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Issues and Challenges in Seismic Risk Evaluation and its Uncertainty Reduction for Nankai Trough Earthquake

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Introduction

A five-year plan of the research project titled "Promotion of observation and research plan of earthquakes and volcanos for contributing to mitigation of disasters" had been proposed in 2013 and started in April 2014 with a cooperative type of research between Earthquake Research Institute, University of Tokyo and Disaster Prevention Research Institute, Kyoto University. The ultimate goals of this research project are the evaluation of uncertainty in seismic risk evaluation and the investigation of the cause of its uncertainty. This project was formulated with 7 research subgroups and 1 platform development group. Related fields of 7 research subgroups are source process, wave propagation and deep sub-surface structure, strong motion estimation, shallow subsurface structure, structural damage estimation, risk evaluation, and stakeholder involvement.

Preliminary study

The preliminary study was performed in the last fiscal year's research (FY2015) (Lee et al., 2016). The objective of the research was to evaluate expected loss or damage to an arbitrary structure at an arbitrary location due to a certain earthquake. Plate boundary earthquakes along Nankai trough (Nankai Trough Earthquake) was considered as the target earthquake. Locations of Kochi prefectural building and Osaka prefectural building and wooden house were selected as target sites and target structure, respectively.

The uncertainty of risk was evaluated based on the Monte-carlo simulations (MCS). The degree of uncertainty was defined as the length of interval from 5% quantile value to 95% quantile value of expected losses in the MCS result as shown in Figure 1. Considering the epistemic uncertainty, 6 models of sources, 5 models of ground motion prediction equations (GMPEs), 1 model of site amplification, 1 model of fragility curve and 2 models of loss model were suggested by related subgroups and applied in the uncertainty calculation of risk. The modelling uncertainties in the GMPEs, site amplification model, and fragility curve model were also applied in the uncertainty calculation using the standard values of corresponding models, but they were not considered in those of source models and loss model because of lack of previous studies.

Sensitivity analysis was performed to investigate which subgroup's uncertainty was most influential to the overall uncertainty. Based on the result of the preliminary study, the uncertainty of GMPEs was mostly influential to the overall uncertainty and those of loss model and site amplification were secondary. In contrast, the overall uncertainty was less sensitive from uncertainties of sources and fragility curve.

Issues and Challenges for the research

Many research agendas were suggested from the preliminary study considering the order of the result of sensitivity analysis. First, the validity of suggested GMPEs needed to be verified because great difference

was observed not only in the expected losses but in the predicted PGVs as shown in Figure 2. Second, more sophisticated loss model needed to be defined because existing loss model was too much simple and had more assumptions compared with other models. Third, the soil amplification models needed to be improved. Fourth, the target site needed to be expanded to show the spatial distribution of risks.

In this fiscal year's research (FY2016), the secondary study has been performed to solve some of these research agendas. Loss model is replaced from the previous model to new model based on the study by Tabata and Okada (2006), in which the risk is defined in terms of fatality and economic consequences. The uncertainty calculation and sensitivity analysis of was performed for the entire regions of Kochi and Osaka prefectures. These two revisions show how the dominating uncertainty sources differ for different locations and risk metrics.

Others of these research agendas have been discussed in the secondary study. The validity of suggested GMPEs have been discussed considering not only GMPEs themselves but also the issue of applying the pass effects with reference to the study by Si et al. (2016). The discussion about improvement of soil amplification model have also been performed especially in terms of the epistemic uncertainty. However, both are concluded as not simple problems but problems need to be discussed deeply with experts of corresponding areas, so it is included in the challenges of the future research.

Summary

The cooperative research "Promotion of observation and research plan for earthquake and volcanic eruption prediction" is briefly introduced. Some research agendas were suggested by the preliminary study. Among them, the sophistication of loss model and spatial expansion of target site were performed in the secondary study. After the secondary study, upgrading of GMPEs in combination with detailed source models considering rapture location and improvement of soil amplification models are remained and they are included another challenges for the future research.

References

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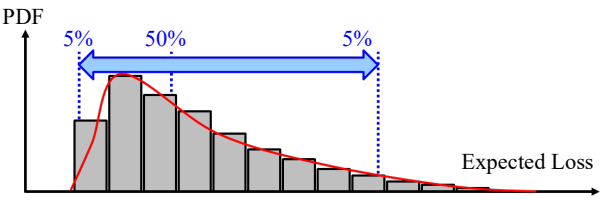

Figure 1. Degree of uncertainty (Lee et al. 2016)

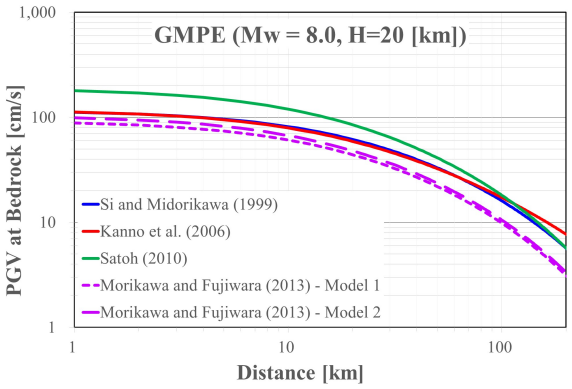

Figure 2. PGVs by 5 GMPEs (Lee et al. 2016)