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Stress analysis of laminated composite and sandwich cylindrical shells using a generalized shell theory

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Abstract. In this article, stress analysis of laminated composite and sandwich cylindrical shells is presented using equivalent single layer higher-order shell theories. A theoretical unification of the several shell theories is presented using a generalized shell theory. A theory is independent of the choice of shape function associated with the transverse shear stress. The present theory satisfies traction free conditions on the top and bottom surfaces of the shell. The principle of virtual work is employed to formulate governing equations and boundary conditions. Closed-formed analytical solutions are obtained using the Navier's solution technique. Numerical results are obtained for simply supported laminated composite and sandwich cylindrical shells.

Keywords: a generalized shell theory; laminated; sandwich; cylindrical shells; stress analysis

1. Introduction

Shell type structures carries loads and moments by a combined membrane and bending actions. Therefore, they are widely used in many engineering applications such as aerospace, automotive, civil, mechanical, etc. The stress analysis of laminated composite and sandwich cylindrical shells is of general interest to the researchers. The laminated shells made up of fibrous composite materials have high strength-to-weight and stiffness-to-weight ratios. Due to low transverse shear moduli of fibrous composite materials, transverse shear deformation is more significant in the kinematics of laminated and sandwich shells. Equivalent single layer (ESL) theories are widely used for the analysis of laminated composite beams, plates and shells. ESL beam, plate and shell theories are mainly classified into classical theory (Kirchhoff 1850), first order shear deformation theory (Mindlin 1951) and higher order shear deformation theories (Sayyad and Ghugal 2015, 2017a, Liew *et al*. 2011, Qatu and Asadi 2012). Classical shell theory and first first order shear deformation theory are inaccurate to predict correct bending behaviour of thick shells made up of composite materials in which transverse shear deformation is more significant. Therefore, researchers have developed higher order shear deformation theories to predict accurate bending behaviour of thick laminated

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