

PRESTRESSING STRAND.**(REV10-2-15)**

SECTION 933 is deleted and the following substituted:

PRESTRESSING STRAND**933-1 Strands for Prestressing**

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

933-1.2 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 Size 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 steel parallel 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 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.

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 Strands:

933-5.2.1 Steel Strand: 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 producer'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 Strand: Meet the applicable requirements of the Materials Manual and the requirements of Table 5-1 for qualification of producers of CFRP strand seeking approval to be placed on the Department's Production Facility Listing. Producers seeking evaluation of a product in accordance with this Specification 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 CFRP 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	>55% - volume

Property	Test Method	Requirement
	Or ASTM D3171	>70% - weight
Moisture absorption	ASTM D570	≤ 0.75% (long term immersion to full saturation)
Glass transition temperature (T_g)	ASTM E1640 - DMA	≥ 230°F
	ASTM E1356 - DSC	≥ 212 °F
Total enthalpy of polymerization	ASTM E2160	Report value for each resin system used
Alkali resistance <i>with</i> 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

Certification: Meet the testing requirements of Table 5-2 for product acceptance on the project. The Contractor shall provide the Engineer with 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. Submit one certification per 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.

Sampling: A minimum of six samples of strand per LOT will be selected by the Engineer. The minimum sample length is seven feet. A LOT will be sampled only after the entire LOT is delivered to the project site or in an offsite storage facility. CFRP strand shall be available for sampling a minimum of three weeks prior to their installation.

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 Prestressing 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.

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