**Ninth Canadian Conference on
Earthquake Engineering
Ottawa, Ontario, Canada
26-29 June 2007**

RESEARCH ON MANAGEMENT SYSTEM COMBINED WITH HARD AND SOFT MEASURES FOR SEISMIC DISASTER RISK REDUCTION

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ABSTRACT

Developed countries such as Japan, can suffer greatly from a natural destructive event such as 1923 Kanto earthquake. The intensity of a seismic disaster is strongly related to the complex combination of the social and economical situation as resource with the natural phenomenon as the cause. To reduce the disaster risk, a management system should be built combining hard and soft measures, in which the hard measures are the mitigation of direct physical damage while the soft measures are dealing with the indirect social damage. And the hard and soft measures should act interactively. In this paper, as a part of the "Academic Frontier Research Project" an effective risk management technique for natural disaster risk reduction including both hard and soft methods and their practicing technique is introduced. The outline of the project is introduced first. Then examples of Hard and Soft measures are shown for a pilot area, Kanagawa prefecture in Japan that has 18 cities and 19 towns.

Introduction

Recently many serious seismic disasters occurred in Japan's main Island such as 2003 Miyagi-ken-oki and 2004 Tokachi-oki earthquakes. It is believed that the region is entering to the recurrence period of major seismic disaster like 1923 great Kanto earthquake (National Astronomical Observatory 2006). Such kinds of disasters are unbearable for current Japanese society, socially and economically (Government of Japan 2005). Therefore it is a must to provide comprehensive disaster prevention measures as tried by Tanaka (2004), Enomoto (2005), and Navarro (2006). We divided such measures into Hard and Soft type. The physical approaches that are usually developed during or after each individual disaster will be considered as hard mitigation measures. The methods to prevent the social and economical disasters after such destructive events are called soft mitigation measures.

Still the earthquake engineer's approach to disaster mitigation is mainly focused on hard measures. However there must be a balance between the hard and soft measures for a time-efficient seismic risk reduction measure especially when it includes the human loss in risk evaluations.

The aging population of Japan and precision of Japanese culture are two basic reasons for preparation of a precise action plan for the people in the event of a seismic disaster. In this paper the outline of the "Academic Frontier Research Project" is introduced first. Then a part of the project which is to construct the effective risk management technique for natural disaster risk reduction including both hard and soft

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methods and their practicing technique is focused on. Examples of our progress in Hard and Soft categories have been shown for Kanagawa prefecture in Japan that has a very wide area covering 18 cities and 19 towns.

Outline of Academic Frontier Research Project

The aim of academic frontier research project is to regulate the risk management system with cooperation between citizens and communities. An effective risk management system for disaster prevention by combining the soft and the hard prevention measures for seismic disaster will be built. In the system the prevention and management methods are localized. A very important task is to accumulate the local disaster mitigation information and present it to the residents. Since the search and rescue must be started by local citizens themselves before the governments start to act, the minimum reaction time to the seismic disaster will be achieved. And the cooperation of soft measures between citizens and communities in a disaster prevention strategy also has been a big social and political challenge. For accomplishment of the project wide range of disciplines e.g. engineering, social sciences, economy, etc. is needed. Several pioneer institutes and organizations have taken part in the research project. Close collaboration and joint research work are important keys for progress.

The Academic Frontier Research Project is divided into six domains of researches:

1: Building the information technology for Natural and Social Environment Information integration
2: Providing the quantitative evaluation techniques for the databases provided from domain 1 Considering the Combination of Hard and Soft Measures
3: Systematic generation of alternatives for practical disaster mitigation strategies based on the quantitative results from domain 2
4: Research and practice on the most suitable risk evaluation methodology for natural disasters
5: Development of risk management system combined hard and soft disaster mitigation measures
6: Development of practicing technique on utilization of risk management system

In this paper the research domain 5 will be focused by considering the results derived from research domains 1 to 4. The strategy for utilizing the risk management system would be developed after investigation and analysis of the practical situation in actual environment.

Pilot Research Area

In order to develop an effective local response measures for the guide of local citizens, communities and governments in case of a destructive event, the regional characteristics need to be identified in the project.

As a pilot research area, Kanagawa Prefecture in Japan is chosen. It is highly urbanized area with centralized population, and is highly vulnerable to the natural disaster, especially to big earthquake. Detailed information of regional features and characteristics in digitized format, such as the geological situation (Fig.1), is partially available in Kanagawa Prefecture, and could be utilized by GIS platform for investigation.

Hard Measures Based on Geotechnical Techniques

Geotechnical Database for the Region

At the first step, we want to build a soil classification map for the whole prefecture based on the proposed soil classification procedure by Fujimoto 2002, Wakamatsu 2004 and Matsuoka 2005 for the evaluation of seismic disaster risk. Borehole data is one kind of geotechnical information to be collected, and we used them to check the amplification characteristics.

After the 1995 Hyogoken Nanbu Earthquake, the earthquake disaster prevention measures using GIS were quickly developed in local municipalities, especially in prefectural governments in Japan. These databases along with those made earlier (Matsuoka 1994 and Midorikawa 1994) are useful for preventive measures,

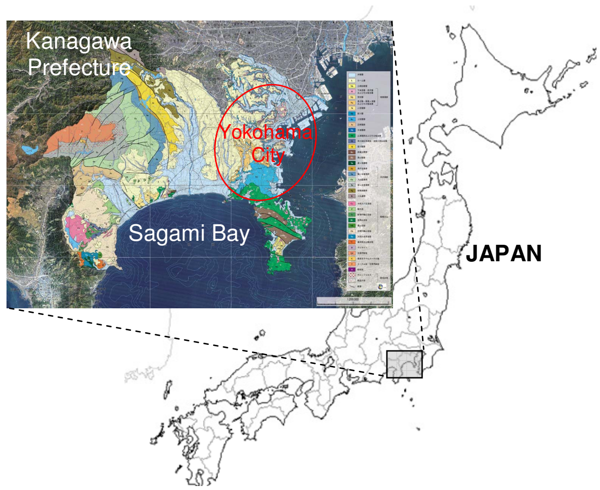
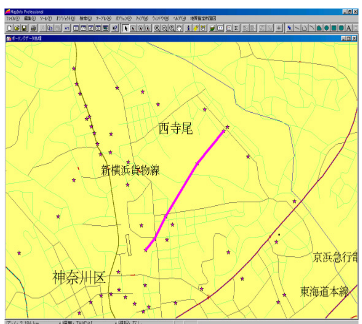
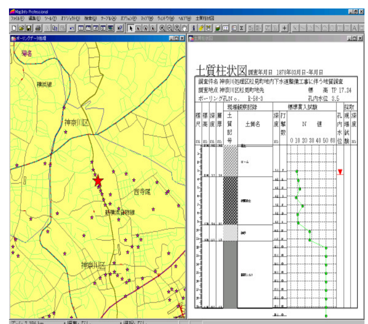


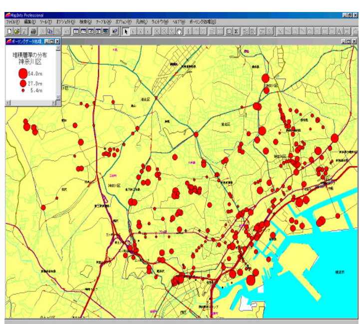
Figure 1. The geographical and geological situation of Kanagawa Prefecture.



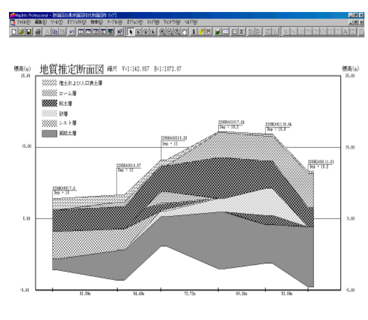
(a) Distribution of the Boreholes



(b) Selective view of data-sheets



(c) Spatial distribution of soil features



(d) Section profiles along arbitrary lines.

Figure 2. Visual presentation of borehole locations, data and geotechnical features by GIS.

damage prediction investigation and reconstruction/restoration management etc. These geotechnical information and borehole data were collected from local and prefectural governments and utilized in our GIS format since it could reduces the total project time greatly. We realized that is a huge task only for itself, since the number of the available boreholes in the region is out of imagination. Kanagawa prefecture has19 towns and 18 cities, each have at least 10 to 15 wards. The geotechnical information is scattered among different authorities such as National, Prefecture, City or Ward, based on the size of the projects in which they are involving.

The utilized digital database for geotechnical information contains N value, depth, density and soil type etc. as well as the geo-coded digitized borehole data. Using this database we are able to present the result quickly and efficiently. A sample is illustrated in Fig. 2a for Kanagawa ward in Yokohama city, where we

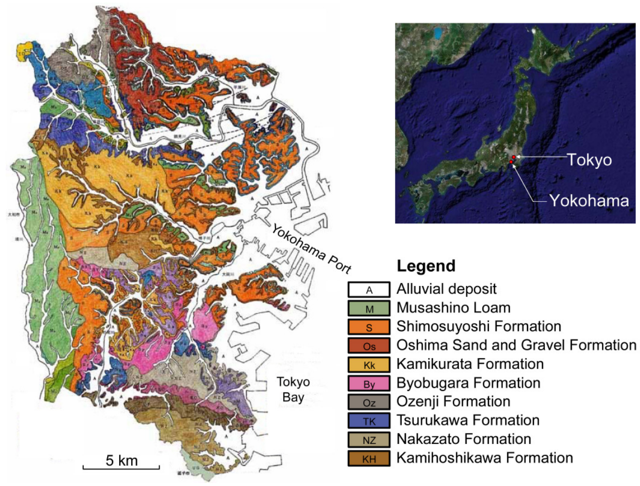


Figure 3. Geographical and Geological Map of Yokohama City

already processed about 500 boreholes. Yamamoto (2006) tabulated the detailed information in a database file suitable for GIS. Identification and finally spatial analysis could be made easily by state of the art GIS software for a visual assessment of the soil structure. Fig. 2b shows a sample of data-sheet represented for each selectable point on the computer monitor. Fig. 2c and 2d show other capabilities of the system to provide a spatial distribution or a cross section soil profile along an arbitrary line.

Building Damage Potential Analysis

Building damage potential is a new concept for fast estimation of regional risk introduced first in Japan by Bureau of city planning of Tokyo Metropolitan government (1998). The building damage potentials are the probable damage volume per unit area relative to the damage in a base area. The base area is usually arbitrary and the values are used as an index range on a map.

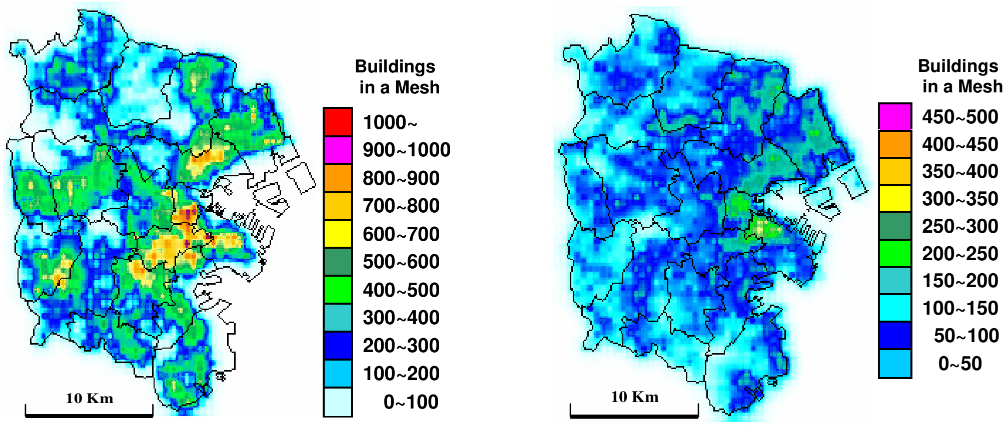
A distribution map of normalized building damage potential is provided for whole prefecture and the vulnerable locations to earthquake are pointed out. In this paper an example of building damage potential analysis is shown for Yokohama, the capital of the Prefecture. Fig. 3 shows the outline of geographical and geological features (Sugimoto1996). Hilly terrace consists of the firm Kanto loam in the west of Yokohama city. On east, low lands are very soft alluvial deposits of even 50m depth, formed by river deposits. Also reclaimed lands are distributed widely in coastal regions along the eastern seashores. The alluvial sites could amplify the seismic waves in many areas that are very vulnerable to the seismic disasters. Also there are high possibilities for liquefaction in lowland areas (Yokohama City 2001).

Generalized Categories for Soil Types

The soil response characteristics have a vital application for microzonation since it has strong influence to the building damage potential. Based on the geotechnical database, the soil structure is investigated at each 500m x 500m meshed grid. The soil classes are summarized into nine categories according to the geological and geographical conditions, and their weighting values that inflect the soil characteristics are listed in table 1. The weighting values will be used for the analysis of building damage potential in the next step according to the developed concept by Tokyo metropolitan government (1998).

Building Database for the Region

We obtained most of the available database about the buildings height, number of stories, plan dimensions, construction materials, predominant period, the foundation type and the construction age of building structure from local governments and compiled them for GIS. Although, the data are very scattered and time consuming as well to identify every parameters for individual building distributed in a region, for any



(a) Type 1 (Wooden Buildings) (b) Types 2 to 5 (Non-wooden Buildings)

Figure 4. Samples of building density distribution map of Yokohama city.

given mesh area the average value of each required parameter or the number of the feature entities could be analyzed by spatial GIS software.

Generalized Categories for Buildings

The Tokyo metropolitan report (1998) used 20 parameters for damage potential analysis, however they showed that the building material and height are most influential parameters to be used for the seismic vulnerability analysis. Five building categories were applied, one for wooden buildings and the other four types for non-wooden buildings based on the number of stories as shown in table 2. Figs. 4a and b show samples of the distributed building density of "wooden building type" and "non-wooden building type",

Table 1. Generalized categories of soil types based on geological and geographical conditions and related weight value for their effect on buildings damage.

Geological and geographical conditions	Category	Weight
Mountains	1	1.0
Table land	2	0.8
Fan	3	0.8
Natural embankment	4	0.5
Dune	5	-
Valley bottom plain	6	0.5
Delta and old river	7	0.4
Reclaimed Land	8	0.4
Others	0	-

Table 2. Classified type of buildings and related weight value for damage potential.

Structural Type	Number of stories	Category	Weight
Wooden Buildings	-	1	0.6
Non-Wooden Buildings	1 ~ 3	2	0.8
	4 ~ 6	3	0.6
	7 ~ 9	4	0.7
	10 ~	5	0.9

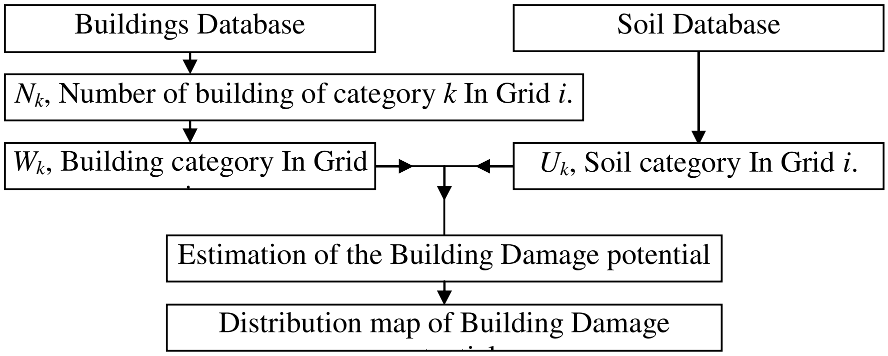


Figure 5. Flow chart for Building Damage Potential calculation.

respectively, for a 500m x 500m meshed grid evaluation.

Building Damage Potential Distribution Map

Generalizing the soil and building categories, we are able to develop a distribution map by detailed and comprehensive calculation of building damage potentials (Enomoto and Yamamoto et al. 2005). The result of building damage potential analysis in Yokohama City is shown as an example. In this estimation, we chose a grid mesh size of 500m x 500m and estimated the damage potential for each grid by a simple relationship between soil characteristics and building type. The potential values are relative and can be normalized to values at a base land. Flowchart in Fig. 5 shows the estimation process. At each grid area the numerical value is calculated by Eq. 1. for each building category

$$P_i = \sum_{k=1}^{m} p_{ik} = \sum_{k=1}^{m} N_{ik}(1 - W_{ik}U_{ik}) \qquad k\text{=1 ~ 5 : Building category} \quad i\text{=Grid number} \qquad (1)$$

Where P_i : Building damage potential for grid i; P_{ik} : Building damage potential for building type k in grid i.; N_{ik} : Distributed number of building type k in grid i; W_{ik} : Weight of building category (Table. 2) in grid i.; U_{ik} : Weight of soil category (Table. 1) in grid i.

The weight values, W_{ik} and U_{ik}, represent the effect of building and soil characteristics individually and do not consider the soil-structure interaction effect directly.

The value of weight tends to be close to 0 if damage risk more eminent and inversely they tend to rise close to 1 in case of safer situation. The result of building damage potential classified into five grades is shown in Fig. 6. Building damage potential values does not predict damage ratio or possible number of damaged building due to specific assumed earthquake, however this value shows the possible total damage potential of building. The building distribution density influences the building damage potential values. The potential values are much larger at the eastern part of Yokohama City, where it is in the dense commercial area and also located over soft soils.

Social Response Investigation and Management as Soft Measures

The mutual support of the local communities and local citizens played a great role during the reconstruction and restoration process after the great 1995 Hanshin-Awaji earthquake disaster (Enomoto et al. 2006). Thereafter the idea of nurturing and using the cooperative power of community or the power of citizens were shaped up for disaster prevention management strategies. Mutual support system between citizens and communities is very powerful and socially effective in such stressful situations. Cooperative activities in the local region and holding the discussion meetings and memorial festivals are very important practices in soft measures.

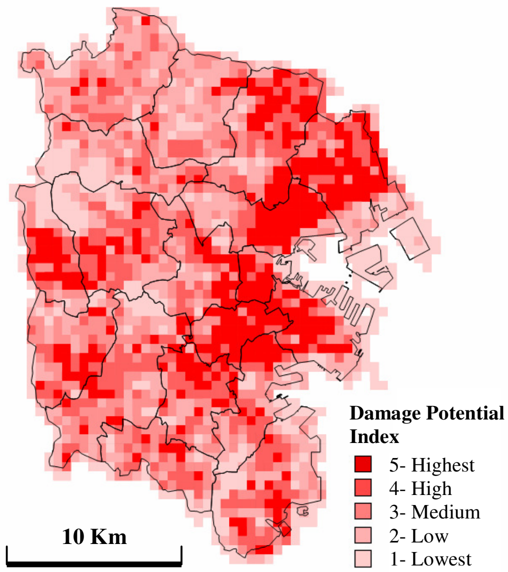


Figure 6. Distribution Map of Building damage Potentials in Yokohama city.

Japan is facing a change of social situation due to the aged society and the obvious technological distance between the old and young generations. The way of social communication between the residents is changing. The rising rate of single people is weakening the social relations between the families and their community, especially in big urbanized cities.

Survey of Community for Disaster Preparedness and Response

We sent questionnaires to "Non Profit Organizations" (NPO)s and volunteer groups to investigate their strength and ability to respond in actual situation, capabilities and mutual support relation (Enomoto, Sato and Yamamoto 2006) . Our final aim was to make sure if our target groups are capable of involving in social disaster prevention activities when they are needed. We also studied the regional characteristics that could influence the activities of these organizations and groups. The questionnaire survey was focusing on the following four groups of questions:

(1) Organization: Strength and ability to respond in actual situation.
(2) Disaster prevention: Disaster prevention measures in ordinary normal situation.
(3) Emergency response: Capability for emergency response immediately after the disaster.
(4) Regional collaboration: Mutual cooperation between other communities and other organizations.

Assigning a quantitative value for each question from 0 to 5, by considering equivalent number of questions we calculated the disaster prevention capability for each of 4 groups of questions (1 to 4), independently.

The questionnaire sheet was distributed in two cities. Kobe City in Hyogo prefecture where people already suffered the big earthquake disaster about 10 years ago and Yokohama City in Kanagawa prefecture where there had been no earthquake disaster for about 80 years. We wanted to compare the influence of having experienced an earthquake disaster with that of not having experienced. The contents of the several questions settled in questionnaire sheet were indicated in Table 3. The number of distributed and returned questionnaire sheets and its returned ratio were summarized in Table 4.

Fig. 7 shows the calculated result of disaster prevention capability using a 4 axis radar chart. This figure clearly shows that the NPOs and Voluntary groups located in Kobe City have a better disaster prevention capability than the ones in Yokohama City because of the big earthquake disaster influence. In comparison between the two organizations, NPO and Voluntary, the capability value of Voluntary group is larger than the value of NPO organization at both, Kobe and Yokohama cities, since the voluntary group's activity is more related to the community and more flexible than the activity of NPO. However one must consider that the results from social disaster prevention evaluations are related to the regional characteristics, therefore normalization is necessary for comparing the quantitative values.

Table 3. Sample questions asked in questionnaire survey.

No.	Sample Questions	Group
Q2	Do you have some manuals for disaster prevention and emergency response activity?	(2)
Q3	Do you have some equipments or tools for emergency response activity	(3)
Q4	Do you know about the regional disaster prevention center near to your residence?	(2)
Q5	Do you have your own disaster prevention center and prepared equipment?	(1)
Q7	Do you know your public evacuation site where you must use in case of a disaster?	(2)

Table 4. Questionnaire statistics.

City	Group	Number of Groups	Distributed sheets	Returned Sheets	Returned Rate
Kobe City	NPO	376	94	63	67%
	Voluntary	471	121	87	72%
Yokohama City	NPO	647	99	64	65%
	Voluntary	417	102	75	74%

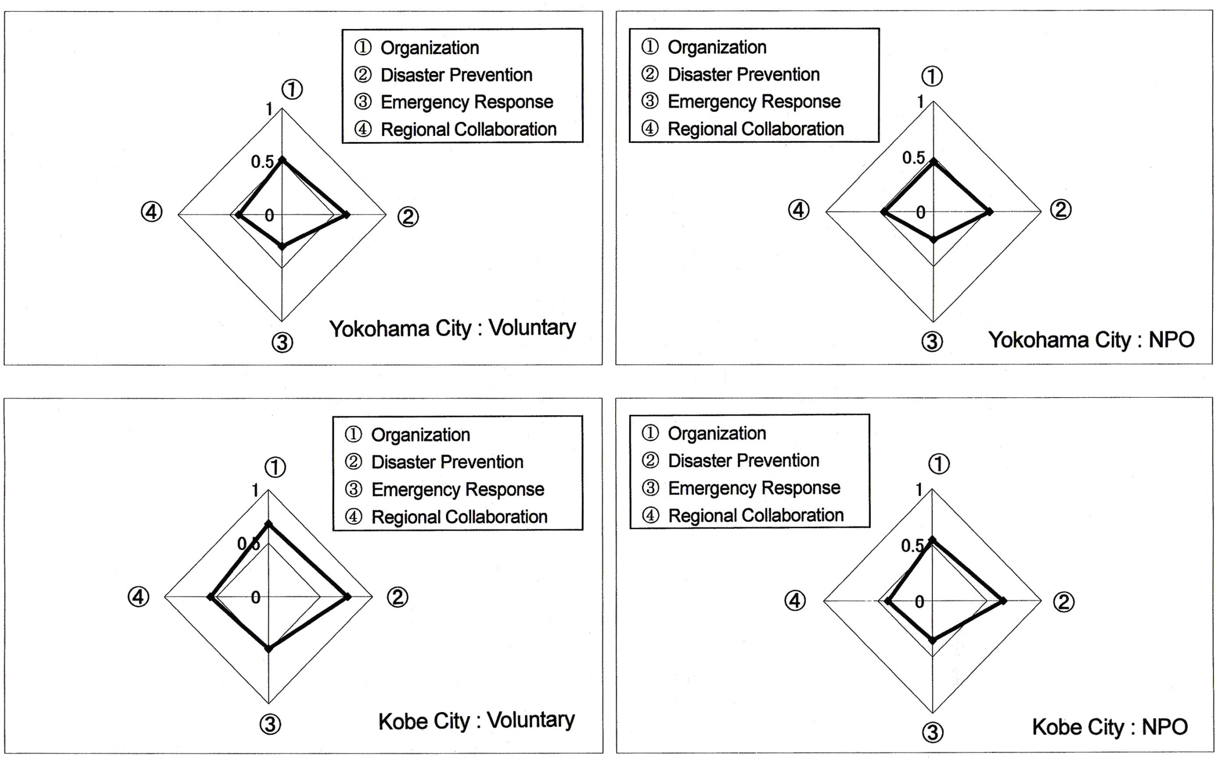


Figure 7. Rader chart of evaluated result about disaster prevention capability of NPOs and Voluntary group compared between Yokohama City and Kobe City.

Some Considerations on Joint Management System for Disaster Prevention

At the beginning stage of a major disaster the search and rescue are vital activities to save lives. As a part of the soft measure we are dividing the immediate post-event activities into three stages. First stage, the local survivors of heavily damaged area must start self-support activities for neighbors and second stage is the public-support activities by assembly of town society, disaster self-prevention society, voluntary groups and NPO. Final stage is the government-support activities for more complicated emergency response in order to prevent the spread of disaster. Training and mobilizing such potentials, require a close cooperation between local government and private organizations such as voluntary groups, NPOs and town societies which are located in same region.

The concepts of self-support, public-support and government-support and their implementation order need to be clarified for community. In this sense, basically, we held open seminars to share the information about disaster prevention and to constitute the people's network in local communities. An interactive internet website (URL : http://bousai-frontier.net) is prepared to provide an educational platform for local communities. Until now more than 10 open seminars, titled as "Practical Disaster Prevention Training Seminar for Town Coordinators", have been held.

Concluding Remarks

Unexpectedly large disasters in Kanto area are unbearable for current Japanese society either socially or economically. Therefore it is a must to provide comprehensive disaster prevention measures. Effective measures are related to the region characteristics both physically and socially. It is very important to construct regional risk management systems to implement the measures. The purpose of "Academic Frontier Research Project" is to develop an effective risk management technique for natural disaster risk reduction and its practice.

In this paper, we introduced a part of the project. Kanagawa prefecture was chosen as pilot area. Using a GIS platform we constructed a series of databases for hard measures e.g. ground seismic response, building damage potential and for soft measures e.g. regional social response. The current data base is well prepared for Yokohama City, in which samples are illustrated.

However the soft measures, for example, activity capability of self disaster prevention organization for community and citizen, NPO and Voluntary group, are not sufficiently advanced. A national will is needed to prepare for disasters. Especially for constitution of any soft measure, the gap between the aged and the young must be taken into account.

The concepts of self-support, public-support and government-support and their implementation order need to be clarified for community. Training and mobilizing of citizen's communities require a close cooperation between local government and private organizations.

It's very important to realize the common utilization of disaster prevention information based on the regional characteristics recognized by local citizen's community and local governments for systematic progress of the soft disaster prevention measures. The mutual activity for citizen's community and local governments played a major role during the Kobe disaster, which can play in same way in case of a destructive event in Kanagawa prefecture.

Acknowledgements

This research is a part of the "Academic Frontier Research Project", titled as "Risk Management with soft & Hard Measures on natural Disaster Risk Reduction" in Kanagawa University, through the grant in aid from "Ministry of education, culture, sports, science and technology". This research could not be done without the effective cooperation of the Kanagawa prefecture's government, cities and ward offices, NPOs and volunteer groups.

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