第Ⅰ部門

Development of Prediction Equation on Long Period Ground Motion for Earthquake Early Warning in Bangkok

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1. INTRODUCTION

Long Period Ground Motions (LPGM) can cause great damage to high-rise buildings locate far away from the earthquake source. In this study, Ground Motion Prediction Equation (GMPE) for Absolute Velocity Response Spectra (AVRS) is constructed as it gives full expression of indoor situation of high-rise buildings compared with other strong-motion indices. GMPE for AVRS is constructed with primary aim for providing Earthquake Early Warning (EEW) of LPGM in Bangkok city with period band of 0.1 to 10 s. However, due to lack of observation data in Bangkok city, regression analysis is done by applying data observed in Japan to check the applicability to situation in Bangkok. In addition to that, an estimation equation is proposed in this study to calculate AVRS for Bangkok when observation data is unavailable.

2. DATA COLLECTION

Acceleration time histories in three directions (NS, EW and UD direction) are collected from 6 earthquakes of M_w 5.1 or greater from November 22, 2016 to March 13, 2020 at 950 JMA observation sites in total. High-pass filter is applied in this study in calculation of velocity time histories to remove low-frequency parts of the record contaminated by long-period noise. Soil condition is examined by V_{S30} values by finding the nearest K-NET and KiK-net stations which is classified as stiff and dense soil.

3. REGRESSION MODEL

The model in this study is based on Dhakal et al. (2015)[1] shown in Eq. (1). Two-stage regression analysis of data set was carried out with least square criterion.

$$log_{10}Y_{ij} = c + aM_i - bR_{ij} - log_{10}R_{ij} + \varepsilon_{ij} + \eta_i \quad (1)$$

where Y_{ij} is maximum absolute velocity response in cm/s from event i at station j, M is magnitude, R is the hypocentral distance in km, ε is intra-event error, and η is inter-event error; c, a and b are regression coefficients for constant, magnitude, and inelastic attenuation, respectively.

4. AVRS FOR BANGKOK

We proposed an estimation equation below to calculate AVRS in Bangkok when observation data is absent by using relative velocity response spectra (RVRS) and peak ground velocity (PGV) in Eq. (2).

$$AVRS(T) = RVRS(T) + \alpha(T)PGV \quad (2)$$

where $\alpha(T)$ is coefficient. Firstly, regression analysis is done on AVRS, RVRS and PGV. In the second step, random values are generated from probability density function of magnitude and hypocentral distance data with 10,000 trials for each natural period and taking average values.

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5. RESULT

We only have acceleration time histories for two earthquakes from one TMD observation site. We examined applicability of regression curve for AVRS based on Eq. (1) directly to situation in Bangkok and found that observed AVRS at all periods are larger than the estimated value. Fig. 1 shows example plot at natural period at 2 s, 4 s, and 7.5 s. For the sake of comparison, maximum and geometric mean of AVRS in NS and EW directions are calculated. Coefficient, $\alpha(T)$, obtained is shown in Fig. 2. For examination of applicability of $\alpha(T)$, due to absence of suitable attenuation model on RVRS and PGV in Bangkok, in this study we use observed value instead to calculate estimated AVRS. The result is shown in Fig. 3 which indicates relatively in good agreement. However, further evaluation is needed if existence of suitable regression model for Bangkok.

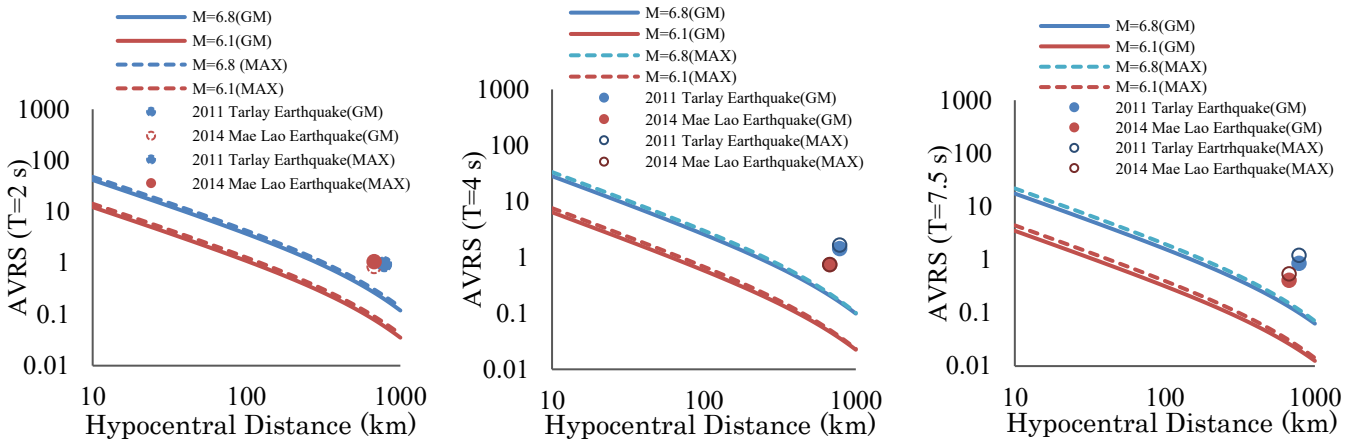

Fig. 1 Regression curve and observed AVRS using maximum (MAX) and geometric mean (GM).

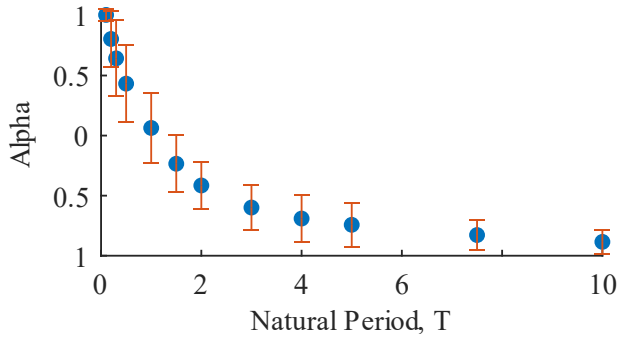

Fig. 2 Coefficient $\alpha(T)$

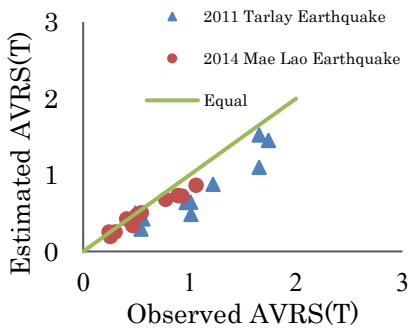

Fig. 3 Estimated and observed AVRS

6. CONCLUSION

GMPE for AVRS using Japan data to further check its applicability to Bangkok and regression model might underestimate situation in Bangkok. Correlation relation proposed to calculate AVRS might be applicable but further evaluation is needed if existence of attenuation equation on PGV and RVRS.

REFERENCE

1) Dhakal, Y. P., Suzuki, W., Kunugi, T. and Aoi, S. (2015): Ground Motion Prediction Equations for Absolute Velocity Response Spectra (1-10 s) in Japan for Earthquake Early Warning, Journal of Japan Association for Earthquake Engineering, Vol. 15, No. 6, pp. 91-111.