THE EFFECT OF REACTIVE PREFORM BINDERS ON COMPOSITE STRUCTURAL PROPERTIES

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INTRODUCTION

CCM is conducting research in cooperation with the US Army Laboratory and Solectria pertaining to the benefits and usage of binders for composite manufacturing

Goals

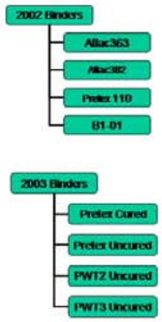
- Manufacture composites with graded properties through the thickness
- Manufacture composites without the use of expensive molds

Potential Solutions

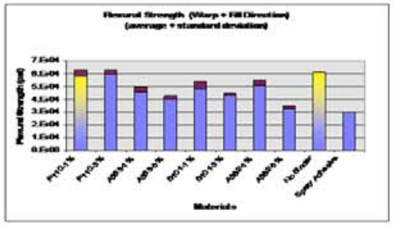
- Spray tackifier (commonly used)
- Has been known to reduce mechanical properties considerably
- Binders
  - Thermoplastic
  - Reactive
  - Rubber

PREVIOUS WORK

Research preformed last year indicated that performs prepared using the Pretex 110 binder displayed mechanical properties similar to neat SC-15/glass composites



PREVIOUS RESULTS



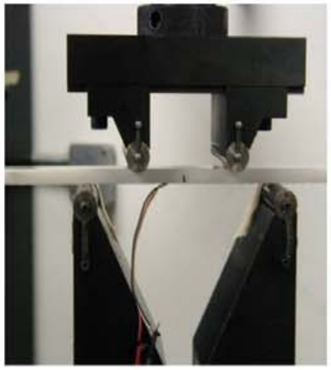
PROJECT

- Perform mechanical characterization tests to assess the effect of the binders on the mechanical performance of the composite
- Composite
  - SC-79 epoxy resin and 24-oz S2 glass woven fabric
- Binders
  - Pretex 110, PWT2, and PWT3
    - PWT2 and PWT3 are experimental binders based on SC-79 chemistry
    - PWT3 includes additional toughening agent
  - 1 wt% present for all binders
- Five groups of samples
  - Pretex cured
  - Pretex uncured
  - PWT2
  - PWT3
  - No binder (control panel)

TESTING

- For each group of samples:
  - Flexure (4-point bending)
    ASTM D 6272
  - Tensile
    ASTM D 638
  - Compression
    ASTM D 3410
  - Interlaminar Shear Strength
    ASTM D 2344
  - Double Cantilever Beam (DCB)
    ASTM D 5528
  - In-Plane Shear
    ASTM D 3518
- At least 5 samples tested for each group

TESTING SET-UP FOR FLEXURE



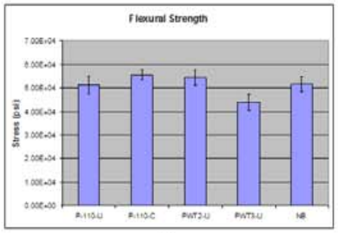
Support span = 16*thickness
Loading span = 0.5*support span
Crosshead speed dependent upon average thickness

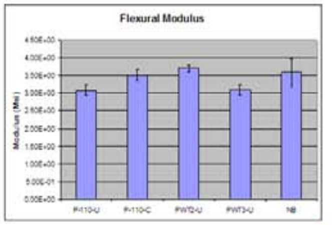
$$R = 0.167ZL^2 / d$$

Z = rate of straining of outer fibers (Z = 0.01)
L = Support span
d = thickness

One strain gage attached
All tests preformed with gage in tension

FLEXURE RESULTS





FLEXURE RESULTS

Flexure Strength and Modulus						
	Strength (psi)	Std Dev	CV (%)	Modulus (Msi)	Std Dev	CV (%)
P-110-U	5.15E+04	3.62E+03	7.0	3.08E+00	1.39E-01	4.5
P-110-C	5.56E+04	2.21E+03	4.0	3.51E+00	1.60E-01	4.6
PWT2-U	5.44E+04	3.53E+03	6.5	3.70E+00	1.08E-01	2.9
PWT3-U	4.40E+04	3.40E+03	7.7	3.09E+00	1.50E-01	4.8
NB	5.16E+04	3.38E+03	6.6	3.59E+00	4.07E-01	11.3

➢Flexural strength was calculated using the formula:

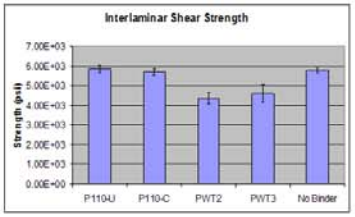
$$S_{flex} = 0.75P_B L / (bd^2)$$

- P = Applied load
- L = support span
- b = width

➢Modulus was calculated using the formula:

$$E_B = S_{flex} / \varepsilon_{flex}$$

IISS SETUP AND RESULTS



➢ Support Span = 4*thickness

Highest short-beam strength
Pretex 110 – uncured
5.86E+03 psi

ILSS RESULTS

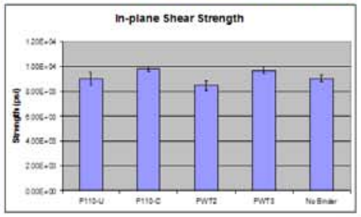
	Strength	Std. Dev.	CV
	psi	psi	%
P110-U	5.86E+03	1.95E+02	3.3
P110-C	5.71E+03	1.63E+02	2.9
PWT2	4.37E+03	2.91E+02	6.7
PWT3	4.60E+03	4.49E+02	9.8
No Binder	5.78E+03	1.38E+02	2.5

Short-beam strength was calculated using the formula:

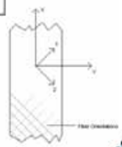
Fabs = 0.75*Pm / (bd)

Pm = Maximum load
b = width
d = thickness

IN-PLANE SHEAR – SET-UP AND RESULTS



Tension test where fibers have a ±45° orientation
Bi-directional strain gage attached



Highest in-plane shear strength
Pretex 110 – cured
9.78E+03 psi

IN-PLANE SHEAR TESTING

In-Plane Shear Strength			
	Strength (psi)	Std. Dev	CV (%)
P110-U	9.01E+03	5.22E+02	5.8
P110-C	9.78E+03	1.96E+02	2.0
PWT2	8.46E+03	4.03E+02	4.8
PWT3	9.70E+03	3.00E+02	3.1
No Binder	9.03E+03	2.43E+02	2.7

Maximum shear stress calculated using the formula:

$$\tau_{12}^{m} = \frac{P^{m}}{2A}$$

CONCLUSIONS

The results of the aforementioned testing showed that cured Pretex 110 and uncured Pretex110 have comparable mechanical properties

Samples can be fully cured to maximize adhesion in performs

Little or no change in values for these properties is observed when the samples with Pretex 110 binder are compared to the control samples with no binder

Using the Pretex 110 binder to manufacture composite parts does not reduce the mechanical performance of the composite

FUTURE WORK

Complete mechanical testing and data analysis
- Tensile tests
- T-peel tests
  - Adhesive properties
  - Various environmental conditions

Conduct research towards the potential use of rubber binders

ACKNOWLEDGEMENTS

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