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EFFICIENT ANALYSIS OF GEOMETRICALLY NONLINEAR DEPLOYABLE THIN SHELL STRUCTURES USING CARRERA UNIFIED FORMULATION

Abstract

In this study, the Carrera Unified Formulation (CUF) is developed as an alternative finite element approach to modelling long, deployable, thin shell structures. The advantage of the CUF approach is in the approximation of the span-wise coordinate axes of a long structure using one-dimensional shape functions. Under this consideration, CUF provides an efficient approach to simulating long deployable shells compared to 3D continuum, 2D shell, or continuum shell based finite element approaches. Due to the slenderness and the length of thin shell structures, both 3D continuum and shell models can be limited in simulating their behavior. In addition, these models can be latent with numerical locking phenomenon. To evaluate the accuracy and the efficiency of CUF, a tape spring shell structure is examined. The analysis is performed in the geometrically nonlinear regime, where the structure is bent to simulate the formation of localized folds during the process of coiling. In this work, the total Lagrangian finite element based on the CUF assumptions is developed. An implicit arc-length method (Riks method) is considered in order to capture the unstable equilibrium path of the tape spring associated with geometric nonlinearities. This study compares the predictions and the efficiency of CUF to the 3D continuum, 2D shell, and continuum shell models available in the commercial software, ABAQUS. Convergence studies are also conducted. In addition, all the simulations are verified with experimental test results. By comparing the experimental and numerical results for the tape spring structure, the goal is to develop and verify the utility of CUF for application towards the broader class of deployable, long thin shell structures.