Prediction of strong earthquake ground motion using empirical attenuation relations in regions with limited seismic observation

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1. Introduction

Estimating strong earthquake ground motions is very important for mitigating the damage and loss of lives caused by earthquake. Estimation can be made using various ways from theoretical to empirical methods. If all necessary physical parameters could be provided, the precise strong motion synthesize would be available. However, acquiring of the parameters entails considerable efforts. Alternatively, an empirical estimation can be made from the attenuation relation determined by regression analysis for the actual observed data of strong seismic motion.

The minimum parameters of the relation are magnitude and distance. The geological site condition is an additional key parameter. Further, the source mechanisms and regional characteristics will reduce epistemic uncertainty in the estimation. The simple formulation with these parameters provides a very useful attenuation relation for assessing seismic hazards

2. Determining the attenuation relation in a region with a limited observation network

Developing an attenuation relation requires a database of strong motions. Other than the K- and Kik-net of the National Research Institute for Earth Science and Disaster Prevention (NIED), Japan, most of Asian region does not have a comprehensive observation system for the strong motion. The database of strong motions in west Eurasia was recently enhanced with data from the 1995 Hyogo-ken Nanbu, Japan earthquake and other regions with identical compressional tectonic regimes. Fukushima *et al*. (2003) used this enhanced database to develop an attenuation relation for the region. Fig. 1 is a comparison of the Peak Ground Acceleration (PGA) predicted by the attenuation relation and the PGA of the enhance database. Fig. 2 shows the ratio between the observed PGA and the PGA predicted by the relation.

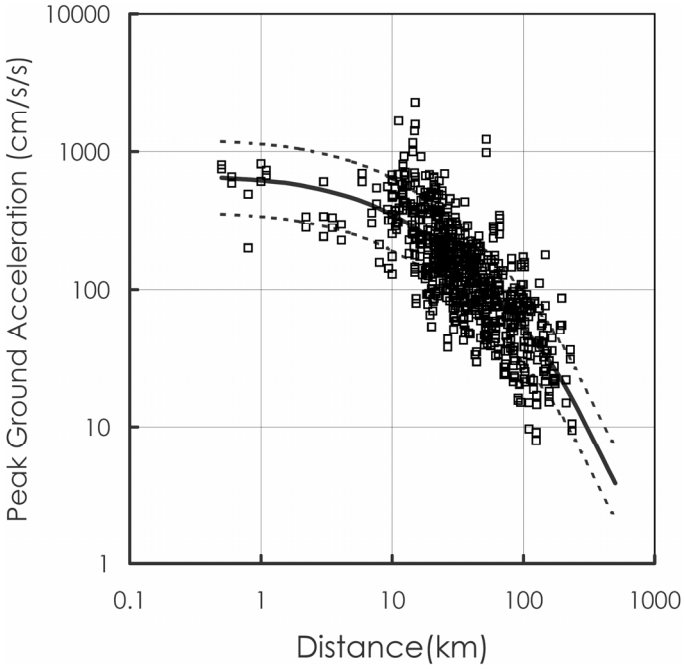

Fig.1 Comparison of the PGA predicted by an attenuation relation (Fukushima et al., 2003) and the observed PGA. Observed data points are normalized to M7.0 and identical soil site conditions. The prediction and the standard error are indicated by solid and dotted lines, respectively.

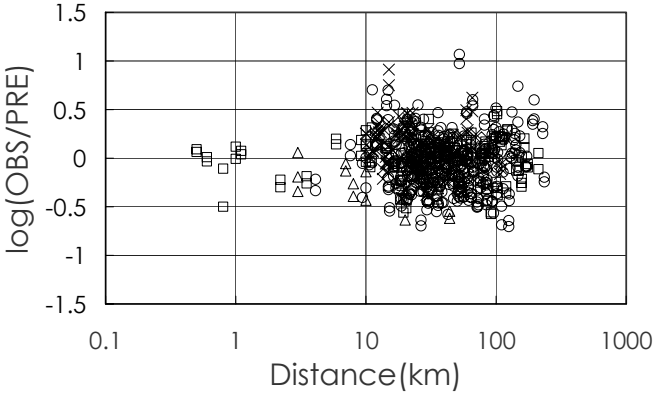

Fig.2 Ratio between the predicted and observed PGAs as a function of distance. Squares, crosses, circles and triangles indicate data for the Hyogo-ken Nanbu , U.S., west Eurasia and Kocaeli regions, respectively.

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Although the data observed in different regions, no significant bias was detected.

This indicates the possibility that attenuation relations can be developed for other regions of Asia, even for regions where the strong motion observation network is limited. By incorporating strong motion data from other regions having the same tectonic regime, the database may have sufficient data for a statistical analysis.

3. Comparison between predicted and observed ground motions

By itself, the attenuation relation is too simple to express physical motion. Therefore, after destructive earthquakes, the observed record should be compared with the motion predicted by the attenuation relation. For example, Fukushima *et al*. (2000, 2002) compared the PGAs predicted by attenuation relations to the observed PGAs from the 1995 Hyogo-ken Nanbu and the 1999 Kocaeli (Turkey) earthquakes, and the predicted PGAs agreed fairly well with the observed PGAs.

Although the database used by Fukushima *et al*. (2003) contained little data from Iran, the PGAs predicted by the attenuation relation compared with the observed PGA for the 2003 Bam, Iran earthquake as shown in Fig. 3. The observed data agreed fairly well with the PGA predicted by the attenuation relation. This kind of comparison will improve the reliability of attenuation relations and help reduce the damage and loss of lives from future earthquakes.

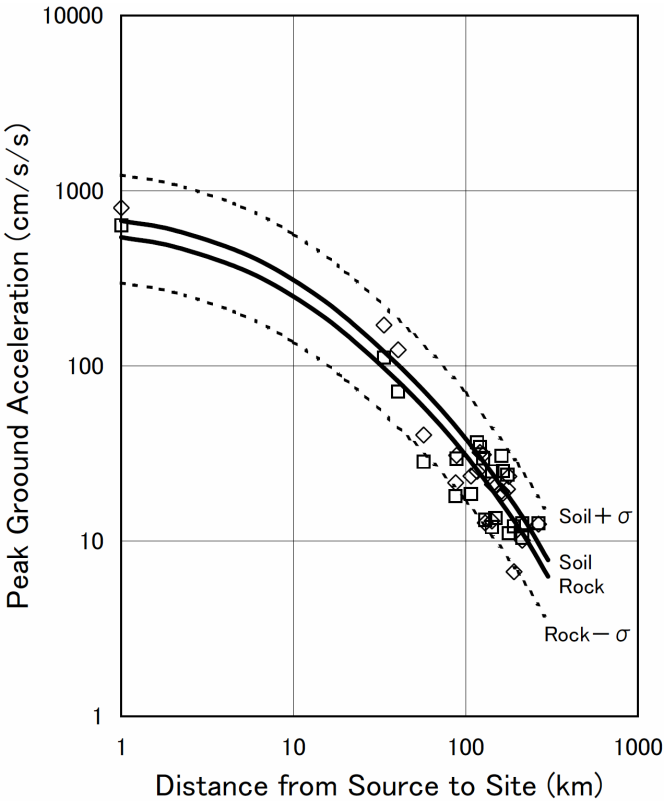

Fig.3 Comparison of PGA predicted by Fukushima et al. (2003) and observed PGA from the 2003 Bam, Iran earthquake. The distance of Bam site (1km) came from personal communication with Dr. Zare, IIEES, Iran, otherwise from Yagi model: (http://iisee.kenken.go.jp/staff/yagi/eq/Iran20031226/IRAN20031226.htm).

4. Conclusion

Attenuation relations applicable to individual region in Asia could be determined by applying data from other regions with an identical tectonic regime. After a large earthquake, particularly one that has been especially destructive, the derived attenuation relation should be confirmed by comparing it with the observed strong motion data. It is clear that this kind of comparison will contribute precise strong motion estimates and mitigate the impact of future earthquakes.

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