THE EFFECT OF DEVELOPED NON-POWER FIRE EVACUATION ASSISTIVE DEVICE ON EVACUATION TIME OF WHEELCHAIR USERS

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ABSTRACT

Purpose of this study was to develop Non-Power Fire Evacuation Assistive Device(NPFEAD) and evaluate the device to help wheelchair users can evacuate from upstairs to down stair without other's help in emergence situation. NPFEAD was composed by ramp, bar, and velocity controller, so that the wheelchair users open the ramp and hold the bar to descend the ramp, then the velocity controller maintain the descending velocity of wheelchair. To evaluated the effect of the NPFEAD, Artisoc(MAS based evacuating simulation program) was used. For the simulation four cases of evacuation situation was set and compared evacuation time to assess the effect of the NPFEAD. As a result, NPFEAD had effect of decrease evacuating time. In conclusion we consume that the wheelchair users could evacuate by themselves when they used NPFEAD even faster than other situation.

BACKGROUND

Increase of accident rate in people with disabilities caused by disaster has been serious problem in all over the world. In 2009 in Korea, two serious disabilities got fire disaster. Even though the all of them were able to recognize the fire, they could not evacuate from the fire because of their lack of mobility capabilities. Also, a wheelchair user waited at evacuating place where mentioned in evacuation manual for people with disabilities, but the wheelchair user got ceiling collapsed before fireman came.

Evacuation of people with disabilities is not a simple problem. Weight of disabled people and wheelchair, level of disability, number of evacuation assistance, sex of the assistance and structure of building must be considered for the evacuating. People with disabilities who are able to walk can use cane and walker to evacuate by themselves. If people with disabilities cannot walk, for example wheelchair users, other people have to help them. However, it is hard to have other people' help for every emergency situation. For this reason, we need to prepare and effort to give opportunity to the wheelchair users to evacuate by themselves. Thus, device that can help wheelchair users to evacuate without others help and can be used in emergency situation is needed to be developed(Sim, 2010).

PURPOSE

The purpose of this study was to develop the Non-Power Fire Evacuation Assistive Device(NPFEAD), and to evaluate the effect of the device using evacuation simulating system.

1. To develop the non-power fire evacuation assistive device
2. To evaluate effect of the NPFEAD on evacuation time using evacuation simulator

METHOD

Development of the NPFEAD

NPFEAD was composed of ramp, velocity control device and rope. The velocity control device including three gears is installed on wall-side of up stair and it controls the wheelchair's descending velocity on the ramp. In addition, high frictional materials were attached on surface of the ramp not to slip on the ramp. Wheelchair and the NPFEAD are connected by the rope, so that when wheelchair descends the ramp, the wheelchair pulls the rope. This pulling force transfers to centrifugal friction force by the gears connected with the rope.

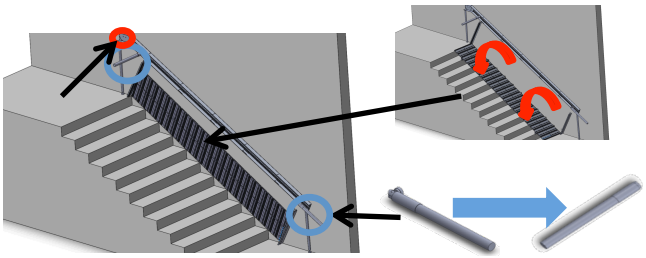


Figure 1. Structure of Non-Power Fire Evacuation Assistive Device (NPFEAD)

MAS based program Artisoc

Artisoc is MAS based program which developed by Kozo Keikaku Engineering Ino.(KKE). The program uses BASIC and LOGO language and two and three dimension space expression is possible. Pedestrian simulation research

Importing simulation data condition

Scenario of the evacuating simulation was composed by four cases(Table 1) and each case tried 20 times of simulation then mean of simulation result time was calculated. For the simulation data, evacuator's size were needed to be defined. The wheelchair users and non-disabled defined as Figure 2. The people in the simulation evacuated from 3rd floor in virtual building(Figure 3). After alarming for evacuation, the people started to evacuated from their room or hallway on 3rd floor to 1st floor through the stair on left side of Figure 3.

Case 1. During the simulation evacuating, 10 wheelchair users evacuated by themselves with NPFEAD(Figure 1). Only one wheelchair user(disabled) could use the NPFEAD each time. One user got downstairs, then the next users could use the NPFEAD. When using the NPFEAD, wheelchair users had 0.5 m/s velocity during to get downstairs. To define he descending velocity, 10 times of NPFEAD velocity tests was tried and mean of the result were applied to the simulation program.

Case 2. 10 wheelchair users and 10 non-disabled evacuated together. During the evacuation, non-disabled people did not help people with disabilities. The wheelchair users used NPFEAD, and non-disabled ran down to stairs. The velocity that applied to the cases was from Ko, Youn, & Kim(2013).

Case 3 and 4. In these cases, non-disabled people supported wheelchair users to evacuate. Non-disabled people used the evacuation chair(Figure 2) to help disabled people to evacuate. In order to define the descending velocity, the advanced research result was referenced(Ko, Youn, & Kim, 2013).

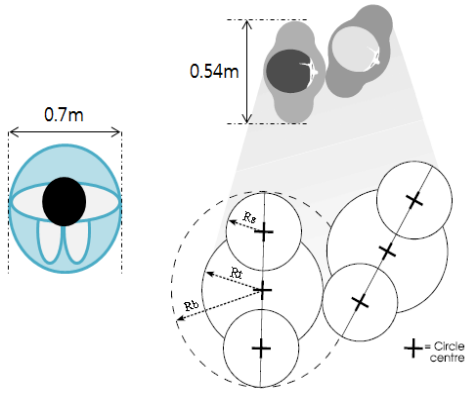


Figure 2. Evacuator size definition in the simulation

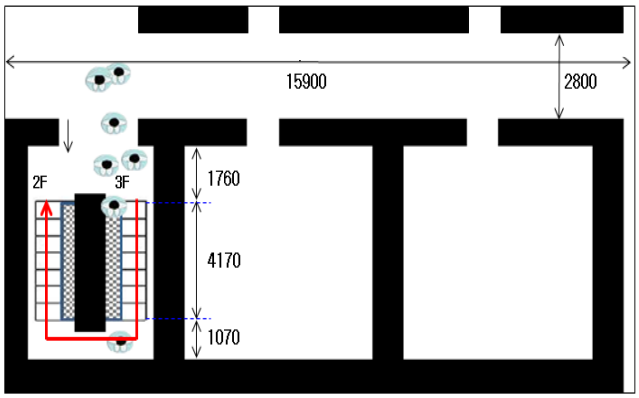


Figure 3. Structure of evacuation space

Table 1: Evacuation Scenario Condition of the Cases

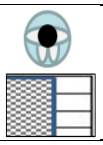
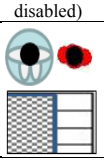
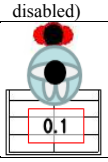
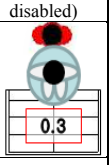
Scenario#	Case 1	Case 2	Case 3	Case 4
Number of participant in the simulation	10(Disabled)	10(Disabled) 10(Non-disabled)	10(Disabled) 10(Non-disabled)	10(Disabled) 10(Non-disabled)
Evacuation model				
Entering velocity	0.1 m/s	0.1 m/s	0.1 m/s	0.1 m/s
Velocity at the stairs	0.5 m/s	0.5 m/s(D) 1.0 m/s(N)	0.1 m/s	0.3 m/s
Velocity at ground	0.83 m/s	0.83 m/s(D) 1.0 m/s(N)	0.91 m/s	0.91 m/s

Figure 4. Evacuation chair in Case 3 and 4

Data Collection and Analysis

Each case of the simulation scenarios executed 20 times, and collected time data of finishing evacuation on every trials. The collected time data of mean was used as a result.

RESULTS

Result of Case 1 was 304.85 seconds. This case was applied NPFEAD. During the simulation, the wheelchair

users waited for descending person to use NPFEAD as a next user. If people evacuate same as simulation in real world, people with disabilities have more possibility escaping from fired building.

Case 2 was wheelchair users and non-disabled people evacuated together, but non-disabled did not help the wheelchairs users. To finish evacuation took 311.7 seconds in Case 2. I took little more time to evacuate than Case, this is because early phase of the evacuation, non-disabled people disrupted wheelchairs going down. After non-disabled people finished evacuating, wheelchairs evacuated smoothly in the simulation. However, if number of wheelchairs and non-disabled people increase, a bottleneck phenomenon can be immerse as the early phase of evacuation showed.

Case 3 and Case 4 were case that non-disabled people helped wheelchair users. Case 3 took 700.65 seconds and Case 4 took 364.25 seconds to finish evacuating. In these case time of evacuation was affected by ability of non-disabled(evacuation assistance) a lot. Also, it is difficult to realize these cases in real situation because at least one healthy non-disabled supporter is needed in order to evacuate one wheelchair, but most of places like hospitals or Social Welfare Center do not enough man power.

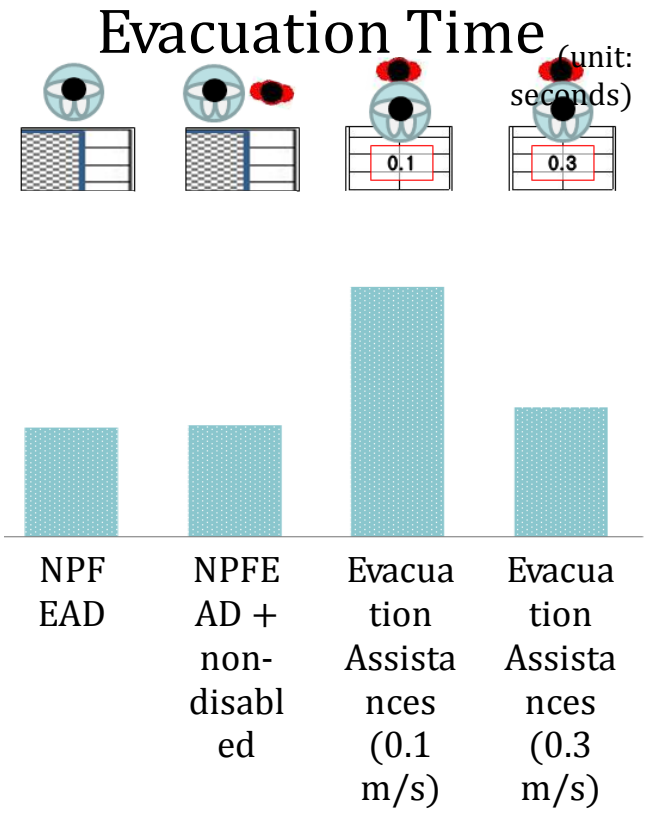


Figure 2: Result of evacuation time by the simulator

DISCUSSION

According to the results above, the NPFEAD can reduce evacuation time and help people with disabilities using wheelchairs to evacuate by themselves. When the NPEAD was used, it was faster than using evacuation chair. 10 of wheelchair users spent 304.85 seconds(Case 1) to evacuate, and 10 of non-disabled people supported wheelchair users to evacuate took 700.65 seconds(Case 2), and 364.25 seconds(Case 4). These result shows that developed evacuation supporting device(NPFEAD) is able to evacuate faster, and give opportunity to wheelchair users to evacuate by themselves from upstairs to downstairs. Moreover, the analysis of effect of the NPFEAD on evacuation time means that the evacuation simulator showed that the NPFEAD reduce evacuation time. This means when wheelchair users have no man and electrical support, they can evacuate by themselves even faster.

CONCLUSION

Many of people with disabilities have difficult to evacuate from the disaster or other accident by themselves. Especially people with wheelchair users in upper than second floor have more risk because of lack of capabilities to get downstairs for evacuation. The NPFEAD was developed to solve this problem, and evaluated by the evacuation simulator. The results mentioned above that procuring capability of evacuation and faster evacuation time are extremely important to safe life for wheelchair users.

Thus, when people with disabilities face to the fire in buildings, they are willing to be given opportunity to save their lives by themselves. The result of this study can be based research for it.

ACKNOWLEDGEMENT

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