

MNL 116-21 Addendum

The following sections of MNL 116-21 are revised to incorporate requirements and the associated commentary for stainless steel strand and for Carbon Fiber Reinforced Polymer (CFRP) tendons.

Section 3.2.2 Prestressing Materials

(Remove existing subsection 1 and replace it with the following.)

1. Pretensioning
 - a. Uncoated, low-relaxation strand conforming to ASTM A416/A416M, Grade 250 (1725), Grade 270 (1860) or Grade 300 (2070)
 - b. Coated, low-relaxation strand conforming to ASTM A882/A882M, Grade 250, Grade 270 or Grade 300
 - c. Low-Relaxation 2205 stainless steel strand conforming to ASTM A1114/A1114M, Grade 240 (1655)
 - d. Carbon Fiber Reinforced Polymer (CFRP) tendon

Section C3.2.2 Prestressing Materials

(Add the following new paragraph.)

There is currently no ASTM standard for CFRP tendon. Use the manufacturer's printed installation instructions and certificates for product properties.

Sections 5.1 and C5.1

(Change the section titles to the following.)

5.1 – Fabrication and Placement of Reinforcement

C5.1 – Fabrication and Placement of Reinforcement

Sections 5.1.2 and C5.1.2

(Change the section titles to the following.)

5.1.2 – Storage of Reinforcement

C5.1.2 – Storage of Reinforcement

Sections 5.1.3 and C5.1.3

(Change the section titles to the following.)

5.1.3 – Fabrication of Reinforcement

C5.1.3 – Fabrication of Reinforcement

Section 5.1.4 Installation of Reinforcement

(Revise section title and add the following new paragraph.)

Follow the manufacturer's printed installation instructions (MPII) for the tying of CFRP reinforcement/tendons to other materials. CFRP tendons shall not be crushed or damaged during the installation process.

Section C5.1.4 Installation of Reinforcement

(Revise the section title and add the following two new paragraphs.)

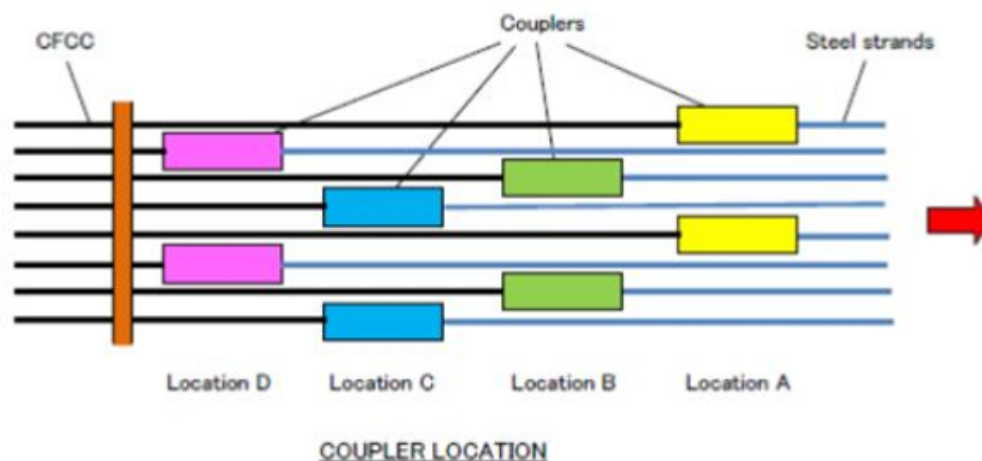
Research has shown that galvanic corrosion between stainless steel reinforcement conforming to ASTM A1114 and carbon steel (ASTM A615 and A767) reinforcement (including Structural welded-wire reinforcement (WWR) (ASTM A1064) and galvanized and ungalvanized embeds made from (Grade 36 and grade 50) is not a concern. (Reference the “Effects of galvanic coupling between carbon steel and stainless steel reinforcements for stainless strand by Qu, D; Qian, S.Y.; Baldock, D.; published by the National Research Council Canada.) Therefore, no special tie wires or insulation are required between stainless steel strand/reinforcement and uncoated steel reinforcement. However, individual owners may still require the use of stainless-steel tie wire or self-locking plastic straps. Other epoxy-coated steel reinforcements may still require nylon, epoxy-coated, or plastic-coated wire ties rather than black wire. Refer to epoxy-coated or project owner requirements.

Due to the lower lateral strength of CFRP tendons relative to steel strand, CFRP tendons are more susceptible to damage than steel strands. Avoid crushing the CFRP tendons when tying them to other items. Crushing the CFRP tendons can lead to premature failure. Common practice is to use plastic coated wire that does not break under the pressure of tight twisting or self-locking plastic straps.

Section C5.2.2 Tensioning of Tendons

(Add the following new paragraphs.)

CFRP tendons require special strand couplers between the dead and live end chucks and the steel strand. Verify the maximum safe load capacity of both the CFRP and the steel strand before jacking. When reusing the steel bridal strands verify there are no grip marks in the strand being stressed. Strand couplers may also be used in a similar way for stainless steel strands. In closely spaced strands, staggering of the couplers is required to prevent interference during the stressing operation which is a worker safety hazard. Never allow couplers to jam into each other. (See Figure below.)



CFRP tendons require unique couplers and procedures to connect the CFRP strands to steel stands. It is important to closely adhere to the manufacturer’s printed installation instructions (MPII) (for the strand

and the couplers) and handling instructions. Clean and inspect both sets of wedges for the coupler in accordance with the MPII after each use. Extreme care in cleaning of couplers and application of product specific lubrication spray is critical to avoid failure and achieving full stressing force. Couplers must be shielded from direct sunlight and heat exposure after stressing operations are completed. Failure to do so could cause separation of tendon connection or partial tendon slippage within the product.

Section C5.2.3.4 Methods of Force Measurement

(Add the following sentence to this section.)

If multiple materials are used, the length and respective material properties of each type must be considered.

Section 5.3.1 Storage of Prestressing Materials

(Revise the section title and add the following sentence to this section.)

Follow the manufacturer's instructions for the proper handling and storage of CFRP products.

Section C5.3.1 Storage of Prestressing Materials

(Revise the section title and add the following sentences to this section.)

CFRP tendon has unique handling and storage requirements, including covering of material from direct sunlight and protection from extreme heat. These requirements will be described in the manufacturer's instructions.

Section 5.3.3 Strand Surfaces

(Add the following sentence to this section.)

CFRP tendon shall be protected from and inspected for cuts and abrasions.

Section C5.3.3 Strand Surfaces

(Add the following sentences to this section.)

Severe loss of strength can occur if the CFRP tendon surface has nicks or abrasions in it. Care must be taken not to drag, scratch, or abrade the cable. Consult the manufacturer's instructions for guidance.

Section 5.3.4 Stringing of Strands

(Add the following sentence to this section.)

The surface of CFRP cables shall not be abraded, kinked, or nicked during placement. CFRP tendons shall not be subject to lateral compression.

Section C5.3.5 Strand Chucks and Splice Chucks

(Add the following sentences to this section.)

Chucks used for 0.7 in. (18 mm) strand should be closely monitored for wear due to producers reporting greater wear.

Clean both sides of the couplers in accordance with the MPII. Do not substitute coupler parts between different CFRP suppliers.

Section 5.3.6 Strand Splices

(Add the following sentence to this section.)

CFRP cable must be coupled to steel pulling strands in the same direction of twist.

Section C5.3.6 Strand Splices

(Add the following sentences to this section.)

When coupling CFRP cable to steel strands, care must be taken to ensure that all strands/tendons have the same direction of twist so that the strands/tendons will not untwist when stressed. Follow the MPII for the proper handling of CFRP products.

Section 5.3.10 Elongation Calculation and Corrections

(Add the following sentence to this section.)

If multiple materials are used, the length and respective material properties of each type of material must be calculated and considered.

(Replace section 5.3.10.5 with the following.)

5. Thermal effects. For abutment anchorage setups where strands are anchored to abutments that are independent from the form/mold, thermal adjustments are required if the temperature of the strand at the time of tensioning differs by more than 25°F (15°C) from the estimated fresh concrete temperature at the time of casting. Consideration shall be given to partial bed length usage and adjustments made when the net effect on the length of bed used exceeds the allowable force in the strand. The thermal coefficient of expansion of carbon steel shall be taken as $6.5 \times 10^{-6}/^{\circ}\text{F}$ ($12 \times 10^{-6}/^{\circ}\text{C}$). An appropriate thermal coefficient of expansion shall be used for other stressing material types, specifically stainless-steel strands and carbon fiber tendons, as supplied by the material manufacturer.

Section C5.3.10 Elongation Calculation and Corrections

(Add the following sentence to this section.)

When using CRFP tendon or stainless-steel strand attached to standard steel strands with couplers, the length and material properties for each material must be addressed separately and the elongations associated with each material type added together along with coupler seating.

5.3.11 Force or Gauge Corrections

(Modify section 5.3.11.5 as shown.)

5. Thermal effects. For abutment anchorage setups where strands are anchored to abutments that are independent from the form/mold, thermal adjustments are required if the temperature of the strand at the time of tensioning differs by more than 25°F (15°C) from the estimated fresh concrete temperature at the time of casting. Consideration shall be given to partial bed length usage and adjustments made when the net effect on the length of bed used exceeds the allowable. The thermal coefficient of expansion of carbon steel shall be taken as $6.5 \times 10^{-6}/^{\circ}\text{F}$ ($12 \times 10^{-6}/^{\circ}\text{C}$). An appropriate thermal coefficient of expansion shall be used for other stressing material types, specifically stainless-steel strands and carbon fiber tendons, as supplied by the material manufacturer.

Section 5.3.12 Final Tensioning of Straight Strands

(Add the following sentences to this section.)

The final force on stainless steel strands shall not exceed 70% of specified tensile strength of the strand after seating.

The manufacturer's recommendations and instructions for the final force on CFRP tendons shall be followed.

Section C5.3.12 Final Tensioning of Straight Strands

(Add the following sentences to this section.)

Stainless steel strands have a lower modulus of elasticity and total elongation which, combined with limited use, has prompted a limit of 70% of the ultimate tensile strength (f_{pu}) at this time.

Follow the manufacturer's recommendations for the final tensioning force applied to CFRP tendons. Preplanning and a detailed work plan, as part of a typical MPIL, is important due to thermal stresses and worker safety. Extreme heating of the anchorage devices on hot, sunny days could cause the slippage of the tensioned tendons. Therefore, the anchorage devices should be protected from exposure to direct sunlight and extreme temperatures after stressing.

Section 5.3.16 Detensioning

(Add the following sentences to this section.)

When detensioning stainless steel strand, a detensioning sequence shall be implemented which limits the amount of strain on the remaining stressed strand, to prevent rupture of the remaining strands.

The manufacturer's instructions for proper techniques for detensioning CFRP cable shall be followed.

Section C5.3.16 Detensioning

(Add the following sentences to this section.)

Due to the lower permissible safe strain in stainless steel strand, a detensioning sequence must be developed that minimizes the additional elongation and strain imparted to the remaining uncut strands, which is caused by elastic shortening of the product during detensioning operations. The use of strand jacks installed on the dead end and used to sequence the detensioning, and the use of gang detensioning a group of strands are two methods that have been used to avoid the concern.

The techniques used for detensioning CFRP tendons are different than those for standard steel prestressing strands. Consult the manufacturer's instructions for the techniques to be used.

Section 6.1.2 Scope of Inspection

(Replace subsection 4 with the following)

4. Checking of blockout position; sealing of forms/molds; rustication strips; cast-in items; coverage, position, amount, grade, size, and material type of reinforcement; and any other critical tolerance items. This also includes verifying that these items are properly secured during placement of concrete.

Section C6.1.2 Scope of Inspection

(Add the following sentences to this section.)

There are many different types of materials available; therefore, it is important to ensure that the correct type of material, as well as the appropriate size and grade, is being used for the project. Stainless steel strand cannot be used as a one-for-one substitution of standard low-relaxation steel prestressing strand.

Section C6.2.2.4 Reinforcing steel and prestressing materials

(Add the following sentences to this section.)

The precast producer should collect and preserve several samples of tendons per lot for any type of CFRP tendon. Shipment and lot numbers with the materials characterization from the set of delivery tickets should also be retained. The producer should require a letter of conformance (Certificated Letter) from the supplier that confirms compliance with the project specifications and the designated force for installation.

Prior to full scale production, tendon and grips/chucks should be tested with respect to proper seating of grips/chucks and special attention paid to seating during production. The shear strength of CFRP tendons is approximately a quarter of the shear strength of steel tendons; therefore, equal setting of wedges is even more important when stressing CFRP tendons. Labs with the appropriate equipment to test CFRP are limited due to the special grips and chucks required.

Section 6.3.2 Supplier's Test Reports

(Replace subsection 5 with the following)

5. Prestressing Tendons (all types and grades)

Appendix E, Reference Literature

(Add the following documents to the list of references)

ASTM A1114/A1114M - Standard Specification for Low-Relaxation, Seven-Wire Grade 240 (1655), Stainless Steel Strand for Prestressed Concrete

"Effects of galvanic coupling between carbon steel and stainless steel reinforcements for stainless strand" by Qu, D; Qian, S.Y.; Baldock, D.; published by the National Research Council Canada

Approved 10-17-25