Generation conditions of long period ground motion in Kanto Basin

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Purpose of the study

In the Kanto Basin in Japan, the long-period ground motion with period between 3 to 10 s is strongly developed when large and shallow earthquakes occur nearby Tokyo. The cause of the long-period ground motion is explained by the seismic waves generated from the shallow earthquakes, propagating over long distances, and strongly amplified in the thick sedimentary layer of the basin. The edge of the basin is considered as a secondary seismic source to develop surface wave.
Recent studies reported that the level of the long-period ground motion was very large from the earthquakes in Niigata but is weaker from the earthquakes in Tohoku (Yuasa and Nagumo, 2012; Furumura, 2014). It is considered that various causes such as the influence of the 3-D structure of the basin, the propagation path, and the orientation of the earthquake to the Kanto Basin are involved in the generation intensity of the long-period ground motion. In order to investigate the cause of the earthquake-dependent development properties of the long-period ground motion in the Kanto Basin, we examined several possible causes based on the seismic wave propagation simulation of the 2004 Niigata Prefecture (Mw6.8) Chuetsu Earthquake (hereafter denote Chuetsu Earthquake).

Orientation of earthquake and generation of long-period ground motion

In order to evaluate the influence of the orientation of the earthquake source in the long-period ground motion generation in the Kanto Basin, we carried out a 3-D finite-difference method simulation of the seismic wave propagation using a sedimentary structure model in the area around Kanto (JIVSM; Koketsu, 2012). We examined the waveform from a set of virtual source based on the fault model of the Chuetsu Earthquake which are placed at equidistance from the Kanto Basin and the direction from northeast to southeastward. The result shows that the long-period ground motion is stronger when the source locates in the direction of the Niigata Chuetsu, and is weaker of the Tohoku. However, the difference was only about 4 times with the velocity response of the natural period of 6 s, which is insufficient to explain a large difference in observation (about 10 times; Furumra, 2014).

Radiation characteristics of surface waves from a source fault

Therefore, we investigated an another cause to examine the radiation characteristics of the surface wave from the source. Here, we conducted a set of wave propagation simulation of the Chuetsu Earthquake with modifying strikes of the source fault. As a result, the level of the long-period ground motion and the peak period of the response spectrum greatly changed with change of the fault strike, which is much larger than that of the source azimuthal effect. Also, it is confirmed that the response level of the long-period ground motion at 6 s becomes largest when the fault strike corresponds to that of the Chuetsu Earthquake (212 deg.).

“Basin-Induced Surface Wave” and “Basin-Transduced Surface Wave”

As a cause of the long-period ground motion in the basin, two different mechanisms, the “Basin-Induced Surface Wave” in which the surface waves generated by conversion from the S waves at the edge of the basin and the “Basin-Transduced Surface Wave” in which the surface waves traveling to the basin is amplified to develop other surface waves, are generally discussed (for example, Kawase and Sato, 1992; Kawase, 1993). In order to investigate the contribution of the basin-induced surface waves in the Kanto

Basin during the Chuetsu Earthquake, we examined by simulation using the model where the free surface is replacing with the rigid boundary condition in the propagation path in order to prevent the propagation of the surface wave to the basin. As a result, the amplitude of the long-period ground motion in the basin drastically decreased, and the velocity response level in the period over 3 s a are weakened to about 1/2. Therefore, it is concluded that the contribution of the basin-induced surface wave is small in generating the long-period ground motion, and is mostly occurred by the surface wave traveling into the Kanto Basin.

Summary and future works

From the above discussion, the strong long-period ground motion observed in the Kanto Basin during the Chuetsu Earthquake was due to the two facts that the surface wave was radiated strongly in the Kanto direction from the source and the surface wave propagated very efficiently to the basin through the propagation path. On the other hand, for the Tohoku earthquake, the opposite situation is conceivable, i.e., the inefficient radiation of the surface wave from the source, and strong attenuation of the surface wave in the propagation path along the Pacific Ocean to the Kanto Basin.

Keywords: long-period ground motion, Kanto Basin, surface wave

