Comparison of strong and weak ground motion characteristics using vertical seismic array data

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Introduction: Ground motions during and after the 2007 Niigata-ken Chuetsu-oki earthquake were observed by the vertical seismic array at the Kashiwazaki-Kariwa Nuclear Power Plant of the Tokyo Electric Power Company. Using them, we estimate S-wave velocities and Q-values of layers above the deepest seismometer and make a comparison of amplification characteristics between strong and weak ground motions.

Array and Data: There are three sets of array (KK1, KK5, and KSH), each of which is composed of four or five accelerometers at different depths and the deepest one is set to 250-300m depth. The velocity structure model of each site is given by boring data. We use the records of seven events including the mainshock (M6.8) and six aftershocks (M3.2-5.8). However, some aftershocks were not recorded at some stations, and ground motions during the mainshock were only recorded at KSH.

Method: We estimate S-wave velocities and Q-values by using spectral ratios between two different depths within the array. We choose the direct S-wave part in the records and obtain the horizontal Fourier spectra. After smoothing the spectral amplitudes, the ratios of surface to underground are estimated. The spectral ratios of aftershocks are similar to each other without regard to events and therefore we take the average of them as the ratio of weak motions. Assuming the horizontally stratified layer structure and normal incidence of SH-wave, we calculate the transfer function by the Thomson-Haskell method with the effect of attenuation. We fix thickness and density of each layer according to the original boring data and the empirical relationship with P-wave velocity (Gardner *et al.*, 1974), respectively. Q-value is assumed in proportion to exponentiation of frequency. We estimate S-wave velocity and Q-value of each layer by fitting the theoretical spectral ratio to observed one using the Genetic Algorithm.

Results: Spectral ratios of aftershocks were similar to each other regardless of events. We found that S-wave velocities became lower in many layers than original values (difference of approximately 40% at a maximum) and Q-value dependency on frequency was stronger with depth. In the spectral ratio of the mainshock, its peak frequency was shifted to lower frequency and the ratio was smaller especially at high frequencies. S-wave velocities estimated from the mainshock were lower greatly in the near-surface layers. Q-values became smaller and independent of frequencies.

Conclusions: S-wave velocities estimated from aftershocks are lower in many layers than original ones. This result is consistent with interval velocity obtained from hand-reading of S-wave onset. S-wave velocities during the mainshock become considerably lower near the surface than those during the aftershocks. Aguirre and Irikura (1997) found the S-wave velocity near the surface at Kobe Port Island did not recover completely after it became lower during the mainshock of the 1995 Hyogo-ken Nanbu earthquake. We will investigate the influence like this by analyzing ground motion data before the mainshock.

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