



## EVACUATION BEHAVIOR FOR STRANDED COMMUTERS DUE TO THE 2018 NORTHERN OSAKA EARTHQUAKE

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### **Abstract**

On Monday, June 18, 2018, at 7:58 a.m., the 2018 Northern Osaka Earthquake occurred in a large metropolitan area during the morning commute. Since the earthquake struck on a weekday, there was an unusually large number of stranded commuters on trains and in train station premises. The countermeasures for stranded commuters that were being promoted at the time focused on workers in business offices and terminal stations. Those measures were inadequate for the stranded commuters of the 2018 earthquake. Similarly, many university students became stranded during their commute to school. The evacuation behavior of the stranded commuters was disordered.

Therefore, a survey was conducted by a questionnaire given to Osaka City University staff and students who were commuting or planning to go to the university at the time of the earthquake to compare their evacuation behavior. The contents of the survey included the commuter's situation at the time of the earthquake, evacuation behavior, evacuation judgment, and disaster prevention awareness.

Among the staff members and students surveyed, 536 staff members and 595 students submitted valid responses. On the day of the earthquake, 443 staff members and 432 students used a railway for their commute to the university. Among the rail commuters, 172 staff members and 281 students experienced the earthquake while on the train or at the station.

Ninety-two staff members and seven students who were on a train or at a train station at the time of the earthquake proceeded to the university after the earthquake. Some of the reasons for proceeding to the university were "I was close to the university, and there were lectures and duties" and "I did not think the lectures would be cancelled." Of the staff members and students who were on the train at the time of the earthquake, 80 staff members and 273 students did not proceed to the university. The reason given by staff members was "the service was suspended." The reasons given by the students were "there might be aftershocks" or "I wanted to be with my family".

According to the survey, 53 staff members and 158 students required more time than expected to return home. The average difference between the expected return time and the actual return time for staff members was -72.1 minutes, with a range of -540 minutes to +600 minutes. The difference for the students was -77.3 minutes, with a range of -700 minutes to +480 minutes.

Staff members and students had the same destination, but there was a difference in evacuation behavior between the two groups. The results are useful for future plans to evacuate stranded commuters.

*Keywords: the 2018 Northern Osaka Earthquake, evacuation behavior, stranded commuters*



## 1. Introduction

On Monday, June 18, 2018, at 7:58 a.m., an earthquake occurred in the northern part of Osaka Prefecture. A 6-lower earthquake was observed for the first time in the prefecture. Many commuter rail lines were suspended since the earthquake occurred on a weekday, during the morning commute. As a result, a large number of people were unable to return home, and the number of train passengers, including those on the Shinkansen, affected by the earthquake reached approximately 2.7 million. This is a rare case because of the large number of people who could not return home after school or work. Since many people could not return home after the Great East Japan Earthquake of 2011, Osaka Prefecture and Osaka City established a council to create measures for stranded commuters at major terminals in Osaka City (Osaka-Umeda Station, Namba Station, Tennoji-Abeno Station, Kyobashi Station, Uehonmachi / Tanimachi 9-chome / Tsuruhashi Stations). The council formulated guidelines and manuals for those stranded commuters and has been conducting training. These guidelines describe the inability of commuters to return home because of the suspension of train lines, and the securing of alternative modes of transportation to support those commuters. However, Osaka Prefecture and Osaka City deemed that there was no large-scale confusion regarding stranded commuters after the 2011 earthquake, so the measures prescribed in the guidelines were not implemented [1]. Contrary to the prefecture's and the city's findings, after the 2018 earthquake, some stranded commuters were confused about what to do until the following day.

The problem of stranded commuters also occurs with various schools where many staff members and students commute by train. Elementary and junior high school students generally have shorter commutes; however, as the students advance to high school and university, the commute becomes longer. It is also expected that there are many students who commute to school using public transportation, because the amount of walking required will exceed the maximum distance [2] of 20 kilometers. Many students who commute to the university were affected by the 2018 earthquake, and it was thought that there were issues obtaining and determining evacuation information. Therefore, Osaka City University Center of Education and Research for Disaster Management conducted a survey of Osaka City University staff members and students about their situations, actions, judgments, disaster prevention awareness, etc., at the time of and after the earthquake. The purpose of this survey was to obtain basic data for studying measures that ensure the safety of staff members and students in the event of a disaster and that assist those who are stranded commuters.

## 2. Research Method

The survey was conducted during the periods of July 9-12 (students) and 19-26 (staff members), 2018. Using a form from Microsoft Office 365, we requested a response from staff members and students on the WEB screen. In order to target students whose commutes were affected by the earthquake, a request was made to students who were scheduled to attend class during the first period of June 18, 2018. The contents of the questionnaire to the university staff and students were the following: demographics of the respondents (8 questions), past experiences with earthquakes (5 questions), commuting status on the day of the earthquake (18 questions), safety confirmation (6 questions), returning home status (7 questions), information collection (5 questions), injuries (6 questions), and disaster preparedness and awareness (4 questions). The research was approved by the Osaka City University Graduate School of Human Life Science Research Ethics Committee (application number 18-22).



### 3. Results

Valid responses were obtained from 536 staff and 595 students.

#### 3.1 Demographics of the respondents

There were 282 male, 248 female and 6 gender unknown staff members. The average age of a staff member was  $44.5 \pm 11.5$  years of age ( $47.5 \pm 10.8$  years of age for men, and  $41.4 \pm 10.8$  years of age for women). There were 307 male and 288 female students. The average age of a student was  $18.5 \pm 0.8$  years of age ( $18.7 \pm 0.9$  years of age for men, and  $18.4 \pm 0.7$  years of age for women).

#### 3.2 Commuting means

The number of staff members and students who used a train for all or part of their commutes was 443 (443/536 82.6%) and 432 (432/595 72.6%), respectively. Of those who did not use a train for their commutes, 93 (93/536 17.4%) were staff and 163 (163/595 27.4%) were students.

#### 3.3 Average commuting time

The average daily commuting time for staff members who use a train for all or part of their commute was  $58.9 \pm 26.3$  minutes. The average daily commuting time of students who use a train for all or part of their commute was  $74.3 \pm 26.9$  minutes. The average daily commuting time of those who did not use a train was  $21.2 \pm 15.2$  minutes for staff members and  $14.0 \pm 12.4$  minutes for students.

#### 3.4 Location at the time of the earthquake

At the time of the earthquake, 263 (49.1%) staff members were at home, 214 (39.9%) were commuting to the university, 35 (6.5%) were at the university, and 24 (4.5%) were at other locations. Of the staff members who were commuting at the time of the earthquake, 44 (20.6%) were at station premises, 128 (59.8%) were inside a train car, 34 were on the road (15.9%), and 8 (3.7%) were at other locations. At the time of the earthquake, 270 (45.9%) students were at home, 311 (52.3%) were commuting to the university, 4 (0.7%) were at the university, and 14 (2.3%) were at other locations. Among the students who were commuting at the time of the earthquake, 57 (18.3%) were at station premises, 224 (72.0%) were in train cars, and 30 (9.6%) were on the road.

#### 3.5 Proceeding to the university after the earthquake

One hundred forty-nine (56.7%) of the staff members who were at home and 121 (43.3%) of the staff members who were commuting to the university proceeded to the university. Sixty-three (23.3%) of the students who were at home and 12 (3.9%) of the students who were commuting to the university proceeded to the university. Of the staff members who were at station premises, 22 (50.0%) proceeded to the university, and 22 (50.0%) did not. Of the 22 that did not proceed to the university, 14 evacuated to evacuation centers. Two (3.5%) of the students who were at station premises proceed to the university, and 55 (96.5%) did not. Of those 55 students, 20 evacuated to shelters. Seventy (54.7%) of the staff members who were in train cars proceeded to the university, and 58 (45.3%) did not. Of those 58 staff members, 26 evacuated to evacuation centers. Five (2.2%) of the students who were in train cars proceeded to the university, and 219 (97.8%) did not. Of those 219 students, 68 evacuated to evacuation centers.

#### 3.6 Expected and actual commuting times

The difference between the expected commuting time and the actual commuting time from home is shown in Figures 1 and 2. The average difference, which is the expected value minus the actual value between the



expected and the actual commuting times was  $1.01 \pm 20.74$  (AVG  $\pm$  SD) minutes for staff members, with a range of -90 minutes to +110 minutes. The average difference for students was  $-0.95 \pm 4.52$  minutes, with a range of -30 minutes to +5 minutes.

The difference between the expected and actual commuting times while commuting is shown in Figures 3 and 4. The average difference between the expected and actual commuting times was  $-72.9 \pm 161.54$  (AVG  $\pm$  SD) minutes for staff members, with a range of -540 minutes to +600 minutes. The average difference for students was  $-8.33 \pm 23.75$  minutes, with a range of -60 minutes to +20 minutes.

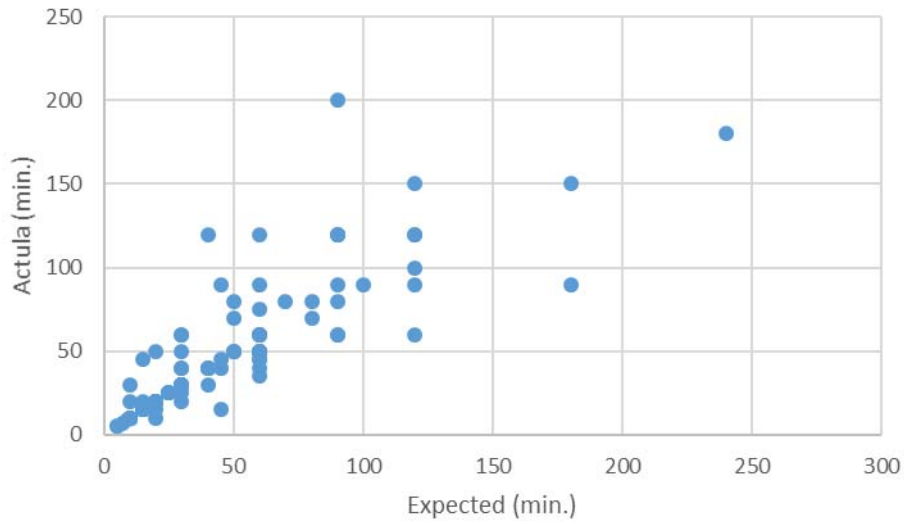


Figure 1 Expected and actual commuting times for staff from home

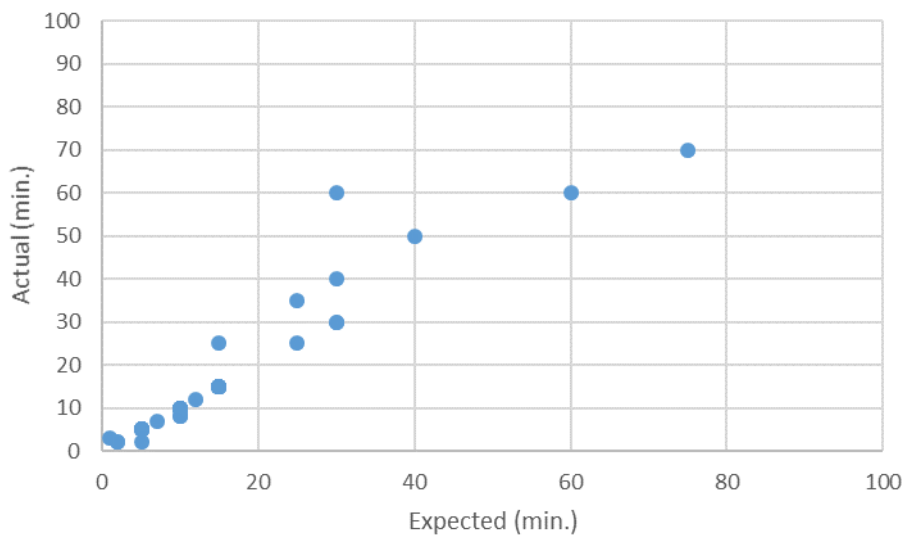


Figure 2 Expected and actual commuting times for students from home

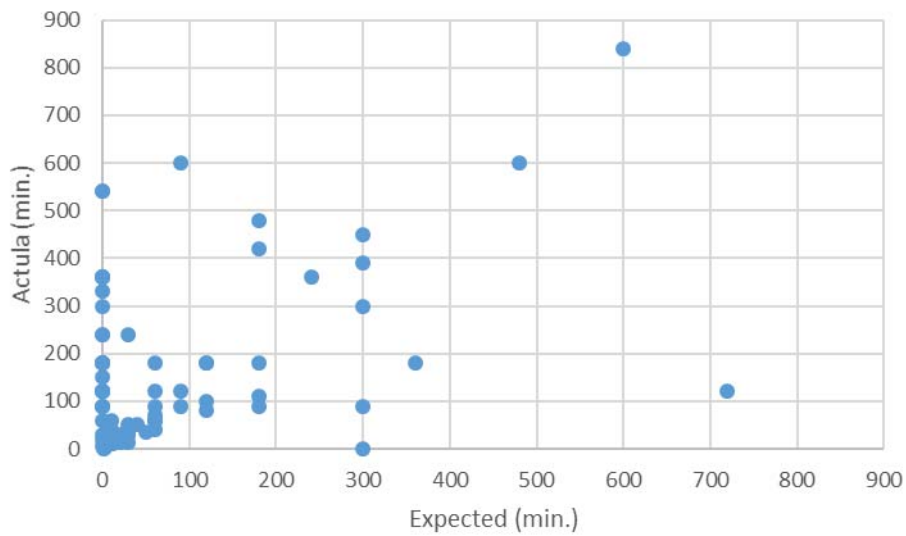


Figure 3 Expected actual commuting times for staff while commuting

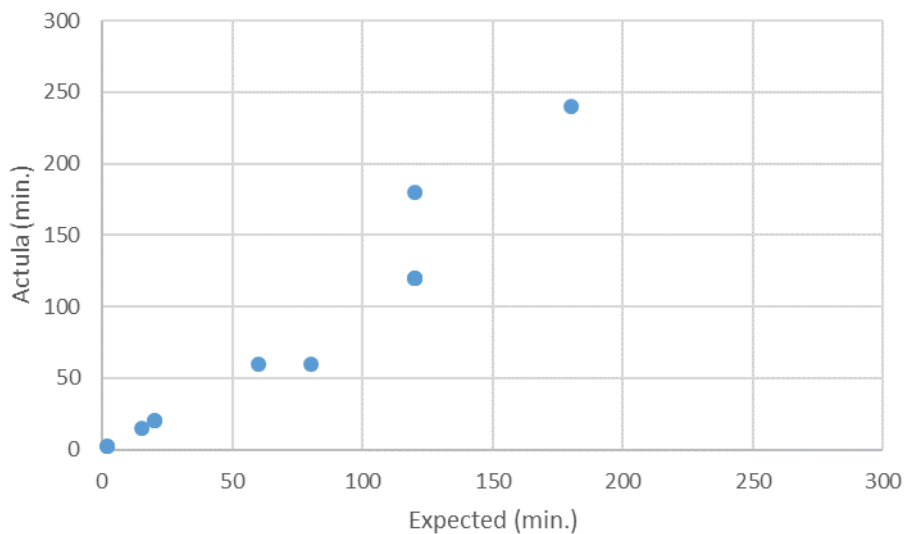


Figure 4 Expected and actual commuting times for students while commuting

### 3.7 Reasons for not proceeding to the university

The main reasons given by staff members for not proceeding to the university were the following: "I was on my way, but I thought that service was suspended, and I could not go to the university"; "I was on my way, but I could not return home because service was suspended"; and "I thought it was important to be with my family at home." The main reasons given by the students were the following: "I thought that service was suspended, and I could not go to the university"; "I thought the university was closed"; "I thought there was a possibility of aftershocks, and I thought I should not go outdoors."



### 3.8 Reasons for proceeding to the university

The main reasons given by staff members for proceeding to the university were the following: "I had to go to the university because of lectures and work," "I thought it was better to go to the university," and "I did not think the earthquake would hinder lectures and work." The main reasons given by the students were the following: "I didn't think an earthquake would hinder my lectures," "I was already more than halfway to the university," and "I did not know the earthquake happened."

### 3.9 Returning home (proceeded to the university)

Of the 305 staff members who went to the university before or after the earthquake, 69 (22.6%) returned home on foot, 124 (40.7%) returned home by rail, and 5 (1.6%) did not return home. Of the 84 students who went to the university before or after the earthquake, 26 (31.0%) returned home on foot, 12 (14.3%) returned home by rail, and 4 (4.8%) did not return home.

### 3.10 Returning home (could not proceed to the university)

Of the staff members who could not proceed to the university (by any means) after the earthquake, 47 (50.5%) returned home on foot. Of the students who could not proceed to the university by train after the earthquake, 161 (53.8%) returned home on foot, and 152 (50.8%) returned home by rail.

### 3.11 Expected return distance

The average expected distances home for staff members and students who could not proceed to the university (by any means) after the earthquake was 5.4 kilometers for staff members (N = 50), and 26.2 kilometers for students (N = 275).

### 3.12 Expected return time and actual return time while commuting

The difference between the expected return time and the actual return time is shown in Figures 5 and 6. The average difference between the expected and the actual return times was  $-72.1 \pm 161.7$  minutes for staff members, with a range of -540 minutes to +600 minutes. The average difference for students was  $-77.3 \pm 168.1$  minutes, with a range of -700 minutes to +480 minutes.

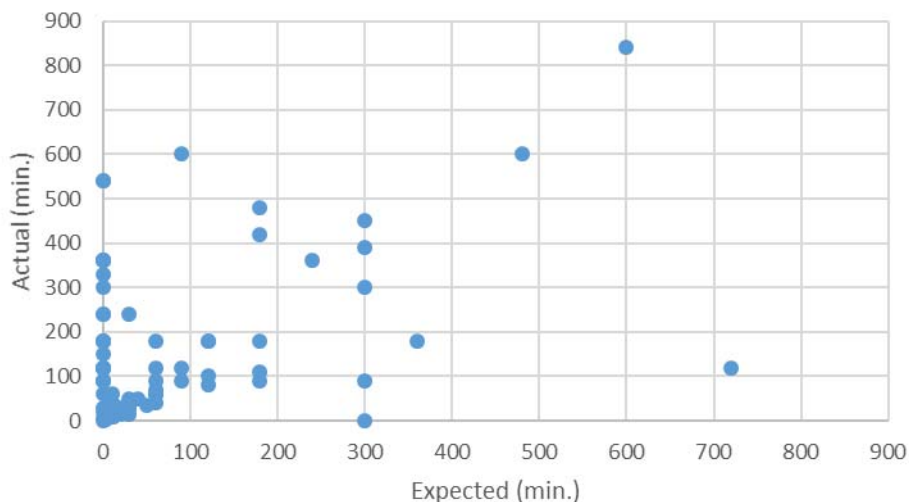


Figure 5 Expected and actual return times for staff members while commuting

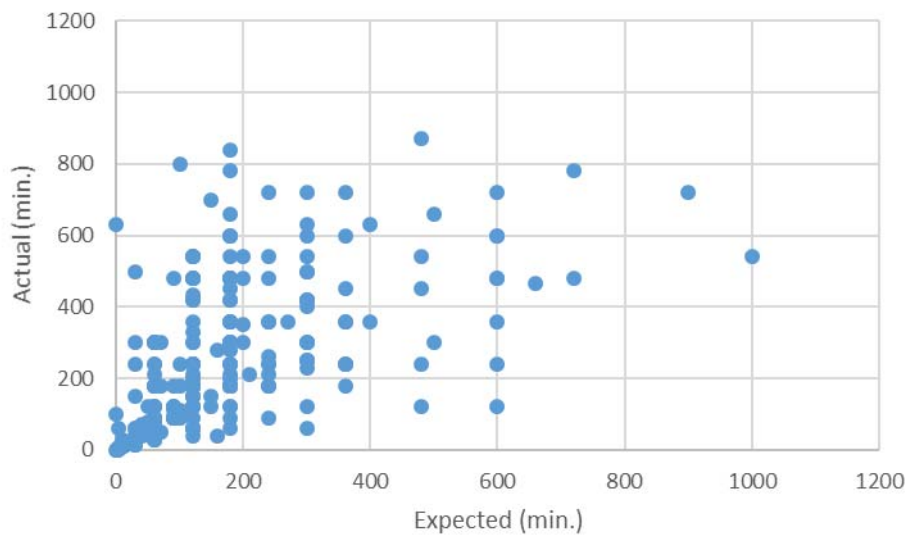


Figure 6 Expected and actual return times for students

#### 4. Discussion

The surveyed university is located in Osaka city, and is directly connected to JR stations and within walking distance of subway stations. More than 80% of staff and 70% of students use railways. If a railway is suspended, as many were in this earthquake, it is thought that it will have a very large effect. The commuting time for staff was about one hour, and the student's commuting time was slightly longer than an hour. Staff members can choose a residence depending on where they work, and students may choose to live near the university or commute from their parents' home.

About 50 minutes before the earthquake, approximately 50% of the staff were at home and about 40% were commuting to the university. Students began lessons 10 minutes later than the starting time for staff members, but about half were at home. About 60% of the staff and about 70% of the students were in train cars when the earthquake happened. It is probable that the staff and students experienced the earthquake in an environment different from their homes and work/school and were forced to make a decision.

The percentage of staff who were at home and proceeded to the university after the earthquake was more than twice that of the students. It is probable that the staff decided to go to work based on their professional responsibilities, even though they did not receive any notices from the university. Similarly, the percentage of staff who were at station premises and proceeded to the university after the earthquake was about 10 times higher than that of the students. It is probable that, after some time passed, the students received a notification that class had been cancelled and decided to return home.

Looking at the expected and the actual travel times for those who were commuting at the time of the earthquake and proceeded to the university afterwards, the expected and actual times were similar. It can be said that this is easy to expect correct time for people who decided to proceed to the university. Commuting from home after the earthquake had similar results.

Looking at the time to return home, both staff and students required more time than expected. It is difficult to decide to return home in the event of a disaster. Staying within a business establishment is recommended because returning home on a simple assumption is risky behavior.



## 5. Conclusion

In this study, we analyzed the post-earthquake evacuation behavior of stranded commuters, which is a major part of earthquake disaster prevention measures in cities. Current measures for stranded commuters assume that the commuters have already arrived at school or work when the earthquake occurs and do not consider the effects on people who are commuting to school or work when an earthquake occurs, as happened with this earthquake. It is common for a city to have a large and diverse population, such as workers and students, moving at the same time, and this can cause great confusion during a large-scale disaster. In this study, we clarified the differences in means of commuting to the university between staff members and students, as well as the differences in judgment and evacuation behavior after an earthquake. Many faculty members went to work despite the earthquake. Also, many people were optimistic about the time needed to return home. It is necessary to take measures to assist stranded commuters based on these characteristics of urban residents.

## 6. Acknowledgement

We would like to thank the staff and students of Osaka City University for their cooperation in this survey.

## 7. References

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