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Estimation of variation in site amplification due to uncertainty of shallow Vs profile from microtremor exploration

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Many model parameters are involved in strong motion simulations, and some of the parameters are difficult to determine in advance for future major earthquakes. The variations of estimated ground motion have been often discussed from numerical simulations considering effects of fluctuation of the parameters for fault models. Uncertainty in subsurface structural parameters, such as S-wave velocity, also affects the variation of the ground motion characteristics. However, ground motion variation due to uncertainty of subsurface structure has not been deeply discussed. One of the reasons can be caused from a difficulty to estimate an uncertainty for the model parameters of subsurface structural model from geophysical or seismological investigations.

In this study I estimated an uncertainty of shallow S-wave velocity profiles from microtremor array explorations using Markov Chain Monte Carlo method (MCMC method in the following). The estimated uncertainty was used to know the variation of the amplification from the sampled S-wave profiles. The MCMC inversion method does not determine one model unlike to conventional inversions. It can provide models whose parameter distributions are proportional to their probability density functions. Therefore we can estimate the variation of the amplifications for soil model parameters from the sampled models with the MCMC method.

I used the results of the shallow microtremor explorations conducted in Monzen-machi in Ishikawa prefecture after the 2007 Noto Hanto earthquake (Yamanaka et al., 2008). The MCMC method by Yamanaka (2011) was applied to the Rayleigh wave phase velocity data at periods of less than 1 second from the microtremor explorations. The sampled shallow S-wave velocity models over the engineering bedrock were used to obtain an average and a standard deviation of the S-wave velocity and the thickness of the shallow soils at each site. Furthermore, 1D amplifications of S-wave were also calculated from the sampled models. The variations of the amplification factors are almost the same (about 30%) at all the periods including fundamental peak period. The average amplification factors become much smoother at short-periods than those at long-period. Since the sampled models have different peak periods for the higher mode amplifications, such higher-mode peaks and troughs are smoothed in averaging operation. I also calculated amplification for a model derived in conventional inversion of the phase velocity. The S-wave velocity model from the conventional inversion shows peaks and troughs of higher-mode in short period range. However, these peaks and troughs are not so accurate considering the uncertainty of S-wave velocity profiles from the microtremor explorations.

Keywords: amplfication, shallow soil, microtremor exploration, S-wave velocity profile, inversion, Markov chain Monte Carlo method