

Automotive Composites Conference Plasan Carbon R&D with A&P Technology and ORNL

Review of Preliminary Data

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Purpose

- The short term goal of this research project is to provide Plasan Carbon Composites with the data to build our FEA tools, and to improve our understanding of braiding technology.

Mission

- To expand Plasan Carbon Composites' ability to predict the post-yield behavior of carbon fiber products braided with multiple hybrid fibers.

Abstract

Plasan Carbon Composites are developing an automotive door system using composites to reduce weight and maintain safety for passengers in a side impact collision. We are trying a novel approach to manufacturing a composite energy absorbing structure which will significantly improve the cost to manufacture the composite structure.

Current Programs & Supporting Technology

➤ Advanced Materials

- ❖ In-house Materials Lab
- ❖ High T_g Resins for advanced paint technologies
- ❖ Thermoplastic Resins - PPS, PET, Nylon
- ❖ Cyclic Resins-Cyclics, Materia, GE
- ❖ Braided Fibers - A&P, Forte
- ❖ Hybrid woven fibers for energy absorption –
 - Fiberglass
 - Nylon
 - Kevlar
 - Innegra

Technical Support from ORNL

- Oak Ridge National Labs will be using the TMAC, which is a unique machine for measuring crash test data at a constant velocity.
- This first test will test how the braid architecture affects impact resistance. At the moment, predictive FEA software is not well established, so we will be involved in comparing the data from this test to the static loading Finite Element Analysis and developing our own software for predicting post yield behavior of braided composites.

Composite Door Beam

Concept

- Triaxial braided sleeve over foam core
 - ❖ Carbon axial yarns
 - ❖ High elongation bias yarns
- Lateral stiffness varies with displacement
- Initial stiffness function of carbon dominated modulus.
- After carbon fails, lateral stiffness is a function of:
 - ❖ Bias yarn stiffness
 - ❖ Bias yarn angle
 - ❖ Foam compressive stiffness

Development Approach

Composite Door Beam

- Use quasi-static tests to develop preliminary data
 - ❖ Focus on stiffness during secondary phase
 - ❖ Measure load vs. displacement
 - ❖ Fix ends of sub element and displace laterally with hydraulic cylinder (use load cell and LVDT)
- Measure influence on stiffness curve of:
 - ❖ Bias yarn stiffness
 - ❖ Bias yarn angle
 - ❖ Foam compressive stiffness

Preliminary Test Matrix

Composite Door Beam

- Non-reduced matrix includes 12 configurations
 - ❖ Nylon (low E) vs. Aramid (high E) vs. Innegra
 - ❖ Low temperature foam vs. high temperature foam
 - ❖ Initial bias angle 30° (low), 45° (med), 60° (high)
- Preliminary study using non-reduced matrix and 1 sub element per configuration
 - ❖ Permits more full understanding of interactions
 - ❖ Single test/configuration poses small risk
- Use test data to develop modeling capability
- Modeling enables an improved design for second phase
- Impact tests used to characterize second phase design

A&P Technology - Braiding



Test Matrix 1

Braid 1		Braid 2		Braid 3		Braid 4		Braid 5		Braid 6	
Rohacell Foam Core											
Bias	Axial	Bias	Axial	Bias	Axial	Bias	Axial	Bias	Axial	Bias	Axial
Carbon	Carbon	Carbon	Carbon/ Innegra	Glass	Carbon	Aramid	Carbon	Nylon	Carbon	Innegra	Carbon
PL7095 (6)						PL7100 (3)		PL7092 (3)			
PL7096 (6)		PL7097 (3)		PL7098 (6)		PL7099 (3)		PL7102 (3)		PL7103 (6)	
PL7094 (3)						PL7101 (3)		PL7093 (6)			

Test Matrix 2

Braid 7		Braid 8		Braid 9		Braid 10	
PET (9lb) Foam Core						PET (6lb)	
Bias	Axial	Bias	Axial	Bias	Axial	Bias	Axial
Carbon	Carbon	Aramid	Carbon	Nylon	Carbon	Nylon	Carbon
PL7168 (6)						PL7169 (6)	
PL7097P REV 1 (4)		PL7099P (4)					
PL7094P (3)				PL7093P (9)			

Test Fixture



TMAC measures crash energy forces at a constant velocity

Preliminary Results

- Carbon-carbon samples were the strongest and most stiff (not a surprise) 1 Triaxial layer \approx 1 kN
- Carbon-Innegra had lower stiffness, (\approx 1/2) but the structure held together in post-yield failure about as well as Kevlar
- Samples need to be made thicker and stronger to utilize the TMAC machine to its full potential
- TMAC should be set at a slower speed for future tests; (quasi-static)
- In order to test for the potential advantages of braiding technology, we will need to modify the test fixture to clamp the sample at each end

Conclusions

- This first round of tests were not as conclusive as we'd hoped but a great deal was learned
- Test fixtures and sample preparation need to be modified; rather than measure the smallest, thinnest elements, additional layers will yield more information
- More testing is required to gather data using a quasi-static loading condition
- Benchmarking tests should be done using steel, chrome-moly, and aluminum beams having similar cross sections.

The Long Term Goal

- This project is designed for the improvement of fuel economy of a typical automobile without sacrificing safety, by an innovative use of composite materials. The increased use of composites in automobiles is the best way to **save weight**, improve fuel economy and **maintain a high level of safety** because carbon composites have been shown to absorb more than 2x as much energy per pound as steel or aluminum. Steel and aluminum have about the same specific strength and stiffness (normalized by weight). Carbon fiber, and other composites are capable of better specific strength, but cost has always been significantly higher. Therefore, the goal of this study is to develop a **manufacturable** composite structure which will be **cost-effective** for large scale use by automotive OEMs. This study is very early in development.