ISOSEISMAL MAP IN NEAR-FIELD WITH REGARD TO FAULT RUPTURE AND SITE GEOLOGICAL CONDITIONS

by

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SUMMARY

A method for estimating the peak accelerations of near-field ground motions with regard to fault rupture, attenuation of seismic waves and site geological conditions was presented. The relation between the amplification factors of ground for peak acceleration and geological conditions was derived. The peak ground accelerations were calculated as the products of the amplification factors estimated from geological conditions and the peak accelerations of the incident waves from seismic bedrock calculated by Midorikawa & Kobayashi's method (1978) with regard to fault rupture. The results showed good agreements with the observed seismic intensities in cases of several large earthquakes.

INTRODUCTION

For the prediction of earthquake damages, it is necessary to estimate the intensities of the strong ground motions in near-field. From many experiences of earthquake damages in the past, it has been pointed out that there is an evident relation between earthquake damages and soil conditions. On the other hand, it has been also remarked that the intensity of the near-field ground motion reflects the nature of fault mechanism strongly. Therefore, the ground surface motions should be considered as the products of the incident waves from seismic bedrock and the amplification factors of layered soil structure. Authors have already proposed the method for calculating the response spectra of the incident waves from seismic bedrock in near-field with regard to fault rupture (1). In this paper, they tried to derive the relation between the amplification factors of ground and geological conditions, and to estimate the distribution of peak ground accelerations in and around the source region.

RELATION BETWEEN AMPLIFICATION FACTOR OF GROUND AND GEOLOGICAL CONDITIONS

The amplification factors of ground for peak acceleration were defined as the ratios of the peak accelerations of the ground surface motions to those of the incident waves from seismic bedrock. In this study, the amplification factors due to the propagation of SH-waves in the layered soil ground, were calculated for 53 sites. As the seismic bedrock, the upper boundary of the Earth's crust, whose shear-wave velocity is approximately 3 km/sec, was adopted. As a result, it was made clear that the amplification factor of ground for peak acceleration A is affected by the shear-wave velocity of surface layer Vs in spite of the composition of soil layers, as shown in Fig.1. The relation between A and Vs is as follows:

$$\begin{array}{lll} A = 5.5 & (Vs < 200 \text{ m/sec}) & \\ A = 40 \times Vs^{-0.374} & (Vs \geq 200 \text{ m/sec}) & \quad \cdots\cdots (1) \end{array}$$

Using the shear-wave velocities corresponding to geological conditions, the relation between geological conditions and the amplification factors can be derived as follows:

$$\begin{array}{lll} A = 5.5 & (\text{Quaternary}) & \\ A = 3.5 & (\text{Neogene}) & \quad \cdots\cdots (2) \\ A = 2.5 & (\text{Pre-Neogene}) & \end{array}$$

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DISTRIBUTION OF PEAK GROUND ACCELERATIONS IN NEAR-FIELD

The peak ground accelerations of individual site can be calculated using the source parameters, the relative position to the fault plane and geological conditions. At first, authors showed the example of the Kanto Earthquake of 1923. The amplification factors of ground were estimated from the geological conditions as shown in Fig.2. The peak accelerations of the incident waves from seismic bedrock were calculated by Midorikawa & Kobayashi's method (1) using Ando's fault parameters (2), as shown in Fig.3. The peak ground accelerations were obtained as the products of the amplification factors and the peak accelerations of the incident waves. The comparison between the calculated peak ground accelerations and the estimated ones from overturning of simple bodies is shown in Fig.4. The tendency that the calculated values are rather greater than the estimated values is recognized. It has been pointed out that the estimated value should be less than the actual value, therefore the calculated values are consistent with the estimated ones in the range of peak acceleration less than 600 gals or so. It means that the effect of the non-linearity of soil layer could not be neglected in the acceleration level over 600 gals or so. Fig.5 shows the isoseismal map. The broken lines show the calculated peak accelerations of 300 and 500 gals. The area of the peak acceleration over 300 gals corresponds to that of J.M.A. intensity VI . Fig.6 shows the distribution of the percentage of collapsed wooden houses. The area of the peak acceleration over 500 gals corresponds to that of the collapsed percentage over 10%.

Other examples of the Mikawa Earthquake of 1945, the Tokachi-Oki Earthquake of 1968, the Miyagiken-Oki Earthquake of 1978 and the Nobi Earthquake of 1891 are also shown in Figs.7 to 10. The distributions of the calculated peak accelerations are in agreement with those of the observed seismic intensities and the percentages of collapsed wooden houses during these earthquakes. Fig.11 shows the comparison between the calculated peak accelerations and the observed intensities by J.M.A. scale. The calculated values 100 and 300 gals correspond to the upper boundary of intensity IV and V, respectively. This relation is consistent with that proposed by Dr. Kawasumi (3). These results mean that the intensity distribution in and around the source region can be predicted with good accuracy by this method. Fig.12 shows the example of the prediction of intensity distribution on the hypothetical Suruga-Wan, Japan, earthquake.

CONCLUSION

Authors proposed a simple method for calculating the peak acceleration of the near-field ground surface motions with regard to fault rupture, attenuation of seismic waves and site geological conditions, and affirmed its reasonableness.

REFERENCES

(1) Midorikawa,S. and H.Kobayashi, 1978, On Estimation of Strong Earthquake Motions with Regard to Fault Rupture, Proceedings of the Second International Conference on Microzonation, pp.825-836.

(2) Ando,M., 1974, Seismo-Tectonics of the 1923 Kanto Earthquake, Journal of Phisics of the Earth, Vol.22, pp.263-277.

(3) Okamoto,S., 1973, Introduction to Earthquake Engineering, University of Tokyo Press.

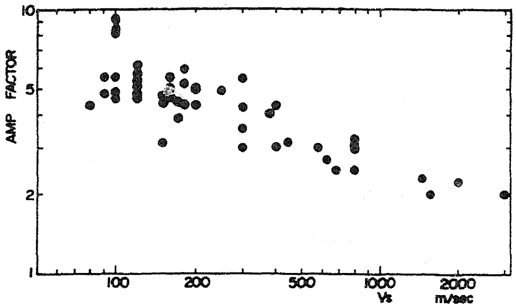

Fig.1 Amplification Factor of Ground vs. Vs of Surface Layer

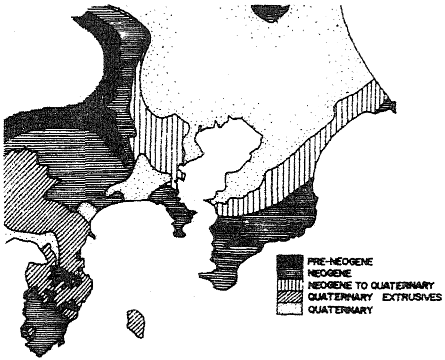

Fig.2 Geological Map

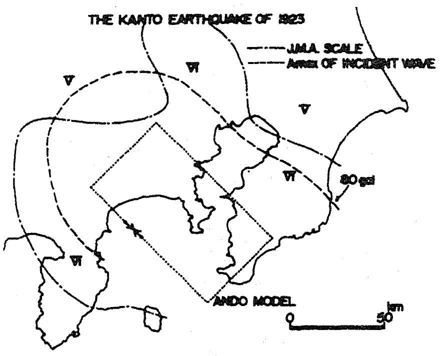

Fig.3 Isoseismal Map

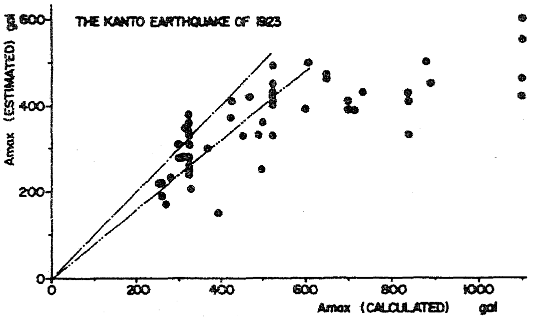

Fig.4 Calculated Peak Acceleration vs. Estimated value from Overturning of Simple Bodies

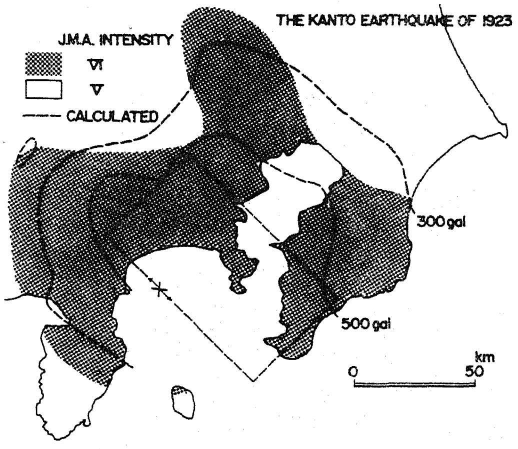

Fig.5 Isoseismal Map

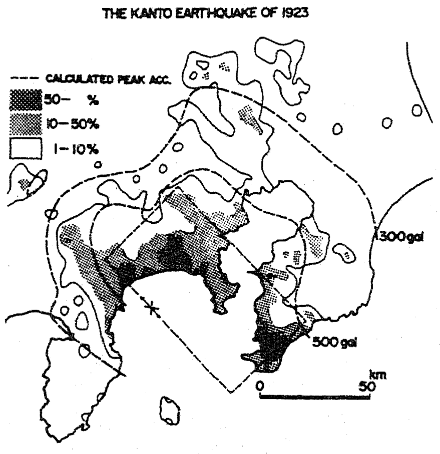

Fig.6 Distribution of Percentage of Collapsed Wooden Houses

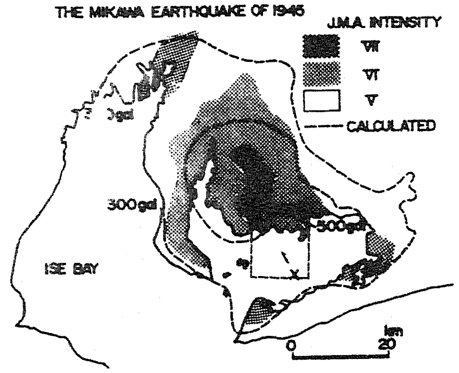

Fig.7 Isoseismal Map

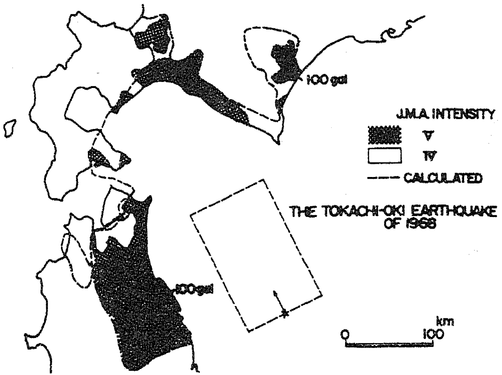

Fig.8 Isoseismal Map

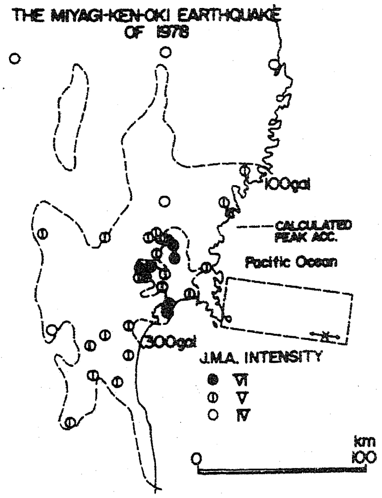

Fig.9 Isoseismal Map

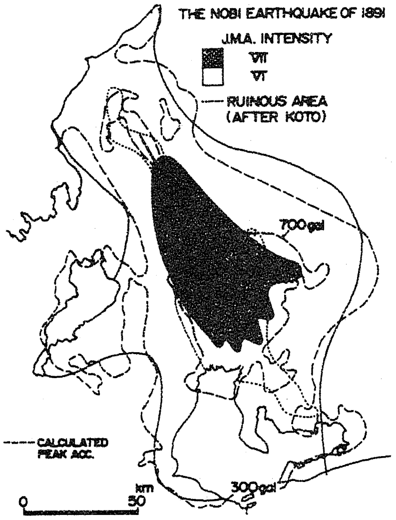

Fig.10 Isoseismal Map

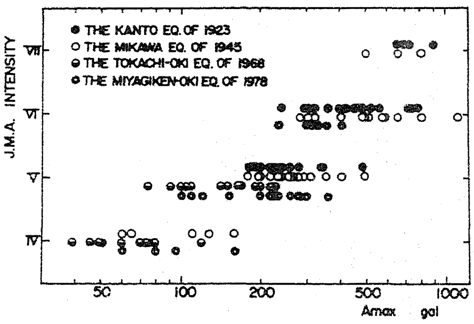

Fig.11 Calculated Peak Acceleration vs. Observed J.M.A. Intensity

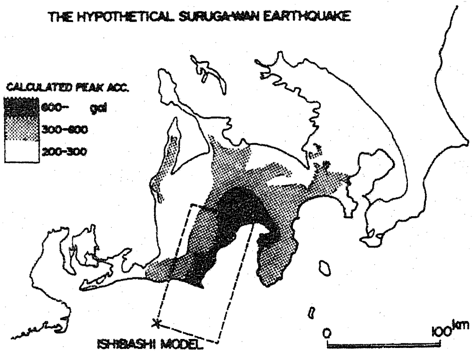

Fig.12 Isoseismal Map