GROUND CONDITION AND DISASTER OF THE
1978 MIYAGI-KEN-OKI EARTHQUAKE IN JAPAN

BY

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SUMMARY

June 12, 1978 an earthquake with 7.4 magnitude struck Tohoku District of Japan. The damage extended throughout each prefecture of the district, and in Sendai City and its neighbourhood the damage was most conspicuous. Main purpose of our immediate field survey was to reveal the seismic intensity and earthquake disaster, and to grasp their relation with the ground condition. We estimated the seismic motions from response analysis for each type of ground, using a great volume of information obtained from our investigation. Difference of seismic intensity depending on the ground condition was sufficiently explained in close connection with actual sufferings.

INTRODUCTION

The earthquake brought serious damage upon the area of Miyagi Prefecture, centering on Sendai City. In addition to heartbreaking victims--27 killed, totally or half collapsed were 4,000 houses and partly-collapsed were 7,000. Furthermore, civil structures and life line facilities suffered noticeable losses. According to areal distribution of these losses we noticed partial maldistribution trend and that most of these losses were concentrated on the coastal plain in the eastern part of the city and on reclaimed land for housing in the surrounding hilly high land. We considered that the disaster distribution has closed relation with the ground condition i.e. topographical features and surface soil. On the other hand, amplitude of seismic motion at ground surface was largely different from place to place. That the difference was also caused by the ground condition is obvious from the results we obtained through tomb-stone toppling survey and questionaire survey on human sensitivity. In order to study the relationship among the three--earthquake damage, seismic motion and the ground conditions the authors et al conducted immediate fact-finding survey and data interpretation. In this paper the authors intend to report the review results obtained by ground response analysis on the relationship between the seismic motion and the ground condition.

GROUND CONDITION AND DISASTER

The topography of the area surrounding Sendai City is largely divided into three--alluvial plain facing the Pacific, terrace flat area inside the city and hilly high land. The outline is shown in Fig. 2. As to the alluvial plain supply and accumulation of sand was made by rivers, such as Nanakita River, Natori River and the Pacific coastal flow. Due to difference

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in supply and accumulation pattern a variety of minor topographies are recognized in the area. They are beach ridge, natural levee, back marsh, etc. Among them beach ridge and natural levee mainly consists of sand ranging from fine to coarse grain. On the other hand, old river bed and back marsh consist of silt or clay mixed with humas soil. Thus, minor topography and surface soil show fine correspondence and form respective ground condition.

Now, standing on such ground condition let us look at the disaster distribution of the ground. For instance, that of wooden house shown in Fig. 1 the damage is noticeable in soft soil such as eastern alluvial plain and reclaimed land (earth-filled area) in the surrounding hilly high land and the damage was generally slight in the old town area consisting of well-compacted terrace flat ground and the like. Further, the damage of civil structures and occurrence of sand boil phenomenon caused by liquefaction of sandy layer seem to have direct or indirect connection with the ground condition.

Well then, what is the ground condition in strict sense which relates to phases of such damage? First, it would be ground characteristics as medium to transmit the seismic motion. In other words, the ground has certain frequency amplification characteristics according to physical properties of the constitutional soil layers and ground construction. Because of the difference in such characteristics different seismic motion is brought about from place to place. Second is the characteristics related to deformation or failure of ground, that is resulted from nature of surface soil. Combination of the two can be said to produce certain seismic motion, ground damage at certain place or to cause resultant structure damage.

GROUND CONDITION AND SEISMIC INTENSITY

Now, let us discuss to what extent the seismic motion varies according to the ground from theoretical viewpoint. Based on many boring data we determined estimate columnar chart in average and established S wave velocity and dynamic deformation characteristics both required for the analysis from existing data and actual measurement. Then, we formulated ground models as shown in Fig. 3 in order to represent respective ground division of the area surrounding the city.

We made seismic motion shown in Fig. 5 act on the base rock (assumed to be Tertiary rock) of each ground division. We prepared two inputs based on acceleration record obtained at Kaihoku Bridge and Tarumizu Dam by the Public Works Research Institute, Ministry of Construction of Japan during the earthquake.

As shown in Fig. 4 the response analysis was made by means of gradual convergence that can consider non-linearity of soil. The program is basically derived from multi refraction theory along wave propagation theory. The author developed it, employing Haskell's matrix solution.

Fig. 6 is to show one example of analytic result at one place. Analytic result of acceleration distribution toward depth direction at each division is delineated as Fig. 7. Fig. 8 is to show each accerelogram at ground surface of each ground model by response analysis.

The preceding analytic results are plotted on schematic profile in contrast with corresponding ground condition as provided in Fig. 9. On the other hand, we conducted investigation on tombstone overturning status and questionaire survey in our immediate study after the earthquake and estimated the intensity of seismic motion. At upper portion of Fig. 9

we showed the estimate intensity in addition to that obtained by the preceding response analysis. Comparatively fine topographical agreement is seen between the two. Also, the figure well illustrates that the seismic motion was large in the sequence from back marsh to natural levee and fan.

Fig. 1 Distribution of collapsed houses in Sendai City

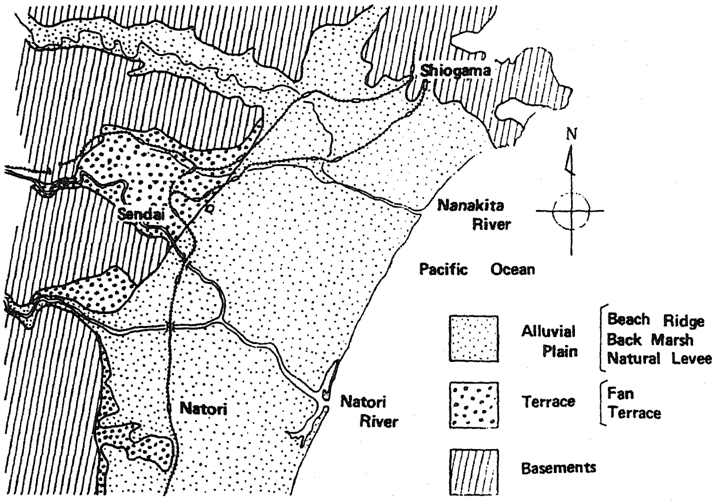

Fig. 2 Topographysical division around Sendai City

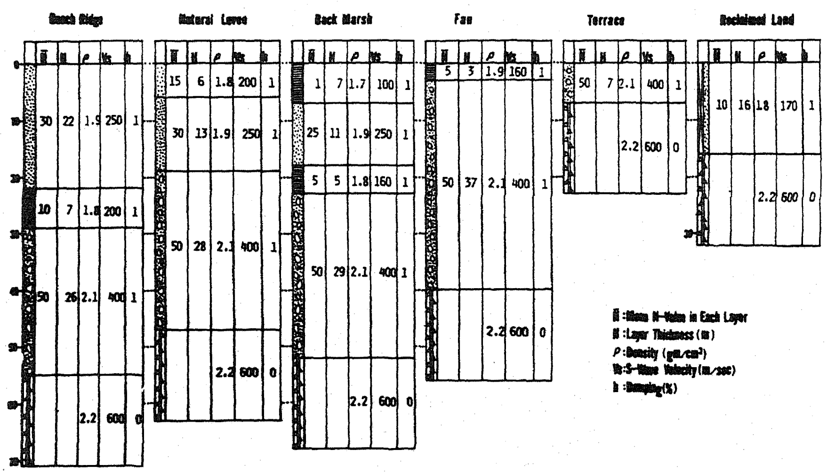

Fig. 3 Ground models for response analysis

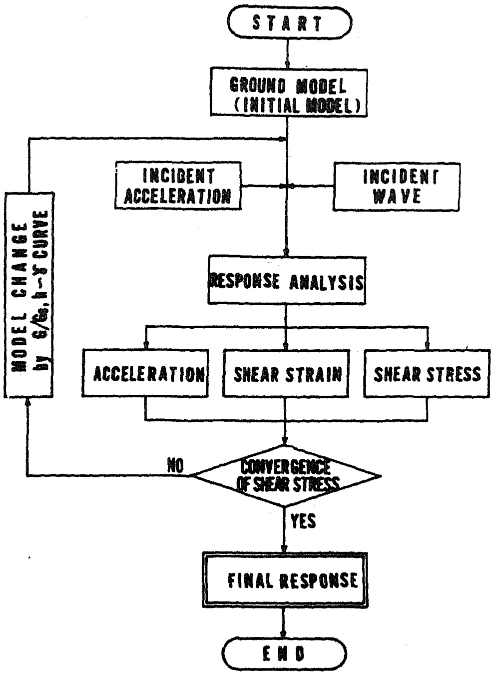

Fig. 4 Flow chart of response analysis

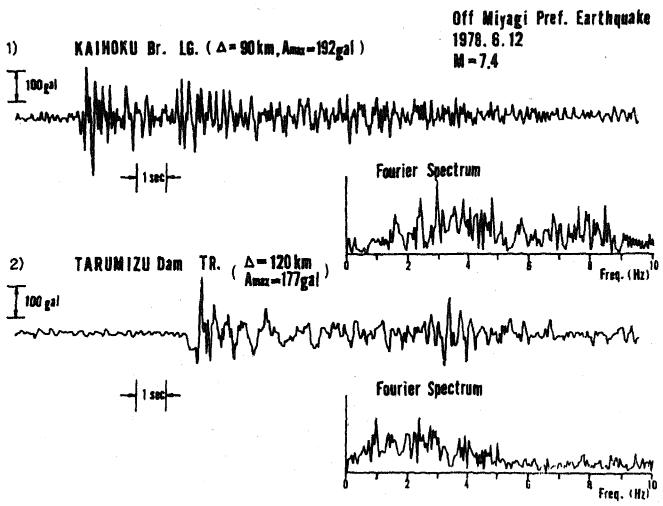

Fig. 5 Input seismic motions

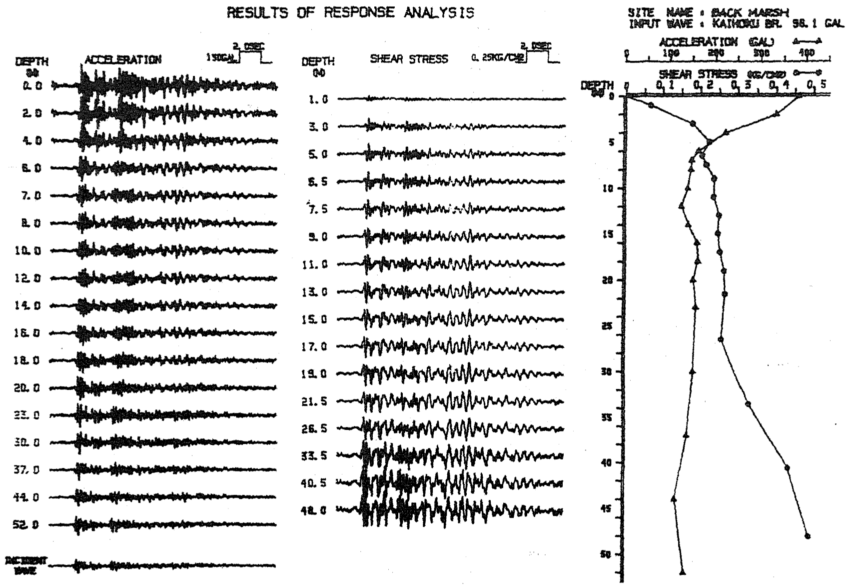

Fig. 6 Example of result of response analysis

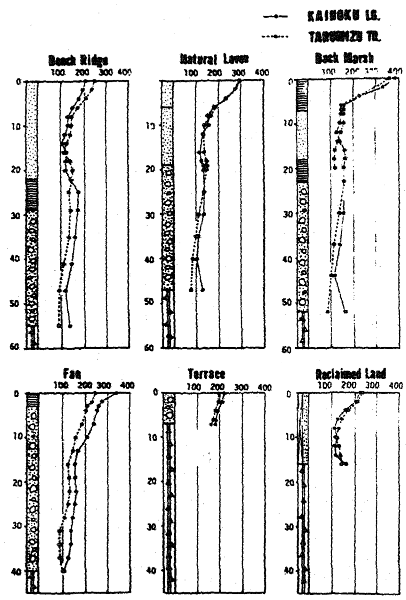

Fig. 7 The distribution of maximum accerelation by depth for each ground

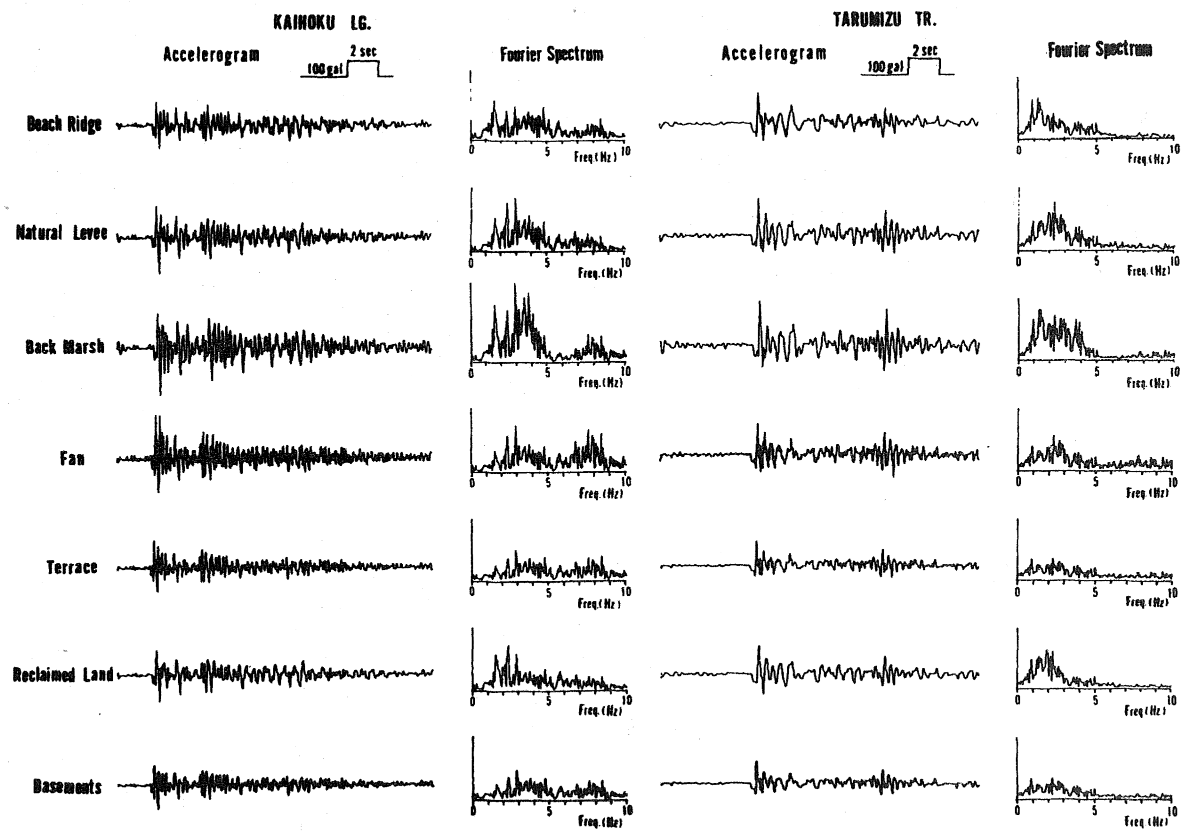

Fig. 8 Surface accerelograms for each ground

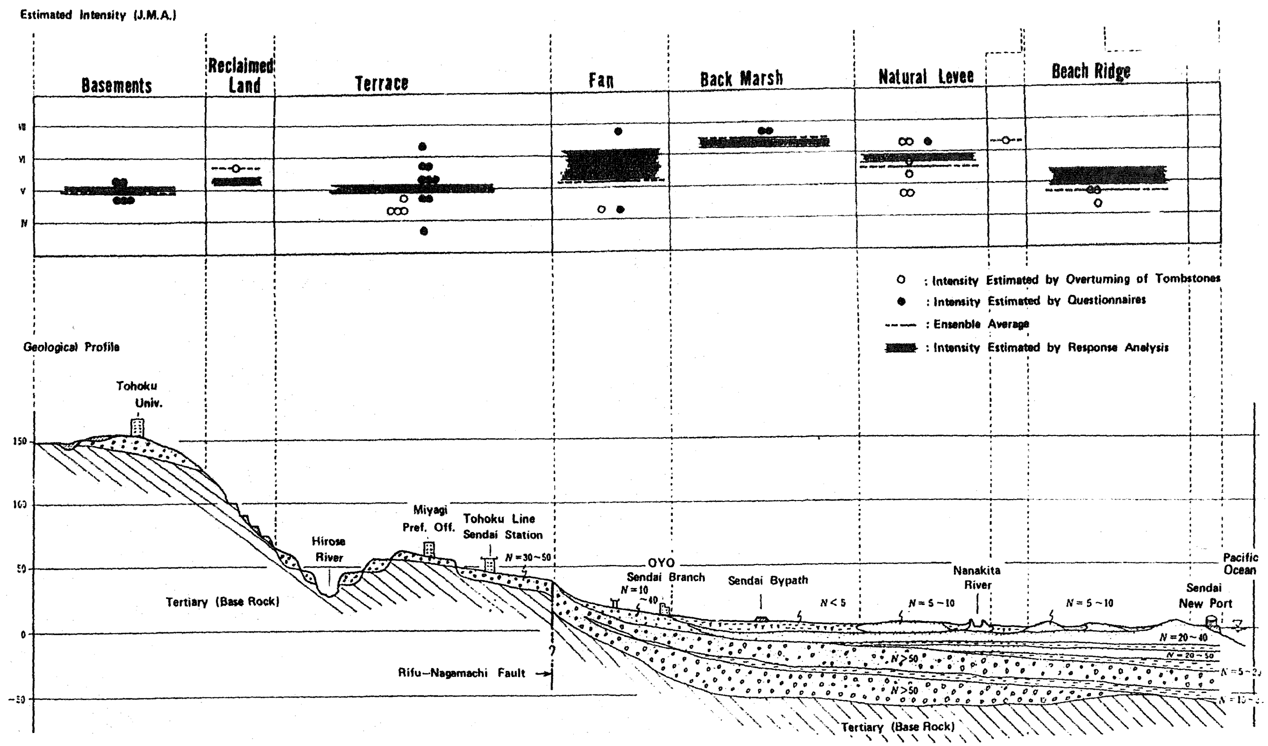

Fig. 9 Ground condition and seismic intensity