Title	SOME PROBLEMS ON THE DETERMINATION OF SEISMIC CHARACTERISTICS OF THE EARTH-GROUND
Author(s)	YOSHIKAWA, Soji
Citation	Special Contributions of the Geophysical Institute, Kyoto University (1963), 3: 333-337
Issue Date	1963-12
URL	http://hdl.handle.net/2433/178445
Right	
Type	Departmental Bulletin Paper
Textversion	publisher

SOME PROBLEMS ON THE DETERMINATION OF SEISMIC CHARACTERISTICS OF THE EARTH-GROUND

BY

Sōji YOSHIKAWA

Introduction

It is a very important problem to know the ground motion during a destructive earthquake from the earthquake engineering point of view. However, the seismogram is very difficult to get at the district where the damages are caused, since a big earthquake occurs very rarely and even when it happens to occur the exact seismogram is not always available at the place. And hence some indirect methods should be taken to determine the vibrational characteristics of the ground. The behavior of the ground due to disturbance such as earthquake, explosion and traffic have been studied in various ways from the standpoint of applied seismology. For example, it is said that the foundation material, geological structure have close relation with the damages caused by these disturbances and besides these the seismicity has to be added to presume the damage in the case of earthquakes.

1. Foundation material

The elastic constants of the materials constituting the earth ground may be measured by seismic prospecting. That is, the propagating velocity of elastic wave at various depth can be measured by changing the distance between the measure point and blast point. The velocity of P-wave is thus easily obtained. When the shot hole is taken deep or a small tunnel is arranged, no surface wave will propagate between the shot point and measure point and hence S-wave is also found comparatively easily in these cases. Thus the propagating velocity of S-wave may be measured. Several experiments have been carried out to measure the velocity of S-wave and were successful in some cases. The density of the material may be obtained easily by taking a sample from the boring core. From Vp, Vs and ρ (density), Poisson ratio, compressibility, Young modulus and rigidity can be caluculated.

The relation between the damage caused by earthquake and these elastic constants are not made so clear as yet, but in some cases close relations between the damage rate of timber house and Poisson ratio, Vp/Vs which was obtained

from the seismic prospecting at the damaged area have been found.[1),2)] With the improvement of technique of measuring the velocity of *S*-wave, the determination of elastic constant will become more easy, which will make it possible to solve the dynamical problems of the foundation during earthquake.

As another factor concerning the seismic characteristics of material, the attenuating and damping constants may be mentioned. The attenuation of the wave with distance and the damping characteristics of the foundation as an oscillating body have important meaning from earthquake engineering point of view. When the decay of earthquake wave with distance is large it is advantageous for the structure, because the energy of seismic wave dyes out very soon and the amplitude is not so much at the place upon which the structure stands. However, at these places, once the vibration is caused the duration time of total oscillation will be very long due to less damping. In actual case the epicenter of the earthquake will be pretty deep and hence the attenuation of the earthquake body wave from the epicenter to the base rock of the ground will not be so different, since the wave travels through the base rock whose absorption coefficient can be regarded as more or less same. In the case of surface wave the circumstances are rather different and the attenuation of wave will depend on the characteristics of surface material. When the alluvium layer is very thick the attenuation of earthquake wave from the base rock to surface will affect the attenuation of the wave and hence it will sometimes be taken into consideration. In ordinary seismic prospecting of the refraction method the depth to be studied is several hundreds meters at most, therefore, from the results of the prospecting it is shown that the damage is generally severer with the increase of the absorption coefficient of the material of the surface layer. And hence it is considered that the damping characteristics of the ground is more effective for the determination of seismic characteristics of the ground when the alluvium layer is not so thick. The absorption coefficient of the surface material will influence the dye out of the body wave only when the layer is very thick. The relative damping characteristics of the earthground may be estimated from the duration time of vibration caused by blasting a certain amount of explosive at a given distance. From experiences, it is known that the damping is larger with the decrease of absorption coefficient. However, the frequency of the wave generated by blast is pretty high when compared with that of natural earthquake and hence it is doubtful whether this tendency is applicable to the case of earthquake. Recently some experiments have been conducted regarding the ground motion caused by atomic explosion and big explosion.[3),4)] As a matter of fact, the frequency in this case is lower than that of ordinary prospecting. From the results of experiments it is confirmed that the

damping characteristics of the ground is larger on hard rock of high propagating velocity of elastic wave. Sometimes the duration time of total vibration on soft ground becomes twice or thrice when compared with that of hard ground.

2. Geological structure

It has been generally believed that the ground has its predominant period in some cases. But the idea of predominant period is not so clear in all cases. The predominant period of the ground has been determined from the analysis of the seismogram or measurements of micro-tremors and regarded as dependent on the geological structure of the place. In some simplified cases the natural period of the ground due to multiple reflection of the seismic wave was studied both theoretically and experimentally.[5] However, the disturbance origin in the case of micro-tremors has not been made clear as yet and in the case of the earthquake the effects of the origin and the path of the seismic wave to the frequency distribution of the periods have to be considered. And hence a synthetic relation between the seismic characteristics and the geological structure of the ground has not yet been obtained.

From experiences it is known that the damages of the wooden houses caused by earthquakes are severer when its base is on the thicker alluvium. But this was not always the case for the structure such as masonry or brick building as were seen in the Kanto earthquake of 1923. It can be easily understood that the combined vibrational effect of the ground and structure will be required for the estimation of the damages caused by earthquakes. Therefore, a clear relation between the geological structure and the vibrational characteristics of the places have to be clarified, which will give a clue for the determination of the damages of the structure. For this purpose the behavior of the ground of a known geological formation subjected to a definite disturbance has to be studied. As described in the previous section, the blast may be used as a disturbance origin. In this case, it is possible to know the frequency distribution of the periods in the vicinity of the blast point and the effect of the path of the wave to the frequency distribution of periods also can be traced by measuring the vibrations at the points between the blast point and measure point. The only difficulty will arise from the high frequency of the explosion generated wave when the amount of charge is small. However, this defect may be covered by increasing the charge and the distance between blast point and measure point. Also, by changing the depth of the blast point from the ground surface the effect of the ground at various depth to the seismic characteristics may be investigated. Since the natural periods of the structure are generally less than a few second the frequency distribution of

the periods of the ground obtained from the analysis of the explosion generated wave will serve for the study of the behavior of the structure subjected to the earthquake when the amount of charge is sufficiently large. In addition to blast the micro-seisms may be used for the determination of the seismic characteristics of the ground when the geological structure are known and the frequency distribution of the period of the ground caused by blast is known, because the periods of the seismic wave will be generally longer in this case which will give more exact information for the study of the vibrational behavior of the ground for the wider range of the periods.

Sometimes the behavior of the ground motion was reported to be different according to the intensity of the earthquake motion.[6),7)] In other words, the differnece of the geological formation did not affect the ground motion when it is strong enough, whereas remarkable difference was found in the case of moderate intensity. In these cases the effects of the geological structure to the seismic characteristics of the ground are very debatable. It is conceivable that the amplitudes of the stress wave observed at the ground surface will be below a certain limit determined by the strength of the material of the superficial layer when it exceeds the elastic limit of the materials.

3. Seismicity

The seismicity of the place is generally determined by the geographical distribution of the past earthquakes. The seismic activity of a district may be studied from the geological viewpoint in this way. However, the lifetimes of the structures are not so long when compared with that of geology. And hence more up-to-date seismicity is sometimes required. Recently with the progress of the study for the forerunning phenomena before earthquakes it has become sometimes possible to presume the seismic activity at the time of observations. The measurements of the crustal deformations and the observation of the microseisms are supposed to be two effective methods for this purpose. As a general concept it is considered that the district is regarded as seismic active when the crustal deformation is remarkable. From the results of observations of microseisms of the places it may be infered whether it has some bearing on a destructive earthquake so long as their relation will be clarified. As can be seen in a certain region the occurrances of earthquakes have originated in the fault directly. In these cases the microseism will be a useful indication to show the activity of the fault. As a matter of fact. these observational results of the crustal deformation and the microseim have to be considered along with the statistical study on past earthquakes. That is, the lay out of the observations should be refered to the geological study as well as

statistics of the past earthquakes so as to give more effective results.

Conclusion

Some methods to determine the seismic characteristics of the ground are discussed. These are summarized as follows.

1. The seismic characteristics of the foundation material and geological formation may be studied in more detail by use of a known disturbance origin.
2. The intensity of seismic wave has to be considered to discuss the local effects of the ground property.
3. The crustal deformation and microseism may be a useful clue for the determination of seismicity of the place.

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