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EFFECTIVE ESTIMATION OF CONFIDENCE IN THE VULNERABILITY ASSESSMENT OF UNCERTAIN STRUCTURAL SYSTEMS

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ABSTRACT

This paper introduces the first attempts to develop a simplified method called ESM (Effective Sensitivity Method) to help managing the seismic assessment of uncertain structural systems. The G-function describing the capacity of structural systems is often available only through numerical models. Here, the case of masonry building clusters (MBC) is studied, for which an ad-hoc analytical procedure (Monti and Vailati, 2009; Vailati *et al*. 2015) is used to describe the response. The confidence is estimated with a first order sensitivity analysis, assuming that the design point is at the mean values of the basic variables and that their estimates are independent. The proposed analytical procedure allows to quantify the confidence in the outcome of the probabilistic assessments of a structural system by calibrating a coefficient α, used to attain specified fractiles of the output variable of interest. The practitioners are given appropriate values of α under table form, depending to the characteristics of the building.

Keywords: seismic capacity, uncertainties, simplified procedure, variance of structural response, reliability methods, masonry building clusters, aggregates.

INTRODUCTION

The structural response is a function of a series of basic variables X affected by uncertainties. The numerical model consists of N random variables $\underline{X}= (\ldots X_i \ldots)$, with $\underline{X}= N(\underline{\mu}_x; \underline{\sigma}^2_x)$. The basic variables $\underline{X}$ relevant to the analysis of structural systems, concern the geometry (dimensions of structural elements, constraint ends), materials (compressive and shear strength, elastic tangential and longitudinal modulus) and the design details (connection between structural elements, connection between slabs and structural elements). It is assumed that the basic variables X are random and uncertain and are moldable under probability theory. The capacity of the structural system is measured with the scalar quantity Y, being a function of the basic uncertain parameters X, is itself affected by uncertainties. Denoting by G(·) such function of capacity, we have that the generic realization y of Y is expressed as:

$$Y = G(\underline{X})$$

The function Y, that it's right to be bias free, is not generally expressed in analytical form, then the calculation of y is performed through numerical analysis on a basic model. The estimate of variance is performing with sensitivity analysis of the first order. The average value of function Y is:

$$\mu_y = G(\underline{\mu}_x)$$

and the exact calculation of the variance of function Y is given as:

$$\sigma^2{}_y = \sum_{i=1}^{n} \left(\frac{\partial G}{\partial X_i} \right)^2 \sigma_{xi}{}^2$$

Since the G model is numeric, the estimate of the variance of structural system is not easy and fast. A simplified and approximate way to evaluate the confidence of the system can be expressed as follow:

$$G(\underline{\mu}_x \pm \underline{\sigma}_x) = Y_{\inf}$$

Solving for y the above equation, we obtain the expression of α, the parameter that gives the relationship between the lower fractile and average value of function Y:

$$\alpha = \frac{G\left(\underline{\mu}_x\right) - G\left(\underline{\mu}_x \pm \sigma_x\right)}{\sqrt{\sum \left(\frac{\partial G}{\partial X_i} \right)_{\mu x}^2 \cdot \sigma_{xi}{}^2}}$$

RESULTS AND CONCLUSIONS

The proposed analytical procedure allows to carry out the confidence in the outcome of the probabilistic assessments of a structural system using the coefficient α as multiplier of standard deviation of a function Y. Its value can be defined respect to the order of the function Y and given to the technicians under table form.

Then, it will be possible to define α respect more percentages of confidence levels, in case a specific range is assigned as goal (the eurocodes are an example).

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