Spatial Variations in Long-Period Strong Ground Motions Observed in the Tokyo Bay Area

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We found spatial variations in long-period (several seconds to around 20 s) strong ground motions observed in the Tokyo bay area. The Tokyo bay area is one of the most important sites in predicting long-period strong ground motions for the Tokyo metropolitan area, because many large oil storage tanks and high-pressure gas tanks are deployed there.

The Fire and Disaster Management Agency (FDMA) of the Japanese central government has installed velocity-type strong-motion seismographs at 18 sites within petroleum industrial complexes around Japan since January 2006. They include 6 sites in the Tokyo bay area. This observation aims at understanding detailed characteristics of long-period strong ground motions in specific petroleum industrial complexes in which large-amplitude long-period motions are predicted for future large earthquakes. We analyzed data from the FDMA stations operated in the Tokyo bay area to examine spatial variations in long-period strong ground motions.

The FDMA stations acquire data basically by the trigger-recording system, and also store continuous data for a certain period (ex. 2 months). This provides us with important data to study long-period shaking that are difficult to obtain perfectly not only by accelerographs but also by trigger-recording systems with velocity-type seismometers. The FDMA data sets include the Mw8.3 event in the Chshima (Kuril) Islands on November 15, 2006, the Mw6.8 event in Taiwan on December 26, 2006, and the Mw8.1 event in the Chshima Islands on January 13, 2007. We analyzed data sets from five far-field earthquakes with an epicentral distance over 780 km including the abovementioned events. These data sets are chosen because observed ground motions contain well-developed long-period components. The stations are located at Yokohama, Kawasaki, Ichikawa, Ichihara, Sodegaura, and Kimitsu. We calculated the envelope of the Fourier acceleration spectra from the two horizontal components for the FDMA stations and the F-net Tsukuba station, and then calculated the ratio of the envelope at the Tokyo bay sites to that at Tsukuba for each event. The F-net Tsukuba station is located on the Cretaceous granitoids and is the closest station to the Tokyo bay area of the F-net stations. We presume that it can be a reference site to evaluate amplifications.

The figure shows the average of the spectral ratios over the events. We find a big difference between the sites in the western side of the bay and in the head of the bay (Yokohama, Kawasaki, and Ichikawa) and the sites in the eastern side of the bay (Ichihara, Sodegaura, and Kimitsu). At the period range from 10 to 14 s, the spectra of the latter group are significantly larger with the maximum factor of 2 than those of the former group. This big systematic difference is not found at periods less than 10 s, although at these periods, the spectra of Ichikawa and Yokohama are generally larger and smaller compared with the rest, respectively. We also find from a closer look at periods less than 10 s that the spectra of Ichihara and Sodegaura are larger than those of Kawasaki and Kimitsu in the period range between 8 and 10 s. It would be interesting to discuss the difference in the spectral features at periods over 10 s between the eastern side and the western side of the bay with the spatial variation of depths to the bed rock with an S-wave velocity of about 3 km/s.