Joint inversion of apparent resistivity and surface-wave phase velocity for shallow soil model

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Vertical electrical survey and microtremor survey are often used for investigation of shallow subsurface structure. In these explorations, one-dimensional ground model is estimated by an inversion of Rayleigh wave phase velocity or apparent resistivity. Furthermore, a joint inversion of apparent resistivity and phase velocity has been also proposed for stable estimation of inversion as compared with inversions of individual data (Hering et al, 1995).

In general, P-wave velocity is calculated by using Vp-Vs relationships during the inversion in the microtremor survey, and therefore the same Vp-Vs relationship is used for all the layers. However, there is an unsaturated zone in which the saturation is not 100% near the surface, and it is known that an S-wave velocity is the same but P-wave velocities are different between unsaturated and saturated zones. Therefore, joint inversion method of apparent resistivity and phase velocity using different Vp-Vs relationships (Shofy, 2017) in saturation and unsaturated zones was proposed in this study.

First, the effectiveness of the proposed method was investigated by numerical experiments using synthetic observation data in a shallow soil model. Similarly to the previous study, the joint inversion can generate stably estimations of the S-wave velocity and resistivity. Furthermore, it was also confirmed that it is successful in inversions of synthetic data with noises and incomplete data expected in actual observations.

Next, this method was applied to actual observation data of apparent resistivity and Rayleigh wave phase velocity obtained by surveys at KiK-net Mashiki in Kumamoto Prefecture. The similar S-wave velocity structure to PS logging was obtained up to the depth of 20 m. Although a difference was observed with respect to the absolute value of P-wave velocity, the boundary of P-wave velocity structure was almost the same. In the future, it is necessary to carry out the proposed joint inversion using data observed at a site where the water-table depth is known to examine the effectiveness of the method.

