Estimation of S-wave velocity structures in Turkey: (1) Adapazari basin

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Adapazari and its vicinity, located near the surface fault associated with the Kocaeli, Turkey, earthquake of 17 August, 1999, suffered severe damage. The damage, however, was distributed in different degree of severity within a relatively narrow area. The damage pattern suggests that not only the source rupture process but also the site characteristics influenced severity of ground motion.

Kudo et al. (2002) performed array observations of microtremors in Adapazari in September and December 1999, soon after the 17 August 1999 Kocaeli earthquake, in order to estimate the S-wave velocity structure. However, the estimated structures are not enough due to the limited array size. In September 2003, we carried out array observations of microtremors and small-scale exploration by a hammer hit for surface (Rayleigh) wave inversion, mainly at the sites where the aftershock data have been obtained. The main aim of these experiments is to estimate more detailed S-wave velocity structures.

The array observations of microtremors deployed a circular array consist of a regular triangle correspond to the circle and one in the center with several radius from 5 to 500 m at one site. We applied the SPAC method for determining the phase velocity in the frequency range from 0.3 to 10 Hz, although the frequency ranges were not the same among the sites. We also applied a conventional small-scale exploration method to use surface waves generated by hammer hits. The observations were carried out by aligning equi-spaced sensors (2 - 5 m) and a few different offsets (e.g., 6 - 50 m). We applied 1-D F-K method (MLM) for the hammer-generated surface waves and could determine the phase velocity for higher frequencies than 10 Hz. We estimated the S-wave velocity structures by surface wave inversion using the genetic algorithm (Yamanaka and Ishida, 1995).

We obtained a quite similar bedrock S-wave velocity (Vs) of 1.2 km/sec with that by Kudo et al. (2002) as well as fine low velocity layers near surface at SKR (strong-motion observation site). The bedrock having a similar velocity is found at depth of 600 m commonly at the aftershock observation sites, Babali, Hastane, (north of the railway station) and the central part of Adapazari. Those areas were heavily damaged among others. Bedrock depth is estimated at about 400 m in the southeast of SKR. In addition, a thick layer of Vs=600 m/s is commonly found at the north of the basin, while that of Vs=800 m/s is estimated at the southeast sites (e.g. Toyota). The shallowest surface layers at Babali and Hastane were 150 m/sec and 133 m/s, respectively. Both sites can be classified into a 'very soft ground'.

The ellipticity of Rayleigh waves based on the estimated velocity structures is compared with the extensive measurements of H/Vs of microtremors and the zonation of the peak periods that were carried out by Fah et al. (2003). They are well correlated in terms of peak period of H/V of microtremors.

We examined the validity of the velocity structural model using aftershock data. The bedrock input motion was estimated by removing the very shallow surface layers using the ground motion at SKR (=IMAR) from the largest aftershock, assuming 1-D wave propagation. Next, we simulated the ground motions at Babali, Hastane, and Toyota by assuming vertically incident S wave using the velocity structures obtained above. We could well reproduce the ground motion in terms of spectral amplitudes as well as time-histories.

The method employed in this study permits us to use wide frequency band of phase velocity dispersion so that we can estimate the fine velocity structure.