Modeling model uncertainty in structural reliability: a variety of approaches

E. Ardillon – EDF-R&D/MRI, EDF Lab Chatou, 6, quai Watier, Chatou, France – emmanuel.ardillon@edf.fr – 33 1 30 87 85 89

S. Audebert – EDF-R&D/AMA, EDF Lab Clamart, 1, avenue du Général de Gaulle, France – sylvie.audebert@edf.fr – 33 1 47 65 34 75

Abstract

The basic uncertainty source considered in Structural Reliability Assessments (SRAs) is the physical uncertainty (also called environmental uncertainty), related to the input non deterministic variables of the physical-mathematical model. Model uncertainty is one among various other uncertainty sources in SRA [MEL 99].

Model uncertainty has been considered in deterministic approaches for a long time: many codified design rules include model coefficients (margins). A review of the scientific literature in this area confirms that model uncertainty is not a prevailing research topic in SRA: in SRA the mathematical model of the structural physical behavior to failure is considered as an input to the analysis, as well as the corresponding deterministic analysis. However, model uncertainty has been a constant concern for the last 3 decades in the SRA researchers' community and is considered with growing interest, especially for risk-sensitive industries; at EDF, a current example is the SICODYN research project, gathering the efforts of 13 academic and industrial research partners to a priori estimate the confidence associated to a dynamical simulation-based prediction and to quantify the model uncertainty and, consequently, the total numerical uncertainty [AUD 10, 12].

Two main sources of uncertainty relating to physic-mathematical modeling were identified in the literature and are commonly allowed:

- hidden or voluntarily omitted variables (reduced dimension);
- approximate mathematical formulation (e.g assumption of linearity, omission of the structural dependences between variables (cross effects), discarding local or particular physical phenomena).

This paper investigates the variety of existing representations of model uncertainty in structural reliability models. The general frame is the multiplicative or additive adjustment factor. A simple example is the model coefficient(s) used in the deterministic approach (e.g. codes and standards in civil engineering). In the semi-probabilistic approach, these coefficients can be directly related to corresponding uncertain variables.

It should also be remembered that theoretical justifications exist for probability representation of model uncertainty.

All modelings utilize unknown parameters as well as a term of residual error. These parameters, likely to be calibrated to improve the predictivity of the model, are built-in either with the basic model, or, in the most current representation, in the corrective term representing the systematic skew of the basic model. Depending on the representations, the residual error is either an model error, or a mixed term combining model error and experimental error, or an experimental error. Various simplifications are met: Gaussian error (no exception), model not skewed (not of corrective term).

References

[AUD10] Audebert, S. SICODYN International Benchmark on dynamic analysis of structure assemblies: variability and numerical-experimental correlation on an industrial pump, *Mécanique et Industries*, 11(6) (2010), 439-451

[AUD 12] Audebert, S. *SICOMORE Project: synthesis of the main results of SICODYN benchmark on structure dynamics.* s.l. : EDF, 2012. H-T61-2011-01766-EN.

[MEL 99] Melchers, R. - *Structural Reliability Analysis and Prediction.* s.l. : Wiley, 1999.