifically and reasonably set the evacuation routes to reduc e the evacuation time difference between the three safety exits and improve evacuation efficiency, thereby re ducing the total evacuation time. For this reason, Scenario 2 was set. Compared with Scenario 1, the safe eva cuation time in Scenario 2 decreased by 34.5 seconds, and the safety evaluation changed from unsafe to safe. This indicates that a reasonable evacuation route plan can reduce the safe evacuation time and improve evac uation safety.

Comparing Scenario 3 and Scenario 4, increasing the width of the safety exits from 2m to 3m reduces the evacuation time by 21 seconds. Increasing the stair width from 1.66m to 1.80m reduces the evacuation time by 51 seconds. That is, when comparing the case of increasing the width of the three safety exits by 50% and increasing the width of the three evacuation stairs by 8.43%, the effect of reducing the evacuation time is rel atively smaller. In other words, increasing the stair width has a greater effect on reducing the evacuation time than increasing the exit width. The reason is that simultaneously increasing the stair width can evenly distrib ute the personnel to the three evacuation stairs in the east, west, and central, thereby reducing the evacuation time. Therefore, increasing the stair width has a greater effect on reducing the evacuation time than increasin g the exit width.

4.3 Personnel Density

To analyze the congestion points during the evacuation process, a density cloud image is presented. Comparing the personnel density of the three evacuation stairs between the 5th and 6th floors in Figures 4, 5, and 6, it can be seen that without planning the evacuation routes, the congestion time of the three evacuation stairs between the 5th and 6th floors is approximately the same. Congestion occurs for about 56 seconds, but the congestion time of the central evacuation stairs between the 5th and 6th floors is the longest, taking up to 290 seconds, while the congestion ends in the two side evacuation stairs between the 5th and 6th floors after about 230 seconds.

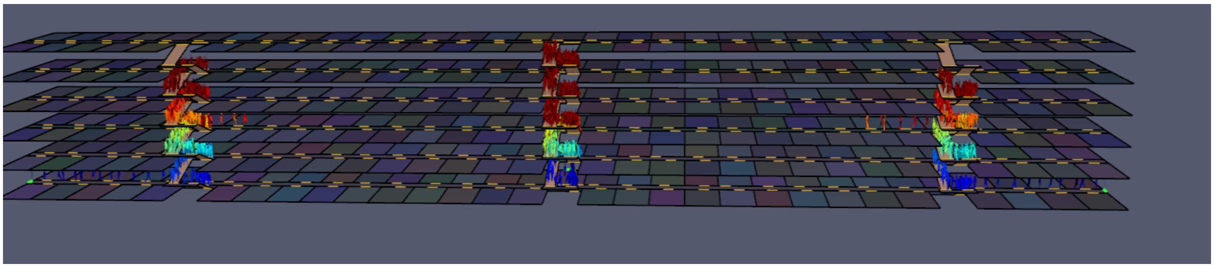

Figure 4: Density Cloud Image at 56 Seconds in Scenario 1

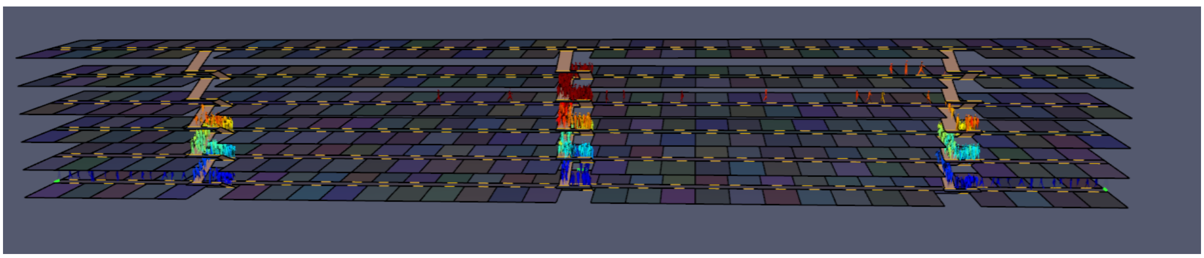

Figure 5: Density Cloud Image at 230 Seconds in Scenario 1

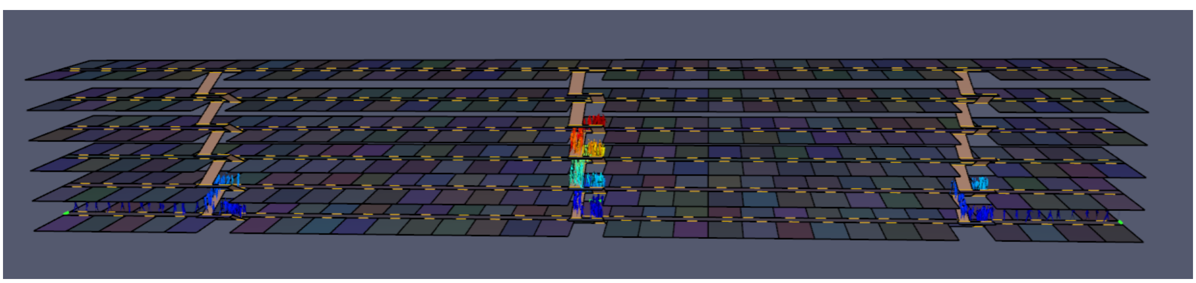

Figure 6: Density Cloud Image at 290 Seconds in Scenario 1

After planning the evacuation routes (Scenario 2), the congestion situation improved significantly. According to Figure 7, the congestion in the three evacuation stairs (east, west, and central) almost ended at 212 seconds.

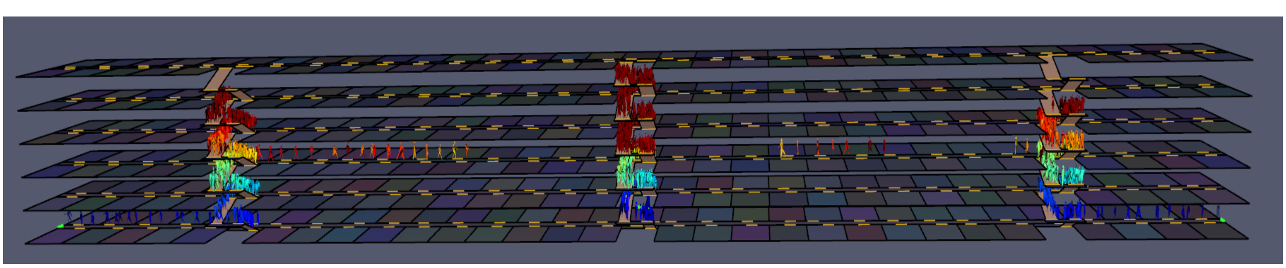

Figure 7: Density Cloud Image at 212 Seconds in Scenario 2

In this way, by planning the evacuation routes, the congestion time between floors is reduced, and the three evacuation routes can almost evacuate simultaneously, allowing the three stairs to have the same evacuation capacity, thus reducing the evacuation time.

5. CONCLUSION

In summary, reducing the number of dormitory personnel, planning evacuation routes reasonably, increasing the width of safety exits, and increasing the width of evacuation stairs can shorten the evacuation time. When all evacuation stairs in the building have the same evacuation capacity, the total evacuation time is the shortest. To solve the problem of personnel evacuation in university student dormitory buildings and reduce the evacuation time, the following three aspects can be considered:

1. Universities should systematically establish emergency response plans and conduct regular emergency evacuation drills to improve the evacuation efficiency of students in dormitory buildings.
2. When arranging student residence, universities should minimize the density of personnel in dormitory buildings, ensure the effectiveness of fire safety facilities, and consider the safety evacuation of personnel in dormitory buildings in case of emergencies.
3. When designing the structure of university student dormitory buildings, universities should consider increasing the width of stairs appropriately, based on complying with relevant laws and regulations, to shorten the evacuation time.

References

[1] Svensson, Stefan. "Experimental Study of Fire Ventilation During Fire Fighting Operations." *Fire Technology* 37, no. 1 (2001): 69-85. DIO:10.1023/A:1011653603104
[2] Wen, Limin, and Baozhi Chen. "Research on Emergency Evacuation Models for Major Accidents." *China Safety Science Journal* (1999): 69-73. DIO:10.3969/j.issn.1003-3033.1999.06.014
[3] Xie, Mingfeng, and Yi Lu. "Simulation Study on Fire and Evacuation in University Teaching Buildings." *Fire Science and Technology* 2021, no. 1 (2021): 85-90.DIO: 10.3969/j.issn.1009-0029.2021.01.020
[4] Zou, Xinjie, Samukhal Bolati, Ming Hao, et al. "Simulation Analysis of Fire Evacuation Safety in University Dormitories Based on Pyrosim and Pathfinder." *Safety and Environmental Engineering* 27, no. 4 (2020): 195-200. DIO:
[5] Zhan, Lianxiang, and Mi Chen. "Simulation Study on Evacuation in University Dormitories Based on Pathfinder." *Digital Communication World* (2021): 47-49. DIO: 10.3969/J.ISSN.1672-7274.2021.05.020
[6] Zhang, Peihong, and Baozhi Chen. "Behavior Patterns of Evacuation During Fire." *Journal of Northeastern University* (2001): 54-56. DIO: 10.3321/j.issn:1005-3026.2001.01.015
[7] Li, Yujie. "Study on Emergency Evacuation Patterns and Firefighting Strategies in University Apartments." Master's thesis, China University of Geosciences (Beijing), 2019. DIO:
[8] GB 50016-2014 (2018 Edition) Code for Fire Protection Design of Buildings. Ministry of Housing and Urban-Rural Development of the People's Republic of China, General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, 2018.