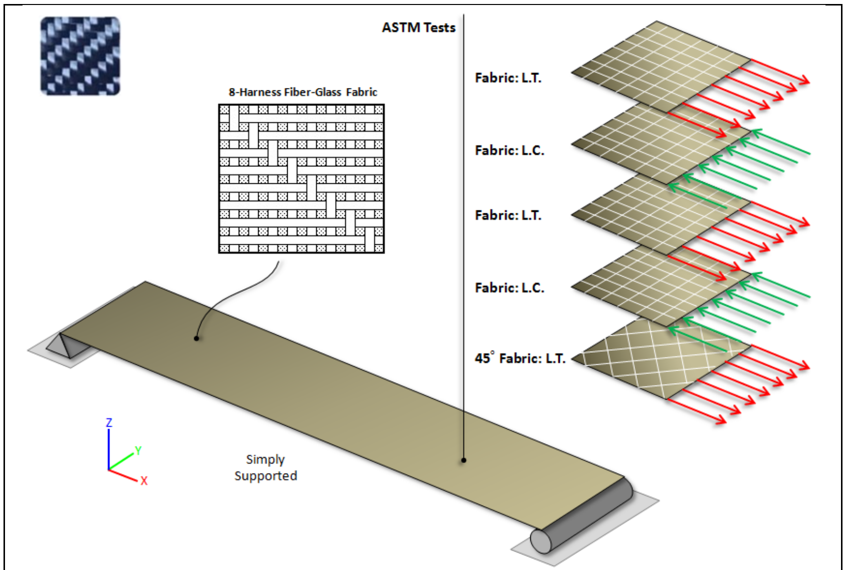
Micro-Mechanics Based Architecture Material Modeling

Challenge

The key challenge of modeling composite architecture based on the current Finite Element approach is its quite time consuming and requires complex modeling. The objective of this case study is to demonstrate optimization of in situ fiber/matrix/braid elastic and mechanical properties from the response variables based on five ASTM static tests, using analytical approach which is fast as well as provides accurate predictions.



Fabric Coupon Model Description

In this case study Toray 7781-2510 fiber-glass fabric material system is modeled assuming 8HS weaves and representing each weave by three stacked fiber/matrix plies, each containing a different fiber volume ratio, depending on the crimp angle. MCQ-Composites offer a way to calibrate the composite architecture based on the data provided by five ASTM tests.

Solution

The methodology employed in the case study includes Classical Laminate Theory (Analytical) and Micro-Mechanics. The step by step process to perform architecture analysis is shown next:

- **STEP1-EGv**: Calibrate the braid/fiber/matrix/laminate system according to the experimental laminate mechanical properties;
- **STEP2-ST**: Calibrate the braid/fiber/matrix/laminate system according to the experimental laminate tensile strength;

- **STEP3-SC**: Calibrate the braid/fiber/matrix/laminate system according to the experimental laminate compressive strength;
- **STEP4-SS**: Calibrate the braid/fiber/matrix/laminate system according to the experimental laminate shear strength;
- **STEP5-InSitu**: Determine the optimized (effective) fiber/matrix properties;
- **STEP6-Laminate**: Determine the optimized laminate properties.

Key Highlights & Benefits
Product: MCQ-Composites (Cure)
Industry: Aerospace
Application: Composite Architecture
Benefits: Architecture Material Modeling using MCQ-Composites is fast and provides accurate predictions

Results & Conclusion

- Excellent comparison between Test Data and MCQ Prediction — Fabric Coupon Elastic and Mechanical Properties is observed

Related Publication

A-Basis and B-Basis Design Allowables for Epoxy-Based Prepreg. TORAY 7781 Finish 558/#2510 Fiberglass Fabric [US Units]. Advanced General Aviation Transport Experiments (AGATE), AGATE-WP3.3-033051-133, Nov. 2002. NIAR, Wichita, KS — USA.

Toray 7781-2510 Fiber-Glass Fabric — Calibration Comparison

	Property	Units	Test	MCQ	% Error
Manufacturer	FVR	%	45.00	48.983	8.85
	VVR	%	3.15	3.146	-0.14
	E_{f11}	[Msi]	—		
	E_m	[Msi]	—		
Fabric Ply (ASTM)	E_{11}	[Msi]	3.448	3.41	-0.99
	E_{22}	[Msi]	3.332	3.34	0.21
	E_{33}	[Msi]	—	2.13	—
	G_{12}	[Msi]	0.634	0.62	-1.67
	G_{23}	[Msi]	—	0.54	—
	G_{13}	[Msi]	—	0.54	—
	v_{12}	—	0.14	0.140	0.11
	v_{23}	—	—	0.27	—
	v_{13}	—	—	0.26	—
	S_{11T}	[ksi]	64.484	58.05	-9.98
	S_{11C}	[ksi]	76.492	69.46	-9.19
	S_{22T}	[ksi]	50.832	55.20	8.59
	S_{22C}	[ksi]	65.436	66.90	2.23
	S_{33T}	[ksi]	—	17.29	—
	S_{33C}	[ksi]	—	35.57	—
	S_{12S}	[ksi]	18.446	18.38	-0.33
	S_{23S}	[ksi]	—	16.75	—
	S_{13S}	[ksi]	—	16.83	—

Test Data vs. MCQ Prediction (Fabric Coupon Elastic and Mechanical Properties)