**BEDFORD**
**13527**

January 27, 2011

# SPECIAL PROVISION

## AMENDMENT TO SECTION 528 – PRESTRESSED CONCRETE MEMBERS

### Prestressed Concrete Deck Panels, Pre–Tensioned and Post-Tensioned

### Prestressed Concrete Deck Panels, Post-Tensioned

### Description

This special provision provides for full depth precast concrete deck panels with bonded longitudinal post-tensioning and contents of this special provision apply to this item only. All provisions of 528 shall apply except as amended or modified below. Refer to PCINER-02-FDPCDS "Full Depth Precast Concrete Deck Slabs: (www.pcine.org) for more information and additional guidelines.

**Add to 1.1**

**1.1.2** This work shall also include the design, detailing, furnishing, post-tensioning and grouting of tendons and all appurtenances required to complete a longitudinally post-tensioned system where indicated on the plans.

**1.1.3 Terms.** Wherever in this specification or in other contract documents the following terms are used, the intent and meaning shall be interpreted as follows:

ANCHORAGE- An assembly of various hardware components, including confining reinforcement, which secure a tendon and its ends after it has been stressed and imparts the tendon force into the concrete.

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.

MEMBER- Member shall be considered to mean the concrete which is to be post-tensioned.

POST-TENSIONING- The application of compressive force to the concrete by stressing tendons after the concrete has been cast and cured. The force in the stressed tendons is transferred to the concrete by means of anchorages.

POST-TENSIONING LAYOUT- The pattern, size, and locations of post-tensioning tendons provided in the plans.

POST-TENSIONING SYSTEMS- A proprietary system where the necessary hardware (anchorages, confining reinforcing, wedges, strands) is supplied by a particular manufacturer or manufacturers of post-tensioning components.

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 elastic deformation of the anchor components.

STRAND- an assembly of several high strength steel wires wound together. Strands usually have six outer wires helically wound around a single straight wire of similar diameter.

TENDONS- High strength steel elements used to prestress the concrete.

WEDGES- 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.

WEDGE PLATE- A steel component of the anchorage containing a number of tapered holes through which the strands pass and are secured by conical wedges.

WIRE- A single, small diameter, high strength steel element and, normally, the basic component of strand, although some proprietary post-tensioning systems are made up of individual or group of single wires.

**<u>Revise</u> 2.9 to read:**

**2.9 Grout for Transverse Shear Keys**

**<u>Add</u> to Materials:**

**2.11 Post-tensioned systems**

**2.11.1 Post-Tensioning Strands** shall conform to 2.4.

**2.11.2 Post-Tensioning Bars** shall conform to the requirements of AASHTO M 275M/M 275-00 (ASTM A722/A 722M-98).

**2.11.3 Anchorages.** All anchorage devices shall meet the requirements of Section 10 of AASHTO LRFD Bridge Construction Specifications, 2004, and latest interims.

**2.11.4 Post-Tensioning ducts.** All post-tensioning ducts shall meet the requirements of Section 10.8.3 of AASHTO LRFD Bridge Construction Specifications, 2004, and latest interims.

**2.11.5 Grout for Bonded Post-Tensioning.** Grout shall be prebagged and of a variety specifically detailed for use in the grouting of post-tensioning ducts. The grout shall meet or exceed the specified physical properties stated herein as determined by the following standard and modified test methods. Grouts shall contain no aluminum powder.

| Property | Test Value | Test Method |
|---|---|---|
| Total Chloride Ions | Max. 0.08% by weight of cementitious material | ASTM C 1152 |
| Fine Aggregate (if utilized) | Max Size < No. 50 Sieve (300 micron) | ASTM C 33 |
| Volume Change @ 24 hrs and 28 days | 0.0% Shrinkage @ 24 hours <=0.3% Expansion @ 28 days | ASTM C 1090 * |
| Expansion | <= 2.0% for up to 3 hours | ASTM C 940 |
| Compressive Strength @ 28 days (Average of 3 cubes) | >= 5000 psi | ASTM C 942 |
| Initial Set of Grout | Min. 3 hours<br>Max. 12 hours | ASTM C 953 |
| Fluidity Test**<br>Efflux Time from Flow Cone | | |
| (a) Immediately after mixing | Min. 20 sec.<br>Max. 30 sec. | ASTM C 939 |
| | or<br>Min. 9 sec.<br>Max. 20 sec. | ASTM C 939*** |
| (b) 30 minutes after mixing with remixing for 30 sec. | Max. 30 sec. | ASTM C 939 |
| | or<br>Max. 30 sec. | ASTM C 939*** |
| Bleeding @3 hours | Max. 0% | ASTM C 940**** |
| Permeability @ 28 days | Max. 2500 coulombs at 30V for 6 hours | ASTM C 1202 |
| Freeze/Thaw durability | Relative dynamic E > 95% | AASHTO T 161 Procedure A |

* Modify ASTM C 1090 to include verification at both 24 hours and 28 days.

** Adjustments to flow rates will be achieved by strict compliance with the manufacturer's recommendations.

*** Grout fluidity shall meet either the standard ASTM C 939 flow cone test or the modified test described herein. Modify the ASTM C 939 test by filling the cone to the top instead of the standard level. The efflux time is the time to fill a one-liter container placed directly under the flow cone.

**** Modify ASTM C 940 to conform to the wick induced bleed test described below.

a) Condition dry ingredients, mixing water, prestressing strand and test apparatus overnight at 75 to 80° F.

b) Insert 800 ml of mixed conditioned grout with conditioned water into the 1,000 ml graduated cylinder. Mark the level of the top of the grout.

c) Wrap the strand with 2-inches wide duct or electrical tape at each end prior to cutting to avoid splaying of the wires when it is cut. Degrease (with acetone or hexane solvent) and wire brush to remove any surface rust on the strand before temperature conditioning. Insert completely a 20-inch length of conditioned, cleaned, ASTM A 416 seven wire strand (0.5 inch diameter) into the 1,000 ml graduated cylinder (possibly using a centralizer). Mark the level of the top of the grout.

d) Store the mixed grout at the temperature range listed above in (a).

e) Measure the level of the bleed water every 15 minutes for the first hour and hourly afterward for three hours.

f) Calculate the bleed water, if any, at the end of the three hour test period and the resulting expansion per the procedures outlined in ASTM C 940, with the quantity of bleed water expressed as a percent of the initial grout volume. Note if the bleed water remains above or below the top of the grout.

**2.11.5.1** Grouts shall be prebagged in plastic lined or coated bags. Stamp grout bags with date of manufacture, lot number and mixing instructions. Any change of materials or material sources requires retesting and certification of the conformance of the grout with the physical properties requirements. A copy of the Quality Control Data Sheet for each lot number and shipment sent to the job site shall be provided to the contractor by the grout supplier and furnished to the Engineer. Prebagged grout with clumps will be rejected.

**2.11.5.2** Materials with a total time from manufacture to usage in excess of six months shall be retested and certified by the supplier before use or shall be removed and replaced.

**2.11.5.3** Manufacturers of post-tensioning grout seeking qualification of their product shall provide certified test reports from an audited and independent Cement Research Laboratory (CCRL) which shows the material meets all the requirements specified herein.

**<u>Add</u> to Construction Requirements:**

### 3.1.7 Post-Tensioning

**3.1.7.1** The post-tensioning system shall provide a minimum compressive force of 250 psi at transverse joints, plus any additional force required in negative moment regions over piers, between panels as detailed in the plans. Any 7-wire strand post-tensioning system that conforms to this specification can be considered for use. The requirements of a system shall include the furnishing and installing of all appurtenant items necessary for the particular stressing system used, including but not limited to ducts, anchorage assemblies, grout, and supplementary steel reinforcing bars for bursting and crack control behind anchorage assemblies and for duct support.

**3.1.7.2 Shop Drawings:** Shop drawings shall conform to the requirements in 3.4 and additional requirements below.

1. The Contractor shall prepare and submit integrated drawings showing all embedded items such as post-tensioning ducts, anchorages, anchorage reinforcement, blockouts, reinforcing steel. These drawings shall be to scale, shall be accurate, and shall have sufficient detail to show the relative positions of all items and their embedded depth. The drawings shall be adequate to ensure that there will be no conflict between the planned positions of the embedded items and that the concrete cover will be adequate. In the event of conflicts between post-tensioning hardware and reinforcement, the location and details of post-tensioning hardware takes precedence over the location of mild steel reinforcement. The Engineer shall review such revisions before work on any affected item is started.
2. Show fully and accurately detailed blockouts, notches, recesses, projections, and the like that might be required by the Contractor’s construction scheme.
3. Details of mild steel reinforcing shall be clearly shown as to size, spacing, and location including all special reinforcing required but not shown on the Contract Plans.
4. Show size and type of ducts for all post-tensioning tendons with their horizontal and vertical profiles clearly detailed. Duct supports, grout tubes, and vents shall be shown including type, size, and location, including the elements to be installed in the cast-in-place pier diaphragms.
5. Details and locations of all other items to be embedded in the girder such as inserts, post- tensioning hardware, conduit penetrations, and the like shall be shown.
6. Details of the anchorage system including confinement reinforcement required for the post- tensioning system shall be shown.
7. Provide details and a complete description of the post-tensioning system to be used. Stressing details shall include method, sequence, and procedure of

prestressing and securing tendons; release procedures and equipment; and sizes and properties of tendons, anchorage plates, anchorage assemblies, reinforcement, and equipment.

8. Data sheets for prebagged grout for post-tensioning tendons, method of mixing and detailed grouting procedure, equipment description and capacity (including standby flushing equipment). Details to be included in grouting procedures shall include, but is not limited to, intended direction of grouting, low point from which grouting will be injected, and sequence of closing vents.
9. Qualifications of the post-tensioning and grouting personnel. One member of the crew completing the work (superintendent or foreman) shall have attended the American Segmental Bridge Institute (ASBI) Grouting Certification Training Program and shall be ASBE Certified Grouting Technicians.
10. A table giving jacking sequence, jacking forces, and initial elongation of each tendon for all post- tensioning shall be provided to Engineer at least 10 days prior to stressing operation. Stressing operations shall not commence until this table is provided to the Engineer.
11. Certified Reports: Submit the following certified test reports prepared by a reputable nationally recognized independent testing laboratory:
    a) Test reports on static pullout bonding strength of the corrugated ducts.
    b) Certified calibration charts shall be furnished with each jack and gauge used.
    c) Certified copies of test results for the post-tensioning anchorage. Anchorage shall be so arranged that the jacking force in the tendon may be verified prior to removal of the stressing equipment.
    d) Test reports of tendon modulus of elasticity, ultimate tensile strength, yield strength, elongation, composition, and in place friction tests if required.

    Stressing operations shall not commence until these reports are provided to the Engineer.
12. Stressing Records: The Contractor is responsible for all stressing records including gauge pressure and elongation for each tendon stressed. The stressing logs shall be submitted to the Engineer daily for review and the Contractor shall reconcile the differences with calculated values of all individual tendons and groups of tendons, prior to next load transfer erection operation or on a weekly basis. The Contractor shall submit a system of tendon identification, individually and in groups, to expedite the tasks of the Contractor and the Engineer in mutual pursuit of the installation and acceptance of the post-tensioning process. Grout logs as called for elsewhere in this Section.
13. Furnish test and verification data as called for elsewhere in this Section.

**3.1.7.3 Design Computations:** Four (4) sets of design computations for the proposed method of post-tensioning shall be submitted for approval with the shop drawings. The design computations shall be signed and sealed by a licensed professional engineer, registered in the State of New Hampshire, and shall include but not be limited to the following information:

1. Computed losses for each tendon such as creep and shrinkage of concrete, elastic shortening, relaxation of steel, losses in post-tensioned prestressing steel due to sequence of stressing, friction and take up of anchorages, and other losses peculiar to the method or system of prestressing that may take place or have been provided for.

2. Jacking force for each tendon.

3. Effective force for each tendon.

4. Anchorage bearing stress at service load.

5. All other computations required for the system of stressing being used, including all reinforcing required to resist bursting stresses. Post-tensioned anchorage zones shall conform to the requirements of Section 5.10.9 of the AASHTO LRFD Bridge Design Specifications.

**3.1.7.4 Post-Tensioning Anchorages:** All prestressing steel shall be secured at the ends by means of permanent type anchoring devices that have been reviewed and accepted by the Engineer. The anchorages shall meet or exceed the following requirements:

1. The anchorages shall develop at least 95 percent of the minimum specified ultimate tensile strength of the prestressing steel, tested in an unbonded state without exceeding anticipated set. Certified copies of test results for the anchorage system to be used shall be supplied to the Engineer at no additional cost. The anchorage shall be so arranged that the prestressing force in the tendon may be verified prior to removal of the stressing equipment.

2. The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. Such devices shall conform to the following requirements:

   a) The average bearing stress in the concrete created by the anchorage plates shall not exceed the values in ***Section 9.2.1 and 14.0 of Division I and Section 4.2 of Division II of the 1999 AASHTO Guide Specifications for Design and Construction of Segmental Concrete Bridges.***

   b) Bending stresses in the plates or assemblies induced by the jacking 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 or cause visible distortion of the anchorage plate, as determined by the Engineer.

3. Should the Contractor elect to furnish an anchoring device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

4. Anchorages must be set in a plane normal to the axis of the tendons such that uniform bearing on the concrete is assured. Wedge-type anchors shall not be used in inaccessible locations.

   Anchorages shall be supplied with a steel reinforcing spiral for those tendons having a prestressing force greater than 300 kips.

5. Anchorages shall be protected as follows:

   a) The anchoring devices shall be recessed so the ends of the post-tensioning steel and all parts of the anchorage will have at least two inches of cover from the panel's surface. The recess shall be filled with a qualified non-shrink grout following post-tensioning.

   b) Anchorage blisters may be required to accommodate the anchorage assemblies and the clear cover requirement. The Contractor can fabricate the end panels with the anchorage assemblies and anchor blocks already installed or can install the anchorage assemblies and fill the anchorage blisters with non-shrink grout, on-site, after the panels have been erected.

   c) As soon as possible, but not exceeding 14 days after post-tensioning is complete, exposed end anchorages, strands and other metal accessories shall be cleaned of rust, misplaced mortar, grout and other deleterious materials. Immediately following the cleaning operation, the entire surface of the anchorage recess (all metal and concrete) shall be thoroughly dried and uniformly painted with an epoxy bonding compound conforming to AASHTO M235, Type II, in accordance with the manufacturer's recommendations. The anchorage recess shall be filled with a non-shrink cement based grout immediately following the application of the epoxy-bonding compound.

6. Local zone reinforcement, required for the performance of the anchorage (based on previous tests and history of successful performance on other projects) shall be provided by the Contractor incidental to the proprietary anchorage system selected.

7. All anchorages shall be provided with a permanent non-metallic grout cap with gasket that fully encapsulates the wedge plate. The grout cap shall be durable and impervious, and shall protect the strands from corrosion. Temporary grout caps will not be permitted.

**3.1.7.5 Samples for Testing:**

1. The following samples of materials and devices selected at locations designated by the Engineer shall be furnished by the Contractor at Contractor's expense. The Engineer shall be present at the time of sampling. The Contractor shall notify the Engineer at least 24 hours in advance of when samples will be taken from stored materials.
   a) Three 7-foot long samples of prestressing wire or bar for each size from each heat number or production lot.
   b) Three 7-foot long samples of prestressing strand for each size from each heat number or production lot.
   c) 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.
   d) One unit of each prestress anchorage to be used on the project.
   e) Samples shall be taken at least 30 days in advance of the time they are to be incorporated into the Work.
2. All strands from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Each lot of anchorage assemblies to be installed at the job site shall also be identified in a similar manner. All unidentified prestressing steel and anchorage assemblies received at the site will be rejected and loss of positive identification of these items at any time will be cause for rejection of their use as intended.
3. The release of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

**3.1.7.6 Testing by Contractor:**

1. The Contractor shall furnish manufacturer's certified reports covering die tests required by these specifications. 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. 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.

**3.1.7.7 Protection of Prestressing Steel:**

1. During and after prestressing steel installation the Contractor shall prevent all water, rain, snow and/or ice from entering the post-tensioning ducts.
2. When acceptable prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are

completed within ten calendar days after the installation of the prestressing steel, rust which may form during said ten days will not be cause for rejection of the steel, provided no pitting has developed over this period. Prestressing steel installed, tensioned and grouted in the manner, all within ten calendar days, will not require the use of corrosion inhibitor in the duct following installation of the prestressing steel. Post- tensioning steel installed as above but not grouted within ten calendar days shall be subject to all the requirements in this section pertaining to corrosion protection, which includes an accepted water soluble corrosion inhibitor and may include rejection because of rust. The corrosion protection system shall be submitted for review and approval prior to the start of any post- tensioning work. Vapor Phase Inhibitor (VPI) is not an acceptable corrosion protection system. The submission for approval shall include certified test reports from an audited and independent research laboratory which indicates the proposed corrosion inhibitor will provide corrosion protection in accordance with the provisions of Federal Specifications MIL-P-3420. Bond testing shall be also performed to prove that the proposed corrosion inhibitor does not impair the bond strength between the cement grout and prestressing steel. Appropriate ventilation is required to avoid toxic effects.

**3.1.7.8 Post-tensioning ducts:**

1. The inside diameter of the ducts shall be at least ¼" larger than the nominal diameter of single wire, bar, or strand tendons, or in the case of multiple wire, bar, or multiple strand tendons, the inside cross-sectional area of the sheathing shall be at least two times the net area of the prestressing steel. When tendons are to be placed by the pull through method, the duct area shall be at least 2 ½ time the net area of the prestressing steel.
2. Transition couplings connecting ducts to anchoring devices shall be galvanized ferrous metal and shall be capable of positively preventing the entrance of cement paste and water from concrete and of sufficient strength to prevent distortion or displacement of the ducts during concrete placement.
3. Splices in ducts used at the cast-in-place concrete diaphragms shall be the same material as used in the members. Joints between the portion of duct protruding from the end of the members and the splice section shall be capable of positively preventing the entrance of cement paste and water from concrete and of sufficient strength to prevent distortion or displacement of the ducts during concrete placement. Duct tape is not considered adequate.
4. Ducts shall be security tied in position, carefully inspected, and repaired before placing of the concrete is started, and care shall be exercised during the placing of the concrete to avoid displacing or damaging the ducts. Metal ducts shall be supported at intervals of not more than 4 feet. Plastic ducts shall be supported at intervals of not more than 2 feet. The tolerance on the location of the tendons shall be plus or minus 0.25 inches at any point and in any

direction. Visual inspection shall be used to confirm a smooth profile with no kinks prior to closing forms.

5. After installation in the forms and bulkheads, the ends of the ducts shall be sealed at all times to prevent entry of water and debris. Following concrete placement, the Contractor shall demonstrate to the Engineer that all empty ducts are free of water and are unobstructed and undamaged. Immediately prior to installation of the prestressing steel, the Contractor shall again demonstrate to the Engineer that all ducts are unobstructed and that they are free of water and debris. An acceptable method of demonstrating that the ducts are unobstructed and free of water and debris is to blow oil-free compressed air through the full length of each duct.

**3.1.7.9 Vent and Grout Injection Pipes:**

1. All ducts and anchorage assemblies for permanent prestressing shall be provided with pipes or other suitable connections at each end and each side of couplers for injection of grout after post-tensioning. In addition all ducts having a tendon profile varying in elevation by more than six inches shall be vented at all high points of the tendon profile and drained at all low points in the tendon profile. In addition, grout vents shall be placed from 3'-6' either side of the high point of the tendon. Any segment of the tendon profile that is horizontal at a high point will have a grout vent placed at no greater then 50 ft increments. Vents and drains shall be ¾" minimum diameter standard pipe or suitable plastic pipe. Waterproof tape shall be used at all connections including vent and grouting pipes. Plastic components shall not react with the concrete or enhance corrosion of the prestressing steel, and shall be free of water-soluble chlorides. The vents shall be mortar fight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents. At all times, pipes shall be capped with water tight plastic caps specifically provided by the post-tensioning supplier, and shall be protected from damage by pedestrian, vehicle and equipment traffic. Any damage to the pipe or cap shall be immediately repaired and misplaced caps shall be immediately replaced.
2. Grout injection pipes shall be fitted with positive mechanical shut-off valves. Vents and injection pipes shall be fitted with valves, caps, or other devices capable of withstanding the pumping pressures specified herein.

**3.1.7.10 Strand Installation**

1. Strands shall be installed in the ducts so as to avoid entanglement and excessive slack. The placement should be such that would allow a linear elongation of the tendons when jacking from 20% to 100% of the jacking force.
2. During and after prestressing steel installation, the Contractor shall prevent all water, rain, snow, and ice from entering the prestressing ducts.

### 3.1.7.11 Post-Tensioning

#### 3.1.7.11.1 Stressing Tendons:

1. 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 working 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 stresses (initial stresses) that will result in the ultimate retention of permanent forces of not less than those shown on the approved 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 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.

2. A qualified representative of the post-tensioning manufacturer who is skilled and experienced in the proposed work shall be on site during all stressing operations. The representative shall be available for (a) inspecting and approving all post-tensioning hardware installation prior to concrete placement; (b) stressing and anchoring tendons; (c) grouting operations.

3. Each jack used to stress tendons shall be equipped with a pressure gauge for determining the jacking pressure. The pressure gauge shall have an accurately reading dial at least six inches in diameter and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force prior to stressing the initial tendon. Certified calibration charts shall be furnished by an independent laboratory with each jack and gauge used on the project. Certified calibration shall be made at the start of the work and every six months thereafter, or as requested by the Engineer. The calibration shall be done while the jack is in the identical configuration as will be used on the site, e.g., same length hydraulic lines. At the option of the Contractor, calibrations subsequent to the initial ram calibration by the load cell 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 line, 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 Engineer for the duration of the project. Any repair of the rams, such as replacing the seals or changing the length of the hydraulic lines, is cause for recalibration of the ram with a load cell. No extra compensation will be

allowed for the initial or subsequent ram calibrations or for the use and required calibrations of a master gauge.

4. Post-tensioning forces shall not be applied until the concrete has attained the compressive strength specified as determined by the cylinder tests.
5. 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 record shall be kept of gauge pressures and elongations at all times and shall be submitted to the Engineer. The post- tensioning force may be verified as deemed necessary by the Engineer. The tendon force measured by gauge pressure shall agree within seven percent of the theoretical elongation. The entire operation shall be checked and the source of error determined and remedied to the satisfaction of the Engineer before proceeding with the work. Elongations shall be measured to the nearest 1/8 in. Equipment for tensioning the tendons must be furnished by the manufacturer of the system (tendons and Contractor, may require additional bench tests and/or friction tests, should the agreement between pressure gauge readings and measured elongations fall outside the acceptable tolerances.
6. The Contractor shall submit computations showing tendon forces and elongations after friction, wobble, and anchor set losses. Losses shall be based on expected modulus of elasticity and actual friction and wobble coefficients and anchor set losses for the system to be used. These parameters shall also appear on the shop plans for all different tendon types.
7. Tendons shall be stressed in the sequence shown on the approved shop drawings. The stressing sequence shall be such that not more than one tendon will be eccentric about the centerline of a member at any time.
8. The Contractor shall take all necessary provisions to avoid crushing of vacant adjacent ducts during the stressing operations.
9. Prestressing steel shall be cut by an abrasive saw within 0.75 to 1.5 inches away from anchoring device. Flame cutting of prestressing steel is not allowed.
10. Within four hours after stressing, protect tendons against corrosion or harmful effects of debris, by temporarily plugging or sealing all opening and vents. Clean rust and other debris from all metal surfaces, which will be covered by the grout cap, and place the permanent nonmetallic grout cap with gasket over the wedge plate.

**3.1.7.11.2 Grouting post-tensioning ducts:**

1. After the tensioning of all tendons has been completed and the prestressing steel has been anchored, the annular space between the duct and the tendons shall be completely filled with grout. The tendons shall be protected against corrosion by a plug at each end to prevent the passage of air, and such plugs shall be left in place until the tendon is grouted. A pressure test on the duct

shall be performed prior to the grout procedure. Duct should be able to achieve 30 psi pressure. Test should not raise pressure greater than 40 psi with closed vents and temporary grout caps.

2. The grouting equipment shall include a colloidal grout mixer capable of continuous mechanical mixing which will produce a grout free of lumps and undispersed cement. The equipment shall be able to pump the mixed grout in a manner which will comply with all provision hereinafter specified. Graduated measuring equipment shall be used for accurate liquid measurement. The pumps shall be positive displacement type and be able to produce an outlet pressure of at least 150 psi. The pump 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 300 psi shall be placed at some point in the grout line between the pumping outlet and the duct inlet. 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 an additive is used, a screen opening of 0.188 inch is satisfactory. This screen shall be easily accessible for inspection and cleaning. 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. Under normal conditions, the grout equipment shall be capable of continuously grouting the longest tendon on the project in not more than twenty minutes.

3. Provide back up grouting equipment and independent back up power supply to ensure that grout placement can continue if primary equipment or power supply fails.

4. Mix the grout in accordance with the manufacturer’s instructions using a colloidal mixer to obtain a homogenous mixture. Perform a fluidity test on the mixed grout, in accordance with the grout material specifications, prior to beginning the injection process. Obtain target flow rates as a function of mixer type used and ambient temperature from the grout manufacturer. Do not begin the grouting process until the proper grout properties have been obtained.

5. Batches shall be placed within 30 minutes of mixing.

6. All grout openings and high point vent openings shall be open when grouting starts. Grout shall be allowed to flow from the first vent after the inlet pipe until all residual flushing water and entrapped air has been removed, at which time the vent shall be capped or otherwise closed. Remaining vents shall be closed in sequence in the same manner. Maintain a continuous flow of grout at a rate not to exceed 30 feet of duct per minute. The pumping pressure at the tendon inlet shall not exceed 250 psi. Normal operations shall be performed at 75 psi. If the actual grouting pressure exceeds the maximum allowable pumping pressure, close the injection vent and inject the grout at the next

vent, which has been, or is ready to be, closed as long as one-way flow is maintained. Do not inject grout into a succeeding vent from which grout has not yet flowed. If a one-way flow of grout cannot be maintained as outlined above, the grout shall be immediately flushed out of the duct with water.

7. Grout shall be pumped through the duct and continuously wasted at the outlet pipe until no visible slugs of water or air are ejected and efflux time of ejected grout is not less than the injected grout. Perform a fluidity test, in accordance with the grout material specifications, on each tendon measuring the grout discharged from the discharge outlet. The measured grout efflux time shall meet the requirements of the Fluidity Test listed in the grout material specifications. If the grout efflux time is not acceptable, discharge additional grout from the discharge outlet. Test grout efflux time. Continue this cycle until acceptable grout fluidity is achieved. Ensure that the tendon remains filled with grout, by closing the ejection and injection vents in sequence, respectively, under pressure when the tendon duct is completely filled with grout. Do not remove the positive shut-offs at the injection and ejection vents or open until the grout has set. At all times, the ducts shall be free of water to avoid damage due to freezing. The temperature of the concrete or air surrounding the tendon shall be 40 degrees F or higher from the time grout is placed until the minimum compressive strength of 800 psi, as determined from tests on 2 inch cubes cured under the same condition as the in-place grout, is obtained. Grout shall not be above 90 degrees F during mixing or pumping. If necessary, the mixing water shall be cooled. The waste fluid that is flushed from the duct shall be captured and disposed of in compliance with applicable laws. All grout that spills shall be collected and disposed of in compliance with applicable laws.

8. 24-hours after grouting, the level of grout in the grout inlet pipes, vent pipes, and grout caps shall be inspected and topped off as necessary with freshly mixed grout. Vacuum grouting or other remedial action may be required by Engineer based on size and extent of voids found.

9. Do not remove or open valves, caps or vent pipes until the grout has set. Ends of steel vents shall be removed at least 1 inch below the concrete surface after the grout has set. Ends of plastic vents shall be removed to 1 inch below surface of the concrete, or 1 inch below deck grade, after the grout has set. Remove all miscellaneous material used for sealing grout caps before carrying out further work to protect end anchorages or filling in anchorage pourbacks and the like. A shrinkage compensating polymer modified grout applicable for vertical patching shall be used to patch holes left from grouting procedures.

10. Daily grouting logs and cumulative record books shall be submitted to the Engineer for review and record within 72 hours of grouting. Information to be provided in the records shall include but shall not necessarily be limited to the following: tendon number, date grouted, number of days between stressing and grouting, brand of prebagged grout, tendon end used for injection, grout

flow test results, grouting pressure, and summary of problems encountered and corrective action taken.

**3.2.1.1.1** For precast concrete deck panels that are not pre-tensioned, proof shall be given by the Contractor that the Fabricator is capable of and has the organization and plant for performing the work in manufacturing the panels. The fabricator shall cast a trial panel, as required by the Engineer.

**Revise 3.22.6 to read:**

**3.22.6 Installation of Partial Depth Deck Panels**

**Add to 3.22**

**3.22.7 Installation of Full Depth Deck Panels**

**3.22.7.1** The full depth panels shall be set to the elevations detailed on the plans. Final panel elevations shall be attained by adjusting the torque on leveling screws to promote an equal distribution of panel dead load to all girders. The torque schedule shall be submitted with the shop drawings for the panels. The torque tolerance shall be +/- 15%.

**3.22.7.2** Panels shall not be used to support construction loads until the bedding concrete has attained a minimum compressive strength equal to the design compressive strength of the panels.

**3.22.7.3** The transverse shear keys and recesses between the precast slabs shall be thoroughly cleaned prior to delivery by means of high pressure washing using a pressure of at least 1000 psi and a delivery rate of not less than 4 gallons per minute. The shear key surface shall be cleaned on site by air blasting prior to placing the grout. If a pre-bagged non-shrink grout is used, the shear keys and recesses shall be prepared and the grout shall be placed according to the grout manufacturer's recommendations. If a cement based, non-shrink grout is used (not pre-bagged) the key areas shall be wet thoroughly prior to grout placement. The grout shall attain a minimum compressive strength of 1500 psi (or minimum strength detailed on the plans) prior to post-tensioning the panels longitudinally.

**3.22.7.4** The deck panels shall be post-tensioned prior to making them composite with the girders unless specific direction to the contrary is detailed on the plans. See post-tensioning requirements elsewhere in this special provision. **Panels shall not be post-tensioned until they have aged a minimum of 45 days.**

**3.22.7.5** After the shear studs have been installed, bedding concrete shall be placed through the shear connector pockets in the deck panels to completely fill the area under the panels and over the flanges. Compressible foam grout dams or temporary formwork shall be used to maintain the concrete within the haunch. All leveling screws and other supplemental supports shall be removed after the bedding concrete has attained strength. Holes left by the removal of the leveling screws shall be filled with an approved non-shrink grout.