Disaster Prevention by Realtime Earthquake Information
- Study on Practical Use in Private Enterprise -

I.Takahashi[1] and S. Nambu[2]

1) Senior Research Engineer, Innovation Center, Institute of Technology, Shimizu Corporation, Japan
2) Deputy Senior Research Engineer, Innovation Center, Institute of Technology, Shimizu Corporation, Japan
ikuo@shimz.co.jp, nambu@shimz.co.jp

Abstract: The system of the "Nowcast Earthquake Information" is being developed, which will send us the realtime information about the hypocenters or the seismic intensity of big earthquakes before the main shocks reach. The development for practical use of the information has started. The information is expected to mitigate the disasters to human lives and structures when big earthquakes occur. In this paper, the practical use of the information is discussed mainly from the viewpoint of private enterprises through the concrete examples and tests. The points and the subjects of the use are also investigated.

1. INTRODUCTION

The big earthquakes occurred continually in the Tohoku and the Hokkaido districts last year. The occurrence of the Tokai, Tonankai, or Nankai Earthquake is a matter of anxiety in near future. Under the circumstances, there are a lot of things to do before such big earthquakes attack Japan.

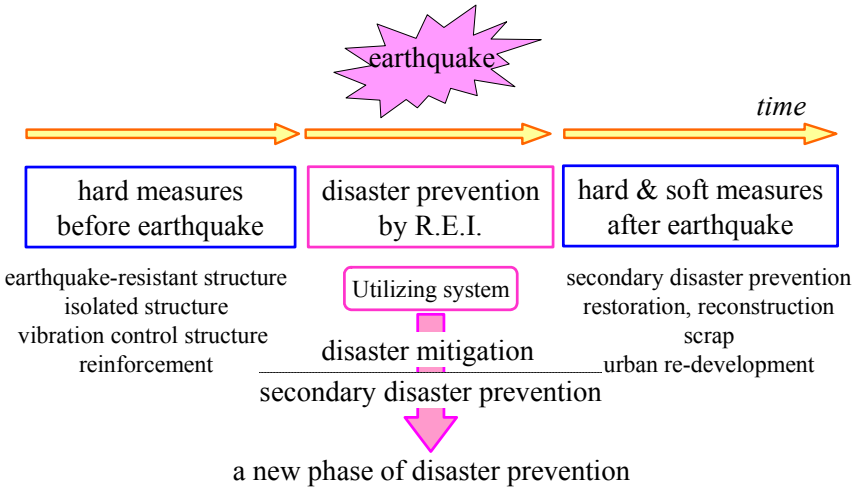


Figure 1 Disaster Prevension by Realtime Earthquake Information

The Japan Meteorological Agency (JMA) has been developing the ìNowcast Earthquake Informationî system, which offers the realtime earthquake information about the epicenters or the seismic intensity before the main shocks reach. The study on the practical use of the information has been in progress simultaneously. It will be possible to make measures according to the information just before the main shocks reach or just after they calm down as shown in Figure 1.

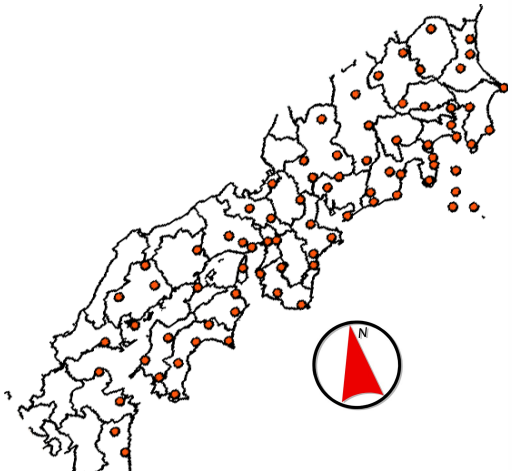
In this paper, the practical use of the information is discussed mainly from the viewpoint of private enterprises through the concrete examples and tests. The points and the subjects of the practical use of the information are also investigated.

2. OUTLINE OF REAL TIME INFORMATION

The UrEDAS (Urgent Earthquake Detection and Alert System) of Japan Railway Company and the SUPREME (Super-dens Realtime Monitoring of Earthquake) of Tokyo Gas Company are known as the application system using the realtime earthquake information in Japan. The former is applied for the safe operation of the Shinkansen Lines as shown in the work by Nakamura (2000). The latter is the control system of city gas supply as shown in the work by Shimizu et al. (2001). The both are developed according to the needs of the business and utilize their own earthquake observation networks.

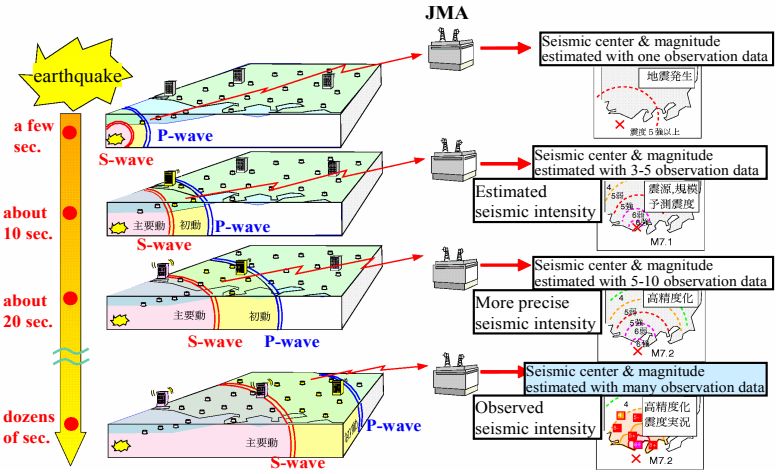
The realtime earthquake information system using the public earthquake observation networks has been studying mainly by JMA, The National Research Institute for Earth Science and Disaster Prevention (NIED) as shown in the work by Kamigaichi et al. (2004), Uhira (2004). The information will be offered to the world from JMA in near future. Sending tests have already started between JMA and several universities or companies. The system started using data from the five observatories around the Tokai district in 2003. The regular sending tests will start in 2004 because the eighty seismographs have been provided for the system from the Kanto to the Kyusyu districts as shown in Figure 2. The observation network is expected to expand to the Hokkaido, the Tohoku districts before long. NIED has been developing the technology of the information system as shown in the work of Horiuchi (2004) in combination of JMA and practical systems in the cooperation with the Real Earthquake Information Consortium (nonprofit organization) as shown in the work of Fujiwara (2004).

The system of the Nowcast Earthquake Information estimates the epicenters and the magnitudes according to the data obtained from the nearest observatories, and sends the information quickly. The



(supplied by JMA)

Figure 2 Distrubution of Seismographs for Nowcast Earthquake Information



(supplied by JMA)

Figure 3 Wave Propagation and Nowcast Earthquake Information

information reaches before S-wave propagates because the estimation is made based on the observed P-waves. The several seconds before the main shocks can be used for the preparedness of the earthquakes. The forecasts of the seismic intensity and the arrival time of the main shocks are included in the information. The accuracy of the information can be improved as the data from the observatories increases as shown in Figure 3.

3. APPLICATION OF INFORMATION

3.1 Characteristics of Nowcast Realtime Earthquake Information

Taking all things into consideration, the Nowcast Earthquake Information has the characteristic as follows:

1) Certainty of Earthquake Occurrence: The information that earthquakes have occurred somewhere can be reliable unless noise is mixed in the data, because it is based on the observation, which is much different from the prediction.
2) Accuracy and Rapidity: The first information is based on the P-wave observed first at the nearest observatory to the epicenter. The rapidity of the first information is much valuable. On the other hand, the degree of the accuracy of the first information canít be very high. More accurate information can be given based on the data from several observatories in a few seconds. At that time, the S-waves have propagated to some extent. The accuracy of the realtime earthquake information is not compatible with the rapidity.
3) Time Margin: If a big earthquake occurs near or under cities, the main shock attacks the cities as soon as the realtime earthquake information reaches or before it does. In those cases, time is not left in preparing for the earthquake.
4) Information Before and After: The accuracy and the rapidity of the information are variable according to the epicenters of every earthquake. On the other hand, the information of observed seismic intensity sent after the shocks calm down is effective to prevent cities and citizens from the secondary damage in every big earthquake.

3.2 Capability in Past Earthquakes

It is very interesting to estimate how effective the realtime earthquake information should be to the disaster prevention if the information system existed when the past big earthquakes occurred.

Figure 4 shows the ratios of cause of death in the 1978 Miyagi-Ken-Oki Earthquake, the 1993 South-West off Hokkaido Earthquake and the 1995 Hyogo-Ken-Nambu Earthquake as shown in the

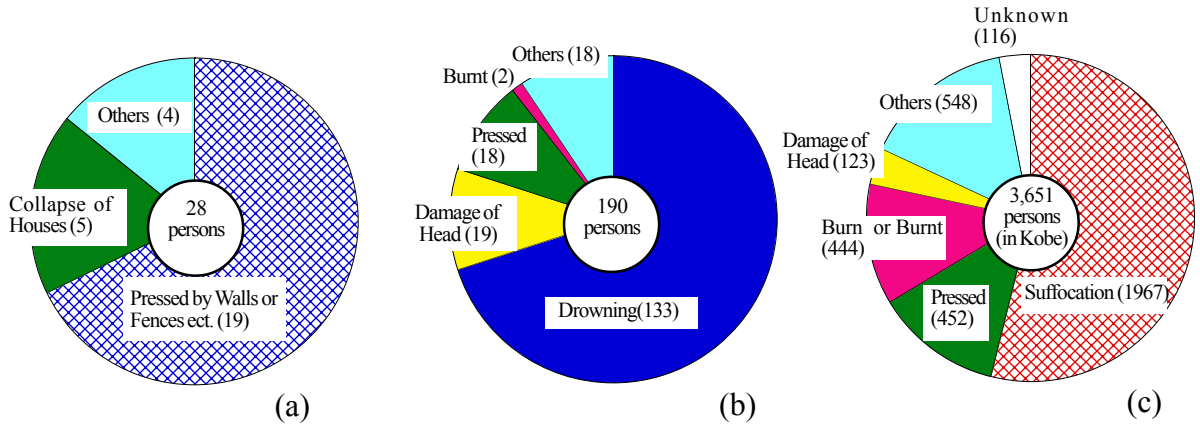


Figure 4 Cause of Death in Past Earthquakes: (a) 1978 Miyagi-Ken-Oki Earthquake, (b) 1993 South-West off Hokkaido Earthquake, and (c)1995 Hyogo-Ken-Nambu Earthquake

work of A.I.J. (1980), A.I.J. (1995) and A.I.J. et al. (2000). In case of the Hyogo-Ken-Nambu Earthquake, the dead in Kobe is shown in the figure. In the Miyagi-Ken-Oki Earthquake, the fact is remarkable that many people died by fall down of walls or fences etc. This earthquake occurred in the evening when the most of people were in active. If they caught the realtime earthquake information somehow several seconds before, the dead should be decreased. Many people were killed by the tsunami in the South-West off Hokkaido Earthquake. It is conjectured that the most of the dead persons were not able to escape or fail. If they knew the possibility of tsunami occurrence, the scale or the arrival time, the victims of the tsunami should be decreased. In the Hyogo-ken Nambu Earthquake about two thirds of dead persons were pressed by houses or furniture. It can be thought that the sharp main shocks collapsed the houses or fell down furniture in a moment. If the realtime earthquake information was sent, the main shocks should attack Kobe before the information reached there because the epicenter was very close to Kobe. If the information was sent a few seconds before, it should not be possible to save their lives because the most of people were sleeping.

Those tell us that while the information is not almighty, it can save human lives if the information is utilized cleverly. The efficiency of the information would depend on usual training or consciousness of disaster prevention.

3.3 Disaster Prevention in Private Enterprises and Realtime Information

In the national anti-disaster plan, the roles of private enterprises are:

- securing the employees and the customers,
- maintaining the business activity and the economic stabilization,
- making contribution to the disaster mitigation in the local community.

Figure 5 shows the relation in the disaster between the companies and the local community. It is difficult for the companies to rescue the community if they are suffered from the disaster. Maintaining the business activity leads to the disaster mitigation in the local community and securing the community leads to the stability of the business.

3.3.1 Practical Use of Realtime Information

Some Examples of the practical use of the realtime information in private enterprises are shown in this section.

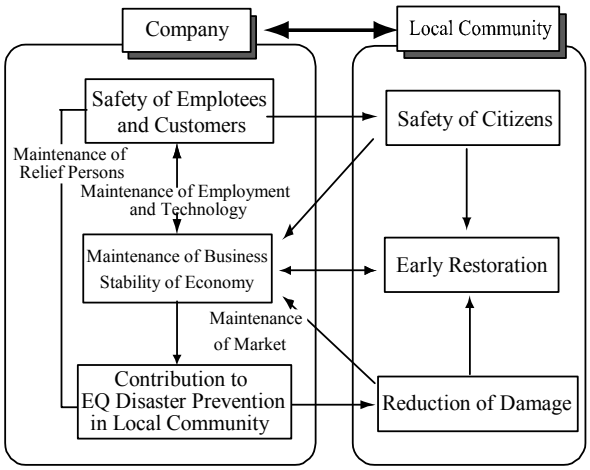


Figure 5 Relation between Private enterprise and Local Community in Disaster Mitigation

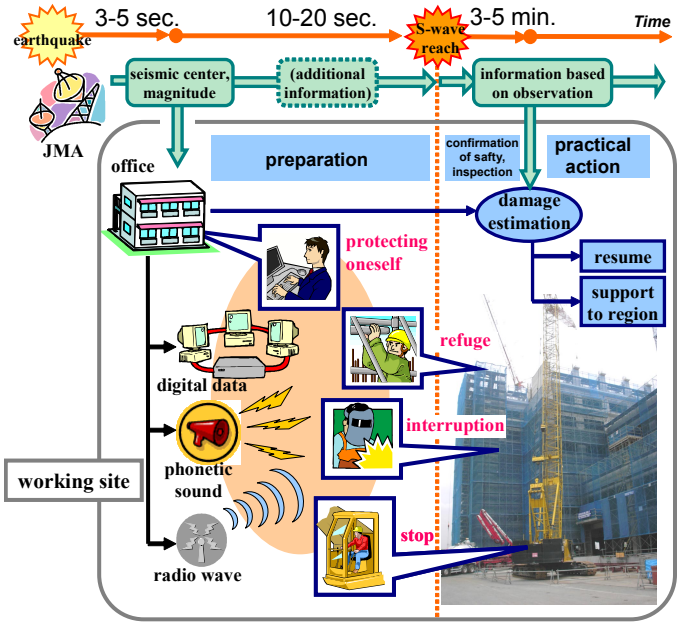


Figure 6 Example of Practical Use of Realtime Earthquake Information in Company

1) Securing Factories or Workplaces

Employees sometimes work at dangerous places or operate dangerous tools or machines in factories or workplaces. There may be toxic substances such as chemicals or combustible oil etc. It is necessary to secure the employees and the facilities by their escaping from heights, interrupting the dangerous works or stopping the dangerous operation of machines as shown in Figure 6. If the realtime information is sent to the employees before the arrival of the main shocks, preparing for the earthquakes is easy. It would be better to take action without being nervous of the scales of earthquakes if safety is prior to all, because there is little economic loss if the information is false. It is important to use the information considering the balance of safety and economic loss, the accuracy, or the contents if economic loss can be caused once a manufacturing process is stopped. In this case, employees may meet the emergency through the judgment according to the information.

2) Safety Confirmation of Employees

It is easy to confirm the safety of the employees within an office building, while it is difficult to confirm the safety of the employees in the disaster when they work here and there in factories or workplaces. If the disaster prevention center established in the company that can take the realtime earthquake information, and the employees have portable terminals such as cellular phones or PHS that can be used for both on business and in emergency, they can obtain the information from the center. When the center sends the earthquake information, it transmits the message at the same time instructing the employees to send the information about their safety after the earthquake. The employees can prepare for the earthquake by the information before it comes. It becomes easy for the center to grasp the safety of the employees in the sites after the earthquake. The point is the instruction of safety confirmation is included in the information and the escape from concentration and confusion of communication lines.

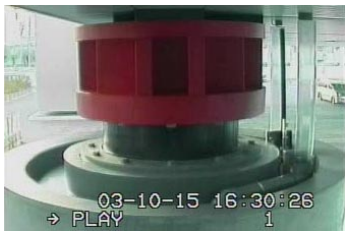
3.3.2 Test of Practical Use

The tests of control of machines and tools or confirmation of the employeeís whereabouts using the realtime earthquake information are in progress in the Institute of Technology in Shimizu Corporation.

1) Record of Base Isolation Device Movement

The new office building of the institute has the base-isolation system that is supported by isolation devices on six columns at the first floor as shown in Picture 1. There is a video camera beside one of the devices for monitoring the movement when the earthquake occurs. Picture 2 is the image from the

Picture 1 Appearance of Office Building (Instutute of Technology in Shimizu Cor.)



Picture 2 Image by Video Camera Biside Isolation Device

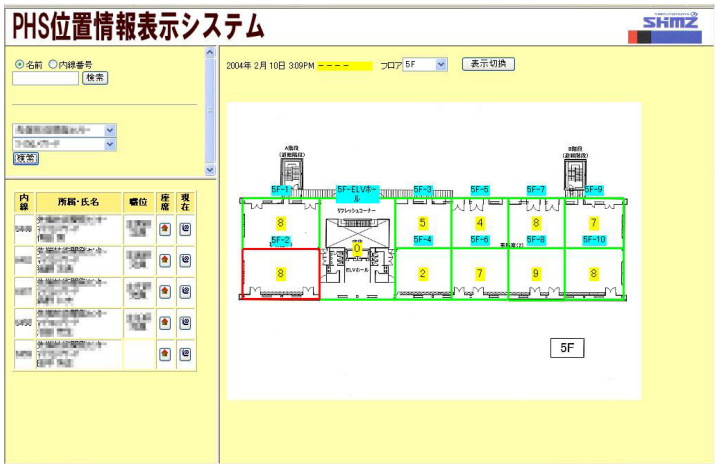


Figure 7 Result of Whereabouts Confirmation of Employees in Office Building

camera. Recording by the camera based on the realtime earthquake information is in the experimental stage. If the information is sent from JMA to the institute, the signal is made to start recording before the main shocks come. Originally the recording system is traceable by connection with the seismograph established in the institute. The control system by the realtime earthquake information works as a backup.

2) Confirmation of Employees' Whereabouts

All the employees have personal handyphones usable within the institute. There is a rule in the institute that they always take the handyphones with them during working, turns off when they go home. Those handyphones are used not only for communication on business but also for monitoring their whereabouts regularly for the purpose of effective air condition control etc. The plan will be considered on a trial basis that the realtime earthquake information is used for starting the monitoring system before the earthquakes come. It makes sure of the monitoring by avoidance of electrical or mechanical troubles. Figure 7 shows the employees' whereabouts on one occasion by the monitoring system. The monitoring system can be effective to the safety confirmation of the employees because there are a few buildings and a lot of facilities in the site.

3.3.3 Point of Practical Use

The points of the practical use of the information as it stands may be as shown bellow:

1) The measures based on the information of an earthquake occurrence or rough estimation of the epicenter are the first step of the practical use because the accuracy of the epicenter or the magnitude estimated varies according to the earthquakes.
2) It is difficult to apply the information if great economic loss is generated by the practical use, e.g. the control system of production processes by the information, when the estimated errors are included in it. The practical use that does not much depend on the accuracy of the information would be better.
3) When an epicenter is close to relevant cities, e.g. an epicentral earthquake, the preparedness by the information is limited because the time margin is small or none. On the other hand, the measures using the information for tall buildings or towers can be effective to the earthquakes which occur in the far, because the ground motion includes long periods components and they take long time to come in such cases.
4) After big earthquakes, the communication concentration or the network confusion is easy to generate as the Hyogo-Ken-Nambu Earthquake. The information is useful for the application with the aim of avoidance of such communication troubles because in many cases the information is sent before earthquakes come.
5) Preparing the application using the information leads to the multiplicity of the disaster prevention measures, as shown in the previous section, because the applications using the information sent before earthquakes come have not been existed up to now.

4. SUBJECTS FOR FUTURE STUDY

In order for the realtime earthquake information to be widespread and useful for disaster mitigation, the subjects as shown bellow should be investigated.

1) Finding Needs: Where or when the realtime earthquake information can be used has not been investigated enough. Finding needs in various scenes considering the characteristics of the information is one of the most important problems.
2) Ascertainment of Accuracy: Verification of the accuracy and improvement of the information are the problems of the sender. The users of the information should understand the system and ascertain the accuracy from the viewpoint of the practice.
3) Means of Communication: Economical, rapid and reliable communication is needed for popularization. Communication using private lines or satellites is not popular at present because of expensiveness.

4) Contents of Information: When the earthquake information is given directly to ordinal people such as employees or customers, the contents should be examined considering the states of human mind to avoid confusion or panic.
5) Usual Use and Training: It is easy for the users to receive the information by the experienced ways. The means of communication which can be used both in usual and in emergency is expected. The practical measures by the information should be incorporated into the disaster manuals and be used repeatedly in the disaster prevention training. The efforts of bringing emergency close to usual are needed.
6) Avoidance of Communication Concentration: Communication concentration is generated frequently just after earthquakes and it leads the situations to the worse. It is difficult to evaluate or simulate such situations. Various means of communication should be prepared for emergency to use the information certainly.

5. CONCLUSIONS

While the improvement of earthquake-resistance performance of buildings or house is one of the most important problems in regard to safety of human lives or minimization of economical loss, it is possible to save many human lives or prevent the damage to spread by using the real time earthquake information. Realization of the practical use of the information is expected before big earthquakes occur in near future.

Reference

Nakamura, Y. (2000), "Status Quo and Future Prospects of the First Practical Alert System by P-wave (UrEDAS) in the World (in Japanese)," *Proceedings of the Second Symposium of Real Time Earthquake Disaster Prevention of Japan Society of Civil Engineering*.

Shimizu, Y., Koganemaru, K., Nakayama, W., and Yamazaki, F. (2001), "Super-dens Realtime Monitoring of Earthquake (SUPREME) in City Gas Supply Facilities (in Japanese)," *Proceedings of the First Annual Meeting of Japan Association for Earthquake Engineering*, 255.

Kamigaichi, O., Tsukada, S., Morimoto, M. and Hasebe, D. (2004), "Development of JMAís Nowcast Earthquake Information (in Japanese)," *Tsuchi-to-kiso (Journal of Japanese Geotechnical Society)*, 52(1), 19-21.

Uhira, K. (2004), "On JMAís Nowcast Earthquake Information (in Japanese)," *Material of the Third Land Safety Net Symposium*, 1-3.

Horiuchi, S., "For Advancement of Real Time Earthquake Information (in Japanese)," *Material of the Third Land Safety Net Symposium*, 15-20.

Fujinawa, Y. (2004), "For Practical Use of Real Time Earthquake Information (in Japanese)," *Material of the Third Land Safety Net Symposium*, 21-25.

Architectural Institute of Japan (1980), "Report on the Damage Investigation of the 1978 Miyagi-ken-oki Earthquake (in Japanese)."

Architectural Institute of Japan (1995), "Report on the Damage Investigation of the 1994 Hokkaido-Toho-Oki Earthquake and the 1994 Sanriku-Haruka-Oki Earthquake (in Japanese)."

Architectural Institute of Japan, Japan Society of Civil Engineering, Japanese Geotechnical Society, Seismological Society of Japan, The Japan Society of Mechanical Enginerrings (2000), "Report on the Hanshin-Awaji Earthquake Disaster General Issue Volume 1, Compendium of Earthquake Disaster including Stochastics Description (in Japanese)."