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H/V Spectral Ratios for Both Microtremors and Earthquake Motions and Interpretation based the Diffuse Field Theory

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Horizontal-to-vertical spectral ratios (HVRs) of microtremors have been traditionally interpreted theoretically as representing the Rayleigh wave ellipticity or just utilized a convenient tool to extract predominant periods of ground. However, based on the diffuse field theory (Sanchez-Sesma et al., 2011) microtremor H/V spectral ratios (MHVRs) correspond to the square root of the ratio of the imaginary part of horizontal displacement for a horizontally applied unit harmonic load and the imaginary part of vertical displacement for a vertically applied unit load at the same position.

The same diffuse field concept leads us to derive a simple formula for earthquake HVRs (EHVRs), that is, the ratio of the horizontal motion on the surface for a vertical incidence of S wave divided by the vertical motion on the surface for a vertical incidence of P wave with a fixed coefficient depending on the bedrock wave velocity (Kawase et al., 2011). The difference of EHVRs from MHVRs comes from the fact that primary contribution of earthquake motions would be of plane body waves. Traditionally EHVRs are interpreted as the responses of inclined SV wave incidence only for their coherent S wave portions.

Before the advent of these compact theoretical solutions, EHVRs and MHVRs are either considered to be very similar/equivalent, or totally different in the previous studies. With these theoretical solutions we need to re-focus our attention on the difference of HVRs.

To that end we have compared HVRs at several dozens of strong motion stations in Japan. When we compared observed HVRs we found that EHVRs tend to be higher in general than the MHVRs, especially in higher frequencies than their fundamental peaks. As previously reported, their general shapes share the common features. Especially their fundamental peak and trough frequencies show quite a good match to each other. However, peaks in EHVRs in the higher frequency range would not always show up in MHVRs. When we calculated theoretical HVRs separately at these target sites, we found that the underground structures that are optimized for EHVRs would not explain perfectly MHVRs.

So we invert underground structures which can explain both EHVRs and MHVRs at the same time based on the different theoretical formula. Using the hybrid heuristic algorithm primarily based on the GA method with generation-dependent probability, we successfully obtain the detailed S-wave velocity structures for these investigated sites. The proposed method using HVRs is quite robust to obtain S-wave velocity structures that can be used quantitative simulation of strong motions at the target sites.

Keywords: microtremors, strong motion, diffuse-field theory