Florida Department of Transportation

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605 Suwannee Street
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SECRETARY

January 12, 2016

Khoa Nguyen
Director, Office of Technical Services
Federal Highway Administration
3500 Financial Plaza, Suite 400
Tallahassee, Florida 32312

Re: State Specifications Office
Section **933**
Proposed Specification: **9330000 Prestressing Strand and Bar.**

Dear Mr. Nguyen:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

The changes are proposed by Charles Boyd of the State Structures Design Office to incorporate specification language for stainless steel and FRP reinforcing and prestressing strand into the Standard Specifications.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to daniel.scheer@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at 414-4130.

Sincerely,

Signature on file

Daniel Scheer, P.E.
State Specifications Engineer

DS/ot
Attachment
cc: Florida Transportation Builders' Assoc.
State Construction Engineer

PRESTRESSING STRAND AND BAR.
(REV ~~11-61623-15~~*1-12-16*)

SECTION 933 is deleted and the following substituted:

SECTION 933
PRESTRESSING ~~STEEL~~*STRAND AND BAR*

933-1 Strands for Prestressing.

933-1.1 Carbon Steel Strands for Prestressing:

The *steel* strands for prestressing concrete members shall be Grade 270, low-relaxation *seven wire* strand and shall conform to the requirements of ASTM A416.

933-1.2 Stainless Steel Strands for Prestressing: *The stainless steel strands for prestressing concrete members shall be a ~~H~~high ~~S~~strength s~~S~~tainless s~~S~~teel (HSSS) ~~duplex (austenitic-ferritic) Grade 2250. Strand shall~~ conforming to the chemical requirements of ASTM A276 , UNS- S31803 or S32205 (Type 2205) and the mechanical and dimensional requirements of ASTM- A416, except the minimum ultimate tensile strength shall be 240 ksi.*

933-1.3 Carbon Fiber Reinforced Polymer (CFRP) Strands for Prestressing: *CFRP strand shall meet the requirements of ACI 440.4, following the test methods from ACI 440.3. The CFRP strand shall meet the additional requirements of this Section following the sampling frequency and number of specimens required by ACI 440.6.*

Table 1-1
Typical Sizes and Loads of Available CFRP Prestressing Strands

Type	*Diameter (in)*	*Effective Cross Sectional Area (in^2)*	*Ultimate Load (P_u) (kips)*
Single Strand - 5.0mm Ø	*0.20*	*0.03*	*9*
7-strand - 7.5mm Ø	*0.30*	*0.05*	*17*
7-strand - 10.5mm Ø	*0.41*	*0.09*	*32*
Single Strand - 9.5mm Ø	*0.38*	*0.11*	*35*
7-strand - 12.5mm Ø	*0.49*	*0.12*	*41*
Single Strand - 12.7mm Ø	*0.50*	*0.20*	*59*
7-strand - 15.2mm Ø	*0.60*	*0.18*	*61*
19-strand - 20.5mm Ø	*0.81*	*0.32*	*71*
7-strand - 17.2mm Ø	*0.68*	*0.23*	*79*
19-strand - 25.5mm Ø	*1.00*	*0.47*	*105*
19-strand - 28.5mm Ø	*1.12*	*0.62*	*134*
37-strand - 35.5mm Ø	*1.40*	*0.92*	*189*
37-strand - 40.0mm Ø	*1.57*	*1.21*	*270*

933-2 *Steel* Bars for Prestressing.

The *steel* bars for prestressing concrete members shall conform to the requirements of ASTM A722, Type II.

933-3 *Steel* Parallel Wire Assemblies for Prestressing.

The wire assemblies for prestressing concrete members shall consist of parallel wires of the number and size shown in the Plans and shall conform to the requirements of ASTM A421.

933-4 Anchorages for Prestressing.

933-4.1 For Strands and Bars: ~~Meet the requirements of Section 960.~~

933-4.1.1 ~~For~~ Steel Strands and Bars: *Meet the requirements of Section~~-~~ 960.*

933-4.1.2 ~~For~~ CFRP Strands: *Meet the requirements of ACI 440.4.*

933-4.2 For *Steel* Parallel Wire Assemblies: Anchorage for parallel wire assemblies may be provided by Type BA (Button Anchorages) cold-end deformation of the wires bearing against suitable anchorage plates, or by Type WA (Wedge-type Anchorages) without cold end deformations, of the sandwich-plate or conical type. The anchorage device shall be capable of developing at least 90% of the specified ultimate strength of the total number of wires anchored.

Conical type anchorages shall be embedded within the ends of the concrete members unless otherwise specified. Anchorages shall generally bear against embedded grids of reinforcing steel of approved type.

Alternate type anchorages will be considered if proposed by the Contractor. Any alternate anchorage will be required to develop the full specified ultimate strength for bars or at least 90% of the specified ultimate strength for parallel wire assemblies.

933-5 Required Tests for Prestressing ~~Steel~~*Strand and Bar*.

933-5.1 General: Tests shall be performed to determine the physical characteristics of prestressing reinforcement. For tests specified to be made by the ~~manufacturer~~*producer*, certified copies of all test results shall be submitted to the Engineer prior to use.

933-5.2*.1 Steel* Strands: Acceptance of *steel* prestressing strands shall be based on samples taken by the Department and the ~~manufacturer's~~ *producer's* certified mill analysis certifying that the test results meet the specification limits of ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the manufacturer's certified mill analysis for each heat or production LOT per shipment of strand.

Certifications for *steel* prestressing strand shall contain, for each heat number or production LOT, all test results required by ASTM A416 and the modulus of elasticity expressed in psi or the stress-strain curve with units identified.

The Engineer will select samples and certified mill analysis representing each shipment at a frequency of one sample per ~~manufacturer~~*producer*, per size of strand, per shipment.

933-5.2.2 CFRP Strands: *Producers of CFRP strand seeking approval to be placed on the Department's Production Facility Listing shall meet the testing requirements of Table 5-1 for each product. Producers seeking evaluation of a product in accordance with ~~with Departmental procedures~~Section 6 must submit test reports conducted by an independent laboratory qualified by an ISO~~-~~ 17025 accreditation agency using personnel with actual experience running the test methods for FRP strand. Submit the test reports to the State Materials Office.*

Table 5-1 Testing Requirements for Qualification of Producers of Prestressing CFRP Strands		
Property	Test Method	Requirement
Fiber Content	ASTM D2584 or ASTM D3171	>55% - volume >70% - weight
Moisture absorption	ASTM D570	≤0.75% (long term immersion to full saturation)
Glass transition temperature (T_g)	ASTM E1640 - DMA or ASTM E1356 - DSC	≥230°F ≥212-°F
Total enthalpy of polymerization	ASTM E2160	Report value for each resin system used
Alkali resistance with load	ASTM D7705; set sustained tensile stress to induce tensile strain of 3000 micro-strain; 3 months test duration	Tensile capacity retention ≥70% of ultimate tensile stress (UTS)
Creep rupture strength	ASTM D7337	≥75% Ultimate tensile strength

933-5.2.2.1 Certification: Meet the testing requirements of Table 5-2 for product acceptance at project level ~~on the project~~. The Contractor shall ~~provide~~submit to the Engineer ~~with~~a certification from the producer of the CFRP strand, confirming that the requirements of this Section are met. The certification shall conform to the requirements of Section- 6. Each certification shall cover only one LOT of CFRP strand materials. ~~The Contractor shall ensure that the test results meet the requirements of Table 5-2 using an independent ISO 17025 accredited laboratory with actual experience running the test methods for FRP strand.~~

933-5.2.2.2 Sampling: The Contractor shall ensure that the test results meet the requirements of Table 5-2 using an independent ISO 17025 accredited laboratory with actual experience running the test methods for FRP strand. A minimum of six samples of strand representing each ~~per~~ LOT or shipment, per manufacturer, and per size of strand will be selected by the Engineer. The minimum sample length is seven feet. ~~A~~The LOT will be sampled ~~only~~ after the entire LOT is delivered to the project site or in an offsite storage facility. Furnish additional strand footage to account for samples selected for testing. CFRP strand shall be available for sampling a minimum of three weeks prior to their installation.

Table 5-2 Testing requirements for Product Acceptance of Prestressing CFRP Strand for a Project		
Property	Test Method	Requirement
Degree of cure	ASTM E2160	≥95% of total polymerization enthalpy
Fiber content	ASTM D3171	Volume fraction ≥55%
Void content	ASTM D2734	≤1%
Moisture absorption	ASTM D570	≤0.25% in 24 hours at 122°F
Tensile Modulus of elasticity	ASTM D7205	≥18,000 ksi
Typical Sizes and Loads	ASTM D7205	See Table 1-1

933-5.3 *Steel* Bars: Acceptance of *steel* prestressing bar shall be based on samples taken by the Department and the ~~manufacturer's~~ *producer's* certified mill analysis certifying that the test results meet specification limits of the ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the ~~manufacturer's~~ *producer's* certified mill analysis for each heat or production LOT and size per shipment of bars. Certifications of *steel* prestressing bar shall contain, for each heat number or production LOT, all test results required by ASTM A722 and the modulus of elasticity expressed in psi or the stress-strain curve with units identified.

The Engineer will select samples and certified mill analysis representing each shipment at a frequency of one sample per heat or production LOT, per size of bar, per shipment.

933-5.4 *Steel* Wires: Acceptance of *steel* wires shall be based on the ~~manufacturer's~~ *producer's* certified mill analysis of test results meeting the specification limits of the ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the ~~manufacturer's~~ *producer's* certified mill analysis for each heat or production LOT per shipment of wire. Certifications of *steel* prestressing wire shall contain, for each heat number or production LOT, all test results required by ASTM A421.

PRESTRESSING STRAND AND BAR.
(REV 1-12-16)

SECTION 933 is deleted and the following substituted:

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PRESTRESSING STRAND AND BAR

933-1 Strands for Prestressing.

933-1.1 Carbon Steel Strands for Prestressing: The steel strands for prestressing concrete members shall be Grade 270, low-relaxation seven wire strand and shall conform to the requirements of ASTM A416.

933-1.2 Stainless Steel Strands for Prestressing: The stainless steel strands for prestressing concrete members shall be a high strength stainless steel (HSSS) conforming to the chemical requirements of ASTM A276 , UNS S31803 or S32205 (Type 2205) and the mechanical and dimensional requirements of ASTM A416, except the minimum ultimate tensile strength shall be 240 ksi.

933-1.3 Carbon Fiber Reinforced Polymer (CFRP) Strands for Prestressing: CFRP strand shall meet the requirements of ACI 440.4, following the test methods from ACI 440.3. The CFRP strand shall meet the additional requirements of this Section following the sampling frequency and number of specimens required by ACI 440.6.

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19-strand - 25.5mm Ø	1.00	0.47	105
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37-strand - 35.5mm Ø	1.40	0.92	189
37-strand - 40.0mm Ø	1.57	1.21	270

933-2 Steel Bars for Prestressing.

The steel bars for prestressing concrete members shall conform to the requirements of ASTM A722, Type II.

933-3 Steel Parallel Wire Assemblies for Prestressing.

The wire assemblies for prestressing concrete members shall consist of parallel wires of the number and size shown in the Plans and shall conform to the requirements of ASTM A421.

933-4 Anchorages for Prestressing.

933-4.1 For Strands and Bars:

933-4.1.1 Steel Strands and Bars: Meet the requirements of Section 960.

933-4.1.2 CFRP Strands: Meet the requirements of ACI 440.4.

933-4.2 For Steel Parallel Wire Assemblies: Anchorage for parallel wire assemblies may be provided by Type BA (Button Anchorages) cold-end deformation of the wires bearing against suitable anchorage plates, or by Type WA (Wedge-type Anchorages) without cold end deformations, of the sandwich-plate or conical type. The anchorage device shall be capable of developing at least 90% of the specified ultimate strength of the total number of wires anchored.

Conical type anchorages shall be embedded within the ends of the concrete members unless otherwise specified. Anchorages shall generally bear against embedded grids of reinforcing steel of approved type.

Alternate type anchorages will be considered if proposed by the Contractor. Any alternate anchorage will be required to develop the full specified ultimate strength for bars or at least 90% of the specified ultimate strength for parallel wire assemblies.

933-5 Required Tests for Prestressing Strand and Bar.

933-5.1 General: Tests shall be performed to determine the physical characteristics of prestressing reinforcement. For tests specified to be made by the producer, certified copies of all test results shall be submitted to the Engineer prior to use.

933-5.2.1 Steel Strands: Acceptance of steel prestressing strands shall be based on samples taken by the Department and the producer’s certified mill analysis certifying that the test results meet the specification limits of ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the manufacturer’s certified mill analysis for each heat or production LOT per shipment of strand.

Certifications for steel prestressing strand shall contain, for each heat number or production LOT, all test results required by ASTM A416 and the modulus of elasticity expressed in psi or the stress-strain curve with units identified.

The Engineer will select samples and certified mill analysis representing each shipment at a frequency of one sample per producer, per size of strand, per shipment.

933-5.2.2 CFRP Strands: Producers of CFRP strand seeking approval to be placed on the Department's Production Facility Listing shall meet the testing requirements of Table 5-1 for each product. Producers seeking evaluation of a product in accordance with Section 6 must submit test reports conducted by an independent laboratory qualified by an ISO 17025 accreditation agency using personnel with actual experience running the test methods for FRP strand. Submit the test reports to the State Materials Office.

Table 5-1
Testing Requirements for Qualification of Producers of Prestressing CFRP Strands

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Glass transition temperature (T_g)	ASTM E1640 - DMA or ASTM E1356 - DSC	≥230°F ≥212°F
Total enthalpy of polymerization	ASTM E2160	Report value for each resin system used
Alkali resistance *with* load	ASTM D7705; set sustained tensile stress to induce tensile strain of 3000 micro-strain; 3 months test duration	Tensile capacity retention ≥70% of ultimate tensile stress (UTS)
Creep rupture strength	ASTM D7337	≥75% Ultimate tensile strength

933-5.2.2.1 Certification: Meet the testing requirements of Table 5-2 for product acceptance at project level. The Contractor shall submit to the Engineer a certification from the producer of the CFRP strand, confirming that the requirements of this Section are met. The certification shall conform to the requirements of Section 6. Each certification shall cover only one LOT of CFRP strand materials.

933-5.2.2.2 Sampling: The Contractor shall ensure that the test results meet the requirements of Table 5-2 using an independent ISO 17025 accredited laboratory with actual experience running the test methods for FRP strand. A minimum of six samples of strand representing each LOT or shipment, per manufacturer, and per size of strand will be selected by the Engineer. The minimum sample length is seven feet. The LOT will be sampled after the entire LOT is delivered to the project site or in an offsite storage facility. Furnish additional strand footage to account for samples selected for testing. CFRP strand shall be available for sampling a minimum of three weeks prior to their installation.

Table 5-2
Testing requirements for Product Acceptance of Prestressing CFRP Strand for a Project

Property	Test Method	Requirement
Degree of cure	ASTM E2160	≥95% of total polymerization enthalpy
Fiber content	ASTM D3171	Volume fraction ≥55%
Void content	ASTM D2734	≤1%
Moisture absorption	ASTM D570	≤0.25% in 24 hours at 122°F
Tensile Modulus of elasticity	ASTM D7205	≥18,000 ksi
Typical Sizes and Loads	ASTM D7205	See Table 1-1

933-5.3 Steel Bars: Acceptance of steel prestressing bar shall be based on samples taken by the Department and the producer's certified mill analysis certifying that the test results meet specification limits of the ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the producer's certified mill analysis for each heat or production LOT and size per shipment of bars. Certifications of steel prestressing bar shall contain, for each heat number or

production LOT, all test results required by ASTM A722 and the modulus of elasticity expressed in psi or the stress-strain curve with units identified.

The Engineer will select samples and certified mill analysis representing each shipment at a frequency of one sample per heat or production LOT, per size of bar, per shipment.

933-5.4 Steel Wires: Acceptance of steel wires shall be based on the producer's certified mill analysis of test results meeting the specification limits of the ASTM or AASHTO as specifically designated. Prior to use, submit to the Engineer the producer's certified mill analysis for each heat or production LOT per shipment of wire. Certifications of steel prestressing wire shall contain, for each heat number or production LOT, all test results required by ASTM A421.