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DOUBLY-CURVED SHELL FINITE ELEMENTS BASED ON MITC-TYPE TECHNIQUE AND UNIFIED FORMULATION FOR THE ANALYSIS OF MULTILAYERED STRUCTURES

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ABSTRACT

Multilayered structures, such as sandwich panels, composite laminated structures are extensively used to build large part of next generation aircraft, spacecraft and advanced components of ship and automotive vehicles.

Analysis of failure mechanisms in layered structures demands an accurate evaluation of strain and stress fields in each lamina. Advanced shell models with variable kinematic as well as zig-zag theories have been proposed in last three decades literature. However, the solutions of real structures with complex geometries and boundary conditions requires the use of computational methods. Among these numerical methods, a relevant role is played by finite element method, FEM [1]. On the other hand, numerical models could introduce numerical mechanisms that put severe limitations on the use of well established continuum mechanic theories. This is the case of the shell formulation which demands specific efforts to overcome shear and membrane locking [2]. Efficient shell elements are known for linear and nonlinear analysis of traditional shell structures made by isotropic one layered materials.

The formulation of an efficient and robust shell finite element for the analysis of multilayered composite structures is the topic of this work. The Mixed Interpolation of Tensorial Components (MITC) technique, which was originally employed for Reissner-Mindlin type plate/shell elements, has been recently extended to refined shell elements with cylindrical geometry to develop locking free multilayered elements [3].

In this work, computationally robust refined shell elements with double constant curvature (see Figure 1) are obtained by referring to variable kinematic modeling in the framework of Carrera Unified Formulation (CUF) [4]. Linear, parabolic, cubic and fourth order displacement fields in the shell thickness direction are used. Both cases of equivalent single layer (the multilayered shell is seen as an equivalent one layered shell) and layer-wise (each layer is considered as an independent shell) variable descriptions are accounted for. Nine

nodes elements are considered and a number of applications are developed for isotropic and multilayered anisotropic shells. The performances of the element are then tested for solving benchmark problems involving both thick and thin multilayered shells.

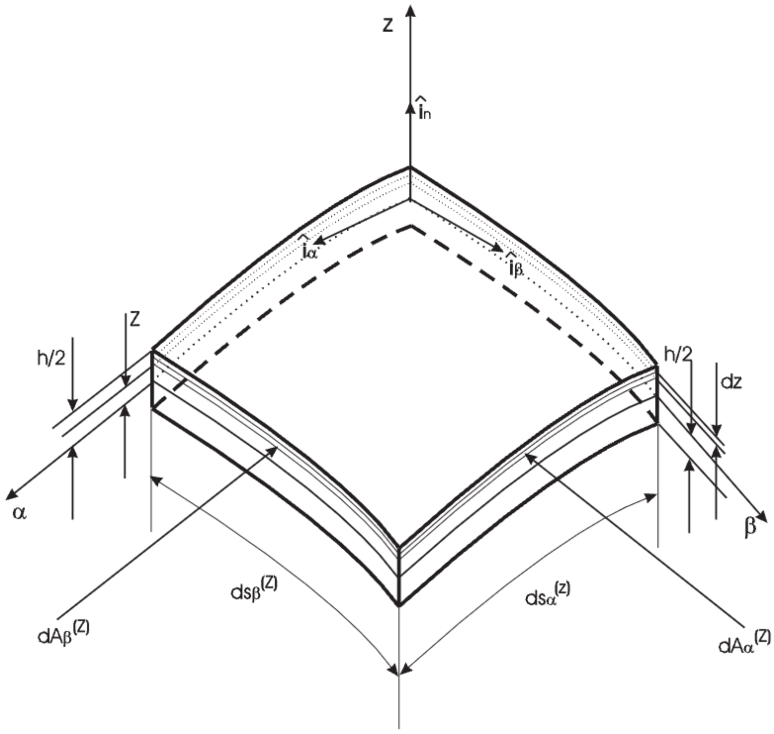

Figure 1: Doubly-curved shell.

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