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Bimodularity of interface layer and curing stress coupling effects on mixed mode fracture behaviour of functionally graded tee joint

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Abstract

Adhesive bonded tee joints are being used excessively in civil, military aircraft and ship building industries to join light weight Fiber reinforced Polymeric (FRP) laminates to other metal or composite structures. The mismatch of thermo-mechanical properties between adherend and adhesive bond line induces residual curing stresses even during manufacturing stages resulting in unaccounted failure and fracture behaviour of adhesive joints. The present work investigates the influence of bimodulus behaviour of adhesive and curing stresses on interface delamination fracture behaviour of tee joints by conducting a sequential thermal and geometrically non-linear finite element analysis (FEA) iteratively for evaluating strain energy release rate along the delamination front. The stress dependent elasticity problem of interface fracture has been studied based on the concepts of Modified Crack Closure Integral (MCCI) for different numerical specimens with tension compression modulus ratio R varying from 1 to 5 along the bond line for the respective functionally graded bimodular adhesively bonded tee joint. It is illustrated that the variation of bimodularity index has a strong influence on the interface delamination crack propagation characteristics apart from the other aspects of functionally grading and thermo-elastic anisotropy. The influence of bimodularity in comparison to functionally grading is found to be much more significant on mixed-mode fracture behaviour depicting dissimilar variation of G_I, G_{II} and G_{III} along the interface failure front indicating retardation of the interfacial failure propagation rate over certain zones of adherend.

***Keywords*:** Bimodulus, curing stress, functionally graded, modified crack closure integral, strain energy release rate.

1. Introduction

The last two three decades has seen extensive application of adhesive bonded technology in weight saving structures reducing both time, material and above all manufacturing costs. Adhesion methodology has become so versatile and such diversified into the new frontiers of aerospace, marine and automotive applications for joining of composite-composite and composite-metal structural parts thereby rendering inconclusive failure and fracture behaviour coming into play limiting their proposed life span. Though it is not