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Solution Verification in Computational Solid Mechanics

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Solution verification is an essential part of simulation governance, a term that refers to procedures established for the purposes of ensuring and enhancing the reliability of predictions based on numerical simulation. Therefore, software used in simulation governance must have technical capabilities that support solution verification, making it possible for analysts to quantify the accuracy of the data of interest computed from the numerical solution.

In mechanical design and certification it is necessary to apply design rules and evaluate designs with reference to the criteria established by the design rules. Application of design rules typically involves the solution of deterministic mathematical problems and extraction of data specified by the design rules. Designers are obligated to verify that all applicable design criteria have been satisfied for the relevant design conditions. This implies that the errors in the numerical approximation of the data of interest must be verified to be within permissible bounds.

A key technical requirement to achieving solution verification is that the definition of mathematical problem must be treated separately from the numerical approximation to the mathematical problem. This is because the choice of the mathematical problem, and the data to be determined from the solution of the mathematical problem, are governed by consideration of the physical reality being modeled and are usually mandated by the design rules. Numerical approximation, on the other hand, is concerned with finding an approximate solution for the mathematical problem, extracting the data of interest from the approximate solution, and verifying that the numerical errors in the data of interest are within small tolerances.

Most software tools used in current engineering practice were not designed to support solution verification in practical applications. To illustrate this point, and clarify some of the key technical requirements of simulation governance, a small set of challenge problems, representative of problems encountered in structural, mechanical and aerospace engineering practice, will be presented. Readers are encouraged to solve one or more of these problems using software tools of their choice.