Investigation of Possibilities to Reduce the Uncertainty of Disaster Risk

○Seung Han LEE, Kazuyoshi NISHIJIMA, Shinichi MATSUSHIMA, Masatoshi MIYAZAWA,
Kimihiro MOCHIZUKI, Takashi IIDAKA, Tetsuo TOBITA, Hiroshi KAWASE, Norio MAKI

1. Introduction

The geodesy sub-committee of MEXT had long proposed their research project of "Promotion of observation and research plan for earthquake and volcanic eruption prediction" to the minister. After 2011 Tohoku earthquake, however, the earthquake prediction society had faced the challenge on how they contribute to the earthquake disaster mitigation more effectively. At the end of 5 year research plan in 2013, the new 5 year plan of research project was proposed with a clear expression whose aim was not limited to observation and research for earthquake prediction but also to the estimation of disaster and countermeasures for it. The title of this new research project is "Promotion of observation and research plan of earthquakes and volcanos for contributing to mitigation of disasters" and it started in April 2015 including a new format of the cooperative research, "Cooperative Research by Liaison between Earthquake Research Institute, University of Tokyo and Disaster Prevention Research Institute, Kyoto University". The final goal of the participant application type project is to evaluate the degree of the uncertainty inherited in the calculated risk in the assessment and to investigate possibilities to reduce such uncertainty. For these purposes, this project is formulated, consisting of 7 subgroups for the research fields related to seismic risk assessment. These are source process, wave propagation and deep subsurface structure, strong motion estimation, shallow subsurface structure, structural damage estimation, risk evaluation, and stakeholder involvement. Another subgroup was formed to develop the platform for seismic risk assessment.

2. Seismic risk assessment

The seismic risk is assessed based on probabilistic seismic hazard analysis (PSHA). The procedure of PSHA can be described as four steps (Kramer, 1996). First step is to characterize the earthquake source. The second step is to characterize the seismicity using the recurrence law. The third step is to predict the relationship among the ground motion parameters using the ground motion prediction equation (GMPE). The last step is to compute the seismic hazard curves.

The entire research project is performed with the format of the cooperative research. Each subgroup respectively contribute to each part of the entire research. The locations, magnitudes and seismicity of earthquake sources are characterized by source process group. The appropriate GMPEs are defined by the wave propagation and deep subsurface structure group and strong motion estimation group. The effects of the soil amplification are considered by the shallow subsurface structure group. The vulnerability functions for target structures in target site are offered by

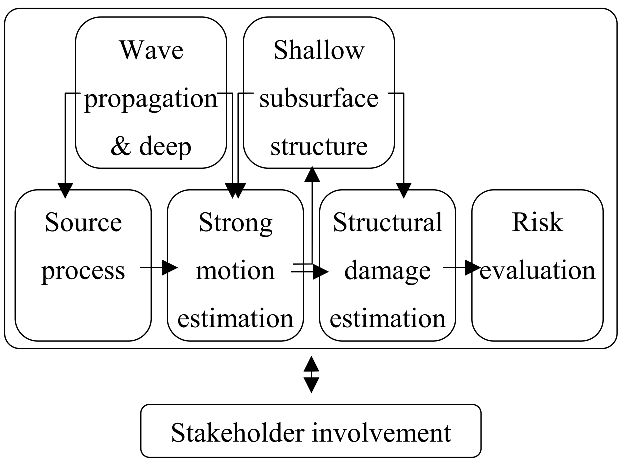


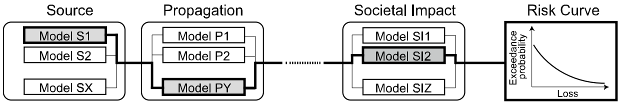
Figure 1. Relations among subgroups

the structural damage estimation group. The inputs from the previous 5 subgroups are used for the calculations of seismic risk by the risk evaluation group, and the results of calculations are provided to stakeholder involvement group. The relation among subgroups is illustrated in Figure 1.

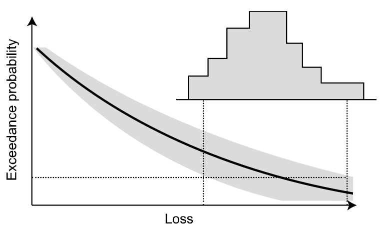
3. Uncertainty evaluation and sensitivity analysis

The misfit of the model to the data is considered as uncertainty of the models of each subgroup and the overall uncertainty of seismic risk is affected by each modelling uncertainty. Each modelling uncertainty is defined by each subgroup and the overall uncertainty is evaluated by the platform development group, which is considered as the combination of modelling uncertainties defined by the 6 subgroups. The evaluation process for the overall uncertainty of seismic risk can be presented as shown in Figure 2.

In Figure 2 (a), one risk curve is calculated when a single model is selected from each module, and is used for calculation. Therefore, if it is assumed that the numbers of models for the source, propagations (GMPEs), soil amplification and vulnerability functions are SX, PY, AZ and VA, respectively, total (SX × PY × AZ × VA) of risk curves are able to be calculated. Because the greater number of risk curves are able to be calculated using Monte-Carlo Simulation (MCS), the probabilistic distribution of risk curves is



(a) The procedure for the seismic risk assessment



(b) The uncertainty associated with evaluated risk

Figure 2. Procedure of uncertainty evaluation

able to be estimated based on the result of MCS as presented in Figure 2 (b). The overall uncertainty inherited in the calculated risk is able to be defined based on the probabilistic distribution of any given parameter related to the risk curve, such mean value, median and quantiles.

The ultimate goal of this project is to investigate possibilities to reduce uncertainties. For this purpose, not only the overall uncertainty in the risk assessment but the uncertainty of each part should be quantified. By the sensitivity analysis with quantified values of uncertainties, it is possible to investigate which part is mostly affect to the overall uncertainty. If the overall uncertainty is significantly varied by the variation of uncertainty of a certain part, the uncertainty of that part should be considered as an important part to reduce the overall uncertainty. The identification of such parts facilitate to prioritize future research needs related to risk assessment, in due consideration with the estimated efforts required and possibilities to reduce the uncertainty of those parts.

4. Summary

The cooperative research "Promotion of observation and research plan for earthquake and volcanic eruption prediction" is briefly introduced. It aims at evaluating uncertainties of disaster risk assessment and to investigate possibilities to reduce uncertainties. The expected outcome is a research agenda for future research needs in order to reduce the uncertainty inherited in the calculated seismic risk, which then facilitate decision making in practice regarding seismic disaster mitigation. The methodology adopted in the project is also described.

References

Kramer, Steven L. (1996). *Geotechnical Earthquake Engineering*, Prentice Hall.