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ABSTRACT:

Characterization and Modelling of the Effect of Out-of-Plane Waviness Defects on the Mechanical Behavior of Composite Specimens

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Structural parts made of long-carbon-fiber laminated composites are increasingly used in high-performance applications, but their manufacturing can introduce out-of-plane ply waviness that severely reduces mechanical strength through premature delamination. The impact of these defects depends on their morphology (length, amplitude) and location, making accurate prediction essential for certification [1].

In this work we propose a modelling strategy to quantify the influence of ply waviness on damage mechanisms and ultimate load. Specimens with deliberately induced waviness (via over-length 0° plies) were characterised by optical microscopy and X-ray CT, and the measured geometry was incorporated into a high-fidelity 3-D ply-scale finite-element model using the ONERA Progressive Failure Model (OPFM) [2].

Model predictions are validated through a comparative analysis with experimentally observed damage sequences. Compared to specimens without defects, delamination emerges as an important damage mechanism from the first damage onset onwards. For thermoplastic matrix composites, the defect triggers the onset of large cracks extending through the entire ply thickness, whereas only small cracks are observed in the zone without defect.

[1] C. Fougerouse, Understanding and modelling of the effects of out-of-plane waviness defects on the mechanical performance of a thermoplastic matrix laminate. Ph.D. thesis, Université ParisSaclay (2023), https://theses.hal.science/tel-04280394.

[2] F. Laurin, N. Carrère and J.F. Maire. A multiscale progressive failure approach for composite laminates based on thermodynamical viscoelastic and damage models. Compos. Part A, Vol. 38, pp. 198-209 (2007).