Determination of an empirical attenuation relation reflecting average characteristics of strong ground motion: Part 2

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Attenuation relations derived from observed earthquake motions are an empirical method to predict the strong motion. Since the relation is reflecting actual characteristics of the records and simple to estimate, local governments are evaluating future earthquake damage, as well as the relation is practically used seismic hazard maps by the Earthquake Research Committee of the national government.

The committee is evaluating strong ground motions for the probabilistic seismic hazard map and the seismic shaking map for specified seismic source fault using attenuation relations by Si and Midorikawa (1999). These relations are for the peak ground acceleration (PGA) and the peak ground velocity (PGV), further a seismic intensity can be evaluated from the PGV, therefore, the committee published only maps for these index. However, the response spectra are required for engineering use (ex. structural designs). Annaka et al. (1997) and Kobayashi and Midorikawa (1982) had developed the attenuation relations of the response spectra but extensive data are observed after them and naturally the recent data is not reflected to their results.

Improvement of the recent observation network is remarkable and not only peak values or the intensity, but also accurate digital seismic waveforms are accumulated. We found that some unexpectable seismic motions exist in the recent observation database. In order to improve accuracy, parameters such as source mechanism, regional feature, and the site amplification are introduced in the newly attenuation relation models corresponding to the irregular data. However, it is very difficult to determine a suitable equation because of the deviation of data and dependency among parameters.

We proposed a new attenuation relation model consisted of necessary and minimum parameters, and some additional correction terms (ACT) for the accuracy. Outputs of the equation shall be not only PGA and PGV but also acceleration response spectra. First, we collect the extensive seismic waveform data as possible as we can, and build the database. Then we determined a new attenuation relation as a standard, reflecting average characteristics of the earthquake motion with minimum parameters: magnitude of earthquake (M), shortest distance from seismic fault plane (X), and seismic focal depth. Regression models are followings,

log A = aM + bX - log (X + d10**eM) + c   (Shallow Events)

log A = aM + bX - log X + c   (Deep Events)

where A is PGA, PGV, or spectral acceleration, a, b, c, d, and e are regression coefficients, respectively. Site effects, regional features (ex. anomalous seismic intensity), and characteristics of seismic source such as stress drop are considered with ACT.

In Kanno et al. (2003), we announced our basic policy in development of the new equation, and presented a standard equation of PGA for shallow events. Since selection of data was not fully completed in the previous, we inspect the deviation for individual events with the average attenuation relation in this study. Most residuals of PGA are less than the standard residual, however, we found out that several are beyond twice of the standard deviation. Especially, PGA of volcanic earthquake is remarkably smaller than the average. We found that the most of records vary within the standard residual, nevertheless extremely large residual for one or several records in one specific event. Those irregular records may be due to trouble of instruments or the other factor, therefore we eliminated them from our database. As well as, we will present about attenuation relations for shallow and depth events, respectively. Furthermore, ACT for site effects, the anomalous seismic intensity and stress drop are also inspected comparing with the standard attenuation relation. Finally, by the comparison with past attenuation relations and the observed strong ground motions, we verify accuracy of the new equation in this study.