Determination of an empirical attenuation relation reflecting average characteristics of strong ground motion: Part 4

Tatsuo Kanno[1]; Akira Narita[2]; Nobuyuki Morikawa[3]; Hiroyuki Fujiwara[3]; Yoshimitsu Fukushima[4]

[1] Hiroshima Univ.; [2] MSS; [3] NIED; [4] Inst. Tech., Shimizu Corp.

Since simple empirical attenuation relations are required for seismic hazard assessments in Japan, we determined attenuation relations for PGA, PGV and acceleration response spectrum with only a few parameters such as moment magnitude (Mw), distance, focal depth (D) and site geology. However, it was very difficult to determine a suitable equation due to dispersions of data and dependency among the model parameters. Therefore, we defined following two simple attenuation equation models for shallower and deeper events than 30 km, respectively.

log A = a1 Mw + b1 X – log(X + d1*10^0.5Mw) + c1 (shallow events) Eq(1)

log A = a2 Mw + b2 X – log(X) + c2 (deep events) Eq(2)

where A is the PGA (cm/sec/sec), the PGV (cm/sec), or the 5% damped acceleration response spectra (cm/sec/sec), and a1, b1, c1, d1, a2, b2, and c2 are the regression coefficients. Eq(2) was reduced the near-source saturation term (d1*10^0.5Mw) from Eq(1), which may not effective to far distance. Then we introduced correction functions for the site geology and anomalous seismic intensity in northeast Japan in order to improve standard error, although we can expect other effective parameters such as source types, fault mechanisms etc.

Geological site correction function was determined with average Vs from surface to 30m depth (AVS30) in our previous study (Kanno et al., 2004) as follow:

log(obs/pre) = p log(AVS30) + q Eq(3)

where, log(obs/pre) is correction terms that the residual between the observed amplitude of PGA, PGV and spectral acceleration (obs) and the prediction value (pre) by the standard attenuation relations in this study. Coefficients p and q are the regression coefficients.

On the other hand, Morikawa et al. (2003) indicated remarkable improvement of an empirical prediction by correction of the anomalous seismic intensity in northeast Japan. We extended this correction to our models, which may be corresponding to high Q of subduction zone. Morikawa et al. (2003) used a distance from the Kuril, Japan and Izu-Bonin trenches as a parameter. However, geographical feature of the trenches and volcanic front seems parallel in this region. Therefore, we used distance from the volcanic front, which is closer than the trench. The model function is shown as follow:

log(obs/pre) = a (Xvf - b) (D - 30) Eq(4)

where Xvf is the distance from observation point to volcanic front, a and b are regression coefficients.

Residuals between observed and predicted amplitude by our attenuation relations were inspected with the parameters. For an example, the PGA and the PGV versus the residual were shown in Figure. Improvements of standard error for PGA by corrections of the anomalous seismic intensity and for PGV by corrections of site geology are considerable. Further, amplitude dependence might be seen slightly, which was clearly indicated by Midorikawa and Ohtake (2003), although they indicated in linear scale of the amplitude.

References:

Midorikawa, S., and Y. Ohtake (2003). Empirical Analysis of Variance of Ground Motion Intensity in Attenuation Relationships, J. Japan Association for Earthq. Eng., Vol. 3[1], pp.59-70.

Morikawa N., et al. (2003). Additional Correction Terms for Attenuation Relations Corresponding to the Anomalous Seismic Intensity in Northeast Japan, J. Japan Association for Earthq. Eng., Vol. 3[4], pp.14-26.

Kanno, T., et al. (2004). Determination of an empirical attenuation relation reflecting average characteristics of strong ground motion Part 3: Additional Correction Terms Corresponding to Site Effects, Abstracts of the Seism. Soc. Japan, fall meeting, P072.

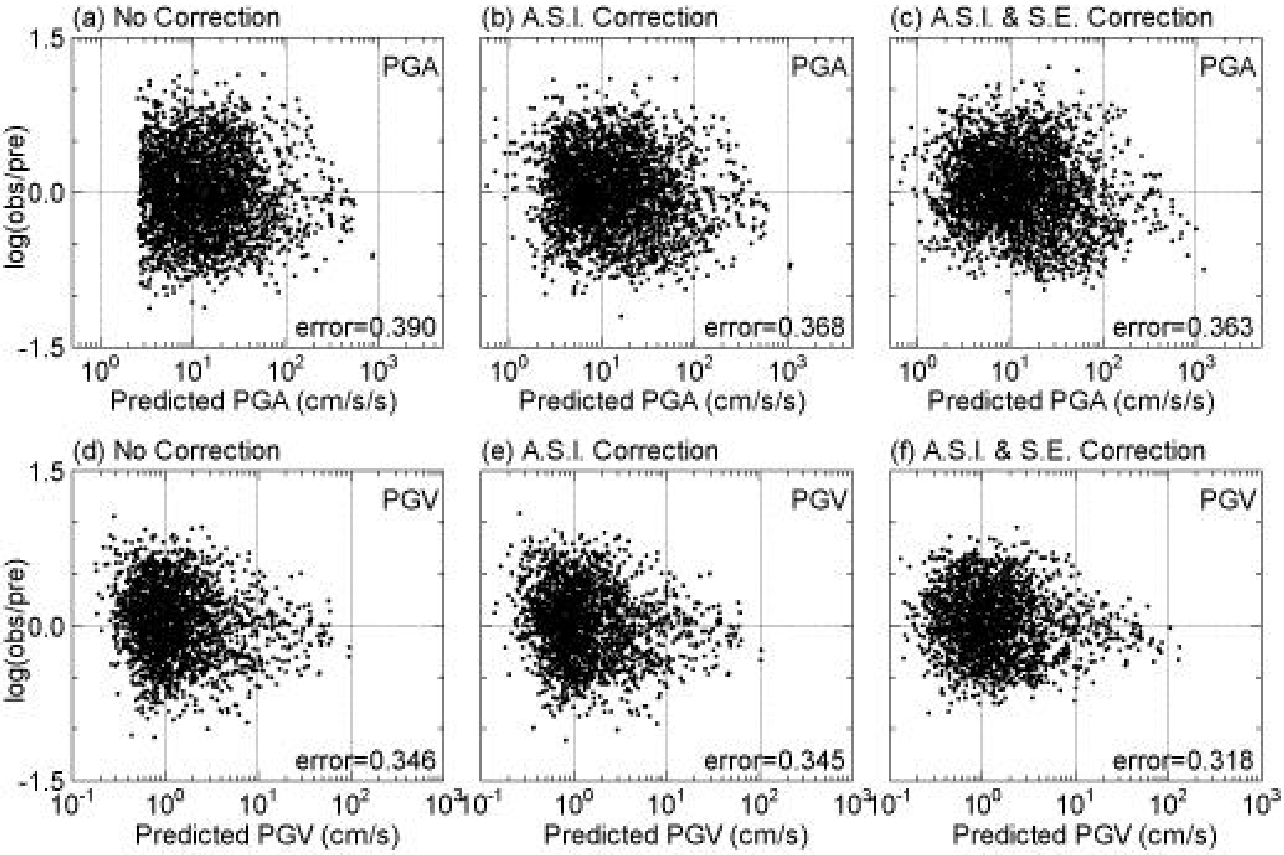

Figure Predicted amplitude versus residuals between observed and predicted amplitude. (a), (b) and (c) for the PGA, (d), (e), and (f) for the PGV. (a) and (d) without any correction, (b) and (e) corrected by site geology, (c) and (f) both corrections by the site geology and anomalous seismic intensity in northeast Japan.