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Characteristics of Long-period Ground Motion in the Osaka Sedimentary Basin due to the 2011 Great Tohoku Earthquake

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The 2011 great Tohoku earthquake (Mw 9.0) occurred on March 11, 2011, and the largest aftershock (Mw 7.7) occurred in the Ibaraki-oki region, adjacent to south boundary of the mainshock's source region. Long-period ground motions (2?10s) of large amplitude were observed in the Osaka sedimentary basin about 550-800km away from the source regions during both events. We collected the strong motion records in and around the Osaka basin and analyzed the long-period ground motions. The amplitude of horizontal components of the ground motion at the site-specific period is amplified at each sedimentary station and its duration is prolonged. The predominant period is around 7s in the bayside area inside the Osaka basin where the largest pSv among the stations inside the Osaka basin were observed. The pSvs at the bedrock sites surrounding the Osaka basin also have their peak values around 7s.

Then, we focus on the propagation characteristics from the source region to the Osaka basin. We compared the pSvs of 7s at the sedimentary stations in the Osaka basin with those in the Kanto basin. The maximum pSv among the Osaka basin is comparable to the maximum pSv among the Kanto basin whose fault distance is about 500km nearer than the Osaka basin. Moreover, the amplitude of observed pSvs is systematically larger than prediction from the empirical attenuation relationship by Kataoka et al. (2008) at non-sedimentary stations in the region between the Nobi and Osaka basins. The large long-period ground motions in the Osaka basin might be generated by the combination of propagation-path and basin effects.

Thus, we simulate ground motions due to the largest aftershock using the three-dimensional Finite Difference Method (GMS; Aoi and Fujiwara, 1999). The reason we use the largest aftershock is that this event has a relatively small rupture area and simple rupture process compared to the mainshock. The size of the model space is 730km (EW) x 330km (NS) x 100km (Vertical) including the source region and the Osaka basin. A three-dimensional velocity structure model based on the Japan Integrated Velocity Structure Model (Koketsu et al., 2008, 2012) is assumed. The minimum S-wave velocity is 350m/s and the grid spacing in the sedimentary layers is 200m for horizontal direction and 100m for vertical direction, respectively. The minimum effective period in this computation is 3s. We estimated a point source using the long-period ground motions (4-10s) at a station close to the source region (KiK-net CHBH14) and used it for our simulation.

We compared the synthetic and observed waveforms in the periods of 4-10s. As well as the observed ones, the amplitude of synthetic waveforms was amplified and the durations were prolonged at the sedimentary stations in the Kanto basin, the Nobi basin and the Osaka basin. The feature of the attenuation relations in the region between the Nobi basin and the Osaka basin was qualitatively reproduced. At the period of 7s, the amplitudes of synthetic waveforms were little underestimated in the Osaka basin.

Finally, we simulate the ground motion during the mainshock. The model space is 730km (EW) x 400km (NS) x 100km (Vertical). The grid interval and velocity structure model are same as those for the largest aftershock. We assume two point sources based on the two southern SMGAs of the four SMGAs estimated by Asano and Iwata (2012). As a result of the simulation, the synthetic waveforms reproduced the observed ones qualitatively. Therefore, we conclude that the large long-period ground motions in the Osaka basin during both events mainly resulted from the combination of those two SMGAs, propagation-path and basin effects.

ACKNOWLEDGEMENTS

We used strong motion data recorded by K-NET, KiK-net and F-net of NIED, CEORKA, BRI, JMA, and Osaka prefecture. GMS provided by NIED is used for the computation.