ITEM 16563.50 M - 48 MPa STRUCTURAL CONCRETE

DESCRIPTION: This work shall consist of the furnishing and installing of structural concrete pier footings by using either precast concrete elements or cast in place concrete elements, including all concrete, reinforcing steel, prestressing steel, and embedded items, and the handling, storage and transport of elements when necessary.

Furnishing, installing, pretensioning and grouting of the prestressing system shall be done in accordance with 718-101 Prestressing System.

CAST-IN-PLACE OPTION

This Specification has been Disapproved by EI 04-021

MATERIALS: Portland Cement Concrete shall comply with the material requirements of §501, Portland Cement Concrete, General with the following modifications:

1. It will be the Contractor's responsibility to design a concrete mixture which will result in an average compressive strength of 48 MPa or greater at the end of 28 curing days.

2. Maximum cement content shall be 445 kg/m³ and the minimum cement content shall be 325 kg/m³. The use of fly ash is permitted.

3. The design air content (entrapped plus entrained) shall be 6.5% with a minimum of 5.0% and a maximum of 8.0%.

4. The design slump shall be 65 mm to 90 mm.

The proposed mix design shall be trial mixed and the results shall be submitted in writing to the Engineer at least 15 working days prior to initial placement. The mix design shall include a description, source of materials, proportions and results including air content, slump and compressive strengths at 7, 14 and 28 days. Tests shall be in accordance with the following ASTM standards:

C192M - "Practice for Making and Curing Concrete Test Specimens in the Laboratory"

C39 - "Test Method for Compressive Strength of Cylindrical Concrete Specimens"

C143 - "Test Method for Slump of Hydraulic Cement Concrete"

C231 - "Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method"

The mix design submittal is for information purposes only. All changes to the mix design shall require the same procedure outlined above.

Additional materials, listed below, required specifically for use in conjunction with structural concrete items shall meet the requirements of the following subsections:

Portland Cement Mortar Bonding Grout	705-22
Bar Reinforcement, Grade 400	709-01
Quilted Covers (for curing)	711-02
Plastic Coated Fiber Blankets (for curing)	711-03
Polyethylene Curing Covers (White Opaque)	711-04
Membrane Curing Compound	711-05
Burlap	711-06
Form Insulating Materials for Winter Concreting	711-07
Admixtures	711-08
Water	712-01
Epoxy Polysulfide Grout	721-03
Concrete Cylinder Curing Box	735-01

This Specification has been Disapproved by EI 04-021

CONSTRUCTION DETAILS:

No construction shall proceed until the submittals required by 718-101 - "Prestressing System" have been reviewed and approved. The provisions of subsections §501-3, and §555-3 shall apply with the following modifications:

1. Sampling of concrete during the placement procedures shall be in accordance with NYSDOT Materials Method 9.2.

2. Cylinder sampling shall consist of the casting at least 1 set of cylinders for every 38 cm from multiple concrete haul units. A minimum of three concrete haul units shall be subject to the casting of cylinders. All units picked for cylinder casting shall be chosen at random by the Engineer. Two cylinders shall be cast from concrete transported by a single haul unit. One of those cylinders shall be cast from the initial delivery of concrete.

   All cylinder casting shall be done by the Contractor under the supervision of the Engineer. Cylinder casting shall be done in accordance with NYSDOT Materials Method 9.2. The Contractor shall supply all necessary molds. Cardboard molds will not be permitted.

   The Contractor shall clearly identify each cylinder to indicate the concrete placement it represents.

3. Concrete not meeting the air content requirements of between 5.0% and 8.0% will be rejected.

4. All cylinders cast under the sampling program shall be cured in the same manner, and under the same conditions as the placement they represent.

Cylinders shall be tested for strength according to the following schedule:

A. At seven curing days.

B. At fourteen curing days.
C. At twenty-eight curing days.

A curing day is defined by subsection §555.3.09A.

5. The strength level of the concrete will be considered acceptable provided the strengths of the tested cylinders meet the following values at the indicated curing time:

   A. 31 MPa average strength at seven curing days with no individual cylinder testing results below 29 MPa.

   B. 36 MPa average strength at fourteen curing days with no individual cylinder testing results below 33 MPa.

   C. 41 MPa average strength at twenty-eight curing days with no individual cylinder testing results below 36 MPa.

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Concrete represented by cylinders meeting test criterion 5A, or 5B, will not require further testing for strength.

6. If the strength of any individual cylinder testing results below 36 MPa at twenty-eight curing days, the Engineer may require an evaluation of the in-place concrete represented by the cylinder. At least three representative cores having a nominal diameter of 100 mm shall be obtained and tested by the Contractor in accordance with ASTM C42-94. The location of the cores shall be determined by the Engineer from the placement that is identified as potentially deficient. When coring, the Contractor shall make every effort to avoid reinforcing steel. After coring, the core holes shall be filled and repaired to the satisfaction of the Engineer with material meeting the requirements of subsection §701-04 CONCRETE REPAIR MATERIAL. Concrete in the placement represented by the cores will be considered adequate if the average strength equals or exceeds 41 MPa and no single core tests less than 36 MPa.

7. Concrete represented by cylinders averaging less than 29 MPa , or cores averaging less than 25 MPa will be subject to rejection and shall be removed upon the orders of the Engineer.

8. All delays to Construction occasioned by testing, investigation, filing documents and obtaining approvals, as described above, shall accrue to the total time taken by the Contractor to complete the work.

PRE-CAST OPTION

Casting of the precast concrete elements shall not begin until a review of the Shop Drawings, required calculations, the prestressing system, and proposed concrete mix design has been completed by the Deputy Chief Engineer Structures (D.C.E.S.).

718 - 101 PRESTRESSING SYSTEM

1. GENERAL. The requirements of the Precast Concrete Construction Manual and the following shall apply:

   A. Compressive strengths shall meet the following:

Age (days)	Minimum Strength (MPa)
7	31
28	41

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   B. An approved high-range, water reducing admixture system shall be used.

   C. Design slump range shall be 50 mm to 100 mm. Maximum slump at placement shall be 150 mm.

   D. Maximum water-cement ratio of 0.40.

   E. Entrained air, by volume, 6.0 ±2.0 percent at point of placement.

CAST-IN PLACE AND PRE-CAST OPTION

Post-tensioning shall be in accordance with 718-101 Prestressing System.

METHOD OF MEASUREMENT: Measurement will be taken as the number of complete units installed as shown on the Contract Plans.

BASIS OF PAYMENT: The unit price bid for each unit shall include all labor, materials and equipment necessary to complete the work.

SCOPE. This work shall consist of furnishing, installing, stressing and grouting post-tensioned prestressing steel in accordance with the details shown on the Plans and the requirements of these Specifications.

It shall also include the furnishing and installing of any appurtenant items necessary for the particular post-tensioning system used which are internal to the concrete, anchorage

assemblies, additional reinforcing bars required to resist stresses caused by anchorage assemblies, and grout used for pressure grouting ducts.

Any prestress system proposed by the Contractor shall comply with the following:

A. Materials and devices used in the post-tensioning system shall conform to the requirements set forth herein.

B. The net compressive stress in the concrete after all losses is at least as large as that provided by the system shown on the Plans.

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C. The distribution of individual tendons at each section generally conforms to the distribution shown on the Plans.

D. The ultimate strength of the structure with the proposed post-tensioning system meets the requirements of Section 9 of the AASHTO Standard Specifications for Highway Bridges, 1992 Edition including all applicable Interim Specifications; and shall be equivalent to the ultimate strength provided by the original design.

E. Stresses in the concrete and prestressing steel at all sections and at all stages of construction meet the requirements of the Design Criteria noted on the Plans.

F. All provisions of the Design Criteria, as noted on the Plans, shall be satisfied.

SHOP DRAWINGS. The Contractor shall submit detailed shop drawings which include, but are not limited to:

A. A complete description of and details covering each of the post-tensioning systems to be used for permanent and temporary tendons. This shall include:

i. Designation of the specific prestressing steel, anchorage devices, bar couplers, duct material and accessory items to be used.

ii. Properties of each of the components of the post-tensioning system.

iii. Details covering assembly of each type of post-tensioning tendon.

iv. Equipment to be used in the post-tensioning operation.

v. Procedure and sequence of operations for prestressing and securing tendons.

vi. Procedure for releasing the prestressing steel elements.

vii. Parameters to be used to calculate the typical tendon force such as expected friction coefficients, anchor set and prestress steel relaxation curves.

B. A table detailing the post-tensioning-jacking sequence, jacking forces and initial elongation of each tendon at each stage of erection for all post-tensioning.

C. Complete details of the anchorage system for post-tensioning including certified copies of the reports covering tests performed on prestress anchorage devices as required by this specification and details for any reinforcing steel needed due to stresses imposed in the concrete by anchorage plates.

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D. For the operation of grouting post-tensioning tendons, the materials and proportions for grout, details of equipment for mixing and placing grout and methods of mixing and placing grout.

E. Calculations to substantiate the post-tensioning system and procedures to be used including stress-strain curves typical of the prestressing steel to be furnished, required jacking forces, elongation of tendons during tensioning, seating losses, short-term prestress losses, long-term prestress losses, temporary overstress, stresses in prestress anchorages including distribution plates and reinforcing steel needed in the concrete to resist stresses imposed by prestress anchorages. These calculations shall show a typical tendon force after applying the expected friction coefficient and anticipated losses for the stressing system to be used including anchor set losses. The modulus of elasticity of the prestressing steel shown in the general notes in the Plans shall be used in elongation calculations. Field adjustments of the elongations shall be made based on the strand area and modulus of elasticity shown in the suppliers Test Reports described in this specification.

F. Complete details of the apparatus and method to be used by the Contractor for the test required in these Special Provisions.

<u>MATERIAL REQUIREMENTS</u>

1. GENERAL. The materials to be incorporated into work covered by this Section shall conform to the requirements set out herein.

2. PRESTRESSING STEEL.

A. STRAND. Strand shall be uncoated, 7-wire strand conforming to the requirements of ASTM A-416. Unless otherwise noted in the Plans or Special Provisions, strand shall be Grade 270 having low relaxation properties.

B. BAR. Prestress bars shall be uncoated, high strength deformed bars conforming to the requirements of ASTM A-722, Type II. Bars shall be Grade 150.

3. BAR COUPLERS. Use and location of prestressing bar couplers shall be subject to approval by the Inspector. A bar coupler shall develop at least 95 percent of the minimum ultimate strength of the prestressing bar on which it is to be used as specified by the manufacturer of the prestressing bar. The elongation at rupture of a coupled tendon shall not be less than the specified elongation at rupture for an intact tendon.

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Testing of couplers shall be performed using samples of the prestressing bar to be used in the work. The test specimen shall be assembled in an unbonded state and, in testing, the anticipated set shall not be exceeded.

4. PRESTRESS ANCHORAGES. All prestressing steel shall be secured at the ends by means of permanent type anchoring devices. Prestress anchorages shall develop at least 95 percent of the minimum specified ultimate tensile strength of the prestressing steel.

The Contractor shall design, furnish and install any reinforcing steel required to resist splitting and bursting forces imposed in the concrete by prestress anchorages.

Testing of prestress anchorage devices shall be performed using samples of the type of prestressing steel to be used in the work. The test specimen shall be assembled in an unbonded state and, in testing, the anticipated set shall not be exceeded.

Anchorage devices shall be arranged so that the prestressing force in the tendon may be verified prior to removal of the stressing equipment.

Prestress anchorage devices shall effectively distribute prestressing loads to the concrete and shall conform to the following requirements:

The average bearing stress in the concrete created by the anchorage plates shall not exceed the values as determined by the following equations:

<u>At Service Load:</u>
$f_{cp} = 0.6\ f'_c \times (A'b/Ab)^{1/2}$
But not greater than $1.25 \times f'_c$

<u>At transfer Load:</u>
$f_{cp} = 0.8\ f'_{ci} \times ((A'b/Ab) - 0.2)^{1/2}$
But not greater than $1.25 \times f'_{ci}$

where

f_{cp} = permissible concrete compressive stress
f'_c = compressive strength of concrete (28 days)
f'_{ci} = specified minimum compressive strength of concrete allowed at the time post-tensioning is applied
A'b = maximum area of the portion of the concrete anchorage surface that is geometrically similar to and concentric with the area of the anchorage
Ab = bearing area of the anchorage

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Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material in the anchorage plate when 95 percent of the ultimate strength of the tendon is applied. Nor shall it cause visual distortion of the anchor plate as determined by the Inspector.

5. DUCTS

A. GENERAL. All duct material shall be sufficiently rigid to withstand loads imposed during placing of concrete and internal pressure during grouting while maintaining its shape, remaining in proper alignment and remaining watertight.

The duct system, including splices and joints shall effectively prevent entrance of cement past or water into the system and shall effectively contain pressurized grout during grouting of the tendon. The duct system shall also be capable of withstanding water pressure during flushing of a duct in the event the grouting operation is aborted.

The interior diameter of ducts for single strand, bar or wire tendons shall be at least 1/4-inch greater than the nominal diameter of the tendon. The interior diameter of ducts for tendons consisting of more than one strand, bar or wire shall be large enough to cause the duct to have an interior area not less than two times the net area of the prestress steel.

B. DUCT TYPE DESIGNATION. Except as otherwise designated in the Plans, the type of duct material used in specific applications shall be as follows:

Number of Strands in Tendon		Tendon Radius '(R) Ft.	Duct Type	
0.5"ϕ	0.6" ϕ		Longitudinal in Superstructure	Transverse in Superstructure
		20 < R	A, B, C	C
1 to 13	1 to 8	10*<R<20	A, B	C
		2<R<10	A	C

		30<R	A, B, C	C
14 to 20	9 to 13	12*<R<30	A, B	C
		2.5<R<12	A	C
		50<R	A, B, C	C
20 to 32	14 to 20	25*<R<50	A, B	C
		3<R<25	A	C

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* This radius is the minimum allowed for a tendon unless otherwise shown in the Plans.

NOTES:

a. Type D duct material shall be used for any portion of a tendon which is not embedded in concrete.

b. Type A duct material shall be used for those portions of a tendon essentially external to the concrete which are embedded in a deviation block or beam.

c. Type A duct material which is embedded in a deviation block shall be bent to a uniform radius along a curve extending between tangent points located 3 inches inward from the face of the deviation block.

KEY TO DUCT MATERIAL:

A - Rigid Steel Pipe
B - Corrugated Metal
C - Corrugated Plastic
D - Smooth Plastic

C. SPECIFIC DUCT PROPERTIES.

1. TYPE A - STEEL PIPE. Steel pipe duct shall be galvanized steel pipe conforming to the requirements of ASTM A-53, Type E, Grade B. The nominal wall thickness of the pipe shall be any thickness shown in Table x 2.2 of ASTM A-53. The pipe shall be bent so as to accurately conform to the alignment of the tendon taking into consideration the minimum bending radius shown in the shop drawings.

2. TYPE B - CORRUGATED METAL. Corrugated metal duct shall be fabricated with either welded or interlocked seams and shall be capable of being bent without crimping or flattening. Sections of duct shall be connected with positive ferrous metal connectors which prevent angle changes at joints.

Duct and metal connectors shall be fabricated from galvanized sheet steel meeting the requirements of ASTM 525, Coating Designation G90. Areas of zinc coating damaged by welding or in fabricating interlocked seams shall be repaired by painting with a zinc dust-zinc oxide paint conforming to Federal Specification TTP-640 or MIL-P-21035. For strand and wire tendons, the duct thickness shall be 26 gauge up to 2-5/8-in. diameter. Ducts larger than 2-5/8-in. diameter shall be 24 gauge. For bar tendons, the duct thickness shall not be less than 31 gauge.

Metal ducts requiring small radii bends shall be prebent before placement in the form.

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Joints between sections of duct shall have no sharp edges which contact the prestressing steel.

3. TYPE C - CORRUGATED PLASTIC. Plastic duct shall be made of polyethylene material and shall conform to the requirements of ASTM D2239 or D3350 with a cell classification PE 335433C or ASTM D1248, Type 3, Grade 34, Category 5. The plastic material shall not react with concrete or enhance corrosion of prestress steel and shall be free of water soluble chloride. Material thickness shall be 0.050 in ±0.010 in.

Corrugated plastic duct shall be corrugated with a continuous spiral having a pitch not less than one-tenth of the radius of the duct.

Corrugated plastic duct shall be designed so that a force equal to 40 percent of the ultimate tensile strength of the tendon will be transferred through the duct into the surrounding concrete in a length of 2 feet 6 inches. Twelve static pull out tests shall be conducted to determine compliance of a duct with the force transfer requirement. If ten of these tests exceed the specified force transfer, the duct is acceptable. The Contractor shall provide to the Inspector certified test reports verifying that the duct meets specification requirements in regard to force transfer.

4. TYPE D - SMOOTH PLASTIC. Smooth plastic duct shall be made of polyethylene material and shall conform to the requirements of ASTM D2239 or D3350 with a cell classification PE 335433C or ASTM D1248, Type 3, Grade 34, Category 5. The plastic material shall not react with concrete or enhance corrosion of prestress steel and shall be free of water soluble chloride. The outside diameter to wall thickness ratio shall be 21 or less.

6. GROUT FOR TENDONS.

718 - 101 PRESTRESSING SYSTEM

A. GENERAL. The grout to be used to fill the voids in tendons shall consist of portland cement, water and admixtures which impart low water content, flowability, minimum bleeding, expansion or non-shrink and, when necessary, set retarding properties to the grout.

B. GROUT COMPONENTS. Portland cement shall conform to the requirements of AASHTO M-85 Type I or Type II. The cement shall be fresh and not contain lumps or other indication of hydration or "pack set". The Contractor shall furnish, for each shipment of cement, a manufacturer's report stating the results of tests made on samples of the material taken during production or transfer and certifying that the applicable requirements of AASHTO M-85 have been met.

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Water shall be potable, clean and free of injurious quantities or substances (chlorides, sulfites and nitrates) known to be harmful to portland cement or prestressing steel.

Admixtures shall consist of chemicals which, when incorporated into the grout mixture, impart the properties of low water content, good flowability, minimum bleeding (sedimentation of cement), expansion or non-shrink and, when necessary, increase in setting time. Admixture containing chlorides, sulfites, fluorides and nitrates shall not be used. The date of manufacture shall be clearly stamped on each container. No admixture for which the shelf life recommended by the manufacturer has expired shall be used.

C. GROUT MIXTURE. The Contractor shall determine the exact kinds of admixtures and proportions of materials to be used to meet the requirements set out in these Special Provisions and which, from prior documented experience with similar materials, equipment and placing conditions, will result in a grout which does not bleed excessively and can be effectively place. The quantity of water in the grout shall be as low as possible, consistent with the fluidity needed for placing.

Prior to beginning grouting operations, the Contractor shall furnish to the Inspector the results of tests performed by a laboratory approved by the Inspector demonstrating that the grout mixture he proposes to use meets the requirements of this Specification. This information shall include a graph relating compressive strength of the grout to age covering ages from 24 hours to 28 days.

A commercial cement-based grout mixture meeting the requirements of this Specification may be used subject to approval by the Inspector.

D. REQUIRED PROPERTIES OF GROUT. Grout shall have the following physical properties:

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Property	Test Value	Test Method
Water-Cement Ratio	Max. 0.45	--
Shrinkage*	0%	ASTM C-1090**
Compressive Strength @ 28 Days (average of 3 Cubes)	Min. 3,000 psi	ASTM C-942**
Initial Set of Grout	Min. 90 Minutes	ASTM C-953**
Efflux Time from Flow Cone	Min. 11 seconds ***	ASTM C-939**

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* This property is applicable only to vertical tendons.

** The test specimen shall be prepared using the materials and in the proportions which are to be used in production of grout.

*** The flow cone test shall not apply to grout which contains an admixture imparting a thixotropic consistency to the grout.

MANUFACTURER'S LOTS. The manufacturer of prestressing steel, prestress anchorages, and bar couplers shall assign an individual number to each Lot of strand, wire, bar or devices at the time of manufacture. Each reel, coil, bundle or package shipped to the project shall be identified by tag or other acceptable means as to Manufacturer's Lot number. The Contractor shall be responsible for establishing and maintaining a procedure by which all prestressing materials and devices can be continuously identified with the Manufacturer's Lot number. Items which at any time cannot be positively identified as to Lot number shall not be incorporated into the work.

Low relaxation strand shall be clearly identified as required by ASTM A-416. Any strand not so identified will not be accepted.

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The Contractor shall furnish manufacturer's certified reports covering the tests required by this Specification. A certified test report stating the guaranteed minimum ultimate tensile strength, yield strength, elongation and composition shall be furnished for each Lot of prestressing steel. Stress-strain curves for prestressing steel shall be furnished. A certified test report stating strength when tested using the type of prestressing steel to be used in the work shall be furnished for each Lot of prestress anchorage devices.

SAMPLING AND TESTING. All testing shall be done in accordance with ASTM Specifications. The following samples of materials and devices selected at locations designated by he Inspector shall be furnished by the Contractor at his expense:

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1. Three 7-foot-long samples of prestressing wire or bar for each size from each heat number or production Lot.

2. Three 5-foot-long samples of prestressing strand for each size from each heat number or Production Lot.

3. If bar couplers are to be used, three specimens consisting of two 4-foot lengths of the specific prestressing bar to be used coupled with the bar coupler to be used.

4. One unit of each prestress anchorage to be used.

Samples shall be furnished well in advance of the time they are to be incorporated into the work.

The State reserves the right to reject for use any material or device which is obviously defective or was damaged subsequent to testing.

TESTING OF POST-TENSIONING TENDONS BY THE CONTRACTOR. The Contractor shall perform certain testing of post-tensioning tendons as specified herein.

IN-PLACE FRICTION TEST OF TENDONS. For the purpose of accurately determining the friction loss in stressing curved tendons, the Contractor shall test in place a curved tendon selected by the Inspector. If deemed necessary by the Inspector to accurately establish friction loss, the Contractor shall perform tests on additional tendons selected by the Inspector. The test procedure shall consist of stressing the tendon at an anchor assembly with the dead end anchor consisting of a calibrated load cell. The results of the tests (loss due to friction) shall be submitted to the Inspector. Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Inspector.

PROTECTION OF PRESTRESSING STEEL. All prestressing steel shall be protected against physical damage at all times from manufacture to grouting or encasing in concrete.

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Prestressing steel that has sustained physical damage at any time shall be rejected. Any reel that is found to contain broken wires shall be rejected and the reel replaced.

Prestressing steel shall be packaged in containers or shipping forms for protection of he steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor, which prevents rust or other results of corrosion, shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Inspector, a corrosion inhibitor may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of Federal Specification MIL-P-3420. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

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The prestressing steel shall be stored in a manner which will at all times prevent the packaging material from becoming saturated with water and allow a free flow of air around the packages. If the useful life of the corrosion inhibitor in the package expires, it shall immediately be rejuvenated or replaced.

At the time the prestressing steel is installed in the work, it shall be free from loose rust, loose mill scale, dirt, paint, oil, grease or other deleterious material. Removal of tightly adhering rust or mill scale will not be required. Prestressing steel which has experienced rusting to the extent that it exhibits pits visible to the naked eye shall not be used in the work. The shipping package or form shall be clearly marked with the heat number and with a statement that the package contains high strength prestressing steel, and care is to be used in handling. The type and amount of corrosion inhibitor used, the date when placed, safety orders and instructions for use shall also be marked on the package or form.

If the period of time between installation of prestressing steel and grouting of the tendon will exceed 10 calendar days, the prestressing steel shall be protected from corrosion during the entire period it is in place but ungrouted as provided below.

When the Plans provided for prestressing steel to be installed in one unit with a length of prestressing steel left projecting to be threaded into another unit during erection all of the prestressing steel shall be protected from corrosion from immediately after it is installed in the first unit until the tendon is grouted as provided below.

When corrosion protection of in-place prestressing steel is required, a corrosion inhibitor which prevents rust or other results of corrosion shall be applied directly to the prestressing steel. The corrosion inhibitor shall have no deleterious effect on the prestressing steel or grout or bonding of the prestressing steel to the grout. The inhibitor shall be water soluble. The corrosion inhibitor, the amount and time of initial application, and the frequency of reapplication shall be subject to the Engineer’s approval.

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INSTALLATION OF DUCTS. Ducts shall be securely tied in position, carefully inspected and required before placing of the concrete is started. Care shall be exercised during the placing of the concrete to avoid displacing or damaging the ducts. Ducts shall be supported at intervals of not more than 3 feet. Any additional mild reinforcing required to support post-tensioning ducts shall be supplied by the Contractor at no expense to the Owner. The tolerance on the location of the tendons shall be plus or minus 1/4-inch at any point. After installation in the forms, the ends of ducts shall at all times be sealed to prevent entry of water and debris.

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Pipes, as specified herein shall be installed on each duct to serve as injection or vent ports during grouting. For other than vertical ducts, any duct which exceeds 200 feet in length and/or has a tendon profile varying in elevation by more than six inches shall be vented at all high points in the tendon profile and, if freezing weather conditions are anticipated prior to grouting, at all low points in the tendon profile.

POST-TENSIONING OPERATIONS.

1. FORCES IN TENDONS. The design of the structure is based on the jack forces, stressing method (one end, alternate end, or both end stressing), assumed friction and wobble coefficient shown in the Plans.

   All post-tensioning steel shall be tensioned by means of hydraulic jacks so that the force of the prestressing steel shall not be less than the value shown on the approved shop drawings. The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 80 percent of the specified minimum ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at initial stresses in a way that will result in the ultimate retention of permanent forces of not less than those shown on the approved shop drawings, but in no case shall the initial stress at the anchors, after anchor set, exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel. Permanent force and permanent stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, losses in post-tensioned prestressing steel due to sequence of stressing, friction and take-up of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

   When friction must be reduced, water soluble oil or graphite with no corrosive agents may be used as a lubricant subject to the approval of the Inspector. Lubricants shall be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately blown dry with oil-free air. The Contractor shall submit a plan for capturing all fluids generated by the flushing method

for approval by the Inspector. No lubricants or flushing water will be allowed to enter any waterways or environmentally sensitive areas.

2. STRESSING JACKS. Each jack used to stress tendons shall be equipped with a pressure gauge having an accurate reading dial at least six inches in diameter for determining the jack pressure. Prior to use for stressing on the project, each jack and its gauge shall be calibrated as a unit by a testing laboratory approved by the Inspector. Calibration shall be done with the cylinder extension approximately in the position that it will when applying the final jacking force and with the jacking assembly in an identical configuration to that which will be used at the job site (i.e., same length hydraulic lines). Certified calibration calculations and a calibration chart, both in English units of measure, shall be furnished to the Inspector for each jack.

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   Recalibration of each jack shall be done at six-month intervals and at other times when requested by the Inspector. At the option of the Contractor, calibrations subsequent to the initial laboratory calibration may be accomplished by the use of a master gauge. The master gauge shall be supplied by the Contractor in a protective waterproof container capable of protecting the calibration of the master gauge during shipment to a laboratory. The Contractor shall provide a quick-attach coupler next to the permanent gauge in the hydraulic lines which enables the quick and easy installation of the master gauge to verify the permanent gauge readings. The master gauge shall remain in the possession of and be calibrated by the Inspector for the duration of the project. If any repair to or modification of a jack is accomplished, such as replacing the seals or changing the length of the hydraulic lines, the jack shall be recalibrated by the approved testing laboratory. No extra compensation will be allowed for the initial or subsequent jack calibrations or for the use and required calibration of a master gauge.

3. STRESSING OF TENDONS. Post-tensioning forces shall not be applied until the concrete has attained the specified compressive strength as evidenced by tests on representative samples of the concrete.

   The tensioning process shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured at all times. A permanent record shall be kept of gauge pressures and elongations at all times and shall be submitted to the Inspector. The post-tensioning force may be verified as deemed necessary by the Inspector. The tendon force measured by gauge pressure shall agree within five percent of the theoretical elongation or the entire operation shall be checked and the source of error determined and remedied to the satisfaction of the Inspector before proceeding with the work. Elongations shall be measured to the nearest 1/16 inch. Equipment for tensioning the tendons must be furnished by the manufacturer of the system. Should agreement between pressure gauge readings and measured elongations fall outside the

acceptable tolerances, the Inspector may require without additional compensation to the Contractor, additional in-place friction tests in accordance with these Special Provisions.

In the event that more than two percent of the individual strand wires in a tendon break during the tensioning operation, the strand (or strands) shall be removed and replaced. Previously tensioned strands shall not be allowed unless approved by the Inspector.

Post-tensioning bars used to apply temporary post-tensioning may be reused if they are undamaged.

This Specification has been Disapproved by EI 04-021

Prestressing steel shall be cut using an abrasive saw within 3/4 to 1-1/2 in. away from the anchoring device.

GROUTING OF TENDONS.

1. GENERAL. After post-tensioning and anchoring of a tendon has been completed and accepted, the space between the prestressing steel and the duct shall be grouted in accordance with this Specification. In the interval between the post-tensioning and grouting operations, the prestressing steel shall be protected as provided in accordance with these Special Provisions. Immediately after post-tensioning, all grout vents of each tendon shall be temporarily sealed with plugs to prevent entrance of air or water and left in place until just prior to tendon grouting.

2. EQUIPMENT. Equipment for batching component materials shall be capable of accurately measuring the materials.

   The mixer shall be capable of continuous mechanical mixing of the ingredients to produce a grout which is free of lumps and in which the ingredients are thoroughly dispersed.

   The grouting equipment shall contain a screen having clear openings of 0.125 inch maximum size to screen the grout prior to its introduction into the grout pump. If a grout with a thixotropic additive is used, a screen opening of 3/16 inch will be satisfactory. This screen shall be easily accessible for inspection and cleaning.

   Grout pumps shall be capable of pumping the grout in a manner which complies with the provisions of this Specification. Pumps shall be a positive displacement type capable of producing an outlet pressure of not less than 150 psi and shall have seals which are adequate to prevent introduction of oil, air or other foreign substance into the grout and to prevent loss of grout or water.

A pressure gauge having a full scale reading of no greater than 300 psi shall be placed at some point in the grout line between the pumping outlet and the duct inlet.

The grouting equipment shall utilize gravity feed to the pump inlet from a hopper attached to and directly over it. The hopper must be kept at least partially full of grout at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct.

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Pipes or other suitable devices shall be provided for injection of grout and to serve as vent holes during grouting. The material for these pipes shall be at least 1/2 inch inside diameter and may be either metal or a suitable plastic which will not react with the concrete or enhance corrosion of the prestressing steel and is free of water soluble chlorides. These pipes shall be fitted with positive mechanical shut off valves capable of withstanding grouting pressures. All connections between a grout pipe and a duct shall be made with metal or plastic structural fasteners and taped with a waterproof tape as necessary so as to assure a water tight connection.

3. MIXING GROUT. The sequence for charging the mixer shall be add water, start mixer and add cement. When cement and water are reasonably well mixed, admixtures shall be introduced in accordance with written instructions of the manufacturer of each admixture. The mixing procedures shall avoid admixture from getting caught on blades or sides of drum and from forming gel globules. The mixing procedure may be varied in accordance with the written recommendations of the manufacturer of the admixtures. The grout shall be mixed until a uniformly blended mixture is obtained and shall be continuously agitated until it is introduced into the group pump. Batches of grout shall be placed within 30 minutes of mixing. No water shall be added to the grout to modify its consistency after the initial mixing operation is completed.

4. CLEANING AND FLUSHING TENDONS. If a water soluble lubricating oil or corrosion inhibiting oil applied to the prestressing steel or an embedded tendon is discontinuous through a joint between segments, the tendon shall be flushed as provided below.

   Immediately prior to grouting operations, the inside of the tendon shall be flushed with water meeting the requirements of these Special Provisions (under pressure) to remove all traces of the corrosion inhibitors used to protect the prestressing steel. Flushing operations shall continue until the discharge water is free of any traces of the corrosion inhibitor. All water containing corrosion inhibitor chemicals shall be collected in containers and disposed of as required by governmental regulations. Following the cleaning operations, water shall be totally drained from within the tendon and it shall be blown out with compressed oil-free air to the extent necessary to dry the prestressing steel and the inside surfaces of the pipe.

5. PLACING GROUT. Grouting shall start at the lowest injection point with all vent holes open. The pumping pressure through the pipe shall be maintained until grout is continuously wasted at the next vent hole and until no visible slugs or other evidence of water or air are ejected and the grout being ejected has the same consistency as the grout being injected. The vent valve shall then be closed, the pumping pressure held momentarily and the valve at the injection port closed.

   The pumping pressure at the tendon inlet shall not exceed 250 psi, however, normal operations shall be performed at 75 psi. If the actual grouting pressure exceeds the maximum recommended pumping pressure, grouting may be injected at any vent hole which has been or is ready to be closed as long as a one-way flow of grout is maintained. When one-way flow of grout cannot be maintained, the grout shall be immediately flushed out of the duct with water.

   The shut-off valves on the pipes serving as injection ports or vent ports shall not be opened until the grout has taken its final set.

   When it is anticipated that the air temperature will fall below 32◦F, ducts shall be kept free of water so as to avoid freeze damage to ducts. No grouting shall be done when the temperature of the grout is below 45◦F. The temperature of the concrete or air surrounding the tendon shall be maintained at 35◦F or above from the time grout is placed until the compressive strength of the grout, as determined from tests on two inch cubes cured under the same conditions as the in-place grout, exceeds 800 psi.

   Under hot weather conditions, grouting shall take place early in the morning when daily temperatures are lowest. No grouting shall be done when the temperature of the grout exceeds 90◦F. It may be necessary to chill mixing water or take other special measures to lower the temperature of the grout.

   After the grout has set, pipes used as injection or vent ports shall be cut off. Metal pipes shall be cut off one-inch below the surface of the concrete. Plastic pipes shall be cut off flush with the surface of the concrete.

PROTECTION OF PRESTRESS ANCHORAGES. As soon as possible but not to exceed 14 days after tensioning and grouting is completed, exposed end anchorages, strands, and other metal accessories shall be cleaned of rust, misplaced mortar, grout, and other such materials. Immediately following the cleaning operation, the entire surface of the anchorage recess (all metal and concrete) shall be thoroughly dried and uniformly coated with an epoxy bonding compound conforming to AASHTO Specification M235, Class III in accordance with the manufacturer’s recommendations.

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Immediately following application of the epoxy bonding compound, tight fitting forms shall be installed and the anchorage recess shall be filled with a non-shrink cement based grout. The grout shall, when tested in accordance with ASTM C-827, exhibit 0.0 percent shrinkage and shall contain no aluminum powder, iron particles, chlorides, sulfites, fluorides or nitrates. After grout patches have been finished and cured, two coats of a mineral stabilized coal tar base emulsion meeting the requirements of Government Specification MIL-P-23236 shall be applied in a manner and thickness as recommended by the manufacturer. Coal tar emulsion shall not be applied to the surface of grout patches which are visible from the roadway.

This Specification has been Disapproved by FHWA-021

BASIS OF ACCEPTANCE. The Prestressing System shall be accepted for incorporation in the precast segments based on the approved shop drawings for the bridge.