



Florida Department of Transportation

RON DESANTIS
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

JARED W. PERDUE, P.E.
SECRETARY

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MATERIALS BULLETIN NO. 23-01

(FHWA Approved: 06/09/2023)

TO: DISTRICT MATERIALS AND RESEARCH ENGINEERS

FROM: Xiaoyan (Sue) Zheng, Ph.D. P.E., Director, Office of Materials

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Xiaoyan Zheng
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COPIES: Will Watts, Dan Hurtado, Scott Arnold, Ananth Prasad (FTBA), Khoa Nguyen (FHWA), David Cerlanek, and Rodrigo Antunes

SUBJECT: FIBER REINFORCED POLYMER PRODUCTION FACILITY APPROVAL PROCESS.

The Office of Materials is waiving the maximum COV requirement for the Moisture Absorption Test (ASTM D570) and increasing the maximum COV threshold for all other tests from 6% to 15% in Subarticle 932-3.3 of the Standard Specifications. The proposed changes are adequate to account for inherent variability within certain test methods without compromising product quality and consistency standards.

Subsection 932-3.3 of the FDOT Standard Specifications shall be superseded in its entirety by the language below. These specification changes shall apply to product qualification testing and acceptance for use on new construction projects.

Should you have any questions please contact Rodrigo Antunes at 352-955-2901 or Alexander Lewis at 352-955-6682.

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932-3.3 Material Requirements: Producers shall submit to the State Materials Office (SMO), a test report of the physical and mechanical property requirements in Table 932-7 and Table 932-8 as applicable for the types and sizes of FRP reinforcing produced. Qualification testing shall be conducted by an independent laboratory approved by the Department for performing the FRP test methods.

Three production LOTS shall be randomly sampled at the production facility by a designee of the SMO. The minimum number of specimens per production LOT and the coefficient of variation (COV) for the test results of each production LOT shall be as indicated in Tables 932-7 and 932-8. Outliers shall be subject to further investigation per ASTM E178. If the COV exceeds the requirements listed in Tables 932-7 and 932-8, the number of test specimens per production LOT may be doubled, a maximum of two times, to meet the COV requirement. Otherwise, the results shall be rejected. A production LOT is defined as a LOT of FRP reinforcing produced from start to finish with the same constituent materials used in the same proportions without changing any production parameter, such as cure temperature or line speed.

Table 932-7 Physical and Mechanical Property Requirements for Straight FRP Reinforcing Bars				
Property	Test Method	Requirement	Specimens per LOT	COV
Fiber Mass Fraction	ASTM D2584 or ASTM D3171	$\geq 70\%$	5 ⁿ	$\leq 15\%$
Short-Term Moisture Absorption	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	$\leq 0.25\%$	5 ^m	--
Long-Term Moisture Absorption	ASTM D570, Procedure 7.4; immersion to full saturation at 122°F	$\leq 1.0\%$	5 ^m	--
Glass Transition Temperature (T _g)	ASTM D7028 (DMA) or ASTM E1356 (DSC; T _m)/ASTM D3418 (DSC; T _{mg})	$\geq 230^\circ\text{F}$ $\geq 212^\circ\text{F}$	3 ^m	$\leq 15\%$
Total Enthalpy of Polymerization (Resin)	ASTM E2160	Identify the resin system used for each bar size and report the average value of three replicates for each system	--	$\leq 15\%$
Degree of Cure	ASTM E2160	$\geq 95\%$ of Total polymerization enthalpy	3 ⁿ	$\leq 15\%$
Measured Cross-Sectional Area	ASTM D7205	Within the range listed in Table 932-6	10 ⁿ	$\leq 15\%$
Guaranteed Tensile Load ^a		\geq Value listed in Table 932-6		
Tensile Modulus		$\geq 6,500$ ksi for BFRP and GFRP		

Table 932-7 Physical and Mechanical Property Requirements for Straight FRP Reinforcing Bars				
		$\geq 18,000$ ksi for CFRP (Type I) Bars $\geq 22,400$ ksi for CFRP (Type II) Strands		
Alkali Resistance with Load	ASTM D7705; Procedure B, set sustained load to 30% of value in Table 932-6; 3 months test duration, followed by tensile strength per ASTM D7205	$\geq 70\%$ Tensile strength retention for BFRP & GFRP $\geq 95\%$ Tensile strength retention for CFRP	5 ^m	$\leq 15\%$
Transverse Shear Strength	ASTM D7617	>22 ksi	5 ⁿ	$\leq 15\%$
Horizontal Shear Strength ^p	ASTM D4475	>5.5 ksi	5 ⁿ	$\leq 15\%$
Bond Strength to Concrete, Block Pull-Out	ACI 440.3R, Method B.3 or ASTM D7913	>1.1 ksi for Bars >0.9 ksi for Strands	5 ^m	$\leq 15\%$
<p>a – Guaranteed tensile load shall be equal to the average test result from all three LOTs minus three standard deviations. n – Tests shall be conducted for all bar sizes produced. m – Tests shall be conducted for the smallest, median, and largest bar size produced. p – Only required for BFRP bars.</p>				

932-3.3.1 Additional Requirements for Bent FRP Bars: For all bars produced by bending straight solid FRP bars before the resin is fully cured, the minimum inside bend radius shall be at least three times the nominal diameters for bar sizes 2 through 8; and four times the nominal diameters for sizes 9 and 10.

The straight portion of a bent FRP reinforcing bar shall be extracted with sufficient length for tensile testing according to Table 932-8. When the bent shape does not allow for the tensile testing of one of its straight portions, test specimens produced at the same time during the same production LOT shall be used.

Table 932-8 Physical and Mechanical Property Requirements for Bent FRP Reinforcing Bars				
Property	Test Method	Requirement	Specimens per LOT	COV
Fiber Mass Fraction – Bent Portion ^b	ASTM D2584 or ASTM D3171	$\geq 70\%$	5 ^m	$\leq 15\%$
Short-Term Moisture Absorption – Bent Portion ^b	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	$\leq 0.25\%$	5 ^m	--

Table 932-8 Physical and Mechanical Property Requirements for Bent FRP Reinforcing Bars				
Property	Test Method	Requirement	Specimens per LOT	COV
Long-Term Moisture Absorption – Bent Portion ^b	ASTM D570, Procedure 7.4; immersion to full saturation at 122°F	≤1.0%	5 ^m	--
Glass Transition Temperature – Bent Portion ^b	ASTM E1356 (DSC; T_m) /ASTM D3418 (DSC; T_{mg})	≥212°F	3 ^m	≤ 15%
Degree of Cure – Bent Portion ^b	ASTM E2160	≥95% of Total polymerization enthalpy	3 ^m	≤ 15%
Measured Cross-Sectional Area – Straight Portion	ASTM D7205	Within the range listed in Table 932-6	5 ^m	≤ 15%
Guaranteed Tensile Load ^a – Straight Portion		≥ Value listed in Table 932-6		≤ 15%
Tensile Modulus – Straight Portion		≥6,500 ksi for BFRP and GFRP ≥18,000 ksi for CFRP (Type I) Bar ≥ 22,400 ksi for CFRP (Type II) Strand		≤ 15%
Alkali Resistance without Load – Straight Portion	ASTM D7705; 3 months test duration, followed by tensile strength per ASTM D7205	≥ 80% Tensile strength retention	5 ^m	≤ 15%
Strength of 90° Bends	ACI 440.3, Method B.5 or ASTM D7914	> 60% Guaranteed tensile load listed in Table 932-6	5 ^m	≤ 15%
Transverse Shear Strength – Straight Portion	ASTM D7617	>22 ksi	5 ^m	≤ 15%
Horizontal Shear Strength ^p	ASTM D4475	>5.5 ksi	5 ^m	≤ 15%

a – Guaranteed tensile load shall be equal to the average test result from all three LOTs minus three standard deviations.
b – Bent portion specimens shall be extracted from a central location within a 90° bend.
m – Tests shall be conducted for the smallest, median, and largest bent bar size produced.
p – Only required for BFRP bars.