A LOCAL SEISMIC INTENSITY ZONING MAP BASED ON SUBSOIL CONDITIONS

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SYNOPSIS

The distribution of seismic damages to buildings relates to the nature of ground and its pattern varies with the type of buildings. Using phenomena of multiple reflection of shear waves in multi-layered soil, authors explained the relation between the strong motion acceleration and nature of layered soil structure. They computed the distribution of acceleration on the ground, seismic damage ratio of wooden houses and seismic intensities during the Kanto Earthquake of 1923, and these were confirmed by the comparison of the actual damages.

INTRODUCTION

It has been indicated at several destructive earthquakes in Japan that the damages due to earthquake vary with local ground conditions and are not distributed uniformly even a local area in a city. These matters are also indicated at the Mexico Earthquake of 1957 from the difference of damages at various places in Mexico City, at the Caracas Earthquake of 1967 from those in Caracas City and at the San Fernando Earthquake of 1971 from those in the Extended Los Angels Area. It is important to ascertain the local seismic intensities based on subsoil conditions for the purpose of more reasonable city planning or district design.

AMPLIFICATION OF AN EARTHQUAKE MOTION IN THE MULTI-LAYERED SOIL

Authors proposed the method for numerical analysis of the propagation of shear waves in a multi-layered ground.(1) Using this method, they explained the relation between the characteristics of strong motion acceleration and the nature of wave propagation in layered soil. The response spectra of strong motion acceleration observed at Hachinohe Harbour during the Tokachioki Earthquake of 1968 have remarkable peaks in about 2.5,0.8 and 0.5 second, as shown in Fig.1. Theoretical ratio of amplification calculated with multiple reflection of shear waves in the multi-layered soil, whose properties determined by the seismic prospecting also has peaks in same period, and the microtremor also has peaks in same period. Concerning the strong motion accelerations observed at Shinjuku during the Earthquake of July 1,1968, these peaks also agree with calculated ones as shown in Fig.2. So from these agreements, it was concluded that the characteristics of ground motions can be assumed at any places where subsoil conditions are known with the method mentioned above.

DISTRIBUTION OF ACCELERATIONS DURING THE KANTO EARTHQUAKE OF 1923 AND LOCAL INTENSITY ZONING MAP

As mentioned above, the difference of earthquake motions on the ground surface depends on the difference of amplification of S-waves in layered soil. Extending this matter to an area of a city, they proposed a method for local seismic intensity zoning maps.(1) They analyzed the

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distribution of the acceleration on the ground surface in the Eastern Part of Kawasaki City and the Down Town of Tokyo due to the Kanto Earthquake. And compairing the reported data of damages with calculated ones, they concluded following matters. Magnitude of acceleration of ground motions are about 300 to 700 gals in Kawasaki, and as shown in Fig.3 those are 200 to 500 gals in the Down Town of Tokyo. Damage ratios of wooden buildings were determined by the value of elasto-plastic response of one mass system due to the calculated ground motions. The distribution of these ratios presented good agreements with the reported ones as shown in Fig.4. Mononobe and Sano illustrated the relation between total damage ratio of wooden buildings and seismic intensities from the damages of the Kanto Earthquake. Comparing the relation obtained from the calculated results with Mononobe's relation, these values were about 100 gals larger than Mononobe's as shown in Fig.5. Mononobe determined seismic intensities by the phenomena of overturning of simple body due to the earthquake ground motion. But the Mononobe's evaluation seemed rather small value for short period range movement, so the two relations could not be compared directly. For this reason, in order to cut off the waves in short period range, they modified the calculated ground motions by a filter having characteristics of a pendulum whose natural period is 0.1 second and damping is critical. Then these modified relations showed good agreement with Mononobe's as shown in Fig.6. They calculated the seismic intensity "Sa" from the acceleration response spectrum of calculated ground motions at each point, and plotted these values on the map for every period of buildings as shown in Fig.7. The reported damage ratios of one and two storied reinforced concrete buildings show different pattern from those of more than two storied. They considered that percentage of the area where the value of "Sa" are over 0.6 represent the ratio of damage, based on the result that the value of "Sa" approximatelly equal to the product of allowable ductility factor and design seismic coefficient.[1] And in Fig.8. they showed the relation between damage ratios and the percentage. The damage ratios of one and two storied buildings show better correlation with the case of T=0.1 sec. than that of T=0.4 sec. And these of more than two storied show better correlation with the case of T=0.4 sec. From these matters, the damage ratio of reinforced concrete buildings was also explained. From these agreements, the ground motions during the Kanto Earthquake could be estimated with large accuracy, and local zonig maps could be made.

CONCLUSION

Authors inferred the seismic intensities using the phenomena of multiple reflection of shear waves in layered soil, and these results were confirmed by the comparison of the Kanto Earthquake records. Authors believe this method is adequate for estimation of seismic intensities and applicable for more reasonable urban design.

REFERENCE

KOBAYASHI,H. and KAGAMI,H. "A Method for Local Seismic Intensity Zoning Maps on the Basis of Subsoil Conditions",Proceedings of International Conference on Microzonation,1972,pp.513-528.

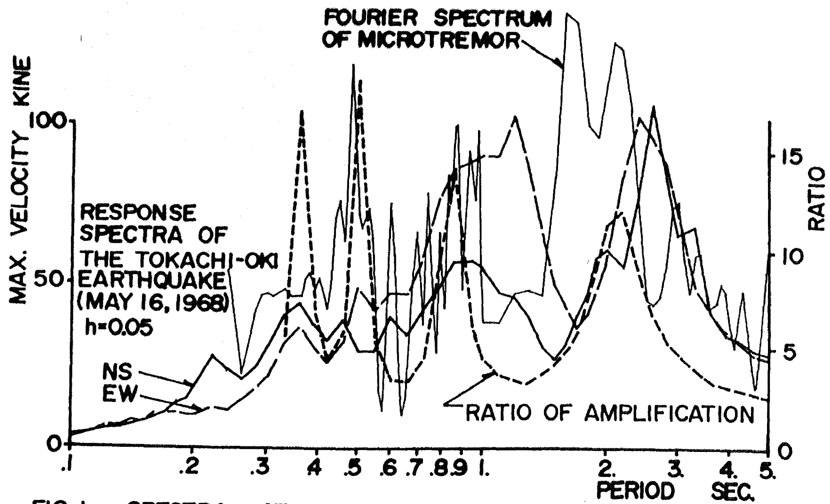

FIG. 1 SPECTRA AT HACHINOHE

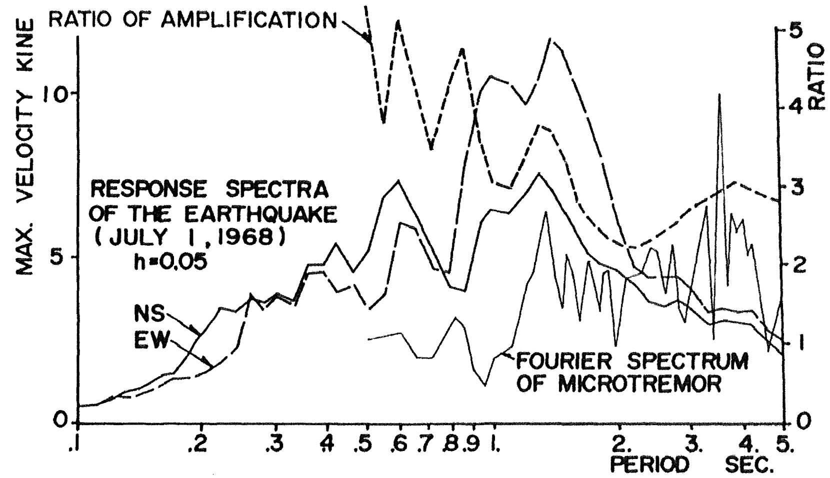

FIG. 2 SPECTRA AT SHINJUKU, TOKYO

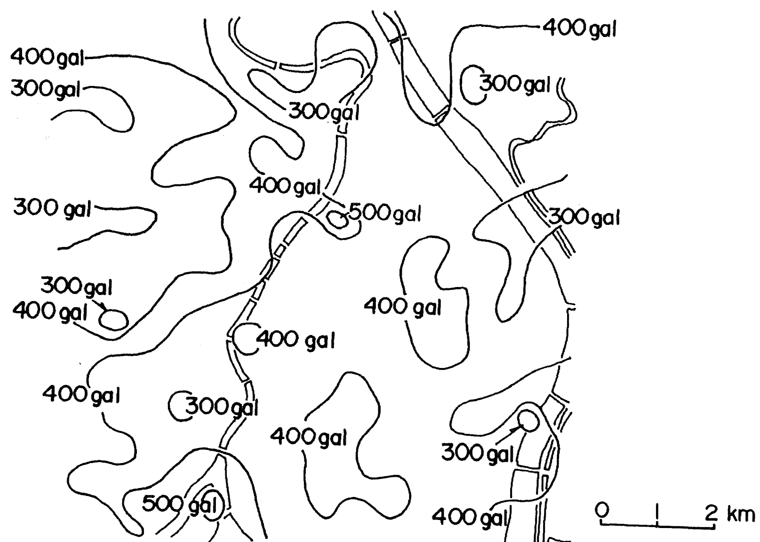

FIG. 3 DISTRIBUTION OF MAXIMUM ACCELERATION (TOKYO)

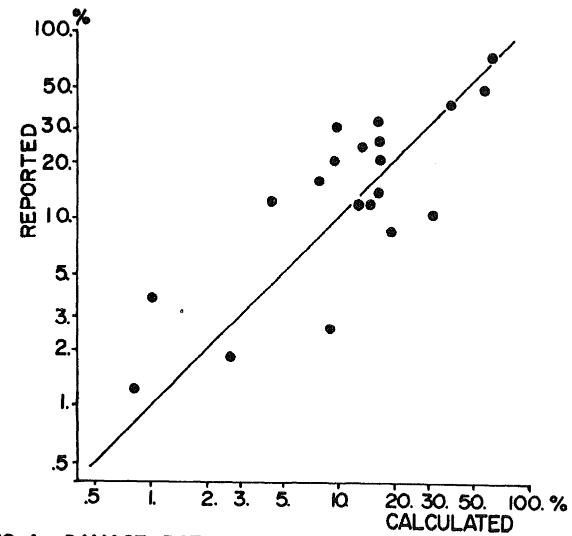

FIG. 4 DAMAGE RATIO OF WOODEN HOUSES DUE TO THE KANTO EARTHQUAKE 1923

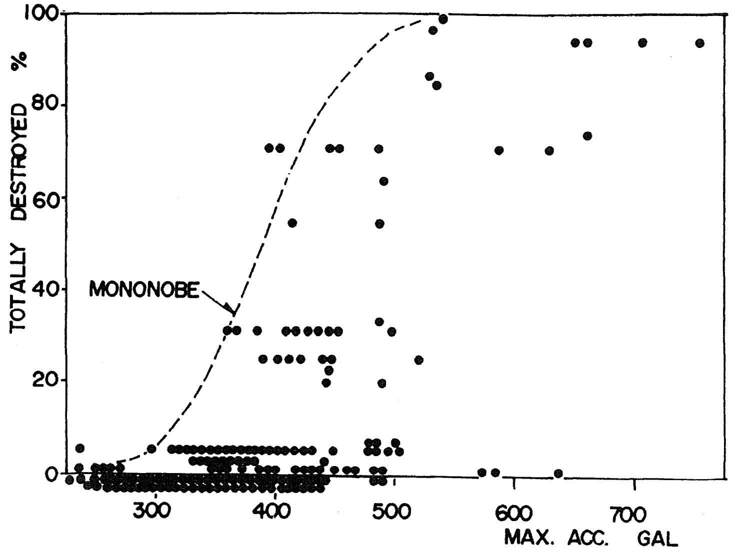

FIG. 5 DAMAGE RATIO OF WOODEN HOUSES DUE TO THE KANTO EARTHQUAKE 1923

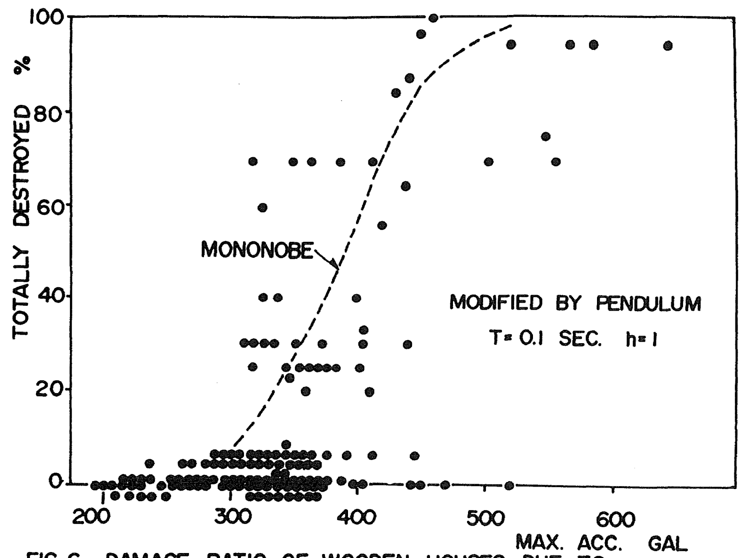

FIG. 6 DAMAGE RATIO OF WOODEN HOUSES DUE TO THE KANTO EARTHQUAKE 1923

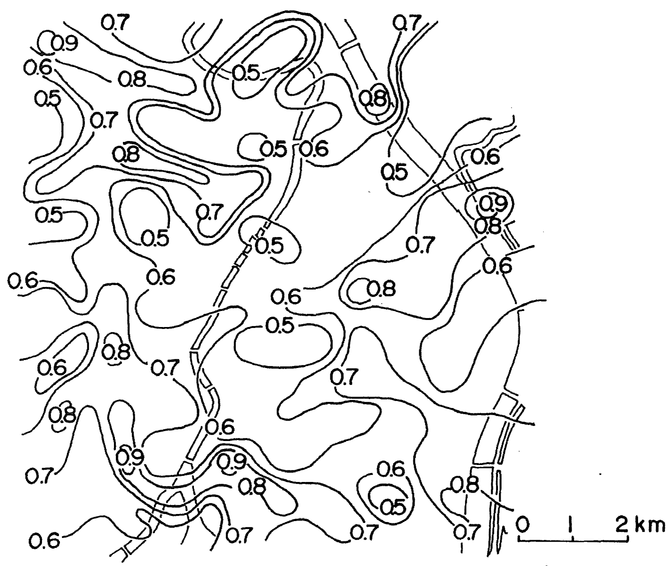

FIG. 7 DISTRIBUTION OF SEISMIC INTENSITY (TOKYO) T=0.4 SEC.

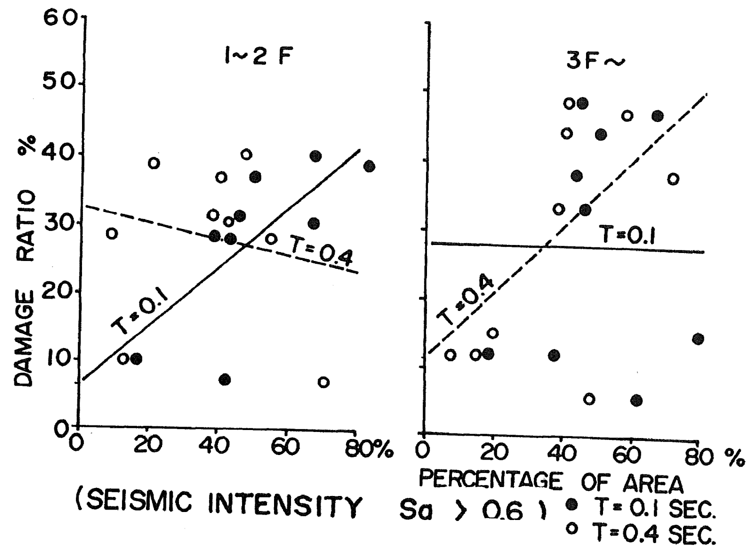

FIG. 8 DAMAGE RATIO OF REINFORCED CONCRETE BUILDINGS