SIMULATING SEISMIC HAZARD OF CITIES USING GIS – A COMPARISON WITH PAST DAMAGE DATA

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Introduction

Estimating seismic hazard of a city needs to collect huge amount of data of buildings in a traditional approach.[1] To overcome this problem, the authors developed a method of establishing structural model of buildings using geometry obtained from 3D GIS data.[2,3] To verify the applicability of the proposed method, this paper simulates seismic hazard in an area in Bunkyo-ku of Tokyo and compares the results with available past damage data.

Simulating seismic hazard using 3D GIS data

The area processed in Bunkyo-ku of Tokyo (Figure 1) is a block of 630m×680m. The 3D GIS data of this area contains around 2000 records of geometric entities. Using the proposed method totally 1738 buildings are identified from the original GIS records. Among them, timber houses and non-timber structures are 1246 (72%) and 492 (26%), respectively. As many timber houses exist in Japan, the dominance of timber houses in a city of Japan is quite typical. As a result, most of the buildings are 1 to 3 stories, with a few from 4 to 10 stories and the highest building is 16 stories (Figure 2(a)). All buildings are constructed with Multi-Degree-Of-Fredom (MDOF) model.[2,3] Figure 2(b) shows a distribution of natural period of buildings modeled from GIS data.

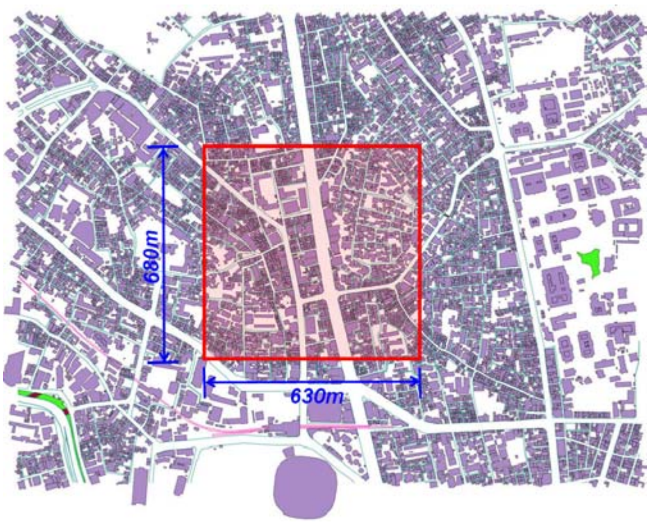

Figure 1 An area picked up in Bunkyo-ku of Tokyo

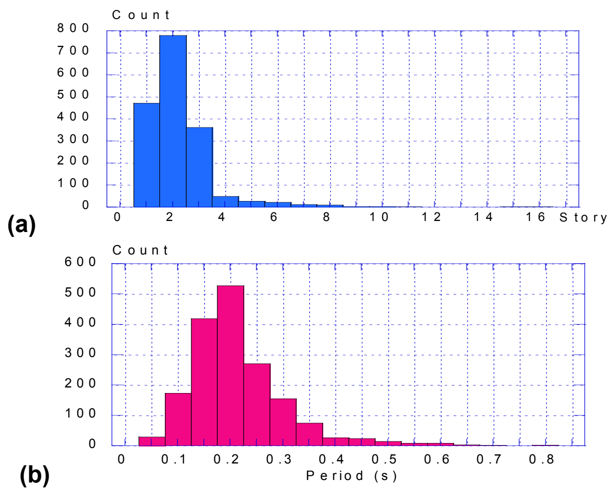

Figure 2 Distribution of (a) story and (b) period

To simulating seismic hazard ground motions from the 1995 Kobe earthquake (two horizontal waves of Takatori) are used. Elcentro ground motion is also used for a comparison. The maximum floor drift angle of structures is computed for each building and is used as a damage index. The levels of damage are divided as collapse to heavy, high to moderate and low damage using different ranges of drifts as great than 1/60, between 1/60 to 1/120 and less than 1/120.[4] Figure 3 illustrates two scenarios of the studied region by showing damage levels with the color and the size of circles, where red, yellow and green present heavy, moderate and low damage, respectively. The damage in percentage of each level of these two scenarios is 21%, 27% and 52% (heavy, moderate and low) for Takatori and 4%, 21% and 75% for Elcentro, respectively.

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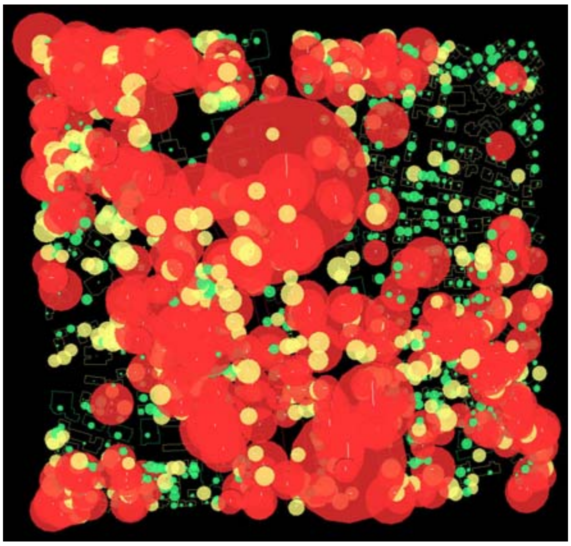
(a)

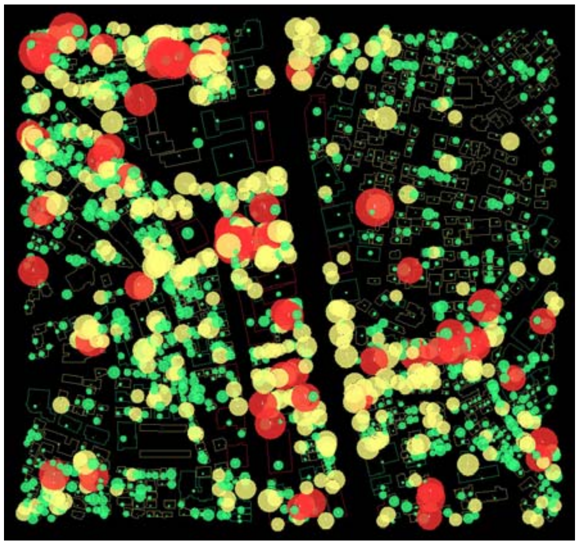
(b)

Figure 3 Maximum story drift angles under (a) Takatori and (b) Elsentro SN ground motions

To compare simulating results with past damage data, a report of damage survey in Nagata district of Kobe during the 1995 Kobe earthquake shows that rates of heavy, moderate and light damage are 40%, 13% and 47% in totally 3495 timber houses, respectively.[5] The damage survey in Nagata district with nine sub-regions also shows quite different damage levels due to different conditions of soil and the percentage of old houses in each area.[5] To take a roughly look, about half of timber houses were obviously damaged. The scenario under Takatori ground motions is comparable with the survey made from the Kobe earthquake.

Conclusions

This paper conducted seismic scenarios using GIS data based structure modeling. An area in Bunkyo-ku of Tokyo is used and about 1,700 buildings were analyzed individually using MDOF model and dynamic analysis under selected ground motions. The maximum floor drift angle is used as a damage index and is compared with past damage data from the 1995 Kobe earthquake.

A roughly comparison shows the scenario under Takatori ground motions agrees with the survey data from the Kobe earthquake, which damage from another scenario (Elsentro) are quite different. This result of comparison suggests that to take a macro view of a city the proposed method can be a candidate for seismic simulation when less information of structures is available. On the other hand, past damage data can also be a help to improve the accuracy of the simulation.

Natural periods of buildings and rough assumptions of damage models are among major reasons that cause limited accuracy of studies in disaster mitigation according to many researchers. While more information is going to be included to 3D GIS, more data can be utilized to improve the proposed method.

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