Development of importance measures in the framework of seismic fragility assessment of NPP.

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This seminar addresses the topic of sensitivity analysis and the definition of importance measures for seismic Probabilistic Risk Assessment (PRA) studies. We construct a set of sensitivity indexes that are of help to seismic risk analysis. In nuclear practice, the fragility curve of a component is evaluated based on seismic margins (or safety factors). These curves are then combined with the seismic hazard curves in order to obtain failure probabilities (in terms of annual frequencies) of components and, finally, of the whole plant via system analysis.

We first present some methods and results for sensitivity analysis at the component level. The latter are useful when the modeler is interested in the most important factors in order to steer modeling efforts and/or data collection.

Based on results of Borgonovo et al. (2011), we secondly define the concept of seismic risk achievement worth (RAW) which measures the shift between the mean risk curve and the conditional mean risk curve given that a component has failed. This importance measure ranks the components with respect to their effect on the seismic fragility curve family. In this respect, we note that failure of components in series transforms the seismic fragility curve family into a unique Heaviside function. In this case, the aleatory event (component failure) eliminates not only aleatory but also epistemic uncertainty. More generally, seismic risk achievement worth can be seen as a measure at the aleatory uncertainty level.

We then introduce a second type of importance measure that looks at epistemic uncertainty. This importance measure conveys the importance of a component with respect to the family of fragility curves considering not only its failure but also the uncertainty in its failure probability. It is based on families of system fragility curves conditional on a realized component fragility curve.

Numerical results are discussed by applications to an EPRI case study. In particular, we compare the insights gained through the latter importance measure to the insights obtained with the seismic RAW.

E. Borgonovo, C.L. Smith, Epistemic Risk Achievement Worth. ESREL 2011.

I. Zentner, E. Borgonovo, A. Pellegri, S. Tarantola, Use of moment independent importance measures in the framework of seismic fragility analysis. SAMO 2010.

EPRI, Applications guide for use of seismic margin assessments in quantitative risk-informed decision-making, EPRI report 1010998, prepared by ABSG Consulting Inc., July 2004.