Application of a fast calculation for full waves microtremor H/V based on diffuse field to identify underground velocity structures

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Based on Diffuse Field Approximation, the Full Waves (DFA-FW) Microtremor H/V Spectral Ratio (MHVSR) is expressed as the square root of imaginary part of the Green’ s functions in the horizontal component to that in the vertical component. The DFA-FW MHVSR evaluated with the underground velocity structures composed of PS logging data is found to be the best matching with the observed MHVSRs at some KiK-net stations, compared with the transfer function of SH waves, H/V spectral ratio of fundamental mode of Rayleigh waves (ellipticity), and H/V spectral ratio of surface waves including contributions from fundamental and higher modes of both Rayleigh and Love waves excited by distributed surface sources. Therefore, the DFA-FW MHVSR should be applied to identify the underground velocity structures at the interested sites.

However, the conventional methods, such as discrete wavenumber method and contour integration method, is very time consuming in calculating the imaginary part of the Green’ s functions. For a given layered medium, the DFA-FW MHVSR is found well approximated with only Surface Waves (DFA-SW) MHVSR of the “cap-layered medium” without fixed bottom which consists of the given layered medium and a large velocity cap layer in the deep added to the bottom of the given layered medium. Because the contribution of surface waves can be simply determined by residue theorem, the computation of DFA-SW MHVSR of cap-layered medium is significantly faster than that of DFA-FW MHVSR computed by other methods. The DFA-SW MHVSR of cap-layered medium, as a fast calculation for DFA-FW MHVSR of layered medium without cap layer, is then applied to identify the underground velocity structures above the bottom of the boreholes at KiK-net strong-motion stations.

The identified underground velocity structures between surface and bottom of boreholes were employed to evaluate DFA-FW MHVSRs which were consistent with the DFA-SW MHVSRs of corresponding cap-layered media. The earthquakes records at KiK-net stations provided the earthquake motions of H/V spectral ratios and spectral ratios of horizontal motions between surface and bottom of boreholes. The consistency between observed and theoretical spectral ratios for earthquake motions, indicated that the underground velocity structures identified from DFA-SW MHVSR of cap-layered medium were reasonable.

Keywords: microtremor H/V spectral ratio, diffuse field approximation, full waves, surface waves, cap layer, underground velocity structures

