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A comparison between different data reduction schemes to evaluate the mode I fracture toughness in carbon-epoxy composite laminates

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Abstract – The objective of this work is to compare values of mode I interlaminar fracture toughness (G_I), for a 0° carbon-epoxy pre-impregnated fabric plies laminate, at room temperature, using different data reduction methods: Modified Beam Theory (MBT), Compliance Calibration (CC), Modified Compliance Calibration (MCC) and Compliance-Based Beam Method (CBBM). Double Cantilever Beam (DCB) tests were performed to evaluate mode I (opening), following ASTM standard test method.

Although composite materials have several advantages compared to metallic materials, one of its disadvantages is the relatively low delamination resistance, one of the most common failure modes of composite structures. Interlaminar fracture toughness represents the energy dissipated by the material as the delamination front advances through a unit area.

A rectangular plate was manufactured using 16 layers of carbon-epoxy pre-impregnated fabric plies orientated at 0° with a PTFE insert at the midplane, from which the specimens were cut. The ASTM DCB test procedure [1] consists of applying load to the specimen arms through bonded loading blocks, in order to open the crack (Fig. 1). During test, load, displacement and crack length are monitored, resulting in the load-displacement curves shown in Fig. 2. MBT, MCC and CC methods are described on ASTM standard for data reduction. However, in CBBM method [2], crack length measurements are not required during tests, simplifying the whole test, from specimen preparation until data acquisition.

According to Table 1 the CBBM method over predicts the toughness values, showing itself a non-conservative method. Therefore, the CBBM method is not recommended for structural dimensioning, but only as reference values.

Table 1: Data reduction methods results

Method	$G_I\left(kJ/m^2\right)$	Standard deviation
MBT	0,587	0,038
MCC	0,584	0,045
CC	0,581	0,040
CBBM	0,617	0,057

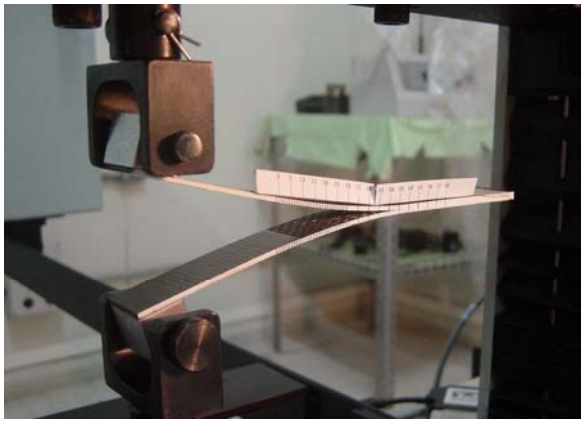

Figure 1: Load application to DCB specimen

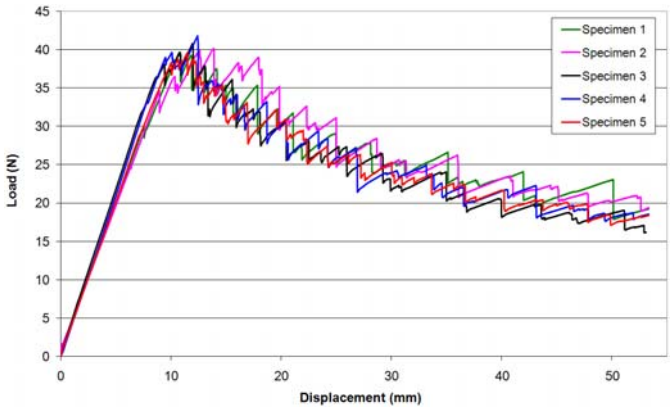

Figure 2: Load-displacement curves for each specimen

References

[1] ASTM D 5528-01, Standard test method for mode I interlaminar fracture toughness of unidirectional fiber-reinforced polymer matrix composites, Annual Book of ASTM Standards, EUA, Vol 15.03, 2001.
[2] Moura, M.F.S.F.; Morais, J.J.L., Dourado, N. A new data reduction scheme for mode I wood fracture characterization using the double cantilever beam test, Engineering Fracture Mechanics, Vol 75, Issue 13, 2008.