9320300 NONMETALLIC ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES
COMMENTS FROM INTERNAL/INDUSTRY REVIEW

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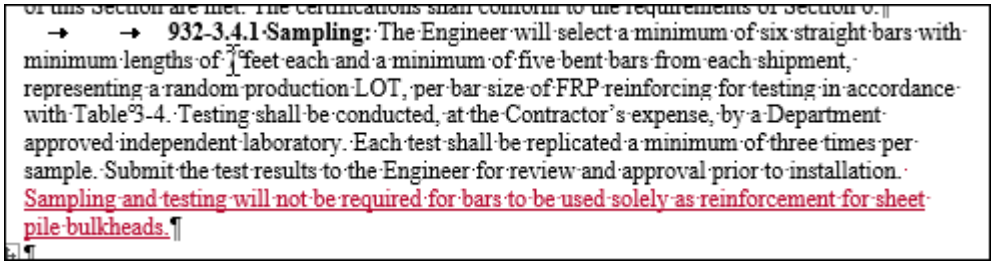
Comments: (7-15-19, Internal)
I understand the rationale behind this; however I'm not in favor, as there could be a billet of bars that arrive onsite that are purposed for more than sheet pile bulkheads which are part of the same LOT. Suggest deleting.


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 3 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.¶

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Response: Unlike steel reinforcing, bars are identified and selected on site for randomly selected confirmation testing based on size and date of production at the producer (LOT), not on a billet basis. This occurs after delivery to the project and the post-delivery testing is at the time and expense of the Contractor. Bars are required to be identified by tagged based on Contract Plans Bar Marks and production LOT. Additional testing can always be requested the Department at our own expense (unless the specimens fail). We will clarify that sampling will still be required for these elements to be held for resolution testing if the case of a dispute.
Change made.

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Comments: (7-19-19)
1. The use of polyester should be categorically excluded. It is proven that they do not provide the necessary durability

Response: The allowable resins will be specifically identified: *"For BFRP and CFRP bars only vinyl ester or epoxy resin systems are permitted."*
Change made.

2. Tensile Modulus requirement for BFRP is NOT specified in Tables 3-2, 3-3, 3-4

Response: This will be added as the same as GFRP.
Change made.

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Comments: (7-21-19)
In the addition of BFRP, the tensile modulus appears to have been overlooked. Tables 3-3 & 3-4 list tensile modulus for GFRP and CFRP, but not for BFRP. Suggest making the modulus for BFRP identical to that of GFRP as both fibre types are very similar in their modulus characteristics, so the modulus of the resultant composite should be very similar.

Response: This will be added as the same as GFRP.
Change made.

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Comments: (8-29-19)
The proposed revision of 9320300 includes the use of basalt FRP bars, however consensus standards such as AASHTO and ACI440 do not yet incorporate the use of basalt fiber. My understanding is that those consensus bodies are lacking peer review research on creep rupture reduction safety factors, performance in accelerated aging protocols that substantiate environmental reduction safety factors, crack width phi factors Kb and other aspects of performance that are less well researched than fibers that appear in those design guidelines. Also there is not an industry consensus ASTM material standard such as D7957 that includes basalt fiber. If basalt FRP bars are not part of AASHTO or ACI or ASTM guidance, how can the state implement them? What evidence on the safety factors does FDOT have that the consensus code writing bodies do not have? Would the state be wiling to share any information it has justifying parity with fibers in those standards and participate in further refinement of the standards?

Response: This specification is being implemented as part of an FHWA sponsored STIC Incentive Grant (STIC-0004-00A) for developing BFRP standards. State DOT's often implement specifications, testing and acceptance procedures before adoption at a broad national level AASHTO, due to competing interest and priorities. After more than 10 years of investigating BFRP, the US composites industry has delayed prioritizing development of consensus standards for BFRP. However, ICC-ES AC454 has provided criteria for acceptance in the building industry since 2014; CAN/CSA S807-19 has been updated to include BFRP reinforcing for publication this year; and SP295 Code of Practice (2017) & GOST 31938 also contain provisions for BFRP, exceeding GFRP rebar in some cases. Current FDOT research reports (BDK82 977-05; BDV30 986-01; BE694) relating to BFRP are also available online (https://www.fdot.gov/structures/innovation/FRP.shtm) along with numerous other national and international research reports. It is expected that ACMA could support development of an ASTM for Basalt Rebar, but this is outside the control of FDOT and AASHTO. We look forward to active industry participation for improving the effectiveness and economy of FRP rebar and refining the long-term durability design values to provide even greater value in future updates.
No change.

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Comments: (date)
I represent Miller & Long Co., Inc., a contractor for cast-in-place concrete in the Washington DC metro area. My company has a keen interest in promoting the use of BFRP rebar in the construction industry. We are also strong proponents of rigorous product and design specifications. My comments regard FDOT's draft 932-03 document released on July 18, 2019.

It appears BFRP rebar will be written into the code using the same specs as GFRP rebar. Our position is that BFRP is a better-performing material than GFRP, and that the performance level should be reflected in the specs. More specifically, we advocate raising BFRP's tensile modulus to >= 7,500 ksi (>= 52 GPa). Tensile load should also be raised based on manufacturers' results from your 2018 STIC study. For clarity, we recommend the following additions: Table 3-2: in the entry for Tensile Modulus, the Requirement reads ">=6,500 ksi for GFRP; >=18,000 ksi for CFRP" Add a line that reads ">=7,500 ksi for BFRP". Table 3-3: in the entry "Tensile Modulus – Straight Portion," same comment as above. Table 3-4: in the entry "Tensile Modulus", same comment as above. Thank you for your consideration.

Response: FDOT signaled to the FRP rebar industry in past meetings, interest in raising some of the minimum threshold acceptance and design limits. We are still awaiting additional test data for validating our long-term modeling well beyond 75 years for some of these parameters. The Tensile Modulus will be initially set at 6500 ksi for acceptance and design of BFRP rebar, with the prospect of raising this and other limits with FRP industry consensus.
Change made.

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Comments: (8-14-19)
We feel that BFRP rebar minimum spec should be set at 7.5 MSI for tensile modulus. Higher minimum will adequately represent basalt fiber inherent properties and will help the industry in general to adapt FRP products in general by giving civil engineers and specifiers greater choices to be able to find materials better suited for various application. It will also encourage more innovation and better quality for teh industry irrespective of the type of fiber being used.

Response: FDOT signaled to the FRP rebar industry in past meetings, interest in raising the tensile modulus, however some of the bars sizes tested under BDV30 986-01 did not reach 7 MSI. We are still awaiting additional test data for validating our long-term modeling under BE694 beyond 75 years. The Tensile Modulus will be initially set for now the same as GFRP at 6500 ksi for acceptance and design, with the prospect of raising this and other limits with FRP industry consensus in future updates.
Change made.

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Comments: (8-14-19)

1) 932-3.1 General second paragraph: Consider the follow changes: ¬ From: “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.” ¬ To: “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). Bars shall be made with thermoset resin systems, excluding polyester. For GFRP, use only bars manufactured using vinyl ester resin systems and with glass fibers classified as E-CR that meet the requirements of ASTM D578.” Rationale: The term ‘thermoset’ is too generic. Most polyester resins are thermoplastics, but polyester can be both a thermoplastic or thermoset, therefore recommend to include “excluding polyester. Moreover, experimental data as well as literature review previously provided to the SMO shows that epoxy based GFRP and BFRP systems meet durability. Additionally, the Carbon Strand/Rebar (CFCC) approved by SMO has an epoxy based system, thus vinyl ester and epoxy type resin systems should be included as long as the material specifications are met.

Response: Agree with excluding polyester. The current language and additional changes in response to other comments from industry review reflect that exclusion. However, adding epoxy as an option for GFRP bars is outside the scope of the proposed revision. The Department will review the available literature on this subject and work with industry on considerations for future revision of this Section.
Change made.

2) BFRP and GFRP tensile properties: Based on experimental data expanding the last decade on the tensile mechanical properties of GFRP and BFRP rebars, it appears that the minimum guaranteed tensile load and modulus do not reflect the current state of manufacturing. The recommendation is to increase at minimum 20% this minimum/guaranteed values to reflect the existing state practice and quality of manufacturing, as indicated below. This increases will also benefit the resulting structural design. ¬ Table 3-1: Minimum guaranteed tensile load – increase all values by 20% ¬ Table 3-2, Table 3-3 and Table 3-4: Increase minimum modulus from 6,500 to 7,800 ksi (20% increase). Also include ‘BFRP’ in table cell. Furthermore, multiple manufactures for both BFRP and GFRP currently manufacture rebar that exceeds the new proposed minimum values. Lastly, the existing minimum/guaranteed material values are derived from the first set of recommendation that were historically proposed in ACI440 based on data of rebar using fibers and resins that do not reflect todays state of practice

Response: Some currently accepted GFRP rebar and recently tested BFRP rebar do not meet these increased limits for selected bar sizes. Additional consultation with the FRP industry is required before changes to these limits can be implemented.

No change.

3) Degree of Cure: Based on testing for the degree of cure, it is noted that the degree of cure obtain directly from the rebar samples may be variable, and the response of the test per ASTM E2160 non-applicable. This is probably due to the relative high fiber content of the sample used in testing. Tests made from resin only made under the same conditions as the rebar maybe more applicable. To this end consider the following: ¬ Table 3-2: i) Total Enthalpy of Polymerization should state 'neat resin' (ie uncured, not mixed); and ii) Degree of cure should include 'cured resin under same conditions as rebar' ¬ Table 3-3: Include 'ASTM 7028 (DMA)' as a reference and corresponding requirement similar to Table 3-2. ¬ Table 3-4: removing the degree of cure test for project tests should be considered, given that the results may not be meaningful from a FRP system with a high fiber content like a rebar. If needed, this test can be included only when SMO office or FDOT Engineer requires it on a project by project basis based on test results.

Response: Agree with clarifying the term "neat resin" for Total Enthalpy of Polymerization in Table 3-2. However, the degree of cure test by DSC on actual bar samples is currently a suitable method to detect whether the polymer remains largely uncured or not. For example, if a partially cured fiber reinforced specimen is tested using the DSC method, the residual enthalpy of polymerization would sufficiently indicate the percent cure. Furthermore, the addition of a test method or removal of the requirement for degree of cure testing will require further investigation and review of available methods prior to any changes.
Change made.

4) 932-3.4.1 Sampling: Similar to bridge structural pads (Section 932-2.3.2) re-testing should be stated if one of the tests per Table 3-4 fails to meet the requirements. Consider adding in this paragraph: ¬ "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. Re-testing an additional minimum of three times per sample per property may be conducted for confirmation in the event of failing a test requirement"

Response: This is a good suggestion, however Section 6-4 (Defective Materials) of the Specifications addresses the procedure for materials that do not meet the requirements. Section 6-4.1 (Engineering Analysis) provides the option for proposing additional testing.
No change.

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