Possibility of microtremor arrays as a device to evaluate attenuation coefficients of Rayleigh waves

*Ikuo Cho[1]

1. National Institute of Advanced Industrial Science and Technology

The Spatial AutoCorrelation (SPAC) method is the most popular method to analyze phase velocities of Rayleigh waves in microtremor array surveys. We usually assume that the incoherent noise is very small and ignorable when using the SPAC method. In fact, however, the fundamental equations of the SPAC method and the derivatives originally involve the parameters of both phase velocity and the Noise-to Signal Ratio (NSR) of the incoherent noises (Cho et al., 2006). We can regard the paring of two equations from them to be a set of equations solved for phase velocity and NSR. By solving this set of equations at each frequency, we can obtain a spectrum of phase velocity (i.e., dispersion curve) that does not include the biases coming from incoherent noises and a spectrum of NSR, e(f).

We conducted microtremor observations within the premises of the AIST, using 28 small arrays with various sizes (i.e., with radii, r, from 0.17 to 7 m). We confirmed that the spectra (2-20 Hz) of NSR, e(f), thus obtained did not vanish, albeit very small amplitudes, even in the frequency ranges where the standard SPAC method (ignoring the incoherent noises) provided with appropriate phase velocities. We found that, in these frequency ranges, the NSRs had positive correlations with array radius.

Those NSRs, correlated with the distances, likely indicate that the incoherent noises were generated with the wave propagation (i..e., intrinsic attenuation/scattering). We considered following Prieto et al. (2009) that this property could be modeled by lowering coherences due to the intrinsic attenuation: the SPAC coefficient can be expressed as exp(-a(f)*r), where a(f) is the attenuation coefficient.

Followed a simple algebra, we can show that the above attenuation coefficient, a(f), corresponds to NSR normalized by array radius, e(f)/r. Therefore, we plotted in a single graph all normalized spectra, e(f)/r, obtained from different arrays. It revealed that the all normalized spectra had similar frequency characteristics representable as a(f)=k f**N on average, where N=2 and k=0.02. Such frequency characteristics generally are similar to those obtainable based on surface wave methods.

The above analysis results indicate the possibility that we can use microtremor arrays as a device evaluating the attenuation coefficient of soil. Validations based on the surface wave methods are the future work.

Keywords: microtremor, array, analysis method, phase velocity, attenuation coefficient

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