Simulation of structural applications and sheet metal forming processes based on quadratic solid–shell elements with explicit dynamic formulation

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Abstract

In this work, nonlinear dynamic analysis of thin structures is investigated using quadratic solid–shell (SHB-EXP) elements. The proposed SHB-EXP elements are based on a fully three-dimensional formulation using an in-plane reduced-integration scheme along with the assumed-strain method in order to alleviate most locking phenomena. These developments consist of a twenty-node hexahedral element, denoted SHB20-EXP, and its fifteen-node prismatic counterpart, denoted SHB15-EXP. The formulation of these elements is combined with fully three-dimensional behavior models, including elastic behavior as well as anisotropic plastic behavior for metallic materials. The resulting formulations are implemented into ABAQUS explicit/dynamic software package in the framework of large displacements and rotations. First, to assess the performance of the SHB-EXP elements, four representative nonlinear dynamic benchmark tests have been conducted. Then, impact / crash problem and deep drawing of cylindrical cup have been performed to demonstrate the capabilities of the SHB-EXP elements in handling various types of nonlinearities (large strains, anisotropic plasticity, and double-sided contact). Comparisons with results obtained by ABAQUS elements as well as with reference solutions taken from the literature show the good capabilities of the developed quadratic SHB-EXP elements for the explicit dynamic simulation of thin structures.

Keywords: finite elements, quadratic solid–shell elements, explicit dynamic analysis, 3D simulations, thin structures, sheet metal forming.

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