Paper ID: 52697
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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COMPRESSIVE RESPONSE AND FAILURE OF A MICROMECHANICAL MODEL FOR CONFINED UNIDIRECTIONAL FIBER REINFORCED COMPOSITE

Abstract

The present computational research is based on an analytical study concerning the confinement of fiber-reinforced polymer composites. The approach used was originally developed for the seismic design of reinforced concrete columns and involves the structure to be confined by transverse reinforcement.

To this end, the Representative Volume Element consists of a bundle of one hundred unidirectional high-stiffness carbon fibers which are radially confined with glass fiber and together embedded in a surrounding epoxy matrix. The longitudinal compressive response of T700S/RTM resin confined with a spiral made of S2-Glass fiber is studied using the ABAQUS commercial finite element (FE) code. The adoption of a closed and ground helical compression spring at constant pitch was determined by its capability of creating a radial compression in a very continuous way avoiding peaks.

The development of a 3D FE based micromechanical model is carried out under the assumption of perfectly straight carbon fibers packed in a hexagonal configuration at a given volume fraction. Although there are parameters that are neglected in this preliminary study like the interphase properties, the randomness of the unidirectional carbon fibers, and the manufacturing process associated defects, the micro-model gives a better estimation of the initial processes of damage and failure.

Subsequently, for this class of materials, initial fiber misalignment along with material nonlinearity leads to the initiation of a fiber kinking mechanism. To study the influence of this mechanism, matrix micro-damage is modelled using Mohr-Coulomb failure criterion to estimate the material nonlinearity whereas the fiber bundle is considered to be anisotropic. Even though kinking is a dynamic event which involves a large amount of kinetic energy, the problem can be simplified using an arc-length based Riks solver. In addition, a parametric study will be carried out to investigate the effects of varying magnitudes of compressive strength with various initial fiber misalignment angles. The load carrying capability is expected to be preserved due to the presence of lateral confinement but the compressive strength will be more affected by fiber misalignment.

If the composite can be manufactured in such a way as to form highly aligned fibers, then this could potentially lead to micro-buckling failure initiation. Therefore, fiber micro-buckling is studied employing a buckle and linear static solver. The prediction of the critical buckling stress is compared qualitatively with the one obtained using Euler's Theory of Column. The results from both the analytical and computational model prediction show a good agreement.