STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0016

JOHN ELIAS BALDACCI
GOVERNOR

DAVID A. COLE
COMMISSIONER

April 24, 2008
Subject: **Norridgewock**
Project No. BH-6900(01) X
Pin No.006900.01
Amendment No. 1

Dear Sir/Ms:

Make the following changes to the Bid Documents:

REMOVE from the Bid Book, SPECIAL PROVISION, SECTION 502, STRUCTURAL CONCRETE, (Cast in Place Architectural Concrete) pages 112 and 113 (2 pages dated March 20, 2008) and **REPLACE** with the attached new SPECIAL PROVISION, SECTION 502, STRUCTURAL CONCRETE, (Cast in Place Architectural Concrete), 2 pages dated April 18, 2008.

REMOVE from the Bid Book, SPECIAL PROVISION, SECTION 535, POST TENSIONING SYSTEM, pages 145 thru 168 (24 pages, dated March 20, 2008) and **REPLACE** with the attach new SPECIAL PROVISION, SECTION 535, POST TENSIONING SYSTEM, dated April 24 (24 pages), 2008.

The following questions have been received:

Question: Reference Note 7 on Sheet 106, "Verify hanger dimensions in the field prior to fabrication." This material has a substantial lead time. Is it truly the intent to have the tie girder and arch completely built before fabricating the hangars? Please clarify.

Response: No, it is not the intent to wait to fabricate the hangars and anchor sockets until after the tie girder and arch rib are built. The bottom steel rod will accommodate some adjustments in the hangar assembly length, and fabrication of this rod should be delayed until the Contractor has verified that the structure has been constructed according to the dimensions shown on the plans.

Question: Is a construction joint acceptable between the pier curtain wall and the round column shafts?

Response: Yes, a construction joint is acceptable between the pier columns and curtain walls.

Question: Please clarify the rebar type for designation "X" on the rebar list. Is this MMFX rebar? Please create a separate Pay Item for this rebar.

Response: The rebar designated as "X" is MMFX. All MMFX is incidental. These provisions are noted in Special Provision 503.

Question: Specification Section 502 – Cast in Place Architectural Concrete 502.14- Finishing Concrete Surfaces, states that after grout rub all surfaces are to be cured with fog spray for 36 hours. This will be exceedingly difficult and expensive. Will a conventional wet cure be acceptable?

Response: Please see the amended Section 502.

Consider these changes and information prior to submitting your bid on **May 21, 2008.**

Sincerely,

FOR

Scott Bickford
Contracts & Specifications Engineer

SPECIAL PROVISION
SECTION 502
STRUCTURAL CONCRETE
(Cast in Place Architectural Concrete)

The following shall be added to this Section:

502.01 Description The furnishing and placing of Portland Cement Concrete shall conform to Standard Specifications Section 502 Structural Concrete, and Special Provision Section 502 Structural Concrete (Span 2). For those portions of the work designated as Architectural Concrete, this Special Provision shall also apply. The Contractor shall conform to the more stringent requirements stated herein for those areas designated as Architectural Concrete.

Architectural Concrete includes:

- All surfaces of the following components:
    a) Structural Concrete Arch
    b) Arch End Connection
- The top and one vertical surface of each Concrete Barrier Rail, on the traveler's side
- Three contiguous surfaces of the Structural Concrete Tie Girder: including the sloped surface supporting the hanger, the vertical surface, and the adjacent sloped surface.

502.0501 Quality Control
Source Limitations for Cast-in-Place Architectural Concrete: The Contractor shall obtain each color, size, type, and variety of concrete material and concrete mixture from one manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.

502.10 Forms and Falsework
The concrete formwork shall be constructed with exterior-grade plywood panels, nonabsorptive, that will provide continuous, true, and smooth architectural concrete surfaces, high-density overlay, Class 1, or better, complying with DOC PS 1.

The chamfers shall be constructed using metal, rigid plastic, elastomeric rubber, or dressed wood; nonstaining in the longest practicable lengths.

A commercially formulated colorless form-release agent shall be used that will not bond with, stain, or adversely affect the architectural concrete surfaces and will not impair subsequent treatments of those surfaces.

Forms shall be fabricated for easy removal without hammering or prying against concrete surfaces. Crush or wrecking plates shall be provided where stripping may damage cast-in-place surfaces. Top forms shall be provided for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Wood rustications, keyways, recesses, and the like, shall be kerfed for easy removal. Form joints and penetrations at form ties shall be sealed with form joint tape or form joint sealant to prevent cement paste leakage.

When forms are reused, the Contractor shall clean surfaces, remove fins and laitance, and tighten to close joints and maintain proper alignment. Split, frayed, delaminated, patched or otherwise

damaged form-facing material will not be permitted. New form-release agent shall be applied prior to placement of additional concrete in a used form.

502.14 Finishing Concrete Surfaces

Corners, edges, and surfaces of cast-in-place architectural concrete shall be protected from damage using guards and barricades. Architectural concrete shall be protected from staining, laitance, and contamination during the remainder of construction period.

The Contractor shall clean concrete surfaces after finishing to remove stains, markings, dust, and debris. Other Work shall be protected from staining or damage due to cleaning operations. Cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes will not be permitted.

The Contractor shall repair and cure damaged finished surfaces of cast-in-place architectural concrete when directed by the Engineer. Repairs shall match color, texture, and uniformity of surrounding surfaces. If structural cracks in newly poured concrete appear, or if the concrete cannot be repaired and cured to the Resident's approval, that concrete shall be removed and replaced at the Contractor's expense. Structural cracks are those that can be described as a surface rupture that exhibits some vertical dislocation or sloping between the broken sections.

502.19 Basis of Payment

Payment will be made under related Section 502 Structural Concrete Items.

SPECIAL PROVISION
SECTION 535
POST TENSIONING SYSTEM

535.01 Description. The work specified in this Section shall consist of furnishing, installing, stressing and grouting 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 prestressing system used, including but not limited to anchorage assemblies, additional reinforcing bars required to resist stresses caused by anchorage assemblies, ducts, vents, inlets, outlets and grout used for pressure grouting ducts.

The members that include post tensioning are the Tie Girder (including the portion within the Arch End Connection), the Intermediate Floor Beams and the End Floor Beams. Work will involve coordinating the post-tensioning of the Intermediate Floor Beams with the connection to the adjacent Tie Girder.

535.02 Definitions and Terminology. The following terms apply to prestressing of bridge construction:

1. Post-Tensioning: The application of a compressive force to the concrete by stressing tendons or bars after the concrete has been cast and cured. The force in the stressed tendons or bars is transferred to the concrete by means of anchorages.

2. Post-Tensioning Scheme or Layout: The pattern, size and locations of post-tensioning tendons provided by the Designer on the Contract Plans.

3. Post-Tensioning System: A proprietary system where the necessary hardware (anchorages, wedges, strands, bars, couplers, etc.) is supplied by a particular manufacturer or manufacturers of post-tensioning components.

4. Tendon: A single or group of prestressing elements and their anchorage assemblies, which impart prestress to a structural member or the ground. Also included are ducts, grouting attachments and grout. The main prestressing element is usually a high strength steel member made up of a number of strands, wires or bars.

5. Strand: An assembly of several high strength steel wires wound together. Strands usually have six outer wires wound in long-pitch helix around a single straight wire of a similar diameter.

6. Wire: A single, small diameter, high strength steel member and, normally, the basic component of strand, although some proprietary post-tensioning systems are made up of individual or groups of single wires.

7. Anchorage: An assembly of various hardware components that secure a tendon at its ends after it has been stressed and imparts the tendon force into the concrete.

8. Anchor plate: that part of the anchorage hardware that bears directly on the concrete and through which the tendon force is transmitted.

9. Wedge: A small conically shaped steel component placed around a strand to grip and secure it by wedge action in a tapered hole through a wedge plate.

10. Wedge Plate: A circular steel component of the anchorage containing a number of tapered holes through which the strands pass and are secured by conical wedges.

11. Set (Also Anchor Set or Wedge Set): Set is the total movement of a point on the strand just behind the anchoring wedges during load transfer from the jack to the permanent anchorages. Set movement is the sum of slippage of the wedges with respect to the anchorage head and the elastic deformation of the anchor components. For bars, set is the total movement of a point on the bar just behind the anchor nut at transfer and is the sum of slippage of the bar and the elastic deformation of the anchorage components.

12. Anticipated Set: Anticipated set is that set which was assumed to occur in the design calculation of the post-tensioning forces immediately after load transfer.

13. Bleed: the autogenous flow of mixing water within or its emergence from, newly placed grout; caused by the settlement of the solid materials within the mass.

14. Duct: material forming a conduit to accommodate post-tensioned tendon installation.

15. Initial Set of Grout: a degree of stiffening of the grout mixture less than the final set, indicating the time in hours and minutes required for the grout to stiffen sufficiently to resist to an established degree, the penetration of a weighted needle test.

16. Final Set of Grout: a degree of stiffening of the grout mixture greater than the initial set, indicating the time in hours and minutes required for the grout to stiffen sufficiently to resist to an established degree, the penetration of a weighted needle test.

17. Fluidity: A measure of time, expressed in seconds, necessary for a stated quantity of grout to pass through the orifice of the flow cone.

18. Grout: a mixture of cementitious materials and water, with or without mineral additives or admixtures, proportioned to produce a pumpable consistency without segregation of the constituents; injected into the duct to fill the space throughout the prestressing steel, anchorages and ducts.

19. Inlet (also inlet pipe or grout injection port): small diameter tubing or duct used for injection of grout into a duct.

20. Outlet (also ejection pipe or grout outlet vent or vent): a small diameter tubing or duct used to allow the escape of air, water, grout and bleed water.

21. Thixotropic: the property of a material that enables it to stiffen in a short time while at rest, but to acquire a lower viscosity when mechanically agitated, the process being reversible. Grouts having thixotropic properties can be highly resistant to bleed. Admixtures that may produce thixotropic properties include anti-bleed admixtures and silica fume.

535.03 Shop Drawings: The Contractor shall submit detailed shop drawings that include, but are not limited to:

a. A complete description of, and details covering, each of the prestressing systems to be used for permanent and temporary tendons. This shall include:
    1. Designation of the specific prestressing steel, anchorage devices, bar couplers, duct material and accessory items.
    2. Properties of each of the components of the prestressing system.
    3. Details covering assembly of each type of prestressing tendon.
    4. Equipment to be used in the prestressing sequence.
    5. Procedure and sequence of operations for prestressing and securing tendons.
    6. Procedure for releasing the prestressing steel elements.
    7. 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 of jacking forces and initial elongations of each tendon at each stage of erection for all prestressing will only be required if the parameters used to calculate the typical tendon force differs from the Plans.

c. Complete details of the anchorage system for prestressing including certified copies of the reports covering tests performed on prestress anchorage devices as required in the following Materials Section C, and details for any reinforcing steel needed due to stresses imposed in the concrete by anchorage plates.

d. For the operation of grouting prestressing tendons; the materials and proportions for grout, details of equipment for mixing and placing grout and methods of mixing and placing grout; also, locations and details of inlets and outlets for grouting and the direction of grouting.

e. Elongation calculations shall be revised when necessary to properly reflect the modulus of elasticity of the wire or strand as determined from in-place friction testing in accordance with the following Materials Section G.2.

f. Complete details of the apparatus and method to be used by the Contractor for the test required by the following Materials Section G.2.

535.04 Materials.

A. General

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

B. Prestressing Steel

1. Strand: Unless otherwise noted on plans, strand shall be uncoated, Grade 270, low relaxation 7-wire strand conforming to requirements of ASTM A-416.

2. Wires: Unless otherwise noted on the plans, wire shall be uncoated, low relaxation wire conforming to the requirements of ASTM A-421.

C. Prestress Anchorages

All prestressing steel shall be secured at the ends by means of permanent type anchoring devices. Anchors manufactured from composite materials will not be allowed. Prestress anchorages shall develop at least 95 percent of the minimum specified ultimate tensile strength of the prestressing steel. Wedges shall be three-part (Two part wedges shall not be used).

Testing of anchorage devices shall be performed using samples representing the type of prestressing steel and concrete strength to be used on the project. The test specimen shall be assembled in an unbonded state and, in testing, the anticipated anchor set shall not be exceeded. Certified copies of test results for the anchorage system shall be supplied to the Department. The anchorage system shall be so arranged that the prestressing force in the tendon may be verified prior to the removal of the stressing equipment.

For tendon anchorages other than those specified on the plans, the design and furnishing of any reinforcement (in addition to the reinforcement shown on the plans) which is needed to resist bursting and splitting stresses imposed on the concrete by the proposed anchorage system shall be the responsibility of the Contractor at his expense.

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

1. The bearing stress in the concrete created by the anchorage plates shall comply with AASHTO LRFD Bridge Design Specifications.

2. 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 Department.

3. Galvanize the embedded body of the anchorage in accordance with ASTM 123. Other components of the anchorage including wedges, wedge plate and local zone reinforcement are not required to be galvanized. Equip all anchorages with a permanent grout cap that is vented and bolted to the anchorage.

4. Trumpets associated with anchorages will be made of polypropylene plastic material conforming with polyolefin containing antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D 3895 of not less than 20 minutes. Perform OIT test on samples taken from the finished product. Test the remolded finished polyolefin material for stress crack resistance using ASTM F 2136 at an applied stress of 348 psi resulting in a minimum failure time of 3 hours.

D. Ducts

1. 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 paste 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 such that the interior area of the empty duct is not less than 2.25 times the net area of the prestressing steel.

2. Corrugated Plastic Duct:

Do not use ducts manufactured from recycled material. Use seamless fabrication methods to manufacture ducts.

Use corrugated duct manufactured from non-colored, unfilled polypropylene meeting the requirements of ASTM D4101 “Standard Specification for Polypropylene Plastic Injection and Extrusion Materials” with a cell classification range of PP0340B14541 to PP0340B67884. The duct shall be white in color containing antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D 3895 of 20 minutes and containing a non-yellowing light stabilizer. Perform OIT test on samples from the finished product. Furnish duct with a minimum thickness as defined in the following table:

Duct Shape	Duct Diameter	Duct Thickness
Round	0.9 inch	0.08 inch
Round	2.375 inches	0.08 inch
Round	3.0 inches	0.10 inch
Round	3.35 inches	0.10 inch
Round	4.0 inches	0.12 inch
Round	4.5 inches	0.14 inch
Round	5.125 inches	0.16 inch
Round	5.71 inches	0.16 inch

Plastic duct shall be corrugated with a pitch not less than 1/10 of the radius of the duct. Material thickness shall be 0.08 inches as manufactured, and 0.06 inches after tensioning.

Minimum Bending Radius for Corrugated Plastic Duct: In addition to the component testing stated herein, the manufacturer shall establish, through testing, the minimum bending radius for the duct. The test apparatus shall be identical to the wear test apparatus with the same

clamping force as a function of the number of strands in the duct; however, modify the procedure as follows: do not move the sample along the strand to simulate wear; the test duration will be 7 days. Upon completion of the test duration, remove the duct and the minimum wall thickness along the strand path must not be less than 0.06 inch for duct up to 3.35 inches diameter and not less than 0.08 inch for duct greater than 3.35 inches in diameter.

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 2.5 feet. 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 Department certified test reports verifying that the duct meets specification requirements in regard to force transfer.

To satisfy the intent of these tests, the results for static pull-out tests from previous projects utilizing identical duct and prestressing steel with similar concrete and grout material may be submitted to the Department in lieu of executing new pull-out tests. However, if the previous results are unacceptable or if there is a significant difference in the materials used, then the Contractor shall provide results from new tests for this project.

2. Corrugated Duct Connections and Fittings: Make all splices, joints, joints between segments couplings and connections to anchorages with devices or methods (i.e. mechanical couplers, plastic sleeves in conjunction with shrink sleeve) producing a smooth interior alignment with no lips or kinks. Design all connections and fittings to be airtight. Duct tape is not permitted to join or repair duct connections. Construct connections and fittings from polyolefin materials containing antioxidant stabilizer(s) meeting the requirements established in 462-4.2.3 or 462-4.2.5.5. For post-tensioned systems intended for use with segmental constructed elements the post-tensioning system shall include duct couplers at the segment joints. The tendon duct coupler located at the segment joint shall be mounted perpendicular to the bulkhead and designed to receive a duct at an angle of 6 degrees deviation from perpendicular. The coupler must be able to accommodate angular deviation of the duct without the tendon strands touching the duct or coupler on either side of the segment joint.

3. Inlets and Outlets (Ports or Vents) for Grout: Inlets (Grout Injection Ports) shall be provided for injecting grout into the duct. Outlets (Grout Exit Vents) shall allow the escape of air, water, rout and bleed water. The inner diameter of inlets and outlets shall be at least 3/4 in for strand tendons and 3/8 in. for single bar tendons. Inlets and Outlets shall be of flexible HDPE or HDPP pipe.

   Plastic Components shall not react with concrete or enhance corrosion of the post-tensioning steel, and shall be free of water-soluble chlorides. Inlets and outlets shall be located and attached in accordance with Construction Requirements.

E. Sampling and Testing of Prestressing Elements: All testing shall be done in accordance with ASTM Specifications. The following samples of materials and devices selected at locations designated by the Department shall be furnished by the Contractor at his expense.

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

2. Three samples of five foot long prestressing strand for each size from each heat number or production Lot.
3. If bar couplers are to be used, three samples with two specimens each consisting of four foot lengths of the specific prestressing bar coupled with a bar coupler from the materials to be used on the project.
4. One unit of each prestress anchorage to be used on the project.
5. For each type of duct material intended for the project, one sample, four feet long, from each production lot or per 10,000 linear feet, whichever is greater. Samples shall be furnished at least 90 days in advance of the time they are to be incorporated into the work.

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

F. Manufacturer's Lots (Contractor's Quality Control): 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 acceptable. 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, yield strength, elongation and composition shall be furnished for each lot of prestressing steel. When requested, typical stress-strain curves for prestressing steel shall be furnished. A certified test report stating strength when tested using the type prestressing steel to be used in the work shall be furnished for each Lot of prestress anchorage devices.

G. Testing of Prestressing Tendons by the Contractor.

1. General: The Contractor shall perform certain testing of prestressing tendons as specified herein.

2. In-Place Friction Test of Tendons: For the purpose of accurately determining the friction loss in stressing draped tendons, prior to stressing a draped tendon, the Contractor shall test, in place, a draped tendon selected by the Department. If deemed necessary by the Department to accurately establish friction loss, the Contractor shall perform tests on additional tendons selected by the Department. The test procedure shall consist of stressing a tendon at an anchor assembly with the dead end anchor incorporating a calibrated load cell. The results of the tests (loss due to friction and modulus of elasticity) shall be submitted to the Department. Apparatus and methods used to perform the tests shall be proposed by the contractor and be subject to the approval of the Department. The Contractor shall notify the Department at least two weeks in advance of performing a friction test. Multiple tests may be required.

H. Grout Materials and Properties

Prepackaged grout shall be used. The prepackaged grout shall meet all the requirements of the February 2001 PTI Guide Specification for Grouting of Post-Tensioned Structures for Class "C" grout. Grout performance testing and on-site testing shall also be as specified in the February 2001 PTI Guide Specification for Grouting of Post-Tensioned Structures.

535.05 Construction Requirements.

A. Protection of Prestressing Steel

1. Before Installation of Tendons in ducts: All prestressing steel shall be protected against physical damage at all times from manufacture to grouting or encasing in concrete. 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 the 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 Department, 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 Specifications MIL-P-3420. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

   The prestressing steel shall be stored in a manner which will at all times prevent the packing 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 that has experienced rusting to the extent 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.

2. After Installation of Tendons in Ducts: The prestressing steel shall be protected from corrosion and the duct system shall be sealed to prevent moisture intrusion from the time of tendon installation to the time of grouting, as provided below.

   The ends of ducts and anchorages and all duct connections shall be sealed at all times following installation in the forms to prevent entry of moisture and debris. In addition, all grout ports and vents shall be closed or plugged at all times during the period prior to grouting.

Grouting shall proceed as soon as possible after installation and stressing of the tendons. The time from installing the tendons in an unstressed condition to grouting after stressing shall not exceed 10 days without approval of the Department.

a. Tendon Protection Between Installation and Stressing: Measures shall be taken to protect the prestressing steel when there is a period of more than 24 hours between installation of the tendons in ducts and stressing. Bare strand projecting out of the duct shall be wrapped continuously in plastic sheeting and sealed using waterproof tape. The plastic wrap shall extend to the tendon anchorage, and the anchorage opening shall be sealed with plastic and waterproof tape sufficient to prevent moisture intrusion. All grout ports and vents shall be closed or plugged, and all duct connections shall be sealed.

b. Tendon Protection During Staged or Segmental Construction: When plans provide for the tendons to be installed in one unit or segment, either longitudinally, transversely or vertically, with a length of bare strand left projecting for purposes of threading into another unit or segment during later erection operations, the provisions described in Construction Requirements Section A.2a shall apply. All of the prestressing steel shall be protected immediately after it is first installed in the first unit or segment until the tendon is grouted in the second unit or segment.

c. Tendon Protection Between Stressing and Grouting: Anchorages should be capped or otherwise sealed again immediately following stressing and cutting of strand tails.

In the aggressive exposure of this project, where permanent end anchorage protection caps are used, the time period between stressing and installation of the permanent end caps shall not exceed 12 hours without approval of the Department.

In all cases, tendons and ducts shall be thoroughly blown dry with oil-free compressed air immediately prior to sealing or capping of the anchorages. In addition, all grout ports and vents shall remain plugged, sealed or otherwise capped, and all duct connections shall be sealed.

d. Use of Temporary Corrosion Inhibitors: The use of corrosion inhibitors such as vapor hase inhibitors or water-soluble oils for temporary corrosion protection is not permitted without prior approval of the Department.

B. Installation of Ducts, Grout Injection Ports and Outlet Vents

1. Ducts: Ducts shall be securely tied in position, carefully inspected and repaired before placing of the concrete is started. Care shall be exercised during placement of the concrete to avoid displacing or damaging the ducts. Internal ducts shall be supported at intervals necessary to prevent deflection and or displacement, not to exceed four feet. Any additional mild reinforcing required to support post-tensioning ducts shall be supplied by the contractor at no expense to the Department. The tolerance on the location of the tendons shall be plus or minus 1/4-inch (6mm) 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.

2. Grout Inlets and Outlets: Pipes shall be installed on each duct to serve as injection or vent ports during grouting. These shall be at locations shown on the Contract Plans or approved Shop Drawings and in accordance with the following:

   - Inlets (Grout Injection Ports) shall be provided for injecting grout into the duct.
   - Outlets (Grout Exit Vents) shall allow the escape of air, water, grout and bleed water. The inner diameter of inlets and outlets shall be at least 3/4 in. for strand tendons.
   - Inlets and Outlets shall be of flexible HDPE or HDPP pipe. The length of an inlet port or outlet vent shall extend sufficiently out of the concrete to allow for proper closing. At all high points the outlet shall connect at the uppermost part of the duct profile - except that vents shall not exit to any top deck slab surface. In the latter case, vents shall be gradually turned down (with no kinks) to exit on the underside of the top slab or to an internal face. Inlets and Outlets shall be placed at locations shown on the Contract Plans, on the Approved Shop Drawings, and on the approved Grouting Operation Plan (below). Locations shall be as follows:
     a. At the top of each tendon anchorage and top of grout cap.
     b. At each high point of the duct profile when the vertical distance between the highest and lowest point is more than 20".
     c. An outlet at each low point of the tendon.
     d. An inlet at the lowest point of the tendon. Note judgment should be used in locating the lowest point. For example, if the absolute low point is in a deviation block for an external tendon, then place the inlet close to the block in the accessible portion of the duct.
     e. At all low points the inlet/outlet shall be free draining.
     f. At major changes in the cross section of the duct, such as couplers and anchorages.
     g. At each side of couplers.
     h. At a distance of approximately 3 ft. from each high point in the direction of grout flow.
     i. At regular intervals along straight tendons in order to facilitate control and monitoring of grouting operations.
     j. At other locations recommended by the Department.

   All connections to ducts shall be made with plastic structural fasteners. Waterproof tape shall be used at all connections including vent and grouting pipes, except where otherwise specified herein. Vents shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents.

   All inlet and outlets shall be permanently sealed to prevent water infiltration to the grouted tendon. Sealing details are to be submitted for approval to the Department. All grout injection and vent pipes shall be fitted with positive mechanical shut-off valves. Vents and injection pipes shall be fitted with valves capable of withstanding the pumping pressures.

3. Care and Protection of Ducts, Vents, Anchorages and Blockouts: Care shall be taken to ensure that all ducts, anchorages, blockouts, openings and vents are kept clean and free of debris, fuel, oils, other contaminants and site trash at all times prior to and after installing the tendons. Temporary plugs, seals and covers shall be used. Minor damage to ducts, defined as a

localized single puncture mark, may be repaired by removing the local damage and splicing duct or couplers onto the intact section (prior to the placing of concrete). Repair of major duct damage, defined as damage that occurs over a length of duct longer than 6 inches, requires the removal and replacement of the entire duct section.

Connections from grout hose to inlet and ejection ports and to vents shall be kept free from dirt and shall be airtight.

4. Pre-Grouting Air Pressure Test of Duct System: Following assembly of the complete duct system, including installation of all ducts, grout inlets and outlets, couplers and connections, and immediately prior to placement of the prestressing tendon or after stressing of the tendon, an air pressure test shall be performed on each complete duct system.

The air pressure test shall involve pressurizing the complete duct system with dry, oil-free air not to exceed 75 psi, and monitoring the pressure in the system for a period of 5 minutes. If the pressure loss during this 5 minutes period exceeds 10%, all sources of leakage shall be identified, and measures shall be taken to reduce or eliminate the identified leaks such that upon repeating the pressure test the pressure loss is limited to less than 10% in 5 minutes.

The operation of each vent shall be tested by blowing dry, oil free air into the duct system and opening and closing each vent in turn.

C. Post-Tensioning Operations

1. General

a. Concrete strength: post-tensioning shall only be applied when the concrete has attained the required compressive strength as determined from test cylinders cured under the same conditions as the structural concrete.

The design of the structure is based on the assumed friction and wobble coefficient shown in the plans. The post-tensioning forces shown are theoretical and do not include losses in the system or thermal effects.

b. Stressing Tendons: All post-tensioning 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 Contract Plans or Approved Shop Drawings or as otherwise approved by the Department. Monostrand stressing shall not be used for tendons with 5 or more strands unless approved by the Department.

c. Maximum Stress at Jacking: The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 80 percent of the specific minimum ultimate tensile strength of the prestressing steel. Tendons shall not be overstressed to achieve elongation.

d. Initial and Permanent Stress: 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 Contract Plans or the Approved Shop Drawings, but in no case shall the initial stress, after anchor set, exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel.

Permanent force and permanent stress are 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, thermal affect, 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 in an approved stressing plan.

e. Excessive Friction: 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 Department. 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 and thoroughly blown dry with oil-free air.

2. Stressing Jacks

a. Stressing Equipment: Each jack shall be equipped with a pressure gauge having an accurate reading dial at least six inches in diameter for determining the jack pressure.

b. Calibration: Prior to use for stressing on the project, each jack and its gauge shall be calibrated as a unit. Initial calibration shall be done, using a proven load cell, at an independent testing laboratory, approved by the Department.

Calibration shall be done with the cylinder extension approximately in the position that it will be 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 Department for each jack and gauge unit.

Recalibration of each jack shall be done at six month intervals and at other times when requested by the Department. 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 calibrated at the same time as the initial calibration of the jacks, and shall be part of the unit for each jack. The data recorded during the initial calibrations shall be furnished to the Department for use in the field. 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. 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 the Department for the duration of the project. If a jack is repaired or modified, including 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. These samples shall be stored under the same conditions as the concrete in order to accurately represent the curing condition of the concrete in place.

The tensioning process shall be so conducted that tension being applied and the elongation of the post-tensioning 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 Department. The post-tensioning force may be verified as deemed necessary by the Department.

For all tendons, the tendon force measured by gauge pressure shall agree within seven 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 Department before proceeding with the work. Elongations shall be measured to the nearest 1/16 in. In determining why the measured tendon force and the theoretical elongation do not agree within seven percent, the Contractor may elect to establish that the apparent modulus of elasticity of the post-tensioning steel varies from the value shown in the general notes to the plans by conducting a bench test on a full size tendon in accordance with a procedure furnished by the Department. This test may be performed at a site remote from the project provided that the Contractor pays the cost to the Department of sending a representative to witness the test. 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 Department may require without additional compensation to the Contractor, additional in-place friction tests in accordance with the Materials Section G2.

Multi-strand post-tensioning tendons having wires that have failed by breaking or slippage during stressing may be accepted providing that:

a. The completed structure must have a final post-tensioning force of at least 98% of the design total post-tensioning force at the affected sections.

b. At any stage of erection, the post-tensioning force across a mating surface must be at least 98% of the force required for that stage.

c. Any single tendon must have no more than 5% reduction in cross-sectional area of the post-tensioned steel.

If these conditions cannot be met, then the affected tendon(s) shall be removed and replaced. Previously tensioned strands shall not be re-used unless approved by the Department. Any of these conditions may be waived by the Department when the Contractor is able to propose an acceptable means of restoring the post-tensioning force lost due to wire failure or slippage.

Prestressing steel shall be cut by an abrasive saw within 3/4 to 1-1/2 inches away from the anchoring device. Flame cutting of prestressing steel is not allowed, except for pretensioned prestressing steel or with the specific approval of the Department on a case by case basis.

D. Grouting

1. General

After post-tensioning and anchoring of a tendon has been completed and accepted, the annular space between the prestressing steel and the duct shall be grouted in accordance with this Specification. The interval between post-tensioning and grouting shall be limited as specified in Construction Requirements Section A.2. Immediately after post-tensioning, all grout vents, anchorages, and duct connections of each tendon shall be temporarily sealed to prevent entrance of air and water until just prior to tendon grouting.

At least six weeks before grouting commences, the Contractor shall submit to the Department for review and approval a "Grouting Operation Plan". Final written approval of the plan is required before grouting occurs. A preliminary approval of the plan will be made by the Department after review of the written plan and incorporation of any comments by the Department have been incorporated and/or addressed by the Contractor. Final approval of the Grouting Operation Plan will be made by the Department after the successful completion of the Grouting Mock-Up Test that is described below. Grouting operations shall be under the supervision of a qualified and experienced person, acceptable to the Department.

The Grouting Operation Plan shall address the following:

a. Names of grouting crew and Supervisor.
b. Experience of crew members and Supervisor.
c. Training to be provided or undertaken prior to operations.
d. Type of equipment to be used, including capacity in relation to demand.
e. Working condition of equipment, back-up and spare parts.
f. Types, brands and certifications of materials
g. Identity of independent testing laboratory for certification of materials.
h. Production of grout fluidity, on-site flow testing, adjustments and controls.
i. Estimate of grout required per tendon or group of tendons
j. Method of controlling rate of flow and filling of ducts
k. Locations, types and sizes of inlet and outlet vents
l. Means of sealing and protecting tendons and ducts prior to grouting
m. Grout mixing and pumping procedures
n. Tendon or groups of tendons to be grouted in one operation.
o. Direction of grouting and sequence of using inlets and closing vents.
p. Procedures for handling blockages, including flushing of ducts.
q. Procedures for possible re-grouting to detect and fill voids.
r. Procedures for controlling w/c ratio and ensuring that the water used is acceptable.
s. Contractor's QC forms that are to be signed daily by Grout Supervisor.
t. Method of communication between members of grouting crew (i.e. Communications between mixer, injector, and shut-off positions via radios)

Before grouting operations commence, a joint meeting shall be held with the Contractor, Grouting Crew, and Department, to discuss and understand the grouting operation plan, required testing and corrective procedures.

After the Contractor's Grouting Plan is given preliminary approval by the Department and before grouting commences, the Contractor will be required to perform a Mock-Up Test. The purpose of this test is to verify that the materials and procedures proposed will properly grout the tendons. It will also serve as training for the grouting personnel on site. The test will be conducted at the project site.

The Mock-Up Test will consist of grouting an external tendon in a clear duct with a duct profile as indicated below. The Contractor must use the same equipment, materials, connections, and procedures that are in the Approved Grouting Plan.

The Test Specimen must be at least 150' in length with a vertical rise at one end of 6' and a vertical rise of 10' on the other end. The tendon will be divided into thirds with a 50' length for the first rise, a 50' length for a straight portion, and a 50' length the last portion. These requirements for the test specimen are shown in the detail shown.

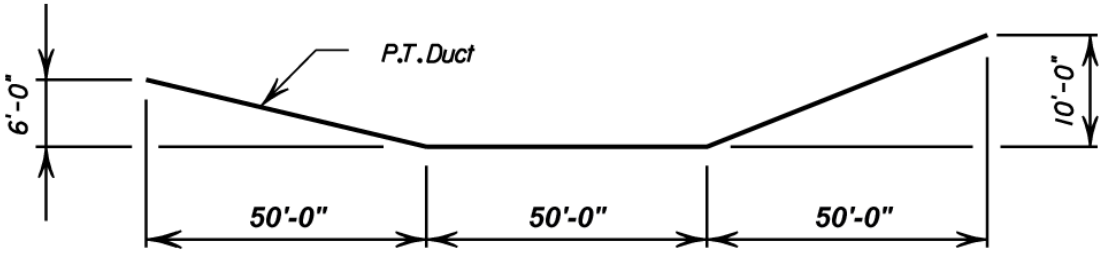
The duct material must be see-through and at least 3" in diameter. Inside the duct, there shall be a seven-strand tendon consisting of normal Post-Tensioning strand. It is not necessary that the Post-Tensioning strand be stressed. If the Contractor thinks stressing of the tendon or other modifications are required to the grout mock-up to demonstrate the success of the Contractors grouting operations, these modifications shall be submitted to the Department for review and approval. Modifications will be considered, but must be at no additional cost to the Department.

The Contractor will submit for approval the test set-up including materials, geometrics, procedures to be followed and the anticipated amount of bleed water for this specimen.

The test will be considered successful if all 3 of the following conditions are satisfied:

(1) The methods and materials in the approved grouting plan can completely grout the tendon.
(2) There are no air voids over 0.5 inches in diameter in the inclined length after the grout has hardened.
(3) There is not excessive bleed water at either end over the anticipated amount.

If the test is run and not considered to be successful by the Department then the Contractor must resubmit his Test Plan procedures to remedy the deficiencies noted by the Department.



GROUTING MOCKUP TEST - TENDON PROFILE

The Contractor must have a successful Mock Up Test completed before post-tensioning operations including stressing can begin.

The cost of all labor, equipment materials and incidental items required to perform this Grouting Mock-Up Test shall be incidental to the cost of the prestressing system.

2. Grouting Personnel Qualifications. All grouting operations shall be carried out by workers trained for the tasks required, and having at least 3 years experience on previously successful projects of similar type and magnitude.

   Grouting shall be performed under the immediate control of a person skilled in the various aspects of grouting, and having experience on at least four previous and satisfactorily completed projects of a similar size and scope. This person shall be named and shall furnish proof of experience as required by the Department.

   One member of each Grouting crew must have ASBI Grouting Certification.

3. Equipment

a. General: Grouting equipment consists of measuring devices for water and admixtures, a mixer, a storage hopper, and a pump with all the necessary connecting hoses, valve, pressure gauges, and test equipment. Accessory equipment shall provide for accurate solid and liquid measures of all materials to be batched.

   The equipment shall have sufficient capacity to ensure that the post-tensioning duct or group of ducts to be grouted can be filled and vented without interruption at the required rate of injection. Under normal conditions, the equipment shall be capable of continuously grouting the longest tendon (or group of tendons) on the project in 30 minutes.

b. Mixer: The mixer shall be capable of continuous mechanical mixing. It shall produce a homogeneous and stable grout free of lumps and undispersed solids (cement or grout mix) and shall be able to deliver a continuous supply of grout to the pumping equipment. (A colloidal mixer is preferred).

   There shall be a gravity feed to the pump inlet from the mixer and/or hopper attached to and directly over it. An additional storage hopper may be incorporated between the mixer and the pump. It shall be fitted with an agitator to keep the grout moving continuously before it is pumped into the duct. The storage hopper shall be kept partially full at all times to prevent air from being drawn into the duct.

   The grouting equipment shall contain a screen having clear openings of 1/8 in maximum size to screen incompletely mixed lumps from the grout prior to its introduction into the grout pump or storage hopper. If the grout contains a thixotropic admixture, a screen opening of 3/16 in will be satisfactory. The screen shall be located between the mixer and the pump, or when a storage hopper is used, between the mixer and the storage hopper. This screen shall be easily accessible for inspection and cleaning.

c. Injection equipment: Grout pumps shall be capable of pumping the grout in a continuous operation with little variation of pressure and shall include a system for re-circulating grout when injection is not in progress. The equipment shall be capable of maintaining a pressure on completely grouted ducts and shall be fitted with a valve that can be locked-off without

loss of pressure in the duct. The use of compressed air for pumping grout shall not be allowed.

Grout pumps shall be a positive displacement type capable of producing an outlet pressure of not less than 145 psi and shall have seals 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 290 psi shall be placed at some point in the grout line between the pumping outlet and the duct inlet.

All piping to the pump shall have a minimum number of bends, valves and changes in diameter and shall incorporate a sampling tee. The diameter and rated pressure capacity of the hoses must be compatible with the pump output, the assumed maximum pressure and the length needed. Grout hoses shall be firmly connected to pump outlets, pipes and inlets of the duct.

d. Stand-by Equipment: During grouting operations, provide adequate flushing equipment to facilitate complete removal of the grout in the event of a breakdown of the grouting equipment or other disruption before the grouting operation has been completed. This equipment shall be kept in working order. Where potable water is unavailable, a tank of sufficient water will be required.

e. Equipment for Thixotropic Grout: The following additional equipment shall be used. The grout equipment shall have two identical charging/holding tank units. Each unit alternates between duties either as a blender or holding tank. The tank units shall have a high-shear (colloidal) mixer and pump and the placing pump shall have exact pressure control capabilities, and be fed from the holding tank. In addition, a pressure filter type grout test kit is required.

4. Mixing Grout

The sequence for charging the mixer shall be: first add water, start mixer and add cement. When cement and water are reasonably well mixed, admixtures shall be introduced in accordance with the written instructions of the manufacturer of each admixture. The mixing procedures shall prevent admixture from getting caught on the blades or sides of the 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 grout 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.

5. Cleaning and Flushing Tendons

Tendons shall not be flushed with water except in situations where a water soluble lubricant is applied to the prestressing steel, as described in Construction Requirements Section C.1e, or as otherwise permitted or directed by the Department.

If flushing is to be performed as required in Construction Requirements Section C.1e or as directed by the Department, the inside of the duct system shall be flushed with water (under pressure) meeting the quality requirements of Materials Section D.1 to remove all traces of the lubricant (or other contaminant). Following the flushing operation, water shall be totally drained from within the duct system and it shall be blown out with compressed oil-free air to the extent necessary to dry the prestressing steel and inside surfaces of the ducts. The waste fluid flushed from the duct system shall be captured and disposed of properly.

6. Injecting Grout

a. General Grouting Procedures: Grouting shall start at the lowest injection port will all vents holes open. A continuous one-way flow of grout shall be maintained at all times.

The maximum rate of grout injection shall be 16 ft per minute for vertical ducts and 50 ft per minute for horizontal ducts.

Grout shall be pumped through the duct and flow continuously at the first vent hole after the injection port until no visible slugs or other evidence of air or water are ejected and the grout being ejected has the same consistency as the grout being injected. At this time, at least two gallons of grout shall be vented from the first vent hole into a suitable receptacle and discarded properly. The first vent valve shall then be closed. Grout injection shall continue until all vents have been closed one after another in the direction of flow following the same process. At intermediate crests where vents have been provided both at the crest and immediately downstream from the crest, the vent downstream of the crest shall be closed before the associated crest vent.

When the tendon duct is completely filled with grout and after the last outlet vent has been closed, the injection port shall be closed immediately following stoppage of the grout pump.

When a one-way flow of grout cannot be maintained, or when grouting is interrupted, the grout shall be immediately flushed out of the duct with water. A water pump shall be available on-site for this purpose as part of the standard flushing equipment. The flushing pressure shall not exceed the grouting pressures listed in Construction Requirements Section D.6b below.

b. Grouting Pressure: The pumping pressure at the tendon inlet shall not exceed 145 psi for the internal PE ducts

However, normal operations shall be performed at approximately 75 psi.

If the actual grouting pressure exceeds the maximum permitted pumping pressure, the inlet shall be closed and grouting shall continue at any vent hole that has been or is ready to be closed as long as a one-way flow of grout is maintained. Grout shall not be injected into a succeeding outlet from which grout has not yet flowed. Any such outlet used for injection shall be fitted with a positive shut-off valve.

c. Temperature Considerations: When it is anticipated that the air temperature will fall below 32ºF, 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 45ºF. The temperature of the

concrete and air surrounding the tendon shall be maintained at 35ºF 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.

When it is anticipated that the air temperature will rise above 80ºF, grouting shall take place early in the morning when daily temperatures are the lowest. No grouting shall be done when the temperature of the grout exceeds 90ºF. The temperature of the grout shall be maintained below 90ºF when the grout is placed.

Ungrouted tendons for extended periods will be permitted given strict compliance with the following criteria.

An increased time between stressing and grouting of tendons will only be allowed for post tensioning which cannot be grouted within the lower temperature limits set forth in this specification, and with the approval of the Department. The Contractor shall take every effort to minimize the length of time and number of ungrouted post-tensioning tendons or bars during the winter months. Grouting of ungrouted post-tensioning shall take priority when temperature limits allow grouting operations to continue.

All grout ports and vents shall remain plugged, sealed or otherwise capped, and all duct connections shall be sealed, except for a minimum number of low vent ports shall remain open to allow full drainage of any condensation. All open vent ports shall never be exposed to the weather for the time that the post-tensioning remains ungrouted.

Upon inspection, if ungrouted post-tensioning shows signs of corrosion (other than light surface rust with no pitting) the Contractor shall immediately take corrective measures. Corrective measures may include, but are not necessarily limited to, re-establishing moisture tight seals, providing alternate corrosion protection, applying external heating and grouting, or tendon replacement and restressing.

Details for protecting ungrouted post-tensioning through extended periods and the procedures for expedient grouting of the ungrouted post-tensioning shall be submitted as a part of the Grouting Operation Plan submittal outlined in Section 535.05 D1 of this specification.

d. Post-Grouting Measures at Injection and Vent Ports: Grouting vents at high points shall be reopened 10 minutes after completion of grouting and any escape of air, water or grout recorded.

Within approximately 30 minutes of grouting and before the grout has hardened, all opened vents shall be checked for voids. At locations where voids are observed, grout shall be topped off through the outlet, or a regrouting operation shall be performed using an injection port and outlet vent. Reseal all vents immediately upon completing inspection and remedial work.

Not less than 48 hours after the completion of grouting, the level of grout at all injection port and outlet vent locations shall be inspected and topped up as necessary with freshly mixed grout. This process will continue until the inspection agency is assured that there are no bleed water or subsidence voids. Subsequent spot inspections may be conducted on one or more

selected anchorages per span as long as no voids are found. If voids are found then all tendons will be checked for voids until the Resident is assured that the voids are not occurring.

e. Post-Grouting Inspection of Anchorages. Not less than 48 hours after the completion of grouting, all end anchorages shall be inspected for the presence of voids behind the anchorage.

The grout injection port on the anchorage shall be drilled out or otherwise cleaned of grout to allow the inspection of potential voids immediately behind the anchorage or within the trumpet region of the tendon. Care shall be taken during the drilling process to ensure that the drilling operation does not come into contact with the strands or bar(s) of the tendon.

Assessment of the potential void space shall involve physical probing through the grout injection port with a suitable wire or probe, or visual inspection using of a flexible fiberscope or videoscope. The presence of a void and an estimation of its extent or length shall be recorded.

All voids identified behind anchorages shall be regrouted as follows:

(1) Regrouting shall involve insertion of a grout tube through the grout injection port into the void space, and filling of the void with freshly mixed grout meeting the requirements of Materials Section H.
(2) Grout tube shall be a flexible plastic of sufficient rigidity to allow grouting under pressure without excessive bulging or rupture. The size of the grout tube shall be 0.5 in maximum O.D.
(3) Grout material shall be placed by pumping the material at low pressures (<100 psi). Pressure shall be sufficiently low to prevent segregation and bleeding of the grout.
(4) Grout tube shall be inserted into the trumpet as far as possible. Tube shall remain within the trumpet and immersed within the grout at all times during the grouting operation except as specified.
(5) The tendon anchorages shall be grouted continuously. No interruptions in grouting will be allowed.
(6) Grouting shall continue until all air, water, or other foreign material is completely purged from trumpet and duct. Grouting shall further continue until an uninterrupted stream of sound, uncontaminated grout flows from the port for a minimum of ten (10) seconds. At this time, the grout tube shall be slowly and continuously removed from the port while grout is still flowing out of the tube under pressure.
(7) Upon completion of grouting, all ports shall be sealed so as to prevent grout leakage until final set of the grout.

Other regrouting methods, including vacuum grouting, may be used if approved by the Department.

f. Post-Grouting Operations: Except as specified in Construction Requirements Section D.6d, shut off valves shall not be opened on injection ports or vent ports, nor shall pipes or caps at port locations be removed until the grout has set.

After the grout has set, pipes used as injection or vent ports shall be cut off as described below.

Pipes shall be cut off at least one inch below the surface of the concrete. The resulting recess shall be filled with a non-shrink mortar, and an elastomeric waterproof membrane shall be applied over the repair area. Suitable waterproofing membrane materials include urethane, neoprene or silicone-based elastomers with the following minimum properties:

Tensile Strength (ASTM D412)	@ 75ºF 100 psi	@ 0ºF 500 psi
Elongation (ASTM D412)	@ 75ºF 500%	@ 0ºF 250%

All waterproofing materials shall be UV resistant, and shall be approved by the Department prior to use.

All miscellaneous material (tie wire, duct tape, etc.) used for sealing grout inlet or vent connections shall be removed prior to carrying out further work to protect end anchorages. End anchorage protection shall be installed as described in Construction Requirements Section D.7.

7. Protection of Prestress Anchorages

a. Permanent, non-corroding grout caps shall be used. The permanent grout cap shall completely encapsulate the anchorage wedge plate, and shall attach directly to the anchor plate. A suitable gasket shall be used to prevent moisture intrusion behind the grout cap. Any bolts or fixtures used to secure the permanent grout cap to the anchorage shall have a minimum cover of 1 inch and shall be of stainless steel or other rust-free material as approved by the Department.

For recessed anchorages, additional protection shall consist of one coat of epoxy bonding compound, approved non-shrink concrete or mortar to fill the anchorage recess, and an elastomeric waterproofing membrane.

Anchorage recesses or encasements shall be filled as specified in Construction Requirements Section D.7b.

Waterproofing membranes shall be as specified in Construction Requirements Section D.7c.

The permanent grout cap shall remain in place at all times following grouting of the tendon.

b. Filling of Anchorage Recesses or Encasements. For external (not recessed) anchorages to be encapsulated with an encasement, mild steel reinforcement or stainless steel anchors shall be provided to anchor the encasement concrete or mortar to the segment or structural member. A minimum of two (2) hairpin reinforcing ties (bar size #4 or larger) or a minimum of four (4) stainless steel anchors shall be used for each encasement. Minimum clear cover to all reinforcement or anchors shall be 2 1/2 in. Hairpin reinforcement may be installed during segment or member fabrication, or following tendon placement and stressing. In the latter case, all reinforcement shall be dowelled into segment or member concrete a minimum of 4 in. and bonded in-place using an appropriate epoxy adhesive approved by the Department. Stainless steel anchors shall be installed in accordance with the manufacturer’s recommendations.

Prior to filling of anchorage recesses or encasements, all exposed end anchorages, strands, grout caps, encasement reinforcement and other metal or non-metal accessories or components shall be cleaned of rust, misplaced mortar, grout and other such materials.

Immediately following cleaning operations, the entire surface of the anchorage recess or area to be covered by the encasement (all metal and concrete) shall be thoroughly dried and uniformly coated with an epoxy bonding compound meeting the requirements of AASHTO Specification M-235, Class III. The epoxy shall be applied in a manner and thickness as recommended by the manufacturer.

Immediately following application of the epoxy bonding compound, tight fitting forms shall be installed to encase the entire anchorage system, including reinforcement ties or anchors, where applicable. The anchorage recess or encasement shall be completely filled with an approved pea-gravel concrete or non-shrink, cement-based mortar. The concrete or mortar filler shall be placed within the time limits specified by the epoxy bonding compound manufacturer. The filler shall exhibit no shrinkage, and shall contain no aluminum powder, iron particles, chlorides, sulfites, fluorides or nitrates.

c. Waterproof Membrane. An elastomeric waterproofing membrane shall be applied at anchorage locations as shown in the plans following finishing and curing of the pour back concrete. Suitable waterproofing membrane materials include urethane, neoprene or silicone-based elastomers with the following minimum properties:

Tensile Strength (ASTM D412)	@ 75ºF 100 psi	@ 0ºF 500 psi
Elongation (ASTM D412)	@ 75ºF 500%	@ 0ºF 250%

All waterproofing materials shall be UV resistant, and shall be approved by the Department prior to use.

The waterproofing membrane shall completely cover the pour-back concrete used to fill the anchorage recess or block-out, and shall extend for a distance of not less than 12 in. beyond the extent of the pour-back concrete. The membrane shall terminate at a groove cut into the concrete not less than 3/8 in. wide by 3/8 in. deep.

E. Records of Stressing and Grouting Operations.

1. Record of Stressing Operations. The Contractor shall keep a record of all post-tensioning operations for each tendon installed and stressed. This shall include, but shall not necessarily be limited to the following:
   (a) Project name, number
   (b) Contractor and/or Sub-Contractor
   (c) Tendon location, size and type
   (d) Date tendon was first installed in ducts
   (e) Coil/reel number for strands or wires and heat number for bars and wire
   (f) Assumed and actual cross-sectional area
   (g) Assumed and actual modulus of elasticity
   (h) Date stressed
   (i) Jack and Gauge numbers per end of tendon
   (j) Required jacking force

(k) Gauge pressures
(l) Elongations (anticipated and actual)
(m) Anchor sets (anticipated and actual)
(n) Stressing sequence (i.e. tendons before and after this)
(o) Stressing mode (1 end only, 2 ends in sequence, or 2 ends simultaneous)
(p) Witnesses to stressing operation (Contractor and Inspector)
(q) Record of any other relevant information

Within 72 hours, the Contractor shall provide the Department with a complete copy of each tendon stressing operation.

2. Record of Grouting Operations. The Contractor shall keep a record of all grouting operations for each tendon installed, stressed and grouted. This shall include, but shall not necessarily be limited to the following:
   (a) Tendon or group of tendons grouted in one continuous operation
   (b) Date grouted
   (c) Number of days from stressing to grouting, per tendon
   (d) Type of grout mix and additives
   (e) Fluidity of grout (flow-cone) per batch for both newly mixed and 30 minute, rested grout
   (f) Density of grout per batch of fresh mix
   (g) Location of injection port and direction of grout flow (note; injection port may not necessarily be at an end anchorage)
   (h) Applied grouting pressure during normal pumping and maximum pressure sustained for one minute after closing all vents grouting
   (i) Theoretical volume of grout anticipated in order to fill the duct or ducts
   (j) Actual quantity of grout in place in the duct(s) after grouting (For one grout mixing and injection operation, this is the quantity mixed less the quantity wasted at the vents, less the quantity remaining in the mixer and injection equipment)
   (k) Summarize any difficulties encountered and corrective action taken
   (l) Witnesses to grouting operation (Contractor and Inspector) within 72 hours, the Contractor shall provide the Department with a complete copy of all tendon grouting operations.
   (m) Condition of anchors at 48 hour inspection as specified in Section 535.04.D.6d

535.06 Method of Measurement. Post-tensioning tendons will be measured as one lump sum, accepted in place.

535.07 Basis of Payment. Unless otherwise specified on the Plans, post-tensioning tendons will be paid for as one lump sum, complete and in place. Payment shall be full compensation for furnishing, installing, stressing and grouting all temporary and permanent post-tensioning tendons

Payment shall also include anchorage assemblies and post-tensioning system hardware which is not embedded in concrete, external ducts, grout and grouting, all testing, anchorage protection systems and all labor, materials, tools, equipment and incidentals necessary for completing the work in accordance with these specifications and the Plans.

This payment shall also include lubricants in the tendon ducts for friction control and flushing the lubricant and/or corrosion inhibitor from the tendon ducts after stressing and prior to grouting.

No separate measurement and payment will be made for anchorage components, local anchorage zone reinforcement supplied as an integral part of a proprietary anchorage system, nor ducts for similar post-tensioning system hardware.

Anchorage components, post-tensioning bar couplers, ducts and similar items of post-tensioning system hardware which are embedded within cast-in-place concrete shall be deemed to be included in the cost of the cast-in-place concrete. Payment shall also include all on-site quality control, testing and records of tendon installation, stressing and grouting operations.

Payment will be made under:

Pay Item		Pay Unit
535.64	Post Tensioning System	Lump Sum