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Technical case studies & lessons learned

Avoiding Finite Element Malpractice through Simulation Governance

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Abstract

The finite element method is used by engineers daily in the design/assessment of components and structures. The number of engineers using such tools is increasing and will increase further with the so-called *democratisation of simulation*. However, whilst the method might appear easy to use, with highly effective graphical user interfaces, the fundamental fact is that it is approximate and can produce significant errors in the hands of the inexperienced engineer. These errors, if undetected, can compromise a design to such an extent that it becomes unfit for purpose or, even, unsafe. The way to avoid such *finite element malpractice* is through the application of sound *simulation governance*. The authors have, together, some 70 years' experience in the application of finite element analysis, in the research and development of finite element methods and in the education/mentoring of young engineers. They have a longstanding interest in *equilibrium finite elements*, which invoke simulation governance by ensuring that, even for coarse models, certain solution properties essential to the designer are not compromised. Although the authors' experience comes mostly from the field of structural engineering, the same principles of simulation governance apply equally to other engineering disciplines where numerical simulation is used.

Case Study on the Practice of Good Simulation Governance

Abstract

The ideas of simulation governance outlined in the article will be applied to a practical engineering design problem involving the selection of a thickness for a steel plate so as to minimise material cost. Although similar to a case where a theoretical solution is known, the support configuration considered perturbs the problem sufficiently for it to be necessary to use the finite element method to obtain a solution. This new solution has singularities in the moments that do not converge with mesh refinement but it is demonstrated that these do not impinge significantly on the strength of the plate.

Practical Conclusions

The principles of sound simulation governance have been demonstrated through the use of a relatively simple design problem. The sort of convergence studies conducted here should form a normal part of every engineering analyst's work since it confirms firstly the finite element system used is up to the job and, secondly, that the model is sufficiently refined as to produce results of acceptable engineering accuracy. These are essential if the analyst's work is to pass the scrutiny of internal and external design review or audit and also, more importantly, make any sensible comparison with experimentally measured responses, i.e., in terms of validation.

The development of theoretical solutions for problems is often not a trivial exercise, but organisations such as NAFEMS publish benchmark problems of this nature not only for elasticity and plasticity but also for an increasing range of physical phenomena that the engineer might come across. It is also finally worth mentioning that finite element analysis may also be used to verify published results; the engineer might be surprised to find that some of these are in error, [26], and others might nowadays be considered as overtly conservative, [29].

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