Microseisms and Subsoil Conditions

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Abstract

Vibration characteristics of the ground by earth tremors were studied by K. Kanai, and applied to investigation of subsoil conditions and of earthquake-proof constructions. Similar relations were found about microseisms, or long period natural earth vibrations. Amplitude distribution of microseisms will show subsoil conditions in large area.

Introduction

The ground is always vibrating. The vibrations are so small in amplitude that usually no one can feel but seismographs of high magnification record them. The earth vibrations are called variously: earth pulsations, earth tremors, microseisms, microseismic disturbances and so on. Their period of vibrations are not constant. Traffics on road cause vibrations of 0.1 sec. period, those of 0.3 sec. period are observed in the uptown of Tokyo and of 0.6 sec. period in the downtown. These vibrations which are of shorter period than microseisms are studied by Dr. K. Kanai of our institute as "earth tremors" with his electric seismograph of which self-vibration period is 1 sec. He classified subsoil conditions in four categories with frequency distribution of vibration periods and with relation between amplitude and period. The classification is suggestive for design of earthquake-proof construction as it shows a dynamic property of subsoil.

The above-mentioned vibrations are of short period. Microseisms are longer in their period, so that they may provide a knowledge of subsoil in wider area than the earth tremors.

Studies on Microseisms

Microseism in Japan was noticed by J. Milne in 1883 when he was there. Many Japanese seismologists, of course, investigated microseisms. F. Omori found three periods of microseisms at Hongō in Tokyo: $q = 2.9$ sec., $Q_1 = 4.5$ sec. and $Q_2 = 7.5$ sec. Comparison of microseisms at different places, Hongō and Hitotsubashi, was also carried out by him. Then he concluded microseisms are proper vibrations of the ground.

Concerning the origin of microseisms, relation between microseisms and typhoon or tropical cyclone was studied. And microseisms were thought as surface waves of the earth caused by sea waves generated by violent wind of typhoon.

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In Europe microseisms were formerly considered to be an effect of breaking of rough sea waves on cliffs of coast, and are propagated in the continent. Recentry Longuet-Higgins published a new theory on the origin of microseisms. The observed data that periods of microseisms is a half of those of sea swells was noticed by him, and incorporated into his theory that microseisms are generated by standing sea waves due to incident and reflected waves at coast.

Investigation of microseisms as progressive waves was made by method of tripartite observations, or observations of microseismic waves at three stations simultaneously. Tripartite observations were carried out by the writer in 1927, and similarity of wave forms at different stations was found. The observations were interruped in Japan by the World War II, but the method was developed in Germany and was applied to weather forecasting in U.S.A.. The method was resumed in Japan soon after the war.

Accuracies of this observation were checked by simultaneous observations at four stations, or a pair of tripartite nets laid in close vicinity. In other cases, moreover, tripartite observations of different component observation was carried out at one of the tripartite stations.

After these critical studies, propagation velocity of microseismic waves was obtained in Tokyo. The velocity observed was about 1000 m/sec or less. Comparing the value with those in other countries, the velocity is small, nevertheless, amplitude of microseisms is large. From these results, it is suggested that amplitude of microseisms is larger while period is longer on soft subsoil than on hard ground.

Microseisms and Subsoil Conditions in Earthquake Districts

I. Shida who studied microseisms in Yamagata Prefecture with the writer showed relative amplitude of microseisms on Shōnai Plain. In Fig. 1 lines indicate equal amplitudes relative to microseisms observed at Sakata Meteorological Station. The lines have correlation to subsurface topography, in other words, microseisms are larger the thicker the alluvial deposite at the observation sites. On sand dunes along the coast of Japan Sea, amplitude of microseisms was unexpectedly small. The amplitude distribution of microseisms is closely related to the damage of the earthquake of 1894.

Correlation of amplitude of microseisms and earthquake damage is studied also in Ogasa County, Shizuoka Prefecture, where the Tōnankai earthquake was devastating. Tripartite observations were applied to study the effects of ground on damage of the earthquake. For the observations three electric seismographs designed by the writer for recording microseisms were used. The results thereof gave the same conclusion that there exists a positive correlation between earthquake damage and amplitude of microseisms.

The study of subsoil condition by observations of microseisms is still premature, but it will be useful for earthquake engineering.

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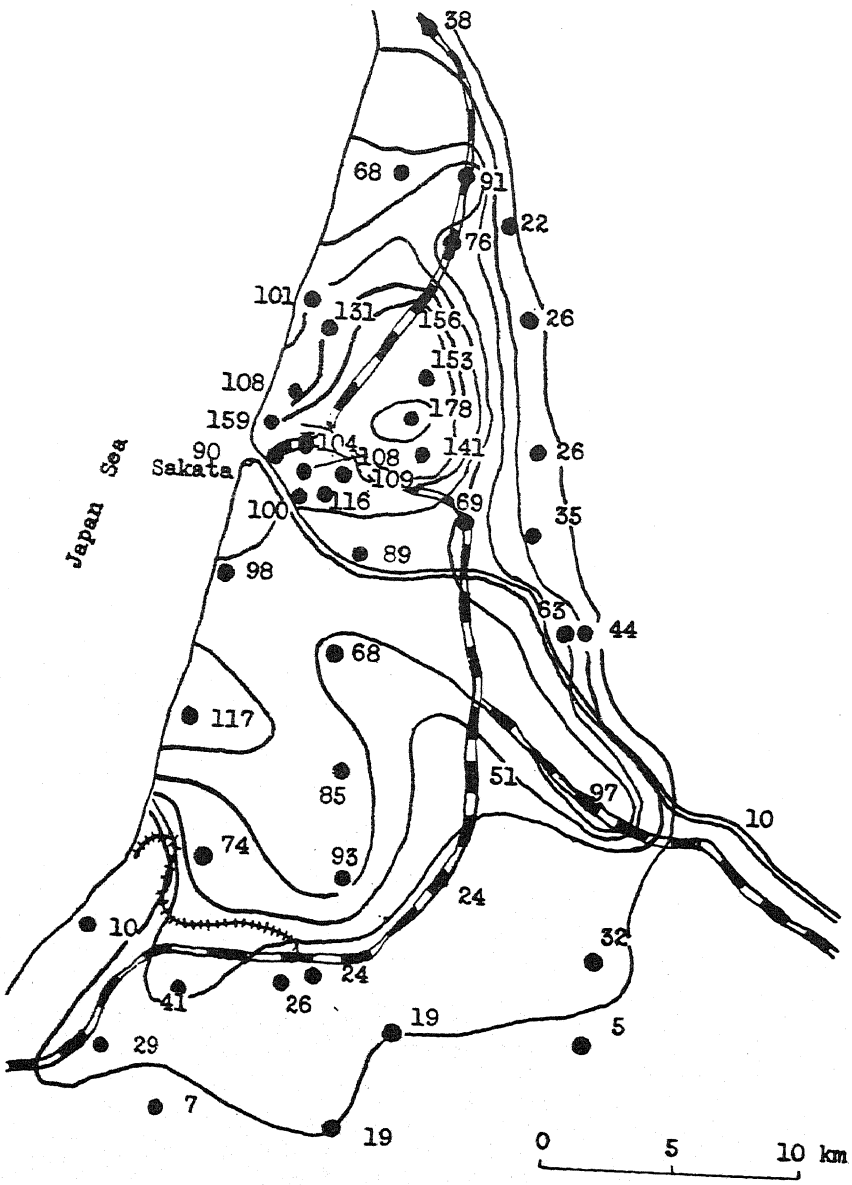

Fig. 1. Relative ampitude of microseisms in Shōnai Plain, Yamagata Prefecture.

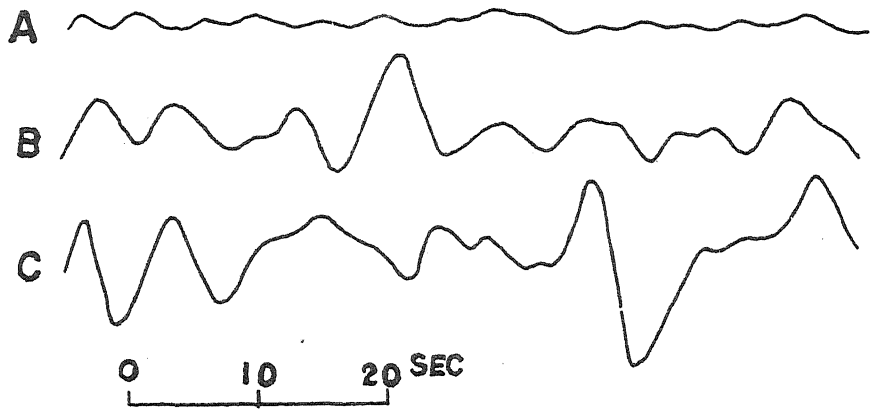

Fig. 2a. Tripartite observations at Ogasa, Shizuoka.
March 26, 1959.
Record in original size.

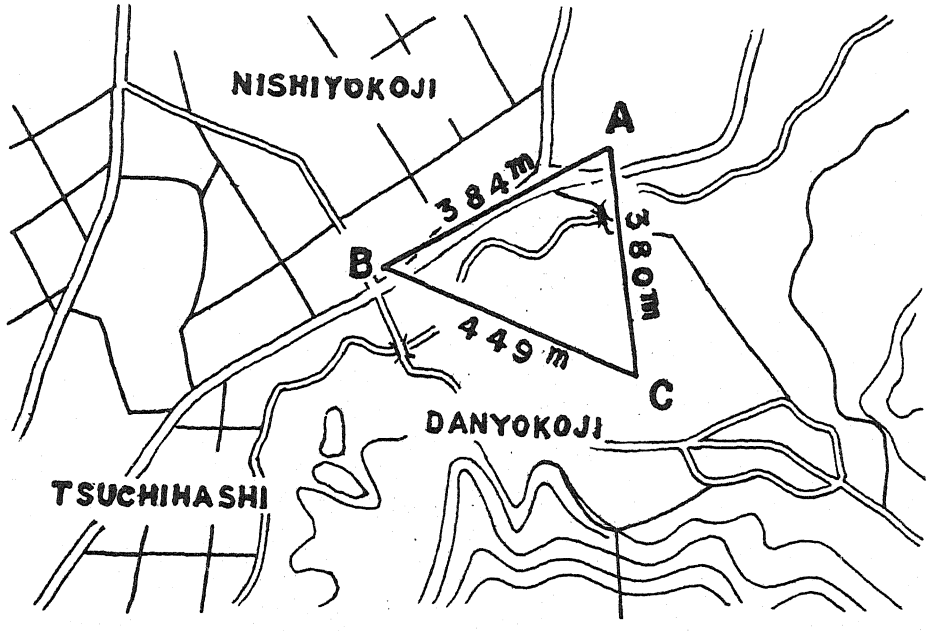

Fig. 2b. Positions of the tripartite stations recorded the above Seismograms.