A UNIFIED NUMERICAL FRAMEWORK FOR MODELING INTERACTIVE FAILURE MODES IN A SINGLE EDGE NOTCHED LAMINATED COMPOSITE UNDER TENSION

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Interlaminar fracture in polymer matrix composite (PMC) laminates, often called delamination, is defined as an out-of-plane discontinuity between two adjacent plies of a laminate. Intralaminar cracks are defined as in-plane discontinuities that advance through the entire laminate thickness in the direction parallel to the fiber direction. These failure modes are competing with each other and one failure mode often initiates other failure mode, resulting in very complicated interactive failure mechanisms.

In this presentation, the interactive failure mechanisms between the intralaminar and interlaminar fracture modes are characterized using finite element analysis with single edge notch tension (SENT) tests. Three major intralaminar failure mechanisms, which are distinct from the microdamage mode, are considered: transverse (Mode I) matrix cracking, shear (Mode II) matrix cracking, and axial (Mode I) fiber fracture. These in-plane damage, once initiated, can trigger other failure mechanisms such as delamination and/or act as delamination migration pathways between adjacent interfaces, leading to the further growth of the delamination. In this presentation, a unified numerical framework is developed to account for these various failure modes to study the interactive failure mechanisms in a single edge notched laminate composite. In plane failure modes are modeled using Enhanced Shapery Theory (EST) and delamination is modeled by Discrete Cohesive Zone Method (DCZM)

From the finite element analysis, delamination triggered by in plane damage is observed and changes in load distribution as a ply in the laminated composite loses a load carrying capability one by one are detected. FEA results are compared against experimental data. The stress-strain response obtained from FEA agrees well with test results and the detailed failure progression is also accurately captured from FEA.