Abstract

Three-dimensional textile composite (3D) is one of the novel classes of composite materials in the twenty-first century. The notable applications of the three-dimensional braided composite are already found in numerous fields like Aerospace (Aircraft, Rockets, Jet planes), Civil structure, Mechanical components, etc. It has distinct advantages over laminated composites, such as anti-delamination capability, high damage tolerance, superior in-plane stiffness, high strength-to-weight ratio, high impact resistance, etc. In 3D textile composite, some of the fibers are oriented in the thickness direction, which is used to increase the stiffness and strength in the thickness direction. The microstructure configuration of the braided materials is pretty knotty. To ascertain the endurance of structural components made of textile composites, studies on variations in mechanical properties and structures are essential. So, it is crucial to establish an accurate mathematical model to compute the equivalent mechanical property of the braided configuration. These kinds of textile composite/ braided structures may be subjected to various loads such as static, dynamic, impact, etc. It is very important to find out the actual responses like vibration, static, and impact the behavior of these structures. In the last two decades, most of the investigations carried out were based on deterministic models, but few researchers focused on the uncertainty/ stochastic analysis of composite plates and shells. Uncertainty quantification is the science of quantitative characterization and reduction of uncertainty in mathematical models and real-world applications. It is very important to incorporate the uncertainties into an explanation for modeling and analysis of the structural members for useful and accurate information about the safe and reliable design

In this present investigation, the equivalent mechanical properties of the 3D braided composite panels are calculated using bridging models based on the volume averaging method (VAM). The 3D third-order shear deformations theory (TSDT) with twelve-degree freedom per node using the eight nodded isoparametric 3D finite element method is used to model the geometry of the shell panels. In this theory, transverse displacement is the function of the thickness coordinates, which are the unique advantages of this theory. The generalized dynamic equilibrium equation is derived from Lagrange's equation of motion. The Matlab ODE solver has been used to solve the standard eigenvalue problem. In the case of rotating panels, for moderate rotational speeds, the Coriolis effect is not considered. The time-dependent dynamic problems are solved using the Newmark direct time integration method. The time histories contact force of the 3D braided panels due to low-velocity impact is calculated based on non-linear modified Hertzian contract law. Various validations and convergence studies are performed to ensure the accuracy and correctness of the present numerical models.

In this study, several deterministic investigations like free vibration, static, forced vibration, and low-velocity impact are studied in detail by varying several parameters. The reliability analysis of twisted 3D braided composite plates and shell panels in stochastic free vibration and static analysis using TSDT by employing the Response surface method (RSM) and Kriging model approach is performed.

Keywords: TSDT; Braided composite; Bridging model; VAM; Plate; Shells; Rotation; Twist structure; MCS; RSM; Static; Free vibration; Forced vibration; Low-Velocity Impact.