

Numerical study about attenuation relations of ground motion in layered medium

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Uetake and Kudo (2003) evaluated the site effects of thirty strong motion observation stations by a spectral inversion method [e.g. Iwata and Irikura (1986)] using nine small or middle class earthquakes ($M=3.8-5.3$, Hypocenter depth =13-23km) occurring near Ashigara Valley, Japan. The Q value (for $V_s=3.5$) obtained at the same time is $20 \cdot f$ (f: frequency) in the range of 1-15Hz. This value is small in comparison with results for deep earthquakes of the Tohoku district or southern part and Kanto area, Japan [e.g. Kato et al.(1998)]. Uetake and Kudo (2003) used geometrical spreading factor of $1/r$ (hypocenter distance) in inversion analysis. There is a relationship of the trade-off between the Q value and geometrical spreading factors. To evaluate the geometrical spreading factor in layered medium, numerical experiment was done using layered ground model.

A layered structure model was made after Higashi and Kudo (1992). Their model was estimated for Ashigara Valley area. Model velocities are $V_s=1.5$ km/s (H (thickness)=0.8km), $V_s=2.4$ km/s (H=2km), $V_s=2.8$ km/s (H=10km), $V_s=3.6$ km/s from the top respectively. The layer of $V_s=1.5$ km/s is equivalent to that of reference site of inversion analysis. The method of Hisada (1995) was used for the numerical waveform calculation. Ricker wavelet with period of 2 seconds was given to the y direction of the source and amplitude of waveforms at the observation points lined up on the ground surface in the x direction was investigated. The Hypocenter depth was used in two case of 20 km and 25 km referring to the hypocenter depth of the earthquakes used in inversion analysis. Inclination of attenuation relation of maximum ground motions obtained by calculation is bigger than 1, and the average inclination for hypocenter distance from 20 to 60km is about 1.5.

If we assumed inclination of geometrical spreading factor as 1.5 in inversion analysis, Q value was obtained as $50 \cdot f$. However, the spectra of the calculation waveforms show complex characteristics for the distance change by the influence of the multi-path reflection.

Next, to study the effects of the lower layer from the hypocenter, a layer with $V_s=4.0$ km/s was attached to under the model and an attenuation characteristics of maximum amplitude was examined. Two case of calculation was done for 10km and 20km of the thickness of $V_s=3.6$ km/s layer. The Hypocenter depth was set at 20km. The influence of the reflection from the $V_s=4.0$ km/s layer appear at about epicenter distance of 50km in case of layer thickness 10km and amplitude of the wave is larger than that of without $V_s=4.0$ km/s layer. It is unchanged to about 100 km in case of 20km.

Above results show that it is difficult to evaluate accurate Q value without sufficient information of underground structure.