Application of the simple technique to estimate subsurface structure with sloped engineering bedrock to microtremor array observation records

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Regarding a long-continuous civil engineering structure such as a railway structure, the geological profile under the structure is not identical and the significant difference in geological property within the limited area possibly induce unexpected seismic behavior in the structure. To ensure the reliability in seismic safety evaluation, the ground property at an objective site should be estimated with appropriate resolution.

As one of the simple and easy techniques to estimate the representative velocity structure, the H/V spectral ratio (RH/V) is widely used, which requires only one observation point. The predominant period (TH/V) of RH/V likely indicates the resonant period of the objective ground. The representative thickness of the subsurface layer can also be identified if the shear wave velocity is known.
The technique, however, theoretically supposes that the layers are flat and spread infinite as same as most of the methods. In other words, the applicability to irregular ground, e.g. the engineering base surface is steeply sloped, is uncertain.

In recent study, Zhang et al. (2015) proposed the estimation technique using only vertical records of two observation sites. It has not only the same advantage as the H/V technique with respect to the simplicity but has the potential to extract the amplification characteristics generated by the sloped bedrock surface. The technique is based on the theory that the cross-spectral density function between two sites for each component can theoretically be shown as the function of three factors: the energy density of the waves Es, the wave number k, and IOG for the corresponding sites and components. Needless to say, the imaginary part of Green function (IOG) is closely related to the amplification characteristics of the objective site.

Using these theory, Zhang et al. focused on the power-spectral density function of respective sites A and O for the vertical component, SAA(ω) and SOO(ω), and took the ratio of them to eliminate the unknown factors Es and k. They showed the predominant period (TIOG) of the ratio of IOGs (RIOG) reflects the geological profile of the two sites by numerical study using two layered model, the layer boundary of which is linearly sloped.

However, the applicability of the technique to actual microtremor data was still unclear, because not only the subsurface structure is more complicated in actual site but observed microtremor data inevitably includes various types of noise, and these facts necessarily effect on RIOG in some way.

To confirm the applicability of the technique using RIOG to actual data, we conducted microtremor array observations over the ground surface, the bedrock surface of which is considered to being steeply sloped, and evaluated the subsurface structure using RIOG and RH/V. With respect to RIOG, we focused on the difference between TIOGs (ΔTIOG) which was calculated for the different pair of RIOG, to evaluate the relative difference in thickness of the subsurface layer between the two sites.

Although both RIOG and RH/V basically seemed to be complicated, the following states were found; It is difficult to find the corresponding peak to the engineering bedrock from RH/V and there are almost no differences between TH/Vs for different observation point. On the other hand, the ΔTIOG gradually change with the location of observation points. These results indicate the applicability of RIOG to an irregular ground.

A future work is to establish the method to estimate absolute thickness of surface layer. It is necessary to investigate the relationship between ΔTIOG and the amount of change in the depth of sloped-engineering bedrock by numerical study.

Keywords: Irregular ground, Imaginary part of Green function, estimation of velocity structure

