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Strength prediction of notched thin ply laminates using finite fracture mechanics and the phase field approach

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Abstract

Thin ply laminates are a new class of composite materials with great potential for application in the design of thinner and highly optimized components, resulting in potential weight savings and improved mechanical performance. These new composites can stir the development of lighter structures, overcoming current design limitations as well as notably reducing the onset and development of matrix cracking and delamination events. This paper presents the application of two recent modeling methods for the failure analysis and strength prediction of open-hole thin ply laminates under tensile loading, which exhibit a brittle response upon failure: (i) the analytical coupled energy-stress Finite Fracture Mechanics (FFMs) technique, and (ii) the FE-based Phase Field (PF) approach for fracture that is incorporated into an enhanced assumed solid shell element. The predictions obtained using both strategies are compared with experimental data. These correlations exhibit a very satisfactory level of agreement, proving the robustness and reliability of both methods under consideration.

Keywords: A. Composite materials; B. FE-modeling; C. Damage modeling; D. Shells.

1. Introduction

Thin ply laminates, composed by flat and straight plies, with dry ply thicknesses as low as 0.015 mm, are a new class of advanced composite materials with potential benefits that can make composite laminates and structures thinner and, consequently, lighter. For a given laminate thickness, the use of thin plies allow more fiber orientation angles to be accommodated, which is particularly interesting for thin laminates; therefore the design space can be substantially widened. This includes the possibility of using smaller relative fiber orientations between adjacent plies, which is beneficial to mitigate the initiation and propagation of interlaminar fracture events between adjacent plies [1]. The incorporation of thin plies also motivates the

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