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THE MECHANICS OF INTERFACE FRACTURE: (3) EXPERIMENTAL ASSESSMENTS

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Abstract: Three partition theories are assessed against experimental results for the prediction of delamination toughness of fiber-reinforced laminated composites. It is shown that Wang and Harvey's classical partition theory [1, 2] gives the most accurate predictions; Davidson et al.'s non-singular field partition theory [3, 4] also gives accurate predictions; but the singular-field partition theory [3, 4] gives poor predictions.

1. Introduction

Partition of mixed-mode fractures is one of the fundamental research topics in the mechanics of interface fractures. There has been a great deal of confusion concerning it due to the many complexities arising from the involvement of factors such as interface properties, crack extension size, material size, and analytical derivation methodologies, to name only a few. Based on a powerful orthogonal pure mode partition methodology Wang and Harvey and their colleagues have carried out a systematic development of partition theories based on classical and shear-deformable beam and plate theories, and 2D elasticity theory for mixed-mode interface fractures including brittle, cohesive, homogeneous and bi-material interfaces under general loading conditions. Multi-scale interface fractures have been considered including delamination in macroscopic fiber-reinforced laminated composites, spallation of microscopic α -Al₂O₃ films grown by oxidation and adhesion energy of multilayer graphene membranes. Excellent predictions have been observed in comparison with experimental tests. Most of the previous confusions have been cleared. Here, some comparisons are presented for delamination in macroscopic fiber-reinforced laminated composites.

2. Results

Experimental tests [5, 6] from various researchers have shown the partition theory based on Euler beam or classical plate theory [1] gives most accurate predictions of prediction delamination toughness of fiber-reinforced laminated composites. This study presents further experimental assessment using the most thorough and extensive experimental test results in literature [3, 4]. Comparisons are presented (Figure 1) between the test results [3, 4] and three partition theories. Two types of laminates are considered. It is shown that the Euler beam or classical plate partition theory [1, 2] gives the most accurate predictions; Davidson et al.'s non-singular-field partition theory [3, 4] also gives accurate predictions; but the singular field partition theory [3, 4] gives poor predictions.

3. Conclusions

This further experimental assessment shows again that the classical partition theory gives ex-

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cellent predictions for the brittle interface fracture toughness of macroscopic material systems. This is because crack extension develops over a finite-size distance in these materials and Euler beam or classical plate partition theory captures ‘finite small growth’ very well due to its insensitivity to crack growth size. 2D elasticity partition theory applies when crack extension develops very close to the crack tip, in the region dominated by the singular-field.

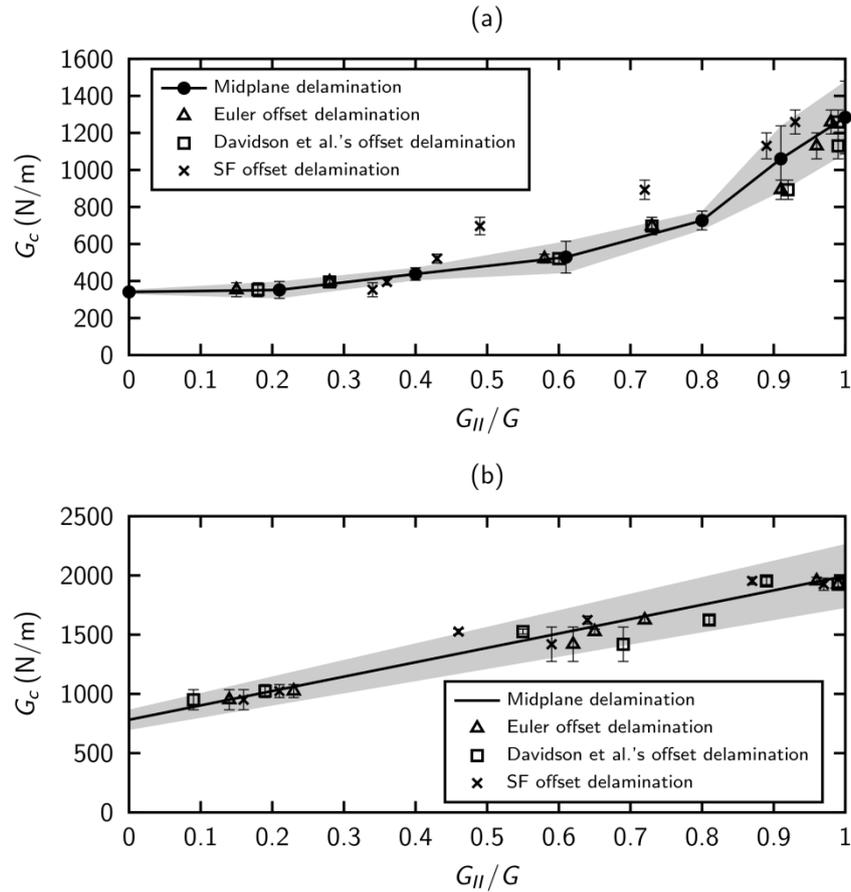


Figure 1. Fracture toughness of midplane and offset delaminations in laminates: (a) Unidirectional C12K/R6376 [2, 3]; (b) Multidirectional T800H/3900-2 [2, 4]

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