Crowding of Support Facilities for People who have Difficulty Returning Home on Foot after a Large Earthquake

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Abstract

When a large earthquake occurs, many people are presumed to have difficulty in returning home. However, no research has been achieved yet to discuss the congestion of supporting facilities for stranded people in terms of site, the number and spatial distribution. In this study, we construct a simulation model, which describes people's behavior such as returning home or going to other facilities after an earthquake occurs. Using the model, we estimate the congestion of facilities which varies according to day of the week or the time when the event occurs.

Keywords: large earthquake, difficulty in returning home, facility for temporary stay, facility supporting people returning home on foot, congestion.

1. Introduction

The Great East Japan Earthquake (March 11, 2011) caused little material damage in the Greater Tokyo Area, but transport systems were paralyzed and a large number of people had difficulty returning home. As a result, the Tokyo Metropolitan Government enacted the Ordinance on Measures for Stranded Persons (which came into effect in April 2013). This ordinance advances measures and preparations by local governments in the Greater Tokyo Area for an imminent earthquake directly beneath the capital city, including designating temporary shelters and support stations to help those trying to return home. In the present study, we estimate the level of crowding of various facilities (temporary shelters, support stations, and train stations) relevant to supporting people who have difficulty returning home in the Greater Tokyo Area by constructing a model to describe the movement of people and their choice behavior regarding facilities after a large earthquake, and simulating movement on foot assuming an earthquake directly beneath the capital city.

2. Construction of Walking Simulation Model

2.1. People and Facilities Subject to Simulation

The people subject to simulation were extracted from the 2008 Tokyo Metropolitan Person Trip Survey data (hereinafter, PT data). Specifically, in order to conduct an analysis that focuses on people returning home on foot from the city center to the outskirts of the city and the crowding of facilities in the city center and its vicinity, people passing even just once through the area within a 20 km radius of the city center (Imperial Palace) were extracted from the PT data and taken as subjects of the analysis.

2.2. Construction of Walking Model

Figure 1 show a model that describes the travel behavior of people in the city after a large earthquake (walking model). Based on the intention model (Osaragi, 2016a), which describes decision-making and behavior of individuals, people who are at their place of work or school when the earthquake strikes were assumed to either stay where they are or head home. Other people were assumed to head either home, to their place of work/study, or to some another place. Among the people who head toward some other place, those who have location information of shelters were assumed to head toward a temporary shelter, whereas those who do not have location information were assumed to head toward the nearest train station. Here, people other than those who stay at their place of work/study were defined as “walkers”, and the timing of the start of their action was established based on the results of a survey carried out after the Great East Japan Earthquake (Hiroi et al., 2011). After starting their action, they were considered to walk toward their destination, stopping at support stations and train stations along the way for a rest and to use the toilet. Also, physical limit distances (Cabinet Office, 2008) were set on the basis of sex and age. When walkers approached a place within 2 km from their physical limit distance, they were assumed to give up on going to their original destination and to change their destination to a nearby temporary shelter or train station (people who have given up on walking). Furthermore, walkers who reached their physical limit distance were assumed to stop walking and stay where they were (people staying in the street).

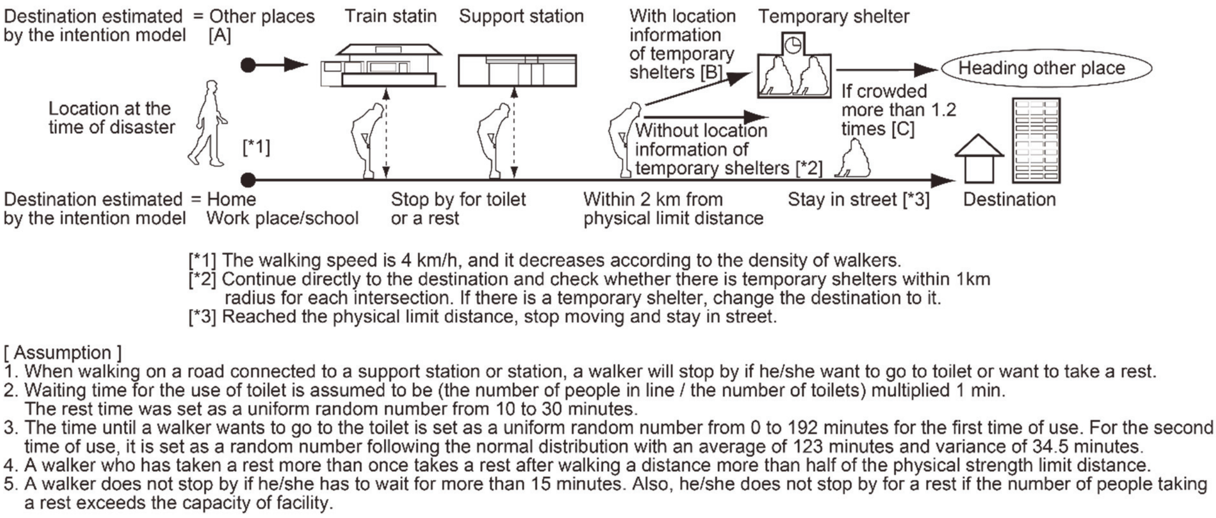

Figure 1. Outline of Walking Model.

2.3. Construction of Facility Choice Model

Facility choice behavior was modeled under various situations and circumstances (Figure 2(1)). First, facilities located further than the reachable distance (Figure 2(2)) and severely overcrowded facilities were considered unlikely to be chosen, and so these facilities were excluded from the destination choices. Then, the model was created by multiplying each facility by a weighting according to each person's situation and circumstances, and assuming that people head toward the facility with the highest value.

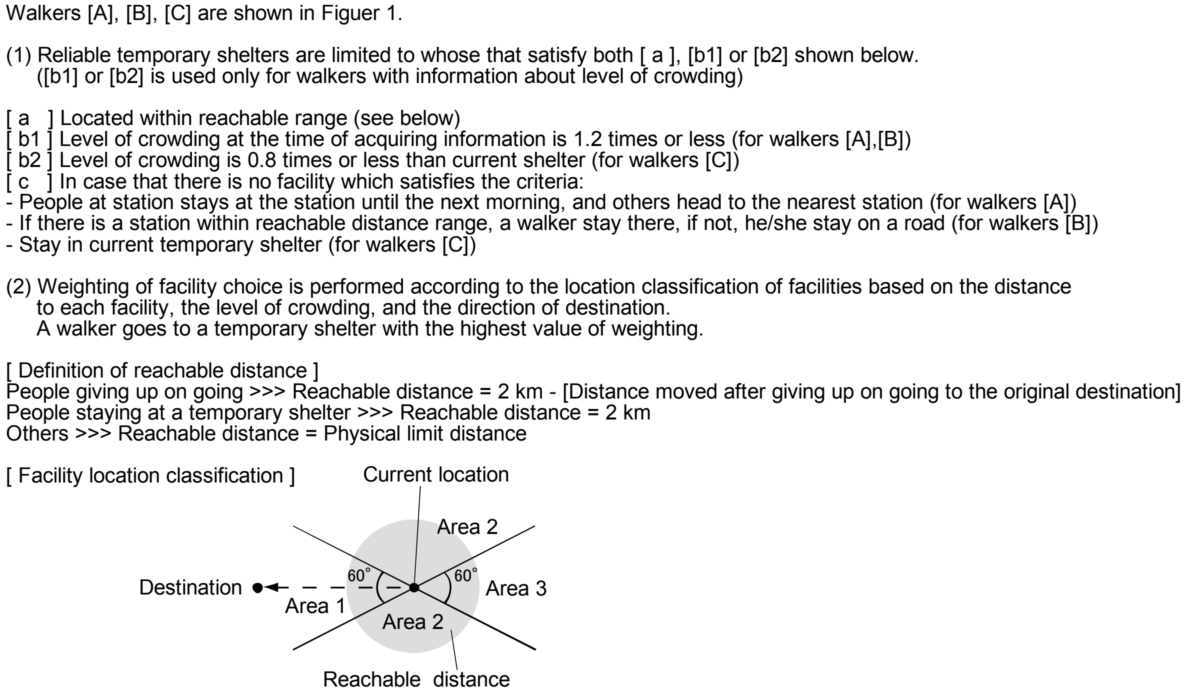

Figure 2. Outline of Facility Choice Model.

2.4. Simulation Assumptions

It is assumed that an earthquake occurs directly beneath the capital city and all public transportation in the Greater Tokyo Area becomes paralyzed. The earthquake was assumed to occur at 9:00, 14:00, or 18:00 on either a weekday or a non-business day (Osaragi, 2016b), and at 8:00 on a weekday only, supposing occurrence during the weekday commuter rush.

3. Estimation Results for Crowding

3.1. Crowding of Temporary Shelters

The level of crowding of temporary shelters is high when the earthquake occurs at 14:00, a time at which there are many people in the city center. Particularly on non-business days, there are many people in the city center eating, shopping, and other activities, and so the level of crowding of train stations and temporary shelters becomes very high (Figure 3(a)). Crowding decreases as distance from the city center increases. However, approximately 12 to 14 km from the city center, crowding increases because many people give up on walking while returning home and the density of facilities is low (Figure 3(b)). Looking at the spatial distribution of crowding, the highest level of crowding is found in the vicinity of Shinjuku Station on a non-business day (Figure 3(c)).

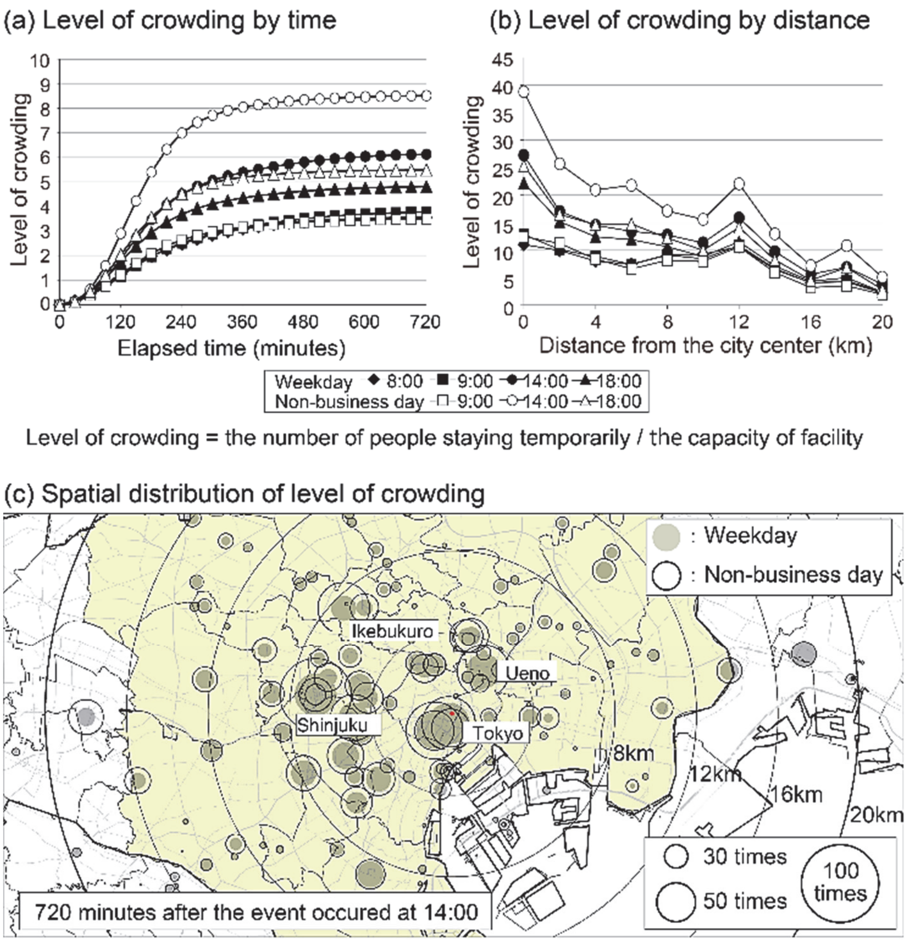

Figure 3. Estimated Congestion Degree of Primary Lodging Facilities.

3.2. Crowding of Support Stations for People Trying to Return Home

On weekdays, many people return home on foot from their place of work/study in the city center to the outskirts of the city, and so crowding of toilet facilities is found to be greater than on non-business days (Figure 4(a)).

Since walkers take a rest after walking for a certain distance, the number of people resting reaches a peak approximately 4 hours after the earthquake on non-business days, and approximately 5 to 6 hours after the earthquake on weekdays (Figure 4(b)). The number of people taking a rest is higher on weekdays than on non-business days, and it is particularly high when the earthquake occurs at 9:00 or 14:00. Looking at the spatial distribution, there is a succession of facilities where the numbers of people taking a rest are extremely high along the main arterial roads (Figure 4(c)).

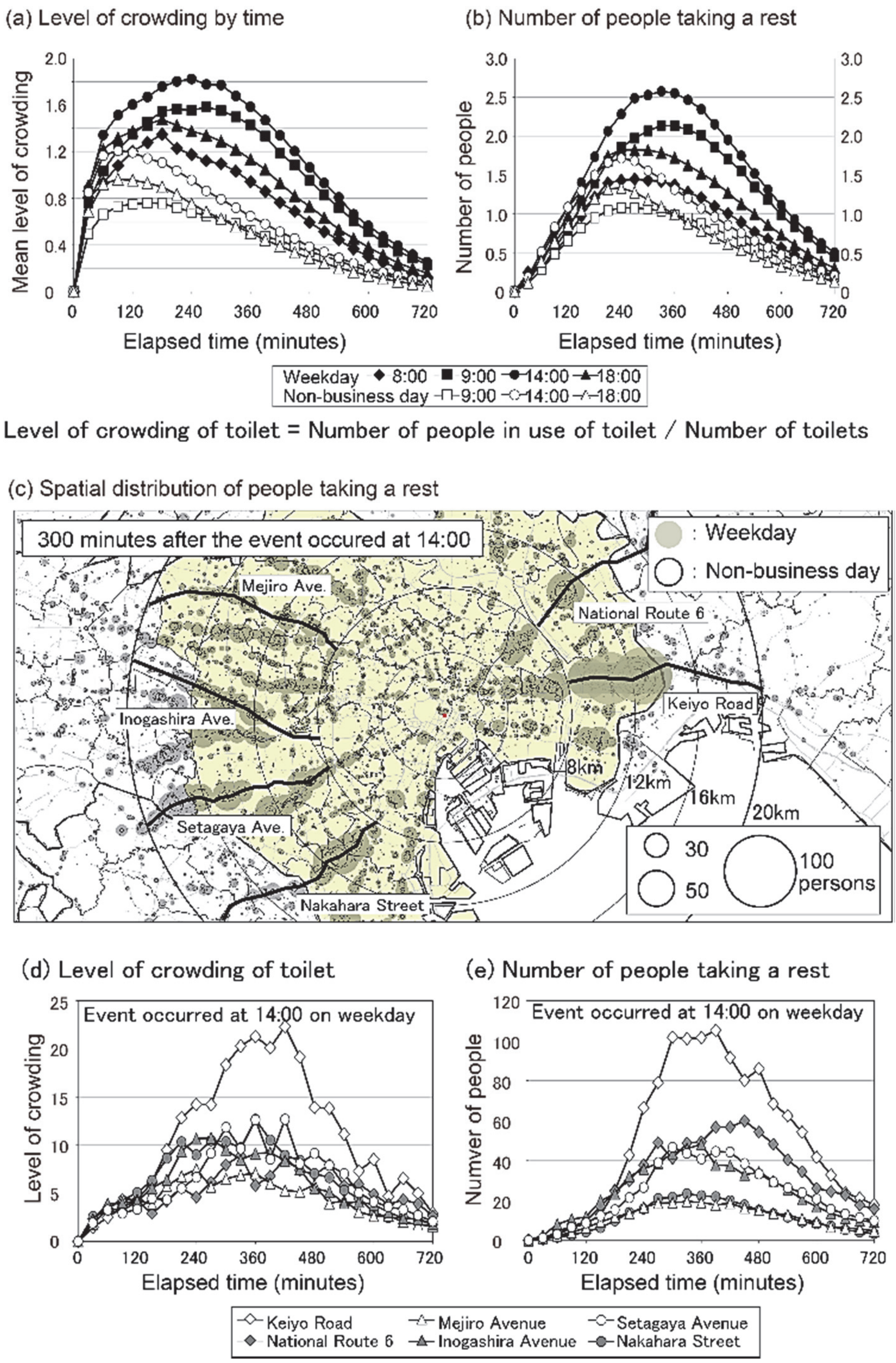

Figure 4. Level of Crowding of Support Station for People Returning Home on Foot.

3.3. Crowding of Train Stations

When the earthquake occurs at 8:00 on a weekday, a time at which many people are on their way to work or school, extremely large numbers of people stay inside train stations (Figure 5(a)). Looking at the spatial distribution, a large number of people stay at each station on Yamanote Line (Figure 5(c)). In contrast, when the earthquake occurs at 14:00 on a non-business day, people staying in the vicinity of the station gather gradually, and they become most numerous between 1 and 2 hours after the earthquake (Figure 5(b)).

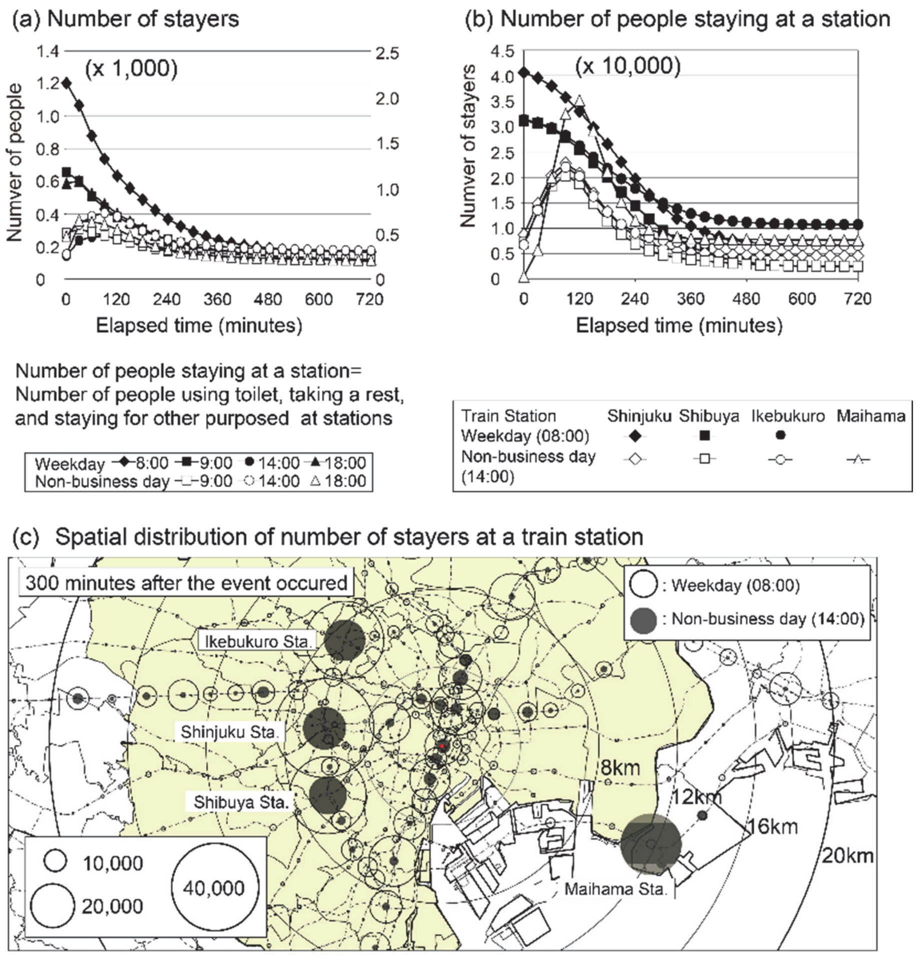

Figure 5. Spatial Distribution of Number of Stayers at a Train Station.

4. Summary and Conclusions

In this study, the travel behavior of people in Tokyo after a large earthquake was modeled, and the levels of crowding of facilities for people who have difficulty returning home were estimated by performing simulations of people traveling on foot. The results showed that temporary shelters become most crowded when the earthquake strikes at 14:00 on a non-business day, a time at which there are many people (eating and shopping) in the city center with nowhere to shelter after the quake. The results also showed that support stations for people trying to return home become crowded when the earthquake occurs at 14:00 on a weekday, an occurrence time that generates a large number of walkers. The number of people staying at train stations is highest when the earthquake occurs at 8:00 on a weekday, a time at which many people are commuting to work or school.

5. References

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