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**USACE / NAVFAC / AFCEC / NASA** | **UFGS-03 23 00 (May 2016)**
**Change 1 - 08/18**

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**UFGS-03 23 00 (November 2009)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**

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SECTION 03 23 00

STRESSED TENDON REINFORCING
**05/16, CHG 1: 08/18**

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**NOTE: This guide specification covers the requirements for furnishing all equipment, materials, techniques and labor for providing and installing steel stressing tendons and accessories for the construction of prestressed concrete. This section was originally developed for USACE Civil Works projects.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**

**********

PART 1 GENERAL

1.1 LUMP SUM PRICES

**********

**NOTE: If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, this paragraph title (LUMP SUM PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs should be inserted into Section 01 20 00.**

**********

1.1.1 Steel Stressing Tendons and Accessories for Prestressed Concrete

1.1.1.1 Payment

Payment will constitute full compensation for furnishing all plant, labor, materials and equipment and performing all operations necessary for steel stressing tendons and accessories for prestressed concrete.

1.1.1.2 Unit of Measure

Unit of measure: lump sum.

1.2 REFERENCES

**********

**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**

**********

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

| | |
|---|---|
| ACI 318 | (2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14) |
| ACI 318M | (2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary |
| ACI SP-66 | (2004) ACI Detailing Manual |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A416/A416M | (2018) Standard Specification for Low-Relaxation, Seven-Wire for Prestressed Concrete |
| ASTM A421/A421M | (2015) Standard Specification for Uncoated |

| | |
|---|---|
| | Stress-Relieved Steel Wire for Prestressed Concrete |
| ASTM A722/A722M | (2015) Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete |
| ASTM C109/C109M | (2020b) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens) |

POST-TENSIONING INSTITUTE (PTI)

| | |
|---|---|
| PTI M10.3 | (2000) Field Procedures Manual for Unbonded Single Strand Tendons |
| PTI M50.3 | (2012) Guide Specification for Grouted Post-Tensioning |
| PTI M55.1 | (2019) Specification for Grouting of Post-Tensioned Structures |
| PTI-CRT-20 G1-1015 | (2015) Manual for Certification of Plants Producing Unbonded Single Strand Tendons |

## 1.3 SUBMITTALS

**********

**NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

**Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.**
**********

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G[, [_____]]

Procedures for Grouting Operations

SD-03 Product Data

Prestressing Method and Equipment; G[, [_____]]

Materials Disposition Records

Prestressing Operations Records

Recycled Content for Steel; S

SD-06 Test Reports

Stressing Tendons and Accessories

SD-07 Certificates

Tendon Installer Qualifications

## 1.4 QUALITY ASSURANCE

### 1.4.1 Tendon Installer Qualifications

#### 1.4.1.1 Unbonded Tendons

Installation crew must have at least two PTI Level 2 certified installers and all other personnel must be PTI Level 1 certified installers. Submit PTI certifications.

#### [1.4.1.2 Bonded Tendons

The direct supervisor of the Post-Tensioning operations must be certified as PTI Level 2 Bonded PT Field Specialist. The foreman of each installation and stressing crew must be certified as PTI Level 2 Bonded PT Field Specialist. The foreman of each grouting crew must be certified as PTI Level 2 PT Field Specialist and ASBI Certified Grouting Technician. At least 25 percent of each crew must be certified in PTI Level 1 Bonded PT-Field Installation. Submit PTI certifications.

]1.4.2 Installation Drawings

Submit detailed installation drawings for stressing tendons and accessories approved prior to commencing the work and showing the type and size of stressing tendons and anchorages, tendon profiles, erection methods, sequence of stressing and stressing calculations.

1.4.3 PTI Certified Plants

Fabrication plant must be certified by PTI-CRT-20 G1-1015.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver materials suitably wrapped, packaged or covered at the factory to prevent being affected by dirt, water and rust. Protect materials against abrasion or damage during shipment and handling. Place materials stored at the site above the ground on elevated, covered platforms.

PART 2 PRODUCTS

2.1 MATERIALS

Stressing tendons and accessories must conform to the requirements of ACI 318M ACI 318 except as specified. Submit certified materials test reports for all required materials tests; note the specific standards followed in the performance of tests, show that materials comply with the applicable specifications for each material shipment, and identified with specific lots prior to use of materials in the work.

2.1.1 Material Recycled Content

For products in this section, where applicable and to extent allowed by performance criteria, provide minimum 75 percent recycled content for steel

2.1.2 Stressing Tendons

Stressing tendons must be clean and free of loose rust, scale and pitting. Permanently protect unbonded tendons from corrosion with an approved applied coating.

2.1.2.1 Seven-Wire Stress-Relieved Strand and Strand Assemblies

Seven-wire stress-relieved strand and strand assemblies must conform to ASTM A416/A416M, Grade [1725 (250)] [1860 (270)], strand diameter as indicated. Strand assemblies may be field assembled with anchor fittings positively attached to strands for bonded tendons only.

2.1.2.2 Stress-Relieved Wire and Wire Assemblies

Stress-relieved wire and wire assemblies must conform to ASTM A421/A421M, Type BA or WA, wire diameter as shown. Wire assemblies must be shop assembled with anchor fittings positively attached to wires.

2.1.2.3 High-Strength Steel Bars

High-strength steel bars must conform to ASTM A722/A722M, Type I or II, Grade 1035 (150) meeting all supplementary requirements.

2.1.3 Accessories

2.1.3.1 Ducts

**********
**NOTE: Use this paragraph for grouted tendons.**
**********

Provide tendon ducts of galvanized sheet steel or plastic, capable of transmitting forces from grout to the surrounding concrete, flexible enough to conform to the tendon profile and strong enough to maintain their shape without deforming, sagging, or collapsing during concrete placement and vibration. The inside diameter of the ducts must be large enough to provide an internal area at least two and a half times the gross area of multiple wire, bar or strand assemblies and must be at least 13 mm 1/2-inch larger than the diameter of a single wire, bar or strand placed in the ducts. Design ducts for watertight connections with all fittings.

**********
**NOTE: Use the next two paragraphs for unbonded tendons.**
**********

2.1.3.2 Tendon Sheathing

Tendon sheathing must have a minimum thickness of 1.25 mm 0.050 inch for polyethylene or polypropylene with a minimum density of 0.9 g/cm$^3$ 0.034 lb/in$^3$. The sheathing must be continuous over the length of the tendon [to provide watertight encapsulation of strand] [between anchorages to prevent intrusion of cement paste or loss of coating for a non-encapsulated system.]

2.1.3.3 Tendon Coating

For unbonded tendons provide a compound with friction-reducing, moisture-displacing, and corrosion-inhibiting properties that is chemically stable and nonreactive with prestressing steel, nonprestressed reinforcement, sheathing material and concrete. The compound must have a minimum coating weight of[ 1.14 kg 2.5 lb for 12 mm 0.5 inch][ 1.36 kg 3 lb for 15 mm 0.6 inch] diameter strand per 30 m 100 feet of strand. Completely fill the annular space between the strand and sheathing over the entire tendon length with the tendon coating.

2.1.3.4 Anchorages and Couplers

Anchorages and couplers must be metal of proven corrosion resistance and compatible with the stressing tendons, capable of developing 95 percent of the actual breaking strength of the strands. Anchorages must be the button-head, wedge, nut and thread, grip nut, thread-bar, threaded plate or other approved type and must be provided with bearing plates bars, rings, bells or other positive-attaching anchor fittings. Provide couplers with housings long enough to permit the necessary movements and fittings which allow complete grouting of all components. Bar couplers must meet the requirements of ASTM A722/A722M and develop 100 percent of the minimum bar ultimate tensile strength.

2.1.3.5 Grout

**********
**NOTE: Use this paragraph for bonded tendons.**
**********

**********
**NOTE: Class A grout is for indoor applications and outdoor nonaggressive exposures. Class B grout is for aggressive exposures such as areas subjected to wet/dry cycles, marine environments or deicing salts. Class C grout can be used for either nonaggressive or aggressive exposure. Class D grout is a specialized grout used in critical applications where the properties of the grout are specified by the engineer.**
**********

Grout for grouting post-tensioned tendons must be a Class [A][B][C][D] in accordance with PTI M55.1. The minimum 7-day compressive strength of 50 mm 2-inch grout cubes, molded, cured and tested in accordance with ASTM C109/C109M must be 20.7 MPa 3000 psi.

2.1.3.6 Encapsulation System

**********
**NOTE: Include this paragraph for unbonded tendons in aggressive exposures.**
**********

Watertight encapsulation of prestressing strand consisting of the following:

2.1.3.6.1 Wedge-Cavity Caps

Attached to anchorages with a positive mechanical connection and completely filled with tendon coating.

2.1.3.6.1.1 Caps for Fixed- and Stressing-End Anchorage Devices

Designed to provide watertight encapsulation of wedge cavity. Sized to allow required extension of strand past the wedges. Attach cap for fixed-end anchorage device in fabricating plant.

2.1.3.6.1.2 Caps at Intermediate Anchorages

Open to allow passage of strand.

2.1.3.6.2 Sleeves

Attached to anchorage device with positive mechanical connection; overlapped a minimum of 100 mm 4 inches with sheathing and completely filled with tendon coating.

2.1.3.7 Nonprestressed Steel Bars

Provide reinforcing bars in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Coordinate placement of nonprestressed steel reinforcement with installation of tendons.

2.1.3.8 Pocket Formers

Pocket formers must be capable of completely sealing wedge cavity and be sized to provide the required cover of the anchorage and allow access for cutting strand tail.

2.1.3.9 Sheathing Repair Tape

Repair tape must be elastic, self-adhesive, moisture proof tape with a minimum width of 50 mm 2 inches, in contrasting color to tendon sheathing. Repair tape must be nonreactive with the sheathing, coating, or prestressing steel.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

Perform required material tests on stressing tendons and accessories by an approved laboratory to demonstrate that the materials are in conformance with the specifications. These tests are at the Contractor's expense.

PART 3 EXECUTION

3.1 INSTALLATION

**********

**NOTE: Include bracketed lines for bonded tendons. Refer to "Selected Post-Tensioning Protection Levels" by L.B. Krauser for guidance for the selection of Tendon Protection Level for specific post-tensioning applications.**

**********

Install or place stressing tendons and accessories as specified and as shown on contract and approved installation drawings. Installation details of stressing tendons and accessories not specified or shown must be in accordance with ACI SP-66, ACI 318M ACI 318 and PTI M10.3. Maintain a minimum radius of curvature of 480-stand diameters for lateral deviations to avoid openings, ducts, and embedded items. Limit tendon bundles to [five][____] tendons. Maintain a minimum of 300 mm 12 inches between center of adjacent bundles. Welding must not be performed near or adjacent to stressing tendons. Do not install stressing tendons until all welding has been completed on supports or any part which might be in contact with the tendons. Securely support unbonded tendons at regular intervals not to exceed 1220 mm 48 inches.[ Grouted tendons must meet protection level [1A][1B][2][3] per PTI M50.3.] Place nonprestressed steel bars in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.1.1 Anchorages

Set anchorages in a plane normal to the axis of the tendons such that uniform bearing on the concrete is assured. Do not switch fixed- and stressing-end anchorage locations from that shown on the approved installation drawings. Use positive connecting anchorages rather than gripping types for anchoring embedded ends of tendons. Permanently protect anchorages and anchor fittings against corrosion. Recess parallel wire anchorage wedges or cores within the members.

3.1.2 Stressing Tendons and Ducts for Grouted Post-Tensioned Systems

**********

**NOTE: Use this paragraph for bonded tendons only.**
**********

Remove protective coverings and wrappings, closely inspect each stressing tendon to see that nicks, scoring, pits or other damage does not exist, and closely inspect high strength steel bars to assure that they are not bent and that threaded ends are in satisfactory condition immediately prior to installation. Strand, wire and bar tendons must be shop or field assembled as required and positively attached to anchorages. Anchor type WA wire assemblies only with wedge type anchorages. Assemble stressing tendons and ducts to required shapes and dimensions and place them where indicated on drawings within specified tolerances and adequately supported. Securely support ducts to be grouted at regular intervals not exceeding 1220 mm 48 inches for round galvanized metal duct and steel pipes, 610 mm 24 inches for round plastic ducts and flat ducts with strand preinstalled and 305 mm 12 inches for flat ducts with strand preinstalled and grout openings and vents must be securely anchored to ducts and to either the forms or reinforcing steel to prevent displacement during concrete placing. The ends of ducts must be effectively protected to prevent entry of water, concrete, grout or debris. Wires of parallel-wire assemblies must not be spliced. Steel bar tendons may be joined by couplers where shown or approved. Strands to be spliced must have the same lay or direction of twist and the ends must be cut by shears or abrasive grinders. No more than one strand may be spliced in any one member where single strand tensioning is employed. Strand splices must be capable of developing the full ultimate strength of the strand. Check for slippage of the splice and correct for differential slippage. Where multiple strand tensioning is used, not more than 10 percent of the strands in any member may be spliced.

### 3.1.3 Sheathing Inspection and Repair

Inspect sheathing for damage after installing tendons. Repair damaged areas by restoring tendon coating and repairing or replacing tendon sheathing. Follow tape repair procedures in PTI M10.3.

### 3.1.4 Prestressing Method and Equipment

Submit descriptions of the proposed prestressing methods and equipment approved prior to the start of prestressing operations and indicating the manufacturer of all prestressing equipment, including tensioning jacks, stress measurement gages, dynamometers and load cells or other devices for measuring stressing loads. Descriptions must include certified calibration records for each set of jacking equipment and testing curves for stress measurement gages which show that the gages have been calibrated for the jacks for which they are to be used.

### 3.1.5 Tensioning Tendons

**********
**NOTE: Determination of the initial prestress force must consider prestress losses in accordance with ACI 318M/ACI 318, Section 18.6.**
**********

Tension stressing tendons as specified and indicated. Determine the stress induced in the tendons by any method of tensioning independently by both (1) measurement of tendon elongation and (2) direct measurement of force using a pressure gauge or load cell. If the results of these two

measurements do not check each other and the theoretical values are not within 7 percent, carefully check the operation and determine and correct the source of error before proceeding further. Concrete cylinder tests must indicate a breaking strength of at least [_____] MPa psi before transfer of stress to ensure that the concrete strength is adequate for the requirements of the anchorages or for transfer through bond as well as meet camber or deflection requirements. The final prestress load in each unit after seating must be as indicated. Take safety measures to prevent accidental injury caused by failure of a stressing tendon or tendon component. Protect the exposed ends of stressing tendons and anchorages from damage during stressing operations to prevent failure.

#### 3.1.5.1 Post-Tensioning

Do not perform tensioning until the concrete has reached the required strength at transfer of stress. Measure the force corresponding to the initial tension by a dynamometer or other approved method as a starting point in determining final elongation. The units must be tensioned until the proper elongations and jacking pressures are attained and reconciled within the limits stated above.

### 3.1.6 Grouting Post-Tensioned Tendons

At least four weeks prior to the start of construction submit written procedures for grouting operations for approval. Perform grouting between each tendon and its enclosing duct within 7 days after completion of the tensioning operation. Do not perform grouting if air temperature below 7.2 degrees C 45 degrees F is anticipated within 48 hours after grouting unless an approved method of temperature control is used. Mix the grout in a mechanical mixer of a type that will produce uniformly and thoroughly mixed grout. First, place water in the mixer followed by cement and admixture. Continuously agitate frout until it is pumped. Discard grout that has not been used within 30 minutes of the first addition of water to ensure the flowability of the grout. Just before grouting, blow the ducts clear by compressed air. With the grout vent open at one end of duct, apply grout continuously under moderate pressure at the other end until all entrapped air is forced out as indicated by a uniform flow of grout from the discharge vent. Close the injection point by an approved means to prevent any loss of grout. For a period of at least 3 days after grouting the tendons, the prestressed members must not have equipment or other loads placed on them. A longer period may be required, depending upon the method of curing and magnitude of imposed stresses.

### 3.1.7 Accuracy of Stress and Elongation Measurement

#### 3.1.7.1 Stress Measurement

Hydraulic gauges, dynamometers, load cells or other devices for measuring stressing load must have an accuracy of reading within two percent for stress measurement. Gauges are required to have been calibrated for the jacks for which they are used within a period not exceeding six months. Perform recalibration at any time that a gaging system shows indication of erratic results in the opinion of the Contracting Officer. Gauges must indicate loads directly in kN pounds or be accompanied by a chart which converts dial readings into kN pounds.

#### 3.1.7.2 Elongation Measurement

After the initial force has been applied to a tendon, establish reference

points for measuring elongation due to additional tensioning forces. They must be located according to the method of tensioning and type of equipment. The system used must be capable of measuring the true elongation plus or minus 2 mm 1/16-inch.

### 3.1.8 Prestressing Operations Records

Compile and submit complete prestressing operations records showing the manufacturer, identification and description of materials and equipment including prestressing tendons and jacking and load measuring equipment; location of prestressing tendons; initial design tensioning loads, final design tensioning loads and actual tensioning loads for tendons; dates tensioning loads applied; and theoretical and actual elongations for tendons before completion of the contract.

### 3.1.9 Tendon Finishing

Do not cut strand tails or cover anchorages until stressing records have been reviewed and approved. Cut strand tail between 13 and 19 mm 1/2 and 3/4 inch from wedges as soon as possible after approval of elongations. Do not damage tendon or concrete during removal of strand tail. Acceptable methods of cutting strand tail include oxyacetylene flame, abrasive wheel, hydraulic shears or plasma cutting. Patch stressing pocket within one day of cutting strand tail. Clean inside surface of pocket to remove laitance or tendon coating before installing patch material. Finish patch material flush with adjacent concrete.

## 3.2 INSPECTION

The Contractor's facilities must be open for inspection by the Contracting Officer at any time.

## 3.3 MATERIALS DISPOSITION RECORDS

Compile accurate materials disposition records, identifying all materials incorporated into the work and showing the disposition of specific lots of approved tested materials. Submit records which identify the incorporation of approved materials into the work before completion of the contract.

-- End of Section --