Simulation of later arrivals generated in Ashigara Valley using 3-D subsurface structure model

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Observed ground motions usually contain not only the effects of one-dimensional response but also that of secondary waves generated by irregularity of underground structure. Since the secondary generated waves in basin are frequently observed as the later arrivals that propagate off-azimuth direction, the study of variation around the basin is needed for evaluation of the basin effects. In this study, excitation and propagation characteristics of later arrivals in Ashigara Valley, Japan were examined by numerical simulation using the three-dimensional model. The valley is a small valley with about 12 km long and 5 km wide. The valley is surrounded by Hakone Volcano in the west, Tanzawa Mountains in the north and Oiso hills in the east and opened to Sagami bay in the south. The Kozu-Matsuda fault forms the eastern margin of the valley. Seismic explorations in this area revealed the underground structure that was characterized by inclined basement rock and reverse fault in the eastern margin of the valley. We simulate the ground motion from the event of October 25, 1996 occurred in the western part of Kanagawa prefecture. The magnitude was 4.7. Hypocentral depth was 23 km. The fault mechanism was reverse fault type. The significant later arrivals including the transverse component were observed in the southern part of the valley in spite of radial polarized incident wave.

The three-dimensional basin model of Ashigara Valley was made from seismic exploration results and time lags between S-arrival and the arrival of S to P converted phases observed in the basin. The structure model consists of five layers and those of S-wave velocities are 0.6 km/s, 1.5 km/s, 2.4 km/s, 3.0 km/s and 3.6 km/s from shallow to deep, respectively. Top three layers form basin and bottom two layers equivalent to the subduction of the Philippine Sea plate. In numerical simulation, a forth-order staggered grid finite difference method was used. Grid spacing is 150 m and time step is 0.005 s.

At first, vertical incident plane S-wave was used to examine the basic response of the model. The input waves were polarized in north-south or east-west direction and incident waveform was Ricker wavelet with frequency of 0.5 Hz. The basin edge in the west side and east side generated the later arrivals and these phases propagated as surface waves with low velocity. The waveforms at sediment sites have significant later arrivals in every direction in spite of polarized input motions. Parameter studies revealed that the arrival time and amplitude of later arrivals strongly depended on S-wave velocity and Qs-value of shallow layers. The characteristics of later arrivals also depended on incident angle and polarization direction of incident wave field. Next, the event of October 25, 1996 was simulated. The calculated waveforms in frequency range between 0.2 and 0.5 Hz simulate observed ground motion well and reproduce the later arrivals excitation in transverse component in southern part of the valley. However, the velocity of later phases and the duration of ground motions reproduced insufficiently. This suggests that modeling of shallow low velocity layers is needed for the simulation of basin effects.