Estimation of subsurface structure in Kashiwazaki using joint inversion of Rayleigh wave phase velocity and receiver function

Hiroaki Yamanaka[1]; Kentaro Motoki[2]

[1] TokyoTech.; [2] Built Environment, Tokyo Tech.

Heavy damage was experienced during the Chuuetsu-oki earthquake in 2007 in the Kashiwazaki city of the Niigata prefecture. A nuclear power plant in the Kariwa village of the prefecture was also damaged during the earthquake. Yamanaka et al. (2007) conducted observations of ground motion from the aftershocks for estimation of local site amplifications in the damaged area. They indicated the appearance of 1-second peaks in the amplifications in the damaged area from the aftershock records. In this study we conducted microtremor array exploration and receiver function analysis in the Kashiwazaki city to reveal subsurface structure of the deep sediments.

The array observations of microtremors were conducted at the two sites in the Kashiwazaki city. The explorations were conducted in the north and south of the Kashiwazaki railway station. Two arrays with radium of 1km and 0.3 km are deployed at the two sites using 7 vertical seismometers. It is noted that the aftershock observation sites by Yamanaka et al. (2007) are included in the arrays. Vertical microtremors were observed in the arrays during 30 to 60 minutes. Phase velocity of the microtremors was estimated at each frequency from a frequency-wave number spectral analysis of the array records. The phase velocities at periods from 0.5 to 3.5 seconds were estimated at the two sites. The phase velocity at the northern array is smaller than that at the southern array suggesting the existence of the deeper sediments beneath the northern array. Phase velocities of microtremors estimated at the Kariwa village by Goto et al. (2007) are higher than those obtained in this study. Therefore it can be suggested that the sediments in the Kashiwazaki city is thicker than that in the Kariwa village.

We next analyze the earthquake records observed at Kashiwazaki station of the K-NET to derive a receiver function. The earthquake records from moderate events with depths of shallower than 20 km and epicentral distance of less than 1000km were used in the analysis. The estimated receiver function has the maximum peak at 2.5 second. This delay time is similar to those in the large basins, such as Kanto basin (Kobayashi et al., 1995).

The strong motion station of the K-NET is located near the northern array of the microtremor exploration. Therefore, we conducted the joint inversion of the phase velocity and the receiver function to a 1D profile. The joint inversion method used is based on Kurose and Yamanaka (2006). However, the misfit function in the joint inversion is minimized using the hybrid heuristic approach by Yamanaka (2007). The parameters to be determined in the joint inversion are S-wave velocity, P-wave velocity and thickness for each layer. Density for each layer is given in advance. We assumed a 5-layers model with a basement having constant S- and P-waves velocities. The velocities of the basement are assumed to be 3km/s and 5.2 km/s in the inversion.

The S-wave velocity of the inverted profile are 0.4, 0.7, 1.3, 2.4, 3km/s. The depth to the top of the basement is about 5 km. The observed phase velocities and receiver function are well reconstructed with the theoretical ones for the inverted profile. Using the velocities of P- and S-waves, the phase velocities observed in the southern array of the microtremor exploration are inverted to a 1D profile from the phase velocity inversion to determine the thickness of each layer. The basement depth is 4.3 km. This is shallower than that for the northern array, indicating the dipping of layers toward the south.