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NUMERICAL SIMULATION OF THE STRESS AND STRAIN BEHAVIOR OF VARIABLE STIFFNESS COMPOSITE PANELS

Abstract

Fiber reinforced composites has been widely used in the field of Aeronautics, Astronautics and automobile because of its own outstanding features, such as high specific strength, high specific modulus, designable performance and integral forming easily. This application can significantly reduce the weight and improve flight performances. Benefits of the directional properties of advanced composites could be fully utilized by varying the fiber angles of layups continuously from point to point, which resulting in stiffness properties that change as a function of location, and so this laminates are termed variable stiffness composite panels. In this manner, it is possible to redistribute the loads, in order to respond more adequately to planar stress variations and also divert the loads from the most sensitive regions, such as holes and notches, leading to high efficiency of composite structure.There has been a number of previous articles surveying work on the failure criteria and structural response of composites under different boundary conditions during the last four decades. However, most of these failure theories only focus on in-plane stresses, without taking account of out-of-plane stresses, such as interlaminar shear stresses. It is known that, as a function of spatial location, the stiffness distribution of variable stiffness laminates is nonuniform, and this might result in large gradients in in-plane stress fields, which contribute to the amplification of the interlaminar stresses, and could lead delamination to the dominant failure mode of these laminates. In this work, a method to approximate these interlaminar stresses invoving the use of closed-form expressions of in-plane stresses and equilibrium equations will be developed and applied to variable stiffness composite panels. Furthermore, a failure theory for prediction of failure initiation taking account of the interlaminar stresses, will be extended and applied to multilayer composite laminates. Pagano's three layer case will be investigated for both constant stiffness and variable stiffness cases as the reference cases. A set of analyses with different layup will be carried out to verify the prediction accuracy of the modified failure criterion.