Abstract

Composite materials have significance presence in all major fields and preferred over monolithic materials due to their higher specific strength, higher specific stiffness, extensive tailoring capability, better corrosion resistance and enhanced fatigue life. Laminated composites are weak in shear due to their low shear modulus. To overcome the limitation of low shear strength of laminated composite, three dimensional (3D) braided composite can be used. Compared to laminated composite, the 3D braided composite have improved stiffness and strength in the thickness direction, better damage tolerance and fracture resistance in impact loading. Braided composite has huge potential for aerospace application. The existence of couplings in laminated composite among extension, shearing, bending, and torsion due to loading increases the complexity in predicting the responses. In order to accurate and precise prediction of behavior, development of an accurate mathematical model is necessary. The present work deals with the development of shear deformation theories for modeling and analysis of laminated and 3D braided composite plates and shells. New displacement theories are proposed by expressing the shear deformation effects in terms of non-polynomial shear strain functions. Based upon the functions employed, the theories are termed as trigonometric deformation theory (TDT) and trigonometric-hyperbolic deformation theory (THDT). These theories are examined in details for their effectiveness in static, free vibration and buckling response of laminated and 3D braided composite plates and shell panels. Both models are based upon shear strain shape function which yields non-linear distribution of transverse shear stresses and also satisfy the traction free boundary conditions on top and bottom surfaces of the plate. Thus, the necessity of shear correction factor vanished. Virtual work principle is used to obtain the governing differential equations and boundary conditions. These models are formulated and validated for the structural responses (static, free vibration and buckling) of laminated and braided composite plates and shells. A variety of numerical examples are analysed. The validity of the proposed theories are demonstrated successfully by comparing the results with the exact solution and other existing methodologies. Comparison of various higher order theories with the proposed theories has been performed. It is observed that both proposed theories are efficient and accurate for the static, free vibration and buckling response of laminated and 3D braided composite plates and shells. Intensive numerical studies of 3D braided composite are performed in detail. It is further observed that the geometric parameter (aspect ratio, span thickness ratio, curvature ratio), boundary condition, fiber volume fraction and braiding angle have significant effect on the response of the laminated/3D braided composite plates and shells. In the framework of finite element analysis, both proposed theories anticipate exemplary results for the laminated and 3D braided composite plates and shells compared to the existing theories. The comparison study clearly clarifies the necessity and importance of present study.

Author keywords: Composite materials; 3D braided composite; Plates and Shells; Shear deformation theories; laminated composite; Finite element analysis.

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