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Velocity structures and strong ground motion validation studies in the Tokyo metropolitan area

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We are carrying out integrated modeling of regional 3-D velocity structures in some Japanese metropolitan areas under the DaiDaiToku Project (Special Project for Earthquake Disaster Mitigation in Urban Areas) Theme I, in order to accurately validate or predict strong ground motions for seismic hazard analysis. Various kinds of geophysical exploration have already been conducted in sedimentary basins of these areas, but refraction, reflection and borehole surveys are too expensive to cover the whole extent of a basin. Gravity and microtremor surveys cannot measure seismic velocity directly, though they can be conducted densely and homogeneously. To resolve these inconsistencies, Afnimar, Koketsu and Nakagawa (2002) proposed to combine data from the refraction and gravity surveys and jointly inverted them assuming a relation between densities and seismic velocity. Afnimar, Koketsu and Komazawa (2003) applied this refraction/gravity joint inversion method to the 3-D velocity structure of the Kanto basin in the Tokyo metropolitan area (TMA) constructing a four-layer model (three sedimentary layers and the basement). Tanaka et al. (2005) improved the model by introducing new data from reflection surveys by the DaiDaiToku project and integrating the results of microtremor surveys (e.g., Yamanaka and Yamada, 2002). Tanaka, Miyake and Koketsu (2006) further improved the model for the strong ground motion validation of a subduction-zone earthquake by introducing the structures of the crust and subducting Philippine Sea plate.

Since this sort of exploration-based model may not be good for the simulation of actual earthquake ground motions in some situation, we further adjusted the velocity structure by using records of 27 earthquakes observed at K-NET stations in the TMA. We calculated the spectral ratios of radial and vertical motions in the surface wave portions (R/V spectra). The structure model was adjusted in such a way that the theoretical R/V spectra for the Rayleigh waves got closer to the observed R/V spectra (Suzuki et al., 2005). The inverse method of Tanimoto and Alvizuri (2006) is also being applied to this dataset. We will finally tune up the adjusted model by carrying out inversions of observed waveforms from medium-size earthquakes for the 2-D structures along profiles between observation stations and hypocenters. This 2-D waveform tuning has already been applied to the Sendai basin (Hikima and Koketsu, 2007) and the Chuetsu region, and its validity was confirmed by comparing observed and synthetic seismograms for the 2003 Miyagi-ken Hokubu and 2004 Chuetsu earthquakes.

We performed long-period ground motion simulation in the obtained 3-D velocity structure model, and carried out the strong ground motion validation for the 1923 Kanto earthquake (Miyake et al., 2006) and the strong ground motion prediction for the hypothetical Tokai earthquake (Miyake et al., 2007). We will briefly show the results of these validation and prediction in our presentation. As various research institutions were motivated to construct velocity structure models for earthquake disaster mitigation, we will also present the comparison of those models with ours. The Earthquake Research Committee of the Headquarters for Earthquake Research Promotion established the Task Group for Velocity Structure Model under the Subcommittee for Evaluation of Strong Ground Motion considering the importance of velocity structure models for strong ground motion prediction in 2005. They began to construct the velocity structure models across Japan and proposed the standard procedure of modeling by organizing the methods used in the Tokyo metropolitan area (Koketsu, Miyake and Tanaka, 2006).