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Phase velocities of long period waves in the Tokyo bay area from the 2011 off the Pacific coast of Tohoku Earthquake

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The propagation velocities of seismic waves are important for study of ground motion characteristics and verification of underground structure model. The evaluation of the propagation velocities of long period ground motions from the records of the 2011 off the Pacific coast of Tohoku Earthquake give the knowledge to prepare for the long-period ground motions from mega thrust events of Nankai Trough. The Tokyo Electric Power Company has been carrying out seismic observation at 13 sites around the Tokyo bay using the broadband velocity type strong-motion seismographs (VSE-355G3). The ground motion during the 2011 off the Pacific coast of Tohoku Earthquake was observed at every station. A long-period (approximately 20 s) pulse wave with large amplitude is recognized in record section. This pulse wave is most clear in the up-and-down component. In addition, this pulse wave seems to propagate from the northeast direction.

We performed frequency-wave number spectrum analysis for the up-and-down motion records of six sites located at around the Kawasaki thermal power station and estimated the phase velocities and propagation directions. The phase velocity at frequency 0.04Hz and 0.05Hz are about 4.0 km/s and 3.6km/s, respectively. The waves propagate from the epicenter direction (N40E). These characteristics coincide with the propagation characteristics of the wave packets recognized in velocity waveforms. Estimated phase velocity disperses from 0.06Hz to 0.17Hz and phase velocity varies from 4.3km/s at 0.06 Hz to 3.4km/s at 0.17Hz. To examine the relation between this dispersion characteristics and underground structure, we extracted the underground structure model for the grid near the Kawasaki site from the underground structure model for trial version of the long-period ground motion prediction map 2009 and calculated phase velocities of the Rayleigh waves. The phase velocities evaluated from the observation record are faster than phase velocity of the fundamental mode and near to the velocities of first higher mode. The results of frequency-wave number analysis may be affected non-stationary wave propagation. We performed semblance analysis using a narrow-band pass filtered waveforms and evaluated the phase velocity for each time sections. The center periods of the filters are 5, 6, 7, 8, 9, 10, 12, 15, and 20 s. The time window length for analysis is 40 s. The phase velocities in period of 12, 15 and 20 s correspond to the velocities of fundamental mode. In period of 5, 6, 7, 8, 9 and 10 s, the estimated phase velocities correspond to the velocities of 1st higher mode. In addition, the comparison of the phase velocity evaluated from transverse component with the theoretical phase velocity of the Love waves show the correspondence with the 1st higher mode in period range from 5 to 10 s, also.

These results suggest that the higher mode surface waves were predominant over the fundamental mode in the long period ground motions of the Tokyo Bay area during the 2011 off the Pacific coast of Tohoku Earthquake. Since the fundamental mode surface waves show big amplitude usually, we need further examination.

Keywords: Phase Velocity, Long-period Seismic Motion, The Tokyo Bay Area, the 2011 off the Pacific coast of Tohoku Earthquake, Frequency-Wavenumber Spectrum Analysis, Semblance Analysis