Investigation Report regarding Behavioral Response of Employees in a Hotel Fire

MASAYUKI MIZUNO and TAKAO WAKAMATSU
Science University of Tokyo
2641, Yamasaki, Noda-shi, Chiba 278-8510, Japan

YOSHIFUMI OHMIYA
Building Research Institute
1, Tachihara, Tsukuba-shi, Ibaraki 305-0802, Japan

AI SEKIZAWA
National Research Institute of Fire and Disaster
3-14-1, Nakahara, Mitaka-shi, Tokyo 181-8633, Japan

ABSTRACT

On November 17, 1998, a hotel fire broke out at Shirahama hot-spring resort, Wakayama prefecture, Japan. When the fire broke out, there were 78 occupants in the hotel, but no one was killed or even injured fortunately. For purpose to find out factors of this safe evacuation, surveys in two styles were conducted on the hotel employees. One in an interview style, asked about the serial property of the fire, and the other in a questionnaire style questioned about the employees' behaviors in the fire. In the former, the employees were individually interviewed about the conditions around them and their behaviors from when they noticed an unusual occurence or perceived the fire to when they escaped to safe areas. As regards the latter, the questionnaire was prepared to clarify the employees' behavior patterns in the fire. The items of the questionnaire are ; "attributes of respondents," "circumstances when something for fire made them aware of an unusual occurence," "circumstances when they perceived the fire," "circumstances when they led and/or directed their guests for evacuation" and "circumstances when the they escaped." Each item contained questions relating to times, locations, factors and behavioral responses. In this report, behavioral responses of the employees and the guests in the fire are illustrated, and the reasons of the successful evacuation were examined.

Key words: Hotel fire, Instance survey, Perception of fire, Human behavior in fire, Behavioral response, Escape guide

INTRODUCTION

A fire occurred at Tenzankaku Hotel located in Shirahama hot-spring resort, Wakayama, Japan, on the evening of November 17, 1998. This fire continued for about 12 hours until it was eventually extinguished next morning, and did widespread damage. Although it was a large-scale fire, there were fortunately no casualties among 32 employees and 46 guests at the hotel.

An investigation on human behavior in this fire was carried out on the hotel employees for the purpose of clarifying what contributed to no casualty. The investigation was composed of two surveys, an interview and a questionnaire surveys, performed as a part of activities of the Tech. Committee for Human Behavior in Fire of the Japan Assoc. for Fire Science and Engineering.

The interview survey was conducted on seven selected employees to grasp the conditions of the hotel as the fire developed. Then, the answers to the interview arranged in a time series. This paper analyzes and discusses;
1. the area in the hotel contaminated by the fire (the smoke and flame, for example), and
2. behavioral responses taken by the employees as the conditions changed.

The questionnaire survey was carried out on all 32 employees who were in the hotel at the fire. The questionnaire was prepared to grasp about employees' behavior pattern in the fire. It is consisted of questions about when, where, and how they were aware of or perceived an emergency and responded to it. The answers and the results were illustrated in tables and figures, and the employees' behavior in the fire was analyzed and discussed below.

Based on the results of the surveys on human behavior in fire, dynamics and phases of occupants' behavior in this fire were analyzed.

Finally, from the results of surveys, the reasons why all the occupants in the hotel could safely escape to outdoors are reported.

OUTLINE OF BUILDINGS OF THE HOTEL

The hotel site is located on a gentle slope of undulations up from the road running along the coastline to the south (toward the ridge of mountains). The hotel consists of several buildings connected to each other, as the results of reconstruction and enlargement. For convenience, these buildings are divided into three major sections in accordance with prescription of Fire Prevention Properties in Fire Services Law; namely "Main building," "Annex 1" and "Annex 2." (See FIGURE 1, 2, and TABLE 1.)

A horizontal connection corridor runs from the 5th floor of section (1) to the 1st floor of section (11), going through all the buildings by way of several sections. (the 5th level connection corridor, hereafter.) Another runs from the 4th floor of section (3) to the 2nd floor of section (6). (the 4th level connection corridor, hereafter) The former is used for access to other sections by both the employees and the guests, and the latter is used only by the employees.

The doorways are at the entrance on the 1st floor of section (1), at the cafe on the 1st floor of

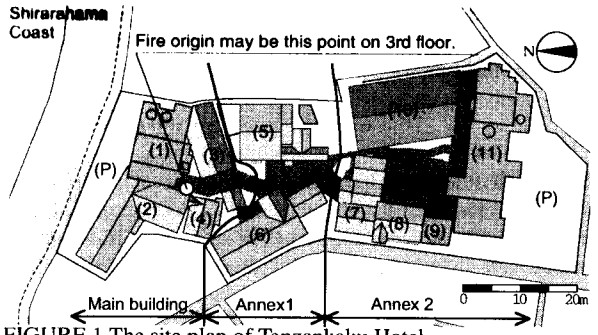


FIGURE 1 The site plan of Tenzankaku Hotel

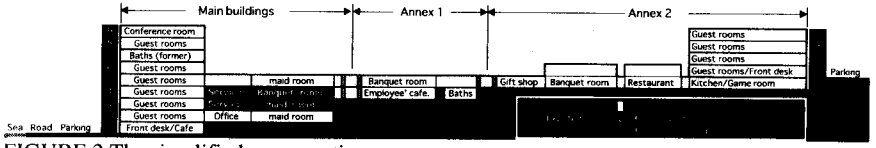


FIGURE 2 The simplified cross section

TABLE 1 Building data shown in FIGURE 1

Large-section	Section No.	Construction	Floor level	Major room uses
The Main	(1)	RC	1-9	Guest rooms (1st : front desk, entryway)
	(2)	W	1-3	Guest rooms (1st : cafe, 2nd : office)
	(3)	W	3-5	Banquet hall, service room
	(4)	W	2-4	Maid rooms
Annex 1	(5)	W	4-5	Bathing room
	(6)	W	4-5	Employee cafeteria, banquet hall
Annex 2	(7)	W	5	Banquet hall
	(8)	W	5-6	Banquet hall
	(9)	RC	5-6	Game rooms
	(10)	S	5-6	Restaurants and theater
	(11)	RC	5-9	Guest rooms (5th : Kitchen, 6th : Front desk, entryway)

Note; section numbers are based on FIGURE 1. The floor levels in this table are based on section (1). In addition, the floor levels of Main Building are based on section (1), Annex 1 on section (6), Annex 2 on section (11).

section (2), at the game room on the 1st floor of section (9) and at the entrance on the 2nd floor of section (11). These were used by the occupants. And, the back door is provided at the employees' cafe on the 1st floor of section (6), usually allowed to use only by the employees.

The total floor area of each large-section is as shown below.

Main Building: 5,732 m2, Annex 1: 1,505 m2, Annex 2: 5,387 m2

The total building area is 4,237 m2 and the total floor area is 12,624 m2.

SUMMARY OF SURVEY

A questionnaire survey was carried out on January 18, 1999, about two months after the fire on 32 employees who were in the hotel at the fire. After that, another interview-style survey (the

interview survey, hereafter) was conducted on seven employees who were very familiar with the circumstances at the fire. However, the survey on the guests was not conducted because of the hotel's policy to protect the privacy of their guests.

Interview Survey

The interview survey was conducted in order to grasp the overall situations at the fire and the various behaviors performed by employees under the influence of the fire development. Interviews of employees were conducted individually, asking about the space conditions and their behaviors at the fire from when they were aware of an unusual occurence or recognize the fire to when they finished evacuation. Seven employees were selected for the subjects of this survey.

Questionnaire Survey

In this survey, questionnaires were prepared to make employees' behavior patterns at the fire clear. FIGURE 3 shows a simplified behavior pattern performed by employees at the fire. First, employees would have taken some behavioral responses after they were aware of an unusual occurence. Then, they perceived the fire from some factors, then led and/or directed their guests out of the hotel. They finally escaped out of the hotel themselves.

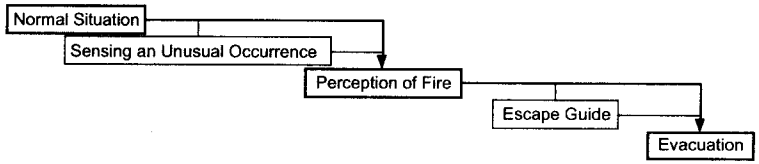


FIGURE 3 A simplified typical behavior pattern of the employees in fire

The questionnaire consists of such items as "attributes of respondent," "circumstances when they were aware of an unusual occurence," "circumstances when they perceived the fire," "circumstances when they led and/or directed their guests out of the hotel", and "circumstances when they escaped themselves." Each item contains questions relating to times, locations in the hotel, factors caused the influence to their psychology and behavioral responses to them.

The survey, was carried out in a collective form, required each respondent to answer by themselves. The all subjects of this survey were 32 employees.

RESULTS OF INTERVIEW SURVEY

The essential information collected from the survey was arranged in a time series, which consists of the conditions and behavioral responses to it. ("the Flow in Time Series," hereafter) The information, provided from each respondent, was arranged along with a progress of the fire. In addition, the definite times is shown in the following;
Around 18:25; an employee at the front desk of section (1) listened to the fire alarm ring, then call another at the restaurant of section (10). Before that time, the latter confirmed the time at 18:20.

18:38; an employee informed the fire occurrence to fire station by the emergency telephone installed at the corridor on the 3rd floor of section (1).
18:41; the fire brigade firstly arrived at the hotel.

Fire Condition during Guests' Evacuation

According to "the Flow in Time Series[2)]", escape guide was performed in Main Building and Annex 2 around 18:40 almost simultaneously, and the guests finished escaping roughly between 18:45 and 18:50. So FIGURE 4 shows the contaminated areas until 18:50, where "the burnt odor" and "the smoke" were confirmed by the employees.

As shown in FIGURE 4, there was no smoke in the corridor in front of guest rooms and the spiral stairs of Section (1) because the fire doors were shut off, installed at the doorway of the service room on the 3rd and 4th floor of Main Building. Therefore, escape route from the guest rooms to the 1st floor was secured. Similarly, the fire doors prevented the smoke from spreading to Annex 1, which were installed doubly at the 4th level connection corridor.

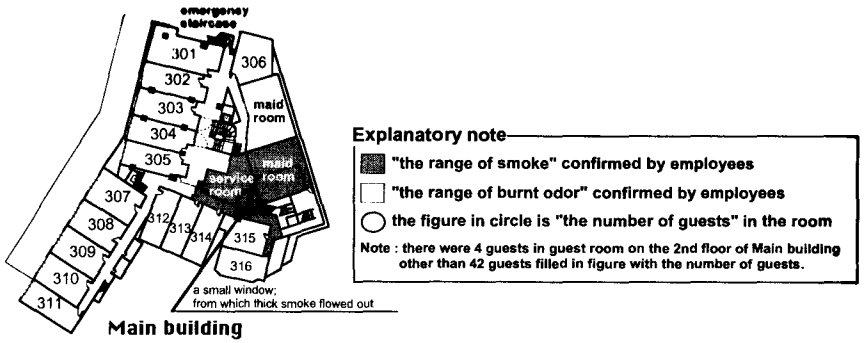
Employees' Behavioral Response and Surrounding Conditions in the Fire

As some employees were aware of an unusual occurence by burnt odor or emergency bell, etc., they checked the conditions in the hotel. As a result, they perceived the fire when they saw thin or thick smoke. They, who perceived the fire earlier than others, took such behavioral responses; attempting to find the fire origin and extinguish the fire initially, etc. However, as it was they could not find it, they eventually called the fire station. Then, they started informing occupants of the fire, and led and/or directed their guests out of the hotel.

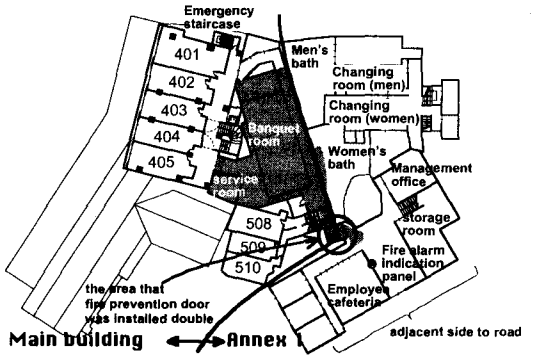
The following explains employees' behavioral responses to the surrounding conditions by each section in detail.

Main Building: Since the emergency bell of the automatic fire alarm system rang in Main Building at around 18:25, an employee at the front desk switched off the bell after confirming the location displayed on the fire alarm panel. Two employees who heard the bell immediately rushed into the front desk and then informed an employee in the restaurant on the 1st floor of Annex 2 by an extension telephone. And they went to check the cause to the 3rd floor of Main Building where the system detected. On the other hand, other employees had already smelled something burning on the 5th floor of Main Building at that time, and they, too, attempted to find the fire origin due in part to having heard the bell.

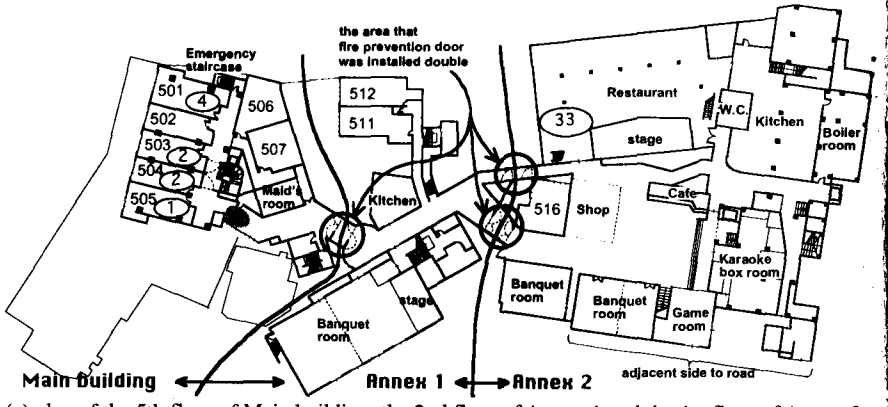
The employees, who arrived at the 3rd floor of Main Building from the front desk, saw white smoke in and around the service room and perceived the fire at that time. They initially seeked the fire origin there in order to extinguish the fire. When they opened a small window installed at south-side wall there, they saw thick smoke enter through it. Therefore, they thought that the fire origin was located on the other side of it. Two of them tried to extinguish the fire using two fire extinguishers without identifying any actual fire. Then they judged it impossible that their early stage fire-fighting efforts accomplished the fire suppression, because they were unable to neither suppress generating thick smoke nor to confirm the fire origin directly.



(a) plan of the 3rd floor of Main building



(b) plan of the 4th floor of Main building and the 1st floor of Annex 1



(c) plan of the 5th floor of Main building, the 2nd floor of Annex 1 and the 1st floor of Annex 2

FIGURE 4 The range of "burnt odor" and "smoke" confirmed by employees

One employee informed the fire station by a hot line of one-button type. In addition, there were a number of guests and employees in the restaurant on the 1st floor of Annex 2 since the fire occurred at dinner time. Another ordered an employee at the restaurant by extension telephone to evacuate their guests into the car park on the south side of Annex 2.

At the same time, as some guests were having dinner in their rooms of Main Building, the employees checked all the guest rooms of Main Building and led and/or directed their guests to safety. Four guests on the 2nd floor escaped to the lobby on the 1st floor of Main Building, while nine guests on the 5th floor escaped to it and/or to the car park on the south side of Annex 2.

Annex 1: The fire doors, installed on both sides of the 4th level connection corridor, closed mechanically and the emergency bell also sounded when smoke detector detected the smoke there. (At that time, in Main building, the employees seeked the fire origin.) An employee in the maintenance office heard the bell rang and switched off it, and went to the connection corridor. He then perceived the fire as he saw thin smoke filling after opening the fire door there.

Other employees in Annex 1 were having dinner or talking on the telephone in the employees' cafeteria. After one of them finished dinner, he went to Main Building. But he went back and informed others that he saw the smoke in the banquet room on the 4th floor of Main Building. They saw thin smoke floating under the ceiling when they went out of the cafeteria. At that time they perceived the fire. In addition, at this time, they met the employee who had been in the maintenance office there. Some employees in Annex 1 led and/or directed their guests out of hotel in Main Building after they perceived the fire.

Annex 2: An employee in the restaurant received the information from the employee at the front desk who had gone to check the cause. At that time, however, he did not understand what had happened because he did not hear emergency bell. After a while, he was aware of an unusual occurence, as he smelled something burnt in front of the restaurant. So he asked the employees in the gift shop whether they smelled something burning. Thereupon they answered that it smelled something burning, so he went to check inside and outside of the hotel. While checking several areas in the hotel, he saw thick smoke at the banquet room on the 4th floor of Main Building and perceived the fire. Afterwards he went to the front desk in Main Building and realized that the fire brigade had already arrived at the hotel.

At that time, the employees on the 3rd floor of Main building had perceived the fire and one of them informed the employees in the restaurant by extension telephone. They led 33 guests in the restaurant to the car park on the south side of Annex 2. The employees in the kitchen next to the restaurant were also informed of the fire by an employee who returned after finishing escape, and started escape to the same place.

Results of Questionnaire Survey

The analysis of answers is described below. These are in order of "attributes of respondents", "awareness of an unusual occurence," "perception of the fire," "escape guide", and "evacuation," etc.

Attributes of Respondent: As shown in FIGURE 5, the numbers of male and female employees were almost equal. The proportion of female was higher in older age groups and male in 20's.

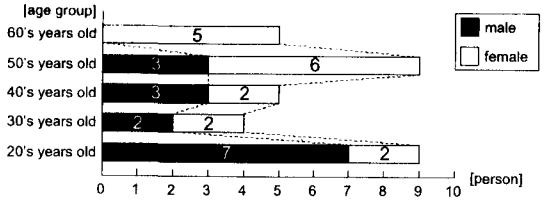


FIGURE 5 Attributes of respondents (by age group and sex)

Awareness of an unusual occurence: About a half of employees was aware of an unusual occurence before perceiving the fire. As shown in FIGURE 6, the number of the employees who were aware of it was more than that of who didn't in Main Building and Annex 1 next to there, but fewer in Annex 2 away from there. There were significant statistical differences among three large-sections in categories of "aware" and "no aware." The order of the high ratio of "aware" to "no aware" was Main building, Annex 1, Annex 2. The closer to the fire origin employees were, the easier it was that they were aware of an unusual occurence prior to perceiving the fire.

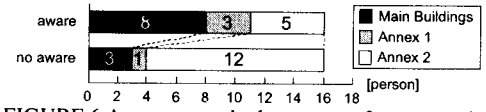


FIGURE 6 Answers to whether aware of an unusual occurence prior to perceiving the fire

As shown in FIGURE 7, the majority of the factors were either burnt odor or emergency bell sound. As the employees smelled burnt odor without respect to the building division, it was considered that burnt odor was spread over wide inside the building. In addition, as eight employees, half of those in Main Building, were aware of an unusual occurence owing to burnt odor before hearing the emergency bell sound, it was determined that burnt odor was let to them close to the fire origin at the earlier stage of the fire.

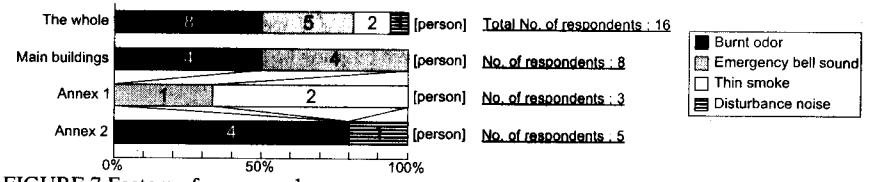


FIGURE 7 Factors of an unusual occurence

As shown in FIGURE 8, the employees generally checked the cause of an unusual occurence or informed others of it after noticing an emergency. The employees who smelled burnt odor tended to inform others of their experience, while those who heard the emergency bell sound tented to check the cause of the alarm system operation by themselves. In addition to above, they replied "thin smoke" and "disturbance noise" checked the cause of those occurences.

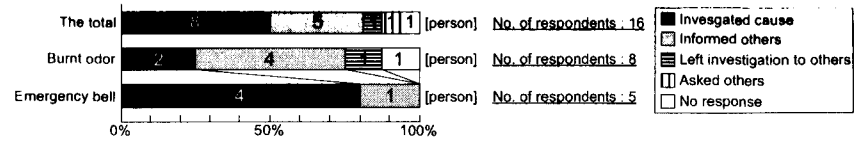


FIGURE 8 Behavioral response to the factor after awaring of an unusual occurrence

Perceiving the Fire: According to (a) in FIGURE 9, the information from others and the smoke (including both thin and thick smoke) was major factors by which employees perceived the fire on the whole building base. According to (b), the smoke and the burnt odor were major factors in Main Building. According to (c), however, the information from others was major in Annex 2 because it was away from Main Building of the fire origin.

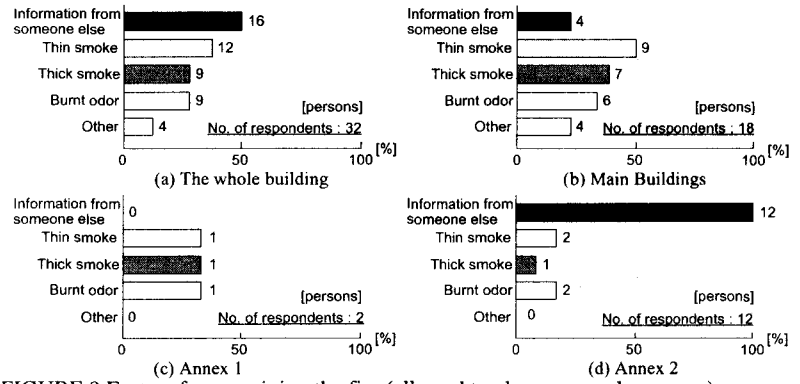


FIGURE 9 Factors for perceiving the fire (allowed to cloose several answers.)

According to TABLE 2, the most reply of the first behavioral response after perception of the fire was gathering information about the location of the fire origin, etc. It was answered as the first behavior more than other turns and its dispersion was narrow. In addition to above, the many reply was secondly informing others about the fire occurence.The second behavioral response was evacuation guide for the guests. It was answered as the second more than other turns, however, its dispersion was spread wide.

TABLE 2 Behavioral responses after perceiving the fire and the sequence (Unit : persons, figures in parentheses represent the numbers of male/female)

Behavior after perceiving the fire	Total	1st	2nd	3rd	4th	5th
Evacuated	32 (15/17)	5 (0/5)	5 (3/2)	**10 (7/3)**	**10 (7/3)**	**2 (2/0)**
Led and/or directed the guests to evacuate	21 (10/11)	4 (3/1)	**9 (4/5)**	6 (2/4)	2 (2/0)	-
Gathered information about the fire origin, etc.	13 (7/6)	**10 (6/4)**	2 (0/2)	1 (1/0)	-	-
Informed others about the fire occurrence	13(5/8)	8 (2/6)	5 (3/2)	-	-	-
Tried to extinguish the fire	6 (6/0)	1 (1/0)	2 (2/0)	3 (3/0)	-	-
Continued behavior taken up to that time	2 (2/0)	2 (2/0)	-	-	-	-
Walked around there unconsciously	2 (2/0)	1 (1/0)	-	1 (1/0)	-	-
Took care of personal matters	2 (1/1)	-	2 (1/1)	-	-	-
Others (Sounded emergency bell, etc.)	1 (1/0)	-	-	1 (1/0)	-	-
	Total	31 (15/16)	25 (13/12)	22 (15/7)	12 (9/3)	2 (2/0)

And, most respondents answered that they informed someone else of the fire as the first or second behavioral response. Therefore, when answers of the first and the second are included together , it turns to be the secondly most response.

Two-thirds of the employees answerd their escape from the hotel as the third or the fourth. In addition, with regard to female employees, they initially chose somewhat passive behavioral responses to the fire, such as their escape or informing someone else about the fire occurence.

Evacuation Guide: According to TABLE 2, two-thirds of all employees led and/or directed their guests to evacuate from the hotel. The other one-third seemed to perceive the fire after their guests had already evacuated the hotel, or took other behavioral responses while evacuating.

According to FIGURE 10, the reasons for evacuation guide start were generally employees' own judgements or the directions from other employees. Therefore, it is considered that they accommodated themselves to the circumstance in the fire and started evacuation guide.

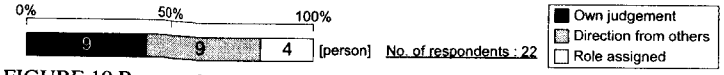


FIGURE 10 Reasons for evacuation guide start

Escape start: Employees seem to have begun escaping from the hotel before the dangers of the fire were close to them, according to FIGURE 11. They began to escape because they had completed evacuation guide to others, or they might be in danger there afterward.

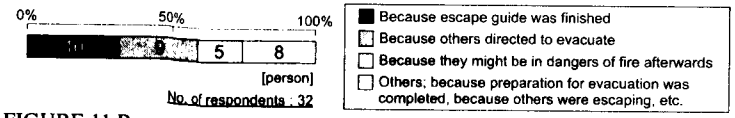


FIGURE 11 Reasons for escape start

Time required until escape start : The average times required from Perceiving the fire to other behavioral phases were calculated, and FIGURE 12 was illustrated with reference to the employees' behavior patterns shown in FIGURE 3.

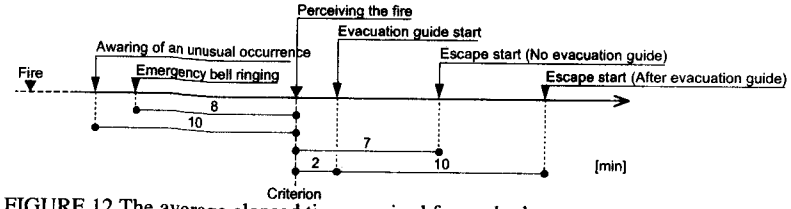


FIGURE 12 The average elapsed time required for each phase

The time from awaring of an unusual occurence to perceiving the fire was about 10 minutes. The time was about 8 minutes in case that the employees replied the emergency bell sound as the

factor of awaring an unusual occurence. And it took about 7 minutes for the employees to start escape after perceiving the fire in case that they didn't perform evacuation guide for their guests. It took about 12 minutes in case that they performed it. Thus, it took somewhat long time because they were not caught by danger as soon as they perceived the fire.

According to FIGURE 13, the sum of the both elapsed times (from ring of the emergency bell to perception of the fire, and from perception of the fire to starting of escape) is roughly within the range of 30 minutes. The earlier the employees perceive the fire, the larger the dispersion of the time from perceiving the fire to starting escape was. The later, while, the smaller its dispersion was. In other words, the earlier, they tended to have time for their activities before escape, but the later, they had to escape immediately after perceiving the fire.

With reference to above, it is estimated that some hotel employees will take evacuation guide for their guests if they could perceive the fire relatively early. Because they rarely caught the danger of the smoke or heat, etc. in the early stage of the fire. In such case they will start escape themselves after either all guests finished to evacuate the hotel or they caught the danger.

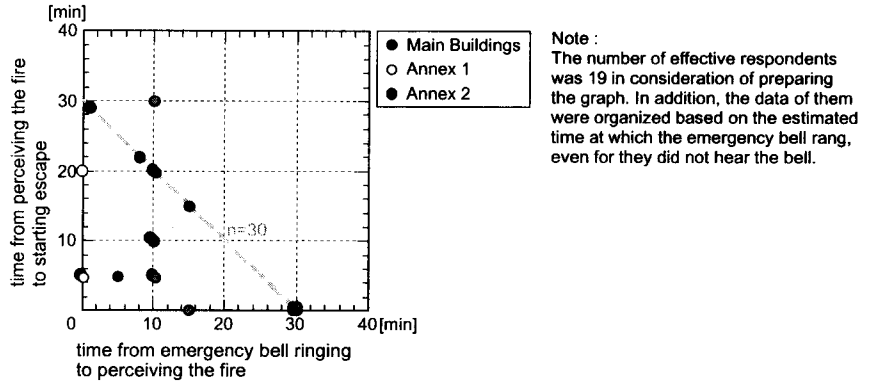


FIGURE 13 The relationship of time between perceiving the fire and starting escape

DYNAMICS OF BEHAVIORAL RESPONSE

Human behavior in fire could be divided into several phases, which are a series of activities to be treated as dynamics of behavioral phases. And a behavioral phase could be composed of (1) a certain factor from a fire, (2) human cognition of the condition, and (3) human behavioral responses to it, if the behaviors are performed based on realization of a certain conditions. In other words, a phase of human behavior in fire should be a package of the above-mentioned (1), (2) and (3). Putting all these together, the occupants' principal behavior in this fire are organized in FIGURE 14.

CONCLUSIONS

The following findings were obtained as a result of investigation the employees'behavioral re-

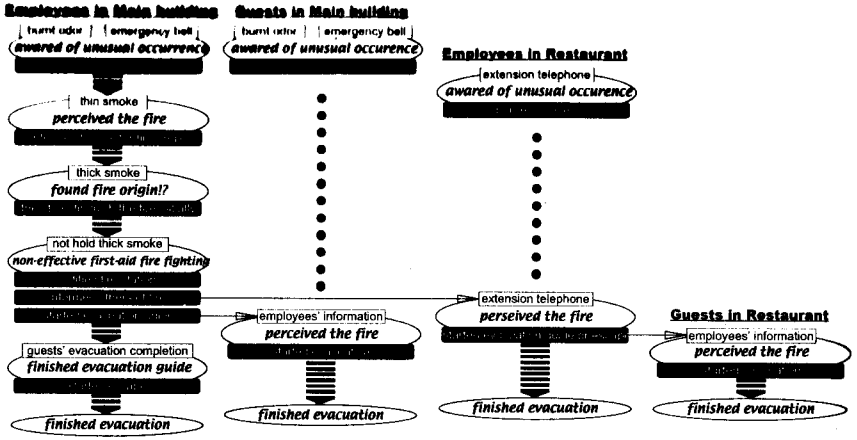


FIGURE 14 Summary for dynamics of the phase of occupants' principal behavior in this fire

sponse to fire taken by these hotel employees.

Despite the complex layout of the building, the fire origin was approximately identified by the information from the automatic fire alarm system. Also, some employees promptly reported the fire situation and took responsive behavior, so the occupants perceived the fire relatively early.

Since the rooms used by the guests were not many and the number of the employees was roughly the same as no. of the guests, the employees could efficiently led and/or directed their guests out of the hotel.

The fire doors closing prevented the corridor from being polluted by the smoke. As a result, the corridors could fulfill their role as escape routes until the occupants evacuated the hotel.

As described above, several factors could be confirmed, including early perception of the fire, employees' evacuation guide for their guests, and the promotion of safe evacuation by ensuring safe routes. It is important to prepare fire safety measures in both hardware and software so that all occupants are able to perceive the fire as quickly as possible.

REFERENCES

1. Jin, T., Watanabe, Y. and Sekizawa, A., "Human Behavior of Guests in the KAWAJI Prince Hotel Fire", Journal of JAFSE, 133, pp.4-16, 1981 (in Japanese)
2. Mizuno, M., Ohmiya, Y. and Takao W., "A Human Behavior in the Tenzankaku Hotel Fire -Interview survey on the hotel employees-", AIJ J. Technol. Des., No. 10, 2000 (in Japanese)
3. Ohmiya, Y., Mizuno, M. and Nakano, M., "Human Behavior in the Hotel Fire at Shirahama -Part 2 The results from questionnaire survey to the hotel employees-", proc. JAFSE, pp. 176-179, 1999 (in Japanese)

Study on Feasibility of Evacuation by Elevators in a High-Rise Building

— A Case Study for the Evacuation in the Hiroshima Motomachi High-Rise Apartments —

AI SEKIZAWA
National Research Institute of Fire and Disaster
3-14-1, Nakahara, Mitaka, Tokyo 181-8633, Japan

SHINJI NAKAHAMA and YUKA IKEHATA
Taisei Corporation
344-1, Nasemachi, Totsuka-ku, Yokohama 245-0051, Japan

MANABU EBIHARA and HIROAKI NOTAKE
Izumi Research Institute, Shimizu Corporation
2-2-2, Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-0011, Japan

ABSTRACT

At a building fire, occupants should usually escape to the ground level or a floor of refuge by stairs, but not by elevators. However, in fact in many of the past fires, not a few people used elevators for their evacuation. Also, it is expected that the number of people who have difficulty to use stairs in evacuation would become larger, since the proportion of aged people in the total population has been rapidly increasing recently in Japan. To consider this situation, we made a simplified elevator service model to evaluate effectiveness of evacuation by elevators, and conducted some case studies in order to examine the feasibility and problems of elevator use for evacuation. As a result of case studies, the diverging point of the advantage of evacuation by elevator to compare with evacuation by stairs appears roughly on 14th floor to 16th floor.

KEYWORDS: evacuation, means of egress, high-rise building, elevator

1. INTRODUCTION

In a situation of a building fire, occupants should usually escape to the ground level or a floor of refuge by stairs, but not by elevators. However, in fact in many of the past fires, not a few people used elevators for their evacuation. In the fire of 20 stories Hiroshima Motomachi High-rise Apartments that occurred in October 28, 1996, more than a half of the total evacuees used elevators from the results of our questionnaire survey. We