

An effective model of a sedimentary-layer structure to evaluate broad-band strong ground motions

Ikuo Cho[1]; Tomotaka Iwata[2]; Masato Tsurugi[1]; Takao Kagawa[1]

[1] G.R.I.; [2] DPRI, Kyoto Univ.

The site-amplification spectra (0.5-10Hz) obtained at seismic observation stations in the Osaka sedimentary basin (Tsurugi et al., 1997, 2002; Iwata et al., 2004) were inverted to obtain S-wave velocity in each layer of one-dimensional velocity structure at each site. The theoretical site-amplification spectra were calculated by one-dimensional S-wave theory. The quality factors were assumed to be constant and depth dependant.

Setting the thickness of each layer in a velocity structure very fine over the depths, from surface to the depth of seismic basement, we took a Bayesian approach where a priori model distribution of velocity structure is given. A combined model of a shallow model made of PS logging data and a deep model of Kagawa et al. (2003), which we call a deep three-layer model because it consists of three homogeneous layers, was regarded as a priori distribution. ABIC was used to determine the variance of (weight on) the a priori distribution. The inverted models commonly have the following characteristics. 1) The S-wave velocity in each layer is well resolved in shallow regions, while those in deep regions are strongly correlated with each other (from the total variance matrixes). 2) The effects of a single layer in a deep portion is rather small as compared with those in a shallow region. 3) The highly-contrasted velocity structure of deep model given a priori is iteratively modified into a smooth gradient structure by the inversion procedure. The results 1) and 2) suggest the validity of our modeling where a detailed-shallow and averaged-deep structure is combined. 3) is caused by the fact that the highly-contrasted deep structure inherently produce some nodes (negative peaks) in low frequency ranges, but no negative peaks are found in the empirical site-amplification spectra.

Based on the above results, we apply a simple modification to the deep three-layer model. The discontinuous, step-like plot of velocity .vs. depth in deep three-layer model is replaced by continuous sequential line plot. When translating a model, we give an appropriate adjustment of S-wave velocity to the deep model so that the vertical travel time of S wave does not change. The following is an examination on the fundamental effects of this modification on the theoretical evaluation of strong ground motions.

Site-amplification spectra: We confirmed that the negative peaks in low frequency ranges are removed by the use of modified model. The model modification does not have considerable influences on the other spectral characteristics.

Envelopes of response waveform: We analyzed the effects of model modification on the complex envelope of response waveform to the vertical incidence of impulsive S wave. The envelope corresponding to the modified model tends to decrease monotonically with time, but that corresponding to the three-layer model tends to have characteristic perturbations due to highly-contrasted velocity structure. We need further examination based on observed records.

Surface waves: The deep three-layer model used in this study is mainly constructed based on the data provided from explorations using microtremors. Thus, this model is the one explaining well the phase velocities of fundamental mode of Rayleigh wave. We compared between these models in a view point of the following surface wave characteristics: the phase velocities, group velocities, transfer functions (medium response/(wavenumber)²), and eigenfunctions of fundamental and 1st higher modes of Rayleigh and Love waves. It reveals that the difference between these models revealed to be small. The consistency in high frequency ranges is due to the fact that we use same shallow model in both models, while the consistency in low frequency ranges come from the conservation of travel time of S wave. We can say that the characteristics of surface waves that the deep three-layer model has are well conserved and taken over by the modified model.