Surface wave dispersion of leakage modes for near-surface surveys

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Surface waves have been studied in near-surface geophysics for prospecting shallow structures in association with earthquake-strong-motion predictions and maintenance of soil structures. The methods are based on the phase-velocity dispersion curves of surface wave which reflect properties in layered media, especially S-wave velocities.

The surfaces of accommodation areas and soil structures are mostly paved or covered with compacted soils or gravels, which have higher densities and S-wave velocities than natural soils underneath the covering layers. When the wave velocity in the upper-most layer is higher than the lower layers and the wave sources exist on surface or in shallow depths, the seismic waves first propagate through the shallower parts and produce the surface waves. The situations are different from those in geophysics, where seismic waves come from the deeper sources in the Earth’ s crust, and the surface waves are formed by the waves that come from the lower-most layer that has the highest S-wave velocity.

When calculating surface-wave dispersion curves, we first assume a lower-most layer that is homogeneous and semi-infinite in the depth direction, and then assume the layered structure over the lower-most layer. Then dispersion curves are calculated for the velocities which are lower than the velocity of the lower-most layer. However, when considering the wave propagation mode in near-surface cases, we may observe surface waves consisting of the waves propagating in shallower parts of the layered structure, especially in the case when the seismic velocities of the surface-covering compacted layers are much higher than the velocities of the layers underneath. In such a case, the model assuming the highest velocity for the lower-most layer are not reasonable, but we better calculate dispersion curves for reverse cases where the seismic velocities in the lower most layer is smaller than the velocities of the surface waves.

In velocity dispersion curves, the mode in which the phase velocity is higher than the velocity of the lower-most layer is called a ‘leakage mode’. The term implies that the energy of surface waves dissipates during lateral propagation because of the propagating waves in the depth direction at the lower-most layer. The leakage modes have complex lateral wavenumbers. We assume complex wavenumbers for calculating dispersion curves of the leakage-modes. Leakage modes have been studied for two- or three-layer models where seismic velocity decreases with depth (Ryden and Lowe, 2004). We calculated for cases which have more numbers of layers underneath the overburden shallow layers. We present examples of leakage-mode calculation and would like to point out some problems related to surface-wave observations in near-surface geophysics:
Pavement effects on surface-wave dispersion curves below a frequency range 10 Hz. Dispersion curves and attenuation of leakage mode in 10-100 Hz. A relationship between appearance of higher-mode and the thickness of low velocity layer.

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