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Microtremor exploration of S-wave velocity structure in Matsumoto basin

Hiroaki Yamanaka[1]; Tomomichi Uchiyama[2]

[1] TokyoTech.; [2] none

Large earthquake with M of 8.5 is expected to occur along the Itoigawa-Shizuoka tectonic line in the Matsumoto basin in the Nagano prefecture. Accordingly, seismic hazard estimation was conducted in the area. It is required in the hazard estimation to prepare reliable data on geological structure down to the basement. Seismic reflection surveys and strong motion observation have conducted in the Matsumoto basin. In this study, microtremor array exploration was performed in the area to reveal S-wave velocity structure of the basin. We also estimate Rayleigh wave group velocity from long-term observation of microtremors with seismic interferometry data processing.

The microtremor array explorations were conducted at 8 sites in the basin. It is noted that three sites of the explorations are near the earthquake observation stations of the K-NET and by Miyake et al. (2006). At each sites two arrays with a radius of 0.6-1.5km and 0.3-1.0 km were deployed with installing seven vertical seismometers. Small arrays with radius of 1 to 50 meters were also deployed at the three sites near the earthquake stations. Rayleigh wave phase velocity was estimated from the frequency-wavenumber spectral analysis and SPAC analysis of array records of vertical microtremores. The estimated phase velocities at the all sites show dispersive features at period range from 0.1 to 4 seconds.

The phase velocities at the all sites were inverted to one-dimensional S-wave velocity profiles using genetic inversion by Yamanaka et al. (1995). We assumed 5-to-6-layers models for the sites where the small arrays were deployed and four-layers model for the sites without the small arrays. The S-wave velocity and thickness for the layers are determined so as to fit theoretical Rayleigh wave phase velocity with the observed one. P-wave velocity is calculated using the relation between S- and P-waves velocities (Earthq. Res. Inst., 2006). The S-wave velocity of the basement is assumed to be 2.9km/s. The subsurface structures in the area are characterized by four layers having S-wave velocities of 0.4, 0.7, 1.2, and 2.9 km/s. The maximum depth to the basement of the profiles is approximately 2km. The basement exists at a depth of about 0.7km at the marginal parts of the basin. The obtained S-wave profiles are in an agreement with those of the seismic surveys.

The long-term observations of microtremors were conducted at two earthquake observation stations that are apart with 4 km. We calculated cross-correlation function of continuous vertical records during 70 days at the sites. The cross-correlation of the microtremors can be regarded as Green's function between two stations (Shariro and Campillo, 2004). Therefore group velocity of Rayleigh wave can be estimated from multiple filtering analysis of the cross-correlation. First we compared signal-to-noise ratios of the cross-correlations from records for different durations. It is conclude that recording of 25 days are required for a sufficient signal-to-noise ratio of the cross-correlation. Cross-correlations in negative and positive times correspond to Green's functions from both sides of two stations (Schnieder, 2004). The estimated cross-correlation is symmetric between negative and positive times indicating the no azimuthal dependence of propagation of Rayleigh waves. Next we analyze the cross-correlation with multiple filtering techniques to estimate group velocity between the two stations. The group velocity is dispersive at periods from 1 to 4 seconds. The theoretical Rayleigh wave group velocity for the S-wave velocity model obtained from the microtremor array explorations is coincident with the observed ones. This indicates the appropriateness of the S-wave velocity data in this study.

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