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A simple reduced integration hexahedral solid-shell element for large strains

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Abstract

In this paper a hexahedral solid-shell element with in-plane reduced integration is developed. The element is intended to the analysis of thin/thick elastic-plastic shells with moderate to large strains. Developed within the framework of a total Lagrangian formulation, the element uses as strain measure the logarithm of the right stretch tensor ($\mathbf{U}$) obtained from a modified right Cauchy-Green tensor ($\bar{\mathbf{C}}$). The modifications, in order to remove transverse shear, Poisson and volumetric locking, are three: a) a classical assumed mixed shear strain approximation for C_{13} and C_{23} b) an assumed strain approximation for the in-plane components $C_{\alpha\beta}$ and c) an enhanced assumed strain for the through the thickness normal component C_{33} (one additional degree of freedom). The first five components of $\bar{\mathbf{C}}$ are interpolated to the integration points from values at the center of the top and bottom faces. An arbitrary number of integration points is used in the transverse direction and a stabilization scheme is used to avoid spurious modes due to the in-plane sub integration. Several examples are presented that show the locking-free behavior and the very good performance of the presented element for the analysis of shells with geometric and material nonlinearities, including quasi-incompressible elastic and elastic-plastic with incompressible plastic flow models.

Keywords: Finite elements, solid-shell, hexahedral, large strains, reduced integration, stabilization

1. Introduction

The continuous improvement in computing facilities and the need to enhance various aspects of the models in order to achieve more faithful simulations has remarkably increased the use of solid elements for both structural