PRODUCING CONDENSED EARTHQUAKE CATALOGUE FOR LIFELINE NETWORKS RISK ASSESSMENT

Elnaz PEYGHALEH
Lecturer in Islamic Azad University of Qazvin (QIAU), Qazvin, Iran
epeyghaleh@gmail.com

Emad MASROUR
M.Sc. Student, KNTU, Tehran, Iran
emasrour@mail.kntu.ac.ir

Mohammadreza ZOLFAGHARI
Associated Professor, KNTU, Tehran, Iran
mzolfaghari@CatRisks.com

Keywords: Hazard Analysis, Lifeline Network, Optimization, Reduced Subset, True Hazard

This paper presents a method to generate a condensed earthquake catalogue in order to be used in lifeline network risk assessment. For examining the existing seismic risk to lifeline network we have to consider all possible earthquake scenarios. In addition, these earthquakes should be considered granularly or in the other words earthquakes need to be seen as individual events, in this case the ability of capturing spatial correlation of ground motion across a region is achieved and one can avoid the ground motion overestimation on lifeline network. Such qualities cannot be captured performing other methods like probabilistic seismic hazard analysis (PSHA).

Despite all the benefits of considering all possible earthquake scenarios, there is one big challenge. By including all scenarios in the risk assessment process, it will be computationally expensive and also time consuming. In this condition reducing the number of earthquakes would be an answer. But if we decrease the numbers erratically, the accuracy will be compromised dramatically. In order to solve this problem, Change et al (2000) introduce a method, named hazard-consistent probabilistic scenario. This method involves selecting a relatively small subset of all possible earthquakes and adjusting their annual occurrence probabilities so that each of the reduced set of events represents all events like that one in terms of the frequency and distribution of ground motion it causes (Vaziri, 2009).

Vaziri (2009) for the first time presented optimization based probabilistic scenario method. In this procedure she used the optimization model with the objective of minimizing hazard curve error in terms of probability ($e_{i,r}$, site/return period error, in Figure 1). As it can be seen in figure 1, the curve with the black circles represents the "true hazard curve'' in one specific site, the curve with the white ones demonstrates the "reduced earthquake set hazard curve''. The objective is making these two curves as close to each other as possible, in this case the error of the hazard assessment process will be minimized and the subsequent results of performing risk assessment based on the "reduced subset'' will be trustable. Using this method provides the user opportunity to have reliable results and avoid the intensive computation at the same time.

All mentioned method however consider PGA values as the ground motion parameter for generating hazard curves which are not appropriate in case where lifeline network elements are exposed to earthquake. Because, in such situation the lifeline network elements are susceptible to PGV and PGD, and considering only PGA is not an accurate way to select the reduced subset of earthquakes and adjusting their probabilities.

Therefore, there are two key features that make our study novel, for the first time we use the PGV parameter as a ground motion value in optimization based hazard-consistent probabilistic scenario method. We can claim that, this method made our earthquake selection more specific and accurate in case of lifeline network risk assessment. Secondly, we have developed the mixed-integer linear optimization model which consider the nonlinear shape (Peyghaleh, 2014) of hazard curves and used one of existing optimization software in order to select the reduced subset from all earthquake scenarios in a pilot region as well as calculate their hazard consistent probability. The optimization process repeat the hazard calculation many times with different subset and make the hazard curve based on and recognize the proper ''reduced subset'' in which the results are close enough to the "true hazard'' for the region where a case study is performed for. The pilot region here is the lifeline network in Tehran, Iran. The result of pilot study including the condensed earthquake catalogue and the probability of each earthquake in this catalogue are presented. In addition, based on results for a case study, the sensitivity of the recommended selected scenarios to hazard curves considering PGV are compared to the recommended selected scenarios to hazard curves considering PGA.

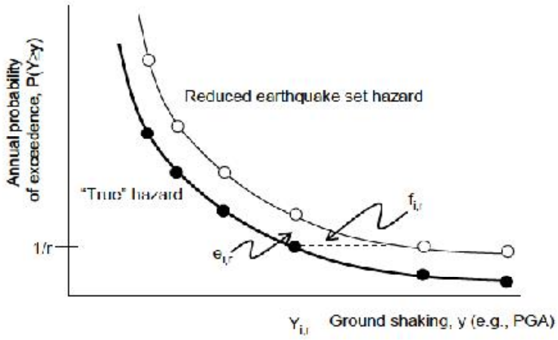

Figure.1 Schematic defining errors between the “true” and reduced set hazard curve for site u. e_i, r is the error for site u and return period r, between point on the “true” hazard curves and the corresponding point on hazard curves developed by the reduced set of earthquake scenarios and hazard consistent annual occurrence probabilities. *r* is an index for the return period, *i*is an index for site or lifeline network element (Vaziri, 2009, Han and Davidson, 2012)

REFERENCES

Chang S, Shinozuka M and Moore J (2000) Probabilistic earthquake scenarios: extending risk analysis methodologies to spatially distributed systems, *Earthquake Spectra*; 16(3): 557–572

Han Y and Davidson R (2012) Probabilistic seismic hazard analysis for spatially distributed infrastructure, *Earthquake Engineering and Structural Dynamics*, Earthquake, Published online in Wiley Online Library (wileyonlinelibrary.com), DOI: 10.1002/eqe.2179

Peyghaleh E (2014) Optimization Modeling for Financial Resource Allocation Towards Seismic Risk Reduction, Ph.D. Dissertation, Department of Civil Engineering, K.N. Toosi University

Vaziri P (2009) Earthquake risk mitigation: hazard identification and resource allocation, Ph.D. Dissertation, School of Civil and Environmental Engineering, Cornell University