

Post-earthquake countermeasures for damaged building in Shizuoka Prefecture

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ABSTRACT: Shizuoka Prefectural Government has made earthquake preparedness since the Tokai earthquake in Suruga Bay was predicted in 1976(See Fig.1). Not only the predicted mainshock but also aftershocks will be a large scale as shown in the Table 1 and therefore the early rehabilitation of the damaged buildings as well as preventive measures against secondary damage due to aftershocks is essential. The main aim of this paper is to present the outline of the measures to minimize building damage due to aftershocks.

Table 1. The mainshock and aftershocks.

Mainshock	Magnitude : 8.0, Distance from epicenter : 0km-70km
Aftershock	Magnitude : 5.0-7.0, Frequency : more than 10 times, Period : more than one month

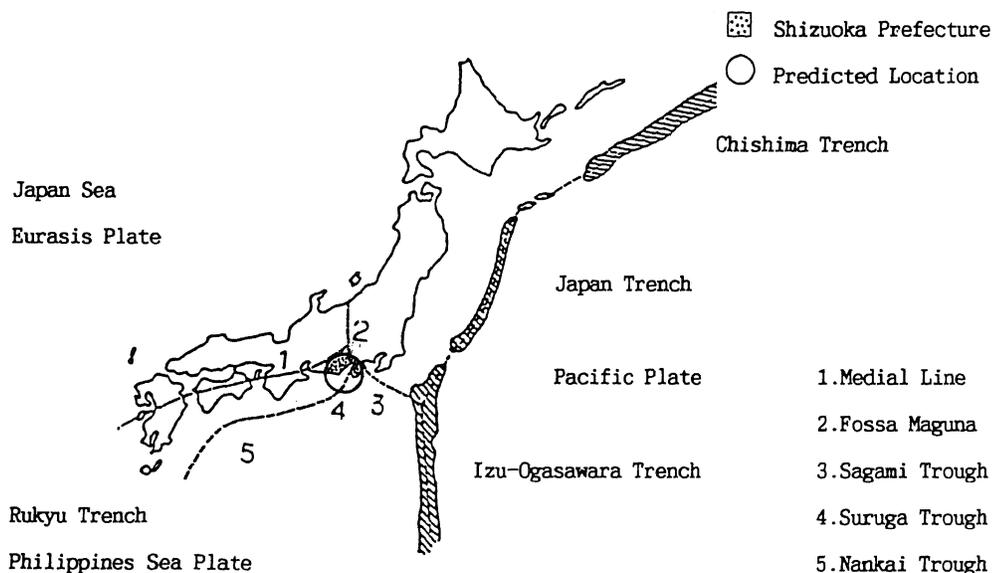


Figure 1. Ocean trenches near Japan and Shizuoka Prefecture.

1 TOKAI EARTHQUAKE AND THE AFTEARSHOCKS

The Tokai earthquake is estimated to be a magnitude 8 earthquake having its epicenter in the area to the west of the Suruga Trough,

which runs from the offing of Omaezaki to Suruga Bay.

1.1 Tokai Earthquake and the reason of occurrence

1. Large-scale earthquake have occurred periodically in the Tokai region every a century as shown in the Table 2. Damage and injury due to resulting tidal waves, landslides and collapse of buildings have been detailed in historical records.

138 yeays have passed since the Ansei Tokai earthquake of 1854.

Table 2. The return periods of Oceanic earthquake

Period	Year	Earthquake	Magnitude
107	1498	Meio	8.6
102	1605	Keicho	7.9
147	1707	Hoei	8.4
138	1854	Ansei	8.4
	1992 (Today)		

2. The area showing no activity in the Enshuu Nada region. Abnormalities in the fluctuation of earth's crust have been observed in the Suruga Bay area but seismic activity continues to remain absent as shown in Fig. 2.

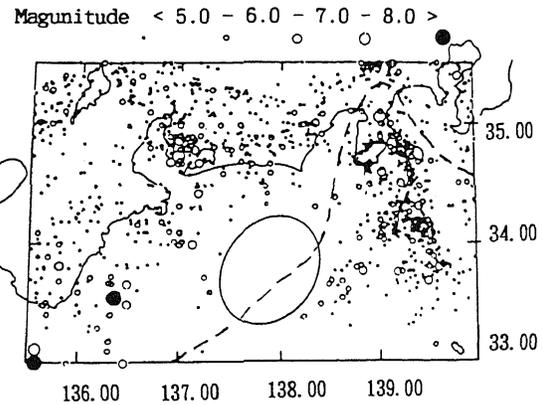


Figure 2. Resent distribution of epicenter in Enshuu Nada region (1926-1976 from Japan Meteorological Agency).

Because of these facts, it has been predicted that an earthquake is likely to occur in the Tokai region in the near future.

1.2 Activity of Aftershocks in Tokai earthquake.

The aftershocks in the Tokai earthquake are estimated to be as same scale as the aftershocks in Tonankai Earthquake (M7.9) in 1944, and magnitude 5 to 7 aftershocks are estimated to occur twenty times for one month as shown in Fig 3 and 4.

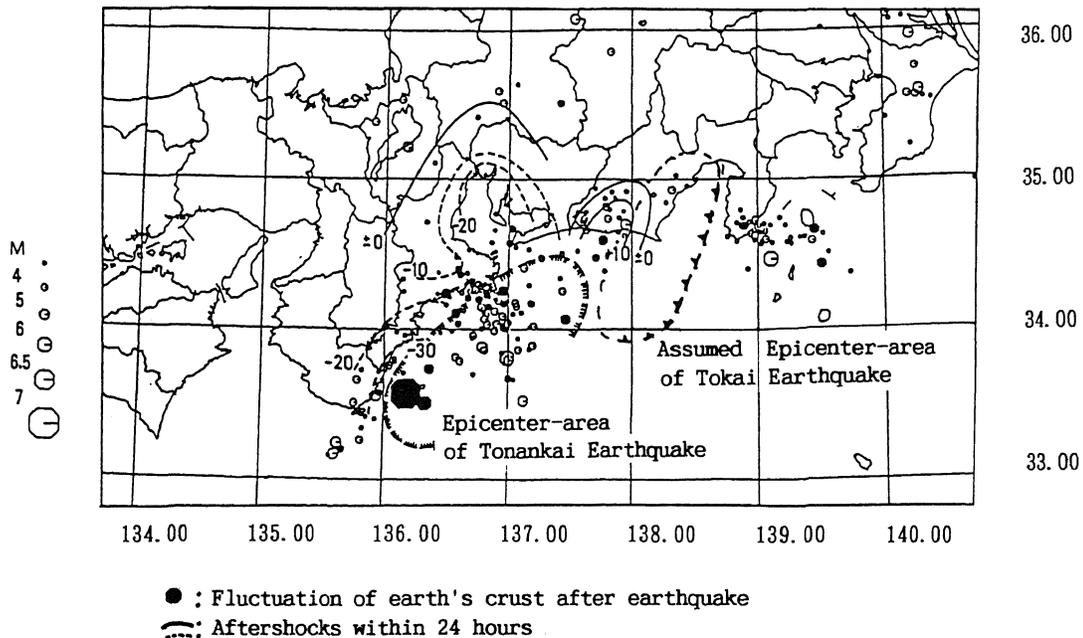


Figure 3. The activity of aftershock in Tonankai earthquake for 30 days (Iwata & Hamada, 1986).

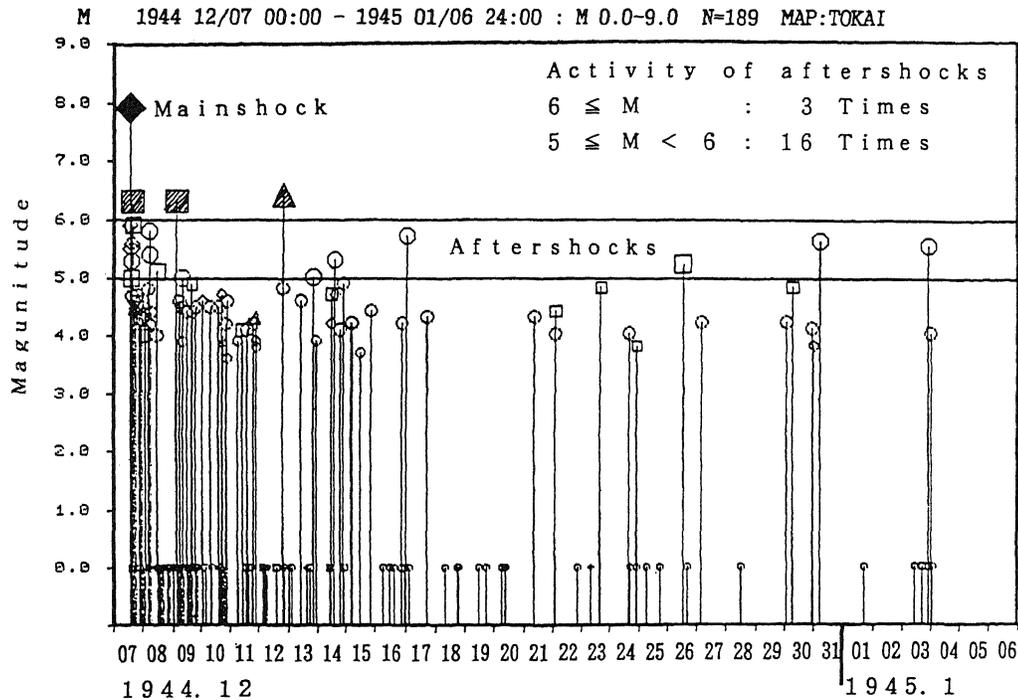


Figure 4. Activity of aftershock and magnitude in Tonankai Earthquake for 30 days (Iwata & Hamada, 1986).

1.3 Assessment of damage potentiality and the number of households which needed the evaluation.

To practice the countermeasures more effectively, it is necessary to have quantitative figures, which enables the authors to exactly set a target. In this sense, the Shizuoka prefectural government has assessed the damage potentiality in the predicted Tokai earthquake.

Based on the assessment, the number of homes needing the evaluation, such as collapsed, damaged and partially damaged homes, will be about 200 thousand which is equal to 20% of whole the households in Shizuoka Prefecture.

The following damage estimates are based resulting The damage from geological factors, ground conditions, spread of fires, and landslides in past earthquakes.

Table 3. Estimated damage

Damage	Houses
Collapsed	69,000
Partially collapsed	121,000
Houses washed away by Tsunami	2,600
Houses flooded by Tsunami	29,400

2 PASSAGE OF SHIZUOKA PREFECTURAL GOVERNMENT COUNTERMEASURES

Viewing back the past earthquakes, it is a very important task to develop systems and methods to evaluate and restore damaged buildings in most countries of the world. Along with this movement, during the period from 1981 through 1985, Ministry of Construction practiced the comprehensive technique development project, "Development of Restoration Technique for Structures Damaged by Earthquake".

In these circumstances, The prefectural government sent the investigation team to Mexico City after the 1985 Mexico Earthquake. The necessity of the post-earthquake countermeasures such as immediate evaluation for the degree of damage was recognized, and since then as well as joining in the National Investigation Committee, Shizuoka prefectural government is implenting these countermeasures.

1. 1988, Prepared a manual for temporary evaluation techniques to the predicted Tokai earthquake.
 2. 1989, Varification of the evaluation items and preliminary training of inspectors.
- Reaserch on the aftershock countermeasures at the scene of the Loma Prieta earthquake.

3. 1990, Supplement of "safety measures for buildings hit by earthquake" to the regional disaster prevention project.

4. 1991, Build up the licence system for the temporary emergency evaluation inspector concernig the degree of damage and training of the inspectors.

-Make known to construction administrators as for evaluation system and evaluation techniques.

-Preparation of evaluation system.

2.1 Temporary emergency evaluation technique manual in Shizuoka prefecture

The Shizuoka prefectural government made an original evaluation manual by referring to the manual "Evaluation Standard for Damaged Building and Technical Instructions for Restoration" supervised and compiled by the Ministry. In contrast with the national government's manual which is used by construction specialists only, The significant feature of our manual is to be divided into two parts; one for specialists, and the other for building owners, and further, it is characterized in separately providing a chapter where the evaluation for the degree of dangerous falling objects is described.

Types of buildings to be evaluated are sorted into 3 categories by structure; wooden, steel frame, and reinforced concrete constructions, and each category is further broken down to about 20 items such as building configuration, sink, inclination, framework damage, impending falling objects, etc.

These items are assessed based on an evaluation check list.

The damage is finally classified into 3 degrees; "Dangerous", "Careful" and "Safe". The evaluation is expected to be done within 10 to 20 minutes per case.

3 IMMEDIATE EMERGENCY EVALUATION SYSTEM OF SHIZUOKA PREFECTURE

Suppose the safety of buildings must be secured by owners, the responsibility to first evaluate whether damaged buildings is safe or not even against aftershocks to prevent the secondary disaster due to themselves.

In the case that the evaluation by owners can not reach a conclusion or has revealed the necessity for further evaluation in detail, it is a principle to ask specialists for the evaluation.

However, it might be difficult to expect owners to make the evaluation promptly and accurately under the circumstances where the society itself is in chaos right after earthquake.

Therefore, considering that related administrations need to work on the evaluation and to take measures based on the results, the Shizuoka prefecture government has made the decision to include the include the immediate emergency evaluation operation in the Shizuoka local disaster preparedness plan which is based on Disaster Countermeasure Fundamental Act , and execute the operation.

3.1 Organization of immediate evaluation system

The actual evaluation will be controlled by architectural departments and divisions of municipal and other local administrations in accordance with the direction from the emergency operation headquarters placed in the prefectural, municipal and other lower ranked governments.

It is also needed to previously arranged the system which allows additional volunteer inspectors to cooperate with the staff of the administration in the case where the number of the staff such as architectural engineers may not be sufficient in evaluating damaged buildings. Therefore, the Shizuoka prefecture government is working on organizing the inspectors, linking them with the system, streamining the mutual communication, and preparing a guideline which clarifies the allocation of responsibility.

1. Organization of evaluation system for practical operation after the occurrence of earthquake.
 - Organization of disaster relief headquarters, construction division in charge police and fire department, construction groups.
 - Establishment of volunteer organization of evaluation inspectors and construction groups.
2. Distinction of the evaluation system
 - The second step evaluation by specialists after the brief evaluation by owners or residents.
 - System for evaluation of many buildings during short period.

3.2 Temporary emergency evaluation insupector and license system

Shizuoka prefecture first, among many other prefectures, started a license system for temporary emergency evaluation inspectors in June, 1991.

In this system, the governor of Shizuoka prefecture qualifies and licenses architects who have finished a seminar course and are willing to collaborate in the

evaluation operation upon disaster.

The license is valid for 5 years, and it is renewed by attending the seminar at the time of expiration. In 1991, 2,040 people attended the seminar, and more than 1,200 of them have applied for the license. The Shizuoka prefectural government aims at training 10,000 inspectors for the next 5 years, and these are equal to almost half of the architects in Shizuoka Prefecture.

4 EVALUATION AND RESPONSE BASED ON THE RESULT

The inspectors must be paired and receive permission from residents before practicing the evaluation. The damage of buildings are classified into 3 degrees; "Dangerous", "Careful" and "Safe". Based on the result of the evaluation, the mayor or a head of other administrations display such a mark as "Dangerous" (Unsafe), "Careful" (Limited Entry) or "Inspected".

1. If a building is evaluated as "Dangerous", a note must be displayed in order to keep people away from it.
2. If an area is evaluated as "Dangerous" due to the potentiality of falling object, a note must be displayed in order to keep people away from the area.
3. If evaluated as "Careful", the paper describing the resulted items to be cautious about must be shown.
4. If evaluated as "Safe", people are allowed into the building and area.
5. Damaged buildings must be demolished or restored.

5 REHABILITATION MEASURES FOR DAMAGED BUILDINGS BY EARTHQUAKE

Based upon the experience of the seismic capacity evaluation on about 2,300 reinforced concrete buildings and the strengthening work on about 580 reinforced concrete buildings, the authors intend to prepare the system for reconstruction measures in the early stage.

6 Conclusion

Since it is the first trial in Japan to establish the measures for damaged buildings after the occurrence of earthquakes, and any existing laws are not expressly provided such measures, the Shizuoka prefectural government started to build up an original system which included the following methodologies; to arrange and develop the system step by step for a better one by resolving problems at each phase,

to make this system thoroughly public to residents and train the inspectors and the responsible staff of administrations to execute the evaluation smoothly,

to continue the existing building reinforcement project and lessen the possibility of buildings to be damaged, and

to build up a cooperative relation with other prefectures, especially with Kanagawa Prefecture, which are developing similar system as well.

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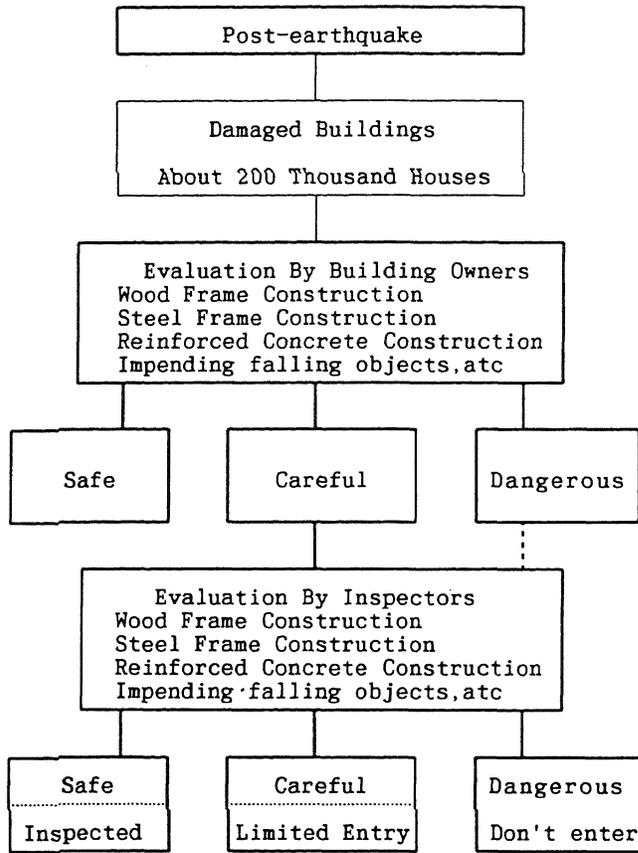


Figure 5. Flowchart in temporary emergency evaluation

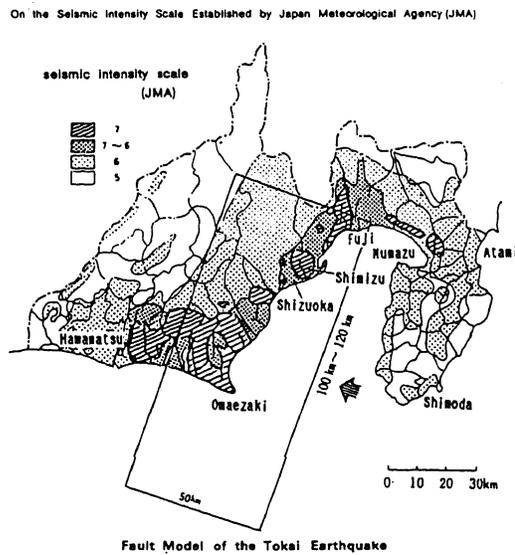


Figure 6. Assumed earthquake strengths for the Entire Prefecture