

Human Behavior During an Evacuation of a Large Office Building Adjacent a Fire Site



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Abstract In 2017 in Tokyo, more than thousand occupants of a seven-story office building evacuated due to fire located at an adjacent site. Because the fire did not occur on their own site, the evacuation was spontaneous and, therefore, not performed according to a normal evacuation manual. This paper investigates the human behavior in this evacuation case, especially focusing on the decision-making process. To do this, the authors conducted face-to-face interviews with four people from the organization who made the decision to let employees evacuate and forty-one employees who evacuated. The major findings of the study are: (1) visual observation of fire through windows influences the occupants' evacuation strategy; (2) occupants tended to postpone leaving the workplace until they received an explicit evacuation cue from others; and (3) multiple occupants chose stairs by taking into consideration that the fire was not in their building. Since the fire compartments had not yet been built and there was no immediate danger to life, these results can also be applied to the evacuation of non-fire floors in a building fire.

Keywords Evacuation · Human behavior · Decision-making · Interview · Office building

1 Background

In June 2017 in Tokyo, there was a fire at a distribution center that was under demolition. Since the burned building was not in use because of the demolition, only a few people were required to evacuate from the distribution center. However, due to a large amount of black smoke from the fire carried by the wind, over a thousand employees working at an office building next to the fire site were evacuated by their company's decision. Ultimately, the fire did not spread to the surrounding buildings

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and the smoke was not toxic enough to claim victims. Despite this, the incident is suggestive as many people evacuated due to the fire in the adjacent building.

The pre-movement phase and route choice are key aspects of human behavior in fires, affecting the required egress time (RSET) [1]. Human response to fires depends a lot on the seriousness of the situation [2]. It has always been debated whether experimental conditions, such as laboratory experiments, evacuation drills, or VR case studies, can reproduce a situation of a fire accurately enough to obtain reliable human behavior data. This is especially true in those conditions that lack the influence of real flames, which provide a strong sense of urgency [3]. Hence, studying real incidents is required and important to strengthen the findings of experimental studies. However, there have only been a few studies that surveyed occupants' behaviors in real fires because of the difficulty in collecting details from rare, unexpected, and confusing disasters. Regarding office buildings, there have been two studies around 1980 in Japan [4–6], one by Brennan [7], and one by Proulx and Reid [8]. Besides these, a lot of studies have investigated evacuation behavior in the 9/11 World Trade Center (WTC) terror attack [9–11]. The High-rise Evacuation Evaluation Database project (HEED project) is the largest project that collects detailed information on evacuees' activities using questionnaires and face-to-face interviews [9]. One of the findings of the HEED project is that the occupants in WTC2, who could see the attacked WTC1 through a window, started the evacuation earlier, on average, than those in WTC1 [10]. In the pre-movement phase, occupants spend the majority of time collecting information about the incident for decision-making [11]. Although observing convincing evidence of fire is hard for occupants of a non-fire floor, occupants in an adjacent building would be able to see it better. Thus, building evacuations arising from fires in other buildings would have peculiar characteristics. However, they have not yet been studied.

In this paper, we surveyed the evacuation from the adjacent office building of which all employees evacuated, focusing on the decision-making process for evacuation. The aims of this study are: Firstly, to explore and compare the characteristics and challenges from adjacent site fire evacuations with on-site fire evacuations; and secondly, to obtain insight into evacuation planning for non-fire floors in a building fire.

2 Situation of the Evacuation

2.1 *The Fire Incident*

The fire site was a demolition site, a four-story distribution center, owned by a food company and located in an urban area in Tokyo. The final burned area was circa 5000 m² of the 9900 m² of total floor area. At the time, 23 workers were involved in the demolition. The fire broke out around four o'clock in the afternoon on a weekday on the first floor through the following process: A spark from a burner that one of

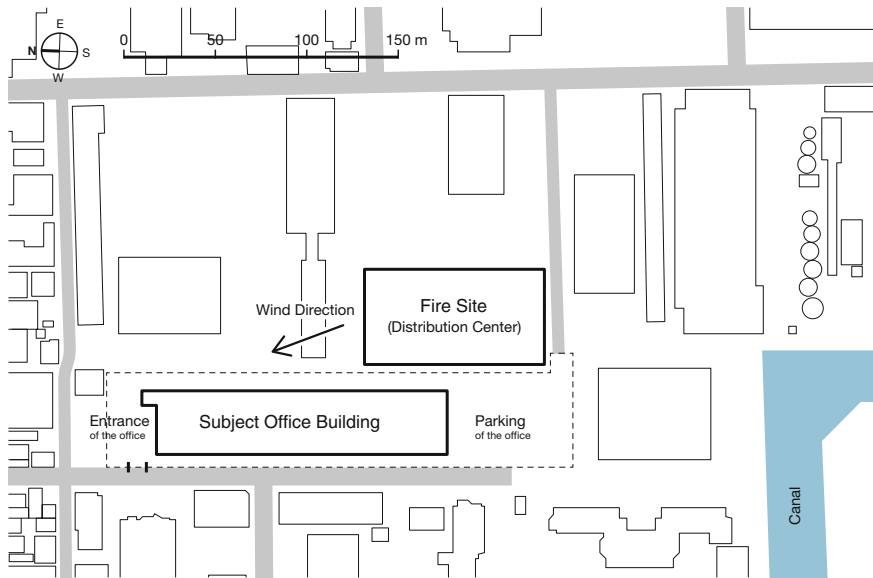


Fig. 1 Location of the subject office building and the fire site

the workers was using to cut a steel frame jumped onto a urethane wall insulation, then the fire spread rapidly with a dense cloud of black smoke. After about three and a half hours, the fire was put out by fire-fighters, which were called by an unknown individual. Since the distribution center was not in use, there were no victims except for the worker that was using the burner that ignited. He survived, but he suffered burns all over his body [12, 13].

The fire did not spread to any other building. However, since it was in a dense building area and the day was windy, an adjacent office on the leeward side, belonging to another company, decided to order a total evacuation for safety. The direction of the wind at that time was from the south-southeast [14], as illustrated in Fig. 1. The subject office building was less than 20 m away from the burned building.

2.2 The Subject Office Building

The office building that was evacuated is seven-stories in which about over thousand employees work. It is owned by a single major construction company and used as one of the head branches; thus, all the employees there belong to the same company group. It can also be said that all evacuees knew the building plan well. However, most of them have never participated to an evacuation drill there.

The second to the sixth floors are normal office spaces, while the ground and first floors are used for specific facilities like a grand entrance lobby, a cafeteria, and

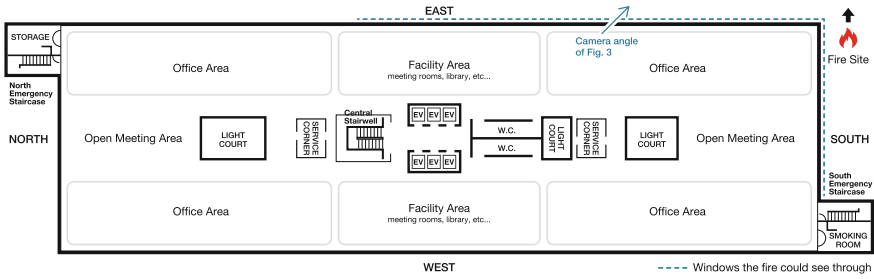


Fig. 2 General floor plan from the second to the sixth floors in the subject office building

seminar halls. Figure 2 shows the general plan of the office floors. The plan has a symmetrical pattern along the north-south and east-west axes. For vertical movement, employees usually use elevators and an open-stairwell in the center of the floor, both of which are not allowed to be used in emergency situations. Emergency staircases are on the edge of the north and south sides. Those staircases are compartmented with fire doors while the central stairwell is open and can be seen from the office area.

Since the fire site is located to the south-east of the office building, the fire could be seen only from the windows on the south-east side (Fig. 3). Nonetheless, people in the west area could also see what was going on in the east because there are neither walls nor tall partitions between west and east except for the central facility areas.



Fig. 3 A video frame of the fire shot through a window from the third floor by an employee before his evacuation

3 Methodology of the Survey

We conducted face-to-face interviews with people from the subject office about the evacuation. The interviewees can be categorized into two groups, the organization-side and the evacuee-side, as described in the following subsections.

3.1 Organization-Side Interviews

The interviewees were two people from the general affairs department of the company (hereinafter referred to as “GA department”) and two people from the disaster control center, which is actually part of the company’s subsidiary. The persons from the GA department included the person who took the call from the disaster control center the day of the fire. The organization-side interviews were done all at once. We asked about the situation and their roles on the day of the fire from the viewpoints of the process of information transfer and the decision-making factors of the evacuation order.

3.2 Evacuee-Side Interviews

The interviewees were employees who evacuated from the office on the day of the fire. There were 41 interviewees in total. They were sampled from each office floor, from the second to the sixth floors, and from different desk positions on the floor, distributed evenly throughout the space. Table 1 shows the distribution of the locations in the office building where the interviewees were when they recognized the fire. The distribution is partly not uniform since some of them were not at their

Table 1 Number of interviewees categorized by evacuation start position

Floor	North-East	North-West	South-East ^a	South-West	Total
Ground floor	1				1
First floor	1	1			2
Second floor	1	2	1	3	7
Third floor	3	3	1	2	9
Fourth floor	2	1		1	4
Fifth floor	3	1	1	2	7
Sixth floor	5	3	1	2	11
Total	16	11	4	10	41

^aThe direction to the fire site

desks when they observed the fire. The interviews with the evacuees took place with two or three interviewers for each interviewee.

The interviewers asked how the interviewees made decisions and acted during the evacuation by following a list of prepared questions. One of the interviewers took notes, either by laptop computer or by hand, while the interviewers were talking with an interviewee.

4 Evacuation Process

This section describes the progress of fire recognition and the evacuation of the subject building based primarily on the organization-side interviews, but partly also on the evacuee-side interviews.

4.1 Recognition of the Fire and Decision to Make the Evacuation Order

As the fire broke out around four o'clock in the evening, most employees were still working since work hours usually ended at a quarter past five. The first person who recognized the fire was a security guard at a guardhouse in the company's private parking on the fire site side. He immediately reported it via radio transceiver to the disaster control center of the office building. Receiving the report, a few people at the control center went to the parking lot to confirm the fire and then called to inform the GA department of the company. A person who took the phone call informed the manager of the GA department. At this point, people in the department could not make a final decision about whether the fire was in an adjacent building or their office building because, even though they were informed that it was the adjacent building by the control center, others said that the roof of their building was burning. There was also no information exchange between the subject office building and the fire site building during the fire.

The manager of the GA department decided to first offer the option to evacuate to all employees and then informed the company executives of the decision afterward, although it was still during office hours and there was no regulation or in-house manual that provided for the evacuation of employees due to an adjacent fire. Since the inside of the office already smelled of smoke, the manager prioritized health and safety generally rather than only responding to the risk of fire.

4.2 Delivery of the Evacuation Order

After the decision to evacuate by the manager of the GA department, employees under him scattered to different floors and conveyed the evacuation to employees verbally.

Meanwhile, a group leader in a secretaries on another floor also recognized the fire. He decided to let his employees evacuate before the evacuation order by the GA department. As he arrived at the entrance of the office building, he found that no one had yet evacuated. He waited at the entrance hall to hear whether an evacuation order would be issued by the organization; however, he did not. Therefore, he went to the disaster control center inside of the building and asked someone there to make an evacuation announcement. At that moment, there were only two or three young men in the disaster control center room because the majority of the people at the center had left to fight the fire in the parking lot to prevent the fire from spreading. Following the request of the group leader for an announcement, they broadcasted an evacuation order to every floor through the PA system. According to the organization-side interviews, the GA department also told the control center to broadcast an evacuation announcement with sentences: "There is a fire in the adjacent area. Please evacuate using the central stairwell or the north staircase." As aforementioned, the central stairwell was not designed to be used in an emergency. However, because the fire was not in the building, they decided to let evacuees use it. The south staircase was, in contrast, excluded since it was located on the fire site side.

However, the acoustic volume of those announcements was too low. Occupants could hear that they were saying something about the fire, but they were not loud enough for most to clearly understand the contents. In those evacuation announcements, the emergency alarm and the official pre-recorded evacuation instructions for fire were not used. Instead, the staff member in the disaster control center broadcasted the evacuation instructions in his own words.

4.3 Execution of the Evacuation and Issuance of the Go-Home Order

With these two evacuation orders, verbally and by broadcast, most of the employees started to evacuate. They went out from the building and assembled at the building entrance. While checking floors, members of the GA department found that some of the employees just ignored the order and continued working at their desks. They, therefore, needed to ask them directly to evacuate. After about five or ten minutes after the evacuation, at around a quarter to five, the GA department issued an announcement allowing all employees to go back to home since office hours were about to end, the fire was still not put out, and the inside of the office was filled with the smell of smoke. Some of the evacuees needed to go back to their desks to collect

their things, and such short-time returns were allowed because it seemed that there was no possibility of the fire spreading. At about six o'clock, the GA department confirmed that there was nobody left in the office building.

5 Evacuees' Behaviors

The behaviors of the evacuees were summarized through an analysis of the evacuee interview records. Remarkable factors of the evacuation were categorized and measured to clarify the decision-making process for evacuation. Some answers were classified by the location of individuals when they recognized the fire.

5.1 Fire Recognition

Table 2 shows the first factors that caused individuals to understand that something unusual was happening before they recognized the fire. At this first stage, they detected an anomaly due to non-visual factors, such as noise, smell, or the movement of others. There was no large difference between the east and west sides or the north and south sides, although the fire could be seen only from the south-east side. Multiple interviewees reported that they first thought the roof of their building was burning because they saw dark smoke coming from the light courts or realized that the inside of the office became darker due to the smoke covering the light courts. One employee answered that they detected something was unusual when he felt heat from a nearby east-facing window. He and other interviewees reported that south-east side windows became hot to the touch.

Table 3 shows the factors by which individuals realized the fire. Two-thirds of the interviewees became aware of the fire by seeing the fire or smoke themselves. While almost all of the interviewees on the south side recognized the fire by seeing

Table 2 First factors for accident perception

Factor	North-East	North-West	South-East	South-West	Total
Noisiness of surroundings	5 (31%)	6 (55%)	2 (50%)	5 (50%)	18 (44%)
Seeing smoke	4 (25%)	1 (9%)		2 (20%)	7 (17%)
Smell	3 (19%)	3 (27%)			6 (15%)
Reports by colleague	2 (13%)	1 (9%)		1 (10%)	4 (10%)
Movement of colleagues			1 (25%)	2 (20%)	3 (7%)
Evacuation announcement	1 (6%)				1 (2%)
Decrease of brightness	1 (6%)				1 (2%)

The percentages in parentheses represent the ratios among each column

Table 3 First factors of fire recognition

Factor	North-East	North-West	South-East	South-West	Total
Seeing fire or smoke	11 (69%)	4 (36%)	3 (75%)	10 (100%)	28 (68%)
Reports by colleague	4 (25%)	4 (36%)			8 (20%)
Others	1 (6%)	3 (27%)	1 (25%)		5 (12%)

the fire/smoke directly, some interviewees on the north side recognized it only by hearing a report. Thus, occupants of the west side moved to the east windows to see the fire site; however, the length of the longitudinal direction of the office plan was too far for onlookers to go to see the fire. Aside from the 24% of the interviewees who could see the fire directly from their desks, 46% of the interviewees said that they purposely moved to a window or another room to see the fire. Alternately, some of the evacuees were unclear where the fire site was even during the evacuation.

5.2 Decision-Making for the Evacuation

Table 4 shows the most important decision-making factors for beginning of the evacuation. Although most of the interviewees answered that they thought that they should evacuate, more than half only started to evacuate after a cue from others. A typical answer was: “I thought that I should. So, I turned off my computer, gathered my personal items, and then waited for an instruction to evacuate.”

Common activities before beginning to evacuate were: saving current work, gathering belongings, talking to or calling colleagues, going to a window and watching the fire, or taking a photo or movie using a mobile phone. The percentage of the interviewees that took photos or videos before evacuating was 22%. One of the interviewees said that they telephoned to the disaster control center and that the center told them to wait for an announcement.

The smell of the smoke was the strongest reason cited for evacuation. As the fire progressed, the smell of the smoke inside the office became stronger and stronger. Some of the interviewees worried that the smoke could be toxic, while others thought

Table 4 Factors on decision-making to start the evacuation

Factor	Total
Evacuation announcement (including those who could not hear the content clearly)	11 (27%)
Order by the GA department	9 (22%)
Self-judgment	7 (17%)
Order by boss	6 (15%)
Conversation with colleagues	1 (2%)
Others	7 (17%)

Table 5 Whether evacuees had anxiousness or concern during the evacuation

Factor	Total
Fire could spread to the office	4 (10%)
Smoke could be toxic	3 (7%)
Some general anxiety or tension	9 (22%)
Not at all	25 (61%)

that they needed to leave the office just because the smell was too uncomfortable to work. As shown in Table 5, most of the interviewees did not believe that there was a danger to themselves.

5.3 Choice of Evacuation Route

Although the central stairwell is for non-emergency use, it was primarily used during the evacuation, as shown in Table 6. As a result, the central stairwell was very crowded during the evacuation. In contrast, most of the occupants avoided using the elevators, which were located next to the central stairwell, even though the elevators worked and were not crowded because they believed that people should not use elevators during an emergency situation. Some of the interviewees who used the central stairwell did know that the central one was not designated as an emergency exit route; nevertheless, they used it either because the fire was not inside of their building or because it was not a consideration at that moment.

The north emergency staircase was also used, especially by the evacuees who were in the north side, but was not used by anybody in the south side (Fig. 4). A large number of evacuees in the south side avoided use of the south staircase, which was located in the direction of the fire site, but they used the central stairwell and none of them went to the north staircase, which was located at the opposite side (Table 7). Multiple interviewees avoided using the emergency staircases because they thought

Table 6 Routes of vertical movement

Factor	North	South	Total
North emergency staircase	12		12
Central stairwell	11	12	23
Elevator	1		1
South emergency staircase		1	1
Lobby stairwell (only between the first and ground floors)	2		2
Multiple staircases		1	1
Not used (already at the ground floor)	1		1

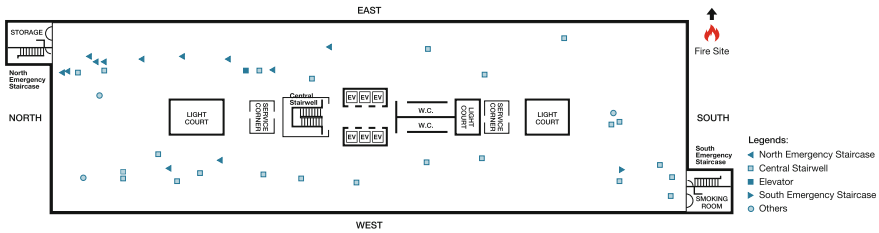


Fig. 4 Distribution of evacuation starting points on floors by classifying into staircase selection

Table 7 Reasons for the choice of the vertical movement route

Reason	North	Central	Elevator	South	Lobby	Multiple	Total
The nearest one	3 (25%)	7 (30%)			2 (100%)		12 (30%)
Followed others	2 (17%)	5 (22%)					7 (18%)
Daily used	1 (8%)	5 (22%)					6 (15%)
Far from the fire	2 (17%)	3 (13%)					5 (13%)
Not crowded	2 (17%)			1 (100%)		1 (100%)	4 (10%)
Suggestion by others	2 (17%)	1 (4%)					3 (8%)
Others		2 (9%)	1 (100%)				3 (8%)

that the exit doors of the emergency staircases might be locked for security reasons and that they would not be able to get through. They said that the door may be able to unlock during a real fire situation; however, they were not sure that it would be unlocked in this case because it was a fire just in an adjacent site.

According to multiple interviews, a significant number of the evacuees switched from the central stairwell to the north staircase on the fourth floor because of a traffic jam in the central stairwell. One occupant decided to switch, and then some others followed. The interviewee who used multiple staircases, as described in Table 6, was one of them.

6 Discussion

6.1 *Decision-Making for Evacuation Under Unclear Circumstances*

Today in Japan, most people are educated about how they should evacuate properly in a building fire. Building owners are also responsible for the evacuation of occupants because of a fire on their site. While evacuation plans for fire are regulated, evacuations due to a neighboring fire are not. Because of that, the occupants were not prepared for the situation.

The official fire alarm was not used during this adjacent fire. Moreover, the disaster control center did not broadcast the evacuation until pressured by an employee. An evacuation announcement is important to allow occupants to evacuate in such a situation in which it is unclear whether they should evacuate. In this incident, some occupants even waited for an announcement when they knew there was a fire. That is, they felt that they needed a definite reason to suspend their work during office hours. The announcement functions not only as a cue to evacuate or as a source of information, but also as permission to leave the position. Therefore, in order to clarify the need to evacuate, it should be considered proper to use the fire alarm during adjacent fires.

6.2 *Evacuees' Assessment of the Adjacent Fire*

Unlike for occupants of building fires, the state of the fire in the adjacent site could be observed by the occupants of the subject office building. Most of the occupants saw the fire directly through windows, and some of them even went to the windows just to observe it closely. Consequently, the occupants recognized the fire at an early stage and understood the positional relationship between the fire and themselves.

At the same time, the occupants belittled the necessity of the evacuation. A substantial number of evacuees understood that the evacuation as “not an actual one,” and therefore, thought that the evacuation route might be different from an “actual” fire situation. The rumor of the locked emergency exits was one of the resulting consequences.

During this fire, the smoke from the adjacent fire site had actually entered the office considerably. The smoke was fortunately not toxic; however, the occupants had to evacuate since it is quite hard for ordinary people to distinguish the toxicity. Therefore, the belittling of the necessity to evacuate could be considered a kind of normalcy bias.

6.3 Use of *Emergency/Non-emergency Stairs*

Regarding this case, non-emergency stairs were used to make the evacuation faster. On the other hand, some evacuees avoided using emergency staircases because they believed that they might be locked. These are both effects of the evacuees' understanding that the fire was "not an actual one." In addition, a significant number of the interviewees thought that the central stairwell was emergency stairs because of the fire shutters surrounding it. The lack of knowledge may be caused by the absence of evacuation drills for every employee. The general evacuation characteristics, "following others" and "using a familiar route," spurred concentration to the central stairwell as well.

7 Conclusions

In this paper, human behaviors in a total evacuation from an office building due to a large fire at an adjacent site were surveyed by interviews with 45 occupants. Evacuations due to an adjacent fire are not commonly planned or regulated. However, for this reason, people know less about what they should do when adjacent fires occur. Regarding this incident, the announcement and evacuation routes did not conform to the proper procedures detailed in manuals for normal fire evacuations.

The remarkable characteristics of human behavior in the evacuation due to an adjacent fire are summarized below:

- No information or evacuation order was conveyed to the subject office from the fire site or other organizations.
- Occupants could observe the adjacent fire from a better angle than a fire in their own building, which allowed a better understanding of the fire state.
- Occupants had less confidence that they should evacuate, and they, therefore, did not move immediately.
- Some occupants thought that emergency staircases could not be used because it was not a real fire situation.
- Occupants took advantage of the main stairwell, which is not allowed for use in a fire.
- Occupants believed that they were safe.

The situation of this incident did not require immediate action, but indeed an evacuation. That is, the occupants' behavior had some similarities to an evacuation from a non-fire floor in a building fire. These include, for example, going to another place to confirm the state of the fire; taking photos/movies of the fire site; or psychological barriers to evacuation without an explicit order. Meanwhile, comprehensively speaking, the uncertainty of the adjacent fire caused the occupants to make individual risk assessments. They decided that fire would not spread to their building, even though the windowpanes became hot. Theoretically, people should evacuate as soon as they

have information about a fire, even if they cannot confirm it; however practically, they often postpone or dismiss the evacuation.

This study confirmed the factors influencing this phenomenon in an actual case. Taking this knowledge into consideration, professionals, such as fire safety engineers, government officials, and building managers, should develop measures to encourage evacuation at an early stage while the risks are still low. This viewpoint can be applied to evacuations, not only due to an adjacent fire, but also due to a non-fire floor evacuation in a building fire.

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