International Journal of Engineering & Technology, 7 (3.8) (2018) 54-57

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Improving the Evacuation Time for 8-Story Office Building Using Pathfinder Simulation

Himawan Hadi Sutrisno [1]*, Jafar Amiruddin[1], Triyono[1]

[1]*Fire Safety Engineering, Dept. Universitas Negeri Jakarta, Indonesia, 13220*
** E-Mail:Himawan-Hadi @Unj.Ac.Id*

Abstract

The evacuation time during fire becomes the determining factor for survival and building occupants often ignore the knowledge and the correct way to evacuate during fire. This lack of knowledge increases panics among the evacuees and causes more casualties. By using the pathfinder simulation, the simulated evacuation time is compared with the real evacuation time to get the recommendation for the improvement of evacuation time to reach the assembly points. The improvement of the evacuation time is done by eliminating the time difference between the simulated evacuation time and the real evacuation time. This study may benefit the method to increase the evacuation ability and to improve the sterilization of the evacuation routes until the assembly points.

***Keywords*:** *Evacuation, pathfinder, fire safety, Emergency stairs.*

1. Introduction

The emergency exits are a mandatory structural facility designed to help humans, or in this case building occupants, to find safety during fire or other disasters. The design of the emergency exits needs to take into account a few important factors: evacuation time, distance to the nearest safe place, the number of occupants, the width of the emergency exits, and the minimum number of the emergency exits. There are a few facilities which should be designed along with the emergency exits: emergency stairs, emergency doors, corridors, emergency lights, direction signs, until alternative sources of power during the disaster.

Aside from the facilities and the infrastructure of the evacuation routes, the short evacuation time and the calmness of the building occupants during evacuation are a few of the factors that determine the success of the evacuation. The international standard for evacuation facilities is regulated in NFPA 101A in 2000 and each government also regulates the standardization of the facilities and infrastructures for evacuation. Generally, the evacuation time becomes the basis to determine the level of danger in the evacuation facilities.

Thinking that the knowledge and procedures for evacuation during fire is not important, the whole building occupants often ignore and pay no attention to the knowledge given by the building management during fire drills/training or when they explain the correct procedure for evacuation. This lack of knowledge increases panic among the building occupants when the real fire happens. The pathfinder software is able to determine the time required to evacuate an 8-story building by comparing the evacuation time produced in the simulation with the real evacuation time. The time difference between the simulated evacuation time and the real evacuation time can be used as the basis to improve the evacuation time. The following sub-chapters explains how data and evaluation are obtained.

2. Literatur Review

Although the calmness of the building occupants during fire is one of the success factors of evacuation[1, 2], the facilities and the infrastructures for evacuation until the assembly points as the safest point should be high in the priority level for design consideration[3].
The methods for evacuation until the evaluation of evacuation facilities have been a very interesting topic to discuss[4-7]. Currently there are two methods for evacuation: the simulation method[4] and the empirical calculation method[8]. According to Michael A P Taylor and Freeman[9], the fire safety factor is influenced by the habits of the building occupants although the geographical factor is proven to be more influential. Therefore, there are many factors that influence the success of the protection and prevention of fire.

The probability of a success during evacuation according to Hoanan CHEN et. al[10] can be calculated using the Monte Carlo method. This method includes the occupant sensitivity factor and the occupancy factor during the evacuation process. Jing-wei Ji et. al[7] conducted a study to learn the ability to evacuate from underground facilities during fire by paying attention to the environmental conditions during fire. The modelling of the evacuation depends on the conditions and the number of occupancy during fire.

Aside from the pathfinder, the evacuation simulation can also be done using a Graphic Processing Unit (GPU)[11] and STEP software[12]. Vliadimir Zyryanov and Feofilova[13] explains that the choice of evacuation route influences the success of the evacuation process and helps prevent casualties. The panic factor during evacuation[14] influences the choices of evacuation routes and the evacuation time made by the occupants during fire.

3. Research Method

Pathfinder is a new evacuation simulator equipped with a feature needed to make the correct decision on the layout of buildings and fire protection system design [15]. The simulator features a double simulation mode and an adjustment to the characteristics of the occupants to allow the user to explore different scenarios and to enable the calculation with conservative limits according to situations desired during evacuation. Starting with the setting of the individual parameters, Pathfinder allows the user to evaluate the evacuation model faster and produces a more realistic graphic compared to other simulators [16]. To obtain the time difference between the simulated evacuation time and the real evacuation time, this study follows the steps which can be seen in the Flow Chart in Figure 1 below.

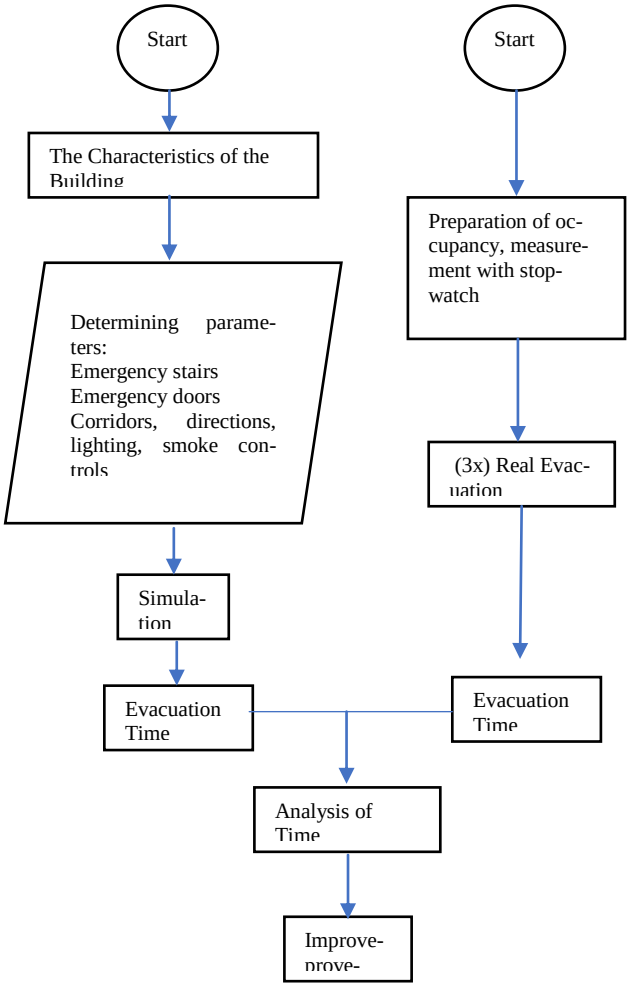

Fig. 1: Flow Chart of Procedure of the Study

In collecting the data, the simulated evacuation time was compared to the real evacuation condition in the field using the same parameters in order to obtain the result which is the closest to the reality. Each parameter inputted in the software data was adjusted with the real characteristics of the building while 35 people participated in the data collection for the real evacuation so that the minimum occupancy rate was fulfilled. The real evacuation was done three times with a one-hour break in between evacuations.

The following are the parameters in the software which must be inputted according to the characteristics of the building.

a. Height - The parameter determines the height of the cylinder for clashes among the occupants. The data are used to limit clashes that might happen among the occupants in different floors when a simulation is done on the floor.
b. Reduction Factor - The parameter of the direction determines whether an occupant is able to pass another occupant in a narrow corridor. The occupant must be able to pass up to half of the width of his/her shoulder.
c. Comfort Distance - The parameter determines the most comfortable distance that an occupant tries to hold when other occupants are around such as when queuing in a line.
d. Persist Time - The parameter determines the maximum amount of time which will be prioritized when the occupant tries to resolve the conflict of movement.
e. Collision Response Time - The parameter controls the distance where the occupants begin to record clashes with other occupants.
f. Slow Factor – The parameter determines a small part of the speed of the occupants which they consider slow.

After all parameters were inputted in the software, the next process was to determine the number of occupancy in the building to obtain the evacuation time based on the simulation.

4. Result and Discussion

During the real evacuation, the building conditions such as the number of exits, the assembly point positions, the conditions surrounding the building (other buildings or equipment around the building) were informed to the whole building occupants. The occupants who were used as the sample in the study were specially informed about the correct procedure for the evacuation. The data was taken from the evacuation time needed by the occupants in the top floor to reach the assembly point as can be seen in Figure 2 and Figure 3 below.

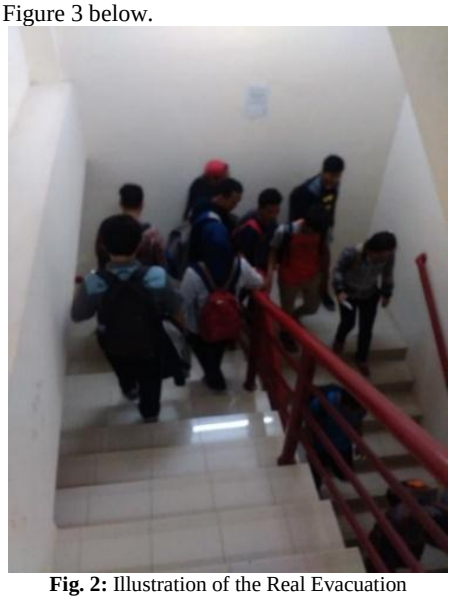

Fig. 2: Illustration of the Real Evacuation

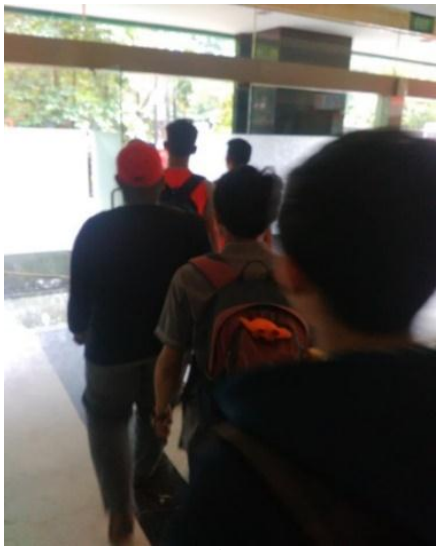

Fig. 3: Illustration of the Real Evacuation

For simulation using the pathfinder software, the filling out of the parameters is illustrated in Figure 4 below.

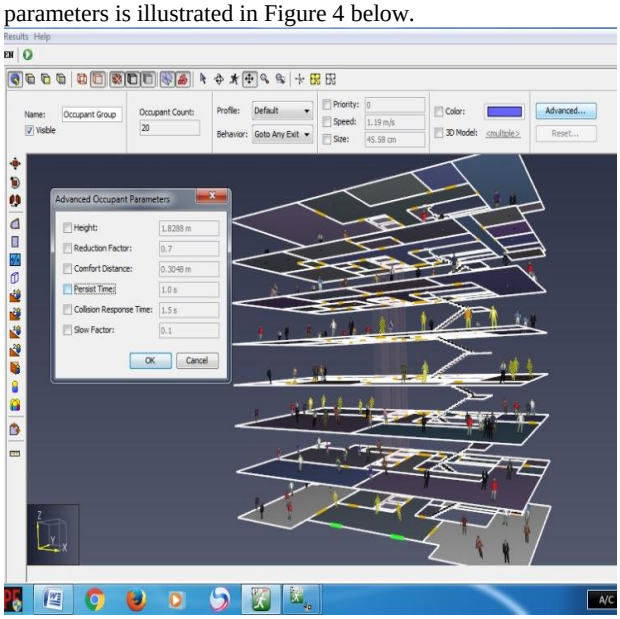

Fig. 4: Determining the Parameters in Pathfinder

Based on the simulation, the total time for evacuation from the top floor to the assembly point was in 3 minutes 36 seconds with the occupants spread in each floor of the building. The evacuation process from the highest floor to the lowest floor is illustrated in Figure 5 below.

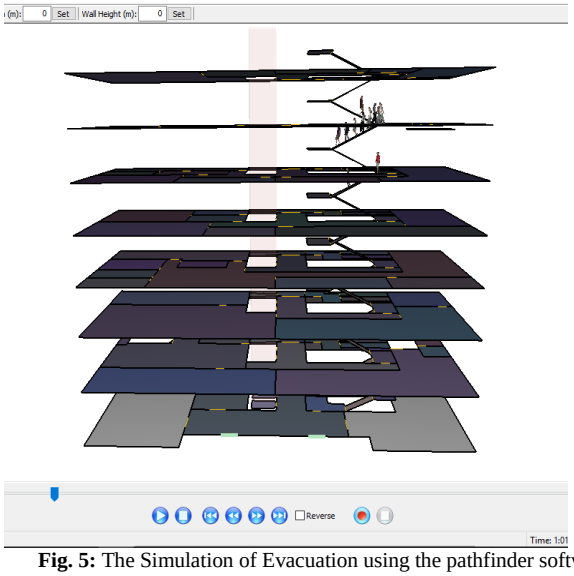

Fig. 5: The Simulation of Evacuation using the pathfinder software

From the simulation above, the times needed in the real evacuation which followed the correct evacuation procedure was compared to the simulated evacuation time. The times needed in the three real evacuations are 3 minutes 48 seconds for the first, 3 minutes 31 seconds for the second, and 3 minutes 18 seconds for the third.

Therefore, the first real evacuation time was 12 seconds longer than the simulated evacuation time. However, the second real evacuation was 4 seconds faster and the third real evacuation time was 18 seconds faster than the simulated evacuation time. This is illustrated in Table 1 below.

Table 1. The Evacuation Times during Fire

NO	Simulation time of evacuation	Real evacuation
1st	3 minutes 36 seconds	3 minutes 48 seconds
2nd		3 minutes 31 seconds
3th		3 minutes 18 seconds

From the result above, it can be seen that the time needed for the first evacuation was much longer than the time produced in the simulation. However, the times needed in the second and third evacuation were shorter than in the first evacuation. the difference in evacuation time can be illustrated as shown below (figure 6)

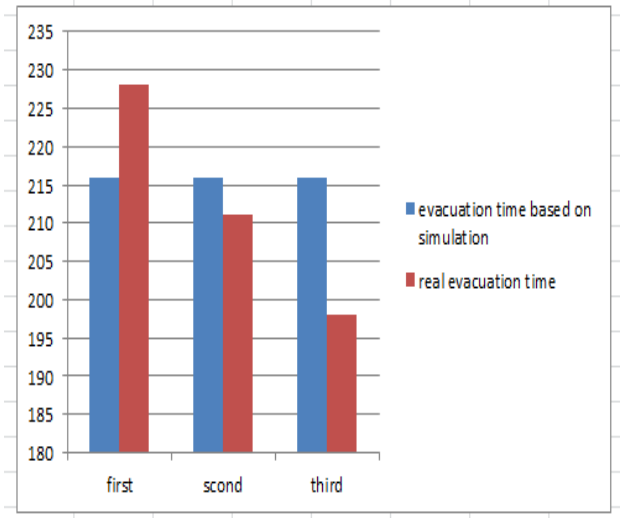

Fig. 6: The difference of evacuation time (simulation and real evacuation

This proves that the more often evacuation drills are conducted, the more accustomed the occupants become to the evacuation procedure and the faster the occupants are able to evacuate. Furthermore, if the occupants are accustomed to the situation during fire, they will be less panic when they walk out of the building to the assembly point. Also, when the occupants are less panic, there will be a less chance of a bottle neck happening or a large number of occupants gathering in one spot in one of the evacuation routes.

5. Conclusion

By obtaining the simulated evacuation time using pathfinder and comparing it with the real evacuation time, the time difference can be used as the reference for improvement in evacuation time. The more often the evacuation drills are done, the better the building occupants are during fire evacuation. This will lower the panic level during fire.

References

[1] C. Ahn, J. Kim, and S. Lee, "An analysis of evacuation under fire situation in complex shopping center using evacuation simulation modeling," *Procedia - Social and Behavioral Sciences*, vol. 218, p. 10, 2016.

[2] M. H. L, W. J. H, M. Z. L, S. J. H, L. S. M, and W. Q. S, "Pre-evacuation Human Reaction in Fire: An Attribution Analysis Considering Psychological Process," *Procedia Engineering*, vol. 52, p. 7, 2013.

[3] X. Zhang, "Study on rapid evacuation in high-rise building," *Engineering Science and Technology, an International Journal*, vol. 20, p. 8, 2017.

[4] V. Alonso, O. Abreu, A. Cuesta, and D. Alvear, "An Evacuation Model for Risk Analysis in Spanish Road Tunnels," *Procedia - Social and Behavioral Sciences*, vol. 162, pp. 208-217, 2014.

[5] J.-j. Chen, X.-g. Wang, and Z. Fang, "Collaborative Evacuation Strategy of Ultra-tall Towers among Stairs and Elevators," *Procedia Engineering*, vol. 135, pp. 170-174, 2016.

[6] Y. Ding, L. Yang, and P. Rao, "Investigating the Merging Behavior at the Floor-stair Interface of High-rise Building Based on Computer Simulations," *Procedia Engineering*, vol. 62, pp. 463-469, 2013.

[7] J.-w. Ji, Y. Meng, Q.-j. Li, and S.-f. Yang, "Study on Factors Affecting Evacuation Capability of a Fire-protection Walk in Underground Buildings," *Procedia Engineering*, vol. 71, pp. 357-363, 2014.

[8] B. Zhang, Z.-s. Xu, Q.-w. Zhao, and Y.-y. Liu, "A Study on Theoretical Calculation Method of Subway Safety Evacuation," *Procedia Engineering*, vol. 71, pp. 597-604, 2014.
[9] M. A. P. Taylor and S. K. Freeman, "A review of Planning and operational models used for emergency evacuation situations in Australia," *Procedia Engineering*, vol. 3, p. 11, 2010.
[10] H.-n. CHEN and Z.-l. MAO, "Study on the Failure Probability of Occupant Evacuation with the Method of Monte Carlo Sampling," *Procedia Engineering*, vol. 211, p. 8, 2018.
[11] M. Poudel, B. Chaudhury, K. Sharma, and P. Y. Tabakov, "GPU based Computational Simulation of Aircraft Evacuation: Temporal and Spatial Analysis," *Procedia Transportation Research*, vol. 29, p. 10, 2018.
[12] J. LIANG, Y.-f. ZHANG, and H. HUANG, "The experiment and simulation analysis of bus emergency evacuation," *procedia Engineering*, vol. 211, p. 427, 2018.
[13] V. Zyryanov and A. Feofilova, "Simulation of Evacuation Route Choice," *Transportation Research Procedia*, vol. 20, pp. 740-745, 2017.
[14] F. Li, S. Chen, X. Wang, and F. Feng, "Pedestrian Evacuation Modeling and Simulation on Metro Platforms Considering Panic Impacts," *Procedia - Social and Behavioral Sciences*, vol. 138, pp. 314-322, 2014.
[15] E. Ronchi, F. N. Uriz, X. Criel, and P. Reilly, "Modelling large-scale evacuation of music festivals," *Case Studies in Fire Safety*, vol. 5, pp. 11-19, 2016.
[16] C. Thornton, R. O. Konsi, B. Hardeman, and D. Swenson, "Pathfinder_ An Agent-Based Egress Simulator," *pedestrian and evacuation dynamics*, p. 4, 13 june 2011.