Appropriate Q value model in the Kanto region for simulating long-period ground motion

*Takahiro Maeda[1], Nobuyuki Morikawa[1], Asako Iwaki[1], Hiroyuki Fujiwara[1]

1. National Research Institute for Earth Science and Disaster Resilience

In this study, we investigate an appropriate Q-value model in the Kanto region for evaluating the ground motion on the engineering bedrock that has S-wave velocity of about 350 m/s by comparing the simulated ground motion with the observed data.

We use the ground-motion simulator (GMS; Aoi et al., 2004) which is a practical tool for seismic wave propagation simulation based on 3D finite difference method with fourth order of accuracy in space and second order in time using discontinuous grids. In the GMS, a method to introduce an anelastic attenuation effect easily in the time domain proposed by Graves (1996) is adopted. In this method, an attenuation function for S wave, $a(x,y,z)=\exp(-\pi f_0 \Delta t/Q_S(x,y,z))$, where Q_S is the spatially variable Q value for S wave, f_0 is the reference frequency and Δt is a time interval, is multiplied to the velocity and stress fields at each time step to introduce the anelastic attenuation. Since the Graves' s method is widely used, we examine the suitable Q value for applying the Graves' s method.

The velocity structure model used in this study is a shallow-deep integrated velocity structure model constructed in the Kanto region by integrating shallow structure (Vs < 350m/s) and deep structure. This velocity structure model was verified by comparing the observed and simulated ground motions of M4-5 earthquakes (Maeda et al., 2015, SSJ). In this verification, emphasis is placed on the reproduction of the periodic characteristics of the ground motion caused by the subsurface structure, and thus a goodness of fit between the observed and simulated ground motion is evaluated in the periodic domain using the Fourier spectral ratio. In the evaluation of the degree of fit, referring to the criteria of the SCEC broadband platform validation exercise (Goulet et al., 2015; Dreger et al., 2015), it is judged that the goodness of fit is high when the spectral ratio is within the range of 1/1.4 to 1.4, while the fit is low when the ratio is 1/2 or less, or 2 or more. Averages of spectral ratios calculated from all the data of 5 earthquakes recorded at 197 observation points and averaged spectral ratio at each observation point are within the range of 1/1.4 to 1.4 in the period range of 2 to 10 second. The verification shows that the shallow-deep integrated velocity structure model has been confirmed to be a highly descriptive model of the observed data. However, the period dependence that the amplitude of the simulated spectra is larger than that of the observed one at the shorter period range is recognized, suggesting the possibility of improving the goodness of fit by changing Q value. Therefore, we set up several Q value models to investigate whether the goodness of fit is improved.

In past studies, the Q value model in which $Q_0(=Q_S)$ is proportional to S-wave velocity as $Q_0=\alpha V_S$ (the unit of V_S is m/s) is adopted. For example, $\alpha=0.2$ is assumed in the Japan Integrated Velocity Structure Model (Koketsu et al., 2008; Earthquake Research Committee, 2012). In this study, we use the Q value model proportional to the S-wave velocity and assume that $\alpha=0.1$, 0.2, 0.5, 1.0, and the reference period ($T_0=1/f_0$) is 3 s. Among them, the setting of $\alpha=0.2$ is the same setting as the above verification. Qualitatively, as α decreases, the effect of attenuation due to Q value increases, so the amplitude of the simulated spectra decreases. As a result of investigating the change of averaged spectral ratio of all the data, the change in α is affecting spectral ratio particularly at the shorter period range and thus it is confirmed that the goodness of fit is improve by setting $\alpha=0.1$. In addition, the average value of the

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spectral ratio for each observation point also tended to be close to 1 when $\alpha = 0.1$.
Furthermore, in addition to the study in the frequency domain above, we also study in the time domain focusing on the duration. Comparing the envelope shapes of the velocity waveforms of observed and simulated records, it is possible to roughly explain the decay characteristics of observed data using the Q value model set in this study. However, since the data length of the observed data is not enough, consideration of an appropriate α in the time domain is a future task.

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