**Master of Science in Engineering**

# Analysis on Disaster Information Effect in Relationship to Occupant Behaviour

**by**

**Donghoon Ji**

Department of Architecture & Architectural Engineering

The Graduate School

Seoul National University

February 2017

# Analysis on Disaster Information Effect in Relationship to Occupant Behaviour

by

**Donghoon Ji**

**A thesis submitted in partial fulfillment**

**of the requirements for the degree of**

**Master of Science in Engineering**

**Seoul National University**

**2017**

# Abstract

# Analysis on Disaster Information Effect in Relationship to Occupant Behaviour

Donghoon Ji
Department of Architecture and Architectural Engineering
The Graduate School
Seoul National University

Existing efforts to reduce egress time in building fire situations have focused on reducing travel time. However, although the ratio of travel time is one-third of total egress time, there are insufficient considerations to reduce perception time and response time, and situations that the safety of occupants cannot be ensured by only reducing travel time were aroused.

Therefore, the need for reduction in perception time and response time has increased, and disaster information got attention to solve these problems. Therefore, this research have accounted for the process of disaster information effect based on the relationship of disaster information and occupant behaviour in terms of reducing egress time.

Through analysis of previous researches, limitations of previous researches about disaster information were identified as an insufficient expandability and less explanatory power of the effect of disaster information. To analyze the process of the effect of disaster information easily, this research would account for occupant behaviour and limited the scope to individual behaviours. Also this research would derive occupant behaviour factors, which can represent a certain type of occupant through a combination of these factors.

By referring the previous researches, this research identified 10 major disaster information and 3 occupant behaviour factors among literatures. In addition, considering the association between the derived factors and egress time, the relationship was organised with 3 disaster information related to locomotion, 5 disaster information related to cognition and 5 disaster information related to familiarity.

Also, this research conducted an experiment to validate the relationship with surveys. Targets of experiment were 4 types of occupant (elderly, the intellectual, the hearing & language and the visually impaired) which could be expressed by occupant behaviour factors of this research, and the validity of this research was confirmed in 4 cases. Finally, by analyzing the experiment results, this research explains the process of disaster information affecting occupant behaviour as ensuring safety by complementing vulnerable occupant

behaviour to the minimum level of safety or by maximizing relatively high occupant behaviour to enough level of safety.

Compared to existing researches which described the relationship of disaster information and occupant behaviour in intuitive level, this research has added explanatory power in terms of reduction of egress time. With further studies of disaster information and group behaviour, these series of researches could provide basic references for disaster information and occupant behaviour.

**Keywords:** Disaster Information, Occupant Behaviour, Evacuation, Egress Time

**Student Number:** 2015-21122

# Contents

# List of Tables

# List of Figures

# Chapter 1. Introduction

Situations of building fire occur frequently and it is fatal to occupant in terms of their safety. According to the Ministry of Public Safety and Security (2015), 59.2% among total fire cases is building fire. Also, net casualties from building fire cases is 82.4% and property damage from building fire cases is 88.4% of total fire cases. Therefore, continuous needs to ensure safety of occupant from building fire aroused.

Methods to ensure safety of occupant were developed as following directions: (1) reducing the occurrence rate of fire; (2) mitigating risk from fire itself (Brown 2009). First, reducing the occurrence rate of fire could be accomplished by fire prevention, such as an inspection to fire prevention system. Second, mitigating risk from fire could be accomplished by reducing egress time. Among these ways as mentioned above, fire prevention has a limitation which cannot accomplish a perfect prevention, in other words reducing the occurrence rate of fire to zero. Reducing egress time therefore should be considered important under the premise of occurrence of building fire.

This research focused on disaster information, which is one of the methods to reduce egress time and aims to figure out the process of disaster information effect. To account for the necessity of this research, research background, objectives and procedure will be proposed in this chapter.

## 1.1 Research Background and Objectives

In situations of building fire, reducing egress time of occupant is necessary as the possibility of success evacuation can be increased (Olsson et al. 2001). Egress time consists of three factors: (1) Perception time which represents the time for recognizing the outbreak of fire through sign of fire or warning alarm; (2) Response time which represents the time for preparing evacuation using prior knowledge such as evacuation route or instructions of equipment; and (3) Travel time which represents the time for actual evacuation to ensure safety (Ng et al. 2006; Park 2012), and existing efforts to reduce egress time focused on the aspect of travel time with the usage of evacuation equipment such as descending life line. Especially, within the context of the appearance of high rise buildings, more considerations focused on reducing travel time, which could be exposed to direct risk from building fire.

However, average travel time is one-third of the total egress time (Shen 2003: requoted in Sagun el al. 2014), and compared with those efforts of travel time, considerations in terms of reducing perception time or response time are insufficient (Simonovic et al. 2005: requoted in Lindell et al. 2007). Also, as the type of occupant diversified, some occupants who have inexperienced understanding of instructions of evacuation equipment or difficulty recognizing the outbreak of fire could not guarantee their safety by reducing travel time (Kim et al. 2011; Spence et al. 2007). Thus, necessity to reduce perception time and response time raised, and disaster information became a significant keyword due to its function of reducing both perception time and response time, which could accomplish the necessity (Perez-Lugo 2004; Sagun et al. 2014).

Meanwhile, disaster information which is needed by occupant depends on occupant behaviour (Sagun et al. 2014). For example, due to their insufficient auditory function, a person with hearing disability receive disaster information ineffectively when the disaster information is provided through audio-based warning alarm. Therefore, disaster information such as warning alarm with visual or vibration signal is needed, which the hearing impaired could receive fully. In other words, disaster information distribution with consideration of occupant behaviour is essential for effective information management of building fire (Guha-Sapir 1986; Sagun et al. 2009).

Considering that the needs of disaster information for occupant are due to their own occupant behaviour, the goal of this research therefore is to analyze the effect of disaster information on occupant behaviour. With this goal, this research aims to identify disaster information and occupant behaviour factors on previous researches. Then, in terms of a reduction of egress time, this research identifies the relationship of disaster information and occupant behaviour. Finally, this research propose a qualitative implication of the process of disaster information affecting occupant behaviour based on the relationship.

## 1.2 Research Scope and Process

This research defines the concept of disaster information as knowledge or data related to the disaster that could reduce both perception time and response time during the phases of 'Before Outbreak', 'Fire Outbreak', and 'During Fire'.

This research is organised by following five steps:

(1) Based on previous researches, identify major disaster information which could be commonly referred; and occupant behaviour factor which could represent various types of occupant.

(2) Organise the relationship of disaster information and occupant behaviour by analyzing the identified factors in terms of reducing egress time.

(3) Design a virtual experiment which shows the reduction of egress time using specific disaster information, and collect data for the experiment and its validation through surveys.

(4) By comparing the experiment results with actual surveys, validate the relationship of disaster information and occupant behaviour proposed in this research.

(5) Propose a qualitative implication; a process of disaster information affecting occupant behaviour by analyzing the experiment results.

The research process and methods are illustrated in Figure 1-1.

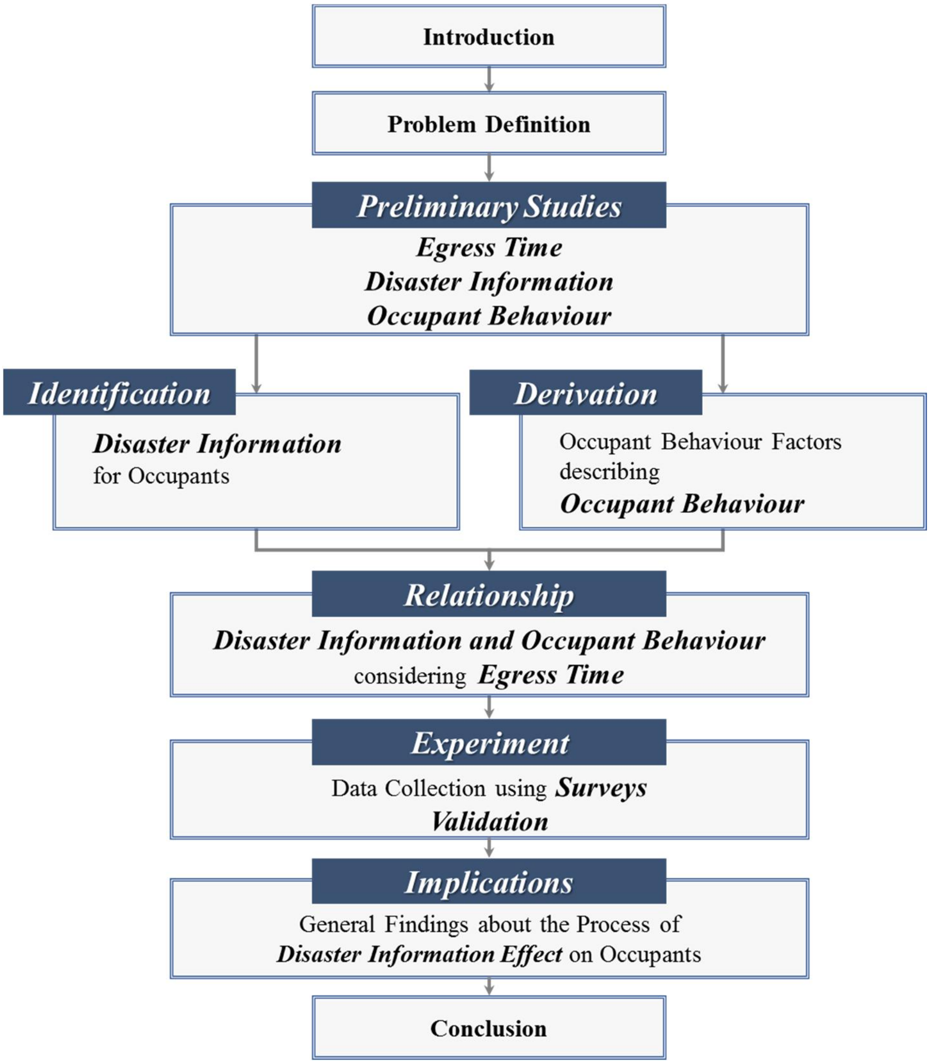


Figure 1-1 Research Process

# Chapter 2. Preliminary Researches

This research aims to identify the process of disaster information effect on occupant based on the relationship of disaster information and occupant behaviour. To describe the relationship, this chapter starts from analysis on previous researches of egress time, disaster information and occupant behaviours. Then, identification of the availability of disaster information to reduce egress time will be accomplished. Finally, this chapter describes the need for consideration of occupant behaviours when utilizing disaster information.

## 2.1 Egress Time

Evacuation is a process of decision making using the status of fire or related disaster information to secure the safety from fire (Park 2012). So, egress time, which means the time spent in whole process of evacuation, is one of the most important factors for securing the fire safety of occupants in buildings.

Egress time consists of perception time ($t_p$), response time ($t_r$), and travel time ($t_{tl}$) (Ng et al. 2006; Park 2012). Perception time, which is the time for occupant to recognize the disaster, represents the section between disaster outbreaks to disaster perceptions (Figure 2-1 - $t_p$). To reduce perception time, quick provision of warning alarm through effective disaster detection is required, and consideration about form of aids that occupants could accept properly is necessary (Lamb et al. 2012). Response time, which is the time to response for disaster and preparing evacuation, represents the section between disaster perceptions to egress start (Figure 2-1 - $t_r$). Some ways can reduce response time such as well-informed knowledge about instructions of evacuation equipment through pre-training or providing information about evacuation route. Finally, travel time, which is the time for actual evacuation, represents the section between egress start to finish (Figure 2-1 - $t_{tl}$). By evacuation equipment such as emergency lift, travel time can be reduced.

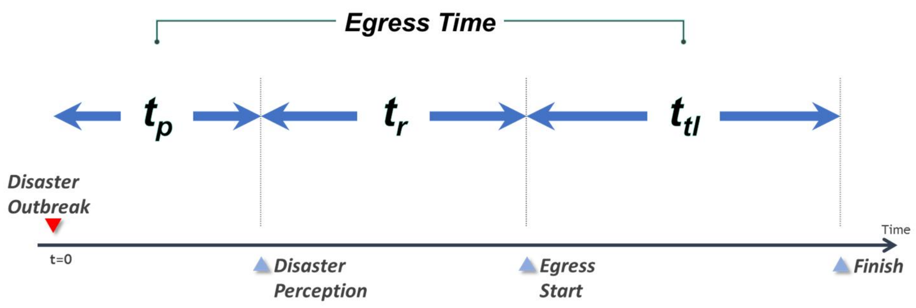


Figure 2-1 Factors of Egress Time

Among all factors of egress time, both perception time and response time are highly influenced by intellectual aspects. It is because that perception time is related with recognition of disaster through external stimulus, and response time is related with preparation of evacuation using prior knowledge. Also since intellectual aids such as instructions of evacuation equipment can reduce travel time, considerations of intellectual aspects for effective reduction of egress time are inevitable.

## 2.2 Disaster Information

Disaster information is a direct/indirect knowledge or interaction related to disaster (Pipes 2006), and it includes warning alarm, location of shelter/exit, instructions of equipment and safety know-hows about evacuation. Disaster information is then transmitted in audio or any other form, affects intellectual abilities such as level of knowledge or decision making and finally assists safe evacuation of occupant (Eldar 1992; Sagun et al. 2014). That is to say, by affecting intellectual aspects of occupants, disaster information could be a method which reduces total egress time (Guha-Sapir 1986).

Previous researches on disaster information focused on (1) vulnerabilities of unique types of occupant such as the disabled or the elderly and (2) factors which could improve these vulnerabilities. Parr (1987) identified vulnerabilities of the disabled in generic disaster and safety needs for securing safety for the disabled, and Spence et al. (2007) proposed the list of disaster information for the disabled like evacuation order and location of shelter and relative importance of the disaster information through surveys. However previous researches which followed these processes limit their scope to unique types of occupant exclusively, so they have an insufficient expandability to account for other types of occupant.

Recent researches therefore focused on availability of disaster information in disaster management in building or regional unit, to identify disaster information for more generic situations. Sagun et al. (2009) proposed orientation of disaster information by actions needed for disaster management such as pre-training, warning and rescue call, and Lamb et al. (2012) identified more specific type of disaster information by analyzing contents of disaster message for occupant. By considering disaster information for disaster management instead of type of occupant, these researches solved the problem of expandability. Yet they have less explanatory power of the reason why particular disaster information is needed to a certain occupant and what effect does the disaster information bring about.

In this research, occupant behaviour will be considered when identifying major disaster information. Compared with the method of considering aspects of disaster management, it is appropriate to describe the relationship of disaster information and occupant behaviour. Also, by analyzing the relationship, it is possible to identify the process of disaster information affecting the occupants.

Table 2-1 Literature Review of Disaster Information

| Author | Concept | Implications |
|---|---|---|
| Parr *(1987)*<br>Spence et al. *(2007)* | Factors for improving vulnerabilities of occupant | - Limited scope (i.e. the elderly)<br>- Insufficient expandability to *account for various types of occupant* |
| Sagun et al. *(2009)*<br>Lamb et al. *(2012)* | Disaster information in disaster management | - Less explanatory power of the *need of disaster information*<br>- Inappropriate to identify the *effect of disaster information* |

## 2.3 Occupant Behaviour

Occupant behaviour is an intrinsic characteristic of individual which (1) is manifested by disaster or (2) affects actions of occupant like evacuation (Choi et al. 2013). Typical occupant behaviours are physical abilities such as velocity which related to gender, age and cognitive abilities, and intellectual characteristics such as level of knowledge, experience of disaster and familiarity with place are also some of the major occupant behaviour (Lamb et al. 2012; Proulx 2002). These behaviours which are limited on individual are called individual behaviour, and related researches aimed to identify individual behaviours of occupant behaviour.

However, actual situations of disaster and evacuation are mostly cases where there are many occupants, so there are limitations to the difficulty of realistic explanation by individual behaviours alone. Recent researches therefore have been directed toward identifying factors for describing more realistic situations. Focusing on the sociality of occupants, mutual information exchange through communication and change of locomotion due to group behaviour (Choi et al. 2013) are advanced examples of occupant behaviour. Nevertheless, the objective of this research is to provide a basis for disaster information management by comprehending the relationship between particular disaster information and occupant behaviour, rather than reflecting realistic occupant behaviour. Thus, this research was conducted on the individual behaviours of occupant behaviour.

As this occupant behaviour are different depending on the type of occupant, disaster information needed by occupants in a disaster situation of buildings also appears differently (Tierney et al. 1988: requoted in Eldar 1992). For example, when a building has a fire, ordinary people who are not familiar with the building would not have enough information about evacuation route, so they select the route by listening to the disaster broadcast or referring to the evacuation guidance light installed in the building (Moon et al. 2011). Therefore, it is important to consider occupant behaviour in order to manage disaster information effectively (Sagun et al. 2014). In order to represent various types of occupant, this research aims to derive occupant behaviour factors. Through a combination of these factors, various types of occupant can be expressed, and insufficient expandability of previous researches can be complemented.

## 2.4 Summary

The previous section (chapter 2.1) had reviewed the constituent factors of egress time. Also limitations of previous researches were identified such as an insufficient expandability and less explanatory power of the effect of disaster information (chapter 2.2). First, this research will consider occupant behaviour to explain the relationship of disaster information and occupant behaviour. To focus on the relationship, the scope of occupant behaviour had been limited to individual behaviours (chapter 2.3). Finally, to complement an insufficient expandability, this research will derive occupant behaviour factors, which can represent a certain occupant through a combination of the factors.

# Chapter 3. Relationship of Disaster Information and Occupant Behaviour

In this chapter, the relationship of disaster information and occupant behaviour is established by following process (Figure 3-1).

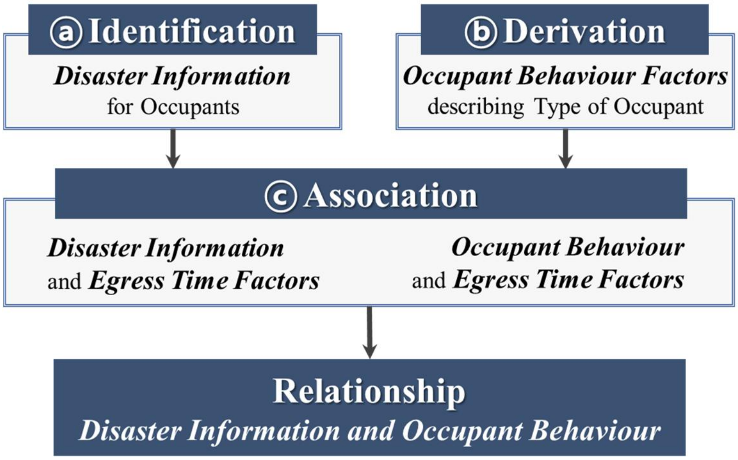


Figure 3-1 Procedure of the Relationship Establishment

First, major disaster information mentioned in previous researches (Figure 3-1 - ⓐ) and occupant behaviour factors that can account for various types of occupant will be identified (Figure 3-1 - ⓑ). After that, each disaster information and egress time factors are going to be associated considering the relation, and so do each occupant behaviour factors (Figure 3-1 - ⓒ). Finally, by organising these associations mentioned above, the relationship of disaster information and occupant behaviour will be established with considerations of egress time.

Based on the relationship, it is possible to confirm which disaster information is needed to reduce egress time in case of a certain type of occupant, which can be represented by a combination of occupant behaviour factors. After establishing the relationship, an experiment to identify general implications about disaster information will be accomplished then the results will be discussed. Finally, the process of disaster information effect on occupant behaviour will be identified by utilizing the relationship.

## 3.1 Identification of Disaster Information

As a result of the literature review of disaster information, this research has been able to identify various disaster information on following Table 3-1, including contents of disaster message suggested by Lamb et al. (2012). Among these, factors that are commonly referred to in previous researches and deemed to be important were [Warning], [Location of Shelter and Exit], [Training], [Information Converting], [Rescue Call] and [Evacuation Aids].

Table 3-1 Common Disaster Information on Literatures

| **Contents of Disaster Message** *(Lamb et al. 2012)* | **Safety Measures** *(Parr 1987)* | **Actions in Disaster Management** *(Sagun et al. 2009)* | **Disaster Information** *(Spence et al. 2007)* |
|---|---|---|---|
| - Evacuation orders given<br>- Impersonal Warning Message<br>- Message Specificity, Certainty and Consistency<br>- Clear Evacuation Instructions<br>- Visual Imagery<br>- Positive Framing of Message | - Convert Information into Proper Form<br>- Evacuation Preparation<br>- Training<br>- Evacuation Aids<br>- Warning Devices | - Pre-training<br>- Raising Public Awareness<br>- Warning<br>- Assignments for Rescue Operations<br>- Rescue | - Evacuation<br>- Shelters<br>- Rescue Operations |

Warning *(Lamb et al. 2012; Parr 1987; Spence et al. 2007)*
Location of Shelter and Exit *(Spence et al. 2007)*, Training *(Parr 1987; Sagun et al. 2009)*
Information Converting *(Lamb et al. 2012; Parr 1987)*
Rescue Call *(Sagun et al. 2009; Spence et al. 2007)*
Evacuation Aids *(Lamb et al. 2012; Parr 1987; Spence et al. 2007)*

Although some of these factors can be derived as disaster information without further considerations since they are disaster information themselves, other factors need more specific classification with rather ambiguous definitions. Compared to [Location of Shelter and Exit] factor for example, which can be derived as disaster information in itself, [Warning] factor is not only disaster information but also a classification that includes more kinds of disaster information, so a specific classification is necessary. Also, [Training] factor is not a form of disaster information in itself, although it is possible to be acquainted with disaster information such as general evacuation know-hows. Therefore, by classifying the factors mentioned above in more detail, 10 major disaster information has been derived as shown in Table 3-2.

First, in the [Warning] factor, this research has derived *#1 - Real Time Forecast of Disasters* and *#7 - Emergency Warning through Portable Device*, and *#2 Location of Shelter and Exit in Facilities* has been derived in the [Location of Shelter and Exit] factor. With the same process, *#3 - General Evacuation Know-how* and *#5 - Instructions of Fire Extinguishing Equipment* from [Training] factor, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light* from [Evacuation Aids] factor, *#6 – Information about Rescue Call* and *#9 - Direct Contact System in Emergency* from [Rescue Call] factor, and *#8 - Information Converting* from [Information Converting] factor have been derived.

Table 3-2 Disaster Information for Occupants

| No. | Disaster Phase | Disaster Information | References |
|---|---|---|---|
| 1 | Before Disaster | Real Time Forecast of Disasters | Warning *(Lamb et al. 2012; Sagun et al. 2009)* |
| 2 | | Location of Shelter and Exit in Facilities | Location of Shelter *(Spence et al. 2007)* |
| 3 | | General Evacuation Know-how | Training *(Parr 1987; Sagun et al. 2009)* |
| 4 | | Instructions of Evacuation Equipment | Evacuation Aids *(Parr 1987; Spence et al. 2007)* |
| 5 | | Instructions of Fire Extinguishing Equipment | Training *(Parr 1987; Sagun et al 2009)* |
| 6 | During Disaster | Information about Rescue Call (How? Where?) | Rescue *(Sagun et al. 2009; Spence et al. 2007)* |
| 7 | | Emergency Warning through Portable Device | Warning *(Parr 1987)* |
| 8 | | Information Converting (Visual Signal, Braille) | Information Converting *(Lamb et al. 2012; Parr 1987)* |
| 9 | | Direct Contact System in Emergency | Rescue *(Sagun et al. 2009; Spence et al. 2007)* |
| 10 | | Direction Guide with Evacuation Guidance Light | Evacuation Aids *(Lamb et al. 2012; Parr 1987; Spence et al. 2007)* |

## 3.2 Derivation of Occupant Behaviour Factors

Through a literature review of occupant behaviour including Sagun et al. (2014), this research has been able to identify various occupant behaviours. Among these, factors commonly referred to previous researches are 'locomotion' which decide the velocity of occupant, 'cognition' which is the ability of occupants to receive external stimulus and make, level of prior knowledge including familiarity with building (hereinafter referred to as familiarity) and 'group behaviour' such as mutual communication between occupants, etc. With the combination of occupant behaviour, a certain type of occupant can be represented.

As the scope of this research was limited to individual behaviours of occupant behaviour since the purpose of this research is investigate the relationship between disaster information and occupant themselves, the corresponding factors like locomotion, cognition and familiarity were derived as Table 3-3, and definitions of these factors were also mentioned.

Table 3-3 Occupant Behaviour Factors

| **Occupant Behaviour Factor** | **Definition** | **References** |
|---|---|---|
| Locomotion | Mobility of occupant on one's own | *Choi et al (2013)*<br>*Proulx (2002)*<br>*Sagun et al. (2014)* |
| Cognition | Cognition of fire outbreak | *Lamb et al. (2012)*<br>*Choi et al. (2013)* |
| Familiarity | Level of knowledge<br>(i.e. prior knowledge, egress route selection) | *Lamb et al. (2012)*<br>*Proulx (2002)*<br>*Sagun et al. (2014)* |

First, locomotion is the most basic factor of occupant behaviour, and to express aspects of the movement of occupant, this research defined locomotion as the mobility of occupant to achieve a certain level of velocity of oneself. Second, to focus to the recognition of disaster outbreak, this research defined cognition as the ability to recognize disaster outbreak using warning alarm and other signs although definition of previous researches was a measure of overall intellectual abilities. Finally, to express the intellectual abilities that could not be accounted for due to the definition of cognition, this research defined familiarity as the level of overall knowledge that occupant currently possess instead of general meanings like the ability to select evacuation route.

## 3.3 Establishment of the Relationship

This research has identified 10 major disaster information and 3 occupant behaviour factors in previous section. In this section subsequently, derived factors of disaster information and occupant behaviour will be associated each other considering egress time factor. Finally the relationship of disaster information and occupant behaviour will be identified by integrating the associations.

### 3.3.1 Association of Disaster Information and Egress Time

The criterion of associating disaster information and egress time factor is whether a particular egress time factor can be reduced using the disaster information. For example, *#1 – Real Time Forecast of Disasters* is able to reduce not response time or travel time but perception time, so *Disaster Information #1* will be associated with a perception time. Also, disaster information like *#8 - Information Converting* can be associated both perception time and response time as reduction of these egress time factors. Following this process, the relationship of disaster information and egress time factors can be identified as Table 3-4.

Table 3-4 Disaster Information with Egress Time Factors

| No. | Disaster Phase | Disaster Information | Egress Time Factor |
|---|---|---|---|
| 1 | Before Disaster | Real Time Forecast of Disasters | 1. Perception Time, $t_p$ |
| 2 | | Location of Shelter and Exit in Facilities | 2. Response Time, $t_r$ |
| 3 | | General Evacuation Know-how | 2. Response Time, $t_r$<br>3. Travel Time, $t_{tl}$ |
| 4 | | Instructions of Evacuation Equipment | 3. Travel Time, $t_{tl}$ |
| 5 | | Instructions of Fire Extinguishing Equipment | 2. Response Time, $t_r$ |
| 6 | During Disaster | Information about Rescue Call (How? Where?) | 1. Perception Time, $t_p$ |
| 7 | | Emergency Warning through Portable Device | 1. Perception Time, $t_p$ |
| 8 | | Information Converting (Visual Signal, Braille) | 1. Perception Time, $t_p$<br>2. Response Time, $t_r$ |
| 9 | | Direct Contact System in Emergency | 1. Perception Time, $t_p$<br>2. Response Time, $t_r$ |
| 10 | | Direction Guide with Evacuation Guidance Light | 3. Travel Time, $t_{tl}$ |

Since perception time is the time spent during recognizing disaster outbreak, disaster information like *#1 - Real Time Forecast of Disasters* that is related to emergency warning was associated with perception time. Especially, *#8 - Information Converting* was also associated, as its importance was highlighted in terms of occupant's effective receiving of disaster information. Second, response time can be reduced through disaster information available during evacuation as it is the time required to prepare evacuation after recognizing disaster. Thus, disaster information like *#2 - Location of Shelter and Exit*, and *#3 - General Evacuation Know-how* was associated. Finally, travel time is the time spent during actual evacuation and it can be reduced by utilizing disaster information like *Disaster Information #3*, as preventing confusion during evacuation. Also *#4 - Instructions of Evacuation Equipment* can reduce travel time by complementing locomotion of occupant and increasing velocity of occupant, so it could be associated with travel time.

### 3.3.2 Association of Occupant Behaviour and Egress Time

Like the associations of disaster information, the criterion of associating occupant behaviour factor to the relevant egress time factor is whether a particular occupant behaviour factor is manifested at a certain egress time. Locomotion of occupant for instance, is manifested in travel time and affects as the main factor for determining the travel time of occupant. As a result, locomotion and travel time can be associated each other. In this way, the association between occupant behaviour factors and egress time factors has been accomplished and the results are as follows:

Table 3-5 Occupant Behaviour with Egress Time Factors

| Occupant Behaviour Factor | Egress Time Factor |
|---|---|
| Locomotion | 3. Travel Time, $t_{tl}$ |
| Cognition | 1. Perception Time, $t_p$ |
| Familiarity | 2. Response Time, $t_r$ |

First of all, locomotion was associated with travel time as in the example above. Second, as the definition of cognition is limited to the recognition of disaster outbreak in this research, cognition was associated with perception time because it is manifested at not response time or travel time but perception time. Finally, familiarity is manifested at response time since this research has defined familiarity as the level of knowledge of occupant including information of evacuation route. Familiarity therefore could be associated with response time.

### 3.3.3 Integration of the Associations

To develop the relationship of disaster information and occupant behaviour, organising the associations of disaster information and occupant behaviour factor should be preceded. And by integrating Table 3-4 and Table 3-5, this research proposed the relationship of disaster information and occupant behaviour considering egress time factors, and the result is as follows:

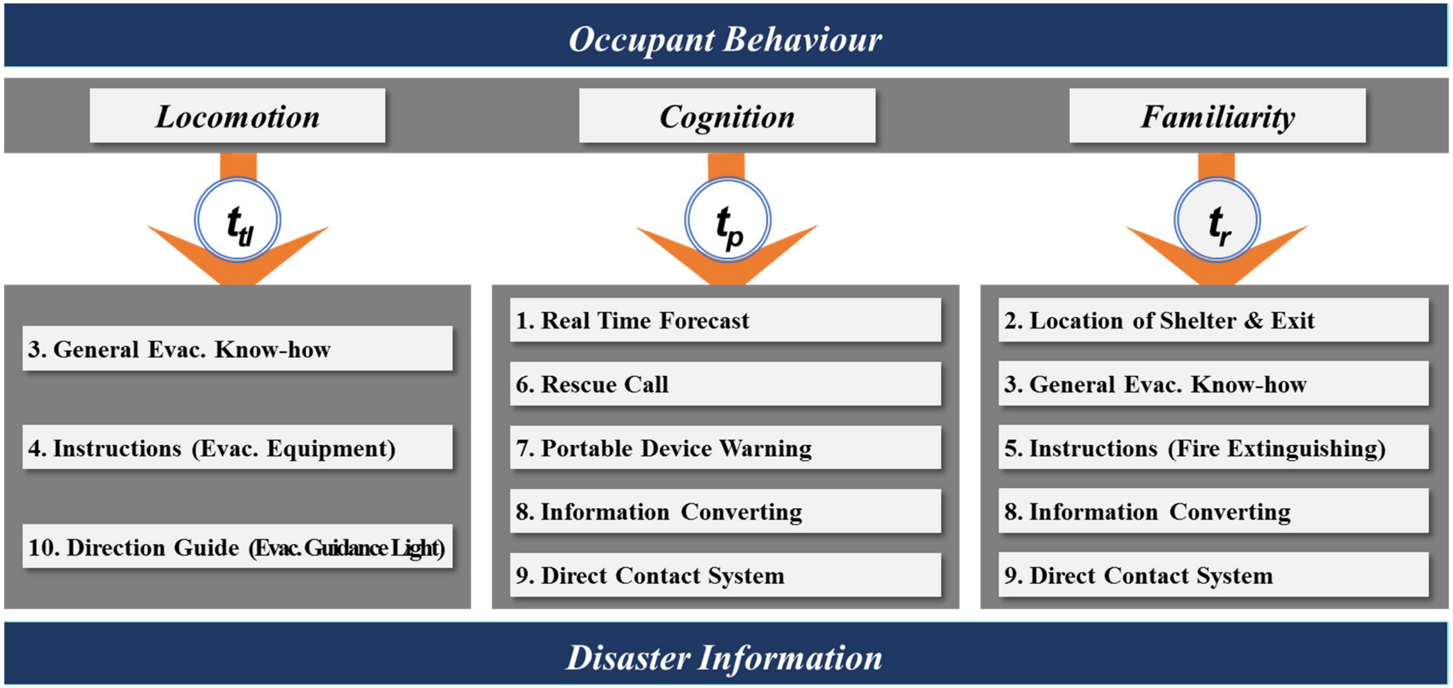


Figure 3-2 Relationship of Disaster Information and Occupant Behaviour

Disaster information related to locomotion is *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light*. And these factors of disaster information have been derived from [Training] and [Evacuation Aids] factors, which were mentioned from previous researches. Also, as the fact that it is possible to reduce travel time through training to inform instructions of evacuation equipment, and utilizing evacuation aids such as evacuation guidance lights (Parr 1987), this result seems to be reasonable.

Likewise, disaster information related to cognition can be derived from [Warning], [Rescue Call] and [Information Converting] factors, which is needed for improving cognition of occupant. This research therefore has associated disaster information from factors mentioned above, *#1 - Real Time Forecast of Disasters*, *#6 - Information about Rescue Call*, *#7 - Emergency Warning through Portable Device*, *#8 - Information Converting* and *#9 - Direct Contact System in Emergency* with cognition and the result also seems to be reasonable.

Finally, disaster information related to familiarity is *#2 - Locations of Shelter and Exit*, *#3 - General Evacuation Know-how*, *#5 - Instructions of Fire Extinguishing Equipment*, *#8 - Information Converting* and *#9 - Direct Contact System in Emergency*, which has been derived from [Location of Shelter and Exit], [Training], [Information Converting] and [Rescue Call] factors. As the level of knowledge can be increased through information of location of shelter or other factors mentioned above (Parr 1987), this result in case of integrating the association of familiarity is appropriate.

## 3.4 Summary

This chapter has been aimed to identify the relationship of disaster information and occupant behaviour in terms of reducing egress time. Therefore, with the procedure of the relationship development (chapter 3.1), previous sections have identified 10 major disaster information (chapter 3.2) and 3 occupant behaviour factors (chapter 3.3). Next, each factors of disaster information and occupant behaviour factors has been associated with related egress time factor (chapter 3.4.1 & 3.4.2), and these associations have been integrated in terms of egress time factor to complete the identification of the relationship (chapter 3.4.3). As a result, this research has proposed the relationship of disaster information and occupant behaviour, with 3 disaster information (*#3*, *#4* and *#10*) related to locomotion, 5 disaster information (*#1*, *#6*, *#7*, *#8* and *#9*) related to cognition and 5 disaster information (*#2*, *#3*, *#5*, *#8* and *#9*) related to familiarity.

# Chapter 4. Experiment and Validation

The relationship of disaster information and occupant behaviour was developed in the previous chapter. To validate the relationship, a plan for the virtual experiment about identifying effective disaster information for reducing egress time of occupant will be proposed in this chapter. Surveys therefore will be conducted to collect quantitative data for the experiment.

## 4.1 Experimental Design

The purpose of this experiment is to identify the disaster information needed to effectively reduce the egress time of occupant when complementing the occupant behaviour in a virtual situation. By applying experiment results to the relationship proposed in previous chapter (chapter 3), it is possible to identify the most effective disaster information to reduce egress time.

For the quantitative analysis of this experiment, quantification of the occupant behaviour factor to be used in the experiment and the experimental plan will be explained in this section.

### 4.1.1 Level of Occupant Behaviour Factors

Unlike previous researches, the relationship developed in this research can be applicable to various types of occupant. To represent the occupant in detail, two levels of occupant behaviour factor were suggested in Table 4-1.

Table 4-1 Level of Occupant Behaviour Factors

| Occupant Behaviour Factor | Level |
|---|---|
| Locomotion | 1. Default (on one's own) |
| | 2. With instructions of equipment |
| Cognition | 1. Default (on one's own) |
| | 2. With warning alarm |
| Familiarity | 1. Default (on one's own) |
| | 2. With disaster information |

Two levels of occupant behaviour factor are proposed: (1) a default status without assistance of disaster information (hereinafter referred to as default status); (2) an assisted status with assistance of a related disaster information like instructions of equipment (hereinafter referred to as assisted status). As default status represents a status of no other assistance, this status can be used to a basic representation of occupant. On the other hand, assisted status can account for the effectiveness of disaster information receiving and utilizing as it is regarded as a status with assistance of disaster information.

Then by quantifying the level of occupant behaviour factor, the degree of the factor (i.e. over/under 50 in 100-point scale) can be figured out, and a certain type of occupant can be represented by a combination of the degree of occupant behaviour factors at default status. For instance, a person with simple intellectual disability, which means no other disabilities exist, has relatively high locomotion because of a certain level of ability to move oneself. Cognition and familiarity however are relatively low as there are obstacles to the recognition of disaster outbreak and the utilization of disaster information due to lack of intellectual abilities. Using the factors of this research, 8 cases of combination and corresponding types of occupant can be derived as Table 4-2.

Table 4-2 Combination of Occupant Behaviour Factors

| Locomotion | Cognition | Familiarity | Type of Occupant |
|---|---|---|---|
| Over 50 in 100-point scale | Over 50 in 100-point scale | Over 50 in 100-point scale | General Public |
| | | Under 50 in 100-point scale | The Hearing Impaired |
| | Under 50 in 100-point scale | Over 50 in 100-point scale | Adolescent (Age under 13) |
| | | Under 50 in 100-point scale | The Intellectual Impaired |
| Under 50 in 100-point scale | Over 50 in 100-point scale | Over 50 in 100-point scale | The Physical Impaired |
| | | Under 50 in 100-point scale | The Visually Impaired |
| | Under 50 in 100-point scale | Over 50 in 100-point scale | Patient (Accommodation) |
| | | Under 50 in 100-point scale | Elderly<br>The Visually Impaired |

As mentioned above, quantification the level of occupant behaviour factor should be preceded to determine the degree of the factor. Thus surveys for the quantification are needed, and the surveys should be targeted to 8 combinations classified in Table 4-2. However, as the difference in occupant behaviour among individuals in the general public or an adolescent (age under 13) is significant, an unspecified individual from these types of occupant have difficulties representing their own type. This causes to obtain consistent experiment results difficult, so the validity of the results cannot be secured. On the other hand, since the elderly and the disabled in related facilities have severe symptoms, different types of occupant are more clearly distinguished and the difference in occupant behaviour among individuals in the same type is small. That is to say, even if an unspecified individual from a certain type is extracted, it can represent the type of occupant. Especially in general cases, the elderly is uncooperative to accommodate new disaster information and improve the level of knowledge (Chung et al. 2008). Also the same tendency applies to the disabled who live in welfare facilities (Parr 1987), so both cases are deemed to have low familiarity. The target of this experiment and surveys therefore was set as follows: the elderly, the intellectual, the hearing and the visually impaired in the related welfare facilities, who has a tendency of low familiarity.

### 4.1.2 Procedure of Experiment

In order to precede the experiment, numerical values (i.e. distance of the evacuation route, walking speed) related to evacuation of the general public is needed. First, the distance of the evacuation route to be used for the virtual experiment was set to 100m. Then the travel time of the general public can be calculated as their average walking speed is 0.7m/s (You et al. 2003). Also, the available cognition time is set to 120 seconds, which is the average time required for the warning alarm to operate after fire outbreak (Zhang et al. 2014). Finally, considering that the travel time is 1/3 of the total egress time (Shen 2003: requoted in Sagun el al. 2014), it is able to calculate the total egress time and response time. The numerical values were organised as following Table 4-3.

Table 4-3 Numerical Values from Evacuation of the General Public

| **Variables** | **Value (Unit)** | **Note** |
|---|---|---|
| Distance of the Evacuation Route | 100 (m) | - |
| Velocity | 0.7 (m/s)* | *Average walking speed of the general public* |
| Travel Time, $t_{tl}$ | 142.86 (s) | $\frac{Distance\ of\ the\ Evac.Route}{Velocity}$ |
| Perception Time, $t_p$ | 120.00 (s)** | *Average Operation Time of Warning Alarm* |
| Total Egress Time | 428.58 (s) | $Travel\ Time \times 3$ |
| Response Time, $t_r$ | 165.72 (s) | $Total\ Egress\ Time - (t_p + t_{tl})$ |

*adopted from You et al. (2003)
**adopted from Zhang et al. (2014)

Using values on Table 4-3 and quantified occupant behaviour factors through surveys, total egress time and each perception time, response time and travel time of default status, which has no assistance from disaster information, can be calculated. Also, by using occupant behaviour factors of assisted status which is assisted by disaster information, each case of total egress time when locomotion, cognition and familiarity are complemented by disaster information can be calculated. Thereafter, occupant behaviour factor that can reduce total egress time most effectively can be identified by comparing the total egress time of default status and assisted status. And it is also possible to identify disaster information which can complement the factor by referring the relationship of disaster information and occupant behaviour developed in this research. Finally, the validity of the relationship will be verified by comparing disaster information identified from the experiment and required for occupant in actual building fire situations. In order to collect the data of required disaster information for occupant, additional questionnaire is needed.

The experiment process is illustrated in Figure 4-1.

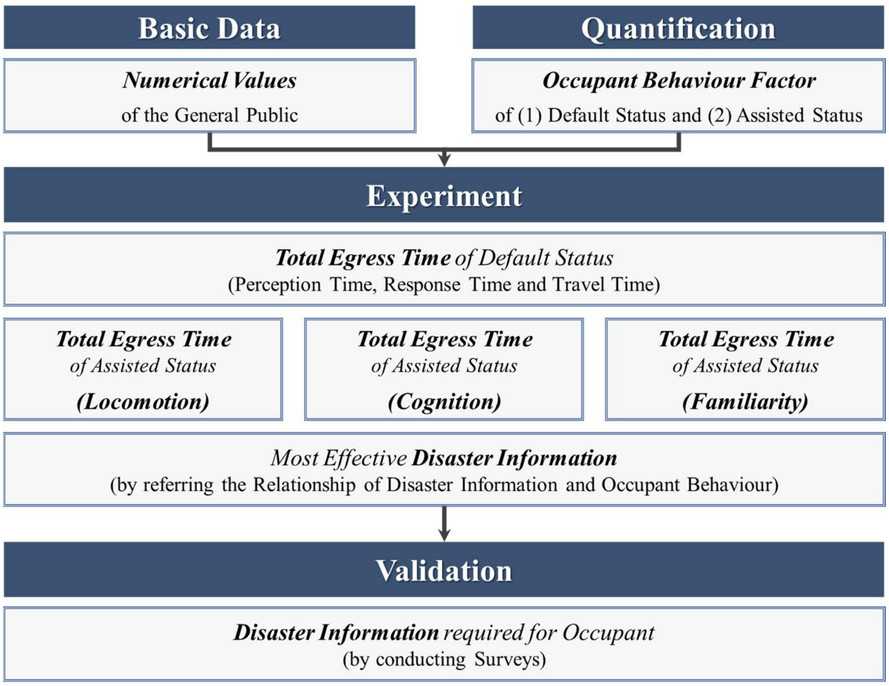


Figure 4-1 Experiment Process

## 4.2 Surveys for Data Collection

As mentioned in previous section, surveys for quantifying occupant behaviour factors and identifying disaster information required for occupants to validate the result is needed. In this section, therefore, surveys with two questionnaires are going to be accomplished.

Survey target was set as the elderly, the intellectual, the hearing and the visually impaired in the related welfare facilities, which have a low familiarity. However, if the questionnaires are answered by the targeted people themselves, the reliability of survey results cannot be ensured due to insufficient intellectual abilities of the respondent. Therefore, by referring an alternative method which is used in related researches, survey questionnaires are going to be answered by staffs of related facilities. This research conducted surveys with 173 facility staffs and social workers, and detailed description can be found in [Appendix A-1].

### 4.2.1 Quantification of Occupant Behaviour Factors

This questionnaire aims to quantify two levels; (1) default status and (2) assisted status of occupant behaviour factor. In order to make it easier to judge the degree of the level of occupant behaviour factor, the level in this questionnaire is evaluated at intervals of 10 points in the range of 100 points (same as the general public) and 0 point (cannot be performed). Then by using the average value of the results, it is possible to quantify the occupant behaviour factors. Generally, factors of assisted status will be evaluated higher than those of default status. However there are possibilities for the contrary results due to the reasons like increased receiving and processing time of disaster information caused by overloaded disaster information (Yates et al. 2011). The result of quantification is as follows:

Table 4-4 Quantification Results - Occupant Behaviour Factors

| Type of Occupant | Occupant Behaviour Factor | Default Status | Assisted Status (Ratio) |
|---|---|---|---|
| Elderly | Locomotion | 19.6 | 25.3 (1.291) |
| | Cognition | 23.2 | 25.1 (1.082) |
| | Familiarity | 17.8 | 21.2 (1.191) |
| The Intellectual Impaired | Locomotion | 44.2 | 57.9 (1.310) |
| | Cognition | 27.5 | 32.5 (1.182) |
| | Familiarity | 19.2 | 25.0 (1.302) |
| The Hearing & Language Impaired | Locomotion | 62.1 | 66.6 (1.072) |
| | Cognition | 43.8 | 46.8 (1.068) |
| | Familiarity | 47.9 | 36.2 (0.756) |
| The Visually Impaired | Locomotion | 32.5 | 44.8 (1.378) |
| | Cognition | 41.7 | 65.2 (1.564) |
| | Familiarity | 40.0 | 55.2 (1.380) |

***Elderly***

According to Table 4-4, each locomotion, cognition and familiarity at default status were identified as 19.6, 23.2 and 17.8, lower than 50. This result agrees with classification of the elderly proposed in Table 4-2, the result therefore can be regarded as valid.

***The Intellectual Impaired***

There is a difference from the previous classification in Table 4-2, as occupant behaviour factors at default status were identified lower than 50. However, since the identified locomotion at default status was evaluated as 44.2, approximate to 50; and the locomotion at assisted status was increased by 31% to 57.9, the result seems to be reasonable.

***The Hearing and Language Impaired***

As each locomotion, cognition and familiarity at default status were identified as 62.1, 43.8, 47.9, factors except cognition agree with previous classification in Table 4-2. Cognition is also approximate to 50, so this result seems to be reasonable.

***The Visually Impaired***

Identified occupant behaviour factors at default status were all under 50, and this result agrees with classification of the visually impaired in Table 4-2. Therefore the result can be regarded as valid.

### 4.2.2 Questionnaire for Validation

To validate the relationship proposed in this research, this questionnaire aims to identify disaster information required for occupants in building fire. In detail, among 10 major disaster information proposed in this research, the disaster information needed for each type of occupant will be surveyed and evaluated on a 5-point scale. Then, by using the average value of the survey results, it is possible to derive the top-three disaster information, which represents the most needed. Finally, by comparing the top-three disaster information with the experiment result, the relationship will be validated. Through this procedure, the validity of the process of disaster information effect which is the objective of this research can also be secured.

Survey result of this questionnaire is shown in Table 4-5. First, disaster information required to the elderly was identified as *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light*. Second, disaster information required for the intellectual impaired was identified as *#2 - Location of Shelter and Exit in Facilities*, *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light*. Third, disaster information required for the hearing and language impaired was identified as *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#7 - Emergency Warning through Portable Device*. Finally, disaster information required for the visually impaired was identified as *#2 - Location of Shelter and Exit in Facilities*, *#8 - Information Converting*, *#9 - Direct Contact System in Emergency* and *#10 - Direction Guide with Evacuation Guidance Light*.

Table 4-5 Survey Results - Disaster Information for Occupants

| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|
| Elderly | 3.69 | 4.44 | **4.53** | **4.61** | 4.18 | 3.99 | 3.95 | 3.63 | 4.38 | **4.51** |
| The Intellectual Impaired | 4.00 | **4.17** | **4.46** | **4.46** | 3.88 | 3.92 | 3.96 | 3.50 | 3.88 | **4.17** |
| The Hearing & Language Impaired | 3.71 | 4.20 | **4.23** | **4.37** | 3.66 | 4.14 | **4.34** | 3.66 | 4.03 | 4.11 |
| The Visually Impaired | 3.97 | **4.59** | 4.24 | 4.48 | 4.34 | 3.97 | 4.29 | **4.69** | **4.59** | **4.59** |

## 4.3 Experiment Results and Validation

In this section, experiment for validating the relationship of disaster information and occupant behaviour has been conducted, in cases of the elderly, the intellectual impaired, the hearing and language impaired and the visually impaired. Experiment result and validity of this research will be given as follows:

### 4.3.1 Case I: Elderly

In the case of the elderly, disaster information to complement locomotion was found to be the most effective in reducing total egress time, which is reduced by 7.51%, compared with complementing others (Figure 4-2). And by applying the result to the relationship of disaster information and occupant behaviour, disaster information related to locomotion such as *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light* can be identified to effectively reduce the total egress time.

Also, from the survey result in Table 4-5, the disaster information in building fires situations that is required for the elderly has been identified as *Disaster Information #3* (4.53), *Disaster Information #4* (4.61) and *Disaster Information #10* (4.51). This group of disaster information agrees with the experiment result, the validity of the relationship therefore can be verified in the case of the elderly.

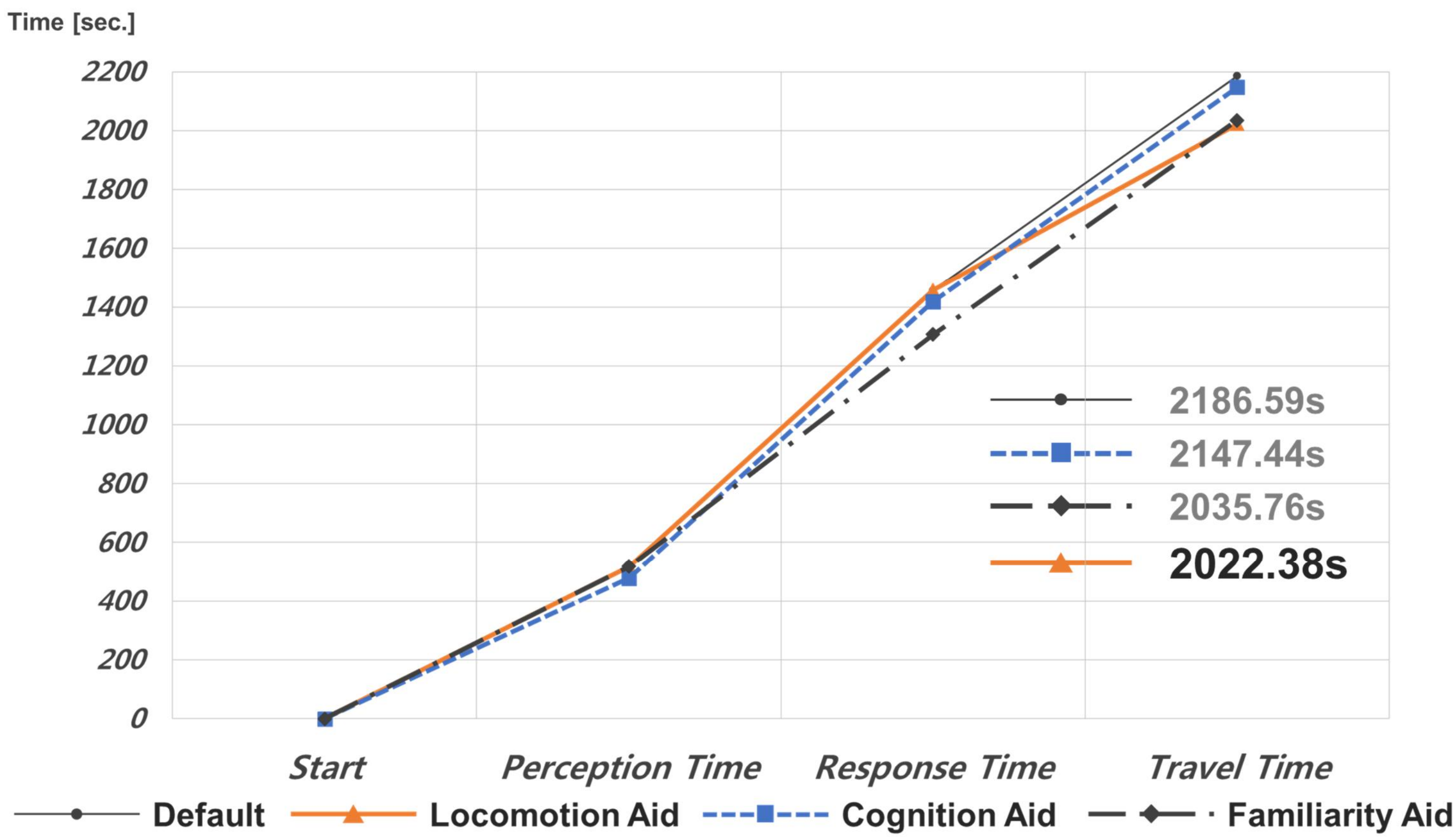


Figure 4-2 Experiment Result - Elderly

### 4.3.2 Case II: The Intellectual Impaired

In the case of the intellectual impaired, disaster information to complement locomotion was also found to be the most effective in reducing total egress time, which is reduced by 7.89%, compared with complementing others (Figure 4-3). And by applying the result to the relationship proposed in previous chapter (chapter 3), disaster information like *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light* can be identified to effectively reduce the total egress time.

Meanwhile, the disaster information in building fires situations that is required for the intellectual impaired has been identified as *Disaster Information #2* (4.17), *Disaster Information #3* (4.46), *Disaster Information #4* (4.46) and *Disaster Information #10* (4.17) from Table 4-5. This group of disaster information includes the disaster information from the experiment result, so it is deemed to agree with the experiment result. And the validity of the relationship can also be verified in the case of the intellectual impaired.

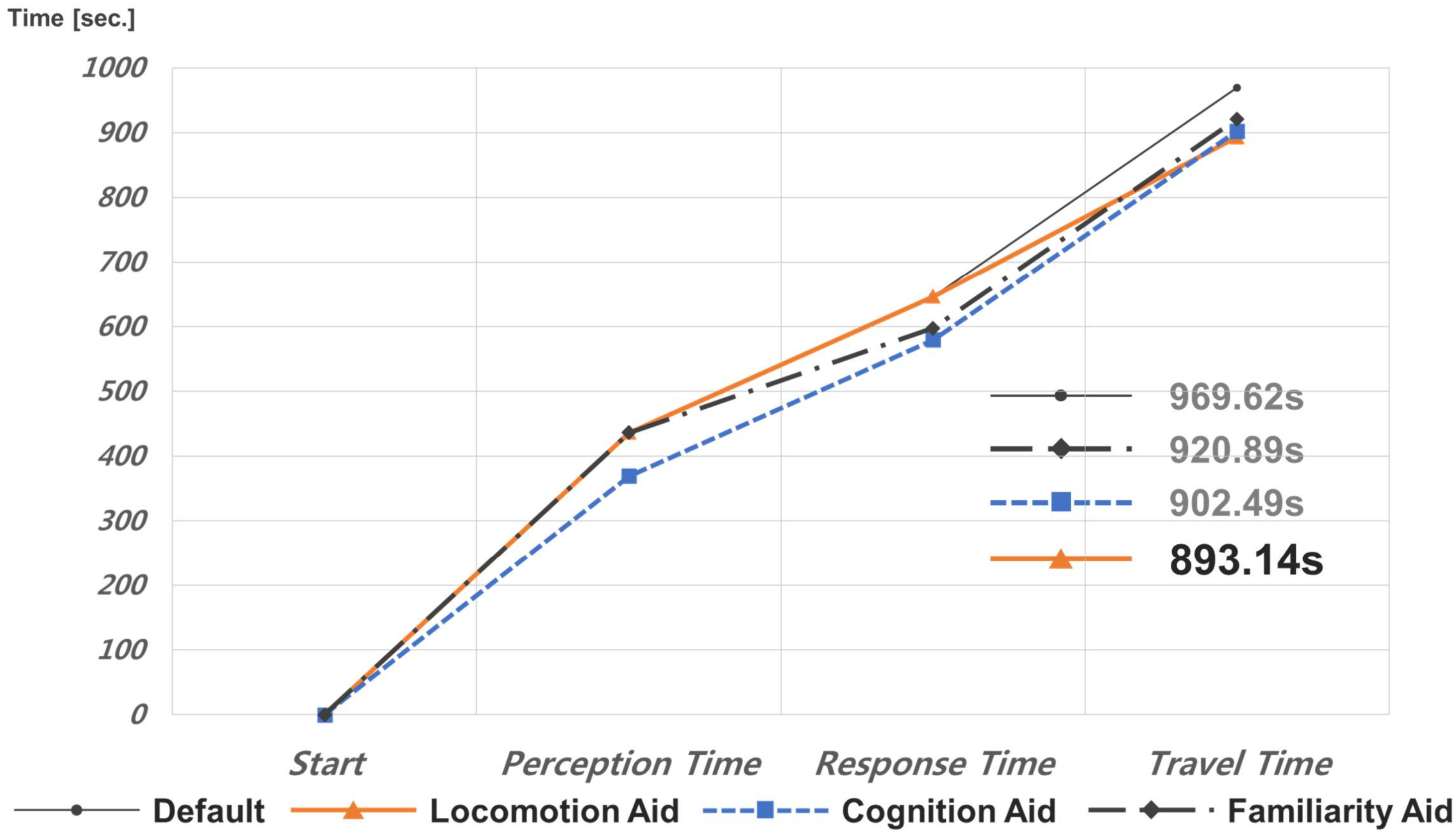


Figure 4-3 Experiment Result - The Intellectual Impaired

### 4.3.3 Case III: The Hearing & Language Impaired

In the case of the hearing and language impaired, disaster information for cognition was found to be the most effective in reducing total egress time, which is reduced by 2.54%, compared with complementing others (Figure 4-4). Also, assisting locomotion is able to reduce total egress time effectively (2.25%), with an increment of 0.29%. And by applying the result to the relationship in previous chapter (chapter 3), disaster information related to cognition such as *#1 - Real Time Forecast of Disasters*, *#6 - Information about Rescue Call*, *#7 - Emergency Warning through Portable Device*, *#8 - Information Converting* and *#9 - Direct Contact System in Emergency*, and locomotion such as *#3 - General Evacuation Know-how*, *#4 - Instructions of Evacuation Equipment* and *#10 - Direction Guide with Evacuation Guidance Light* can be identified to effectively reduce the total egress time.

Also, from the survey result in Table 4-5, the disaster information that is required for the hearing & language impaired in building fire situations has been identified as *Disaster Information #3* (4.23), *Disaster Information #4* (4.37) and *Disaster Information #7* (4.34). This group of disaster information is included in the experiment result, so it is also deemed to agree with the experiment result. Thus the validity of the experiment result using the relationship can be verified in the case of the hearing and language impaired.

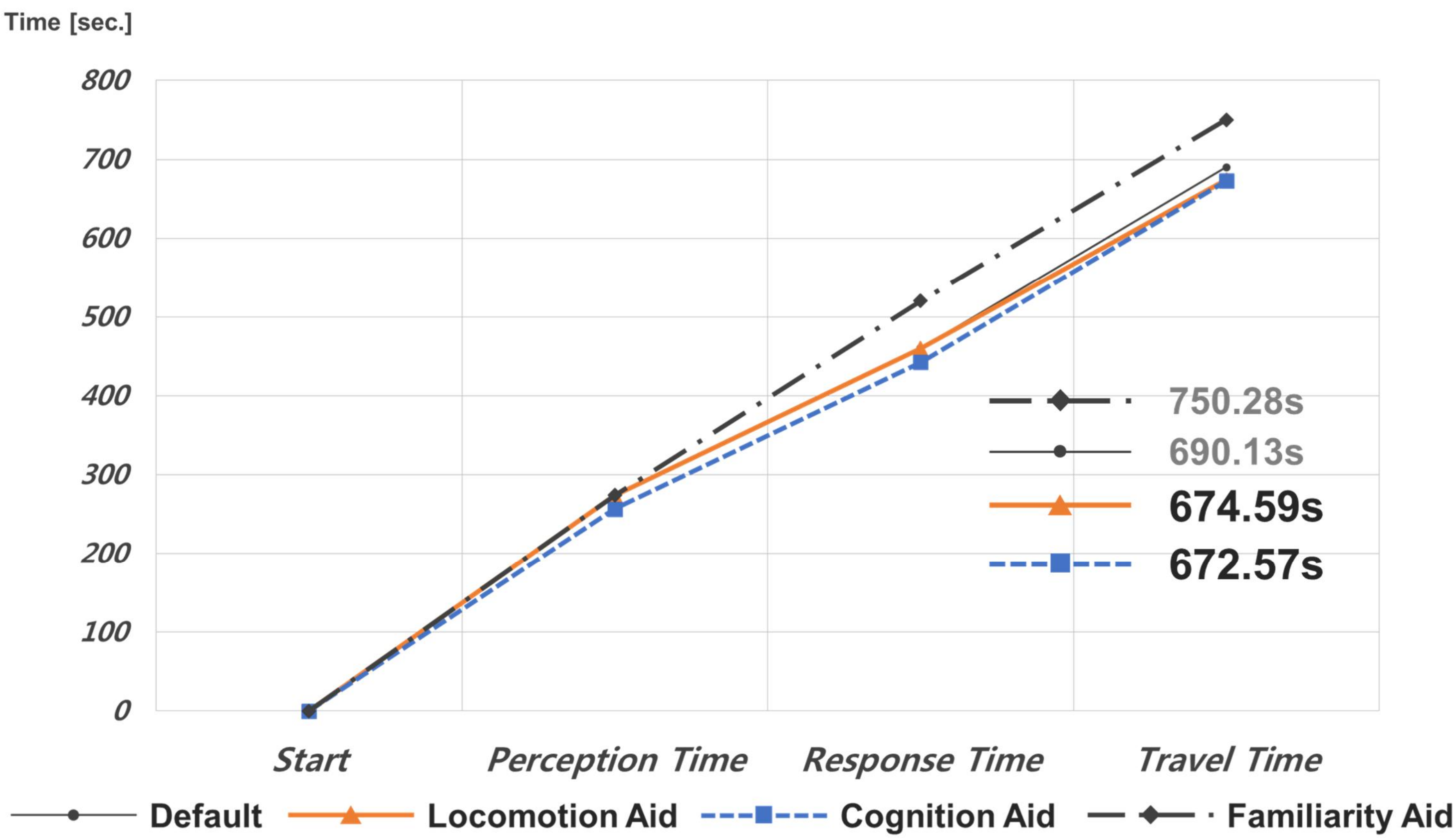


Figure 4-4 Experiment Result - The Hearing & Language Impaired

### 4.3.4 Case IV: The Visually Impaired

Finally, in the case of the visually impaired, disaster information for familiarity was found to be the most effective in reducing total egress time, which is reduced by 12.35%, compared with complementing others (Figure 4-5). And by applying the result to the relationship in previous chapter (chapter 3), disaster information related to familiarity such as *#2 - Locations of Shelter and Exit*, *#3 - General Evacuation Know-how*, *#5 - Instructions of Fire Extinguishing Equipment*, *#8 - Information Converting* and *#9 - Direct Contact System in Emergency* can be identified to effectively reduce the total egress time of the visually impaired.

Meanwhile, from the survey result in Table 4-5, the disaster information that is required for the visually impaired has been identified as *Disaster Information #2* (4.59), *Disaster Information #8* (4.69), *Disaster Information #9* (4.59) and *Disaster Information #10* (4.59). Among the identified disaster information, 3 disaster information except *Disaster Information #10*, which stand for 75% of the survey result, agrees with the experiment result. So the validity of the experiment result based on the relationship can be verified in the case of the visually impaired, but additional analysis on this error is required.

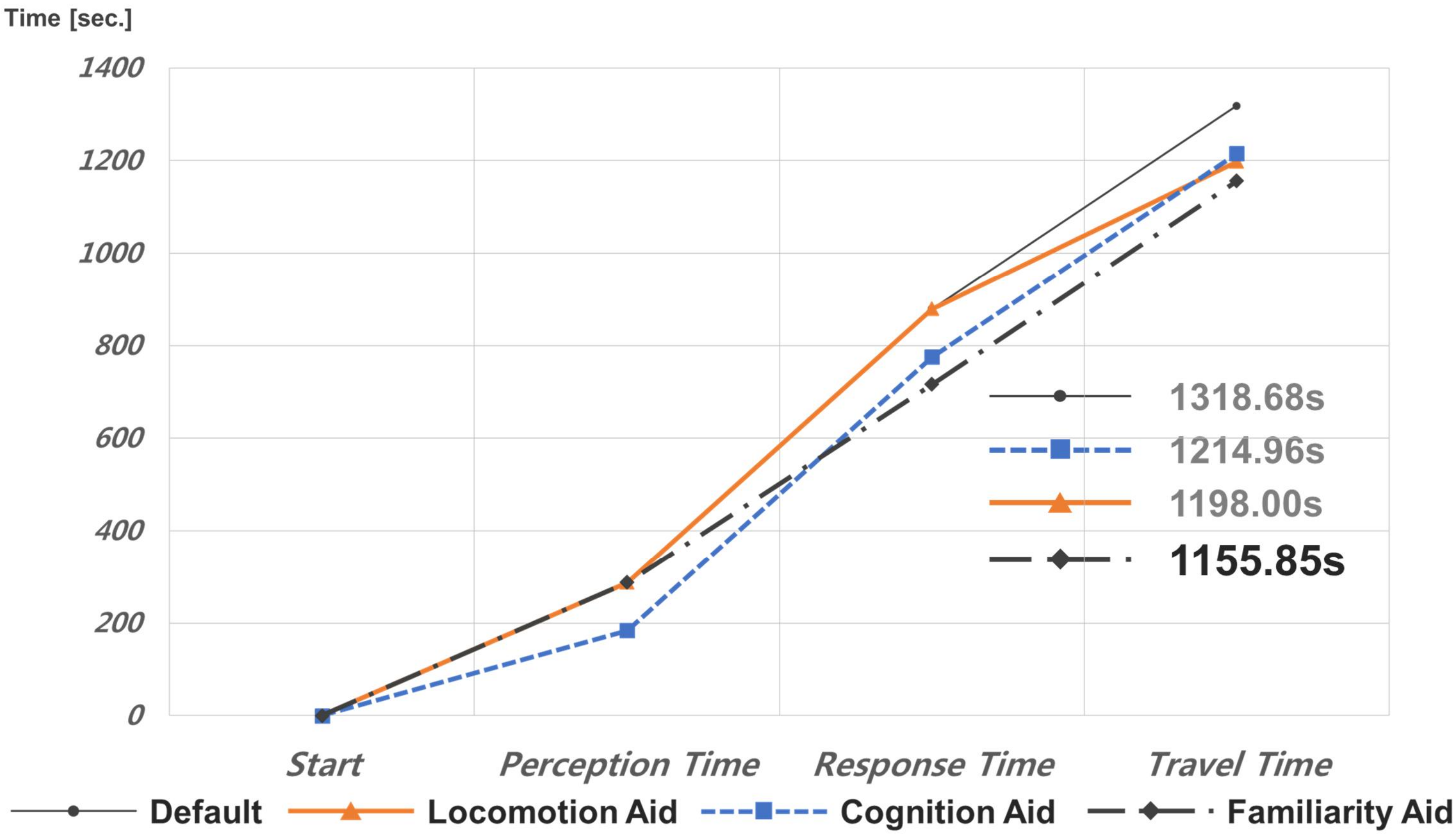


Figure 4-5 Experiment Result - The Visually Impaired

## 4.4 Summary

This chapter has been aimed to conduct an experiment using the relationship of disaster information and occupant behaviour and validate the results. With these purposes, a virtual experiment to identify the disaster information that can effectively reduce total egress time for each targeted type of occupant (elderly, the intellectual, the hearing and language and the visually impaired) has been designed (chapter 4.1). And factors required for the experiment were organised such as (1) quantified occupant behaviour factors and (2) disaster information required for occupants. Subsequently, data, which correspond with the required factors mentioned above, were collected by surveys (chapter 4.2). Finally, using the collected data, this research conducted the experiment and results are as follows:

(1) *Elderly*: Disaster information for locomotion (#*3*, #*4* and #*10*) is effective, and the required disaster information required is also #*3*, #*4* and #*10*.

(2) *The Intellectual Impaired*: Disaster information for locomotion (#*3*, #*4*, and #*10*) is effective, and the required disaster information is #*2*, #*3*, #*4* and #*10*.

(3) *The Hearing and Language Impaired*: Disaster information for cognition (#*1*, #*6*, #*7*, #*8* and #*9*) and locomotion (#*3*, #*4* and #*10*) is effective, and the required disaster information is #*3*, #*4* and #*7*.

(4) *The Visually Impaired*: Disaster information for familiarity (#2, #3, #5, #8 and #9) is effective, and disaster information required for the elderly is also #2, #8, #9 and #10.

The validity of the proposed relationship has been verified for all 4 cases of the elderly, the intellectual, hearing and language and visually impaired. However, in the case of the visually impaired, additional analysis on the error is required as the validation result agrees as 75%.

# Chapter 5. Process of Disaster Information Effect

In previous chapter, experiment designed to investigate disaster information that can reduce egress time effectively was conducted. Thereafter the validity of the relationship of disaster information and occupant behaviour has been verified in 4 types of occupant: elderly; the intellectual impaired; the hearing and language impaired; the visually impaired. Furthermore to consider the error in the case of the visually impaired, further analysis on the experiment result is needed.

This chapter discusses the experiment result to figure out findings about the process of disaster information effect. Then by organising the findings, the effect of disaster information on occupant behaviour, the main objective of this research, will be suggested.

## 5.1 Discussions

Through previous experiment, this research was able to identify the disaster information that can most effectively reduce egress time of the targeted types of occupant. Also, a specific occupant behaviour factor which was affected by identified disaster information can be found. In this section, for further analysis to find more general findings about the process of disaster information effect, these results of each cases will be discussed based on the relationship of disaster information and occupant behaviour.

### 5.1.1 Case I: Elderly

According to the experiment result shown in the previous chapter (chapter 4), locomotion affects the most to total egress time of the elderly. The reason why the disaster information that can assist the elderly with locomotion is most effective is as follows:

As their every occupant behaviour factors like locomotion have been reduced, the elderly has difficulty performing all actions related to evacuation. Therefore, disaster information for the elderly affects the process of improving insufficient occupant behaviour to achieve the minimum level for safety. In this perspective, reducing travel time, which may be more directly at risk due to situations such as exposure to toxic gases from the fire is deemed as the most effective way to obtain safety of the elderly (Eldar 1992). In other words, by referring the relationship of disaster information and occupant behaviour, locomotion which is related to travel time should be complemented, and this process seems to be the reason of the result mentioned above.

### 5.1.2 Case II: The Intellectual Impaired

According to the experiment result shown in the previous chapter (chapter 4), locomotion has affected the most to total egress time of the intellectual impaired, same result as the case of the elderly. However, despite the result of both cases are same, the process of disaster information affecting locomotion is described differently, and the reason is as follows:

As can be seen in the preceding Table 4-4, the intellectual impaired has relatively high locomotion, although cognition and familiarity are insufficient due to declined intellectual abilities. So their process of disaster information effect on locomotion can be described as maximizing relatively high locomotion to ensure enough safety. Compared with the elderly, as the process is described as complementing insufficient locomotion to ensure the minimum level for safety, the difference between processes can be found. That is to say, although same disaster information is needed to complement same occupant behaviour, the process of disaster information affecting occupant behaviour can be different: (1) complementing insufficient occupant behaviour to ensure the minimum level of safety; (2) maximizing relatively high occupant behaviour to ensure enough level of safety. And the process of a certain type of occupant can be figured out by referring quantified occupant behaviour factor based on the relationship in chapter 3.

### 5.1.3 Case III: The Hearing & Language Impaired

In the case of the hearing and language impaired, one thing should be focused on is that the disaster information needed for them is 8 kinds related to both cognition and locomotion. The reason why many disaster information, 80% of those proposed in this research, has been identified as follows:

First, as locomotion of the hearing and language impaired is relatively high by referring Table 4-4, it has been maximized by related disaster information to ensure enough safety. In case of cognition however, which is insufficient (Table 4-4), related disaster information should have ensured the minimum safety of occupant by complementing cognition. However, identified data of cognition may refer not actual insufficiency but difficulties to receive disaster information in terms of the form of disaster information. It is because of the majority of disaster information is based on auditory stimulus that cannot be received effectively to the hearing and language impaired. As can be seen in Table 4-5, *Disaster Information #7*, which is non-audio-based, is one of the most required disaster information for the hearing and language impaired. Therefore, disaster information in an appropriate form to be accommodated affects the status of cognition, from insufficient factor that is to be complemented to the factor of relatively high level that is to be maximized. By this change of cognition, disaster information for cognition will effectively reduce total egress time.

To sum up, the hearing and language impaired requires both disaster information for locomotion and disaster information for cognition. And this is deemed as the reason of the result mentioned above.

### 5.1.4 Case IV: The Visually Impaired

Unlike other cases, an error of validation (1 disaster information among four of them; 25%) occurred in the case of the visually impaired and further analysis is needed as mentioned above. To consider the error, we focus on the result that disaster information related to familiarity is the most effective for the visually impaired, and then the findings will be discussed.

First, since the visually impaired can accommodate audio based disaster information, both cognition and familiarity at assisted status are identified to be high. Also, although locomotion at default status is identified to be low due to insufficient visual acuity, the assisted status is identified to be high.

In this situation, the visually impaired utilizes disaster information in two ways as follows: (1) maximize both cognition and familiarity; (2) complement insufficient locomotion. Compared with maximizing cognition which only causes a decrease in perception time, maximizing familiarity affects the process of preparing evacuation to be assisted. And as the assisted process causes not only a decrease in response time but also preventing confusion during evacuation through proper evacuation route selection, this process can also affect travel time (Sagun et al. 2014). Therefore, assisting familiarity, which could also reduce travel time, is the most effective way to reduce total egress time, and the reason why disaster information for familiarity is the most effective to the visually impaired can be explained.

Based on the discussions above, the error of validation can be explained. In this research, familiarity has been defined as the level of overall knowledge that occupant currently possess. Thus, disaster information like *#3 - General Evacuation Know-how* can be utilized not only at the preparation of evacuation but also at actual evacuation, as illustrated in Figure 3-2. However, the relationship of disaster information and occupant behaviour only has the association between familiarity and response time, not considering travel time. Thus there is difficulty explaining the phenomenon mentioned above, and if the definition of familiarity is developed with a more specific classification of knowledge, more realistic explanation would be possible.

## 5.2 Effect of Disaster Information on Occupants

In previous section, experiment results have been discussed based on the relationship of disaster information and occupant behaviour. In four cases including the elderly, general findings about the effect of disaster information has been identified. And by organising the findings, qualitative implications about the process of disaster information affecting occupant behaviour can be suggested as follows:

One of the first the process is (1) complementing insufficient occupant behaviour to ensure the minimum level of safety (hereinafter referred to as complementing process). This process can be identified in cases of all three occupants behaviour factors of the elderly; and locomotion of the visually impaired. Another process is (2) maximizing relatively high occupant behaviour to ensure enough level of safety (hereinafter referred to as maximizing process). The maximizing process can be identified in cases of locomotion of the intellectual impaired; locomotion and cognition (on condition of non-audio-based disaster information) of the hearing and language impaired; and cognition and familiarity of the visually impaired.

Among these two processes, manifestation of the process on a certain occupant behaviour factor can be predicted by referring the quantified occupant behaviour factors of the relationship (chapter 4). For example, maximizing process for cognition will be manifested to an occupant with relatively high cognition. However, the priority of these processes, which means the order of manifestation when both processes can be manifested to the occupant, cannot be found in this research. As this implication seems to be important when to manage the most effective disaster information for each types of occupant by considering the effect of disaster information, further research with this implication is needed.

## 5.3 Summary

This chapter has been aimed to discuss the experiment result to identify the process of disaster information effect. First experiment results of each cases have been discussed to find out the general findings of the effect of disaster information to occupant behaviour (chapter 5.1). Then by organising the findings, implications which account for the process of disaster information affecting occupant behaviour have been identified (chapter 5.2).

First, two processes of disaster information affecting occupant behaviour have been identified as follows: complementing process; and maximizing process. Second, manifestation of these processes can be predicted by referring quantified occupant behaviour factors of the relationship proposed in this research, but the priority of the process cannot be found. These implications are deemed as important when managing disaster information properly, so further researches to account for this implication are needed.

# Chapter 6. Conclusion

In building fire situations, existing efforts to reduce egress time of occupant proceeded to reduce travel time, and considerations to reduce perception time and response time were relatively inadequate. In addition, situations in which the safety of occupants could not be secured only by the reduction of travel time occurred. To solve this problem, disaster information which can decrease both perception time and response time has become a significant keyword. From this point of view, this research has aimed to investigate the process of disaster information effect on occupant behaviour, based on the relationship disaster information and occupant behaviour.

This chapter first summarizes the results of this research, and suggests the possible contributions for disaster information management in building fire situation. A direction for further researches then is proposed based on limitations of this research.

## 6.1 Research Summary

As mentioned above, this research first has identified the relationship of disaster information and occupant behaviour in terms of reducing egress time of occupant. Then, experiments for validating the identified relationship have been conducted with surveys and general findings about the effect of disaster information have been discussed with experiment results. As a result, the processes of disaster information affecting occupant behaviour have been explained in two cases. Specific results of this research have been summarized as follows:

(1) Among disaster information during the phases of ‘Before Outbreak’, ‘Fire Outbreak’, and ‘During Fire’, this research have identified 10 major disaster information including real time forecast of disasters, and also identified 3 occupant behaviours like locomotion, cognition and familiarity. Then, by considering the association between derived factors and egress time, this research have developed the relationship of disaster information and occupant behaviour with 3 disaster information related to locomotion, 5 disaster information related to cognition and 5 disaster information related to familiarity.

(2) To validate the identified relationship, experiments based on surveys have been conducted, and the validity of this research was confirmed for 4 types of occupant; elderly, the intellectual impaired, the hearing & language impaired and the visual impaired, the representative types of occupant that can be expressed using the occupant behaviour factor of this research.

(3) Finally, by analyzing each result, the process of disaster information effect on occupant behaviour has been proposed as: ensuring safety by complementing vulnerable occupant behaviour to minimum level for safety; by maximizing relatively high occupant behaviour to enough level for safety.

## 6.2 Contributions

In building fire situations, occupants need disaster information to ensure their safety. Unlike previous researches which described relationship of disaster information and occupant behaviour in intuitive perspective, this research first has added explanatory power to the relationship of disaster information and occupant behaviour with the concept of egress time. In other words, applying the research concept of this research such as developing an advanced relationship of disaster information would be possible. For example, adding more disaster information or distinguishing occupant behaviours; and explaining the relationship of disaster information and occupant behaviour with other associations like information flow through disaster manager or broadcasting equipment would provide advanced understandings of disaster information.

Also, in regards to the process of disaster information effect which was identified from this research, it can be used as a basic reference for analysis of disaster information and occupant behaviour for effective disaster information management. As the importance of disaster information is magnified, appropriate distribution of disaster information considering needs from occupant would be possible.

## 6.3 Future Researches

This research sets the scope of occupant behaviour to individual behaviours to investigate the effect of disaster information to an individual occupant. However, if the result of this research is applied to buildings with various types of occupant, various disaster information should be provided for each occupant at the same time. Since this situation, overloading of information leads to rather inefficient results (Yates et al. 2011), further considerations of additional occupant behaviour based on group behaviour such as interactions between occupants is needed. Therefore, it will be possible to effectively manage disaster information in various buildings as further research is conducted in the above direction.

# Bibliography

Brown, C. A. (2009). Best practices in fire prevention and protection, in *The Safety Professionals Handbook*, 1st ed. (ed. Haight, J. M.), American Society of Safety Engineers, Des Plaines, IL.

Choi, M., Park, M., Lee, H. and Hwang, S. (2013). "Analysis of Building Emergency Evacuation Process with Interactions in Human Behaviors", *Korea Journal of Construction Engineering and Management*, KICEM, 14(6), pp. 49-60.

Chung, S., Park, H., Choi, Y. and Lee, J. (2008). "A Study on the Coping Behavior of Older People in the Warning Phase of Disaster", *Journal of Korean Society of Hazard Mitigation*, KOSHAM, 8(5), pp. 71-76.

Eldar, R. (1992). "The Needs of Elderly Persons in Natural Disasters: Observations and Recommendations", *Disasters*, 16(4), pp. 355-358.

Guha-Sapir, D. and Lechat, M. F. (1986). "Information Systems and Needs Assessment in Natural Disasters: An Approach for Better Disaster Relief Management", *Disasters*, 10(3), pp. 232-237.

Gwynne, S., Galea, E. R., Lawrence, P. J. and Filippidis, L. (2001). "Modeling Occupant Interaction with Reconditions using the buildingEXODUS Evacuation Model", *Fire Safety Journal*, 36(4), pp. 327-357.

Kim, J., Hwang, E. and Youn, H. (2011). "The Impact Analysis of Including a Weak Person of Disaster Factor for Safety Assessment of Evacuation Simulation", *Journal of the Architectural Institute of Korea Planning & Design*, AIK, 27(12), pp. 37-44.

Kuligowski, E. D. (2003). "The Evacuation of a Performance-based Design Process for a Hotel Building: The Comparison of Two Egress Models", M.S. Thesis, Dept. of Fire Protection Engineering, Univ. of Maryland, College Park, MD.

Lamb, S., Walton, D., Mora, K. and Thomas, J. (2012). "Effect of Authoritative Information and Message Characteristics on Evacuation and Shadow Evacuation in a Simulated Flood Event", *Natural Hazard Review*, 13(4), pp. 272-282.

Lindell, M. K. and Prater, C. S. (2007). "Critical Behavioral Assumptions in Evacuation Time Estimate Analysis for Private Vehicles: Examples from Hurricane Research and Planning", *Journal of Urban Planning and Development*, 133(1), pp. 18-29.

Mayhorn, C. B. (2005). "Cognitive Aging and the Processing of Hazard Information and Disaster Warnings", *Natural Hazards Review*, 6(4), pp. 165-170.

McGuire, L. C., Ford, E. S. and Okoro, C. A. (2007). "Natural Disasters and Older US Adults with Disabilities: Implications for Evacuation", *Disasters*, 31(1), pp. 49-56.

Ministry of Public Safety and Security. (2015). "Statistics Annual Report of Ministry of Public Safety and Security".

Moon, S. and Seong, H. (2011). “u-Disaster Prevention System based Real-Time Fire Monitoring in a Building Facility”, *Korea Journal of Construction Engineering and Management*, KICEM, 12(1), pp. 107-114.

Ng, CM. Y. and Chow, W. K. (2006). "A Brief Review on the Time Line Concept in Evacuation", *International Journal on Architectural Science*, 7(1), pp. 1-13.

Olsson, P, Å. and Regan, M. A. (2001). “A Comparison between Actual and Predicted Evacuation Times”, *Safety Science*, 38(2), pp. 139-145.

Park, J. (2012). “A Study on the Main Characteristics and Factors of the Process of Beginning Egress during the Fire at the Buildings: Focus on Overseas Fire Cases including the Japanese”, *Journal of Korean Institute of Fire Science & Engineering*, 26(2), pp. 59-68.

Parr, A. R. (1987). “Disasters and Disabled Persons: An Examination of the Safety Needs of a Neglected Minority”, *Disasters*, 11(2), pp. 148-159.

Perez-Lugo, M. (2004). “Media Uses in Disaster Situations: A New Focus on the Impact Phase”, *Sociological Inquiry*, 74(2), pp. 210-225.

Pipes, T. S. (2006). “Information Disasters and Disaster Information: Where Information Science Meets Emergency Management”, Disciplines, Disasters and Emergency Management, Charles C. Thomas Publisher, Springfield, IL, USA, pp. 293-321.

Proulx, G. (2002). "Evacuation Planning for Occupants with Disability", Internal Report No.843, Fire Risk Management Program, Institute for Research in Construction, National Research Council Canada.

Reiman, T. and Pietikäinen, E. (2012). "Leading Indicators of System Safety - Monitoring and Driving the Organizational Safety Potential", *Safety Science*, 50(10), pp. 1993-2000.

Sagun, A., Anumba, C. J. and Bouchlaghem, D. (2014). "Safety Issues in Building Design to Cope with Extreme Events: Case Study of an Evacuation Process", *Journal of Architectural Engineering*, 20(3): 05014004.

Sagun, A., Bouchlaghem, D. and Anumba, C. J. (2009). "A Scenario-based Study on Information Flow and Collaboration patterns in Disaster Management", *Disasters*, 33(2), pp. 214-238.

Shen, T. S. (2003). "Building Planning Evacuations for Emergency Evacuation", Ph.D. Dissertation. Worcester Polytechnic Institute, Worcester, MA.

Simonovic, S. P. and Ahmad, S. (2005). "Computer-based Model for Flood Evacuation Emergency Planning", *Natural Hazards*, 34(1), pp. 25-51.

Spence, P. R., Lachlan, K., Burke, J. M. and Seeger, M. W. (2007). "Media Use and Information Needs of the Disabled during a Natural Disaster", *Journal of Health Care for the Poor and Underserved*, 18, pp.394-404.

Tierney, K. J., Petak, W. J. and Hahn, H. (1988). “Physical Disability and Earthquake Hazard Mitigation”, National Science Foundation, Report No. CEE, 8303654.

Wilhelmi, O. V., Purvis, K. L. and Harriss R. C. (2004). “Designing a Geospatial Information Infrastructure for Mitigation of Heat Wave Hazards in Urban Areas”, *Natural Hazards Review*, 5(3), pp. 147-158.

Yates, D. and Paquette, S. (2011). “Emergency Knowledge Management and Social Media Technologies: A Case Study of the 2010 Haitian Earthquake”, *International Journal of Information Management*, 31(1), pp. 6-13.

You, H., Kim, E., Lee, J., Kim, S. and Lee, P. (2003). “A Study on Walking Velocity of Old Men in Korean”, *Proceedings of the Korea Institute of Fire Science & Engineering Conference*, 15, pp. 407-414.

Zhang, X., Li, X. and Hadjisophocleous, G. (2014). “A Probabilistic Occupant Response Model for Fire Emergencies”, *Fire Safety Journal*, 68, pp. 41-51.

# Appendices

## Appendix A. Survey Description and Questionnaires

## Appendix B. Experiment Notes

## Appendix A-1 Survey Descriptions

| Category | Contents |
|---|---|
| Survey Schedule | August 4th, 2015 ~ August 17th, 2015 |
| Survey Respondent | 173 people from 9 related organisations<br>(Facility staffs and social workers) |
| Elderly<br>(Total 82 people) | 한국노인복지중앙회 (3 people)<br>명지병원 공공보건의료사업단 (9 people)<br>동명노인복지센터 (20 people)<br>시립서부노인전문요양센터 (25 people)<br>서초구립 중앙노인복지관 (25 people) |
| The Intellectual Impaired<br>(Total 25 people) | 서울지적장애인복지관 (25 people) |
| The Hearing & Language Impaired<br>(Total 36 people) | 삼성소리샘복지관 (16 people)<br>서울농아인협회 (20 people) |
| The Visual Impaired<br>(Total 30 people) | 서울특별시립 노원시각장애인복지관 (30 people) |

## Appendix A-2 Questionnaire - Quantification of Occupant Behaviour Factors

| Occupant Behaviour Factor | Definition | Level | Rate | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Locomotion | Mobility of occupant on one’s own | 1. Default (on one’s own) | | | | | | | | | | | |
| | | 2. With instructions of equipment | | | | | | | | | | | |
| Cognition | Cognition of fire outbreak | 1. Default (on one’s own) | | | | | | | | | | | |
| | | 2. With warning alarm | | | | | | | | | | | |
| Familiarity | Level of knowledge<br>(i.e. prior knowledge, egress route selection) | 1. Default (on one’s own) | | | | | | | | | | | |
| | | 2. With disaster information | | | | | | | | | | | |

## Appendix A-3 Questionnaire - Validation

| No. | Disaster Information | Rate<br>1 2 3 4 5 |
|---|---|---|
| 1 | Real Time Forecast of Disasters | |
| 2 | Location of Shelter and Exit (in Facilities) | |
| 3 | General Evacuation Know-how | |
| 4 | Instructions of Evacuation Equipment | |
| 5 | Instructions of Fire Extinguishing Equipment | |
| 6 | Information about Rescue Call (How? Where?) | |
| 7 | Emergency Warning through Portable Device | |
| 8 | Information Converting (Visual Signal, Braille) | |
| 9 | Direct Contact System in Emergency | |
| 10 | Direction Guide with Evacuation Guidance Light | |

## Appendix B-1 Experiment Note - Elderly

| **Elderly** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
|---|---|---|---|---|---|---|---|---|---|
| | Lv. 1 (Default) | Lv. 2 (With instructions) | Lv. 1 (Default) | Lv. 2 (With warning) | Lv. 1 (Default) | Lv. 2 (With information) | ***Tp*** | 517.24 sec. | *120.00 * 100 / 23.2* |
| Quantification Result | 19.6 | 25.3 | 23.2 | 25.1 | 17.8 | 21.2 | ***Tr*** | 940.48 sec. | *3 * Ttl - (Tp + Ttl)* |
| Ratio | - | 1.291 | - | 1.082 | - | 1.191 | ***Ttl*** | 728.86 sec. | *142.86 * 100 / 19.6* |
| | | | | | | | *sum* | **2186.59 sec.** | *Tp + Tr + Ttl* |
| **1. Locomotion Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
| | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | ***Tp*** | 517.24 sec. | *Tp* |
| | | **25.3** | **23.2** | | **17.8** | | ***Tr*** | 940.48 sec. | *Tr* |
| | | **1.291** | **-** | | **-** | | ***Ttl*** | 564.65 sec. | *Ttl / 1.291* |
| | | | | | | | *sum* | **2022.38 sec.** | *Tp + Tr + Ttl / 1.291* |
| **2. Cognition Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
| | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | ***Tp*** | 478.09 sec. | *Tp / 1.082* |
| | **19.6** | | | **25.1** | **17.8** | | ***Tr*** | 940.48 sec. | *Tr* |
| | **-** | | | **1.082** | **-** | | ***Ttl*** | 728.86 sec. | *Ttl* |
| | | | | | | | *sum* | **2147.44 sec.** | *Tp / 1.082 + Tr + Ttl* |
| **3. Familiarity Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
| | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | ***Tp*** | 517.24 sec. | *Tp* |
| | **19.6** | | **23.2** | | | **21.2** | ***Tr*** | 789.65 sec. | *Tr / 1.191* |
| | **-** | | **-** | | | **1.191** | ***Ttl*** | 728.86 sec. | *Ttl* |
| | | | | | | | *sum* | **2035.76 sec.** | *Tp + Tr / 1.191+ Ttl* |

## Appendix B-2 Experiment Note - The Intellectual Impaired

| **Intellectual Disability** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
|---|---|---|---|---|---|---|---|---|---|
| | Lv. 1 (Default) | Lv. 2 (With instructions) | Lv. 1 (Default) | Lv. 2 (With warning) | Lv. 1 (Default) | Lv. 2 (With information) | ***Tp*** | 436.36 sec. | *120.00 * 100 / 27.5* |
| Quantification Result | 44.2 | 57.9 | 27.5 | 32.5 | 19.2 | 25 | ***Tr*** | 210.05 sec. | *3 * Ttl - (Tp + Ttl)* |
| Ratio | - | 1.310 | - | 1.182 | - | 1.302 | ***Ttl*** | 323.21 sec. | *142.86 * 100 / 44.2* |
| | | | | | | | *sum* | **969.62 sec.** | *Tp + Tr + Ttl* |

| **1. Locomotion Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
|---|---|---|---|---|---|---|---|---|---|
| | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | ***Tp*** | 436.36 sec. | *Tp* |
| | | **57.9** | **27.5** | | **19.2** | | ***Tr*** | 210.05 sec. | *Tr* |
| | | **1.310** | **-** | | **-** | | ***Ttl*** | 246.73 sec. | *Ttl / 1.310* |
| | | | | | | | *sum* | **893.14 sec.** | *Tp + Tr + Ttl / 1.310* |

| **2. Cognition Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
|---|---|---|---|---|---|---|---|---|---|
| | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | ***Tp*** | 369.23 sec. | *Tp / 1.182* |
| | **44.2** | | | **32.5** | **19.2** | | ***Tr*** | 210.05 sec. | *Tr* |
| | **-** | | | **1.182** | **-** | | ***Ttl*** | 323.21 sec. | *Ttl* |
| | | | | | | | *sum* | **902.49 sec.** | *Tp / 1.182 + Tr + Ttl* |

| **3. Familiarity Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
|---|---|---|---|---|---|---|---|---|---|
| | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | ***Tp*** | 436.36 sec. | *Tp* |
| | **44.2** | | **27.5** | | | **25** | ***Tr*** | 161.32 sec. | *Tr / 1.302* |
| | **-** | | **-** | | | **1.302** | ***Ttl*** | 323.21 sec. | *Ttl* |
| | | | | | | | *sum* | **920.89 sec.** | *Tp + Tr / 1.302+ Ttl* |

## Appendix B-3 Experiment Note - The Hearing & Language Impaired

| Hearing Disability | Locomotion | | Cognition | | Familiarity | | Total Egress Time | | Equation |
|---|---|---|---|---|---|---|---|---|---|
| | Lv. 1 (Default) | Lv. 2 (With instructions) | Lv. 1 (Default) | Lv. 2 (With warning) | Lv. 1 (Default) | Lv. 2 (With information) | ***Tp*** | 273.97 sec. | *120.00 * 100 / 43.8* |
| Quantification Result | 62.1 | 66.6 | 43.8 | 46.8 | 47.9 | 36.2 | ***Tr*** | 186.11 sec. | *3 * Ttl - (Tp + Ttl)* |
| Ratio | - | 1.072 | - | 1.068 | - | 0.756 | ***Ttl*** | 230.04 sec. | *142.86 * 100 / 62.1* |
| | | | | | | | *sum* | **690.13 sec.** | *Tp + Tr + Ttl* |

| 1. Locomotion Aid | Locomotion | | Cognition | | Familiarity | | Total Egress Time | | Equation |
|---|---|---|---|---|---|---|---|---|---|
| | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | ***Tp*** | 273.97 sec. | *Tp* |
| | | **66.6** | **43.8** | | **47.9** | | ***Tr*** | 186.11 sec. | *Tr* |
| | | **1.072** | - | | - | | ***Ttl*** | 214.50 sec. | *Ttl / 1.072* |
| | | | | | | | *sum* | **674.59 sec.** | *Tp + Tr + Ttl / 1.072* |

| 2. Cognition Aid | Locomotion | | Cognition | | Familiarity | | Total Egress Time | | Equation |
|---|---|---|---|---|---|---|---|---|---|
| | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | ***Tp*** | 256.41 sec. | *Tp / 1.068* |
| | **62.1** | | | **46.8** | **47.9** | | ***Tr*** | 186.11 sec. | *Tr* |
| | - | | | **1.068** | - | | ***Ttl*** | 230.04 sec. | *Ttl* |
| | | | | | | | *sum* | **672.57 sec.** | *Tp / 1.068 + Tr + Ttl* |

| 3. Familiarity Aid | Locomotion | | Cognition | | Familiarity | | Total Egress Time | | Equation |
|---|---|---|---|---|---|---|---|---|---|
| | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | ***Tp*** | 273.97 sec. | *Tp* |
| | **62.1** | | **43.8** | | | **36.2** | ***Tr*** | 246.27 sec. | *Tr / 0.756* |
| | - | | - | | | **0.756** | ***Ttl*** | 230.04 sec. | *Ttl* |
| | | | | | | | *sum* | **750.28 sec.** | *Tp + Tr / 0.756+ Ttl* |

# Appendix B-4 Experiment Note - The Visually Impaired

| Visual Disability | Locomotion | | Cognition | | Familiarity | | Total Egress Time | | Equation |
|---|---|---|---|---|---|---|---|---|---|
| | Lv. 1 (Default) | Lv. 2 (With instructions) | Lv. 1 (Default) | Lv. 2 (With warning) | Lv. 1 (Default) | Lv. 2 (With information) | ***Tp*** | 287.77 sec. | *120.00 * 100 / 41.7* |
| Quantification Result | 32.5 | 44.8 | 41.7 | 65.2 | 40 | 55.2 | ***Tr*** | 591.35 sec. | *3 * Ttl - (Tp + Ttl)* |
| Ratio | - | 1.378 | - | 1.564 | - | 1.380 | ***Ttl*** | 439.56 sec. | *142.86 * 100 / 32.5* |
| | | | | | | | *sum* | **1318.68 sec.** | *Tp + Tr + Ttl* |
| **1. Locomotion Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
| | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | ***Tp*** | 287.77 sec. | *Tp* |
| | | **44.8** | **41.7** | | **40** | | ***Tr*** | 591.35 sec. | *Tr* |
| | | **1.378** | **-** | | **-** | | ***Ttl*** | 318.88 sec. | *Ttl / 1.378* |
| | | | | | | | *sum* | **1198.00 sec.** | *Tp + Tr + Ttl / 1.378* |
| **2. Cognition Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
| | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | **Lv. 1** | Lv. 2 | ***Tp*** | 184.05 sec. | *Tp / 1.564* |
| | **32.5** | | | **65.2** | **40** | | ***Tr*** | 591.35 sec. | *Tr* |
| | **-** | | | **1.564** | **-** | | ***Ttl*** | 439.56 sec. | *Ttl* |
| | | | | | | | *sum* | **1214.96 sec.** | *Tp / 1.564 + Tr + Ttl* |
| **3. Familiarity Aid** | **Locomotion** | | **Cognition** | | **Familiarity** | | ***Total Egress Time*** | | ***Equation*** |
| | **Lv. 1** | Lv. 2 | **Lv. 1** | Lv. 2 | Lv. 1 | **Lv. 2** | ***Tp*** | 287.77 sec. | *Tp* |
| | **32.5** | | **41.7** | | | **55.2** | ***Tr*** | 428.52 sec. | *Tr / 1.380* |
| | **-** | | **-** | | | **1.380** | ***Ttl*** | 439.56 sec. | *Ttl* |
| | | | | | | | *sum* | **1155.85 sec.** | *Tp + Tr / 1.380+ Ttl* |

# 국 문 초 록

건축물 화재상황에서 피난시간을 감소시키기 위한 기존의 노력은 피난행동시간의 감소에 집중되었다. 그러나 피난행동시간의 비율이 전체 피난시간의 1/3 임에도 불구하고 이를 제외한 인지시간과 초기대응행동시간을 감소시키기 위한 고려는 부족한 실정이며, 피난행동시간만을 감소시킴으로써 피난성공률을 향상시킬 수 없는 상황 또한 발생하게 되었다.

따라서 인지시간과 초기대응행동시간의 감소에 대한 필요성이 증대되었고, 이를 해결하기 위해 재난정보가 주목 받게 되었다. 따라서 본 연구는 재난정보가 재실자특성에 영향을 미치는 과정을 분석하기 위해 피난시간의 감소 측면에서 재난정보와 재실자특성의 관계를 설명하는 재난정보-재실자특성 연관성을 도출하였다.

먼저 선행연구 분석을 바탕으로 재난정보에 관한 기존 연구의 한계점을 부족한 확장성과 재난정보의 영향에 관한 설명력 부족으로 파악하였다. 본 연구는 재난정보의 작용과정을 보다 용이하게 분석하기 위해 재실자특성을 반영하고 그 범위를 개인적 특성으로 설정하였다. 또한, 재실자특성을 구성하는 재실자특성 요소를 도출하여 다양한 재실자 유형을 반영할 수 있도록 하였다.

예비적 고찰을 종합하여 관련된 선행연구에 언급된 재난정보와 재실자특성 중, 10 가지 주요 재난정보와 3 가지 재실자특성 요소를 도출하였고, 해당 요소와 상호 관련된 피난시간 구성요소를

고려하여 이동능력과 관련된 재난정보 3 개, 인지능력과 관련된 재난정보 5 개, 친숙도와 관련된 재난정보 5 개를 연결한 재난정보-재실자특성 연관성을 제시하였다.

이후 설문조사를 통하여 도출된 연관성을 검증하기 위한 가상의 실험을 수행하였다. 실험 대상은 본 연구의 재실자특성 요소를 이용하여 표현할 수 있는 4 가지 대표 유형(노인, 지적장애인, 청각 및 언어장애인, 시각장애인)이며, 4 가지 경우 모두에서 본 연구의 타당성을 확보할 수 있었다. 최종적으로 실험 결과를 분석하여 재난정보가 재실자특성에 영향을 미치는 과정을 부족한 요소를 보완하여 최저수준의 화재안전성을 확보하는 과정과 일정 수준 보유한 요소를 극대화하여 화재안전성을 확보하는 과정으로 분석하였다.

본 연구를 통해 직관적인 수준에서 설명되는 기존의 재난정보-재실자특성 간의 관계에 피난시간의 감소라는 관점에서의 설명력을 더하였고, 향후 다양한 재실자 유형이 존재하는 상황에서의 재난정보 관계에 대하여 후속연구가 진행된다면 재난정보와 재실자특성을 고려하는 후속 연구에 기초적 자료를 제공할 것으로 기대된다.

**주요어:** 재난정보, 재실자특성, 피난, 피난시간

**학 번:** 2015-21122