



# EARTHQUAKE DISASTER PREVENTION OF YOKOHAMA CITY

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**ABSTRACT:** The Great Hanshin-Awaji Earthquake gave critical damages to Kobe City. With the experience of Kobe City, Yokohama City has made full-scale review on the earthquake disaster prevention countermeasure plan. This paper reports earthquake disaster prevention activities based on scientific knowledge in Yokohama.

**Key Words:** READY, Shake map, Quakeproof Reinforcement of Buildings

## INTRODUCTION

The Great Hanshin-Awaji Earthquake that occurred at daybreak on January 17<sup>th</sup>, 1995 clearly showed the vulnerability of a modern city. While raising many questions it also taught us important lessons regarding the type of crisis management system that national and local governmental bodies should establish in modern society and the necessity for each citizen's awareness of disaster prevention and engagement in disaster prevention activities.

After this earthquake Yokohama City had established committees and round table committees that conduct various needed research and studies in order to implement earthquake countermeasures that were scientifically valid through discussions with seismologists and seismological engineering experts. Yokohama City Round Table Committee for Earthquakes had implemented the following research and studies so far.

- ① Collecting of the earthquake data observed in Yokohama
- ② Research and investigation on the earthquake occurrence mechanisms beneath Yokohama
- ③ Proposal on the systems for reducing earthquake hazards
- ④ Investigation on earthquake ground motion levels that should be taken into account on designing structures

The results of the studies done by the Round Table Committee have been applied to many of the earthquake countermeasures. This paper reports earthquake disaster prevention activities in Yokohama based on scientific knowledge.

And many people lost their lives when they were buried under collapsed buildings in the Great Hanshin-Awaji Earthquake. Yokohama City has actively carried out quakeproofing works for public and private buildings. This paper reports projects for quakeproof reinforcement of buildings, too.

## READY (REaltime Assessment of earthquake Disaster in Yokohama system)

To secure the system and approach of headquarters for disaster measures at the initial stage and for the planning of efficient disaster measures, Yokohama City has built up earthquake disaster prevention systems including the seismograph system that accurately collects detailed earthquake information in the city following an earthquake and the earthquake damage estimation system that gives highly accurate estimates of damage that works in combination with the seismograph system.

REaltime Assessment of earthquake Disaster in Yokohama system (READY), a comprehensive system that organizes these individual systems has been worked out based on the discussions at Yokohama City Round Table Committee for Earthquakes about the possibility of an earthquake in Yokohama directly above its epicenter and the necessity of taking measures for such earthquakes. This system allows accurate and stable gathering of information: seismic intensity information within 3 minutes, estimated damage information within 20 minutes, and information on actual damage to road within 60 minutes. The information is used for making efficient and accurate decisions on the policy of operations at the headquarters of disaster measures.

This comprehensive system is composed of the following respective systems.

### (1) High Density Strong Motion Seismograph Network

The High Density Strong Motion Seismograph Network includes 150 observation stations with strong motion seismographs in the city. This network connects these observation stations with the Office of Disaster Measures, Fire Defense Bureau, and Yokohama City University. Quake information is transmitted from the seismographs in the 150 observation stations to the Observation Center within a few minutes after an earthquake occurs.

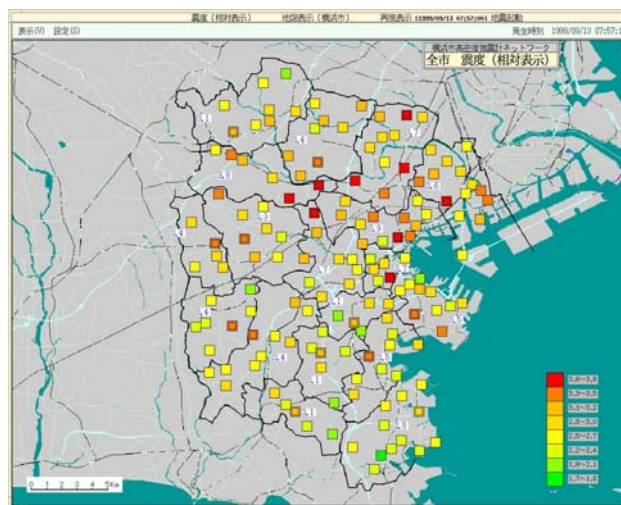


Fig.1 High Density Strong Seismograph Network

### (2) GIS-based Earthquake Damage Estimation System

The GIS-based Earthquake Damage Estimation System estimates the distribution of seismic intensity, liquefaction, and damage to wooden buildings for every 50m×50m area based on the quake information gained through High Density Strong Seismograph Network and other sources. The quake information is gathered from the 9 borehole seismographs (placed on the engineering bedrock level at depths of 20m to 60m) primarily in coastal areas, as well as the 150 strong seismographs in the High Density Strong Motion Seismograph Network.

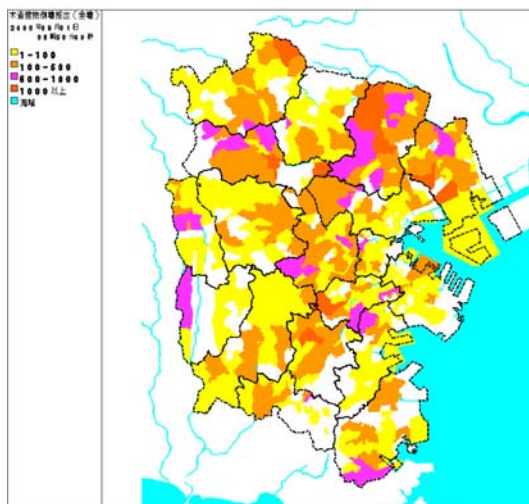


Fig.2 Estimated map of the collapse of wooden houses

### (3) Damage Information Gathering and Integration System

The Damage Information Gathering and Integration System quickly and effectively gathers and integrates information on the damage to roads obtained from the 18 civil engineering offices in the city on the map.

Yokohama City has an agreement with the construction industry association of the city regarding emergency operations at the time of disasters. Under this agreement, when an earthquake exceeding an intensity of 5.0 on the Japanese scale occurs, personnel from 499 designated companies are dispatched to the 97 arterial roads to check the condition of damage. Reports include information on road cave-ins and landslides in the area they are responsible for, and reports to civil engineering office.

After that, the information is input into the Damage Information Gathering and Integration System at each civil engineering office and integrated at the Office of Disaster Measures and Road Bureau. Based on this system, the Office of Disaster Measures grasps the conditions of damage to roads in the whole city and leads relief operations by designating relief routes to disaster stricken areas.

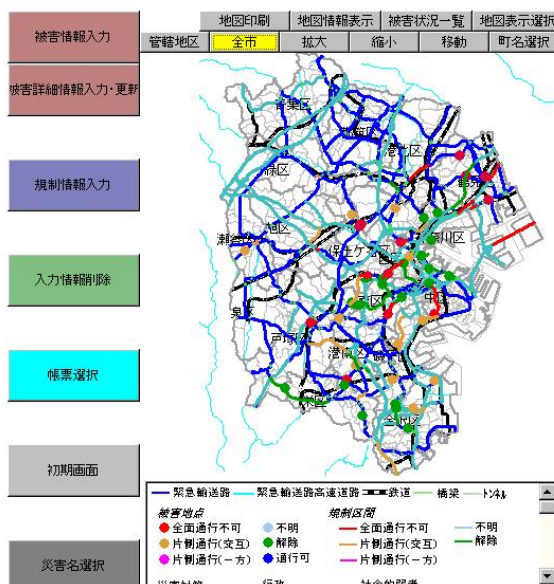


Fig.3 Damage Information Gathering and Integration System

## PREPARATION OF SHAKE MAP

Yokohama City predicted ground shakings at various sites in the city generated by presumed earthquakes such as the South Kanto earthquake and others, and compiled into shake maps.

Until now, though the subsurface ground has been examined in detail by boring exploration and other methods, but the deeper part of the ground structure has not been revealed yet. So, ground shakings generated by a large earthquake have been estimated by comparatively simple procedures.

Because the structure down to several km from the earth's surface has been revealed by our investigation, the ground shaking in the city could be predicted by using the latest seismological computation procedures and by taking the structure obtained into account.

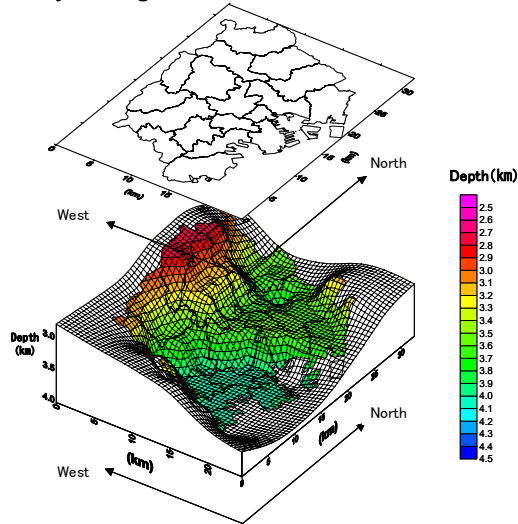


Fig.4 Three dimension plot showing depth of seismic basement

At the first, we synthesized seismic waves at 150 seismographic stations of the High Density Strong Motion Seismograph Network for the presumed earthquakes. Then, based on the waveforms computed, seismic intensities were estimated by using the READY. Finally, the intensities were compiled into a map for each earthquake. It is characteristic that the mesh spacing of usual shake map is 500m, but that of the present map is so fine as 50m. (Fig.5)

As well as a shake maps, we predicted liquefaction in the city generated by presumed earthquakes, and compiled into liquefaction maps. (Fig.6)

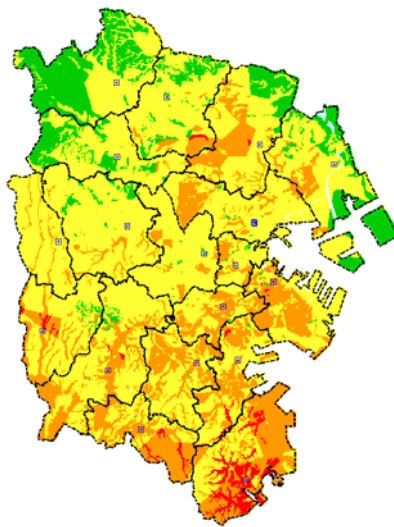


Fig.5 Shake map (South Kanto Earthquake)

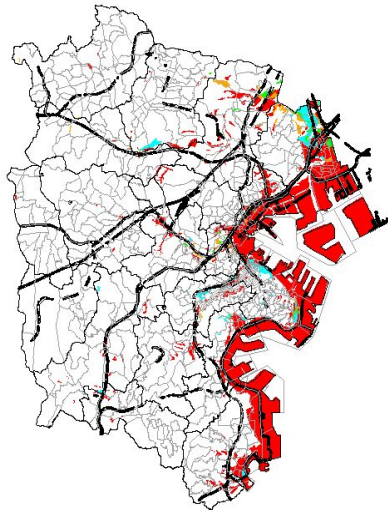


Fig.6 Liquefaction map (South Kanto Earthquake)

### **EARTHQUAKE-PROOF IMPROVEMENT OF WOODEN HOUSE AND CONDOMINIUM**

In order to protect the collapse of wooden housing by strong ground shaking of a large earthquake, a housing earthquake-proof examination without charge and a subsidiary aid are carried out by Yokohama City.

Table 1 Support rate of the subsidiary aid

Income tax of household	Assistant rate	Upper limit of subsidy
0 yen --- 42,000 yen	9/10	5.40 million yen
42,001 yen --- 156,000 yen	3/4	4.50 million yen
156,001 yen --- 397,000 yen	1/2	3 million yen
397,001 yen and more	1/3	2 million yen

Object of the housing earthquake-proof examination without charge is; 1) One- or two-storied wooden houses whose building permit was received and construction work was started before the end of May, 1981, 2) the total floor space under 215 square meters, and 3) private house in which owner lives, and built by the conventional building method. Experts authorized by the mayor as a specialist for the housing earthquake-proof examination conduct the examination without charge on behalf of the city. As a result of the examination, when the overall score determined by experts was less than 0.7, which means that the house is in danger of collapse in a large earthquake, the system of the subsidy of reconstruction expenses for earthquake-proof improvement will be applied to the house.

The reconstruction expense as an object of the aid is 6 million yen at maximum, and the subsidy depends on the income (income tax of the household). The support rate consists of the 4 grades as seen in Table 1.

In the case of condominiums that attained the architecture confirmation and started the construction work before the end of May, 1981, a preliminary earthquake-proof examination without charge will be carried out by the city, when the management association of the condominium applied the examination to the city. The city will assist a part of the examination expenses, when experts of examination judged that the regular examination (more precise examination) would be necessary, as a result of the preliminary examination conducted. The subsidy is half of the examination cost, and the upper limit is 30,000 yen per apartment of condominium.

Furthermore, the management association of condominium can utilize the system that 13.2% for

reconstruction expenses of earthquake-proof improvement are assisted, when all of the following three terms were satisfied by the condominium: 1) The number of stories above the ground is 3 and more, and the total floor space is 1,000 square meters and more, 2) it was judged that there was the necessity of the improvement as a result of the regular examination, and 3) the recognition of “Law of the Earthquake-proof Improvement Promotion” was received.

## CONCLUSIONS

As mentioned earlier, Yokohama City is engaged in various projects for disasters. However, when a disaster actually occurs, it is impossible to prevent damage only by implementing the measures prepared by administration in advance. In order to cope with disasters, it is important for each citizen to be prepared. Yokohama City provides a variety of programs that can be used by citizens before the time of emergency, such as the Wooden House Quakeproof Diagnosis System mentioned earlier. Also, the city has stockpiles of machinery and materials for disaster prevention at local and other disaster prevention bases so that citizens can use them in emergencies.

Yokohama City decides to continue promoting disaster measures in a more practical way based upon the principle of being equal to occasions and being inventive in cooperation with citizens, communities, the private sector, and disaster prevention organizations for the creation of a city strong in disasters and secure in its civil life. This is the basis for the administration of Yokohama City. We sincerely ask continuous understanding and cooperation of personals concerned in our efforts.

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