Intervals and fuzzy sets versus vague probabilistic models in reliability analysis

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Keywords: *Reliability analysis; Intervals; Fuzzy probabilities; Bounds on probabilities; Chebyshev's inequality.*

Abstract

In civil engineering practice the information available for a reliability analysis is often limited or vague. In many cases only bounds can be specified for the parameters involved in the mechanical model. In order to consider this uncertainty in a subsequent numerical analysis realistically, an appropriate modeling and quantification are required. Most desirable in view of the meaning of the results as a basis to derive justified decisions is a comprehensive probabilistic modeling. However, if there is a lack of information, the selection of a specific probabilistic model is a subjective decision with several options. The associated results may then be dominated by artificial information only pretending a rational basis for decisions. This situation can be problematic if the decisions are critical. On the other hand, one could decide to not impose any probabilistic statements and specify intervals for the input, which definitely cover all possible parameter values. This does also not imply any scheme for the occurrence of values between the interval bounds. The associated results are then definitely conservative but maybe too unspecific to derive decisions of practical value.

This situation suggests that a reasonable modeling and quantification may be found as an intermediate option with both probabilistic and non-probabilistic elements. Probabilistic information can then be utilized as extensive as possible, and intervals and fuzzy sets can be specified to cope with poor and vague information without introducing artificial statements on probabilities. In this paper, selected options for the modeling and quantification of the available information are scrutinized by way of a reliability analysis of a simple geotechnical structure. This comparative study includes traditional probabilistic modeling, probabilistic approximations, interval modeling, and imprecise probabilities. The selected options are analyzed in view of (i) an appropriate modeling of the information actually available in practical cases, (ii) the transfer of the uncertainty to the computational results, and (iii) the interpretation of the results.