REFERENCE EARTHQUAKE INFORMATION FOR PROMPT CRISIS MANAGEMENT

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Abstract

Reference Earthquake Information (REI) is proposed to cover the information gap that decision makers undergo after a disastrous earthquake. When a strong earthquake hits Japan, a reference earthquake is selected from a list of 20 major earthquakes based on the observed spectrum intensity (SI), the type of stricken area, and so on. The SI distribution maps and disaster information of the major earthquakes are compiled into the earthquake disaster information catalog. REI provides the SI distribution map and disaster information of the reference earthquake right after an earthquake and is expected to support prompt crisis management by the decision makers and administrators.

Introduction

Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) conducts inspection of facilities under its administration after an earthquake with maximum JMA (Japan Meteorological Agency) seismic intensity of 4 or higher occurs. It usually takes several hours to complete the inspection in the daytime and becomes longer as the damage becomes heavier, spreads broader, and in the nighttime. The headquarters for disaster control has little information on the damage to the facilities at its initiation until the inspection is completed and reported. This information gap hampers prompt crisis management by the headquarters.

In this paper, the Reference Earthquake Information (REI) is proposed to cover the information gap and support decision making. REI simply provides information of a reference earthquake, i.e. a past earthquake of which damage to the facilities is considered similar to the one just occurred. The information includes spectrum intensity (SI) distribution maps and numbers of damaged facilities of the reference earthquake. Comments on damage estimation based on the comparison between the SI distribution map of the reference earthquake and SI map of the one just occurred are also included. Note that the format, contents, etc. of REI described in this paper can be changed because the investigation is still under way.

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Format and Contents of Reference Earthquake Information

Figure 1 shows an example of REI, which was made assuming that the Suruga Bay earthquake in 2009 just occurred. The top-left figure shows the SI map of this event observed by the MLIT Seismograph Network, which consists of 700 online seismographs installed with intervals of 20 to 40 km along rivers and national highways administered by MLIT (Uehara and Kusakabe, 2004). The data server of the Seismograph Network uploads the SI map to NILIM website (http://www.nilim.go.jp/japanese/database /nwdb/html/newearthquake) within 10 minutes after an earthquake with maximum JMA seismic intensity of 4 or higher occurs. The data server uploads a peak ground acceleration (PGA) map and JMA seismic intensity map at the same time. SI was chosen as the best index to represent ground motion intensity because it has the best correlation with damage to facilities in the past major earthquakes.

The top-right figure is the SI distribution map of the reference earthquake. The SI distribution maps of past major earthquakes were prepared using strong motion records observed by JMA, NIED (National Research Institute for Earth Science and Disaster Prevention), MLIT, and so on. The bottom-right table shows key numbers, such as death toll and damaged facilities, in order to image the disaster caused by the reference earthquake. The SI distribution maps and the key numbers of the past major earthquakes are compiled into an earthquake disaster information catalog, so that they can be picked out as soon as the reference earthquake is selected.

The bottom-left space is left for comments on damage estimation based on the comparison between the SI distribution map of the reference earthquake and SI map of the one just occurred. The first comment describes the reason why the reference earthquake was selected for this event. The second and third comments compare the maximum SI and the area suffered strong motion with high SI, respectively, of the reference earthquake and this event.

Procedure for Selecting a Reference Earthquake

A reference earthquake will be selected as soon as a strong earthquake hits Japan. Therefore, the procedure for selecting the reference earthquake must be simple and clear. On the other hand, damage of the reference earthquake has to be similar to that of the one just occurred. The type of stricken area, maximum SI or seismic intensity, magnitude, and focal depth can be obtained just after an earthquake and were found to be important factors to make damage of two earthquakes similar to each other.

Even if the same strong motion attacks urban area and mountainous area, facilities damaged in these two areas are quite different. Viaducts and levees are possibly damaged in urban area, while slopes and dams may be damaged in mountainous area. Thus, the type of stricken area is an important factor to take this fact into account when a reference earthquake is selected.

20 major earthquakes since 1968 are classified by the type of stricken area and maximum SI as shown in Table 1. Earthquakes before 1968 are not in the table because strong motion records obtained during these earthquakes are not enough to make the SI distribution maps. Urban, mountainous, and coastal/local areas represent types of stricken area in the table.

It seems not easy to select a reference earthquake from Table 1 because some cells include two or more earthquakes, while some other cells have no earthquake. Therefore, a procedure for selecting a reference earthquake was organized as shown in Figure 2. The procedure starts with getting information on the earthquake and observed record (1, 2) and selecting the type of stricken area (3).

Questions (4, 5) are set to check whether the strong motion around the source region is caught by the Seismograph Network. If the hypocenter is inland and shallow and the maximum seismic intensity observed by JMA is larger than that by the Seismograph Network, the strong motion around the source region is likely missed by the Seismograph Network. In this case, JMA seismic intensity is used to select a reference earthquake instead of SI observed by the Seismograph Network.

Finally, a reference earthquake is selected based on the factors shown in Table 1 (6, 7, 8). The more earthquakes will be placed in Table 1, the more similar earthquake can be selected as a reference earthquake in the future.

Concluding Remarks

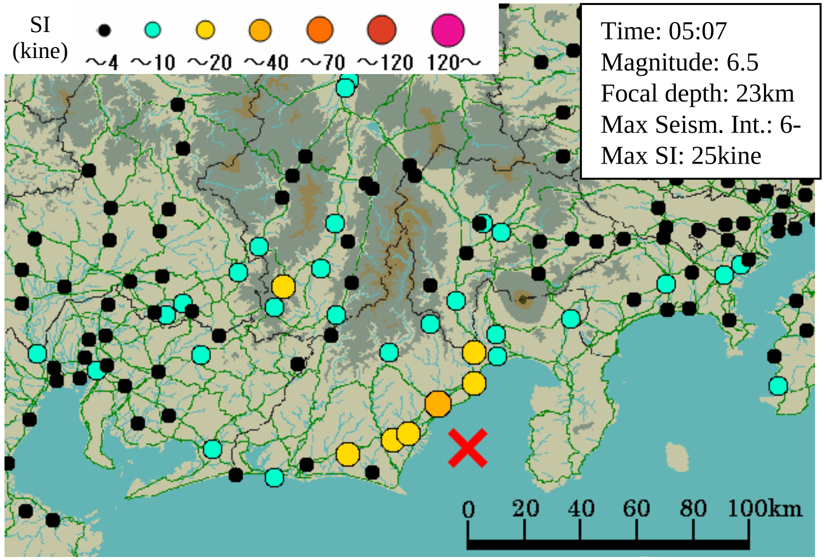
Reference Earthquake Information (REI) is proposed with its format and contents to cover the information gap that decision makers undergo after a disastrous earthquake. A procedure for selecting a reference earthquake is also presented. SI map of an earthquake just occurred will be upgraded to SI distribution map, which looks the same as those made for the past earthquakes, in order to make the comparison of the two maps easier.

Reference

Uehara, H. and Kusakabe, T.: Observation of strong earthquake motion by National Institute for Land and Infrastructure Management, *Journal of Japan Association for Earthquake Engineering*, Vol. 4, No. 3 (Special Issue), pp. 90-96, 2004.

Reference Earthquake Information

11 Aug 2009 Earthquake occurred in the Suruga Bay



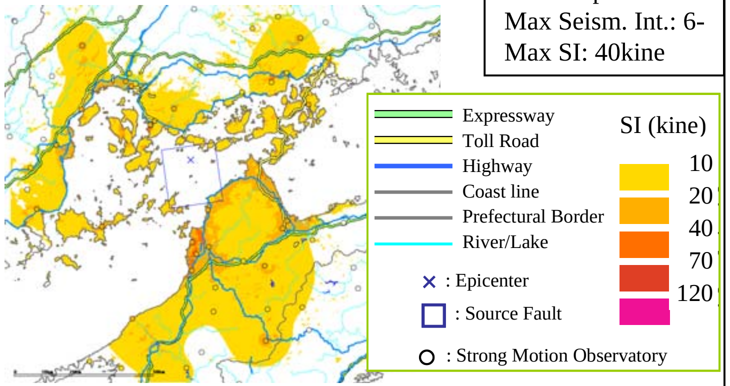
Time: 05:07
Magnitude: 6.5
Focal depth: 23km
Max Seism. Int.: 6-
Max SI: 25kine

1) Geiyo earthquake in 2001 was chosen as a “reference earthquake” because the observed SI, magnitude, and focal depth are close to this event and observed ground motion was strong in the coastal area.
2) The damage in the most affected area is estimated as heavy as the reference earthquake because the maximum SI is at the same level.
3) The damaged area is estimated smaller than the reference earthquake because the area suffered strong motion with high SI is smaller than the reference earthquake.

Note: The above estimation may be different from the actual damage because earthquake damage is affected by the topographical and geological conditions and kinds and distributions of facilities in the stricken area.

Reference Earthquake: 24 Mar 2001 Geiyo earthquake

Time: 15:27
Magnitude: 6.7
Focal depth: 46km
Max Seism. Int.: 6-
Max SI: 40kine



Key numbers

Casualty	Death: 2, Serious: 43, Slight: 245
Damaged Housing	Complete: 70, Partial: 774, Slight: 48,994
Damaged Facility	**Sediment disasters** Landslides: 1, Slope failure: 18 Damaged facility: 0 **Road** Traffic regulation: Highway & Expressway: 4, Other: 30 Damaged facility: Highway & Expressway: 4, Other: 783 **River** Damaged facility: National 5, Other 61 **Port** Damaged facility: 149

Figure 1: An example of Reference Earthquake Information (assuming the Suruga Bay earthquake in 2009 just occurred)

Table 1: A table classifies 20 major earthquakes by the type of stricken area and maximum SI.

SI (kine)	Type of stricken area		
	Urban	Mountainous	Coastal/Local
20-40 (I=5+)	P)1978 Off Miyagi (M7.4, D=40km) maxSI=40, maxI=V		P)1993 Off SW. Hokkaido (M7.8, D=35km)* maxSI=29, maxI=V P)1968 Off Tokachi (M7.9, D=0km) maxSI=39, maxI=V S)2001 Geiyo (M6.7, D=46km) maxSI=40, maxI=6-
40-70 (I=6-)	C)2005 Off W. Fukuoka (M7.0, D=9km) maxSI=51, maxI=6-	C)2003 N. Miyagi (M6.4, D=12km) maxSI=51, maxI=6+ C)1997 NW. Kagoshima (M6.6, D=12km) maxSI=56, maxI=5+	S)2009 Suruga Bay (M6.5, D=23km) maxSI=47, maxI=6- P)1983 Mid Japan Sea (M7.7, D=14km)* maxSI=49, maxI=V S)1994 Off E. Hokkaido (M8.2, D=28km) maxSI=54, maxI=VI S)2003 Off Miyagi (M7.1, D=72km) maxSI=59, maxI=6- S)1993 Off Kushiro (M7.5, D=101km) maxSI=69, maxI=VI
70-120 (I=6+)		C)2008 Iwate-Miyagi Inland (M7.2, D=8km) maxSI=84, maxI=6+ C)2000 W. Tottori (M7.3, D=9km) maxSI=114, maxI=6+	P)1994 Far Off Sanriku (M7.6, D=0km) maxSI=71, maxI=VI
120- (I=7)	C)1995 S. Hyogo (M7.3, D=16km) maxSI=138, maxI=VII	C)2007 Noto Peninsula (M6.9, D=11km) maxSI=122, maxI=6+ C)2004 Mid Niigata (M6.8, D=13km) maxSI=161, maxI=7	P)2003 Off Tokachi (M8.0, D=45km) maxSI=121, maxI=6- C)2007 Off Mid Niigata (M6.8, D=17km) maxSI=134, maxI=6+

M: JMA magnitude, D: focal depth, maxSI: maximum observed SI (kine), maxI: maximum JMA seismic intensity

P): plate-boundary earthquake, S): intra-slab earthquake, C): inland crustal earthquake, *: earthquakes with tsunami disaster

JMA seismic intensity scale was changed from 8 scales to 10 scales in 1996. Seismic intensities of earthquakes before 1996 is used Roman number, while those after 1996 is used Arabic number. Seismic intensities V and VI were divided into two scales each, (5- , 5+) and (6-, 6+), respectively, in 1996.

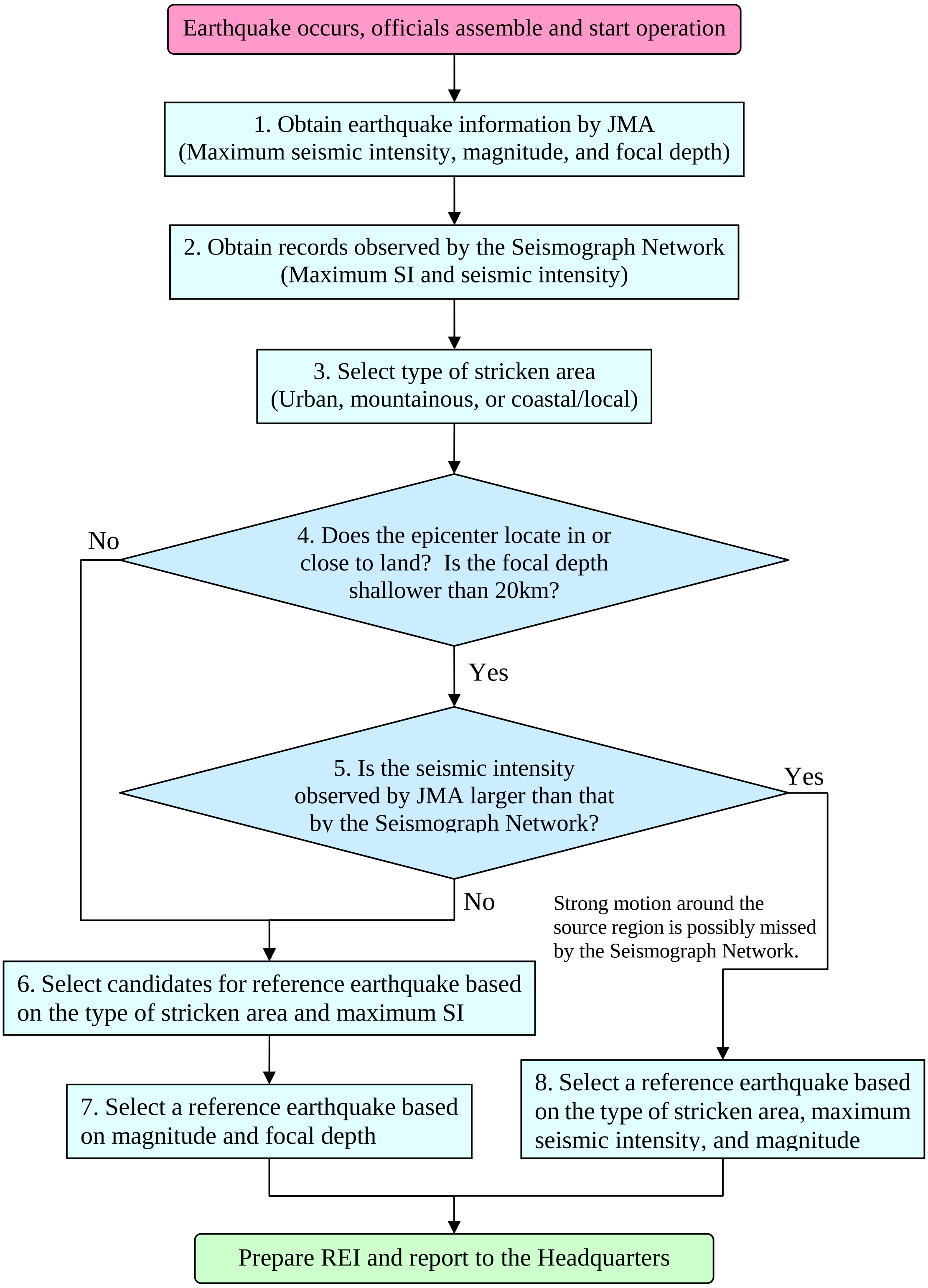


Figure 2: A procedure for selecting a reference earthquake.