International Journal of Advanced Culture Technology Vol.8 No.1 243-247 (2020)
DOI https://doi.org/10.17703/IJACT.2020.8.1.243

IJACT 20-3-32

A Study on the Efficiency of Evacuation Guidance and Non-evacuation Guidance in Case of Fire

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Abstract

In the era of the fourth industrial revolution, safety of disasters is being emphasized above all else, and electric fires are most frequent during disasters, and human and property damage is very serious. In this paper, we propose a study that can determine the efficiency of evacuation and non-evacuation guidance due to the large difference in casualties depending on the traffic line in the case of fire. Evacuation guidance was assumed to be a situation in which adequate evacuation routes were guided by a recorded voice or a trained staff, and non-evacuation guidance was assumed to be a situation without anything. Evacuation simulations were carried out using a evacuation simulation tool called PATHFINDER and SIMULEX for the analysis of the efficiency of evacuation and non-evacuation guidance. As a result, the evacuation time was similar, but in the case of non-evacuation guidance, it was not guided to the safe zone, which could cause serious damage.

Keywords: *Fire, Evacuation Guidance, Non-evacuation Guidance*

1. INTRODUCTION

The number of fires occurring in South Korea in 2018 is 42,337 cases, including 2,224 injured, 369 dead and 555.2 billion won in property damage, which must be a waste of financial and national costs. Of these, the number of fires caused by carelessness is the highest at 20,352, followed by electric fires at 10,471[1]. In the event of such a large number of fires, preventing accidents could reduce the number of deaths and injuries.

In order to prevent advance, various education and fire prevention through intelligent sensors are necessary, and securing safety for people will be the most important. In particular, proper evacuation guidance is important in the early stages because fire deaths are due to the suffocation of smoke, including toxic gases[2]-[4].

In this paper, we want to find out how to reduce future disaster damage by comparing evacuation guidance and non-evacuation guidance in the case of fire.

Manuscript received: January 15, 2020 / revised: February 9, 2020 / accepted: February 17, 2020
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2. A THEORETICAL STUDY AND SIMULATION TESTS

2.1 A Theoretical Study on the Fire Model

The FDS(Fire Dynamics Simulator), a model developed by the NIST(National Institute of Standard and Technology) in the United States, is a CFD(Computational Fluid Dynamics) model and is an analysis of the fluid flow caused by fire. Navier-Stokes Equation is used to interpret slow motion by heat and is based on LES(Large Eddy Simulation). In addition to the flow of heat smoke, it is also possible to describe sensors and fire extinguishing devices, and a program called Smokeview was used for 3D visualization.

The formulas for the fire room criteria are as follows.

$$t_{start} = \frac{2\sqrt{\sum A_{area}}}{60} = \frac{\sqrt{\sum A_{area}}}{30}$$

t_{start} : Time required for the fire to start evacuation due to a fire

A_{area} : The living room and the part of the building that cannot be evacuated without passing through the living room.

The setting assumes that fire growth is Fast, and the maximum growth value is ventilation dominated fire.

$$\dot{Q}_V \approx 1500\, A_o \sqrt{H_o}$$

$\dot{Q}_V$: Maximum H.R.R. for ventilation controlled fire (kW)

A_o : Area of ventilation openings (m^2)

H_o : Height of ventilation openings (m^2)

2.2 Application of Simulation Tests

The building was analyzed based on the actual building, and the non-fire room possible evacuation time standard for an office building was set at W2 basis as provided in performance-oriented design methods and standards for firefighting facilities and etc[5]. The acceptance personnel calculation standard was set at 4.6m2/person in the office also based on the [5], while the acceptance personnel calculation standard for the corridor was set at 9.36m2/person and 3.7m2/person in commercial areas.

According to the calculation standard above, the number of people for Area-A in the building was set at 345 and the number of people Area-B was set at 348, which was the total number of 693. The fire was said to have occurred in 3 locations, and each area was to compare and analyze the guidance and non-guidance situations according to the fire. Evacuation simulations was used with PATHFINDER and SIMULEX, which is commonly used.

Case 1 was set to have 693 total personnel and location of fire was set to occur in Area-A office Fire 1, 13 people who were originally in the room, 15.3 seconds for evacuation time, and 180 seconds for non-fire room evacuation time.

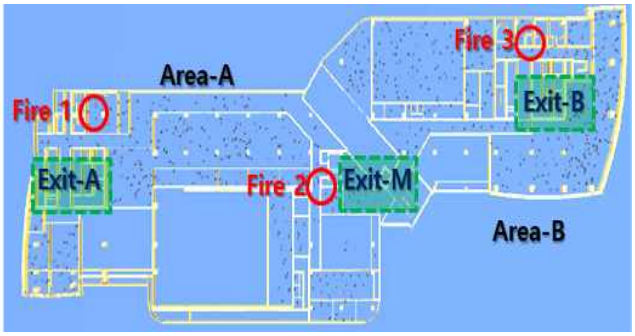

Figure 1. Fire Simulation Diagram

Case 2 was set to have 693 total personnel and fire place was set in multi-purpose room Fire 2 between Area-A and Area-B. 17 people were originally in the room with 17.8 seconds for evacuation, and 180 seconds for non-fire room evacuation time.

Case 3 was set to have 693 total personnel and fire place was set to have fire in the Area-B Fire 3 lounge. 4 people were originally in the room with 8.5 seconds for evacuation, and 180 seconds for non-fire room evacuation time.

Three evacuation areas were available: Exit-A, Exit-M and Exit-B.

3. PAPER TITLE AND AUTHOR INFORMATION

3.1 Comparison of Results for Evacuation Guidance and Non-evacuation Guidance by Fire

In case of Case 1, a fire occurred in Area-A, while Area-B is relatively safe. At Area-A, the distribution of visibility risk was the greatest because of the flow of smoke after a fire.

In case of Area-A Exit A with non-guidance, the final evacuation time was 344 seconds because of the human traffic near Exit A, and it was completed in 225 seconds with guidance. Exit M with non-guidance, the final evacuation time was 290 seconds and increased to 337 seconds with guidance due to the increase in the number of people coming in from near Exit M and Area-A for safe evacuation from the fire. In a non-guidance situation, there was a high probability of damage from exposure to smoke in near Exit A. Exit B of Area-B did not distribute personnel to Exit M as a safe distance from fire, so the final evacuation time increased as the number of people used increased.[See Figure 2]

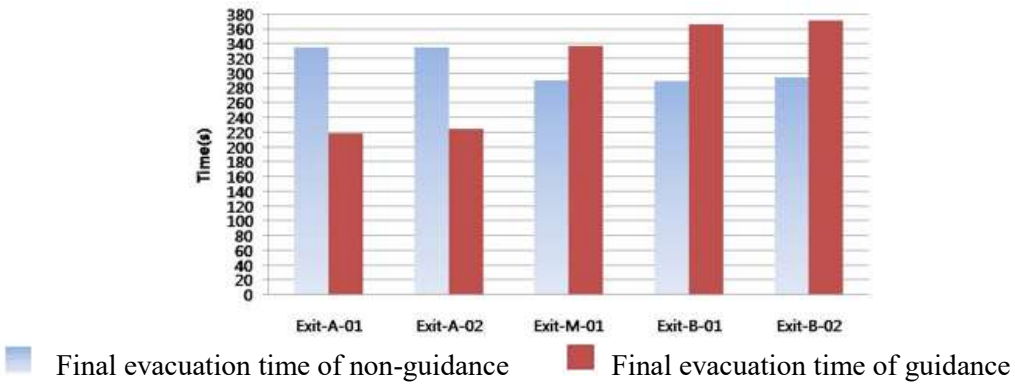

Figure 2. Case 1 Fire Simulation Analysis Results

In case of Case 2, there was a fire near Area-A Exit M, so Exit M was not available to be used due to the high risk of fire accidents.

In case of Exit A of Area-A, the final non-guidance evacuation time was 340 seconds, but in case of guidance, it was completed in 372.27 seconds. The final evacuation time of Exit M was completed in 283 seconds, but the flow of smoke led to the greatest distribution of visibility risk. Also, it was found that there was a high risk of casualties from smoke inflow since the door of Exit M was not a special evacuation step protected by pressurization if it is opened. With the guidance, Exit M was not available to be used due to the high risk of smoke exposure and limited visibility. In case of Exit B of Area-B with non-guidance, the final evacuation time was 294 seconds, but in case of guidance, it was completed in 365 seconds because of not using Exit M.[See Figure 3]

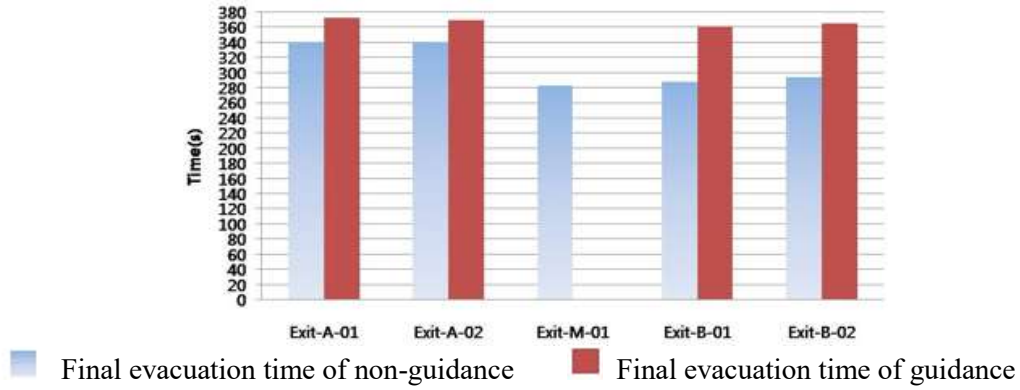

Figure 3. Case 2 Fire Simulation Analysis Results

In case of Case 3, there was a fire near Area-B Exit B, and Exit B was not available to be used due to the high risk of fire accidents.

In case of Area-A Exit A, the final non-guidance evacuation time was 340 seconds, but in case of guidance, it was completed in 378 seconds. The evacuation time of Exit M was completed in 288 seconds with the non-guidance, and it was completed in 382.52 seconds by accommodating the personnel of Area B for Exit M with less fire risk. In case of Exit B of Area-B, the final non-guidance evacuation time was 288 seconds, but it was not available for use with guidance due to the high risk of fire.[See Figure 4]

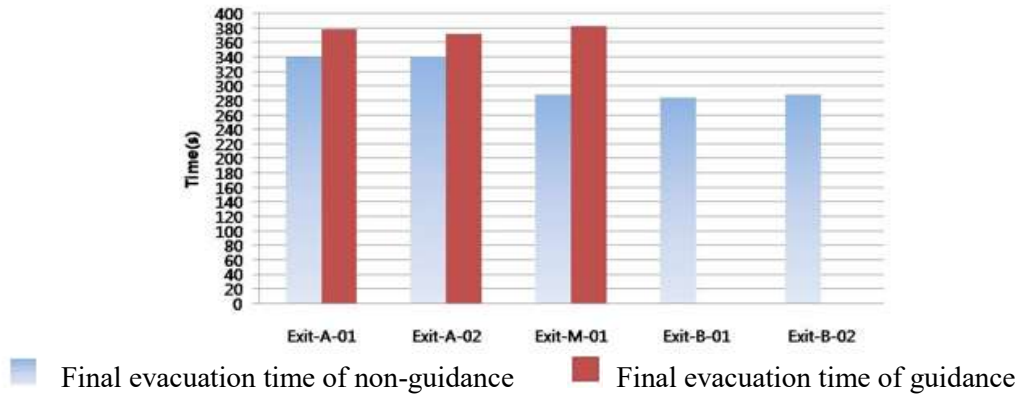

Figure 4. Case 3 Fire Simulation Analysis Results

4. CONCLUSION

In this paper, although the efficiency of non-guidance evacuation with the evacuation time comparison is mostly higher, there can be many casualties from the smoke of the fire, so safe evacuation with the guidance is necessary.

In particular, it was shown that it was most important to inform directions and locations to secure safer passageways rather than guided time, as it was not a good thing due to the short time of evacuation time.

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