Experimental characterisation of buckling-driven delamination growth in four-point bending tests

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Delamination cracks in composite laminates may originate from manufacturing defects, low-energy impacts, and many other causes. Once present, a delamination crack may propagate due to local buckling producing high interlaminar stresses at the crack front [1]. To investigate this phenomenon, many authors have suggested carrying out four-point bending tests on composite laminated specimens with mid-span, through-the-width delamination cracks [2, 3, 4]. In previous work, we developed an analytical solution for an elastic-interface model of such a test [5].

Herein we present the results of an experimental campaign aimed at validating the abovementioned mechanical model. A 300 x 400 mm^2 laminated plate was manufactured using quasi-unidirectional carbon-fibre fabric and epoxy resin by Microtex Composites for a total of 16 plies and a nominal thickness of 4.8 mm. Ten 220 x 13 mm^2 specimens were cut from the plate to conduct four-point bending tests according to the ASTM standard [6]. A 40 mm long artificial delamination was created at the mid-span of each specimen by introducing a thin layer of polytetrafluoroethylene (PTFE) between the second and third plies.

The experimental tests were conducted using the facilities of the Multi-scale Analysis of Materials Laboratory (MUSAM-Lab) at IMT. A Zwick-Roell universal testing machine with 10 kN load cell was used for displacement control with a rate of 1 mm/min. The Correlated Solution kit for 2D Digital Image Correlation (DIC) was employed to measure the full-field displacement and the delamination length during the test. Snapping instability was observed, followed by crack propagation. Plots of the load vs. crack opening displacement and delamination length have been obtained and compared to the theoretical predictions of our previous model.

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