P64

Ground Motion Variability in the Kyoto Basin for Earthquakes Occurring on the Hanaore Fault

〇Thinzar Yadanar, Fumiaki NAGASHIMA, Shinichi MATSUSHIMA

Introduction

A reliable seismic hazard assessment depends on accurate ground motion estimation and its associated uncertainty. Ground motion estimation is generally conducted using two main approaches: empirical-based and physics-based. The empirical-based approach generally uses ground motion models (GMMs) developed through the regression of observed data. While GMMs are straightforward to apply, they have limited ability to capture the detailed source, site and path effects. On the other hand, the physics-based approach, such as the ground motion simulation, requires detailed source and subsurface information and can explicitly incorporate these effects into the estimated ground motions. The main purpose of this research is to propose an approach for modeling ground motion variability, which is applied in probabilistic seismic hazard analysis (PSHA), by combining empirical- and physics-based approaches.

In this study, we identified the reasonable variability of ground motions expected in the Kyoto Basin for earthquakes occurring on the Hanaore fault, which runs in a north-south direction along the eastern part of the Kyoto Basin. The Hanaore fault consists of three segments: northern, central and southern segments, based on the historical activity. Because the probability of earthquake occurrence in the northern segment was relatively low, ground motion simulations were performed for the central and southern segments. The central segment is a right lateral strike slip fault with the length of 20 km, while the southern segment is a reverse fault with the length of 15 km. Ground motion simulations for a JMA magnitude 7.3 earthquake were conducted to predict the peak ground velocity (PGV) on the engineering bedrock for 800 stations in and around Kyoto basin. A total of 243 earthquake scenarios were simulated by changing the locations of strong motion generation areas (SMGAs) and rupture initiation points, and the average and variability of ground motions were identified across the resulting PGVs.

Ground Motion Simulations

Earthquake scenarios were adopted from the Japan Seismic Hazard Information System (J-SHIS) and followed the recipe for ground motion prediction by the Headquarters for Earthquake Research Promotion (HERP) for fault geometry. New scenarios were generated by varying locations of SMGAs and rupture initiation point. The subsurface structure model (version 2) provided by J-SHIS was used, and the layer with shear wave velocity of 600 m/s was assumed as the engineering bedrock in this study.

Low-frequency waveforms ($f \leq 2.4$ Hz) were simulated by the 3D finite difference method (FDM) using fourth-order spatial finite difference method with a discontinuous grid on the Ground Motion Simulator (GMS). High-frequency waveforms ($f \geq 2.4$ Hz) were generated using the Stochastic Green's Function Method (SGF). Both software were provided by the National Institute for Earth Science and Disaster Resilience (NIED). The low- and high-frequency waveforms obtained from the two methods were combined using a matching filter with a matching frequency of 2.3 Hz to obtain the broadband ground motions on the engineering bedrock.

Discussion

The average and variability of PGV across the 243 ground motion simulations were identified. The average PGV against the shortest fault distance obtained in this study was compared with the PGVs by GMM of Si and Midorikawa (1999) (Fig. 1). The solid and dashed red lines represent the PGV and the standard deviation (σ = 0.23) predicted by using the GMM, respectively, while the blue dots indicate the average PGV across the 243 scenarios at 800 stations. The distance range was divided into 13 logarithmically spaced bins, and the geometric mean and standard deviation for each bin were calculated and are shown as back error bars. The results from the two methods show comparable average PGV and standard deviation; however, the simulation results exhibit smaller variations at a distance around 10 km.

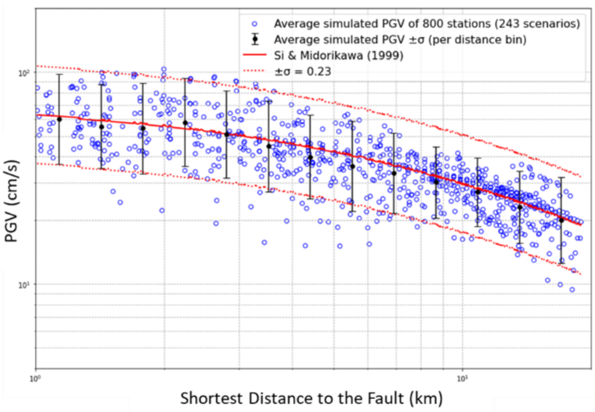

Fig 1. Comparison of PGV obtained by this study and GMM of Si and Midorikawa (1999)

To quantify the variation of PGV, we calculated the geometric coefficient of variation (GCV) of PGV across all scenarios, and the spatial distribution of GCV is shown in Fig. 2. The stations were classified into three categories: outside basin (circles in Fig.2), at the basin edge (rectangles) and inside basin (triangles) based on the average shear wave velocity of the upper 50 m of the subsurface structure (AVS50 = 600 m/s).

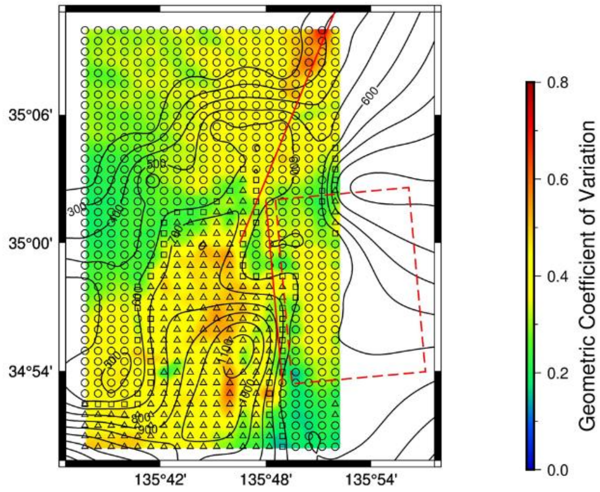

Fig 2. Distribution of GCV of PGV across 243 scenarios

High GCV values are observed not only outside of the basin, mainly at the stations close to the central segment, but also within the central basin at intermediate distances from the southern segment. These results indicate that ground motion variability depends not only on the shortest fault distance but also on the basin characteristics, highlighting the importance of accounting for basin effects when modeling the uncertainty of ground motion in PSHA.

References

HERP (2003): Long-term evaluation of the Mikata-Hanaore fault zone

Aoi, S. and Fujiwara, H. (1999): Bull. Seism. Soc of Am., 89,918-930.

Aoi, S. et al. (2004): Ground Motion Simulator: GMS, Butsuri-Tansa (Geophysical Exploration), 57, 651-666

Dan, K. and T Sato (1998), Dan, K., et al. (2000): J. Structural and Construction Engineering, No.509, 49-60 and No.530, 53-62

Fujiwara, H. et al. (2009). Technical Note of the NIED 336, 528pp.

Irikura, K. and Miyake, H. (2001): J. Geography, 110,849-875.

Si, H. and Midorikawa, S. (1999): J. Structural and Construction Engineering. No 523, 63-70