Variational design sensitivity analysis of a non-linear solid shell with applications to buckling analysis

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This contribution is concerned with variational design sensitivity analysis of a non-linear solid shell element, see [1] for details, which is based on the Hu-Washizu variational principle. Variational design sensitivity analysis is a branch of structural optimisation. Here, variations of the material configuration are considered and the changes of the state variables and of the objective functional are observed. The sensitivity information is derived on the continuous level and discretised to yield the analytical expressions on the computational level. Especially the pseudo load matrix and the sensitivity matrix, which dominate design sensitivity analysis of shape optimisation problems, are derived.

Shell elements are most commonly used to model thin structures because of their efficiency and accuracy. The design of such structures is extremely important for their stability, robustness and for their load-bearing capacity. Design sensitivity analysis provides information which allow the engineer to find the appropriate shape of a shell and to understand the influence of geometry and layout variants on its behaviour. Unfortunately, considering the coordinates of all finite element nodes as design parameters leads to a large amount of sensitivity information which can not be easily interpreted by engineers. Such information is stored in pseudo load and sensitivity matrices.

We apply singular value decomposition (SVD) to the pseudo load matrix and the sensitivity matrix to detect the most valuable part of information and to transform sensitivity results in a form which is comprehensible for engineers. Similar investigations were made for parameter-free shape optimisation in [2] and for topology optimisation problems in [3]. The proposed theoretical concept is demonstrated on the example of non-linear buckling analysis of shells. Here, proper imperfection modes which lead to the lowest load-bearing capacity are created automatically applying SVD to the pseudo load matrix. Numerical examples illustrate the advocated technique.

References

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