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Procedia Environmental Sciences 22 (2014) 387 – 396

Procedia Environmental Sciences

12th International Conference on Design and Decision Support Systems in Architecture and Urban Planning, DDSS 2014

A method for evaluation of wide-area evacuation difficulty in case of a major earthquake

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Abstract

In densely built-up wooden residential areas, buildings and streets must be improved so as to safeguard against high risks, which may occur during a major earthquake. In this paper, we evaluate an improvement project in terms of the difficulty of wide-area evacuation by using a multi-agent simulation model. Results show that despite an overall decrease in the average number of people who have difficulty in evacuating, some buildings along narrow and long streets still have high risk that residents cannot evacuate to any evacuation areas.

Peer-review under responsibility of the Eindhoven University of Technology, Faculty of the Built Environment, Urban Planning Group

Keywords: Major earthquake; wide-area evacuation difficulty; densely built-up wooden residential area; property damage; improvement project; multi-agent simulation

1. Introduction

In densely built-up wooden residential areas, there is the possibility that big fires occur during a major earthquake. Moreover, it is highly likely that the complex network, consisting of narrow streets, prevents people from evacuating smoothly to evacuation areas. To put it another way, people's safety depends on the elements

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Peer-review under responsibility of the Eindhoven University of Technology, Faculty of the Built Environment, Urban Planning Group
doi:10.1016/j.proenv.2014.11.036

constituting towns, e.g. material of buildings, width of streets, and density of buildings and streets. Therefore, the government and municipalities have developed many improvement projects for making towns more robust against disasters.

The status of each project has been mostly evaluated in terms of the ratio of incombustible buildings. This indicator enables us to make a connection between its numerical value and the average fire-safe performance of the whole town. However, the above indicator has two disadvantages: (1) it is not suitable to directly evaluate the wide-area evacuation difficulty in certain areas such as city blocks; (2) local residents and residential developers cannot easily realize the effects of the improvement projects in densely built-up wooden residential areas.

In this paper, we evaluate the projects from the perspective of the difficulty of wide-area evacuation. The difficulty is evaluated based on the potential of the difficulty of wide-area evacuation and time and distance for arriving at any temporary refuges or evacuation areas. The value of this indicator is obtained by simulation analysis and expresses the possibility that people cannot evacuate to an evacuation area after a major earthquake. More specifically, we evaluate a past project for improving densely built-up wooden residential areas on the basis of a comparative analysis of wide-area evacuation difficulty, time, and distance before/after improvement (Fig. 1.) Furthermore, we consider critical factors of the difficulty of wide-area evacuation.

There are many studies on densely built-up wooden residential areas, but a few attempts have been made for effect validation of improvement projects in terms of disaster prevention. For instance, Igarashi and Murao[1] evaluated the progress of improvement projects in the whole target areas based on several indicators (such as the density of wooden buildings and the risk of building-collapse.) However, it is difficult to evaluate the safety of certain areas (such as city blocks and streets.) The improvement effects of wide-area evacuation difficulty by projects have not been discussed sufficiently.

Some studies discuss the safety of evacuation routes in densely built-up wooden residential areas. Noda, et al.[2] categorize real city blocks based on the accessibility to major streets and propose improvement methods in the blocks by category. Iijima, et al.[3] evaluate the environment of evacuation routes on the basis of field work. It is important for us to focus on the formation of streets and discuss with local residents disaster prevention planning. Nevertheless, there are few studies about the effects of such activities. Ibrahim et al.[4] discuss the risk of evacuation routes in case that people evacuate to evacuation areas through wide streets with comparatively low risk of fire-spreading. However, the models in their study do not address complicated situations such as building-collapse, street-blockage, and congestion caused by stranded people after a major earthquake.

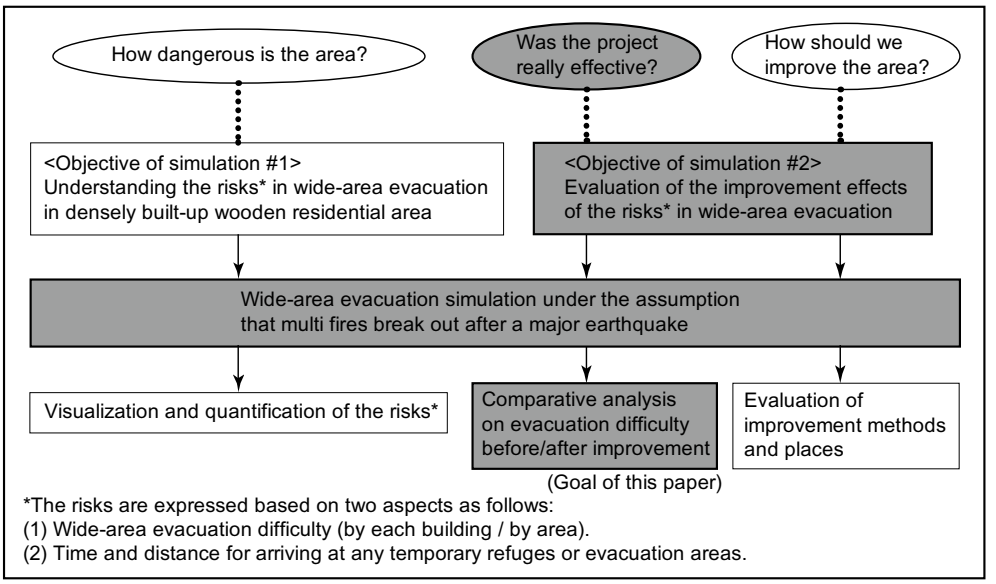

Fig. 1. Objectives of the simulation in this paper (grey color).