Simulation of Structural Applications and Sheet Metal Forming Processes Based on Quadratic Solid-Shell Elements With Explicit Dynamic Formulation

Hocine Chalal, Farid Abed-Meraim
LEM3, UMR CNRS 7239, Arts et Metiers ParisTech, 4 rue Augustin Fresnel, 57078 Metz, France
hocine.chalal@ensam.eu, farid.abed-meraim@ensam.eu

Abstract

In the engineering industry, thin structures are commonly used to save material, reduce weight and improve the overall performance of products. The finite element (FE) analysis of such thin structural components has become a powerful and useful simulation tool. Over the last decades, considerable effort has been devoted to the development of 3D FE that are capable of modeling thin structures both accurately and efficiently [1]. In this regard, the solid-shell concept proved to be very interesting, due to its multiple benefits [2-4]. More specifically, solid-shell elements combine the advantages of both structural and continuum FE. The current contribution proposes quadratic solid-shell elements for the 3D modeling of thin structures in the context of explicit dynamic analysis. The formulation of these FE is based on a purely 3D approach, with displacements as the only degrees of freedom. To prevent various locking phenomena, a reduced-integration scheme is used along with the assumed-strain method. The resulting formulations are computationally efficient, since only a single layer of elements with an arbitrary number of through-thickness integration points is required to model 3D thin structures. The performance of these elements is first assessed through a set of selective and representative nonlinear benchmark tests. Then, attention is directed to the simulation of deep drawing processes involving complex non-linear loading paths, anisotropic plasticity and double-sided contact. The numerical results demonstrate the good performance of the proposed elements in the modeling of 3D thin structures, using only a single element layer through the thickness.

References

1. T. Belytschko and L. Bindeman. Assumed strain stabilization of the eight node hexahedral element. Computer Methods in Applied Mechanics and Engineering 105 (1993) 225-260.
2. F. Abed-Meraim and A. Combescure. SHB8PS-a new adaptive, assumed-strain continuum mechanics shell element for impact analysis. Computers and Structures 80 (2002) 791-803.
3. A. Legay and A. Combescure. Elastoplastic stability analysis of shells using the physically stabilized finite element SHB8PS. Int. J. Num. Meth. Engng. 57 (2003) 1299-1322.
4. F. Abed-Meraim and A. Combescure. An improved assumed strain solid-shell element formulation with physical stabilization for geometric non-linear applications and elastic–plastic stability analysis. Int. J. Num. Meth. Engng. 80 (2009) 1640-1686.