Continuous observation in travel time difference of ACROSS signal using seismic array

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Experiments using seismic array for receiving the signal by ACROSS vibrators are carried out for three months in a cross-shaped vault at Mizunami, Gifu Prefecture, Japan. ACROSS (Accurately Controlled Routinely Operated Signal System) is a system to make a monitoring with high resolution for the temporal variation in seismic velocity using precisely controlled signal, which repeats accurately. We deployed a seismic array, which consists of 15 seismometers with the spacing of 8 meters, in the vault at the distance of 2.4 km from the ACROSS source. Observation systems such as an extensometer, borehole strainmeters, borehole seismometers and water gauges are deployed near the site. These devices will enable us to find the causes of the temporal variation especially due to ground water. We continuously operated the two ACROSS sources with frequency modulation centered at 17.52 and 25.53 Hz, modulation amplitude of 2.5 Hz and modulation period of 20 seconds. In this study, we aimed to detect the temporal variation in travel time for some particular phases in a static structure.

Transfer function between the ACROSS sources and each seismometer is obtained by applying a deconvolution to the observed data with a theoretical force of the source. We evaluated a propagation direction and an apparent velocity for some particular phases in distribution of semblance value. The P and S waves were arrived at 0.7 and 1.2 seconds with apparent velocities of 4.0 [km/s] and 2.5 [km/s], which was interpreted as refracted waves from the basement layer of granite.

Temporal variation in travel time is analyzed for remarkable phases appeared in distribution of semblance value. The differences in the travel times for the phases are calculated for the records at all the calender time with reference to a particular calender time using cross-spectrum method. Waveforms obtained by the array are stacked by beamforming according to an apparent velocity of the phases to improve signal-to-noise ratio, which govern the resolution of travel time difference. We stacked the waveforms for the P and S waves, and evaluated the temporal change in the travel time for the data with 2 hour stacking. Using these high quality data, resolution of 0.5 ms was achieved in travel time difference for the S wave.