# Information collection of road blockage for improving accessibility of fire brigades at a large earthquake

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**Abstract**

In the event of a devastating earthquake, a number of roads will be damaged and/or blocked by collapsed buildings. It is assumed, therefore, that the use of emergency vehicles is expected to be paralyzed and unavailable. In this paper, we evaluate the information collection of road-blockage that will assist fire brigades in their effective and efficient access to the locations of fires. More specifically, first, we construct a simulation model that describes the movement of fire engines under the condition of street-blockages caused by collapsed buildings. Next, using the proposed model, we attempt to evaluate the effects of street-blockage information collected by residents for improving the accessibility of fire engines. Finally, we demonstrate that the access time to the locations of fires can be effectively reduced by using the road blockage information.
*Keywords*: large earthquake, fire brigade, accessibility, road blockage, information collection, multi-agent simulation

## 1 Introduction

Estimated Damage from a Tokyo-Epicentered Major Earthquake [4] is reporting that fire will occur from 800 or more buildings, and 20,000 or more people will be killed by fire. The rapid fire-fighting is very important for damage reduction [3]. However, in the densely built-up wooden residential areas, narrow streets will be blocked by collapsed buildings, and fire-fighting activities are likely to be interfered [1]. Given the urgency of Tokyo-Epicentered Major Earthquake, it is necessary to consider the strategy of fire-fighting under the assumption of the occurrence of road blockage [2]. We will perform the simulation of road blockage and fire brigade movement, and demonstrate the effects of collecting road-blockage information for the access time of fire brigades.

## 2 Modeling of road blockage and fire brigade movement

For estimating physical damage, we adopt some sophisticated models that were built on the basis of the damage survey on major earthquakes that occurred in the past. By applying these models, property damage of building collapse and road blockage are estimated.

As for the movement of fire brigade, we construct a model that describes their behaviours. Fire brigades will drive to water conservancies by fire engines, and move to burning-buildings with carrying hoses. A method of searching route by fire brigades is modelled as follows.

In the case that no information on road blockage is available, a new route to a destination (burning-building) is searched using all roads. When fire brigades encounter a road blockage on the way to the destination, a route is searched again from that position. At this moment, they memorize the encountered locations of road blockage. In the case that information on road blockage is obtained, a route is searched using all roads excepting known blocked roads.

## 3 Impact of road blockage in arrival time of fire brigade

### 3.1 Assumption of simulation

Assuming the occurrence of Tokyo Bay Northern Earthquake (M7.3), we create different physical damage patterns by using the established models, and perform simulations of fire brigade movement 100 times. We assume the following four cases (a) - (d), and the necessary time for arriving at the burning-building (access time) is estimated.

Case (a) *no-blockage*: road blockage does not occur.

Case (b) *no blockage-information*: road blockage occurs, but no information about road blockage is obtained.

Case (c) *no-blockage on emergency transportation roads*: The road blockage occurs, but no emergency transportation road is blocked.

Case (d) *perfect blockage-information*: road blockage occurs, but we know all the locations where roads are blocked.

### 3.2 Delay of arrival time due to road blockage

From comparison of "*no blockage-information*" with "*no-blockage*", we can know the access time increases up to about 270% in average. Hence, the impact of road blockage on the arrival time is very large.

### 3.3 Effects of earthquake resistance of roadside buildings located along emergency transportation roads

In the case of "*no-blockage on emergency transportation roads* ", it is possible to reduce access time more than 50%. This fact indicates the importance to prevent any blockages on the emergency transport roads. However, there exist regional differences in the decrement of the access time, since the dependency on emergency transportation roads varies according to regions.

### 3.4 Shortening of arrival time by use of road-blockage information

In the case that all the locations of road blockages are known (*perfect blockage-information*), the above regional differences are not large. Also the decrement rate of access time in any areas is about 55% in average. Namely, we can effectively shorten the access time of fire brigades in any region, if we could collect the information about road blockage just after the event occurs.

## 4 Collecting disaster information

### 4.1 Modeling of information collection by local residents

We assume three models (*gathering-collection*, *random-collection*, *mixed-collection*), which describe the behaviors of information collection by residents.

The number of residents to collect blockage information is assumed to be about 0.1% from total residents, and their locations at the time of the event are allocated at random on intersections of roads.

(1) *gathering-collection* residents are assumed to collect blockage information while moving to the nearest fire station, and after arriving at the fire station, they don't collect any information.

(2) *random-collection* residents are assumed to walk randomly during 10 minutes after the event occurs, and to collect the blockage information. It is assumed that they try to walk on streets which they have never go through before.

(3) *mixed-collection* residents are composed of the above-mentioned residents (1) and (2) (50% for each).

### 4.2 Regional characteristics of effects of information collection

The information collected by the *gathering-collection* residents is sometimes overlapped in the vicinity of fire stations, and they do not collect information after arriving at fire stations. Therefore, the rate of collected-information after 10 minutes is around 25%. The rate of collected-information by *random-collection* residents is over 40%. Their capability of collecting information is superior to that of *gathering-collection* residents. However, the access time of fire brigades to the destinations is efficiently reduced, when information is collected by *gathering-collection* residents. Unblocked roads, which are observed by *random-collection* residents, tend to be discontinuous. In contrast, unblocked roads, which are observed by *gathering-collection* residents, allows efficient movements. This is because access routes are obtained continuously and radially from fire stations, and also, blockage situations in the vicinity of the fire stations can be almost completely available. The *mixed-collection* residents perform stably highly effective, since they compensate the disadvantage and also activate the advantages of *gathering-collection* and *random-collection*. Moreover, unlike "*perfect blockage-information*", the access time of any information collection shows regional differences. That is, when collecting the information by a limited number of residents, it is necessary to distribute the local residents to collect information according to the regional characteristics of road-blockage.

## 5 Summary

We analyzed the access time of fire brigades to burning-buildings under conditions of physical damage in the event of a major earthquake in Tokyo. Although the access time of fire brigades during road blockage becomes about 270 percent, we demonstrated that it can be reduced to the same level as when there is no road blockage, if the information of locations of road blockages could be obtained. We constructed a model, which describes the information collection of road blockage by residents after the event occurs. Finally, by performing a simulation, we demonstrated that the collected-information can shorten the access time of fire brigades.

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