Specification of uncertain and variable model data in non-deterministic finite element analysis

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Abstract

Numerical analysis is used throughout in technical analysis and scientific research. The paper takes structural finite element analysis as a reference. In many cases precise numerical data on one or more model parameters are not available, either because the parameter does not have a single value or because its value is not precisely known. However, some conditions must be met in order for a non-deterministic analysis run to yield practically relevant results. The paper discusses these conditions, the types of analysis that are feasible, the requirements on the input data, and the availability of useful data.

There are two basic categories for non-deterministic analysis : probabilistic analysis is feasible in case of aleatory uncertainty, and non-probabilistic analysis can be used in case of epistemic uncertainty. Input data require a specific numerical formalism, with probability density functions for aleatory uncertainty and interval or fuzzy numbers for epistemic uncertainty. In addition to these distinct categories, there are intermediate categories. In a first section, the paper briefly presents a consistent structure for the representation of uncertain data in each of the cases of non-determinism.

The second section of the paper gives a wide selection of non-deterministic model data as they are reported in numerical analyses in journal articles and conference papers. Despite the apparent simplicity of data formats, the authors feel that engineers in general and even researchers unfortunately use data formats in an inappropriate manner. The unavailability of validated input data is a circumstance that is often encountered, but that does not justify inadvertent assumptions.

The authors perceive a need for a coordinated effort by the scientific research community to collect reliable data on different types of model parameters in an appropriate format for non-deterministic analysis and to make available these data to their fellow researchers and to the engineering community. The third section of the paper discusses the needs for data collection of non-deterministic data. The availability of data determines the type of non-deterministic analysis that can be executed without unintentional misrepresentation of data and inadvertent introduction of unvalidated assumptions. Inversely, a specific type of analysis can only be executed when the model data are available in a suitable format.