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A study on the Pedestrian Evacuation Characteristic in University Students Dormitory through Full-Scale Experimental

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Abstract

Driven by economic development, contemporary society is growing specialized and diversified in each sector, and growth is accelerating; same thing is true in architecture field. There is emergence of numerous types of buildings to facilitate diverse purposes of human activities. Recently, as university dormitory buildings are constructed through project of private construction and lease to government (BTL), dormitory buildings are growing taller, but the operations and emergency countermeasure still do not keep up with such trend of building heightening. And recently many foreign students are currently studying in Korean University and most of these students live in foreigner dormitories. The dormitory buildings have a relatively high risk of fire and evacuation safety by compare to other buildings. As well as foreign students because of cultural differences and lack of language skills can be put to greater difficulties in emergency. Therefore, this study analyzes the evacuation performances of university dormitory buildings through Full-scale evacuation experimental. In addition, this study searches for physical elements of evacuation performance to be improved through Full-Scale Experimental, on which basis, purports to improve evacuation performance of the subject university dormitory buildings ultimately. The results that lower about 0.45m/s degree full evacuation speed than walking speed (1.3m/s (flat)), the common. This shows that do not significantly affect the speed of gender in the similar age group of early 20s. Although the rooftop-right-exit was the smallest of exit-doors, experiment-subjects were evacuated by 45% toward to the rooftop right exit. Through such processes, this paper is intended to furnish the fundamental materials when planning university dormitory buildings which are able to minimize the damages and protect individuals and their properties.

Keywords: Evacuation Performance, Fire-Safety, Full-Scale Evacuation Experimental, Human Evacuation Behavior, University Student Dormitory

1. Introduction

The university dormitory buildings have a relatively high risk of fire and evacuation safety aspects among building purposes. Because it is composed of a certain number of a closed space that scale residence building. In addition to the personal space, it is difficult to fire safety fire huge load of each space. And in terms of refuge accommodation space is composed of many individual university dorm building and high density living. For this reason, it is difficult university dorm building evacuation in case of fire. Especially girls dormitory and apply strong security on the door (escape path) reason of effective management and student personal safety. This also works in an emergency evacuation is difficult reasons. And recently, the government and domestic universities are to plan and deploy a wide range of activities to attract foreign students for ensure global competitiveness. As a result of these efforts, many foreign students are currently studying in Korean University. Most of these students live in

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foreigners university dormitories. In the case of foreign students because of cultural differences and lack of language skills can be put to greater difficulties in emergency. Thus, this study is evacuation simulation experiment for improving the safety of the university dorm evacuation. This experiment setting that can occur with the real fire scenario simulation. And experiments that were evacuated to the ground after the alarm targeting students actually live. In this paper, we analyze characteristics through them, evacuation speed, characteristics of the evacuation route choice behavior during the evacuation of the subjects (students) research. What we achieve through this study is to provide technical resources for evacuation routing and evacuation safety when designing college dorm as clearly the vulnerability of the fire and evacuation safety in university dorm. Conducted a full scale evacuation experiments for students who are living in a real college dorm to dorm in the present study, we analyzed the proportion of each egress selection of subjects and measure the speed of evacuation. We investigated characteristics, evacuation speed, the evacuation of the evacuation route choice behavior of the subjects (dormitory resident students) based on this.

2. Experimental Procedure

Experiments were consisted of two parts on foreigner and general dormitory. The subjects of the experiment have been live for more than one year in the university dormitory and they currently have been lived in a dormitory.

2.1 Overview of Experimental Place(Korean University Dormitory)

Analysis in the event of a disaster such as fire and evacuation rate and was the subject of evacuation behavior by evacuation experiments for ensuring the safety of the university dormitory residents evacuated from college dorm this experiment are shown in Table 1 below is a summary of the experiment. The living space consists of 184 can accommodate 924 people and the dormitory building. Consists of two people per room or living room is a single room and bathroom as a shower every living space. Figure 1 shows building image and base plane of experimental subject building.

In addition, each floor has one common room and the first floor has laundry rooms, management office, public toilet, and warehouse. Male students use 1–4 floor and female students use 5–8 floor in this dormitory. Some time (meal time) then the bottleneck occurs at the main entrance.

Table 1. Overview of the Experiment (Korean University Dormitory)

Date		2014.05.07
Location		C University Dorm in Korea
Building Stories		8 Stories
Space composition		Single room:24, Twin room:160, Lounge:8, Management office:2, Laundry room:2 Public toilet:1, Warehouse:1
Subjects	**Male**	21 people
	Female	116 people

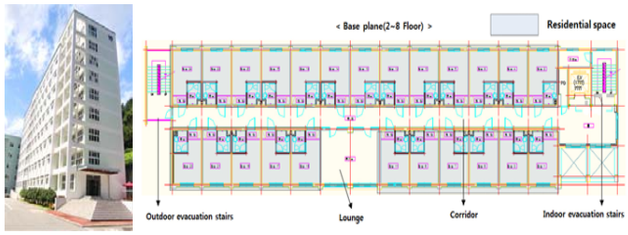

Figure 1. building image and Base Plan (Korean University Dormitory). Experimental subject

The survey divided by the staircase and corridor evacuation experiments. The stairs and corridors where walking speed difference occurs in the dorms. This space is safe compartment that important evacuation path in an emergency. Among students who live in dormitories 137 students (Male:21people, female:116people) participated in the experiment. We assume that in the microwave oven on the 5th floor lounge fire occurred and expanding catch fire to the surrounding combustibles fire. Also, the smoke generator was used to produce a smoke condition. And we were educated subjects that allowed for individual activities in each of the room and when subjects hear the fire alarm to evacuate the direction they want. Evacuation path are corridors, main staircase, evacuation stair. The final exit is four available (1st floor left exit, 1st floor right exit, Rooftop left exit, Rooftop right exit).

2.2 Overview of Experimental Place (Foreigner University Dormitory)

The experiment was conducted at foreigner dormitory building in the C-university. This experiment was intended for foreigners and those who live in the experimental area

Figure 2. Final exit image.

(dormitory) are also not Korean. Overview of the building is shown in Figure 3.

Residents were waiting in each room and after the fire alarm they was started to evacuate at once. We informed to the resident about the experiment contents before the experiment. The Residents were to determine evacuation routes according to their will without a fixed evacuation route. A total of 32 subjects were international students and their characterizations are given in Table 2. Also for the identification of the subjects we were attached to their room number written paper on area of back and stomach.

2.3 Experimental Method and Conditions

Measurement of the experiment was performed using the CCTV. This is done to rule out factor that could affect the evacuation speed. We recorded behavior of subject about the evacuation path and final exit. Through the recorded video and blueprint, we analyzed evacuation speed of subjects, select of exit and evacuation route. We installed CCTV and recording subject behavior on the evacuation path and final exit. This is done to rule out factor that could affect the evacuation speed. Through the recorded video, we analyzed evacuation speed of subjects, select exit rate, select evacuation route Etc. for the identification of the subjects they were attached to a paper on the area of back and stomach. Figure 4 is CCTV, recording equipment and smoke generation equipment used in the experiment.

We measure the time it takes to move past the stairs and corridors to finally complete evacuation point after the fire alarm through analysis of the recorded image. And identifying the movement of each subject were examined and the moving distance with reference to the drawings. We calculated for each of the evacuation speed of the subject using this. Also we analyzed the behavior of the subject and evacuation time according to the characteristics in space and gender. Figure 5 shows the CCTV recorded images during the experiment.

Figure 3. building image and Base Plan (Foreigner University Dormitory). Experimental subject

Table 2. Overview of the Experiment (Foreigner University Dormitory)

Date	2014.10.10							
Location	C University Foreigner Dorm in Korea							
Building Stories	8 Stories							
Space composition	Multiple dwelling house of gallery type (1 living room, 2bath rooms, 3rooms(double room)							
Subjects	32People(1F:0, 2F:14, 3F:3, 4F:15)							
	Mongolia		China		Vietnam		Japan	
	Male	Female	Male	Female	Male	Female	Male	Female
	2	7	13	4	.	3	.	3

3. Evacuation Characteristics of Koreans Resident Dormitory

3.1 Evacuation Speed Analysis

Collect and analyze data relating to the evacuation from the evacuation experiment with the actual college

Figure 4. Equipment used in the experiment.

Figure 5. CCTV recorded images during the experiment.

students living in dormitories in the present study. Show an average evacuation speed of Figure 6. Lower about 0.45m/s degree full evacuation speed than the common walking speed (1.3m s (flat)[3]).

Table 2 shows the results of evacuation speed. In all cases of Gender, floor and exit, the staircase was greater the difference between the speed of the downward movement and upward movement. Downward movement speed was approximately 0.26m/s faster than upward movement speed. (Average speed of downward: 0.92m/s, Average speed of upward: 0.66m/s). There were no significant differences in evacuation speeds between men and women, these results show that the gender do not significantly affect to evacuation speed in case of similar age group of early 20s. In addition, evacuation speed is the slowest in the 6th floor. This is because the smoke was generated from the 6th floor. However, evacuation speed of 6 layers was similar to speed of the other layer. This shows that this does not have a significant impact on the evacuation of smoke evacuation speed because it is a simple form of all the corridor floor and these corridors continuously have been used by subjects in normal. In addition, because of they knew that this training situation.

The corridor average evacuation speed analyzed by 1.04m/s (Male:0.89m/s, Female:1.06m/s). Female evacuation speed was approximately 0.2m/s faster than Male evacuation speed. And staircase average evacuation speed analyzed by 0.75m/s (Male: 0.76m/s, Female: 0.75m/s). (Figure 7) Therefore, the difference between the evacuation speed in the vertical space and horizontal space was found that clearly. Also, evacuation speed distribution in the corridor is wider than that of the stairs. It can be seen that a uniform movement in the evacuation speed when moving the vertical space (stairs). However, the same

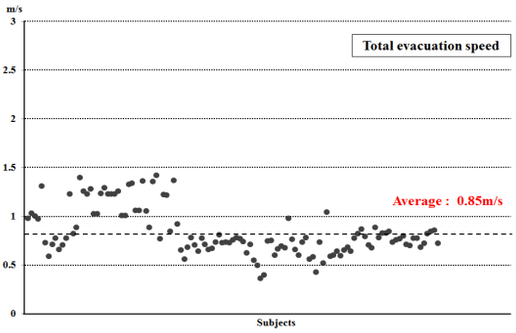

Figure 6. Total evacuation speed (Koran University Dormitory).

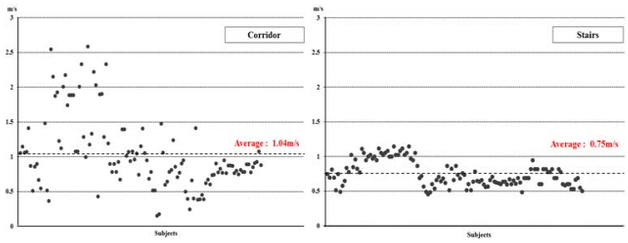

Figure 7. Evacuation speed in corridor and stairs (Koran University Dormitory).

person, even if the horizontal space (corridor) can be seen that the movement speed is non-uniform. And evacuation speed according to the final exit of the subjects selected by the 1st floor right exit was the fastest. (Horizontal:1.8m/s, Vertical (Down):1.22m/s). This results that was subjects have used always the main entrance on the right exit. Because subjects have using always the main entrance on the right exit derived results. In other words, if not, when you continue to use the exit (moving route) evacuation differ about 1.0m/s. In other words, the difference of 10m/s(Max 1.17m/s, Min 0.89m/s) between the evacuation speed than when Subjects are moving to a different exit when you go to use in the past continue to exit.

3.2 Select Exit Proportion

Experimental subject building has final exit of the four. Although the roof top-right-exit was the smallest of exit-doors, experimental subjects were evacuated by 45% toward to the rooftop right exit. The table 3 gives the percentage retention subjects selects the exit. Especially, though the difficulty to evacuation upward, 52% of subjects using the 5~8 layers were evacuated to the roof right exit.

The subjects did not go directly to the exit is 18 people. They were wandering the corridor. 15 people are students who live in the 6th floor. We generate a smoke with a generator on the 6th floor. This shows that the smoke is the most important element of the evacuation direction setting of subjects. (Figure 8)

3.3 Evacuation Characteristics of for Resident Foreigner Dormitory

We analyze data relating to the evacuation from the evacuation experiment targeting the actual foreign students living in dormitory. Figure 9 shows an average evacuation speed.

Table 3. Evacuation Speed Analysis (Korean University Dormitory)

Characteristics		Corridors	Stairs			Subjects
			Average	Up	Down	
Gender	Male	1.06	0.76	-	0.76	15
	Female	0.89	0.75	0.66	1.01	104
Floor	2,3 Floor	0.92	0.71	-	0.71	11
	4 Floor	0.79	0.89	-	0.89	4
	5 Floor	1.73	1.00	0.86	1.01	28
	6 Floor	0.73	0.61	-	0.61	26
	7 Floor	0.89	0.66	-	0.66	22
	8 Floor	0.82	0.69	-	0.69	28
Exit	1st floor left exit	0.91	0.85	-	0.85	16
	1st floor right exit	1.80	1.22	-	1.22	26
	Rooftop right exit	0.63	0.66	0.66	-	23
	Rooftop left exit	0.89	0.73	0.73	-	54

Valid data :119 subjects

Table 4. Proportion exit selection (Korean University Dormitory)

Exit	Proportion
1st floor left exit	13%
1st floor right exit(Main Entrance)	22%
Rooftop right exit	19%
Rooftop left exit	45%

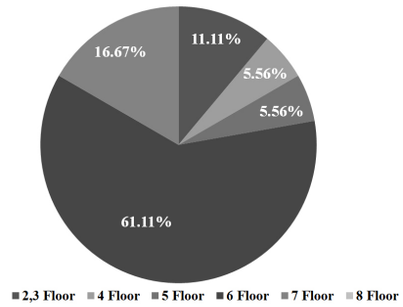

Figure 8. Residential floor of subjects who lost exit (Koran University Dormitory.

Total evacuation average speed (1.03m/s) is faster than speed in the Korea University Dormitory. It is because that all subjects moved to 1th floor in foreign dormitory

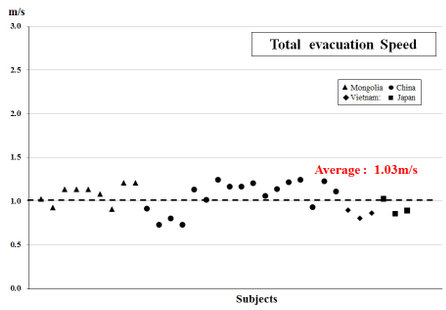

Figure 9. Total evacuation speed (Foreigner University Dormitory).

evacuation experiment. In fact, average evacuation speed except subjects move to the rooftop is similar on 1.0m/s in the Korea university dormitory experiment. There is no difference in the evacuation speed, depending on the country. (Mongolia:1.09m/s, China: 1.06m/s, Vietnam: 0.85m/s, Japan: 0.92m/s). Also, analysis of the speed according to the gender is that it does not significantly affect the speed. This is the opposite from what is appeared in the evacuation speed difference by gender in higher age groups. Table 5 shows the exit selection proportion. The test subjects were people living in the lower levels (1–4 layers). So I did not evacuation the roof. They were evacuation to mainly use the main entrance.

In addition, students and international students and Korea will be the biggest difference between culture and language. Accordingly, in this study we compared the relationship to the language level of subjects and the result of evacuation experiment. Figure 10 shows the evacuation speed according to the level of language students. Language level evaluation was carried out five scale evaluated for listening and speaking. The method of evaluation is composed of a self-assessment (50%) evaluation and professor evaluation (50%). The final result of the language level is the average of the two indicators.

In the comparison result, there was no significant difference is evacuation speed. But it was found that the level of the language is evacuation speed is slightly slower,

Table 5. Proportion Exit Selection (Foreigner University Dormitory)

Exit	Proportion
1st floor left exit	37%
1st floor right exit(Main Entrance)	63%
Rooftop right exit	0%
Rooftop left exit	0%

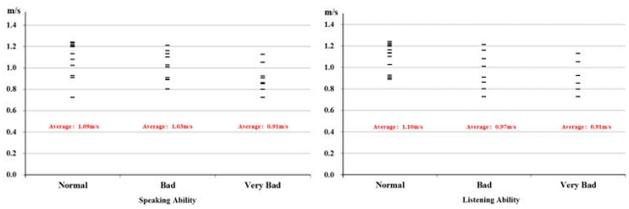

Figure 10. Analysis of the average evacuation speed according to the language level (Foreigner University Dormitory).

depending on the lower. Depending on the language level was analyzed that the impact on the evacuation speeds. Therefore, it is necessary to arrange a dormitory room, depending on the language level.

4. Conclusion

This study analyzes the evacuation performances of university dormitory buildings through Full-scale evacuation experimental. As a result of the study, average evacuation speed in case of fire showed 0.85m/s and the vertical (stair) part movement evacuation rate was found to significantly lower. Also evacuation speed can be influenced by the gender and age. However, age and gender did not affect significantly the evacuation speed in experimental results on dorm evacuation In addition, the results of the experiment show that evacuation characteristics which Lower levels of residents moved to the first floor and middle and upper floors residents moved to roof. The proportion of residents want to select frequently used exit was higher. In particular, the evacuation speed of residents who often used to go to exit differ on 10m/s (Max 1.17m/s, Min 0.89m/s). Depending on the language level was analyzed that the impact on the evacuation speeds. Through such processes, this paper is intended to furnish the fundamental materials when planning university dormitory buildings which are able to minimize the damages and protect individuals and their properties.

5. Acknowledgement

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