INFLUENCE OF RELATIVE POSITIONING OF TOWS ON MECHANICAL PROPERTIES OF THIN WOVEN COMPOSITES

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Limited capacity in launch vehicles was overcome by the usage of deployable structures. They allow large structures to be packed into compact configurations. Woven fibre composite laminates eliminate the need of mechanical actuators which are heavy and complex to operate. Further the woven fibre composite laminates has gain a significant recognition in the aerospace industry, because of their self-deploying nature, high strength to weight ratio and tailorable material properties. However, these structures experience extreme curvatures during stowage, which result in change in mechanical properties of the material. Hence, it is important to predict the changes in mechanical behaviour of woven fibre composites to optimize future designs. Several studies have been conducted to capture the variations in mechanical properties by changing various characteristics of woven fibre laminates using analytical methods and numerical modelling techniques due to the highly expensive experiment procedures. Numerical modelling techniques provide high leverage over the other methods due to complex nature of the material and availability of high computational power.

A meso-mechanical representative unit cell (RUC) is generally used to represent woven fibre composite for predicting mechanical behaviour in numerical modelling environment. Several parametric studies have been conducted to predict the effect of various geometric and material properties on mechanical behaviour. However, relative positioning of tows has not been studied in detail. The objective of this research is to capture the influence of phase difference between two plies on change in material stiffness of a two-ply plain weave laminate using homogenized Kirchhoff plate based meso-mechanical unit cell modelling technique. First, a series of meso-mechanical RUC models with different relative positionings of tows were modelled. Then the constitutive relationship was derived for each RUC model. Here, 0°, 90° and 180° phase difference cases were considered and variation of extensional stiffness, shear stiffness, bending stiffness and twisting stiffness along with phase differences were analysed. Then, the obtained finite element results were compared against the experiment results available in literature.

It has been shown that, the axial and bending stiffness values have considerable variations and minimal change has been observed in shear and torsional stiffnesses with relative positioning of tows. The experimental validation concludes that, the developed meso-mechanical unit cell model is capable of capturing the bending stiffness with a good accuracy but overpredicts the axial and shear stiffnesses. Further refined analysis on phase difference angle of tows considering cases in between can be used to improve the accuracy of prediction. Further consideration should be given on the models with asymmetric relative positions, that may lead to a shift in neutral plane of RUC and eventually affect the axial-bending coupling response of the material.

Keywords: woven fibre composites; phase difference; numerical modelling; representative unit cell; ABD Stiffness Matrix

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