Proceedings of Ninth World Conference on Earthquake Engineering
August 2-9, 1988, Tokyo-Kyoto, JAPAN (Vol.II)

2-1-2

PROPOSAL OF THE CORRELATION BETWEEN THE MAGNITUDE AND THE ISOSEISMAL INTENSITY AREA

Tatsuo USAMI[1], Masamitsu MIYAMURA[2], Masaki KAMATA[2] and Otozo HAMAMATSU[3]

[1]Professor of Shinshu University
[2]Kobori Research Complex, Kajima Corporation, Tokyo, Japan
[3]Former Chief of Volcano Section in J.M.A.

SUMMARY

The authors have developed a detailed seismic intensity distribution map in Japan for 416 damaging earthquakes during 99 years. Making use of these data, new correlation equations between the magnitude and the isoseismal intensity area have been proposed by a developed computer algorithm. The procedure is applied for the seismic intensity data of earthquakes which have occurred not only in the inner island but also in oceanic regions. New correlation curves for oceanic regions which are derived from regression analysis are compared with previous studies.

INTRODUCTION

The concept of "Seismic Intensity Scale" determined by human response is quite ambiguous, however, for engineering purposes it is a useful measure of the intensity of the earthquake. Therefore, the authors investigated the detailed seismic intensity distribution of past damaging earthquakes which have occurred in Japan from 1886 through 1984 based on the "Original Report of Earthquake Investigation Data" by the J.M.A. (Japan Metrological Agency). All of the data are stored on computer disks. In a previous study (Ref.1), the regression equation was proposed for the earthquakes which have occurred in the inner island of Japan. In this paper, the correlation between the isoseismal area and the magnitude in oceanic regions is studied. For oceanic regions no data is available on the human response to the earthquakes, however, it is possible to extrapolate the land data out over the ocean. A new computer program which calculates the most probable line and area was developed for this purpose.

EVALUATION OF ISOSEISMAL AREA IN OCEANIC REGIONS

Epicenters of large earthquakes which affect seismic design of important structures are distributed in oceanic regions surrounding Japan, however, no data is available for the analysis of earthquakes occurring in oceanic regions. Therefore, in order to describe the most probable figure of isoseismal area in oceanic regions, a new computer algorithm is developed. In the analysis, the following two procedures are adopted uncertainty of oceanic area :

Method 1 The general flow diagram of the algorithm to compute the isoseismal area is shown in Fig.1. The procedure is as follows.

(1) Input of objective earthquake:
Input the distribution of seismic intensity scale data of an objective damaging earthquake.
(2) Characterization of objective intensity scale:
Transform the intensity data to circular cylindrical coordinates and characterize the objective intensity data.
(3) Elimination of isolated data from objective intensity data:
First, search the minimum and maximum angle, θmin and θmax, to the epicenter. The narrow band angle θw is assumed for the θ-direction and accumulate the objective data from the far side, while other data are from the near side. Second, the rate of the accumulative number between the objective data plotted in the outside area and others in the inside are assigned and a boundary is drawn based on the rate, herein the rate is 7:5. The data outside the boundary are defined as isolated data. Finally, eliminate the isolated data by moving the band θw from min to max.
(4) Selection of envelope data:
Select envelope data from objectives.
(5) Interpolation:
Interpolate the objective envelope data by smoothed "Spline" function.
(6) Calculation of the isoseismal area:
Draw the isoseismal intensity curve, and calculate the isoseismal area. Compute the objective area A_0 which is the inside of the line, and evaluate the isoseismal area A (IV,V) based on Eq. (1).

$$A = \frac{2\pi}{\bar{\theta}} A_0 \qquad (1)$$

Method 2 Fig.2 shows the general flow diagram of the algorithm to compute the isoseismal area by method 2. The procedure is as follows.
(1) Input of Objective Earthquake:
Input the distribution of the seismic intensity scale data of an objective damaging earthquake.
(2) Relationship Between the Epicentral Distance and the Intensity:
Investigate the relationship between the epicentral distance and the intensity.
(3) Evaluation of the Boundary:
Evaluate the boundary between the objective intensity data and the others. First, accumulate the objective data from the far side, while other data from the near side. Fix the boundary where the rate between the accumulate number of the objective data and the others is 7:5.
(4) Calculation of the Isoseismal Area:
Calculate the isoseismal area based on Eq. (2).

$$A = \pi r^2 \qquad (2)$$

where A : Area of IV or V
r : distance from the epicenter to the boundary

In accordance with the flow diagram, the examples of the described curves for a typical earthquake are shown in Fig.3. From the figure, it is shown that the computed smoothed curve well represent the overall isoseismal intensity scattering, and the area obtained by method 1 approximately corresponds to that of method 2. Considering the relationship developed in the previous study (Ref.1), method 1 is mainly used for the analysis.

CORRELATION BETWEEN MAGNITUDE AND ISOSEISMAL INTENSITY AREA

This analysis is carried out for damaging earthquakes which have occurred in oceanic regions to study the correlation between the magnitude and the isoseismal intensity area of IV and V. The distribution of the data suggests an almost linear relation between the magnitude and the area, and the regression equation was defined in Eq.3 as in the previous study. (Ref.1)

$$\log A = aMj + b \qquad (3)$$

where A : Area of IV or V
Mj : Magnitude of J.M.A
a,b : Coefficients of regression analysis

Fig.4 shows the comparison of obtained regression curves for inland and oceanic regions. The data in island earthquakes is distributed between magnitude 5 and 7, while oceanic earthquakes range between 6.5 and 8. These curves suggest the isoseismal area of oceanic earthquakes become large compared with that of inner earthquakes.

Figs.5 and 6 shows the computed regression curves for all of the data, both in inland and oceanic earthquakes, by methods 1 and 2. From the figures, it is confirmed that the scattering of data is rather small and the regression curves obtained by two methods correspond well. A Comparison with previous studies (Ref 3.4) is also shown in Fig.5. The result of intensity IV in this study corresponds well to the study (Ref.4), while in the case of intensity V, the difference seems to be large.

CONCLUSIONS

The major results of the study are as follows.

1) A new computer algorithm is developed to calculate the approximate isoseismal lines and evaluate the area in oceanic earthquakes.
2) Correlation equations between the magnitude and the isoseismal intensity area are proposed for the large earthquakes which have occurred in oceanic regions using the result of the regression analysis. These curves will be useful for the prediction of damaging area for future earthquakes.

REFERENCES

1. Muto, K. and T. Usami, et al., "Statistical Analysis based on the Newly Completed Seismic Intensity Map In Japan," Proc. of the 3rd U.S. National Conference on Earthquake Engineering, (1986).
2. Utsu, T., "Catalog of Large Earthquakes in Region of Japan from 1885 through 1980, "Bull. Earthq. Rws. Inst., Vol.57, 401-463, (1982).
3. Muramatu, I., "Relation between the Distribution of Seismic Intensity and the Earthpuake Magnitude," Research Report of Educatioal Depertment of Gifu Unibersity, 168-176, (1971).
4. Katumata, M. and K. Tokunaga, "Relation between Isoeismal Area of Intensity IV and Earthquake Magnitude, and Earthquake Intensity of J.M.A. with Corresponding Maximum Acceleration," Quarterly Journal of Seismology, Vol.XXXVI No.3,4, 89-96, (1971).
5. Trifunac, M. D., "On the Correlation of Seismic Intensity Scales with the Peakes of Recorded Strong Ground Motion," B.S.S.A., Vol.65 No.1, 139-162, Feb. (1975).
6. Usami, T., "Tables of Dameged Earthquakes in Japan," Press of Tokyo Univ., (1975).

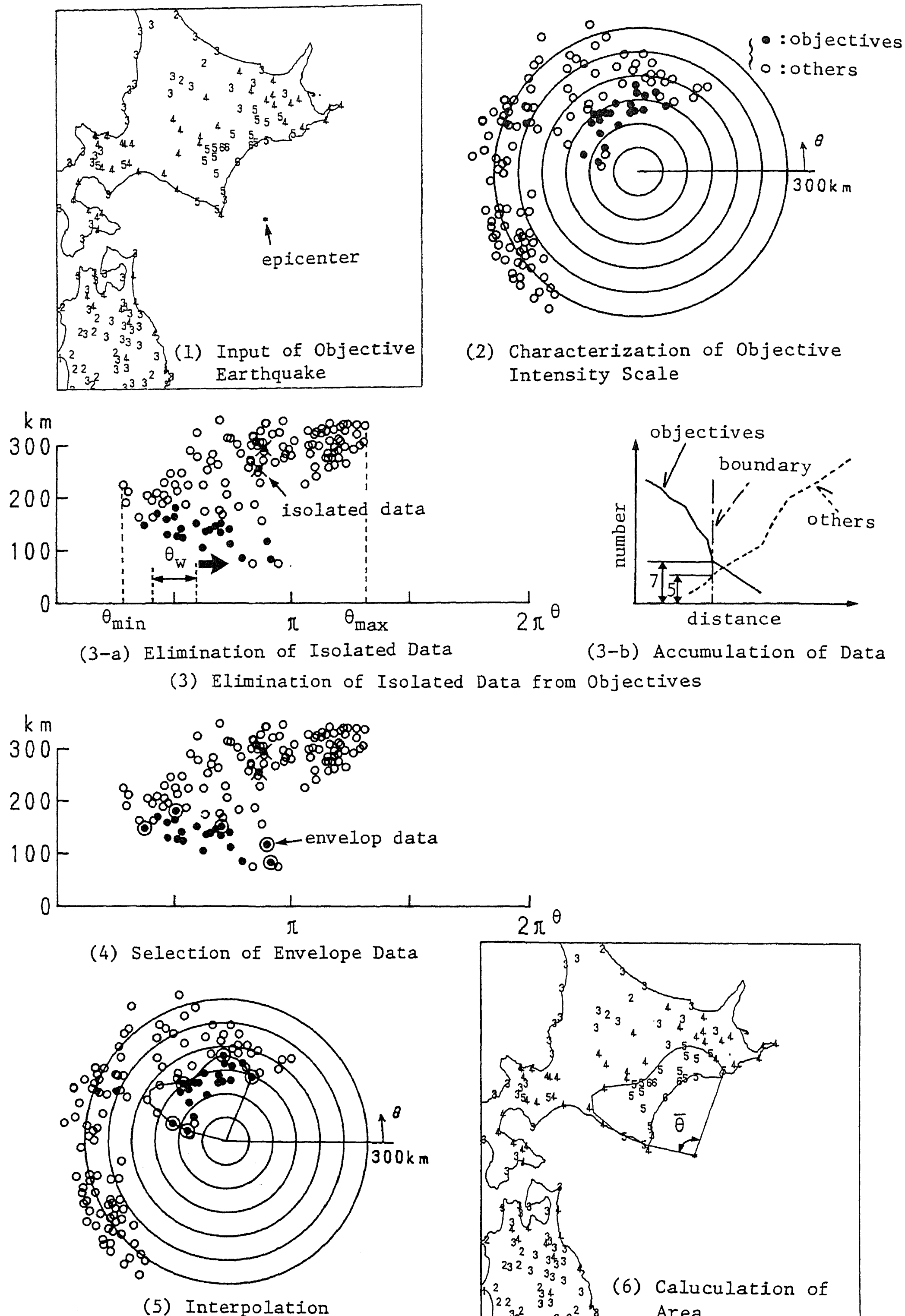
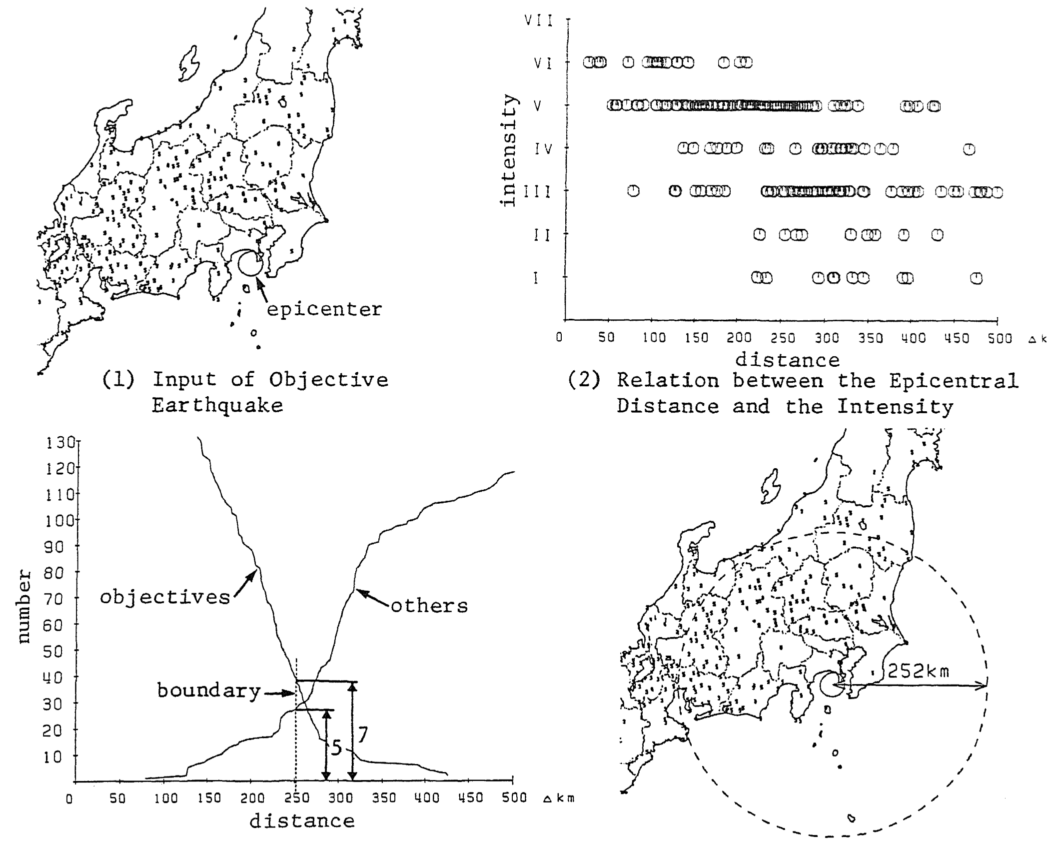


Fig.1 The General Flow Diagram for the Isoseismal Area by Method 1



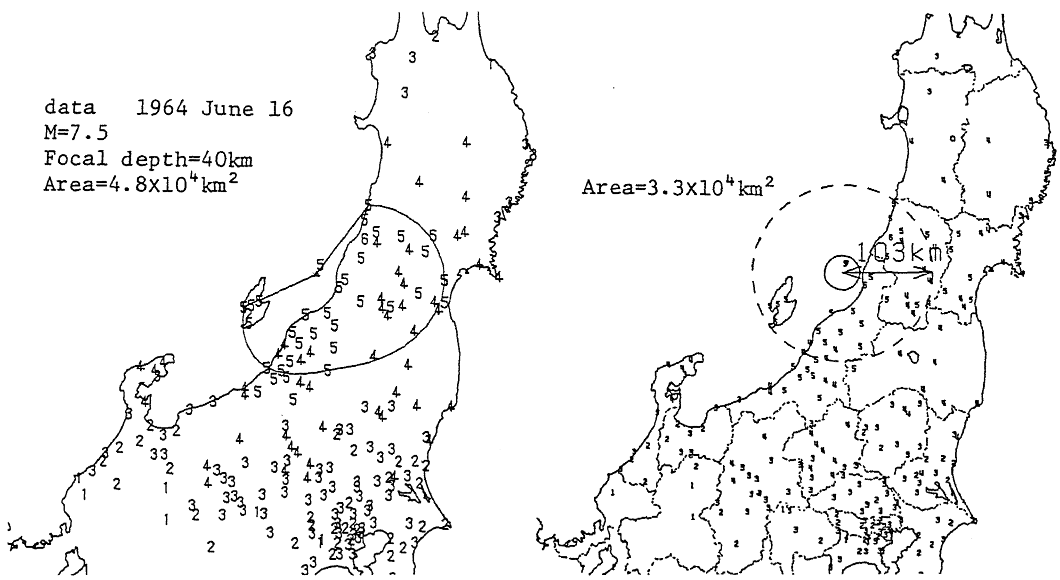
(1) Input of Objective Earthquake

(2) Relation between the Epicentral Distance and the Intensity

(3) Evaluation of the Boundary

(4) Caluculation of Area

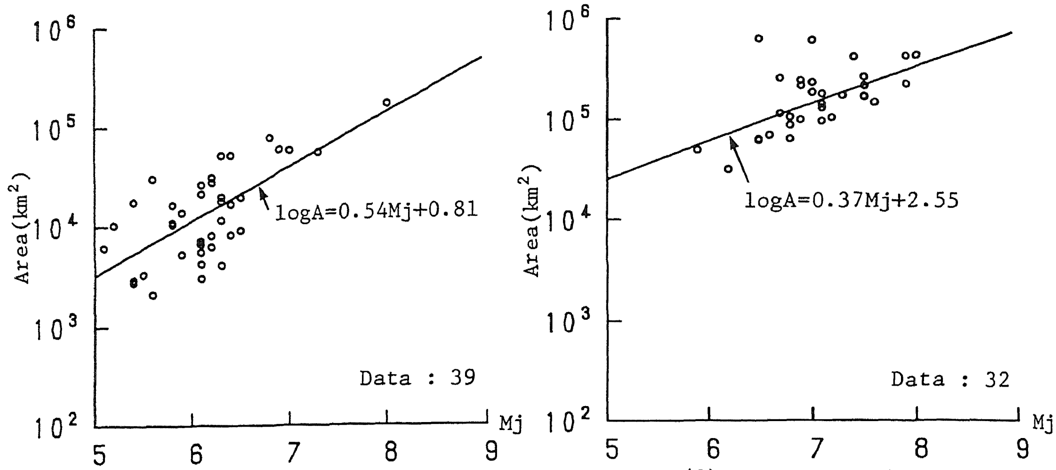
Fig.2 The General Flow Diagram for the Isoseismal Area by Method 2



(1) Method 1

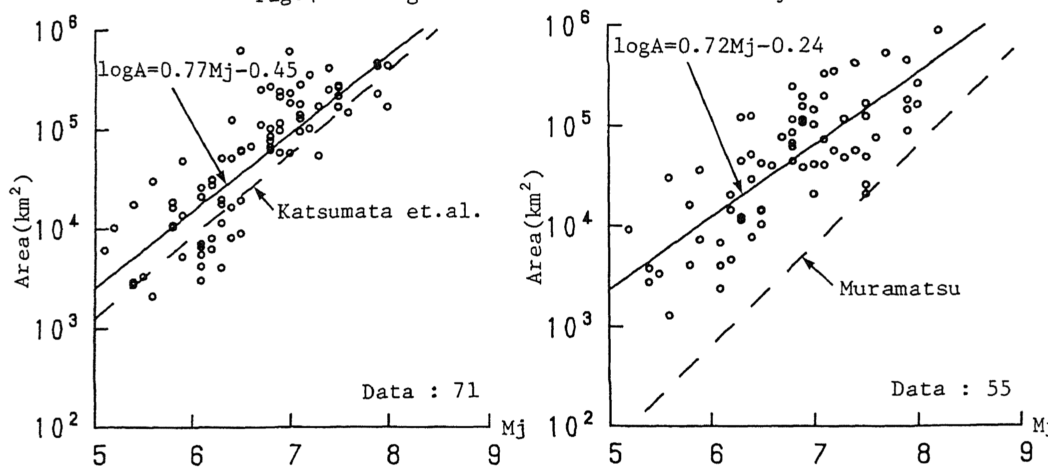
(2) Method 2

Fig.3 Examples of Isoseismal Area for Intensity V



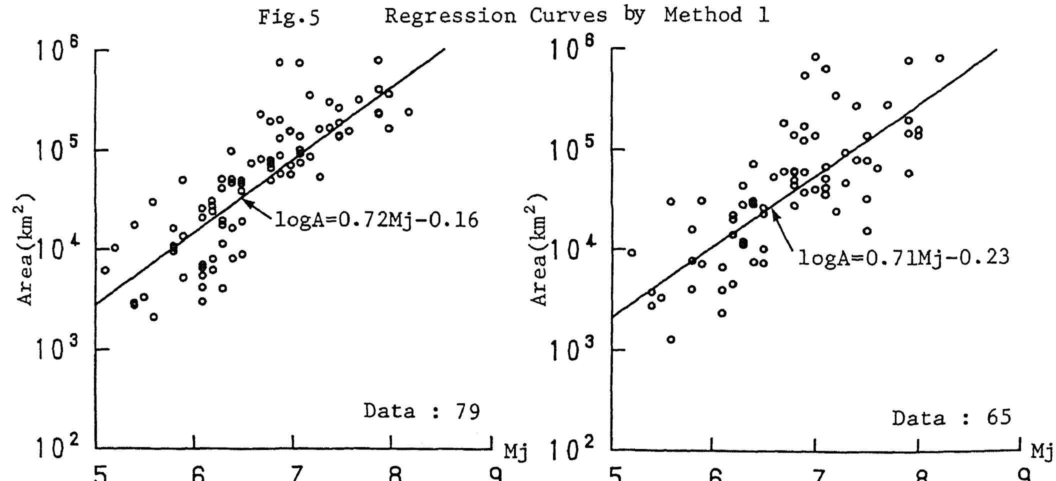
(1) Inland (2) Oceanic Regions

Fig.4 Regression Curves for Intensity IV



(1) Intensity IV (2) Intensity V

Fig.5 Regression Curves by Method 1



(1) Intensity IV (2) Intensity V

Fig.6 Regression Curves by Method 2