A Method for Dynamic Characteristics Estimation of Subsurface using Microtremor on the Ground Surface

Yutaka NAKAMURA*, Dr. Eng.

As methods for dynamic characteristics estimation of surface layers, investigation with boring and a method which employs microtremor are well known so far. Boring investigation, one of the most accurate methods is costly and time consuming and is not available all the time. The method that employs microtremor is handy but has not produced satisfactory result to this day.

This paper describes a new processing method that employs microtremor observation yet producing accurate estimation of characteristics of the ground motion. The method uses vertical component and horizontal components.

As a result, the spectrum ratio of the horizontal components and vertical component of microtremor bears resemblance to transfer function for horizontal motion of surface layers.

1. Introduction

A survey on the earthquake damage shows that, considering seismic intensity equal, the effects on structures vary considerably: some are free from damage almost completely while others suffer heavy damage. This phenomenon occurs due to difference in the seismic response characteristics of the structures. The surface layers carrying these structures also differ substantially in the effect of earthquake due to difference in their seismic response characteristics. The effect range is specific to the structure as far as the structural characteristics are concerned. In the case of surface layers, however, the effect covers a certain spread of the area. Consequently, understanding of characteristics of surface layers may be said to be an important review item in analysis of the earthquake disasters.

In this context, the characteristics of surface layers (particularly, the seismic response characteristics of surface layers) have been investigated positively by the administrative agencies and other authorities.

Boring exploration will surely offer highly accurate data concerning the dynamic characteristics of surface layers. To understand the surface layer characteristics over a wide area, however, lots of borings must be made in high density. Boring exploration is therefore not a ready means because it demands considerable manpower and substantial time as well as tremendous cost. From this view point, a study has been extensively made on the method to estimate the dynamic characteristics of surface layers using the microtremor (readily measurable). If large structures are not to be considered, the microtremor of a frequency range of 0.5 – 20 Hz will be measured. This frequency range tends to include tremors induced artificially, but it is necessary for investigation of characteristics of surface layers that the effect of a specific source not be large. Accordingly, measurements have to be carried out during midnight (around 3:00 a.m.) when the social activities stop almost completely in order to eliminate the effect of a tremor whose source can be identified. But this procedure will substantially detract the benefit of the micro tremor (i.e., readiness for measurement).

This paper proposes a new method to estimate the dynamic characteristics of surface layers by measuring solely the microtremor of the surface. According to this method, stable estimation of the predominant frequency and amplification factor can be made even in the presence of a certain degree of artificial tremor and there is no need any more for time restriction on microtremor measurement.

2. Effect of Surface Layers on Seismic Motion

Earthquake involves release of the strain energy accumulated in the focal region and propagation of a part of the energy thus released to the surrounding. The dynamic characteristics 0 (f), f means frequency, observed at a certain point include all of the wave motion radiation characteristic F(f) at the focal region, dynamic characteristic T(f) of the wave motion propagation route up to the observation point, and dynamic characteristics S(f) of the surface layers at the observation point.

Fig. 1 shows how the difference in earthquake and observation point is reflected in the tremor waveform. The acceleration waveform for 5 seconds around the maximum value is indicated vertically and horizontally, with similar earthquakes arranged vertically and same observation points horizontally. The magnitude of earthquakes rises toward the left of the figure. Evidently, the seismic acceleration waveforms at observation points are generally quite similar without much variation between different earthquakes, though there exists a trend that a high-frequency tremor prevails when the magnitude of earthquake is small and the low-frequency tremor prevails when the magnitude is large. This means that the observed seismic waveform is similar for the same observation point (i.e., the same surface layers characteristics S(f)) even when the radiation characteristic F(f) or propagation characteristic T(f) is different. In other words, it may be said that the effect of surface

* Geotechnical Engineering & Disaster Prevention Laboratory