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Use of Simulation in Structural Reliability

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Abstract

Reliability-based concepts are nowadays widely accepted in structural design. However, before such concepts can be effectively implemented, the actual design problem often needs to be considerably simplified. This is mainly due to two reasons. First, in their simplest formulation reliability-based procedures require the structural performance to be represented by explicit functional relationships among the load and the resistance variables. But, unfortunately, when the structural behavior is affected by several sources of nonlinearity, as always happens when the load carrying capacity has to be investigated, such relationships are generally available only in an implicit form. Second, for structural systems with several components, a complete reliability analysis includes both component-level and system-level estimates. Depending on the number and on the arrangement of the components, system reliability evaluations can become very complicated and even practically impossible for large structural systems.

The actual role played by these limitations may strongly depend on the criteria adopted to model the uncertainties related to the geometrical and mechanical properties involved in the structural problem. Basically, uncertainty modeling can be approached by a probabilistic or by a fuzzy formulation. The probabilistic approach assumes the intrinsic stochastic variability of the random variables as known. In the practice of structural design, however, it is very frequent that a lack of information occurs about such randomness. This makes the fuzzy approach, in which the uncertain parameters are bounded between suitable minimum and maximum value, more meaningful for a consistent solution of the problem.

In this paper it is shown how uncertainty can be easily handled in design practice by using basic simulation methods. Numerical tools are provided to implement reliability concepts by using a probabilistic approach, or a fuzzy approach. The numerical applications are associated with the safety evaluation against the ultimate limit state of structural collapse, and are then developed in the context of limit analysis. The results of both the probabilistic and fuzzy modeling of the uncertainties are compared with reference to the reliability analysis of elementary beams, as well as of more complex framed structural systems.