Characterization of CFRP mode I and mode II cohesive element parameters for 0//0 and +45//-45 interfaces

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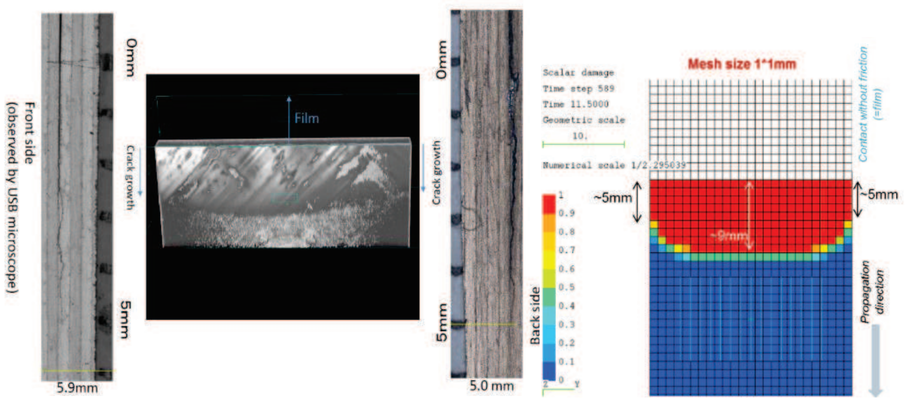
Abstract

Decades of research on composites showed that delamination is one of the most critical parameters responsible for failure of a laminated composite design. Today, the research community is investing effort in understanding, characterizing and predicting the delamination onset and propagation under static and fatigue loading. Characterization of Mode I (opening) and Mode II (shearing) interface failure mode have been extensively studied for 0//0 interfaces [1–8]. However, simulation requires also delamination prediction at “non-zero” interfaces (+ϴ//-ϴ, ϴ being a non-zero angle between two consecutive plies where the delamination occurs). Characterization of such interfaces in static and fatigue are not yet covered by standardized methods but prove to be key for industrial usage [9–12]. This work presents and proposes a robust process flow to characterize interlaminar static properties for CFRP at 0//0 and +45//-45 interfaces. Initial estimation of the interlaminar cohesive element parameters were derived from a set of testing data via standard analytical formulations (compliance calibration, Modified beam theory …). The onset detection was cross-evaluated using optical method (microscopy) and FEA correlation (including damage intraplies model). Finally influence of the testing method (ASTM, JIS), pre-cracking method (mode I or mode II resulting in different crack front shape), pre-crack length and resin system on the identified parameters were investigated using scanning electron microscopy, dynamic mechanical thermal analysis, FEA correlation and X-Ray.



a) *b)*

Figure 1 – a) microscopic and X-Ray pictures ENF +45//-45 interfaces with mode I pre-crack method, b) FEA prediction of onset and propagation in mode I “pre-cracking method” for +45//-45 interfaces.

The process flow for parameter identification herein proposed covers static parameters for standard separation law of cohesive zone models used in Simcenter 3D - Samcef and will be extended to fatigue parameter identifications for the interlaminar fatigue prediction models.

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