North American Pultrusion Conference

Alkaline Durability of Pultruded BFRP Bars for Concrete Reinforcement

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About Olin

ONLY BACK-INTEGRATED GLOBAL EPOXY PRODUCER

~8,000 EMPLOYEES

HQ in U.S.

LEADING THE WAY IN EPOXY since the 1950s

SUPERIOR LOGISTICS NETWORK

PRODUCTION AND TECHNOLOGY LABS ON FOUR CONTINENTS

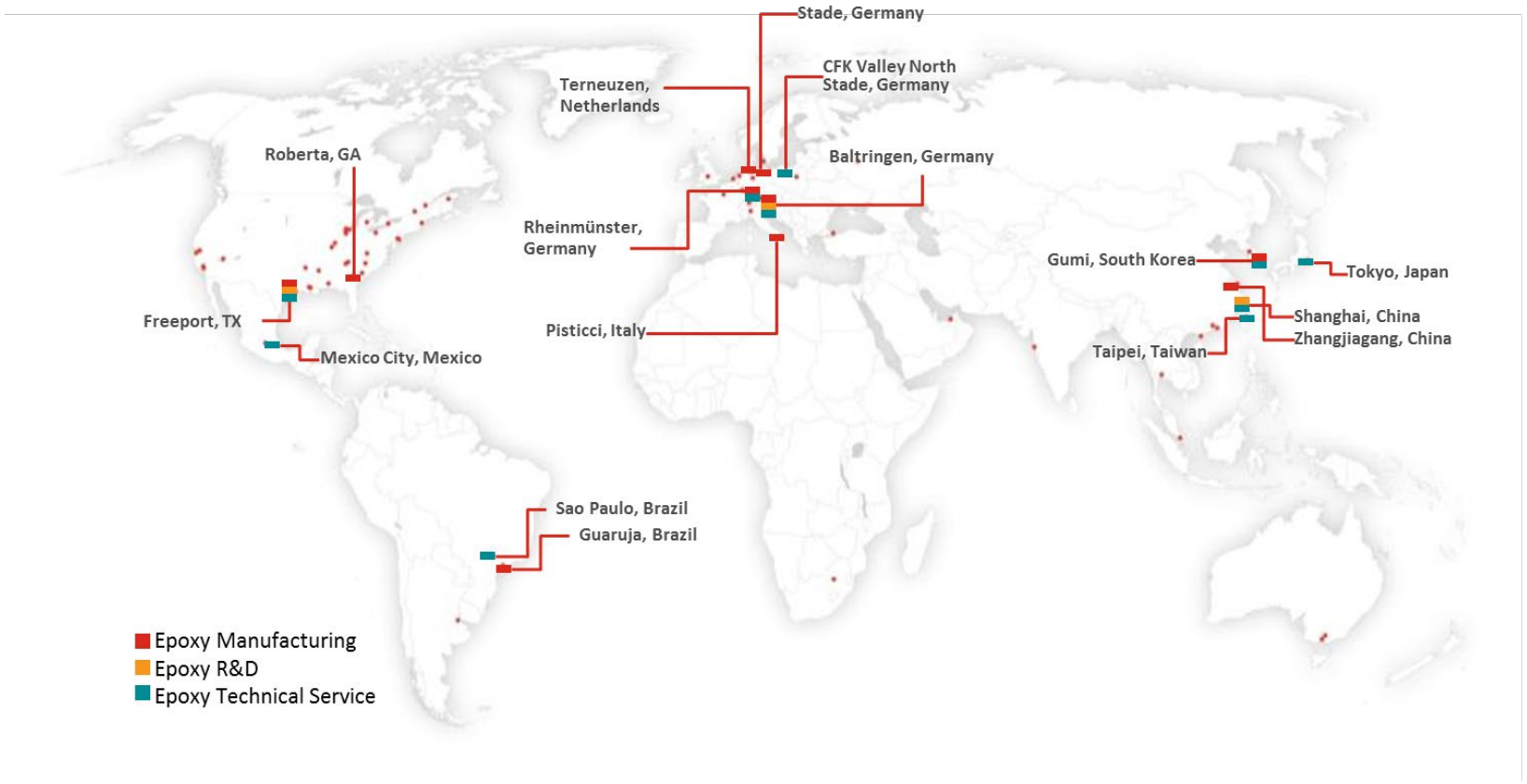
R&D COLLABORATION

Investing in technology and working closely with customers to develop game-changing solutions

ON THE NYSE FOR >100 YEARS

Global Epoxy Presence

Manufacturing and R&D Centers on Four Continents with an Extensive Global Logistics and Distribution Network



Applications of Epoxy Based Composites

Composites based on Epoxy matrices have been used in various applications with extreme durability.

Why Epoxy For FRP Rebar?

STYRENE AND VOC FREE

HIGH CORROSION RESISTANCE

EXCELLENT FATIGUE AND MECHANICAL PERFORMANCE

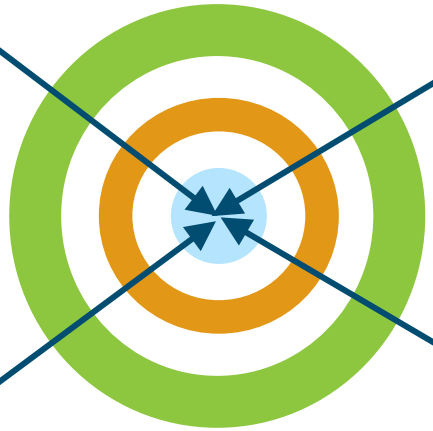
VERSATILE CURE AND PROCESSING

SUPPLY CHAIN RELIABILITY

Objectives

Evaluate the performance of epoxy based BFRP rebars made by industrial production

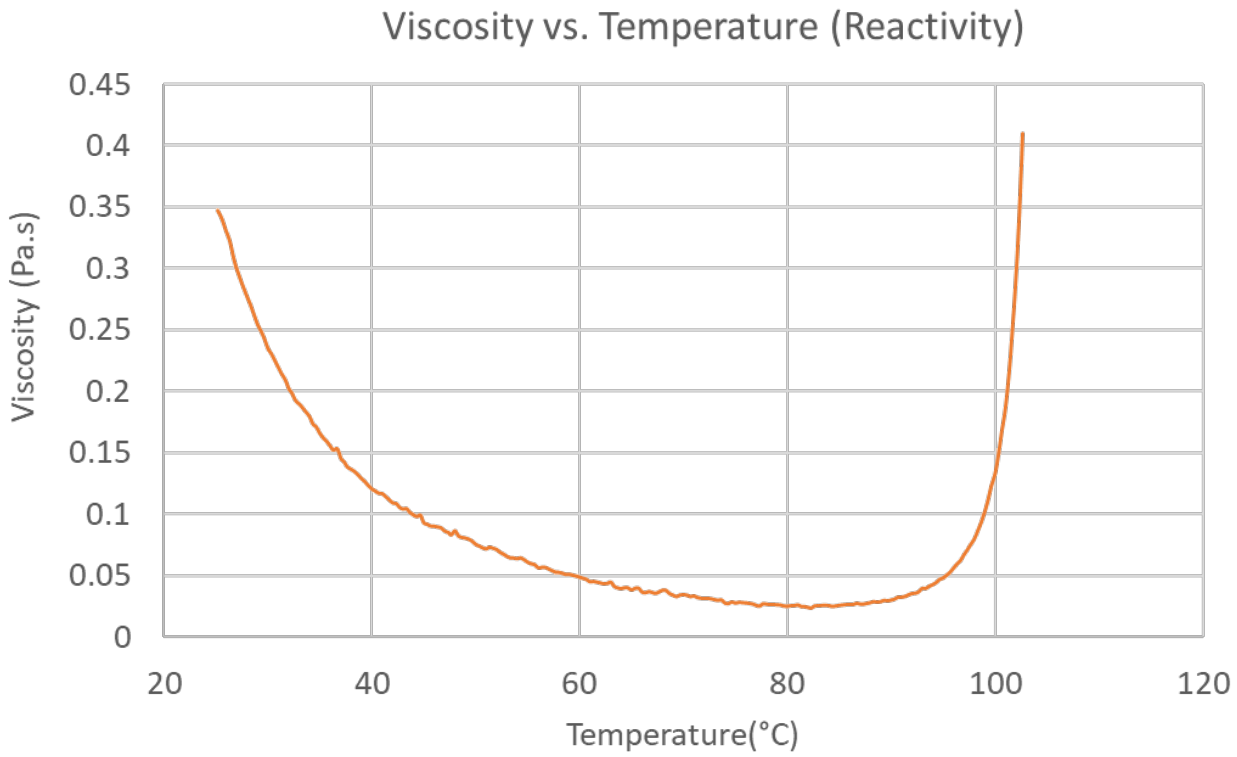
Collect mechanical properties of BFRP rebars before and post alkaline solution treatment

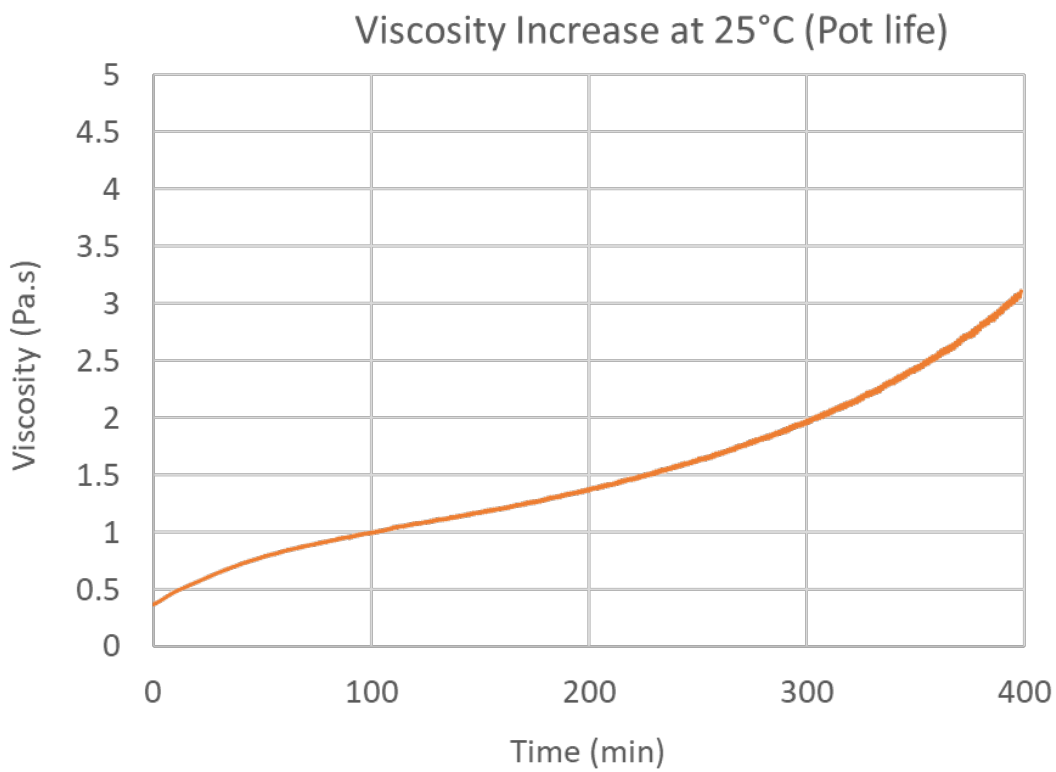


Compare the data acquired from BFRP rebars to FDOT 932 or ASTM D7957

Analyze alkaline durability of BFRP Rebar for Concrete Reinforcement

Rheo-kinetics of Epoxy System



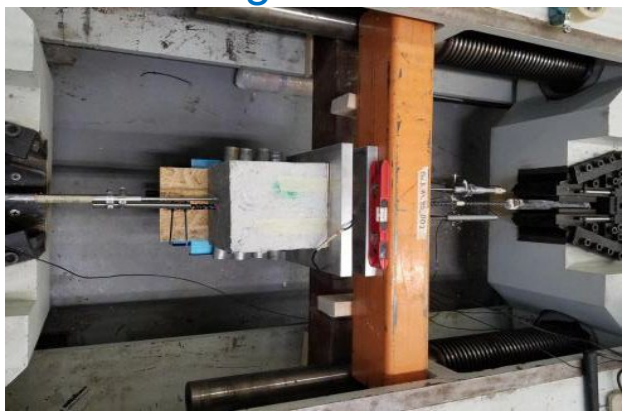


Desired balance of fast reactivity and long pot life

Experiment- Testing Methods (Selected)

ASTM D7205 Tensile

ASTM D7913
Bond Strength to Concrete



ASTM D7914 Bent Bar

ASTM D7617
Trans. Shear Behavior

ASTM E2160
Enthalpy of Polymerization

ASTM E2160
Glass Transition Temp.

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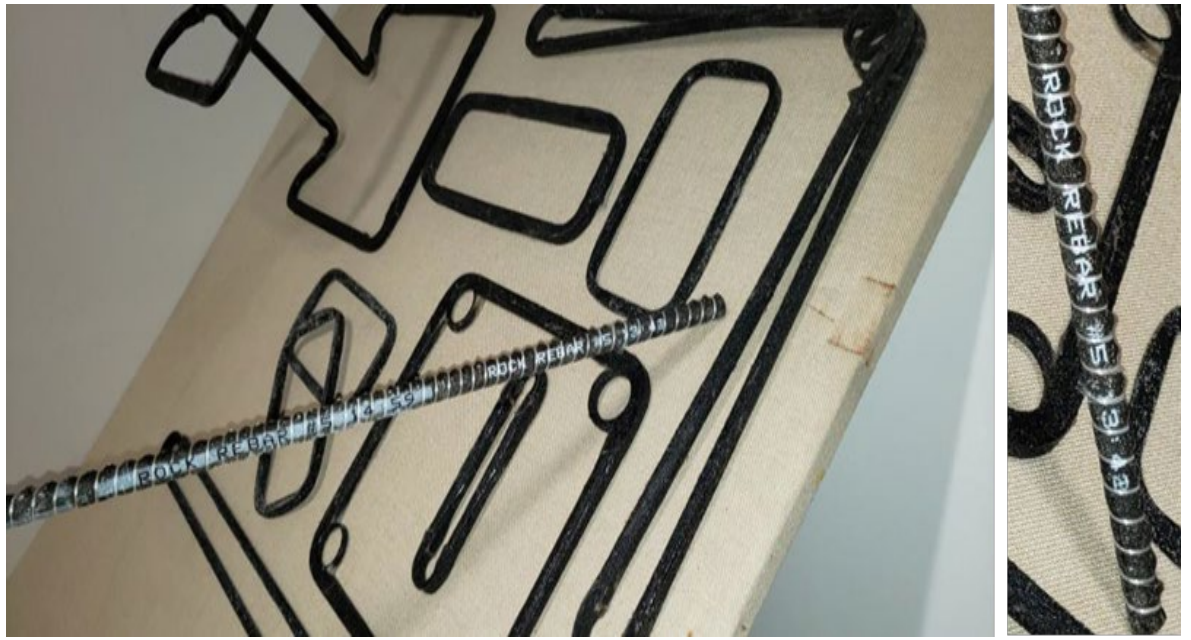
Tested by Structures and Materials Laboratory in University of Miami

BFRP Rebar Behavior Prior to Alkaline Solution Treatment

*Selected data from Sample #5

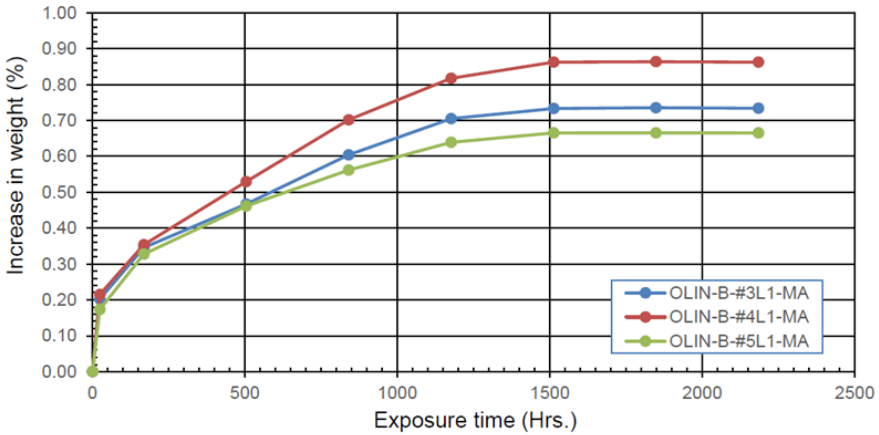
Methods	Test Description	SPEC. FDOT 932	Test Values	Comment
ASTM D7617	Guar. Transverse Shear Strength	>19 ksi	21.0 ksi	Pass
ASTM D2584	Fiber Content (by weight)	>70 %	79.8 %	Pass
ASTM D7205	Guar. Tensile Force	29.1 kip	33.1 kip	Pass
	Tensile Modulus of Elasticity	≥ 6.5 Msi	7.0 Msi	Pass
	Tensile Strain	≥ 1.1%	1.6 %	Pass
ASTM D792	Measured Cross Sectional Area	0.288 to 0.388 in2	0.292 in2	Pass
ASTM D570	Moisture Absorption Short Term	≤ 0.25 %	0.17 %	Pass
	Moisture Absorption Long Term	≤ 1.00 %	0.67 %	Pass
ASTM D7913	Guar. Bond Strength	>1100 psi	1227 psi	Pass
ASTM E2160	Degree of Cure	>95%	99.1 %	Pass
	Glass Transition Temperature (DSC)	>100 °C	139 °C	Pass

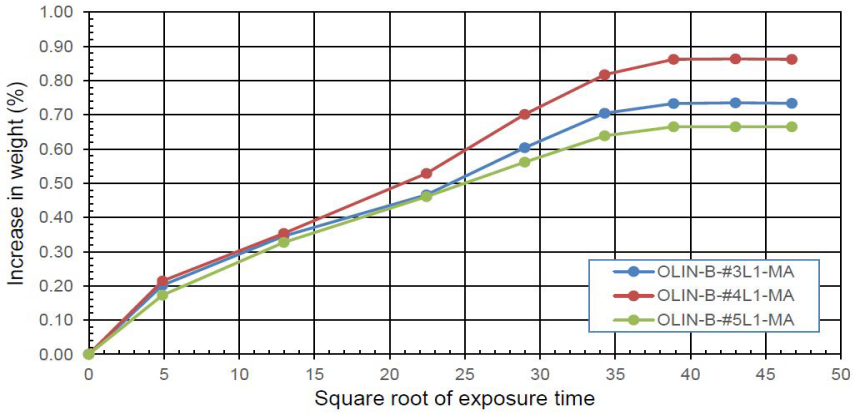
- 3 sizes of rebars (0.109, 0.207, 0.292 in^2) were tested
- All three BFRP rebars meet or exceed FDOT 932 SPEC.



Lab Accelerated Treatment for Alkaline Resistance

- Post Alkaline Resistance per ASTM D7705 guideline, 90 days at 60 °C
- Saturated water adsorption after 90 days treatment





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Durability Performance - Post Alkaline Solution Treatment

Test Method	Test Description	Spec. FDOT 932	Values	Result
SAMPLE #3				
ASTM D7205	Tensile Load Retention (with load)	>70 %	78.3 %	Pass
ASTM D7617	Trans. Shear Strength Retention	n/a	84.2 %	n/a
ASTM E2160	Degree of Cure	>95 %	99.06 %	Pass
	Glass Transition Temperature (DSC)	>100 °C	139 °C	Pass
SAMPLE #4				
ASTM D7205	Tensile Load Retention (with load)	>70%	92.3 %	Pass
ASTM D7617	Trans. Shear Strength Retention	n/a	107.6 %	n/a
ASTM E2160	Degree of Cure	>95 %	99.4 %	Pass
	Glass Transition Temperature (DSC)	>100 °C	128 °C	Pass
SAMPLE #5				
ASTM D7205	Tensile Load Retention (with load)	>70 %	89.8 %	Pass
ASTM D7617	Trans. Shear Strength Retention	n/a	106.2 %	n/a
ASTM E2160	Degree of Cure	>95 %	99.1 %	Pass
	Glass Transition Temperature (DSC)	>100 °C	139 °C	Pass

- All three BFRP rebars meet or exceed FDOT 932 SPEC
- Trans. Shear behavior indicates adequate thermoset protection

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Summary

- Nominal **#3, #4 and #5** BFRP (Basalt Fiber Reinforced Polymer) rebars were made with epoxy system by industrial production.
- A thorough study on those BFRP rebars was conducted at UM-SML (**University of Miami, Structures and Materials Laboratory**), a FDOT (Florida Department of Transportation) qualified testing facility.
- The **durability performance** was evaluated through an accelerated environmental treatment that involved a 90-day immersion in alkaline solution at 60 ^{o}C.
- Prior to the accelerated environmental treatment, the BFRP rebars exhibit physical-mechanical properties that **meet or exceed FDOT 932 specifications**, or **ASTM D7957**.
- Post treatment evaluations indicate that the BFRP rebars possess **higher tensile load retention (78%-92%)** than the FDOT 932 requirement/ GFRP rebars (>70%).
- Overall, the testing outcomes suggest epoxy based BFRP is capable providing safe and reliable rebars that meet FDOT requirements.

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