Constructing Interaction Scenarios of High-Building Interior in Fire

Hua Qin[1,2], Linghua Ran[3], and Shaohong Cai[4]

[1] Department of Industrial Engineering, Beijing University of Civil Engineering and Architecture, Beijing 100044, P.R. China
[2] Beijing Engineering Research Center of Monitoring for Construction Safety, Beijing 100044, China
[3] China National Institute of Standardization, Beijing 100088, China
[4] School of Information and Communication Engineering, Beijing University of Posts and Telecommunications, Beijing 100876, China
qinh03@mails.tsinghua.edu.cn, ranlh@cnis.gov.cn, cctmm@163.com

Abstract. Many fires in buildings have indicated that behavior of occupants in period of pre-movement is important for the survival. Pre-movement time and pre-movement behavior are currently referred as most important factors during evacuation. The objective of this study is to identify the factors that influenced pre-evacuation time of occupants during an actual fire evacuation and to quantify the factors. This study proposes three kinds of factors influencing the human behavior in the event of fire in period of the pre-movement, which are fire characteristics, building characteristics, human characteristics. Through simulating fire scenes of building interior, this study will investigate occupants' performance in the period of pre-movement. This paper is part of the study, which is to construct interaction scenarios of building interior in fire.

Keywords: Interaction scenarios, evacuation simulation, human behavior, fire.

1 Introduction

Some research indicated that in real evacuations pre-movement time exhausted even more than 20 minutes [1, 2, 3].The pre-movement time is very more important to escape to a safe place. Furthermore, incident analyses have indicated that there is a connection between a delayed evacuation and a high number of fire deaths or injuries, particularly in residential buildings and hotels [4]. Therefore, pre-movement time and pre-movement behavior are currently referred as key aspects of the evacuation process. In order to achieve a more accurate assessment of the life safety during a fire, a better understanding of occupant behavior during evacuation is required. The objective of this paper is to identify the factors that influenced pre-evacuation time of occupants during an actual fire evacuation and to quantify the factors by stating how much pre-evacuation time was gained or lost due to each factor. Since fire response performance is dependent upon the external environment in which an individual is

P.L.P. Rau (Ed.): CCD/HCII 2013, Part II, LNCS 8024, pp. 329–335, 2013.

present, the research for fire prevention measures should be the interaction between human behavior and the characteristics of the external environment. To obtain adequate fire response performance, this study will investigate occupants' performance in fire in the simulating building interior. This paper is part of the research, which is to construct interaction scenarios of building interior in fire. Further investigation will be conducted based on these circumstances.

2 Methodology

Based on previous research [5, 6, 7, 8, 9], this study proposes three kinds of factors influencing the human behavior in the event of fire in period of the pre-movement. These are as followers: fire characteristics, building characteristics, human characteristics. The first factor is the nature of fire. And the second factor is physically environment which occupants' behaviors are carried out. The two factors are external. The third factor is human nature and is internal factor.

2.1 Building Interior Characteristics

Some research indicated that occupants would stay in home or hesitate to escape from the house, which means that in real evacuations pre-movement time exhausted from five minutes to over 25 minutes [1, 2]. So, one aim of this study is to explore when and how occupants exit the home. Without detailed data about the information that occupants act their behaviors in home while hearing fire alarm, it is important to design the interior characteristics. First, this study presumed that the ordinary family had a two-bedroom apartment located in the middle of high-building. The layout of one floor is shown in figure 1. The interior of the apartment will vary on five parameters according to situation, which are furniture, communication tools, property, and kids and the aged.

2.2 Behavioral Scenarios

Based on previous research, this study proposed that four types of characteristics of the occupants should be investigated, which were demographic information, personality, risk perception, and fire experience.

Demographic Information

Demographic information collects educational level, age, family composition, dwelling house and so on. The participants would be divided into different groups according to different attribution (See Table 1).

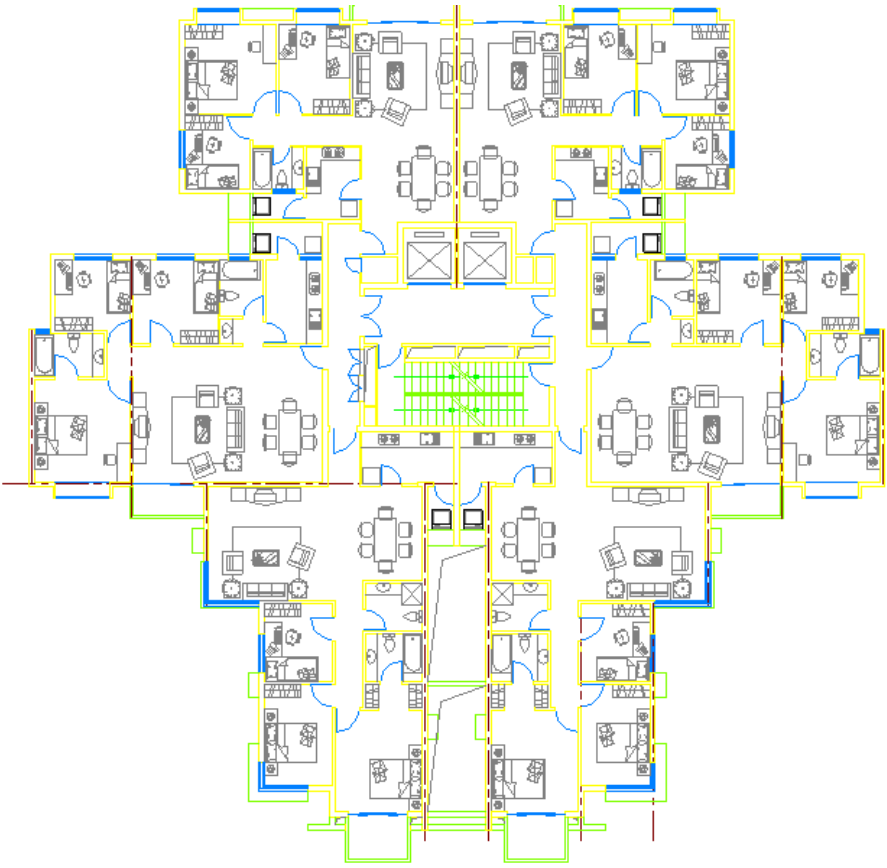

Fig. 1. The layout of one floor

Table 1. People groups

Gender	Age	Family composition	Dwelling house	mobility
Male	<30	Without a child (less than 6 years old) and without an old person (more than 65 years old)	Not more than two-bedroom house	Normal person
Female	30-50	With less than 3 children and old persons (totally)	At least three bedroom house	Reduced motility
	>50	With not less than 3 children and old persons (totally)		

Personality

Personality includes influenced by others, stress resistance and self-efficacy [10, 11, 12]. In the event of fire, most persons follow others. While others escaping they will take action. Another personality trait influencing decision-making is stress resistance.

While fire happens occupants' capacity for processing information is exceeded, so the level of psychological stress will rise. The third trait is self-efficacy. The trait influence occupants' selection, duration and effort while the occupants encounter fail, difficulty or disaster.

Risk Perception

Risk perception is the subjective experience that persons capture the features of the accidents and recognize the severity of risks [13, 14]. Persons have different responses in terms of the different perceived cues. And even the same cues presented, people are likely to respond in different ways [15]. The reason is that persons' actions vary based on the cues perceived, interpretations of the situation, and the decisions [16]. Based on the decision making, occupants will perform the actions. According to previous research [17, 18, 19], this study proposed a questionnaire to investigate risk perception and behaviors in everyday life including five dimensions such as safety and health risk, finance investment risk, entertainment risk, ethical risk and social communication risk.

Fire Experience

Relevant experience is another important characteristic [20, 21]. Commonly, less-endowed members will benefit from the efforts of the more experienced members to bring them to escape, presumably a reason they keep with them. Fire experience of a person includes fire disaster experience, evacuation drills, fire training or other emergency training.

2.3 Fire Characteristics

This factor is the nature of the fire itself. A fire is a process of combustion of materials. With the fire growing the critical factors of the fire are perceived by the occupants. Perceptible characteristics can be sub-divided into elements which can be seen, smelt or heard [22]. And the fire growth rate is another important characteristic in determining fire fatality, since many fatal incidents are characterized by rapid fire development after its initial discovery [23].The fire alarm system is designed as an emergency alarm communication system. The emergency alarm communication system has the capability to provide automatic pre-recorded messages upon receipt of an alarm signal indicative of a fire emergency. In terms of previous researches, this study proposes four types of characteristics, which are fire's growth rate, emergence of flame and smoke, fire alarm, and fire location in the building (Table 2).

Table 2. Related fire characteristics

Fire's growth rate	Flame and smoke	Fire alarm	Fire location
Low	A little	No	Upstairs
Middle	Some	Vague messages	Downstairs
Fast	A lot of	Clear messages	

3 User Performance

The important issues taken into consideration in this system for simulating occupant evacuation in virtual environment include: navigation, interaction in the virtual environment, investigation participants' thoughts while escaping in the virtual environment (Fig 2).

The participants can navigate freely in the virtual environment as if they walk in the real interior. The navigation is controlled by a mouse. When the user clicking the left button and moving left or right, they will move in that direction in the virtual environment. And moving up and down they can look up and down. Besides navigation, other interactions are also allowed while picking up objects within the virtual environment. While participants picking up the objects, the environment would respond the activities. The objects include furniture, firefighting equipment, properties, and communication tools and so on. After participants completing interactions, questionnaire would turn up that reflecting participants' thought while interacting.

Fig. 2. Visualization of Flame and Spreading smoke in the virtual interior

In order to identify the factors that influence pre-evacuation time and behavior of occupants, the evacuation routes and evacuation time are calculated.

Acknowledgement. The research project presented in this paper is a part of the Project "Emergency Behavior during Pre-movement Time in High-rise Building Fire", which was supported by the Beijing Natural Science Foundation. The authors would like to acknowledge the support of the Beijing Natural Science Foundation for this project (9122008).

References

1. Proulx, G., Reid, I.: Occupant behavior and evacuation during the Chicago Cook County Administration Building fire. Journal of Fire Protection Engineering 16(4), 283–309 (2006)

2. Averill, J.D., Mileti, D.S., Peacock, R.D., Kuligowski, E.D., Groner, N., Proulx, G., Reneke, P.A., Nelson, H.E.: Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Occupant Behavior, Egress, and Emergency Communications. In: NIST NCSTAR 1-7, NRCC-48362. National Institute of Standards and Technology, Gaithersburg, MD (2005), http://wtc.nist.gov/oct05NCSTAR1-7index.htm
3. Fahy, R.F., Proulx, G.: Human Behavior in the World Trade Center Evacuation. In: Proceeding of the Fifth International Symposium on Fire Safety Science, pp. 713–724 (1997)
4. Purser, D.A., Bensilum, M.: Quantification of behavior for engineering design standards and escape time calculations. Safety Science 38, 157–182 (2001)
5. Kobes, M., Helsloot, I., De Vries, B., Post, J.G.: Building safety and human behavior in fire: A literature review. Fire Safety Journal 45, 1–11 (2010)
6. Kobes, M., Post, J., Helsloot, I., Vries, B.: Fire risk of high-rise buildings based on human behavior in fires. In: Conference Proceedings FSHB 2008. First International Conference on fire Safety of High-rise Buildings, Bucharest, Romania, May 7-9 (2008)
7. Deloitte, From risk perception to safe behavior. Article on the Safety Institute of Australia Ltd. (2006) website, http://www.sia.org.au/downloads/SIGs/Resources/From_Risk_Perception_to_Safe_Behaviour.pdf
8. O'Connor, D.J.: Integrating Human Behavior Factors into Design. In: Fire Protection Engineering, pp. 8–20 (2005)
9. Proulx, G.: Occupant Behavior and Evacuation. In: Proceedings of the 9th International Fire Protection Symposium, Munich, pp. 219–232 (2001)
10. Johnson, C.W.: Lessons from the evacuation of the world trade center, 9/11 2001 for the development of computer-based simulations. Cognition, Technology and Work 7, 214–240 (2005)
11. Cornwell, B.: Bonded fatalities: relational and ecological dimensions of a fire evacuation. Sociological Quarterly 44, 617–638 (2003)
12. Proulx, G.: A stress model for people facing a fire. Journal of Environmental Psychology 13, 137–147 (1993)
13. Communities and Local Government. Understanding People's Attitudes Towards Fire Risk –Final Report to Communities and Local Government, Fire Research Series 13/2008. Department of Communities and Local Government, London (2008)
14. Sjöberg, L., Moen, B.E., Rundmo, T.: Explaining Risk Perception. An Evaluation of the Psychometric Paradigm, vol. (84). RotundePublikasjoner, Trondheim (2004)
15. Mileti, D.S., Sorensen, J.H.: Communication of Emergency Public Warnings: A Social Science Perspective and State-of-the-Art Assessment. Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge (1990)
16. Kuligowski, E.D.: Modeling human behavior during building fires. NIST Technical Note 1619. National Institute of Standards and Technology, Gaithersburg (2008)
17. Bina, M., Graziano, F., Bonino, S.: Risky driving and lifestyles in adolescence. Accident Analysis & Prevention 38, 472–481 (2006)
18. Parker, D., McDonald, L., Rabbitt, P.: Elderly drivers and their accidents: The Aging Driver Questionnaire. Accident Analysis & Prevention 32, 751–759 (2000)
19. Wang, P., Rau, P.-L.P., Salvendy, G.: Chinese drivers' risky driving and risky taking in other life situations. International Journal of Occupational Safety and Ergonomics 17(2), 155–164 (2011)

20. Marwell, G., Oliver, P.: The Critical Mass in Collective Action. AMicro-Social Theory. Cambridge University Press, London (1993)
21. Peacock, R., Kuligowski, E.D.: Workshop on Building Occupant Movement During Fire Emergencies. Special Publication 1032. National Institute of Standards and Technology, Gaithersburg (2005)
22. Frantzich, H.: A Model for Performance-based Design of Escape Routes, Department of Fire Safety Engineering. Department of Fire Safety Engineering. Lund Institute of Technology, Lund University (1194)
23. Sime, J.D.: An occupant response shelter escape time (ORSET) model. Safety Science 38, 109–125 (2001)