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Numerical simulation of two-dimensional in-plane crack propagation in FRP laminates

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Abstract

A numerical investigation was carried out in order to simulate experimental results previously obtained concerning two-dimensional (2D) in-plane crack propagation in laminated glass fiber-reinforced polymer (GFRP) plates. The laminated plates were designed with an embedded circular pre-crack and subjected to quasi-static out-of-plane loads. In order to study the transition from standard fracture mechanics tests, where the crack propagates only in one dimension (1D), to 2D scenarios, additional double cantilever beam (DCB) experiments were carried out on the same material system. Three-dimensional finite element models were developed for the simulation of the experimental fracture responses and cohesive elements were used to take into account the fracture mechanisms acting on the fracture process zone. Compared to the 1D DCB specimens, a much higher value of the total strain energy release rate (SERR) was obtained for the 2D plates, which was correlated to their higher flexural stiffness and to the stress stiffening effect caused by the stretching of their deformed part. Furthermore, and based on the numerical results, it was proved that the area of the fully developed fiber-bridging in the plates can be directly obtained from the experimental compliance vs crack area curves.

Keywords: 2D crack propagation; laminates; fracture; fiber-bridging; finite element analysis.

1. Introduction

Despite the good structural performance of fiber-reinforced composite materials (FRPs) [1], mechanisms such as delamination in laminated components may lead to a considerable

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