TITLE: Isoparametric shell finite elements based on Unified Formulation

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The most of the finite elements, available in literature, are formulated on the bases of axiomatic-type theories. The majority of early FEM calculations were performed on the basis of classical models such as the Kirchhoff-Love theory or the First-order Shear Deformation Theory (FSDT), but they present several limits. In recent years, considerable attention has been paid to the development of higher order shell models that are able to approximately represent three-dimensional effects. Especially, the possibility to use complete three-dimensional material laws within shell analysis has been the major motivation for the development of such models. Ramm and Bischoff formulated a shell finite element based on a 7-parameter theory [1], including a stiffness stretch of the shell, in which the extra strain term is incorporated via the enhanced assumed strain concept in order to overcome the locking phenomenon. Following this example, a shell finite element based on the Carrera's Unified Formulation (CUF) is here presented. The CUF has been developed by Carrera [2] for layered structures and its main feature is to include in a unified manner many theories that differ for the order of expansion of displacements in the thickness direction and the variable description at multilayer level, Equivalent Single Layer (ESL) or Layer Wise (LW). The isoparametric element interpolation is used in order to extend the analysis to structures with arbitrary geometry. A nine-nodes element is considered and the Mixed Interpolation of Tensorial Components (MITC) method is applied to contrast the membrane and shear locking. The governing equations are derived from the Principle of Virtual Displacements for the linear static analysis of some typical problems from the literature and the solutions are calculated using the different models contained in the CUF.

References:

[1] Bischoff, M., Ramm, E., On the physical significance of higher-order kinematic and static variables in a three-dimensional shell formulation, *International Journal of Solids and Structures*, 37, 2000, 6933-6960.

[2] Carrera, E., Theories and finite elements for multilayered plates and shells: a unified compact formulation with numerical assessment and benchmarking, *Archives of Computational Methods in Engineering*, 10(3), 2003, 215-296.