World Academy of Science, Engineering and Technology
International Journal of Mechanical and Materials Engineering
Vol:13, No:12, 2019

Investigation of Failure Mechanisms of Composite Laminates with Delamination and Repaired with Bolts

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Abstract : The interactive deformation and failure mechanisms, including local bucking/delamination propagation and global bucking, are investigated in this paper with numerical simulation and validation with experimental results. Three dimensional numerical models using ABAQUS brick elements combined with cohesive elements and contact elements are developed to simulate the deformation and failure characteristics of composite laminates with and without delamination under compressive loading. The zero-thickness cohesive elements are inserted on the possible path of delamination propagation, and the inter-laminate behavior is characterized by the mixed-mode traction-separation law. The numerical simulations identified the complex feature of interaction among local buckling and/or delamination propagation and final global bucking for composite laminates with delamination under compressive loading. Firstly there is an interaction between the local buckling and delamination propagation, i.e., local buckling induces delamination propagation, and then delamination growth further enhances the local buckling. Secondly, the interaction between the out-plan deformation caused by local buckling and the global bucking deformation results in final failure of the composite laminates. The simulation results are validated by the good agreement with the experimental results published in the literature. The numerical simulation validated with experimental results revealed that the degradation of the load capacity, in particular of the compressive strength of composite structures with delamination, is mainly attributed to the combined local buckling/delamination propagation effects. Consequently, a simple field-bolt repair approach that can hinder the local buckling and prevent delamination growth is explored. The analysis and simulation results demonstrated field-bolt repair could effectively restore compressive strength of composite laminates with delamination.

Keywords : cohesive elements, composite laminates, delamination, local and global bucking, field-bolt repair
Conference Title : ICAMME 2019 : International Conference on Automotive, Mechanical and Materials Engineering
Conference Location : Barcelona, Spain
Conference Dates : December 16-17, 2019