SEISMIC HAZARD MAPPING PROJECTS IN JAPAN

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Abstract: The national seismic hazard mapping project of Japan started in 1999. In the project, two types of the maps such as the deterministic and probabilistic maps will be produced by March, 2005. The maps provide the general view of seismic hazard in the whole of Japan, and are considered as the basic map. The project by a local government is also going on in order to produce the advanced regional map for improvement of disaster consciousness and preparedness of citizens. Applications of the maps should be further discussed not only in the engineering community but also in the general public.

1. INTRODUCTION

Following on the lessons learned from the Great Hanshin-Awaji Earthquake disaster, the Special Measure Law on Earthquake Disaster Prevention sponsored by legislators was enacted in July 1995 to promote a comprehensive national policy on earthquake disaster prevention. The Headquarters for Earthquake Research Promotion, a special governmental organization attached to the Prime Minister's office (now belongs to the Ministry of Education, Culture, Sports, Science and Technology), was established in accordance with this law. In April 1999, the Headquarters established its fundamental mission statement on research over the next ten years, where initiatives for development of national seismic hazard maps were proposed. Following the proposal, the Earthquake Research Committee, which is one of the committees in the Headquarters, started the national seismic hazard mapping project of Japan in order to produce seismic hazard maps covering the whole of Japan by March, 2005 (Fujiwara et al., 2003). This paper introduces the national seismic hazard mapping project and the related projects in Japan.

2. NATIONAL SEISMIC HAZARD MAPS

2.1 Outline of the Project

The Headquarters for Earthquake Research Promotion have promoted surveys of major active faults, long-term evaluations of the possibility of occurrence of large earthquakes, and surveys of deep sedimentary basin structures. In order to utilize the results for disaster mitigation, the Headquarters decided to start the project for producing the national seismic hazard maps based on most recent knowledge and techniques on strong motion prediction.

For this project, the subcommittee for evaluation of strong ground motion was established in the Earthquake Research Committee. To examine the strong motion prediction techniques to be used, the working group was also established under the subcommittee. The National Research Institute for Earth Science and Disaster Prevention (NIED) was selected to be the responsible institution for the project. To support their work, the technical committee for probabilistic seismic hazard map was established in the NIED.

In the project, to understand the general view of seismic hazard in the whole of Japan, two types of the maps will be produced. One is a deterministic ground shaking map with specified seismic source fault. This type of the map is also called a scenario earthquake ground shaking map. Another is a probabilistic ground shaking map that shows possibility with which a certain area is attacked by strong shaking in a certain period by means of probability. The reason for adopting two types of the maps is that these two maps have different merits and should be selected according to the objectives. The deterministic maps will be produced for ten to twenty scenario earthquakes which have high potential of occurrence or may give high impact to urban areas. The probabilistic maps with different probabilities of occurrence will be produced for the whole of Japan.

2.2 Deterministic Ground Shaking Map

For the deterministic map, the hybrid simulation method (eg. Irikura and Kamae, 1999) is mainly employed. The empirical method (eg. Si and Midorikawa, 2000) is also used as supplementary one. In the hybrid simulation method, the shorter period ground motion is computed by the stochastic Green's function method, and the longer period motion is computed by the theoretical finite difference method considering the three-dimensional deep underground structure. The heterogeneous source model is adopted, considering asperities with larger slip and higher stress drop on the fault plane. The source parameters are determined following the standardized recipe (Irikura, 2002). The deep underground structure is modeled based on the available data including the results from surveys of deep sedimentary basin structures initiated by the Headquarters.

By this procedure, the time history of the ground motion at engineering bedrock where shear-wave velocity is about 400 m/s is computed for each element of the 1km-mesh system. Since surface soils vary strongly site by site, it is difficult to prepare the surface soil models with adequate spacing. Therefore, the peak ground velocity on surface is simply computed by multiplying the peak velocity at engineering bedrock and the amplification factor estimated from the site geomorphological condition (eg. Matsuoka and Midorikawa, 1995). The peak ground velocity is converted to the JMA seismic intensity using the empirical relationship.

As of Febrary, 2004, the deterministic maps have been published for five active fault earthquakes such as the Yamagata Basin, Miura Peninsula, Futagawa-Hinata, Morimoto-Togashi, and Itoigawa-Shizuoka fault earthquakes and for three subduction earthquakes such as the Miyagi-ken-oki, Nankai, and Tonankai earthquakes. As example, the deterministic seismic intensity maps for the Yamagata Basin fault earthquake are shown in Figs. 1. In this earthquake, the results for four cases with different locations of the asperities on the fault are shown in order to indicate variability of the prediction.

2.3 Probabilistic Ground Shaking Map

A probabilistic ground shaking map is presented by three parameters such as intensity, time period and probability of strong shaking. On the map reflected are long-term evaluations of the possibility of occurrence of large active fault and subduction earthquakes which have been published by the Headquarters. In the calculation, the earthquakes are classified into seven different types (Ishi et al., 2003):

1) characteristic earthquakes along the major 98 active fault zones in Japan;
2) earthquakes along the other active faults,
3) earthquakes in the major 98 active fault zones except the characteristic earthquakes,
4) characteristic inter-plate earthquakes along the subduction zones,
5) inter-plate earthquakes along the subduction zones except the characteristic earthquakes,
6) intra-plate earthquakes along the subduction zones,
7) crustal earthquakes whose fault planes could not be identified in advance.

The time-dependent model of earthquake occurrence is used for earthquakes whose occurrence patterns have been investigated, but the Poisson model is used for most earthquakes. The logic tree is not used for simplicity. With the probabilistic models of earthquake occurrence for these earthquake types, seismic hazard curves are computed in terms of ground motion intensity and probability of exceedance at each element of the 1km-mesh system. The empirical attenuation relationships of ground motion and the amplification factor based on the site geomorphological condition are used in the calculation. At several principal sites, the contribution factors of major earthquakes on the hazard curves at each probability level are presented in order to show the impact of each earthquake. The preliminary probabilistic maps have been published for the northern part of Japan. Figures 2 show the seismic intensity maps with 5%, 10% and 39% probabilities of exceedance in 30 years, respectively.

3. ADVANCED REGIONAL MAPS

3.1 Detailed Seismic Hazard Map

The seismic hazard maps will provide basic information for;

1) improvement of earthquake awareness of citizens,
2) seismic design of structures,
3) strategies of disaster mitigation planning,
4) seismic risk evaluation of facilities, and so on.

When a citizen look the seismic hazard map, he thinks that a) Is my house in the red zone ? and b) If my house is in the red zone, what should I do ? (Olshansky, 2000). To reply his questions, the map should be the micro-scale one. The national seismic hazard maps are basic ones and too large in scale to catch citizen’s strong interest. As an advanced map for citizens, the detailed hazard map for the region will be necessary.

For this purpose, the city of Yokohama (2001) published “Yokohama City Shake Map” in June, 2001. More than 15,000 borehole data in the city were compiled. The soil profile sections were drawn from the borehole data and the geomorphological information, and the soil condition of the city is classified into 268 types. The data from borings or measurements of S-wave velocity are used to build up the generalized underground model for each soil type. For the mapping, the 50m mesh system is adopted because of strong spatial variation of the geomorphological conditions in the city.

Using the detailed subsoil data, the deterministic ground shaking maps are computed for several scenario earthquakes including the recurrence of the1923 Kanto earthquake. Figures 3 are the map for the Kanto earthquake and its close-up, respectively. About 100,000 copies were printed and distributed to citizens. As the results, the numbers of applicants for seismic performance appraisal of wooden house and for seismic retrofitting subsidies by the city increased to about 2000 and 150 in 2001, respectively. These numbers are twice of those in the previous year. This is an evidence of improvement of earthquake awareness of citizens by the map.

3.2 Information Map for Earthquake Emergency Preparedness

As mentioned above, the detailed seismic hazard map is useful for easy understanding the regional seismic risk. However, if we focus our objectives on improvement of citizen’s emergency preparedness, the detailed hazard map does not provide sufficient information. An Information map for earthquake emergency preparedness should be developed. The information map may consist of three kinds of maps, such as a risk map, evacuation aid map, and fire fighting and rescue aid map (Ishizawa and Midorikawa, 2002). Figures 4 shows preliminary evacuation aid and fire fighting and rescue aid maps. In the maps, the items which are related to evacuation actions, such as evacuation place, road width, slope failure potential and building damage. Now the city of Yokohama is being developed this kind of the map.

The maps will be provided on the web GIS system.

4. CONCLUDING REMARKS

The national project on seismic hazard mapping of Japan started in 1999. In the project, two types of the maps such as the deterministic and probabilistic maps will be provided by March, 2005. The maps are to understand the general view of seismic hazard in the whole of Japan, and to be considered as the basic map. The project by a local government is also going on in order to produce the advanced regional map for improvement of disaster consciousness and preparedness of citizens. Applications of the maps should be further discussed not only in the engineering community but also in the general public.

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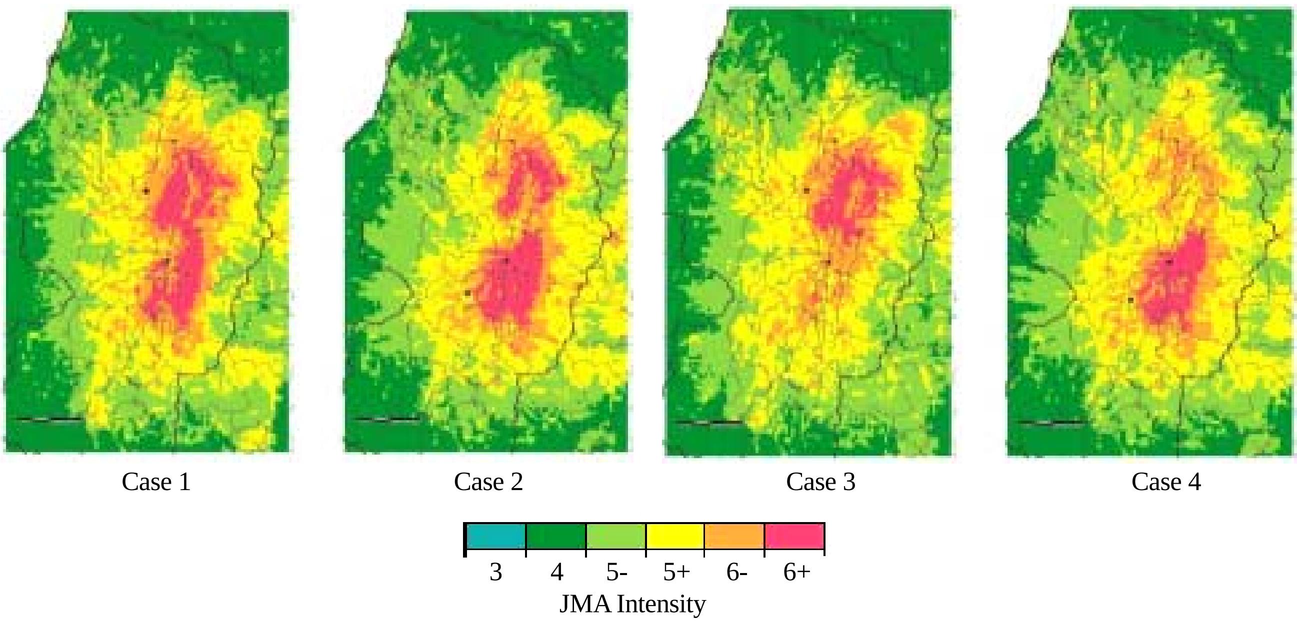
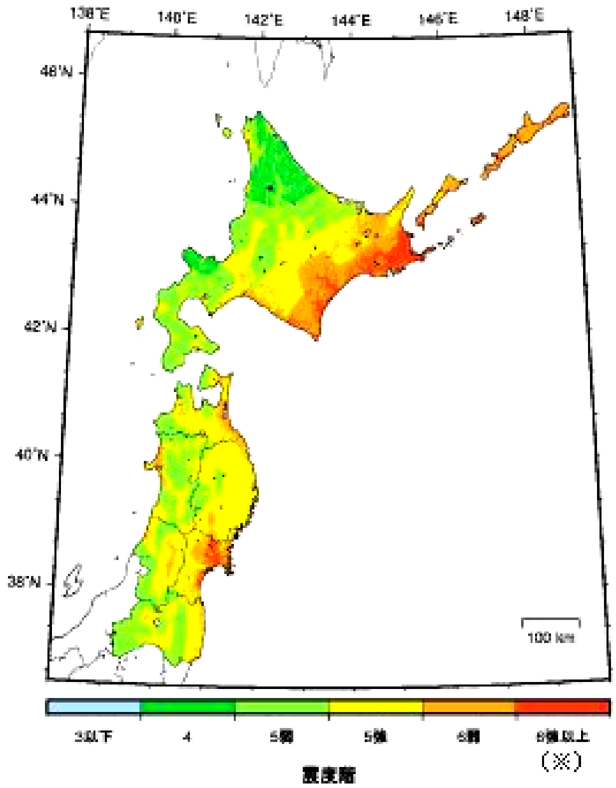
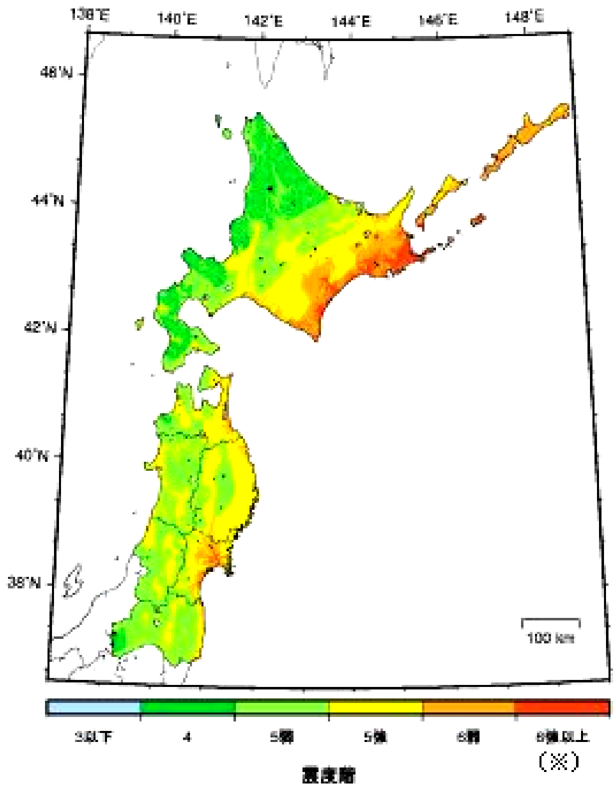


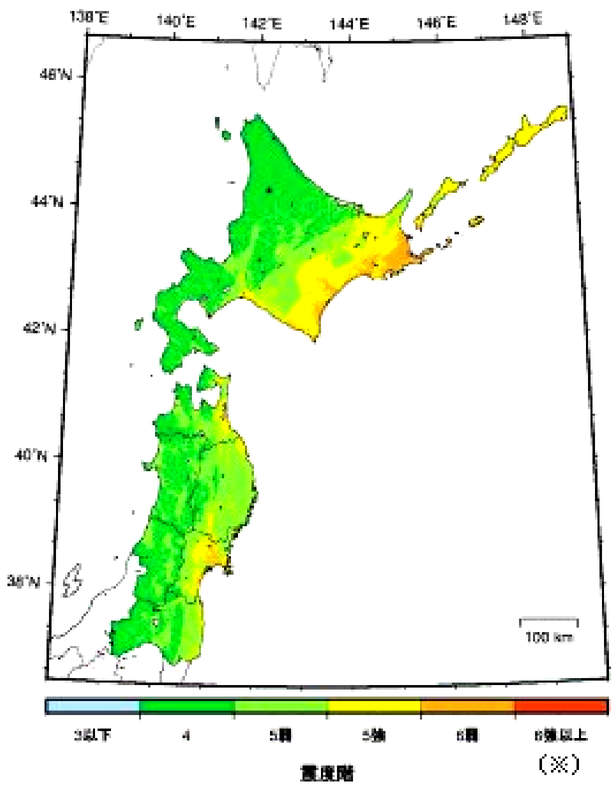
Figures 1 Deterministic Seismic Hazard Maps for the Yamagata Basin Fault Earthquake



(a) seismic intensity with 5% probability of exceedance in 30 years



(b) seismic intensity with 10% probability of exceedance in 30 years



(c) seismic intensity with 39% probability of exceedance in 30 years

Figures 2 Probabilistic Ground Shaking Maps

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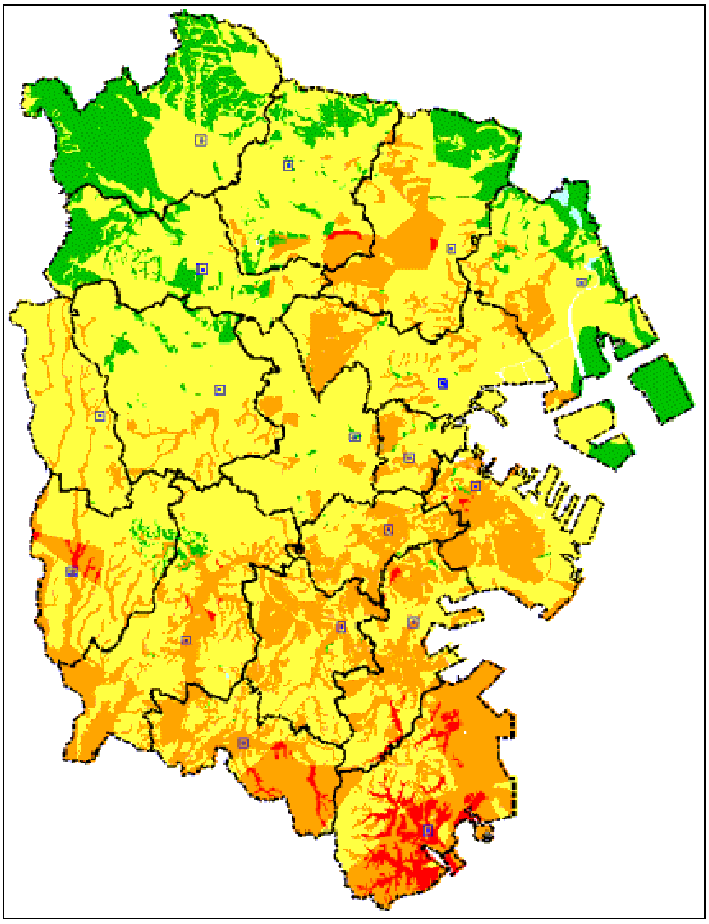
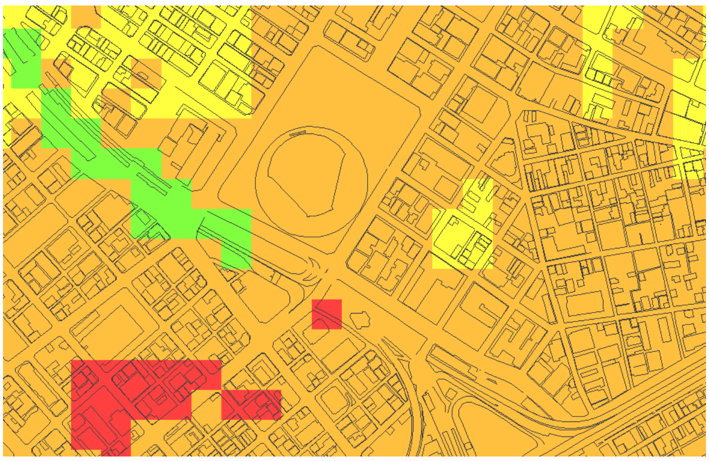


(a) whole area map



(b) close-up map

Figures 3 Yokohama City Shake Map

(a) evacuation aid map

(b) fire fighting and rescue aid map

Figures 4 Information Map for Earthquake Emergency Preparedness