Seismic intensity distribution deduced from questionnaire surveys after two earthquakes of 2004 and 2007 in Mitsuke City, Niigata Prefecture, Japan

Yasumasa NAKAJIMA[1], Norio ABEKI[2], Iware MATSUDA[3] and Norifumi NISHIGAYA[4]

[1] *Research Fellow, Institute of Science and Technology, KANTO GAKUIN University, JAPAN*
[2] *Professor, Dept. of Architecture, College of Engineering, KANTO GAKUIN University,JAPAN*
[3] *Professor, College of Economics, KANTO GAKUIN University,JAPAN*
[4] *Graduate Student, Dept. of Architecture, College of Engineering, KANTO GAKUIN University,JAPAN*
Email: yasumasa-nakajima@hotmail.co.jp,abeki@kanto-gakuin.ac.jp,matsuma@kanto-gakuin.ac.jp, m0743010@kanto-gakuin.ac.jjp

ABSTRACT :

Mitsuke City was shaken by two earthquakes of 2004 and 2007. The former was the Chuetsu Earthquake with the magnitude of Mw6.6, which epicenter was located about 30 km apart from the city. It brought the intensity of 5+ in JMA scale, and damaged the city considerably by liquefaction and strong ground motion. The latter was the Noto Peninsula Earthquake which magnitude was Mw6.7, and its epicenter was located about 250 km apart from the city. The city felt the intensity of 4 in JMA scale without any damage.
Since damages due to the earthquake of 2004 were different among the city, we carried out a questionnaire survey and field works in order to make the regional difference of damages and seismic intensity clear. As a result, we could confirm that local site effects due to soil conditions were reflected in them.

KEYWORDS: Questionnaire Survey, Seismic Intensity Distribution, Seismic Microzoning

Local Site Effects, Surface Geology

1. INTRODUCTION

The method for examining high-density seismic intensity distribution by a questionnaire survey was tried first by Ohta et al. (1979, 1998) in Kawasaki City after the Eastern Yamanashi Earthquake of 1970. Since then, many researchers have adopted the method to clarify intensity distribution precisely. They could analyze the relation between the intensity and the foundation conditions quantitatively, and they could relate the precise intensity distribution to building damages. After the Great Hanshin Earthquake Disaster of 1995, the questionnaire was revised in order to apply to seriously damaged area with the seismic intensity of 6 ~ 7 in JMA Scale. A questionnaire survey has been known its possibility for using damage assessment or seismic microzoning.

We carried out questionnaire surveys twice after the 2004 Chuetsu Earthquake and the 2007 Noto Peninsula Earthquake in Mitsuke City. Questionnaires were distributed to all the households. In addition, to make clear the dynamic characteristics of surface geology in Mitsuke City, we carried out the microtremor observation, PS-logging and array observation of microtremor (Abeki et. al., 2006). Our main purposes were to examine the relation between seismic intensity distribution and damages and to compare the difference of site effect due to the strength of earthquake motion and the different epicenters.

2. Profile of the 2004 Chuetsu Earthquake and the 2007 Noto Peninsula Earthquake

As shown on Table 1 and Fig.1, hypocentral characteristics and wave propagation pass to Mitsuke City are different. That means the affect to Mitsuke City is different.

Table.1 Profile of Earthquakes.

	2004 Chuetsu EQ.	2007 Noto Peninsula EQ.
Date	2004/10/23	2007/3/25
$M_J(M_W)$	6.8(6.6)	6.9(6.7)
Lat.	37.30 ° N	37.32 ° N
Lon.	138.84 ° E	136.68 ° E
Depth(km)	9.0	11.0
Mo	9.2×10^{18}Nm	1.4×10^{19}Nm

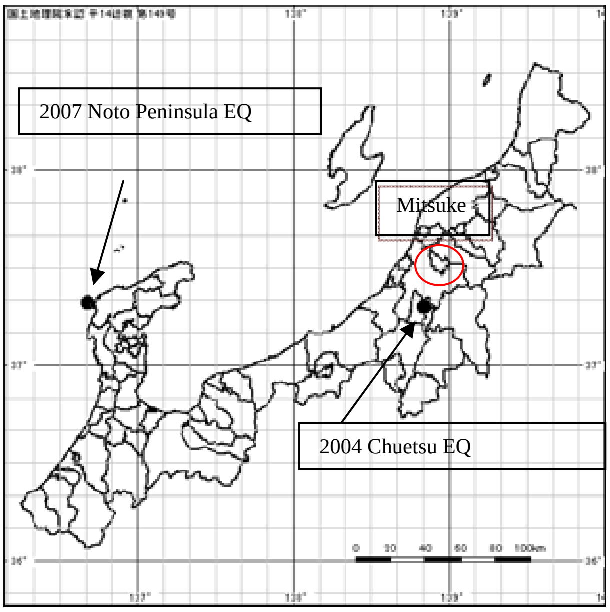

Figure.1 Outline of Surveyed Area and Epicenter of Two Earthquakes.

3. Outline of Survey Area (Mitsuke City)

Figure .2 is a landform classification map of the survey area. The area classified into three major regions; mountain and hill, the KariyaTagawa valley and the Citynano River lowlands.

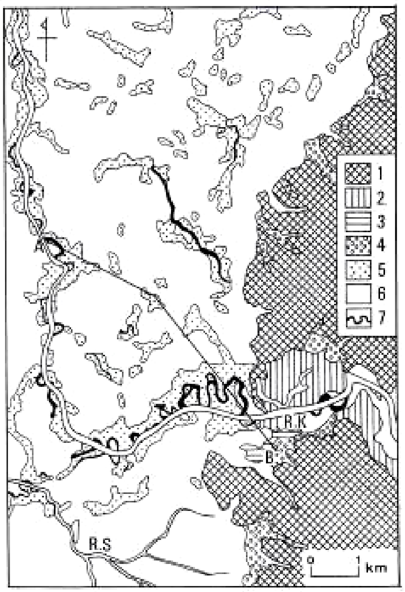

Figure2 Landform classification
1:Mountain and hill, 2:Higher terrace, 3:Lower terrace, 4:Alluvial fan and gravelly valley flat, 5:Natural levee, 6:Flood plain, 7:Abandoned river R.K:Kariyatagawa River, R.S:Saruhashi River
Solid line shows the location of geologic cross-section A-B

The mountain and hill area having 40 to 180m in height is composed of Neogene and Quaternary deposits. Alluvial fans and debris flow bars are formed near the area where stream leaves the source area. Alluvial terraces called Kariyatagawa upland develop in Kariyatagawa valley, which are classified into the higher and the lower terraces. The higher terrace with the height of 24 to 30 m has the relative height of about 5 m from the valley flat. The lower terrace is located where Kariyatagawa River leaves its source area. Its height is about 20 m and continues to the natural levee being along Kariyatagawa River. Leaving from the source area, Kariyatagawa River develops flood plain in the Shinanogawa lowland. The meandering river course was reformed to be strait for the purpose of protecting flood. The distribution of natural levees and abandoned channels means that Kariyatagawa River changed its course frequently.

.

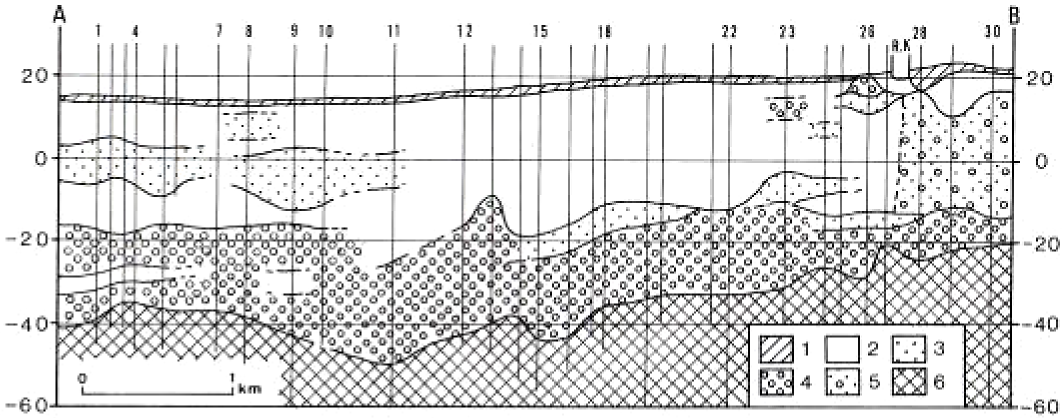

Figure 3 Geologic cross-section A-B
1:Filled up soil, 2:Clay and silt (Mud), 3:Sand, 4:Gravel、
5:Sand and gravel containing fine materials, 6:Basal Rock R.K:Kariyatagawa River
Location of the cross-section is shown on Figure-2

Figure .3 is a geologic cross-section in the Shinanogawa lowland, which location is shown on Figure .2. Since most of the materials used for making Figure .2 are bore hole records of a well for withdrawing underground water, explanation of soils is not good except gravelly deposits containing water. Thick gravel layer distributes deeper than about 20 m in depth. Its thickness is more than 20 m in the northern part, but it becomes less than 10 m in the southern part. This gravel layer is the basal gravel of Recent deposits, most of which has been brought by Shinanogawa River. The reason why the thickness of the gravel layer becomes thinner towards south is that the depth of valley bottom becomes shallower and that the gravel distributing in the southern part is formed by Kariyatagawa River. Thick mud layer composed of clay and silt covers the basal gravel, which are deltaic deposits during Holocene transgression. Sand layer is intercalated in the mud layer at the height of about 0 m between nos.1 and 11, but not between nos.12 and 22. It is possible that sand layer was ignored because of being not important for a well for ground water.
The sand layer or gravel layer distributing near the surface of between nos.23 and 26 is the deposits composing natural levee. Between nos.28 to 30 on the left bank side of Kariyatagawa River, about 30 m thick sand and gravel layer containing fine materials distributes lower than 20 m in height. These deposits are thought to be formed in the valley bottom of Kariyatagawa River. The uppermost materials compose the upper terrace.

4. Questionnaire Surveys.

4.1. Outline of the questionnaire survey

The object of these questionnaire surveys is to make detail distribution of seismic intensity clear in Mitsuke City. Questionnaires were distributed to all households of the City on April 22, 2005 after the Chuetsu Earthquake and May 18, 2007 after the Noto Peninsula Earthquake. The respondent ratios are 20% or more. Concerning the Chuetsu Earthquake, 4,538 questionnaires among 13.865 were returned, and 2,814 among 13,982 in case of the Noto Peninsula Earthquake. The number of response were enough to analyze the seismic intensity distribution..

4.2. Seismic Intensity Distribution in Mitsuke City.

The mean value of intensity deduced from the questionnaire survey is 5.38 for the Chuetsu Earthquake and 3.27 for the Noto Peninsula Earthquake. According to the Japan Meteorological Agency, the intensity was 5+ and 4, respectively. These intensity were recorded at one seismometer set in City office.

We tried to calculate the seismic intensity for an every block to examine local site effect. The seismic intensity distribution of the 2004 Chuetsu Earthquake is shown in Figure .4. The seismic intensity is lower in the eastern part consisting of a steep range of hills, and the areas showing higher intensity exist in the central part of the City and western part. Figure .5 shows the seismic intensity distribution of the Noto Peninsula Earthquake. Although the strength of earthquake motion is different from that of the Chuetsu Earthquake due to hypocentral distance and magnitude, the seismic intensity is lower in the eastern part and higher in the central part of the City. Same tendency can be seen in distribution of the seismic intensity.

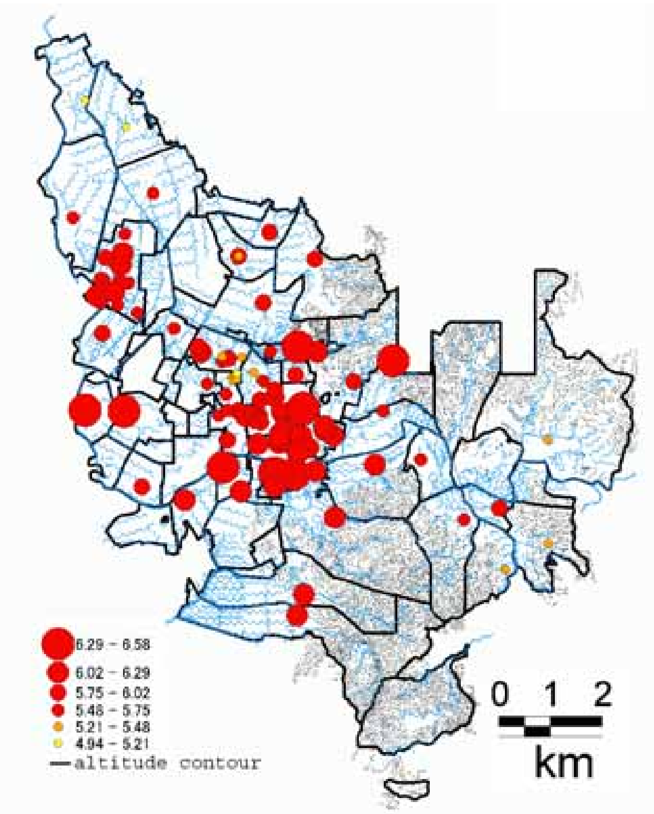

Figure 4. Seismic Distribution Map Map for 2004 Chuetsu EQ.

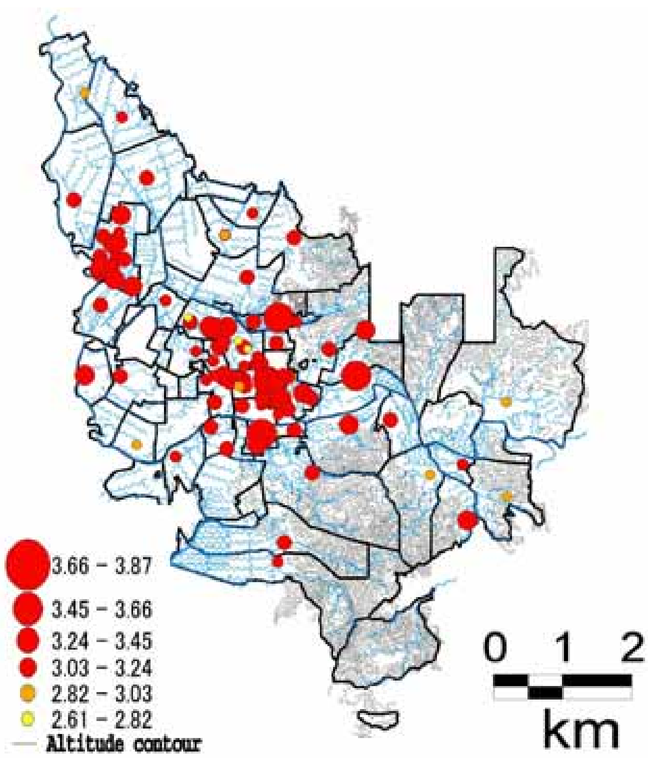

Figure 5. Seismic Distribution Map Map for 2007 Noto Peninsula EQ.

In order to examine the effect of different hypocentral distance, relation between hypocentral distance and seismic intensity showed in Figure.5 and attenuation curve was calculated. Figure 6. shows the relation between seismic intensity calculated from the attenuation curve (A.S.I) and that deduced from the questionnaire survey (Q.S.I) at five points in the survey area in case of two earthquakes. This figure means that even if the epicentral distance is much different, the ratio of Q.S.I to A.S.I is about same. As a result, we can say that although seismic intensity changes due to the hypocentral distance (attenuation) and magnitude, intensity distribution depends on ground characteristics. If ground characteristics and its site effect are known, we can estimate the intensity distribution due to an unspecified earthquake having various hypocenter and magnitude.

In order to examine the effect of different hypocentral distance, relation between hypocentral distance and seismic intensity showed in Figure .5 and attenuation curve was calculated. Figure .6 shows the relation between seismic intensity calculated from the attenuation curve（Matsuzaki et.al.,2006） (A.S.I) and that deduced from the questionnaire survey (Q.S.I) at five points in the survey area in case of two earthquakes. This figure means that even if the epicentral distance is much different, the ratio of Q.S.I to A.S.I is about same. As a result, we can say that although seismic intensity changes due to the hypocentral distance (attenuation) and magnitude, intensity distribution depends on ground characteristics. If ground characteristics and its site effect are known, we can estimate the intensity distribution due to an unspecified earthquake having various hypocenter and magnitude.

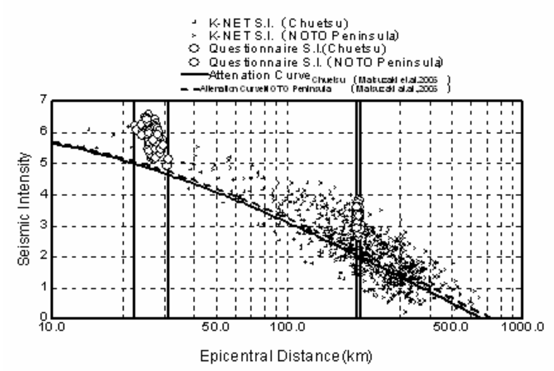

Figure.6 Relationship between Epicentral Distance and Seismic Intensity

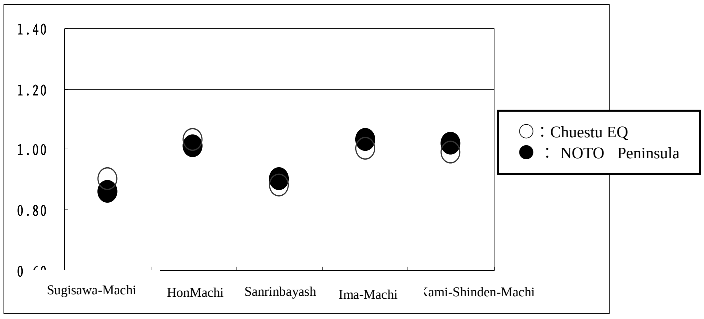

Figure 7 Ratio of Questionnaire S.I to Attenuation S.I.

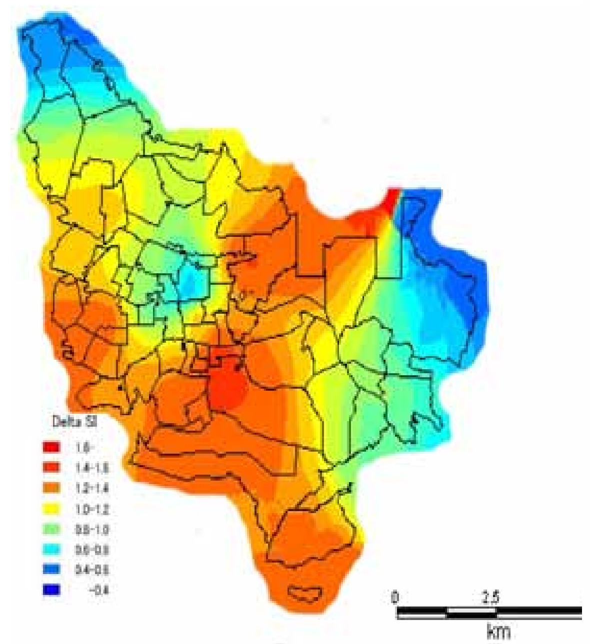

Figure 8. Distribution Map of Seismic Intensity Ratio for 2004 Chuetsu EQ.

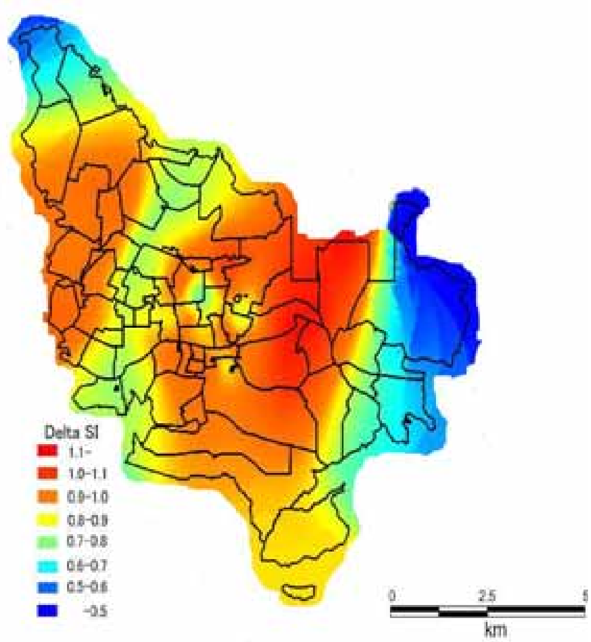

Figure 9. Distribution Map of Seismic Intensity Ratio for 2007 Noto Peninsula EQ.

The smoothed distribution map of the ratio of the seismic intensity deduced from questionnaire survey to that calculated by attenuation curve are shown in Figure 8 and Figure 9 for two surveyed earthquakes. Although some of differences are seen, distribution patterns are so similar that they are acceptable. These Figures can be recognized as showing the local amplification effects of Mitsuke City, that is, a kind of seismic microzonation map.

5. Conclusion

The seismic intensity distribution due to two earthquakes with the different hypocenter was discussed through the results of questionnaire surveys. Although a hypocenter and magnitude are different, distribution of amplified ratios is almost same. Seismic intensity deduced from questionnaire survey becomes an effective tool for seismic microzoning.

Acknowledgement

We are thankful to the Mitsuke City Office and residents of the City for their cooperation in questionnaire surveys. The National Research Institute for Disaster Prevention allowed us to use K-NET register. This research was conducted as a part of the "Strategic Development Studies of Symbiosis Technologies with the Aim of Urban Construction Stock Reproduction" (KANTO GAKUIN University) that is the academic frontiers promotion program 2004 by the Ministry of Education, Culture, Sports, Science and Technology.

REFERENCE

Yutaka Ohta, Noritoshi Goto and Hitomi Ohashi.(1979). A Questionnaire Survey for Estimating Seismic Intensities, Bulletin of the Faculty of Engineering, Hokkaido University, No.92,pp117-128.

Yutaka Ohta, Maki Koyama and Koichi Nakagawa.(1998). Revision of Algorithm for Seismic Intensity Determinationby Questionnaire Survey –In High Intensity Range-. Journal of Japan Society for Natural DisasterScience, Vol.16, No.4,pp307-323.

Norio ABEKI, Yasumasa NAKAJIMA, Iware MATSUDA, Hiroyoshi KIKU, Naoki MAEDA, Eiichi ISHII, Azuma CityBATA, Hiroyuki SAITO, Kazuro BANDO, Tomoharu URAYAMA, Ken-ichiro SAITO, Miyuki KAIHOTSU and Mika NAKANE. (2006). On the relation between the surface geology and the damages in Mitsuke City caused by the 2004 Chuetsu Earthquake. Third International Symposium on the Effects of Surface Geology on Seismic Motion Grenoble, France, 30 August - 1 September 2006 Paper Number: 119.

Shinichi MATSUSAKI, Yoshiaki HISADA and Yoshimitsu FUKUSHIMA.(2006). ATTENUATION RELATION OF JMA SEISMIC INTENSITY APPLICABLE TO NEAR SOURCE REGION. J. Struct. Constr. Eng., AIJ, No. 604, 201-208, Jun. Architectural Institute of Japan.(2006).

Yasumasa NAKAJIMA, Norio ABEKI and Iware MATSUDA. (2006). On the Questionnaire Survey for Estimation of the Seismic Intensity Distribution in Mitsuke City Caused by 2004 Mid-Niigata Earthquake. AIJ Journal Technology and Design No.24. pp465-470