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2-2-5 A STUDY ON THE SEISMIC MICROZONING FOR 23 WARDS OF TOKYO METROPOLIS

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SUMMARY

In order to investigate the seismic microzoning in the Tokyo Metropolis, we compiled questionnaires concerning the seismic intensity in the two recent middle-scale earthquakes that occurred near Tokyo. The target area was the 23 wards of Metropolitan Tokyo and the questionnaires were distributed to public junior high schools (424 schools) in this area. In this paper, we have made clear the distribution of seismic intensity and investigated the relation between the intensity and the surface ground condition, and we obtained much useful information relating to the seismic microzoning.

INTRODUCTION

It is important to investigate the seismic microzoning in urban areas with a concentrated large population like central Metropolitan Tokyo, from the point of view of reducing the damage of an earthquake disaster. We complied questionnaires connected to the seismic intensity in the 1985 Oct. 4th Southern Ibaragi Pref. Earthquake (M=6.1) and the 1986 June. 24th earthquake off South-east Boso Pen. (M=6.5) in order to investigate the distribution of the seismic intensity in the 23 wards of Metropolitan Tokyo. In this paper, based on the results of these questionnaires, we estimated the seismic intensity (JMA Intensity Scale) at each site in the 23 wards of the Tokyo Metropolis and made a distribution map of seismic intensity by using a 500m x 500m meshed map. Then we tried to investigate the appropriateness of the seismic microzoning which had already been discussed by the Tokyo Metropolitan Government, especially, by concentrating upon the dynamic characteristics of the surface ground condition.

SUMMARY OF EARTHQUAKES

The summary of both earthquakes investigated for the density of distribution of seismic intensity are described as follows. Fig. 1 shows the epicenters.

[1985 Oct. 4th Southern Ibaragi Pref. Earthquake]

Hypocenter: 35°52'N, 140°10'E, Depth : H=71.6km
Magnitude : M=6.1 , Intensity (JMA Scale): V (Tokyo)

[1986 Jun. 24th Earthquake off South-east Boso Pen.]

Hypocenter: 34°49'N, 140°43'E, Depth : H=73.0km
Magnitude : M=6.5 Intensity (JMA Scale): IV (Tokyo)

INVESTIGATION METHOD AND SEISMIC INTENSITY DISTRIBUTION

The questionnaires used in both investigations were of the same format and we used the investigation method authorized by Dr. Y. Ohta called the HOKUDAI Method. In the Southern Ibaragi Pref. Earthquake, the people targeted in the questionnaires were the parents of the students attending the public junior high schools, and in the case of the South-east Boso Pen. Earthquake, the questionnaires were distributed to the teachers of the public junior high schools in Central Tokyo. The number of distributed sheets and the response rates are shown in Table.1. Based on the above-mentioned results for both earthquakes, we assumed the seismic intensity (JMA Scale) at each site and estimated the distribution of the seismic intensity in the 23 wards of Metropolitan Tokyo using the same moving average method to clarify the distribution of seismic intensity evaluated in this investigation as shown in Fig.2 and Fig.3. By the results of this investigation, a common tendency was recognized that the zones showing the highest intensity lay at the coast of Tokyo Bay and, in general, the seismic intensity was higher at the eastern part of the 23 wards of Metropolitan Tokyo relative to the western part.

SURFACE GROUND CONDITION AND DYNAMIC CHARACTERISTICS

In Central Tokyo, the surface ground condition, which was defined by soft layers situated upon a hard layer whose N-value was larger than 50, was divided into 22 types (A - V Type) by considering the topographical and geological information according to the 500m x 500m meshed map by the Tokyo Metropolitan Government. And then, based on the above-mentioned surface ground condition types, the dynamic characteristics (predominant period, magnification factor etc.) of each type were evaluated by the earthquake response calculation method. In order to investigate the co-relation between the estimated seismic intensity distribution and the surface ground condition, we considered 5 indices, namely the thickness of surface ground (H), predominant period (To), maximum magnification factor (Rmax), average S-wave velocity (Vs) and energy density magnification factor (Ren=Rmax x To). The values of the above mentioned 5 indices in relation to each surface ground type are shown in Fig.4 and Fig.5. From these figures, it is clear that the thickness of soft layer (H) is less than 10m at points A, C, E, J, S and T, is from 10m to 30m at points B, D, F, G, H, K, L, M, N and U, and is more than 30m at points I, O, P, Q, R and V. And the predominant period (To) is shorter than 0.3sec. at points A, B, C, D, E, J, K, S and T, is from 0.3sec. to 0.5sec. at points F, G, L and U, and is longer than 0.5sec. at points H, I, M, N, O, P, Q, R and V. The average S-wave velocity (Vs) is mostly distributed near the value of about 170m/sec. except for the S, T and U points which show lower values. As mentioned above, the predominant period clearly shows differences according to the thickness of surface ground condition but the maximum magnification factor (Rmax) is about from 6 to 7 times and a clear difference is not recognized. The energy density magnification factor (Ren) shows a clearly remarkable difference, that is to say, the magnification is less than 2 times at points A, B, C, D, E, J, K, S and T, is from 2 to 5 times at points F, G, H, L, M, N and U, and is larger than 5 times at points I, O, P, Q, R and V. These 22 types of surface ground conditions are grouped into 3 classes.

RELATION BETWEEN SEISMIC INTENSITY AND SURFACE GROUND CONDITION

Table 2 shows the index values of H, To, Rmax, Ren and SI which were averaged for each ground condition type. Fig.6 shows the relation between the thickness (H) and seismic intensity (SI) and Fig.7 shows the relation between the predominant period (To) and SI. Also Fig.8 shows the relation between the maximum magnification factor (Rmax) and SI and Fig.9 shows the relation between the energy density magnification factor (Ren) and SI respectively. Comparing the above-mentioned relations in the two earthquakes, a more consistent and clear tendency is shown in the case of the Southern Ibaragi Pref. Earthquake than in the case of the earthquake off South-east Boso Pen. Especially, in the case of the 3 relations excepting the maximum magnification factor (Rmax), the evaluated seismic intensity distribution shows a better corelation with the surface ground condition and its dynamical characteristics. As shown in Fig.4 and Fig.9(a), especially in the case of the relation between Ren and SI, 22 types of ground conditions are grouped into 3 classes by the value of Ren ($Ren \leq 2$, $2 \leq Ren \leq 5$ and $5 < Ren$) and I, O, P, Q, R and V Types which have a value of Ren larger than 5 times show high intensity. But inversely A, B, C, D, E, J, K, S and T Types, which have a value of Ren less than 2 times show low intensity except for E Type. This tendency appears more clearly in the case of the Southern Ibaragi Pref. Earthquake. And we think that the co-relation between the surface ground condition and the seismic intensity appeared in the above case especially because of the hypocenter (ex. hypocentral distance, source mechanism etc.), and shows the compatibility with the seismic microzoning which have been made by the Tokyo Metropolitan Government.

SEISMIC MICROZONING OF 23 WARDS OF TOKYO METROPOLIS

From the result of this investigation concerning the distribution of seismic intensity, the evaluated seismic intensity was related to the surface ground condition used in the seismic microzoning by considering the dynamic characteristics. Using the above-mentioned result, the zone which was relatively well vibrated in the 23 wards of Tokyo is of the I, O, P, Q, R and V Types which are spread over the east part of Central Tokyo and the thickness of the soft layer of these types is 40m deep and more and the zone corresponds to the lowland of buried valley bottom. The zone of medium vibration is of F, G, H, L, M and U Types, which are constituted of the alluvium layer and the soft layer is relatively thin. In the Topography, these types correspond to the buried coatal terrace and buried wave-cut platform, which are situated on both sides of above-mentioned lowland of buried valley bottom and extend from north to south like a longitudinal belt in Central Tokyo. And then the zone showing least vibration is of the A, B, C, D, E, J, K, S and T Types, which lie at the western part of Central Tokyo, and these types are constituted by the diluvium layer where the soft layer is thin. In the Topography, these types correspond to the table land. Fig.10 shows the above-mentioned three zones.

CONCLUSIONS

The conclusions of this paper are summarized as follows.

1) The dense distribution of seismic intensity was made clear in the 23 wards of Metropolitan Tokyo in two recent middle-scale earthquakes and both distributions showed the same tendency. These results are very useful for the study of seismic microzoning.

2) The correspondence of the seismic intensity distribution and surface ground condition was recognized very well, and especially, the index of the energy density magnification factor (Ren) corresponds to the seismic intensity remarkably.

3) It is necessary to consider the seismic microzoning by taking into account the actual distribution of seismic intensity in company with the surface ground condition.

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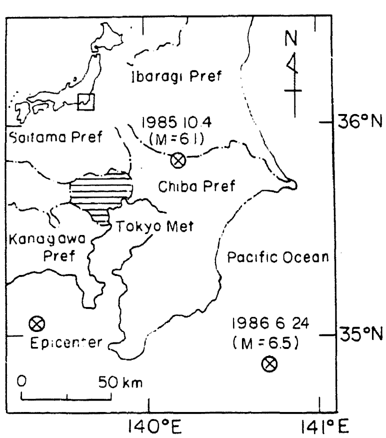


Fig-1 Epicenters of both earthquakes

Table-1 Distribution and Collection of questionnaires

	1985.10 4 Southern Ibaragi Pref. Earthquake	1986 6. 24 South-east off Boso Pen. Earthquake
Public Junior High Schools	424 schools	424 schools
Collected schools	407 schools	392 schools
Rate of collection	96.0 %	92.0 %
Distributed sheets	33920 sheets	8480 sheets
Answered sheets	26657 sheets	7912 sheets
Rate of Answer	78.6 %	93.3 %

Table-2 Seismic Intensity and Index Value of Each Type

Type	South-east off Boso Pen. Eq. non-averaged SI JMA	South-east off Boso Pen. Eq. averaged SI JMA	South-east off Boso Pen. Eq. non-averaged SI JMA	South-east off Boso Pen. Eq. averaged SI JMA	Thickness of soft layer H(m)	Predominant Frequency (Period) fo (Hz)	Maximum Magnification Factor R_{max}	Energy Density Magnification Factor R_{en}
A	3.6	3.6	3.0	3.1	8	5.3 (0.19)	7.1	1.4
B	3.6	3.6	3.2	3.2	23	3.3 (0.30)	5.7	1.7
C	3.6	3.6	3.2	3.1	6	6.7 (0.15)	6.1	0.9
D	3.6	3.6	3.1	3.2	15	8.3 (0.12)	6.4	0.8
E	3.7	3.7	3.3	3.3	5	7.1 (0.14)	4.9	0.7
F	3.6	3.7	3.2	3.3	11	2.9 (0.34)	7.2	2.5
G	3.7	3.7	2.9	3.2	23	2.6 (0.38)	5.6	2.1
H	3.8	3.7	3.2	3.3	25	1.4 (0.71)	7.0	4.9
I	3.8	–	–	–	38	1.2 (0.83)	6.7	5.6
J	3.6	–	–	–	3	9.1 (0.11)	5.9	0.7
K	3.6	3.6	3.2	3.2	11	3.5 (0.29)	5.7	1.7
L	3.5	–	–	–	19	2.5 (0.40)	6.0	2.4
M	3.6	3.6	3.1	3.2	21	1.4 (0.71)	6.9	4.8
N	3.6	–	–	–	29	1.8 (0.56)	6.2	3.4
O	3.7	3.7	3.2	3.2	30	1.2 (0.83)	7.0	5.7
P	3.9	3.9	3.4	3.4	40	1.0 (1.0)	7.3	7.3
Q	3.7	3.8	3.1	3.2	46	0.9 (1.11)	7.1	7.8
R	3.8	3.8	3.2	3.2	56	0.8 (1.25)	7.0	8.8
S	3.6	3.6	3.1	3.2	3	7.7 (0.13)	7.0	0.9
T	3.6	3.6	3.2	3.2	7	4.4 (0.23)	8.4	1.9
U	3.5	3.6	3.1	3.2	11	2.5 (0.40)	8.2	3.3
V	3.8	–	–	–	36	1.0 (1.0)	7.4	7.4

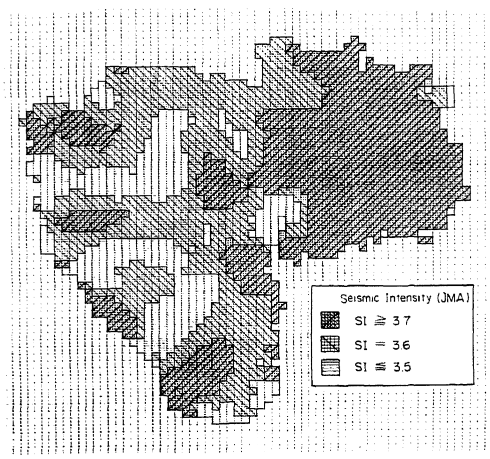


Fig-2 Distribution of Seismic Intensity in JMA Scale (1985 Oct. 4th Southern Igaragi Pref. Earthquake)

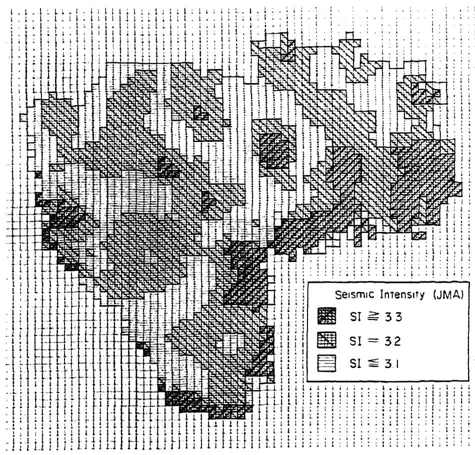


Fig-3 Distribution of Seismic Intensity in JMA Scale (1986 Jun. 24th South-east off Boso Pen. Earthquake)

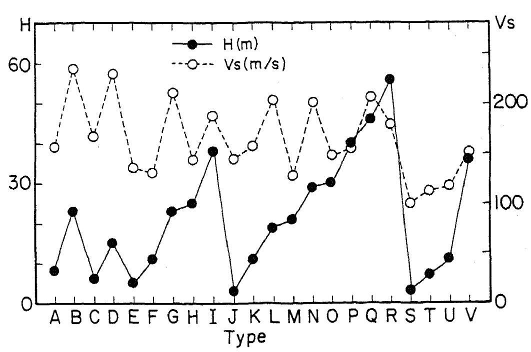


Fig-4 Thickness of Soft Layer and Averaged S-wave Velocity of Each Type

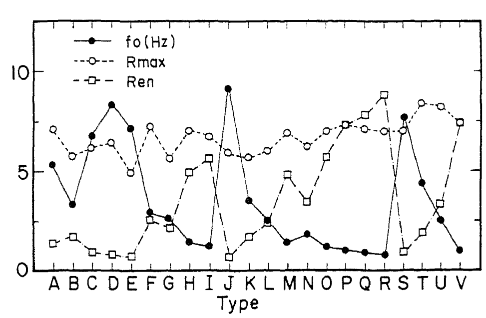
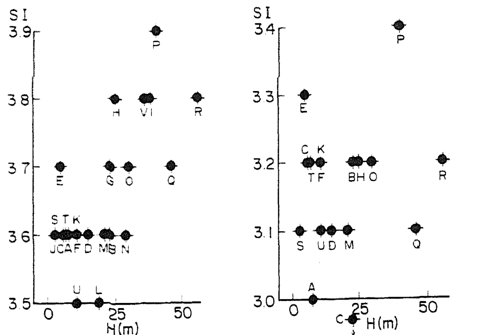
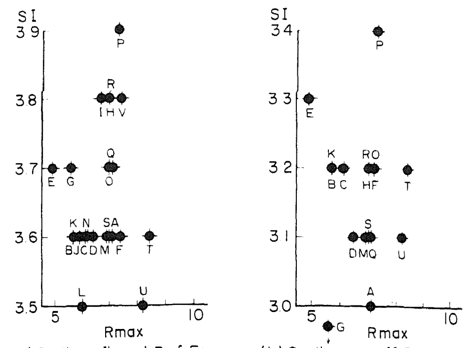


Fig-5 Index Value of Dynamical Chavactevistics of Each Type



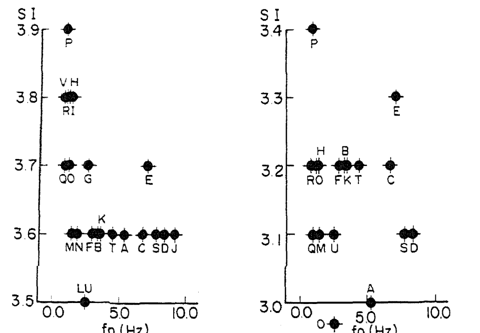
(a) Southern Ibaragi Pref. Eq. (b) South-east off Boso Pen. Eq.

Fig-6 Relation Between the Thickness of Soft Ground (H) and Seismic Intensity (SI)



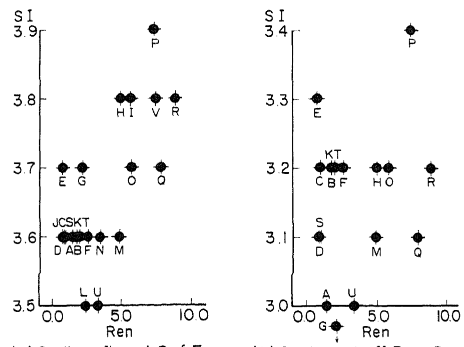
(a) Southern Ibaragi Pref. Eq. (b) South-east off Boso Pen. Eq.

Fig-8 Relation Between the Maximum Magnification Factor (Rmax) and SI



(a) Southern Ibaragi Pref. Eq. (b) South-east off Boso Pen. Eq.

Fig-7 Relation Between the Predominant Period (To) and SI



(a) Southern Ibaragi Pref. Eq. (b) South-east off Boso Pen. Eq.

Fig-9 Relation Between the Energy Density Magnification Factor (Ren) and SI

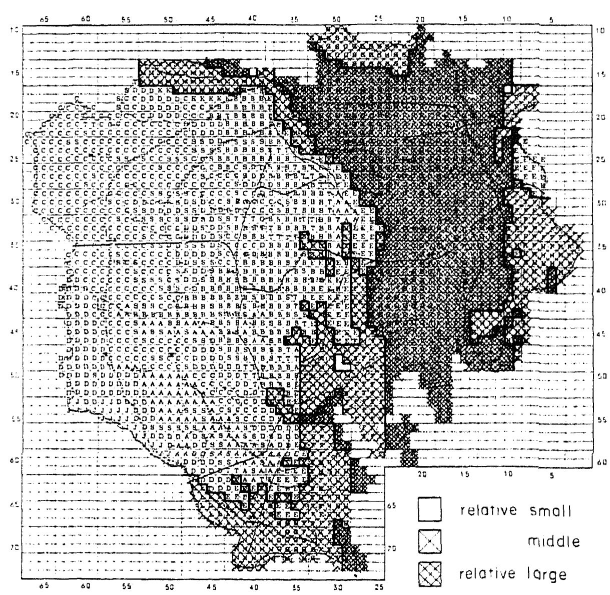


Fig-10 Relative Easiness of Ground motion in Central Tokyo