A FULLY NONLINEAR 7-PARAMETER SHELL MODEL AND A TRIANGULAR FINITE ELEMENT FOR THE ANALYSIS OF THIN-WALLED SHELL STRUCTURES

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This work presents the fully nonlinear 7-parameter shell formulation of [1] together with a triangular shell finite element for the solution of the resultant static boundary value problem. In a wider spectrum than [2,3], our approach accounts for thickness variation as an additional nodal DOF, based on the concept of shell director yet with the same standard Reissner-Mindlin kinematical assumption. We define energetically conjugated cross sectional stresses and strains, and appealing is the fact that both the first Piola-Kirchhoff stress tensor and the deformation gradient appear as primary variables.

Finite rotations are exactly treated by the Euler-Rodrigues formula in a pure Lagrangian framework. A plane reference configuration is assumed for the shell mid-surface, but initially curved shells can also be considered if regarded as a stress-free deformed state from the plane position. As a consequence the use of convective non-Cartesian coordinate systems is not necessary, and only components on orthogonal frames are employed.

Elastic constitutive equations are consistently derived from fully three-dimensional finite strain constitutive models. As thickness deformation is incorporated within the shell kinematics, the usual plane-stress approximation is unnecessary and very large strain problems can be more realistically represented. The resulting linearized weak form is always symmetric, and extension to inelastic shells is straightforward once a 3-D stress integration scheme within a time step is at hand.

The corresponding 6-node triangular shell element is furthermore presented, as a generalization of the T6-3i triangle introduced by the authors in [3]. A common quadratic interpolation scheme is set for the displacements and for the thickness stretching on all nodes, while a nonconforming linear rotation field is placed at the mid-sides only. No numerical tricks such as ANS, EAS or reduced integration with hourglass control are needed to improve its performance. Accuracy of the element and the robustness of our formulation are assessed by several numerical examples, with a good focus on stability problems. As already stated in [3], we believe that the combination of reliable triangular shell elements with powerful mesh generators is an excellent tool for the nonlinear analysis of thin-walled structures.

References

[1] P. M. Pimenta, E. M. B. Campello and P. Wriggers, “A fully nonlinear shell formulation with thickness change and a triangular finite shell element”, to be published in 2003.
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