A new solid-shell finite element dedicated to non-linear thin-to-thick structures - application to energy production facilities and safety structures

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ABSTRACT

Thin or thick shell like structures are naturally present in most industrial structures and particularly in nuclear power plants such as pipes, tanks, reactor-buildings, to name just a few. Their mechanical modeling imply to describe properly shell kinematics and to capture accurately through-thickness phenomena. To satisfy those requirements, solid-shell elements are a good option. In the present contribution, we propose a solid-shell element formulated in large Green-Lagrange deformation adapted for modeling geometric nonlinear problems combined with contact and elastic-plastic behaviour. This solid-shell element has nine nodes: eight located at the vertex and the ninth placed at the element centre. The middle-node is endowed with only one degree of freedom, in the thickness direction, allowing the assumption of a quadratic interpolation of the transverse displacement. Unlike solid-shell finites elements reported previously in the literature and formulated under the hypothesis of plane stress, the new solid-shell element here mentioned uses a complete three-dimensional constitutive law thanks to the middle-node. Moreover, to handle the various locking problems that usually arise on solid-shell formulation, the reduced integration technique is used as well as the assumed shear strain method. Finally, to assess the effectiveness and performance of this new formulation, we have investigated a set of popular benchmark problems involving geometric non-linear analysis as well as elastic-plastic behaviour.

REFERENCES