# EFFECTIVENESS OF THE QUESTIONNAIRE SURVEYS AT THE TIME OF DESTRUCTIVE EARTHQUAKES FOR THE EARTHQUAKE ENGINEERING STUDIES

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## SUMMARY

Detailed questionnaire surveys were carried out with regard to two recent earthquakes in Japan. Regarding the Oita earthquake the area bounded by the isoseismal line of intensity 5.5 by JMA scale (8.5 by MM) showed excellent accord with the area in which significant seismological and engineering events of this earthquake took place concentratedly. With the Miyagi-oki earthquake, detailed survey was made for the intensity distribution in tall buildings. Examining in detail the vibration mode of tall buildings in case of earthquake seems to have definit correlation with intensities in every floor of these tall buildings studied from questionnaire surveys.

## 1. INTRODUCTION

In the case of the large destructive earthquake the knowledge on the distribution of seismic intensity is providing one of the most important material to be investigated. By means of the intensity reporting system by the professional observers or by volunteer local people rough estimate of the intensity distribution could be made clear without much difficulty. Along with rapid progress in the field of earthquake engineering, it has become strongly needed to draw out a map showing detailed distribution of seismic intensities.

In the case of a large destructive earthquake, aiming at obtaining informations on the accurate and detailed seismic intensity at as many places as possible, a post card survey has been carried out since old days distributing questionnaires. In 1965, in association with the activity of the Special Committee for establishing the countermeasures against earthquake destructions in Kawasaki City, Prof. Yutaka Ohta of Hokkaido Univ., in cooperation with others, developed a new questionnaire having much more improved versions.[1)]

Using this improved questionnaire, in the case of the Oita earthquake of 1975 and the Miyagi-oki earthquake of 1978, the author carried out extensive survey on the seismic intensity distribution to cover very large areas.

## 2. SEISMIC INTENSITY DISTRIBUTION AT THE TIME OF THE OITA EARTHQUAKE OF 1975

On April 21, 1975, an earthquake of magnitude 6.4 by Richter scale occurred in the north central part of Kyushu Island, Japan, accompanying the severe damage to the Kuju Lakeside Hotel of reinforced concrete building and to many other wooden houses in the epicentral area. The seismic

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intensity at these sites might be over 6 by JMA scale (about 9.5 by MM).[2] For the purpose of collecting detailed information on the distribution of seismic intensity.

14,000 sheets of questionnaires were distributed. By the aid of the electronic computer, one seismic intensity was worked out from one questionnaire. the mean value of intensities in each administrative district such as towns or villages or sub-divided section of a district was taken as the intensity that represents each district or sub-divided section. Seismic intensities obtained in this way are shown by numerals in "Fig. 1". Details of the iso-seismals around the epicentral area are shown in "Fig. 2". Though there were observed many questionnaires that gave Intensity 6, especially those that came from the towns very close to the epicenter, the maximum intensity averaged in the unit sub-section of district was found to be 5.5. The shape of the isoseismals is seen not in concentric circles but rather oval shape having the longer axis from northwest to southeast for a length of 15 km.

Regarding the Oita earthquake extensive studies and investigations were carried out by great many people in the fields of seismology, geology, earthquake engineering. Summalizing all these studies, it is greatly interesting and important to note that an area bounded by an isoseismal line of intensity 5.5 by JMA scale determined by questionnaire surveys, represents an area in which significant events were observed. These events are: (1) Seismometrically located epicenter was found just middle of this area. (2) Foci of the aftershocks that took place some after the main shock were distributed only in this area. (3) In this area, concentrations of earth fissures, land slides, and other earthquake damage such as wooden house destructions were observed. (4) Existence of a latent fault was confirmed along the longer axis of this oval area. (5) Above assumption is consistent with fault mechanism studies and the fault model solution using the initial P wave arivals. (6) The maximum ground acceleration estimated from the field survey of the overturned gravestones gave the figure of 420 gals throughout in this area.

## 3. SEISMIC INTENSITY DISTRIBUTION OF THE MIYAGI-OKI EARTHQUAKE OF 1978

On June 12, 1978, an earthquake of magnitude 7.4 occurred in the northeastern part of Japan. The same questionnaire survey was made as was the case of the Oita earthquake, using almost same questionnaire card of 15,000 sheets. In the case of the Miyagi-oki earthquake, however, with regard to the very tall buildings in the Sendai City, it was reported that fairly a large earthquake damage has taken place in the upper floors. Aiming at to make clear the difference in the seismic intensity with the difference in the height of floors, special survey was carried out. The maximum intensity appeared in the isoseismal map of the Miyagi-oki earthquake is 5.5 as is seen in the area in and around Sendai.

## 4. INTENSITIES IN THE TALL BUILDINGS AND HIGH-RISE BUILDINGS

Aiming at to make clear the difference in the seismic intensity with the difference in the height of floors, questionnaire survey was carried out with respect to 12 tall buildings in the City preparing the questionnaire cards that contained special question items for the use of the tall building surveys. The seismic intensity in Tokyo and Kawasaki (Δ=350km) was 4 by JMA scale. With regard to 13 tall apartment buildings in Kawasaki City and 5 high-rise buildings in Tokyo, questionnaire surveys were carried out. In all cases, with regard to each tall building, 20 sheets of questionnaire were distributed to each floor from the basement to the top floor.

Results of the questionnaire survey for the tall buildings in Sendai are shown in "Figs.3-a" and "3-b". "Fig. 3-a" is the apartment buildings of the same type construction by the Japan Housing Corporation of 5-story buildings. "Fig. 3-b" represents 5 tall office buildings in Sendai, three of them are 10 stories and two others are 13 and 15 stories. In Sendai City, ground intensity given by questionnaire surveys were 5.1 which gave a good accord with the ground floor intensity of these tall buildings as will be seen in "Figs. 3-a" and "3-b". While definit increase of the intensity is observed with the increase in the height of floors for all of these tall buildings. This trend is most clearly observed for the 5-story apartment buildings of the reinforced concrete structures. Nearly one unit intensity increase is observed for the height increase of 5 stories. On the contrary, for the tall buildings that exceed 10 stories such a simple rate of increase with height seems not so clear.

With regard to the tall buildings of 15 stories in Kawasaki, as will be seen in "Fig. 4-a", the increase of intensity with height becomes more complicated. The high-rise buildings in Tokyo, as will be seen in "Fig. 4-b", the intensities of the ground floor were given as 3.1 or so with regard to all three high-rise buildings. Intensities in the higher floors are not showing such tendency as increasing with height monotonously but giving almost same value regardless in the difference in height, though the scatter around the center value may be considered somewhat large. Detailed studies will be called upon so that the closer correlation between the observed intensities in each floor of high-rise building with the vibration mode of the high-rise building under the excitation of the earthquake ground motions. In any case, however, it is clearly observed that these high-rise buildings were not vibrating in their first mode vibration under the earthquake motion, when the shock was not so large.

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1) Ohta, Y. (1974). Microzoning map of Kawasaki City derived from questionnaire surveys (in Japanese), Report on the Special Committee for Earthquake Disaster Prevention in Kawasaki City. pp.4-52.
2) Omote, S., A. Miyake and H. Narahashi (1977). Maximum ground acceleration in the epicentral area — Field studies on the occasion of the Ohita Earthquake, Japan, of April 21, 1975 —, Bulletin of the International Institute of Seismology and Earthquake Engineering. Vol.15, pp.67-82.


Fig. 1 Isoseismals of the Oita earthquake derived from questionnaire survey.

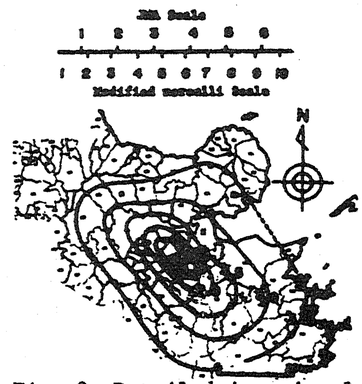


Fig. 2 Detailed isoseismals around the epicenter.

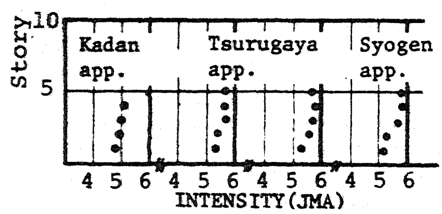


Fig. 3-a Intensity distribution in every floor of 5 story appertments in Sendai.

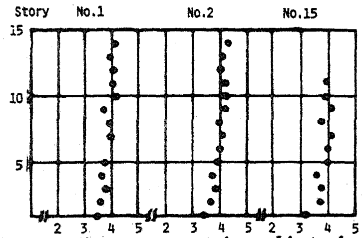


Fig. 4-a Intensity distribution of 12-15 story apartments in Kawasaki.

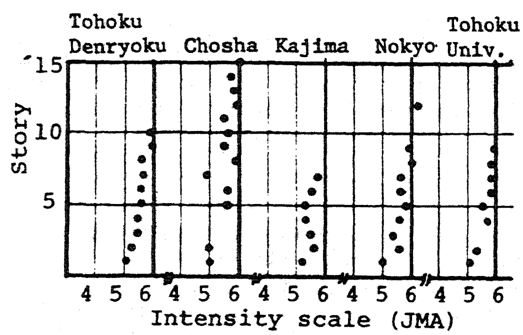


Fig. 3-b Intensity distribution of 7-10 story office buildings in Sendai.

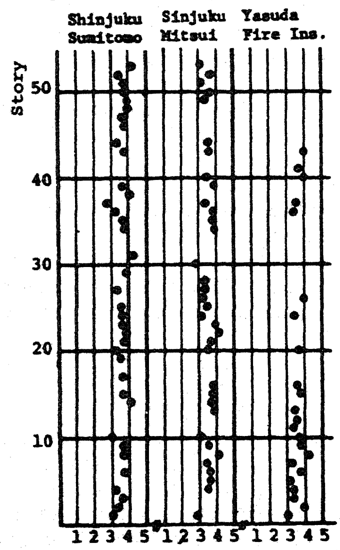


Fig. 4-b Intensity distribution of high-rise buildings in Tokyo.