RELATION BETWEEN THE FORMATION OF SOIL LAYERS AND THE VIBRATIONAL CHARACTERISTICS OF THE GROUND

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Summary

In this paper is investigated the relation between the vibrational characteristics of the ground and the formation of soil layers as has been found through the measurememt of microtremors made in the site where the ground condition is known in detail. As a result, it is ascertained that the value of predominant period of the ground has a fairly close relation to the thickness of superficial soil layer in spite of a fairly irregular formation of the ground.

1. Introduction

It has been known that microtremors of the ground can be explained fairly well by considering the multiple-reflection of shear wave in the layers, though not in all cases. Further, some recent studies*1 report that this fact may be applicable to the longer period waves of microtremors of the ground. This matter will show that the measurement of microtremors becomes much more useful for the engineering purposes. Indeed, in Japan, many number of measurements have been carried out, but not always systematically in wide areas. There are, however, a few cases in which the measurement was carried out extending over a wide area, in connection with the geological survey of the ground.

Under these circumstances, the relation between the formation of soil layers and the vibrational characteristics of the ground is investigated. The measurement of microtremors was carried out in an island (2km x 3km) located in the bay of Tokyo. In addition, a comparison is made between the vibrational characteristics of the ground at the time of earthquake and those of microtremors at an ordinary time.

2. Condition of the ground

Fig.1 illustrates the profile of the ground which was drawn basing upon the results of borings, performed at about 450 points distributed in the island. It can be seen in this figure that the superficial soil layer of which thickness ranges from about 30m to 60m is composed of sand fill and soft alluvial clay. Beneath it, a diluvial sand layer lies. The formation of soil layers shows somewhat complicated feature because of the existence of two deeply dissected valleys.

3. Measurement of microtremors

In order to investigate the vibrational characteristics of the ground, two-horizontal-component measurement (i.e., X and Y directions in Fig.2) of microtremors was carried out by means of the displacement meters at 92 points, set at an interval of 300m covering the whole area of the island. Spectrum analyses were made efficiently of the recorded waves of microtremors with the aid of a spectrum analyzer.

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4. Result of wave analysis

Spectrum curves constructed for the recorded microtremors at 92 points, mentiond above, may be classified into two types according to their patterns. In our case, the spectrum curves having a single steep peak are classified into type A, and those having multiple peaks into type B. In Fig.2, is shown the distribution of the type of spectral patterns; together with the contourlines drawn for the thickness of superficial soil layer. Also in this figure, we can see a tendency that the type-A patterns chiefly appear in the area where a thick superficial soil layer exists, while type-B patterns are seen rather in the area where this layer is comparatively thin.

Next, we shall consider the relation between the thickness of superficial soil layer and the value of predominant period of the ground. In Fig.3 (a)~(c), are shown separately the range of depth measured down to the diluvial basal layer and that of the value of predominant period determined from the spectrum curves. According to these three figures, the distribution of the predominant period may give a fair fit to that of the thickness of superficial layer, respectively, in every range.

On the other hand, Fig.4 shows the distribution of the predominant period obtained from transfer function calculated for the shear wave models of superficial layer as were made basing on the results of soil investigation etc.*2 The result agrees fairly well with that of the measurement of microtremors shown above (Fig.3).

Lastly, in Fig.5, are compared the spectrum curves which were constructed for the earthquake accelerogram (earthquake of May 16, 1976) obtained at point-J, with those for the record of microtremors at point-I. Two spectrum curves give a similar pattern to each other. This means that the vibrational characteristics of the ground at the time of an earthquake appear also in microtremors at an ordinary time, though we may not conclude only by this case.

Main results of our investigation are as follows :

1. Predominant period which appears as a peak in the spectrum curve, constructed for the recorded microtremors at every point of measurement, becomes longer as the thickness of the superficial soil layer becomes large.
2. The distribution of the value of predominant period and that of the thickness of superficial layer agree with each other.
3. Furthermore, the results obtained from transfer function calculated for the shear wave models agree with those from the measurement of microtremors.
4. Pattern of the spectrum curve constructed for the obtained earthquake accelerogram is similar to that for the record of microtremors which were obtained near the point where the earthquake observation was made.
5. It may be possible that the behavior of the ground at the time of earthquake is deducible from both the results of soil investigation and the measurement of microtremors.

Acknowledgment

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*2 Ohta,Y. and Goto,N. (1976) : Estimation of S-Wave Velocity in Terms of Characteristic Indices of Soil, BUTSURI-TANKO(Geophysical Exploration), Vol.29, No.4, pp.252-261.

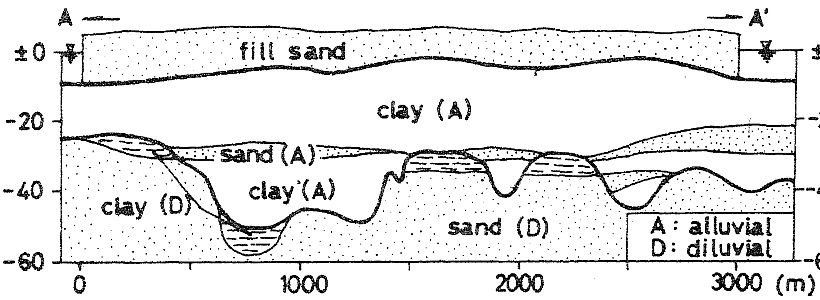


Fig.1 Geological profile A - A'.

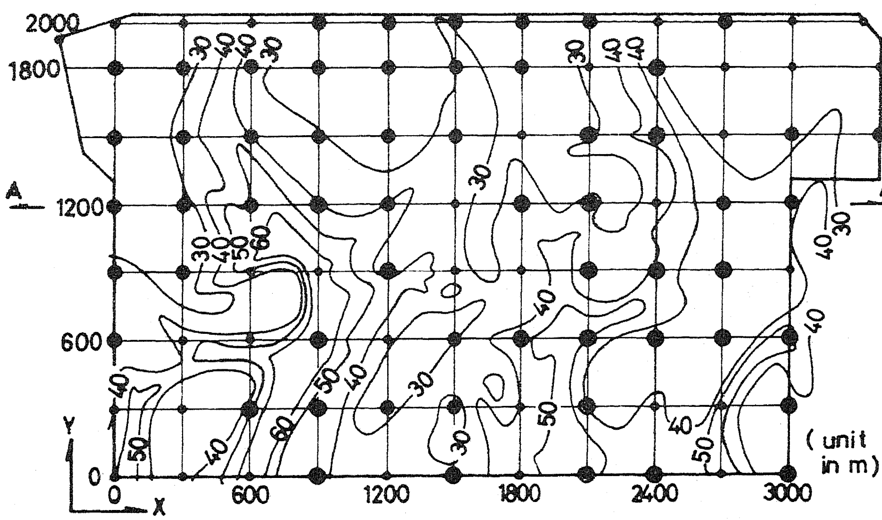
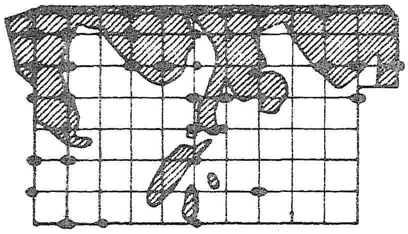
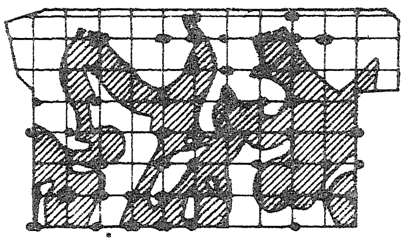


Fig.2 Location of measuring point (○) of microtremors, spectral pattern (◎:A, ●:B) and the contourlines for thickness of superficial soil layer.

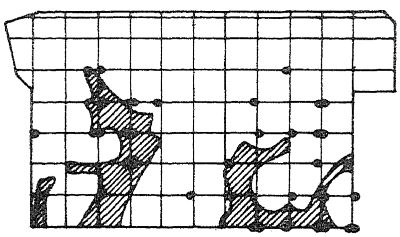
● : X direct.
o : Y direct.



(a) T ≤ 1.1sec, Z ≤ 30m



(b) 1.1 < T < 1.3sec
30m ≤ Z ≤ 45m



(c) T ≥ 1.3sec, Z ≥ 45m

Fig.3 Distributions of predominant period(T) of microtremors and thickness(Z) of superficial layer.

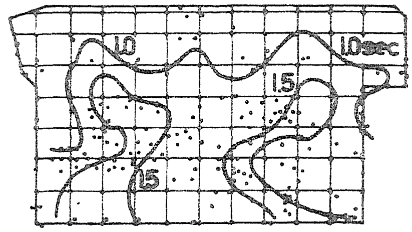
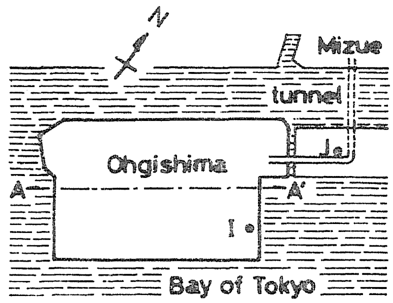


Fig.4 Contourlines for Predominant periods (1.0, 1.5 sec) obtained from transfer function.



Index map showing point I, J and profile A - A'.

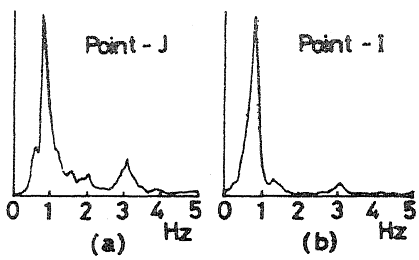


Fig.5 Power spectra: (a) earthq. of May 16,1976 ; (b) microtremors.