BUILDING VIRTUAL CITY FOR DISASTER MITIGATION – AN IMPLIMENTATION OF BUNKYO-KU, TOKYO USING 3D GIS DATA

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Introduction

Establishing models of buildings of a megacity is very important for disaster mitigation. A traditional approach employs manpower to collect data of huge amount of buildings and applies statistic based analysis.[1] This paper provides a new method of constructing structural models of buildings in a city using 3D GIS data. An implementation is given by constructing building models of an area in Bunkyo-ku, Tokyo using available GIS data.

SDOF/MDOF approaches [2]

The available GIS data, as shown in Figure 1, are a profile of a building in 2D and a height of this building. The profile of one building is given in a polygon with an outer loop and possible inner loops (holes). To build a simplest Single Degree-Of-Freedom (SDOF) structural model, a total mass and shear stiffness of a building need to be obtained (Figure 2). Natural periods, the most important dynamic feature of building structures, can be estimated using empirical equations with height and dimension of buildings. Original GIS data don't give the information of number of stories of buildings. As a building is designed according to engineering codes with predefined usages, number of stories can be obtained by a reasonable guess using the height and profile of this building. The mass density of each story can also be obtained using the same method. This way, the total mass of one building can be computed out. Stiffness can therefore be calculated using a basic equation of dynamic relation. A well adopted simplified structural model for buildings is a Multi-Degree-Of-Freedom (MDOF) model, which has a condensed mass at each story of a building. Using superposition method a MDOF system can be condensed into a SDOF system by providing a mode shape related a natural frequency.

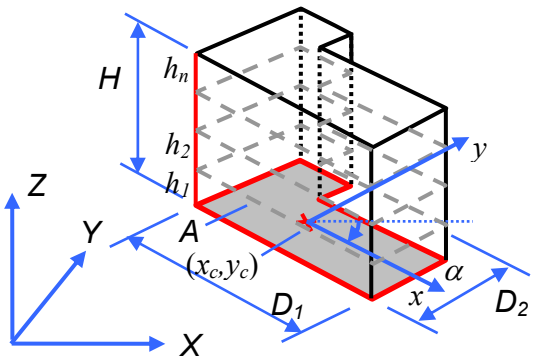

Figure 1 Structural information from GIS data

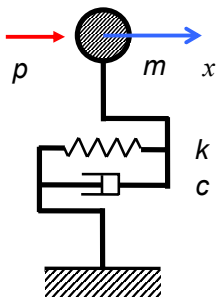

Figure 2 A simplified SDOF model

Implementation of Bunkyo-ku, Tokyo

GIS data from a block of area in Bunkyo-ku, Tokyo (Figure 3, 2km×1.5km) are processed using the above approach. The total number of buildings within this area exceeds 10,000. A 3D view on a picked-up area is shown in Figure 4. Structural models constructed are shown in Figure 5 and 6. A short line with in each building shows the centre, main

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direction and dimension along the main direction of this building (Figure 5). A 3D view of structural models is given in Figure 6, where vertical lines show building's heights. Boxes represent condensed masses at each story of buildings.

Concluding remarks

HAZUS system's probabilistic strategy established a common way to evaluate vulnerability of cities. However, to implement such a system, it is a big burden to prepare huge amount of data. The proposal offered by this paper provides a new way to solve this problem. In addition, having structural models enables dynamic seismic analysis for buildings. This, in a consequence, makes it possible to evaluate vast amount of buildings based on each building's feature. The method of analyzing seismic response of individual buildings using simplified models is well established. Structural models that are constructed by this paper's method, can be firstly verified by selected on-site data, the available dynamic features (natural period etc.) of typical buildings in a studied area; then the models can be adjusted for a better performance. Furthermore, as more and more information is/will be available from GIS, such as usage, age of a building, detailed 3D shapes of a building, the proposed modeling method can be further developed and improved.

Reference

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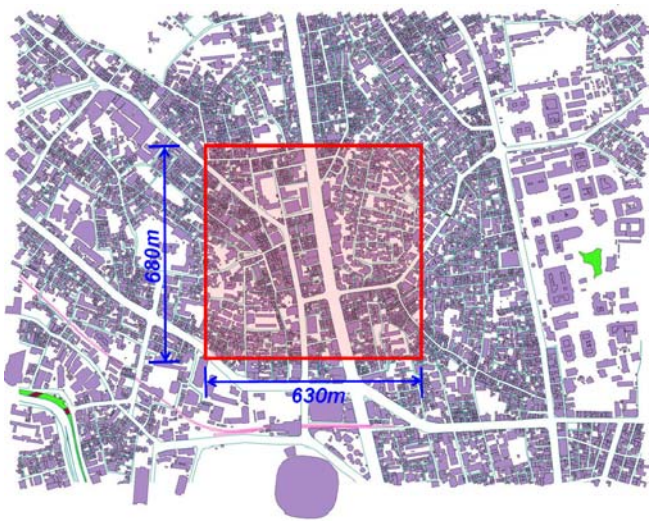

Figure 3 An area picked up in Bunkyo-ku, Tokyo

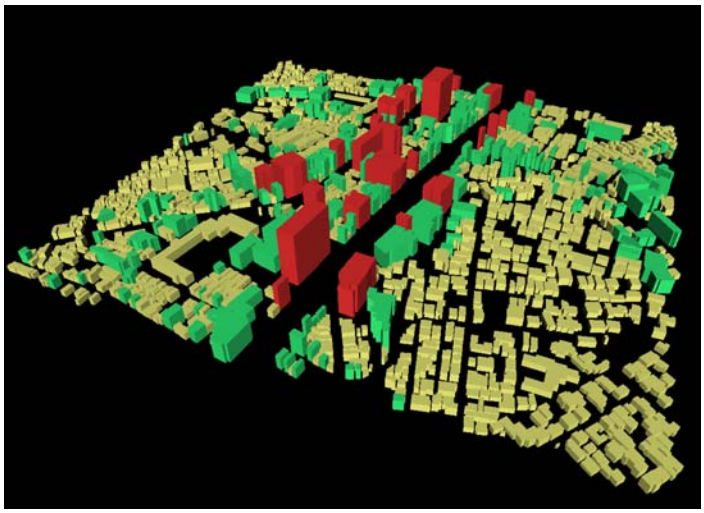

Figure 4 A 3D View of the region

Figure 5 Structural models of buildings

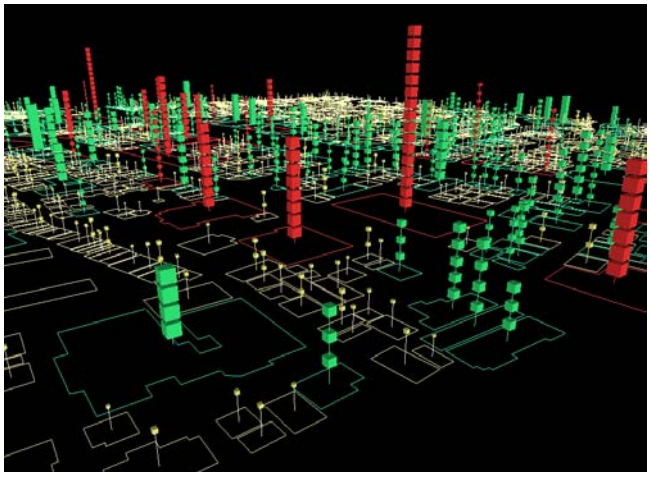

Figure 6 A 3D view of structural models