ORIGINATION FORM
Proposed Revisions to the Specifications
(Please provide all information - incomplete forms will be returned)

Date: 5-17-2019

Office: *Structures Design*

Originator: Steven Nolan

Specification Section: 932

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Article/Subarticle: 932-3

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Will the proposed revision require changes to:

Publication	Yes	No	Office Staff Contacted
Standard Plans Index	◉	○	Cheryl Hudson
Traffic Engineering Manual	○	◉	
FDOT Design Manual	○	◉	
Construction Project Administration Manual	○	◉	
Basis of Estimate/Pay Items	○	◉	
Structures Design Guidelines	◉	○	Scott Arnold
Approved Product List	○	◉	
Materials Manual	◉	○	Chase Knight

Will this revision necessitate any of the following:

Design Bulletin ☐ **Construction Bulletin** ☐ **Estimates Bulletin** ☐ **Materials Bulletin** ☐

Are all references to external publications current? **Yes** ◉ **No** ○

If not, what references need to be updated? (Please include changes in the redline document.)

Why does the existing language need to be changed?

1. Basalt FRP reinforcing has been under investigation by FDOT for 10 years and has very similar performance to the currently adopted Glass FRP reinforcing bars, which potential future improvements in design efficiency.
2. Clarify certification and testing requirements.

Summary of the changes:

Add Basalt (BFRP) rebar as an equivalent option to GFRP rebar.

Are these changes applicable to all Department jobs? **Yes** ◉ **No** ○
If not, what are the restrictions?

Contact the State Specifications Office for assistance in completing this form.
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M E M O R A N D U M

DATE: July 18, 2019

TO: Specification Review Distribution List

FROM: Stefanie D. Maxwell, Manager, Program Management Office

SUBJECT: Proposed Specification: **9320300 Nonmetallic Accessory Materials for Concrete Pavement and Concrete Structures.**

In accordance with Specification Development Procedures, we are sending you a copy of a proposed specification change.

This change was proposed by Steve Nolan of the State Structures Design Office to modify the language.

Please share this proposal with others within your responsibility. Review comments are due within four weeks and should be sent to Mail Station 75 or online at http://www2.dot.state.fl.us/ProgramManagement/Development/IndustryReview.aspx . Comments received after **August 15, 2019,** may not be considered. Your input is encouraged.

SM/dt
Attachment

NONMETALLIC ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES.

(REV ~~6-26-19~~7-8-19)

SUBARTICLE 932-3 is deleted and the following substituted:

932-3 Fiber Reinforced Polymer (FRP) Reinforcing Bars.

932-3.1 General: Obtain FRP reinforcing bars from producers currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Use only solid, round, thermoset basalt fiber reinforced polymer (BFRP), glass fiber reinforced polymer (GFRP) or carbon fiber reinforced polymer (CFRP) reinforcing bars. Bars shall be manufactured using pultrusion, variations of pultrusion, or other suitable processes noted in the producer's Quality Control Plan, subject to the approval of the State Materials Office (SMO). For GFRP, use only bars manufactured using vinyl ester resin systems and glass fibers classified as E-CR that meet the requirements of ASTM D578.

932-3.2 Bar Sizes and Loads: The sizes and loads of FRP reinforcing bars shall meet the requirements in Table 3-1. The measured cross-sectional area, including any bond enhancing surface treatments, shall be determined according to Table 3-2.

Table 3-1
Sizes and Tensile Loads of FRP Reinforcing Bars

Bar Size Designation	Nominal Bar Diameter (in)	Nominal Cross Sectional Area (in^2)	Measured Cross-Sectional Area (in^2)		Minimum Guaranteed Tensile Load (kips)	
			Minimum	Maximum	BFRP and GFRP Bars	CFRP Bars
2	0.250	0.049	0.046	0.085	6.1	10.3
3	0.375	0.11	0.104	0.161	13.2	20.9
4	0.500	0.20	0.185	0.263	21.6	33.3
5	0.625	0.31	0.288	0.388	29.1	49.1
6	0.750	0.44	0.415	0.539	40.9	70.7
7	0.875	0.60	0.565	0.713	54.1	-
8	1.000	0.79	0.738	0.913	66.8	-
9	1.128	1.00	0.934	1.137	82.0	-
10	1.270	1.27	1.154	1.385	98.2	-

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 3-2 and Table 3-3 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 State Materials Office. The minimum number of specimens per production LOT shall be as indicated in Table 3-2 and Table 3-3. The coefficient of variation (COV) for each test result shall be less than 6%. Outliers shall be subject to further investigation per ASTM E178. If the COV exceeds 6%, 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 3-2
Physical and Mechanical Property Requirements for Straight FRP Reinforcing Bars

Property	Test Method	Requirement	Specimens per LOT
Fiber Mass Fraction	ASTM D2584 or ASTM D3171	≥70%	5[n]
Short-Term Moisture Absorption	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	≤0.25%	5[m]
Long-Term Moisture Absorption	ASTM D570, Procedure 7.4; immersion to full saturation at 122°F	≤1.0%	5[m]
Glass Transition Temperature (Tg)	ASTM D7028 (DMA) or ASTM E1356 (DSC; T_m)/ASTM D3418 (DSC; T_{mg})	≥230°F ≥212°F	3[m]
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	--
Degree of Cure	ASTM E2160	≥95% of Total polymerization enthalpy	3[n]
Measured Cross-Sectional Area	ASTM D7205	Within the range listed in Table 3-1	10[n]
Guaranteed Tensile Load[a]		≥ Value listed in Table 3-1	
Tensile Modulus		≥6,500 ksi for GFRP ≥18,000 ksi for CRFP	
Alkali Resistance with Load	ASTM D7705; 3 months test duration, followed by tensile strength per ASTM D7205	≥ 70% Tensile strength retention	5[m]

Table 3-2 Physical and Mechanical Property Requirements for Straight FRP Reinforcing Bars			
Property	Test Method	Requirement	Specimens per LOT
Transverse Shear Strength	ASTM D7617	>22 ksi	5[n]
Horizontal Shear Strength[p]	ASTM D4475	>5.5 ksi	5[n]
Bond Strength to Concrete, Block Pull-Out	ACI 440.3R, Method B.3 or ASTM D7913	>1.1 ksi	5[m]
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.			

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 3-3. 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 3-3 Physical and Mechanical Property Requirements for Bent FRP Reinforcing Bars			
Property	Test Method	Requirement	Specimens per LOT
Fiber Mass Fraction – Bent Portion[b]	ASTM D2584 or ASTM D3171	≥70%	5[m]
Short-Term Moisture Absorption – Bent Portion[b]	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	≤0.25%	5[m]
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]
Degree of Cure – Bent Portion[b]	ASTM E2160	≥95% of Total polymerization enthalpy	3[m]
Measured Cross-Sectional Area – Straight Portion	ASTM D7205	Within the range listed in Table 3-1	5[m]

Table 3-3 Physical and Mechanical Property Requirements for Bent FRP Reinforcing Bars			
Property	Test Method	Requirement	Specimens per LOT
Guaranteed Tensile Load[a] – Straight Portion		≥ Value listed in Table 3-1	
Tensile Modulus – Straight Portion		≥6,500 ksi for GFRP ≥18,000 ksi for CRFP	
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]
Strength of 90° Bends	ACI 440.3, Method B.5 or ASTM D7914	> 60% Guaranteed tensile load listed in Table 3-1	5[m]
Transverse Shear Strength – Straight Portion	ASTM D7617	>22 ksi	5[m]
Horizontal Shear Strength[p]	ASTM D4475	>5.5 ksi	5[m]

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.

932-3.4 Material Acceptance: Submit to the Engineer, a certification for each production LOT from the producer of the FRP reinforcing bars, confirming that the requirements of this Section are met. The certifications shall conform to the requirements of Section 6.

932-3.4.1 Sampling: The Engineer will select a minimum of six straight bars with minimum lengths of 7 feet each and a minimum of five bent bars from each shipment, representing a random production LOT, per bar size of FRP reinforcing for testing in accordance with Table 3-4. Testing shall be conducted, at the Contractor's expense, by a Department approved independent laboratory. Each test shall be replicated a minimum of three times per sample. Submit the test results to the Engineer for review and approval prior to installation. Sampling and testing will not be required for bars to be used solely as reinforcement for sheet pile bulkheads.

Table 3-4 Testing Requirements for Project Material Acceptance of FRP Reinforcing Bars				
Property	Test Method	Requirement	Test Required for Straight Bar	Test Required for Bent Bar

Fiber Mass Fraction	ASTM D2584 or ASTM D3171	≥70%	Yes	Yes – bent portion[b]
Short-Term Moisture Absorption	ASTM D570, Procedure 7.1; 24 hours immersion at 122°F	≤0.25%	Yes	Yes – bent portion[b]
Glass Transition Temperature	ASTM D7028 (DMA) or ASTM D3418 (DSC; $_{mg}$)	≥230°F ≥212°F	Yes	Yes – bent portion[b]
Degree of Cure	ASTM E2160	≥95% of Total polymerization enthalpy	Yes	Yes – bent portion[b]
Measured Cross- sectional Area	ASTM D7205	Within the range listed in Table 3-1	Yes	Yes – straight portion
Guaranteed Tensile Load[a]		≥ Value listed in Table 3-1	Yes	No
Tensile Modulus		≥6,500 ksi for GFRP ≥18,000 ksi for CFRP	Yes	No

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.