8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

Uncertainty Models in Engineering Analysis, Design, and Optimization

Sambasiva R. Singiresu

Department of Mechanical
and Aerospace Engineering
University of Miami
Coral Gables, FL 33124
USA

Key Words: *Uncertainty models, Engineering Design, Probabilistic models, Interval models, Fuzzy models.*

ABSTRACT

Many practical engineering systems are too complex to be described by precise models and in exact terms, because real-life phenomena have to be simulated by mathematical approximations. Due to the uncertainties present in many design factors of the system, it is impossible to perform the analysis, design and optimization computations using traditional deterministic approaches. In general, the response of a structural system is influenced by the geometry, load and material property parameters. The geometry parameters, obtained through construction/manufacturing/machining processes, are usually specified in terms of their nominal values and variabilities or tolerances. Many types of loads, such as wind, earthquake and snow loads, as well as those induced during resonance conditions in machines, are not known in precise terms; only information about past loads are known. Similarly, when the material properties, such as yield strength and Young's modulus, are determined through experiments, they are found to exhibit scatter. Thus all the parameters involved in structural analysis, design and optimization are uncertain.

The imprecision or uncertainty of most engineering systems can be modeled using probabilistic, fuzzy or interval methods. In the probabilistic method, the uncertain parameters are assumed to be random variables/processes and the system performance is defined in terms of the probability of failure or reliability. Some of the popular methods of evaluating reliability include the response surface, fast probability integration, advanced mean value, Monte Carlo, and system reliability techniques. When the parameters of the system contain information and features that are vague, qualitative and linguistic, a fuzzy approach can be used to predict the response. In this approach, membership functions are defined to model subjective and linguistic descriptions and fuzzy rules of inference are applied to predict the response of the system. The interval analysis assumes that each uncertain parameter is represented as an interval number. The range or interval of the response parameter increases with the ranges and number of input parameters as well as the size and complexity of the problem. An interval-truncation method can be used to predict an approximate response of the system. In the evidence-based methods, information about the uncertain parameters is assumed to be known from multiple sources implying the existence of large epistemic uncertainty in the system. The multiple evidences are combined using Dempster-Shafer theory to construct a coherent picture of reality for use in analysis or

design.

This paper presents the application of the different types of uncertain models in the analysis, design, and optimization of structural systems along with some numerical results.

REFERENCES

[1] W. Wu and S. S. Rao, “Interval approach for the modeling of tolerances and clearances in mechanism analysis,” *J. Mech. Des*., Vol. 126, pp. 581-592, 2004.

[2] Q. Liu and S. s. rao, “Fuzzy finite element approach for analysis of fiber-reinforced laminated composite beams,” *AIAA Journal*, Vol. 43, pp. 651-661, 2005.