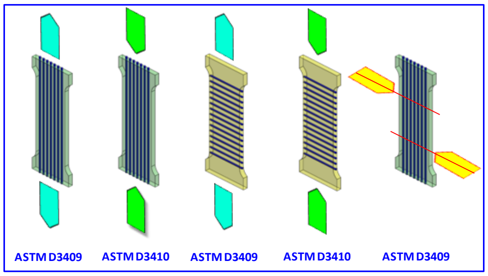
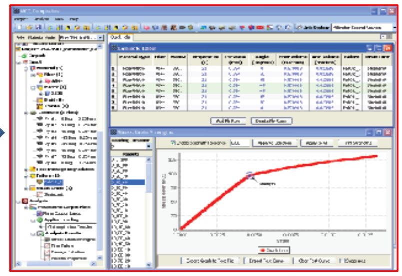
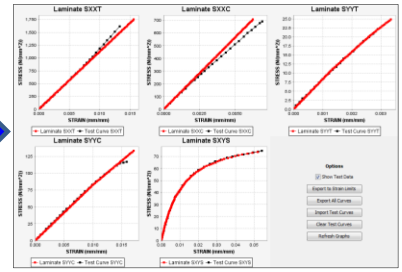
MCQ COMPOSITES

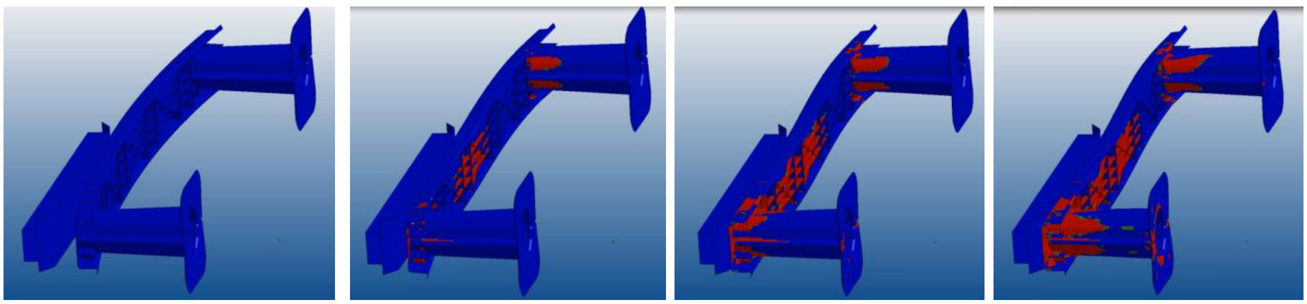


ASTM Standard Coupon Test Data





Material Characterization and Calibration



USAMP-DOE DE-EE0005661 VMM Composites Project

Multi-Scale Progressive Failure Analysis

MCQ Composites is a tool that allows engineers to characterize composites materials, optimize material layouts and evaluate the effect of manufacturing defects on performance and damage tolerance. With its easy-to-use graphical interface, it helps to facilitate material qualification, multi-scale modeling, and design analysis of long/continuous fiber polymer matrix composites. In a short amount of time, end-users are able to generate vast amounts of information for the composite material of interest. MCQ Composites is independent of finite element modeling as it utilizes a unit cell approach for the multi-scale progressive failure analysis.

Key Features:

- ✓ Supports full breadth of 2D/3D composite architectures
- ✓ Considers effect of defects and scatter
- ✓ Determines lamina/laminate limit loads, stresses, and strain
- ✓ Supports multiple failure criteria (in-built)
- ✓ Supports anisotropic matrix
- ✓ Generates material propertities used with commercial FE software and has been validated for several classes of Polymer Matrix Composites

Key Benefits:

- ✓ Rapid assessment of properties
- ✓ Reduction in testing with cost savings
- ✓ Validated material library
- ✓ Strength allowable for reliability
- ✓ Identification of damage initiation/propagation to failure
- ✓ Identification of damage/failure modes
- ✓ Results verified with test data
- ✓ Multi-scale progressive failure analysis

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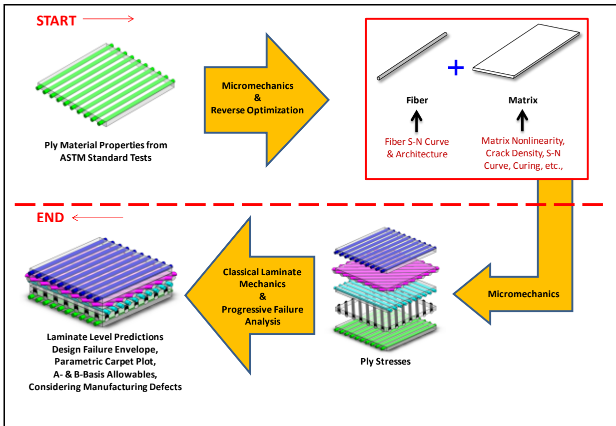

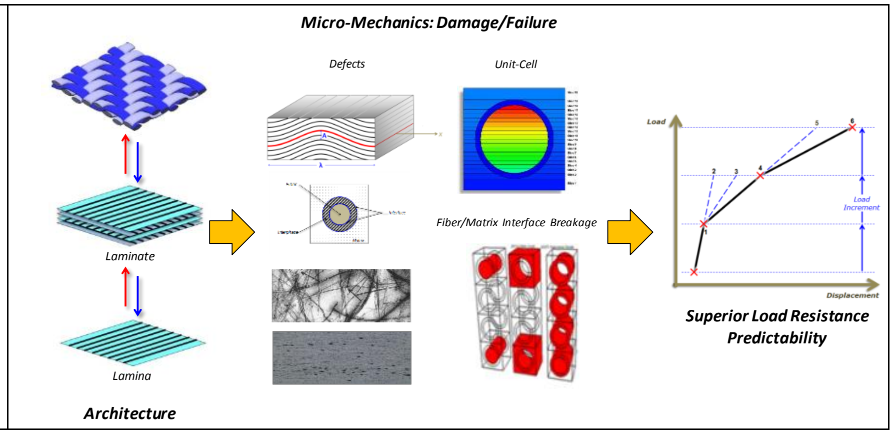

Modules

• **Fiber/Matrix/Ply Calibration**	Reverse engineer the in-situ Young's modulus, Poisson's Ratio, Strength of transversely and isotropic fibers and isotropic matrix from tested in-plane ply properties.
• **Architecture, Fiber/Matrix Calibration**	Reverse engineer the braid architecture from coupon test data. It can be used for reverse engineering the in-situ Young's modulus, Poisson's Ratio, Strength of transversely and isotropic fibers and isotropic/anisoptropic matrix from tested in-plane laminate properties.
• **Ply Mechanics**	Verify ply properties from fiber and matrix constituent properties and variation in fiber and void volume ratio. The analysis relies on micro-mechanics theory.
• **Ply Characterization**	Graphically verify the variation in ply properties and dominant failure zones with variation in fiber and void volume fraction and loading direction orientation with respect to the fibers.
• **Laminate Mechanics**	Predict laminate level material properties using fiber/matrix, ply properties as input along with braid cards for fabric, woven or 3D architecture. Analysis relies on progressive failure analysis, micro-mechanics and classical laminate theory.
• **Material Non-Linearity**	Predicts the in-situ matrix stress strain curve from in-plane shear ASTM standard test data. The analysis can be used to reverse engineer any fiber or ply nonlinearity as well. The analysis relies on progressive failure analysis, micro-mechanics and classical laminate theory.
• **Progressive Failure**	Performs the analysis for the input using material degradation models and iterative process based on user input to ultimately predict the strength, modulus, and laminate and layer-by-layer damage evolution process.
• **Design Failure Envelope**	Predicts failure envelope for lamina or laminates based on the chosen failure criteria after the above calibration process.
• **Parametric Carpet Plot**	Predicts graphical representation of strength and other material properties of laminates containing symmetric and balanced plies in three different orientations.
• **A- & B-Basis Allowables Calculator**	Predicts A- and B-basis strength allowables based on simple test data.
• **A- & B-Basis Allowables Simulator**	Predicts A- and B-basis strength allowables based on material and fabrication uncertainty in the composite laminate material. You can directly enter the scatter from the unidirectional ASTM standard tests as the variation in the constituents.
• **Manufacturing Defects Mechanics**	Predicts effect of manufacturing defects; fiber waviness on ply level properties.
• **Manufacturing Defects Characterization**	Graphically predicts effect of manufacturing defects on ply level properties as a function of variation in fiber waviness.
• **Constituent Fatigue Life**	Reverse engineer in-situ stress versus cycles to failure curve for the matrix using in-plane shear, transverse tension, and longitudinal tension fatigue life curves obtained typically from ASTM standard tests or literature.
• **Progressive Fatigue Life**	Predicts fatigue life curve for laminates from ply or constituent level fatigue life input.
• **Strain Rate Effect**	Calculates Strain Rate of materials/deformation for many materials
• **Curing**	Calculates curing effects; degree of cure, modulus vs. temp, strength vs. temp, density vs. temp, and viscosity vs. temp