10th International Conference on Composite Science and Technology
ICCST/10
A. L. Araújo, J. R. Correia, C. M. Mota Soares, et al. (Editors)

Abstract ID-PL01

LARGE DEFORMATION ANALYSIS OF LAMINATED COMPOSITE AND FUNCTIONALLY GRADED STRUCTURES: RECENT DEVELOPMENTS E MODELS

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Summary: In this lecture a high-order spectral/hp continuum shell finite element for the numerical simulation of finite deformation mechanical response of isotropic, laminated composite, and functionally graded elastic shell structures is discussed [1,2]. The shell element is based on a modified first-order shell theory with a seven-parameter expansion of the displacement field. The seventh parameter is included to allow for the thickness stretch and the use of fully three-dimensional constitutive equations in the numerical implementation. The virtual work statement is integrated numerically through the shell thickness at each quadrature point of the mid-surface; hence no thin-shell approximations are imposed in the numerical implementation. The finite element coefficient matrices and force vectors are evaluated numerically using appropriate high-order Gauss-Legendre quadrature rules at the appropriate quadrature points of the element mid-surface. For laminated composite shells, a user prescribed vector field (defined at the nodes) tangent to the shell mid-surface is introduced. This discrete tangent vector allowes for simple construction of the local bases associated with the principal orthotropic material directions of each lamina. As a result, one is free to employ skewed and/or arbitrarily curved elements in actual finite element simulations. Through the numerical simulation of carefully chosen benchmark problems, it is shown that the developed shell element is insensitive to all forms of numerical locking and severe geometric distortions and predicts very accurate displacement and stress fields.

Acknowledgements: The research reported herein was supported by Air Force Office of Scientific Research (Award No. FA-9550-09-1-0686) and CONACYT scholarship to the second author.

References

[1] G. S. Payette and J.N. Reddy, "A seven-parameter spectral/hp finite element formulation for isotropic, laminated composite and functionally graded shell structures," Computer Methods in Applied Mechanics and Engineering, 278, 664-704, 2014.
[2] J. N. Reddy, An Introduction to Nonlinear Finite Element Analysis, 2nd ed., Oxford University Press, Oxford, UK, 2015.