

\*\*\*\*\*  
USACE / NAVFAC / AFCEA UFGS-03230 (September 2001)  
-----  
Preparing Activity: USACE (CW) Superseding  
UFGS-03230 (December 1992)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMLR dated 22 December 2004

Latest change indicated by CHG tags

\*\*\*\*\*

### SECTION TABLE OF CONTENTS

#### DIVISION 03 - CONCRETE

#### SECTION 03230

#### STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE

09/01

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 LUMP SUM PRICES
  - 1.2.1 Steel Stressing Tendons and Accessories for Prestressed Concrete
    - 1.2.1.1 Payment
    - 1.2.1.2 Unit of Measure
- 1.3 SUBMITTALS
- 1.4 CERTIFICATION OF PRESTRESSING TECHNICIANS
- 1.5 DELIVERY, STORAGE AND HANDLING OF MATERIALS

#### PART 2 PRODUCTS

- 2.1 MATERIALS
  - 2.1.1 Stressing Tendons
    - 2.1.1.1 Seven-Wire Stress-Relieved Strand and Strand Assemblies
    - 2.1.1.2 Stress-Relieved Wire and Wire Assemblies
    - 2.1.1.3 High-Strength Steel Bars
  - 2.1.2 Accessories
    - 2.1.2.1 Ducts
    - 2.1.2.2 Anchorages and Couplers
    - 2.1.2.3 Grout
- 2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

#### PART 3 EXECUTION

- 3.1 INSTALLATION
  - 3.1.1 Prestressing Method and Equipment
  - 3.1.2 Installation Drawings
  - 3.1.3 Anchorages
  - 3.1.4 Stressing Tendons and Ducts
  - 3.1.5 Tensioning Tendons
    - 3.1.5.1 Pretensioning
    - 3.1.5.2 Detensioning

- 3.1.5.3 Post-Tensioning
- 3.1.6 Grouting Post-Tensioned Tendons
- 3.1.7 Accuracy of Stress and Elongation Measurement
  - 3.1.7.1 Stress Measurement
  - 3.1.7.2 Elongation Measurement
- 3.1.8 Prestressing Operations Records
- 3.2 INSPECTION
- 3.3 MATERIALS DISPOSITION RECORDS

-- End of Section Table of Contents --

\*\*\*\*\*  
USACE / NAVFAC / AFCEA UFGS-03230 (September 2001)  
-----  
Preparing Activity: USACE (CW) Superseding  
UFGS-03230 (December 1992)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004

Latest change indicated by CHG tags

\*\*\*\*\*

### SECTION 03230

#### STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE 09/01

\*\*\*\*\*

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.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

\*\*\*\*\*

#### PART 1 GENERAL

##### 1.1 REFERENCES

\*\*\*\*\*

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

\*\*\*\*\*

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.

ACI INTERNATIONAL (ACI)

ACI 318/318R	(2002) Building Code Requirements for Structural Concrete and Commentary
ACI 318M/318RM	(2002) Metric Building Code Requirements for Structural Concrete and Commentary
ACI SP-66	(1994) ACI Detailing Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 150	(2002ae1) Portland Cement
------------	---------------------------

ASTM INTERNATIONAL (ASTM)

ASTM A 416/A 416M	(2002) Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
ASTM A 421	(1998a) Uncoated Stress-Relieved Steel Wire for Prestressed Concrete
ASTM A 722/A 722M	(1998; R 2003) Uncoated High-Strength Steel Bar for Prestressing Concrete
ASTM C 109/C 109M	(2002) Compressive Strength of Hydraulic Cement Mortars (Using 2-in. [50-mm] Cube Specimens)
ASTM C 939	(2002) Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C 940	(1998a) Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory

1.2 LUMP SUM PRICES

\*\*\*\*\*  
NOTE: If Section 01270 MEASUREMENT AND PAYMENT 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 01270.  
\*\*\*\*\*

1.2.1 Steel Stressing Tendons and Accessories for Prestressed Concrete

1.2.1.1 Payment

Payment shall 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.

#### 1.2.1.2 Unit of Measure

Unit of measure: lump sum.

#### 1.3 SUBMITTALS

\*\*\*\*\*

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

\*\*\*\*\*

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

##### SD-02 Shop Drawings

Installation Drawings[; G][; G, [\_\_\_\_]]

Installation drawings for tendons and accessories shall be submitted and approved prior to commencing the work.

##### SD-03 Product Data

Prestressing Method and Equipment[; G][; G, [\_\_\_\_]]

Descriptions of proposed prestressing method and equipment shall be submitted and approved prior to the start of prestressing operations.

#### Materials Disposition Records

Records which identify the incorporation of approved materials into the work shall be submitted before completion of the contract.

#### Prestressing Operations Records

Complete records of the prestressing operations shall be submitted before completion of the contract.

### SD-06 Test Reports

#### Stressing Tendons and Accessories

Certified materials test reports shall be submitted for all required materials tests, note the specific standards followed in the performance of tests, show that materials comply with the applicable specifications, be submitted for each material shipment and be identified with specific lots prior to use of materials in the work.

### SD-07 Certificates

#### Certification of Prestressing Technicians

Certificates for prestressing technicians shall be submitted prior to start of prestressing operations.

## 1.4 CERTIFICATION OF PRESTRESSING TECHNICIANS

Submitted certificates for prestressing technicians who will use the proposed system in the work shall certify by name that these technicians are thoroughly trained and skilled in the use of the system.

## 1.5 DELIVERY, STORAGE AND HANDLING OF MATERIALS

Materials shall be suitably wrapped, packaged or covered at the factory to prevent being affected by dirt, water and rust. Materials shall be protected against abrasion or damage during shipment and handling. Materials stored at the site shall be placed above ground on elevated, covered platforms.

## PART 2 PRODUCTS

### 2.1 MATERIALS

Stressing tendons and accessories shall conform to the requirements of ACI 318M/318RM ACI 318/318R except as specified.

#### 2.1.1 Stressing Tendons

Stressing tendons shall be clean and free of loose rust, scale and pitting. Unbonded tendons shall be permanently protected from corrosion with an approved applied coating.

#### 2.1.1.1 Seven-Wire Stress-Relieved Strand and Strand Assemblies

Seven-wire stress-relieved strand and strand assemblies shall conform to ASTM A 416/A 416M, Grade [250] [270], strand diameter as shown. Strand assemblies may be either shop or field assembled with anchor fittings positively attached to strands.

#### 2.1.1.2 Stress-Relieved Wire and Wire Assemblies

Stress-relieved wire and wire assemblies shall conform to ASTM A 421, Type BA or WA, wire diameter as shown. Wire assemblies shall be shop assembled with anchor fittings positively attached to wires.

#### 2.1.1.3 High-Strength Steel Bars

High-strength steel bars shall conform to ASTM A 722/A 722M, Type I or II, meeting all supplementary requirements.

### 2.1.2 Accessories

#### 2.1.2.1 Ducts

Tendon ducts shall be of ferrous metal, 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 shall be large enough to provide an internal area at least twice the gross area of multiple wire, bar or strand assemblies and shall be at least 6 mm 1/4-inch larger than the diameter of a single wire, bar or strand placed in the ducts. Ducts shall be designed for watertight connections with all fittings. Galvanized ducts will not be permitted.

#### 2.1.2.2 Anchorages and Couplers

Anchorages and couplers shall be metal of proven corrosion resistance and compatible with the stressing tendons, capable of fully developing the minimum guaranteed ultimate strength of tendons without excessive slip and approved. Anchorages shall be the button-head, wedge, nut and thread, grip nut, thread-bar, threaded plate or other approved type and shall be provided with bearing plates bars, rings, bells or other positive-attaching anchor fittings. Couplers shall be provided with housings long enough to permit the necessary movements and fittings which allow complete grouting of all components.

#### 2.1.2.3 Grout

Grout for grouting post-tensioned tendons shall consist of a mixture of Portland cement, shrinkage compensating admixture and potable water of which final proportions shall be based on test results of sample mixtures. Cement shall conform to ASTM C 150, Type I or II. The shrinkage compensating admixture shall produce a 2 percent minimum and a 10 percent maximum unconfined expansion when tested in accordance with ASTM C 940, shall not contain aluminum powder, chlorides, fluorides or nitrates, may be dispensed in solid or liquid form and must be approved by the Contracting Officer prior to its use. The water content shall be the minimum necessary for proper placement but the water-cement ratio shall not exceed 0.50 by weight. The pumpability of grout shall be determined in accordance with ASTM C 939. The efflux time of a grout sample immediately after mixing shall not be less than 11 seconds. The minimum 7-day compressive strength

of 50 mm 2-inch grout cubes, molded, cured and tested in accordance with ASTM C 109/C 109M shall be 17.2 MPa. 2500 psi.

## 2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

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

## PART 3 EXECUTION

### 3.1 INSTALLATION

Stressing tendons and accessories shall be installed or placed as specified and as shown on contract and approved installation drawings. Installation details of stressing tendons and accessories not specified or shown shall be in accordance with ACI SP-66 or ACI 318M/318RM ACI 318/318R. Welding shall not be performed near or adjacent to stressing tendons. Stressing tendons shall not be installed until all welding has been completed on supports or any part which might be in contact with the tendons.

#### 3.1.1 Prestressing Method and Equipment

Descriptions of the proposed prestressing methods and equipment indicating the manufacturer of all prestressing equipment, including tensioning jacks, stress measurement gages, dynamometers and load cells or other devices for measuring stressing loads, shall be provided by the contractor. Descriptions shall 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.

#### 3.1.2 Installation Drawings

Detailed installation drawings for stressing tendons and accessories showing the type and size of stressing tendons and anchorages, erection methods, sequence of stressing and stressing calculations shall be provided by the Contractor.

#### 3.1.3 Anchorages

Anchorages must be set in a plane normal to the axis of the tendons such that uniform bearing on the concrete is assured. Positive connecting anchorages rather than gripping types shall be used for anchoring embedded ends of tendons. Anchorages and anchor fittings shall be permanently protected against corrosion. Parallel wire anchorage wedges or cores shall be recessed within the members.

#### 3.1.4 Stressing Tendons and Ducts

Protective coverings and wrappings shall be removed and each stressing tendon shall be closely inspected to see that nicks, scoring, pits or other damage does not exist and high strength steel bars shall be closely inspected to assure that they are not bent and that threaded ends are in satisfactory condition immediately prior to installation. Strand, wire and bar tendons shall be shop or field assembled as required and positively attached to anchorages. Type WA wire assemblies shall be anchored only with wedge type anchorages. Stressing tendons and ducts shall be assembled



to required shapes and dimensions and placed where indicated on drawings within specified tolerances and adequately supported. Ducts shall be securely fastened at close intervals 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 shall be effectively protected to prevent entry of water, concrete, grout or debris.

Wires of parallel-wire assemblies shall not be spliced. Steel bar tendons may be joined by couplers where shown or approved, provided they are capable of developing the guaranteed minimum ultimate strength of the bars.

Strands to be spliced shall have the same lay or direction of twist and the ends shall be cut by shears or abrasive grinders. No more than one strand shall be spliced in any one member where single strand tensioning is employed. Strand splices shall be capable of developing the full ultimate strength of the strand. Slippage of the splice shall be checked and correction made for differential slippage. Where multiple strand tensioning is used, not more than 10 percent of the strands in any member shall be spliced.

### 3.1.5 Tensioning Tendons

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

Tensioning of stressing tendons shall be as specified and shown. The stress induced in the tendons by any method of tensioning shall be determined 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 within 5 percent, the operation shall be carefully checked and the source of error determined and corrected before proceeding further. Concrete cylinder tests shall 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 shall be as shown. Safety measures shall be taken by the Contractor to prevent accidental injury caused by failure of a stressing tendon or tendon component. The exposed ends of stressing tendons and anchorages shall be protected from damage during stressing operations to prevent failure.

#### 3.1.5.1 Pretensioning

Strand tendons may be tensioned by jacking of groups of strands or may be tensioned individually by means of a single-strand jack. Before final tensioning, all tendons shall be brought to a uniform initial tension of approximately 4.5 kN 1,000 pounds per strand per 60 m 200 feet of bed, with a minimum of 4.5 kN 1,000 pounds and a maximum of 13.5 kN 3,000 pounds per strand. The force corresponding to the initial tension shall be measured by a dynamometer or other approved method to aid in determining the final elongation. After this initial tensioning, the tendons shall be stressed to the total tension indicated on the drawings using hydraulic or mechanical equipment with gauges or dynamometers graduated and calibrated to accurately determine the load applied. Draped pretensioned strands shall be tensioned partially by jacking at the end of the bed and partially by uplifting or depressing strands, or they shall be held in their draped positions by means of rollers, pins or other approved methods and tensioned

entirely by jacking. Approved low-friction devices shall be used at all points of change in slope of draped strands while tensioning draped strands, regardless of the tensioning method used. Cable stress shall be maintained between anchorages until the concrete has reached the specified compressive strength.

#### 3.1.5.2 Detensioning

Forces from pretensioned strands shall be transferred to the concrete by either the multiple-strand release or the single-strand release method. The stress transfer shall not be performed until concrete strength, as indicated by test cylinders, has reached the specified transfer strength. If concrete has been heat-cured, the detensioning shall be done immediately following the curing period while the concrete is still warm and moist. During detensioning, the prestressing forces shall be kept nearly symmetrical about the vertical axis of the member and shall be applied in a manner that will minimize sudden loading. Eccentricity about the vertical axis shall be limited to one strand.

a. Multiple-Strand Release: In this method, all strands shall be detensioned simultaneously and the load transferred gradually to the concrete by hydraulic jacking.

b. Single-Strand Release: In this method, all strands shall be detensioned by slow heat-cutting the strands in accordance with a pattern and schedule as approved. The strands shall be heated using a low-oxygen flame until the metal gradually loses its strength, causing release of the strands to occur gradually. The low-oxygen flame shall be played along the strand for a minimum of 125 mm. five inches. Strands shall be so heated that the failure of the first wire in each strand shall occur after the torch has been applied for a minimum of five seconds.

#### 3.1.5.3 Post-Tensioning

Tensioning shall not be performed until the concrete has reached the required strength at transfer of stress. Before final tensioning of tendons, all tendons shall be brought to a uniform initial tension of approximately 10 percent of the full load. The force corresponding to the initial tension shall be measured by a dynamometer or other approved method as a starting point in determining final elongation. A temporary overstress above the final prestress force as approved by the Contracting Officer shall be used to overcome stress losses. The units shall be tensioned until the proper elongations and jacking pressures are attained and reconciled within the limits stated above. Straight tendons may be tensioned from one end. Curved or draped tendons shall be stressed by simultaneous jacking from both ends using a common pump with identical hoses and jacks, unless otherwise shown.

#### 3.1.6 Grouting Post-Tensioned Tendons

Grouting between each tendon and its enclosing duct shall be performed within 5 days after completion of the tensioning operation. Grouting shall not be performed 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. The grout shall be mixed in a mechanical mixer of a type that will produce uniformly and thoroughly mixed grout. First water shall be placed in the mixer followed by cement and admixture. Grout shall be continuously agitated until it is pumped. Grout that has

begun to set shall be discarded. Just before grouting, the ducts shall be flushed with clean water and then blown clear by compressed air to removed excess water. With the grout vent open at one end of duct, grout shall be applied 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. The discharge vent shall then be closed and the pressure raised to 340 MPa 50 psi minimum and held for at least 1 minute. The injection point shall then be closed 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 shall 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 shall 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 12 months. Recalibration shall be performed at any time that a gaging system shows indication of erratic results in the opinion of the Contracting Officer. Gauges shall indicate loads directly in kilonewtons pounds or be accompanied by a chart which converts dial readings into kilonewtons pounds.

#### 3.1.7.2 Elongation Measurement

After the initial force has been applied to a tendon, reference points for measuring elongation due to additional tensioning forces shall be established. They shall be located according to the method of tensioning and type of equipment. The system used shall be capable of measuring the true elongation plus or minus 2 mm. 1/16-inch.

### 3.1.8 Prestressing Operations Records

The Contractor shall compile and submit complete prestressing operations records to the Contracting Officer. These records shall show 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.

## 3.2 INSPECTION

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

## 3.3 MATERIALS DISPOSITION RECORDS

Accurate materials disposition records identifying all materials incorporated into the work and showing the disposition of specific lots of approved tested materials shall be compiled by the Contractor.

-- End of Section --