SP-010314
(New)

Iowa Department of Transportation

SPECIAL PROVISION

FOR

PRECAST POST-TENSIONED SLAB PANELS

Pottawattamie County
IM-080-1(308)2--13-78

Effective Date
October 16, 2007

THE STANDARD SPECIFICATIONS, SERIES 2001, AND IM 570 ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

SECTION 1 – PRECAST POST-TENSIONED SLAB PANEL CONSTRUCTION

DESCRIPTION

Precast post-tensioned slab panel construction shall consist of fabrication, on-site and off-site storage, transporting and erecting of the precast slab panels and for the furnishing, installation, post-tensioning and grouting of tendons. In accordance with this specification, furnishing and installation of materials shall include any appurtenant items necessary including but not limited to ducts, couplers, anchorage assemblies, any supplementary reinforcing steel, grout for transverse shear keys, concrete for shear stud pockets, girder haunches, and pressure grouting of ducts. All slab panels shall be placed and post-tensioned together in accordance with the contract documents. All post-tensioning related materials and procedures shall be per the manufacturer's recommendations which shall conform to AASHTO, PTI and ASTM.

The Contractor shall submit written Quality Control and Production Plans to the Engineer at least 30 calendar days prior to any panel production. The Quality Control and Production Plan must be accepted by the Engineer prior to any fabrication. The Quality Control Plan shall be in accordance with Materials I.M. 570. In addition, the Quality Control Plan shall detail the correspondence and submittal process. The Production Plan shall detail the proposed fabrication method and the procedures that will be used to accomplish production using this fabrication method.

SHOP DRAWINGS AND CALCULATIONS

Information Required: The Contractor shall submit detailed shop drawings, calculations and manuals which include, but are not necessarily limited to, the following:

A schedule of the timing and sequence of slab panel casting and erection.

Details of the forms for the manufacture of each slab panel. The forms shall be capable of resisting the maximum prestress force to which they are subjected to without permanent displacement and to within the tolerances as stated in this special provisions.

Calculations and details for lifting, storage, or stacking of the slab panels. (Note: any additional strengthening of the slab panels to accommodate stacking shall be at no additional expense to the Contracting Authority).

Details of inserts or lifting holes including any necessary localized strengthening and the materials and methods to fill and finish such holes.

Details and calculations for any localized strengthening for concentrated supports, loads, or reactions from any special erection equipment placed in locations not already allowed for in the plans.

Details of all embedded items, all appurtenant items, and all protruding items.

Fully and accurately dimensioned views showing the geometry of each slab panel or slab panel type including projections, recesses, notches, opening, and blockouts.

Appropriate details of changes from dimensions shown on the plans where variations are made to slab panels, including any special reinforcing required but not shown on the plans, with clear and concise cross-reference to the appropriate plans to which the variations apply.

Details of and supporting calculations for any modifications to reinforcement at anchorages, made necessary for accommodating the elected post-tensioning system hardware.

A procedure for the casting and geometry control of the slab panels in accordance with the information provided in the contract documents.

Sequence and method for erection of the slab panels.

Method of erection of the slab panels to maintain geometry control in all directions (horizontal or vertical).

Method of forming the haunches.

Designation of the specific post-tensioning steel, anchorage devices, couplers, duct material, duct size, grout injection and outlet vents, and accessory items to be used.

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

Details covering assembly of the post-tensioning tendons.

Equipment to be used in the post-tensioning operation.

The sequence of stressing of the post tensioning strands. The sequence shall be such that the stresses are uniform across the cross section throughout the post tensioning operation.

Sequence of operations for post-tensioning and securing tendons.

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

Details of special reinforcing at “local Zones” of anchorages.

Table detailing the post-tensioning jacking sequence, jacking forces, and elongation of each tendon, including stressing end seating losses, at each stage of erection for all post-tensioning.

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

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

Calculations to substantiate the post-tensioning system and procedures to be used, including stress-strain curves typical of the post-tensioning steel to be furnished, required jacking forces, elongation of tendons during tensioning, seating losses, short-term prestress losses, long-term prestress losses, temporary overstress, stresses in prestress anchorages, including distribution plates and reinforcing steel needed in the concrete to resist stresses imposed by post-tensioning anchorages. These calculations shall show a typical tendon force after applying the expected friction coefficient and anticipated losses for the stressing system to be used including seating losses.

The submittal shall be sealed by a professional engineer registered in the State of Iowa.

Submittal Procedures:

All submittals by the Contractor shall be submitted sufficiently in advance of the start of construction to allow a 30-calendar day review period. All submittals not approved and requiring resubmittal shall be subject to the above review time period, with the review time beginning anew for each such submittal. The Contractor shall coordinate all submittals between his various subordinates (contractors, suppliers, and engineers) to allow for a reasonable distribution of the review effort required by the Engineer at any given time. Final approval shall be received before any fabrication begins. Manufacturer's literature shall be supplied where applicable. All shop drawings are to accurately detail the actual methods, materials, equipment, etc., that the Contractor will be using in the field on the project. Deviation is not permitted unless approved by the Engineer.

Materials

A. General: Use materials which conform to this special provision and the requirement prescribed in Section 2407 for the particular kind and type of materials specified.

B. Concrete: Use concrete as specified in section 2 of these special provisions. Screenings are not allowed as a substitute for silica sand for use in concrete for Precast Slab Panels.

C. Reinforcing Steel: Use ASTM A615, grade 60 reinforcing steel which meets the requirements of Article 4151.03. Epoxy coated reinforcing steel shall be used.

CASTING REQUIREMENTS

A. General: Casting of slab panels shall not begin until the Engineer approves the relevant shop drawings, calculations, concrete forms, concreting operations and the post-tensioning system components and layout. (Approval of post-tensioning stressing elongations and forces for field use is not required at this stage but required prior to erection.)

B. Forms: The Contractor shall be responsible for the design and engineering of the forms as well as their construction. All exposed formed surfaces of each element of the structure shall be formed with the same material to produce similar concrete surface textures, color, and appearance. Obtain the Engineer's approval of forms prior to initiating casting operations. Build the details shown on the Plans or as amended by approved shop drawings into the forms.

The Engineer will review forms for suitability. Any forms determined unsuitable shall be repaired or replaced.

Where sections of forms are joined, ensure that offsets in flat surfaces do not exceed 1/8 inch in. and that offsets with corners and bends do not exceed 1/4 inch

All joints in the forms and contact points with bulkheads and existing panels shall have good fitting seals to prevent loss of fine material and cement grout.

The Contractor shall check and inspect forms on a regular weekly basis to ensure proper alignment and geometric accuracy. Forms which fail to meet the specified casting tolerances shall not be used until such corrections are made to produce slab panels within the specified tolerances.

EMBEDDED ITEMS

A. General: Embedded items shall be in accordance with specifications for prestressed and post-tensioned construction and the requirements herein.

B. Embedded Post-Tensioning Ducts:

1. Post Tensioning Ducts:

Place the ducts accurately (within 1/4 inch tolerance) at locations shown on the plans and tie securely in place at 24” maximum spacing to prevent displacement or movement during concrete placement. The Contractor shall provide additional support bars as necessary to achieve this requirement. The Contractor shall coordinate the placement of the post-tensioning ducts with the mild reinforcing steel and the pre-tensioning strands as shown in the plans.

Duct embedded in the panels shall be made out of a single piece. No joining or coupling of ducts will be allowed within the panels. Coupling of ducts is only allowed to join ducts between two adjacent panels at the transverse joints.

Show the method and spacing of duct supports on appropriate Shop Drawings.

Ensure that all alignments are smooth and continuous with no lips, kinks or dents.

Carefully check and repair all ducts as necessary before placing any further concrete.

After installing the forms, ensure that all ends of ducts, connections to anchorages, splices, vents and the like are sealed water-tight at all times to prevent the entry of water and debris.

2. Grout Vents, Injection and Ejection Pipes:

All ducts and anchorage assemblies for permanent post-tensioning shall be provided with grout vents or other suitable connections. The grout vents shall be placed at each anchor, at each high point of duct within each span and at low point of each span, if applicable, for the injection of grout after post-tensioning. Ducts shall be vented at low points to prevent freeze-thaw damage. Vents shall be 1/2-inch minimum diameter standard pipe or suitable plastic pipe. All connections to ducts shall be made with plastic structural fasteners. Waterproof tape shall be used at all connections including vent and grouting pipes. Duct tape is not allowed. Plastic components shall not react with the concrete or enhance corrosion of the post-tensioning steel, and shall be free of water-soluble chlorides. The vents shall be mortar-tight, and shall provide means for injection of grout through the vents and for sealing the vents.

Ends of plastic vents shall be removed after the grout has set.

All grout injection and vent 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. Valves and caps shall not be removed or opened until the grout has set.

3. Anchorage Assemblies:

Secure all post-tensioning tendons at the ends by means of permanent type anchoring devices. The post-tensioning manufacturer shall supply special reinforcement, such as spirals or grids, for the longitudinal tendons. The anchorage device shall be capable of developing 100% of the specified ultimate strength of the post-tension tendons, when tested in an unbonded state, without exceeding the anticipated set.

Prior to placing concrete in the forms, fix all anchor plates and anchor castings in their respective position in the forms, connected to their duct and sealed to prevent mortar intrusion. Ensure that anchor plates and castings are rigidly fixed in the forms to maintain their correct alignment and position during concrete placement and consolidation.

The plans do not indicate the necessary reinforcing steel required to resist “Local Zone” bursting and splitting stresses imposed in the concrete by the post-tensioning anchorage. The Manufacturer shall, at his expense, design the “Local Zone” reinforcing steel to resist local bursting stresses imposed on the concrete by his selected anchorage system, and furnish any additional steel required at no additional cost. Design of anchorages so that the average concrete bearing stresses is in compliance with the “AASHTO LRFD Bridge Design Specifications”. Test and provide written certification that anchorages meet or exceed the tensile requirements in the AASHTO LRFD Bridge Construction Specifications.

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

Equip each anchorage with a permanent grout cap that is vented and bolted to the anchorages.

C. Reinforcing Steel: Fabricate and place reinforcing steel in accordance with the Plans or as superseded by the approved shop drawings and as required herein.

CONCRETE PLACEMENT, CONSOLIDATION, AND FINISHING

A. General: Do not deposit concrete into the forms until the entire set-up of the forms, reinforcement, shields, anchorages and embedded items have been thoroughly inspected and checked.

Do not place concrete until the Engineer is satisfied that all the above items have been properly inspected and checked, and the rate of producing and placing the concrete will be sufficient to complete the casting and finishing operations while the concrete is workable, that experienced concrete finishers are available where required for finish work and that all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.

During conveying and placement, protect concrete against undue drying or rise in temperature and inclement weather.

B. Concrete Placement Equipment: Use concrete placement equipment of a size and design which permits placing concrete while the concrete is workable. Clean all equipment at the end of each operation or workday and, prior to reuse, check the equipment and clean off hardened concrete and foreign materials.

C. Concrete Placement and Consolidation: Discharge individual loads of concrete into the forms, and place and consolidate in the required locations.

Place and consolidate concrete with care so that post-tensioning shields, anchorages, and any other embedded items are maintained in their proper positions and are not damaged.

Use external vibrators for consolidating concrete when the concrete is inaccessible for adequate consolidation by internal means. When external vibration is used, construct the forms sufficiently rigid to resist displacement or damage.

Vibrate concrete in a manner which avoids displacement or damage to reinforcement, post-tensioning shields, anchorages and other embedded items.

No construction joints are allowed within a slab panel.

D. Finishing: Strike off the top surface of the slab panel with an approved mechanical screed operated by a self contained power source.

Furnish and use a straightedge at least 2.0 feet longer than the slab panel while finishing the concrete surface of slab panels. Use the straightedge approximately parallel to the centerline of the slab panel to strike an accurate surface between the bulkhead and the top of the match cast slab panel at all positions across the panel width.

The top concrete surface shall be intentionally roughened or raked to a 1/4 inch minimum amplitude.

E. Proving of Post-Tensioning Ducts: Upon completion of concrete placement, prove that the post-tensioning ducts are free and clear of any obstructions or damage and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. Use a torpedo having the same cross-sectional shape as the duct, and be ¼" smaller all around than the clear, nominal inside dimensions of the duct. Make no deductions to the torpedo section dimensions for tolerances allowed in the manufacture or fixing of the ducts. For straight ducts, use a torpedo at least 2.0 feet long. If the torpedo will not travel completely through the duct, the Engineer will reject the member, unless a workable repair can be made to clear the duct, all to the satisfaction of the Engineer. Pass the torpedo through the duct easily, by hand, without resorting to excessive effort or mechanical assistance.

F. Problems and Remedies: The Engineer will reject ducts or any part of the work found to be deficient. Perform no remedial or repair work without the Engineer's approval.

G. Shear-Keyway Grout/Mortar:

Mortar or grout for keyways, shall be a non-shrink mortar. The mortar shall be prepared, placed and cured per manufacturer's specifications. Minimum strength of the mortar shall be 6000 psi prior to applying post-tensioning. Exposed concrete surfaces at blockouts and recesses shall be treated with a bonding agent prior to filling. The strength requirements of the grout shall be met by conducting compressive strength tests on sample test cylinders taken during the pouring of the grout in the required areas as indicated in the plans. The sample tests shall be conducted in accordance with ASTM C109 for the testing of the grout. Curing method(s) shall be similar to the curing method used during the construction.

CURING

A. General: Steam curing in accordance with Article 2407.10 is required.

B. Removal of Forms: Prior to removing the forms, protect the plastic concrete from adverse weather effects.

Keep supporting forms in place until the concrete has reached the required strength for form removal according to the contract documents.

Test cylinders shall be made and cured in the same manner as the slab panel, to confirm the form release strength prior to removing forms.

Avoid cracking or damaging the slab panel when removing the forms, especially shear keys. Notify the Engineer of any damage which occurs and repair with a method approved by the Engineer.

C. Test Samples: Provide additional test samples and testing for compressive strength on precast slab panels to control the construction activities and to ensure adequate strength of these components at various stages of their manufacture and assembly.

Make test cylinders in accordance with IM 315, cured in the same manner as the structural components to ensure adequate compressive strength has been achieved in accordance with the plan requirements for the following conditions:

1. Prior to form release and/or moving the components to storage.

2. Prior to placing a component into position in the structure and/or stressing of longitudinal post-tensioning tendons.

No direct payment will be made for the concrete testing. All costs for such testing will be included in the bid items Precast Post-Tensioned Slab Panels.

D. Age at Erection: Unless otherwise approved by the Engineer, precast components must be at least 14 calendar days old prior to incorporating into the structure.

TOLERANCES

A. General: In addition to Article 2407.12 of the Standard Specifications, the following tolerances shall apply to the fabrication of precast components and shall prevail when in conflict with Article 2407.12.

All Fabricated Slab Panels:

Flat Surface (deviation from a plane at any location, including sweep)

±1/8 inch per ten foot not to exceed a total of 1/4 inch

B. Corrections: Control dimensions from panel to panel and compensate for any deviations within a single panel or series of panels so that the overall dimensions of the completed structure meet the dimensions and overall erection tolerances shown on the plans and allowed by this special provision.

C. Repairs: Repair minor breakage, spalling, or honeycomb not over 1 inch deep by a method approved by the Engineer. Major breakage, spalling, or honeycomb in excess of 1 inch deep is subject to the Engineer's structural review. If found to be satisfactory, repair these areas using a method approved by the Engineer.

PRECAST SLAB PANEL HANDLING, STORAGE AND SHIPMENT

Handle slab panels with care to prevent damage. Handle slab panels using only the devices shown on the shop drawings for this purpose. Store all precast slab panels level in the flat position. Firmly support all precast slab panels for storage and shipment as per approved shop drawings. Do not stack slab panels one upon another unless approved by the Engineer.

Prior to shipment, the Engineer will review each segment for compliance. Thoroughly clean the faces of all joints of laitance, bond breaking compound and any other foreign material by light sand blasting prior to shipment.

Fully secure the slab panels against shifting during transport. Provide a storage area of suitable stability for the slab panels to prevent differential settlement of the slab panel supports during the entire period of storage.

The cost of this work will be included in the pay item for Precast Post-tensioned Slab Panels.

METHOD OF MEASUREMENT

Precast post-tensioned slab panels will be measured by the each.

BASIS OF PAYMENT

Payment for precast post-tensioned slab panels will be at the Contract unit price for "Precast Post-tensioned Slab Panels" per each.

Such prices and payments will be full compensation for manufacture, storage, transport, assembly and erection of the precast slab panels complete and in place, including successful placement, stressing and grouting of all post-tensioned bars in a particular slab panel and filling all concrete blockouts (shear pockets and haunches) and similar miscellaneous details. These prices and payments will also include material testing, special erection equipment, post-tensioning, tools, labor and incidental items necessary for completing the work in accordance with the plans, specifications and approved shop drawings.

No additional payment will be made for extra concrete necessitated by approved modifications to the panels or structure needed to accommodate the Contractor’s construction methods.

No additional payment will be made for extra reinforcement necessitated by approved modifications to the panels or structure for the purposes of the Contractor’s construction methods.

No additional payment will be made for extra post-tensioning necessitated by approved modifications to the panels or structure for the purposes of the Contractor’s construction methods

SECTION 2 - HIGH PERFORMANCE CONCRETE FOR PRECAST POST-TENSIONED SLAB PANELS

DESCRIPTION

This work shall be done according to Section 2407 of the Standard Specifications and as modified in this special provision.

This work shall consist of providing high performance concrete for precast post-tensioned slab panels. High performance concrete consists of producing a concrete mix with low permeability and high strength.

MATERIALS

Coarse aggregate shall be crushed limestone meeting Class 3 durability or better.

Trial Batch Concrete: The Contractor may submit up to two trial batches of concrete per project at no cost. The Contractor will be charged $500 for each additional trial batch submittal or resubmittal. The District Materials Engineer may waive trial batch testing for a mix, provided the mix was previously tested and resulted in satisfactory mix properties. Adjustments to a previously approved mix, not requiring a new trial batch, will be at the discretion of the District Materials Engineer. The trial batch concrete shall be of a size typically used in day-to-day operations and shall be made at least 60 calendar days prior to placement.

The trial batch concrete shall be representative of the production concrete.

The District Materials Engineer shall be notified at least 7 calendar days prior to batching. The Engineer will cast all samples from the trial batch concrete.

Trial batch concrete shall be tested for permeability by the Engineer. Two permeability samples shall be cast in 4 inch by 8 inch plastic cylinder molds and capped. Within 7 calendar days of casting the samples shall be delivered to the Central Materials Testing Laboratory. The samples shall remain in their plastic molds with their lids until delivered. The samples shall be stripped of their molds and wet cured to an age of 7 calendar days in the moist room. After 7 calendar days, the samples shall be submerged in water heated to 100°F until an age of 28 calendar days or more. Two test specimens shall be obtained from each cylinder. Permeability shall be tested in accordance with AASHTO T 277 at 28 calendar days or more. A coulomb reading of 1500 or less, based on the average of four test results, shall be considered acceptable.

Trial batch materials, proportions, and test results shall be reported to the District Materials Engineer for approval.

BASIS OF PAYMENT

No separate payment will be made for the required use of High Performance Concrete.

The cost of designing, testing, and producing high performance concrete shall be incidental to the price bid for Precast Post-tensioned Slab Panels.

SECTION 3 - POST-TENSIONING GROUT

DESCRIPTION

Grouts shall be prepackaged in plastic lined or coated bags. Grout bags shall indicate 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 this Special Provision. 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. Materials with a total time from manufacture to usage in excess of six months shall be retested and recertified by the supplier before use or the material shall be removed and replaced.

PRODUCT APPROVAL

Post-tensioning grout components sources will need written approval for use and shall be materials which conform to this Special Provision and the requirements prescribed in Section 2407 of the Standard specifications, for the particular kind and type of material specified.

Manufacturers of post-tensioning grout seeking evaluation of their product shall submit an application in accordance with I.M. 409 and include certified test reports from an audited and independent Cement Concrete Research Laboratory (CCRL) which shows the material meets all the requirements specified herein. Compliance with the requirements stated in the Simulated Field High Temperature Fluidity Test And The Accelerated Corrosion Test Method(ACTM) may be by written manufacturers certification.

MIXING

The material shall be mixed in accordance with the manufacturer's recommendations.

GROUT PROPERTIES

A. Gas Generation: The grout shall not contain aluminum powder or components, which produce hydrogen gas, carbon dioxide or oxygen.

B. Laboratory Test: The grout shall meet or exceed the specified physical properties stated herein as determined by the following standard and modified ASTM test methods.

Property	Test Value	Test Method
Total Chloride Ions	Max. 0.08% by mass of cementitious material	ASTM C 1152
Fine Aggregate (if utilized)	Max Size **No. 50 Sieve (300 micron)	ASTM C 33
Volume Change @24 hours and 28 days.	0.0% to +0.3%	ASTM C 1090*
Expansion	**2.0% for up to 3 hours	ASTM C 940
Compressive Strength 28 day(Average of 3 cubes)	**8000 psi	ASTM C 942
Initial Set of Grout	Min. 3 hours Max 12 hours	ASTM C 953
Pumpability and Fluidity for Non-Thixotropic Grouts(Flow Cone Efflux Time)	Immediately after mixing: Min. 20 sec., Max. 30 sec. After letting stand for 30 min. and remixing for 30 sec.: Max. 30 sec.	ASTM C939

Pumpability and Fluidity for Thixotropic Grouts(Modified Flow Cone Efflux Time for 1 Liter Discharge**)	Immediately after mixing: Min. 9 sec., Max. 20 sec. After letting stand for 30 min. and remixing for 30 sec.: Max. 30 sec.	Modified ASTM C939**
Bleeding @ 3 Hours	Max 0.0 percent	ASTM C 940
Permeability @ 28 days	Max. 2500 coulombs At 30 V for 6 hours	ASTM C 1202

*Modify ASTM C1090 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 C939 flow cone test or the modified test described herein. Modify the ASTM C939 test by filling the cone to the top instead of to the standard level. The efflux time is the time to fill a one liter container placed directly under the flow cone.

SIMULATED FIELD HIGH TEMPERATURE FLUIDITY TEST

Perform a conditioned laboratory high temperature grout fluidity test as described below using production grouting equipment utilizing both mixing and storage tanks. For the test to be successful, the grout meeting the requirements of this special provisions, Grout Physical Properties, must have an efflux time of not greater than 30 seconds at the end of the one hour test period. Efflux time may be determined by either ASTM C939 or the modified ASTM C939 described herein.

A. Perform the test in a temperature conditioned laboratory. Condition the room, grout, water, duct, pump, mixer and all other equipment to be used to 90^{o} F temperature for a minimum of 12 hours prior to the test.

B. Use 150 feet of duct (tube) for the test. Use a duct with an inside diameter of 1" plus or minus ¼".

C. Mix the grout to the specified water content at and pump the grout through the duct until the grout discharges from the outlet end of the duct and is returned to the pump.

D. Start the one hour test period after the duct is completely filled with grout. Record the time to circulate the grout through the duct. Constantly pump and recirculate the grout into the commercial grout mixer storage tank.

E. Pump and recirculate the grout for a minimum of one hour.

F. At 10 minute intervals throughout the test period, record the pumping pressure at the inlet and test the grout and record the temperature, and fluidity at the discharge outlet.

ACCELERATED CORROSION TEST METHOD (ACTM)

Perform the ACTM as outlined in Appendix B of the "Specification for Grouting of Post-Tensioned Structures" published by the Post-tensioning Institute. Report the time to corrosion for both the grout being tested and the control sample using neat grout.

A grout that shows a longer average time to corrosion in the ACTM than the control sample is considered satisfactory.

BASIS OF PAYMENT

No separate payment will be made for furnishing and installing the post-tensioning grout.

The cost of this work will be included in the pay item for Precast Post-Tensioned Slab Panels.

SECTION 4 - POST-TENSIONING

DESCRIPTION

Furnish, install, stress and grout post-tensioned tendons, through ducts in the concrete, stress to a predetermined load and anchor directly against the hardened concrete, initially imparting stresses through end bearing. Then inject grout into the ducts to completely fill all remaining voids and to seal the permanently stressed high strength bars.

Furnish and install all hardware and any other appurtenant items necessary for the particular post-tensioning system used, including but not limited to ducts, anchorage assemblies, supplementary steel reinforcing bars and grout used for pressure grouting ducts and all associated operations.

Submit shop and working drawings in accordance with these Special Provisions.

TERMINOLOGY

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

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

C. Duct: Material forming a conduit to accommodate post tensioning tendon installation and provide an annular space for the grout which protects the prestressing steel.

D. Anchorage: An assembly of various hardware components which secures a high strength bar at its ends after it has been stressed and transfers a compressive force into the concrete.

E. Anchor Plate: That part of the anchorage that bears directly on the concrete and through which the post-tensioning force is transmitted.

F. Set (Also Anchor Set): Anchor Set is the total movement of a point on the strand just behind the anchor 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.

G. Anticipated Set: Anticipated set is that set which was assumed to occur in the design calculation of the post-tensioning forces at the time of load transfer.

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

I. 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, when injected into the duct to fill the space throughout the prestressing steel, anchorages and ducts.

J. Grout cap: A device that contains the grout and forms a protective cover sealing the post-tensioning steel at the anchorage.

K. Inlet: Tubing or duct used for injection of the grout into the duct.

L. Outlet: Tubing or duct to allow the escape of air, water, grout and bleed water from the duct.

M. Post-tensioning: A method of prestressing where tensioning of the tendons occurs after the concrete has reached a specified strength.

N. Prestressing steel: The steel element of a post-tensioning tendon, which is elongated and anchored to provide the necessary permanent prestressing force.

O. Pressure Rating: The estimated maximum pressure that water in a duct or in a duct component can exert continuously with a high degree of certainty that failure of the duct or duct component will not occur (commonly referred to as working pressure).

P. 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 a similar diameter.

Q. Tendon: A single or group of prestressing steel elements and their anchorage assemblies imparting prestress forces to a structural member or the ground. Also, included are ducts, grouting attachments, grout and corrosion protection filler materials or coatings.

R. Tendon Type: The relative location of the tendon to the concrete shape, internal or external.

S. 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. Grouts having Thixotropic properties can be highly resistant to bleed. Admixtures that may produce Thixotropic properties include anti-bled admixtures and silica fume.

T. Wedge Plate: The hardware that holds the wedges of a multi-strand tendon and transfers the tendon force to the anchorage assembly. (Commonly referred to as anchor head.)

U. Wedge: A conically shaped device that anchors the strand in the wedge plate.

MATERIALS.

A. Post-tensioning Steel:

1. Strands: Unless otherwise noted on the plans, use uncoated low relaxation 7-wire strand meeting the requirements of ASTM A 416, grade 270. .

B. Ducts:

1. General: Unless specifically noted on the Plans or otherwise approved by the Engineer, use ducts for post-tensioning meeting the requirements of this Specification.

2. Size of Ducts: Ducts as specified on the Contract Plans.

3. Polyethylene (P.E.) Ducts and Pipes: Ducts and pipes shall be sufficiently rigid to withstand concrete placement, grouting and construction loads without damage or excessive deformation, while remaining watertight.

Plastic material used shall not react with concrete or enhance corrosion of the high strength bars and shall be free of water soluble chloride.

Smooth pipes shall not be used in locations embedded in the concrete.

Ducts, pipes and all connections shall be capable of withstanding the pressure required for flushing the ducts in the event of an aborted grouting operation.

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.

Duct system, including duct coupling at transverse 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.

Furnish duct with end caps to seal the duct interior from contamination. Ship in bundles which are capped and covered during shipping and storage. Protect ducts against ultraviolet degradation, crushing, excessive bending, dirt contamination and corrosive elements during transportation, storage, and handling. Do not remove end caps supplied with the duct until the duct is incorporated into the bridge component. Store duct in a location that is dry and protected from the sun. Storage must be on a raised platform and completely covered to prevent contamination. If necessary, wash duct before use to remove any contamination.

Coupling of ducts between transverse joint shall use shrink sleeves having uni-directional circumferential recovery manufactured specifically for the size of the duct being coupled consisting of an irradiated and cross linked high density polyethylene backing for external applications and linear density polyethylene for internal applications. Furnish adhesive having the same bond value to steel and polyolefin plastic materials. Ensure the heat shrink sleeves have an adhesive layer that will withstand 150 degrees F operating temperature and meet the requirements of the table below:

Property	Test Method	Minimum Requirements	
		Internal Application	External Application
Minimum Fully Recovered Thickness		92 mils	111 mils
Peel Strength	ASTM D 1000	29 pli	46 pli
Softening Point	ASTM E 28	162º F	216º F
Lap Shear	DIN 30 672M	87 psi	58 psi
Tensile Strength	ASTM D 638	2,900 psi	3,480 psi
Hardness	ASTM D 2240	46 Shore D	52 Shore D
Water Absorption	ASTM D 570	Less than 0.05%	Less than 0.05%
Color		Yellow	Black
Minimum Recovery	Heat Recovery Test	33%	23%

Install heat shrink sleeves using procedures and methods in accordance with manufacturer’s recommendations.

C. Grout Vents, Injection and Ejection Pipes: Provide vents made of standard pipe or suitable plastic pipe with a minimum diameter of 1/2 inch. Neither metallic nor plastic components, if selected and approved, shall react with the concrete or enhance corrosion of the post-tensioning steel. Use plastic components free of water soluble chlorides.

Provide grout injection pipes fitted with positive mechanical shut-off valves.

Provide vents and ejection pipes fitted with valves or other devices capable of withstanding the grout pumping pressures.

D. Grout: Use grouts meeting the requirements of Section 3, Post-Tensioning Grout, to grout all post-tensioning systems.

E. Anchorage Assemblies:

All prestressing steel shall be secured at the ends by means of permanent type anchoring devices. Dead end anchorages shall not be used. Two-part wedges will not be approved for anchoring prestressing strands.

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

Cast anchorages with grout outlets suitable for inspection from either the top of front of the anchorage. The grout outlet will serve a dual function of grout outlet and post-grouting inspection access. The geometry of the grout outlets must facilitate being drilled using a 3/8” diameter straight bit to facilitate endoscope inspection directly behind the anchor plate. Anchorages may be fabricated to facilitate both inspection locations or may be two separate anchorages of the same type each providing singular inspection entry locations.

Trumpet materials shall be a polyethylene or polyolefin containing antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D 3895 of not less than 20 minutes. 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. The thickness of the trumpet at the transition location (choke point) will not be less than the thickness of the duct

Use permanent grout caps made from fiber reinforced polymer or ASTM A 240 Type 316L stainless steel. The resins used in the fiber reinforced polymer shall be either nylon, Acrylonitrite Butadiene Styrene (ABS) or polyester. For products made from nylon, the cell class of the nylon according to ASTM D5989 shall be S-PA0141 (weather resistant), S-PA0231 or S-PA0401 (ultimate strength not less than 10,000 psi with UV stabilizer added). Seal the cap with “O” ring seals or precision fitted flat gaskets placed against the bearing plate. Place a grout vent on the top of the cap. Grout caps must be rated for a minimum pressure rating of 150 psi. Use ASTM A 240 Type 316L stainless steel bolts to attaché the cap to the anchorage. When stainless steel grout caps are supplied, provide certified test reports documenting the chemical analysis of the steel.

F. Samples for Testing:

1. General: Testing shall conform to the applicable ASTM Specifications for the post-tensioning material used.

Furnish all material samples for testing at no cost to the Department.

Consider the job site or site referred to herein as the location where the post-tensioning steel is to be installed, whether at the bridge site or a removed casting yard.

2. Pre-Stressing Steel: Furnish samples for testing as described below for each manufacturer of prestressing steel to be used on the project.

With each sample of prestressing strand furnished for testing submit a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

Allow the Engineer to sample the following materials, selected by the Engineer at the plant or jobsite, from the steel used for post-tensioning operations well in advance of anticipated use:

a. For strand: Three randomly selected samples, 5 feet long, per manufacturer, per size of strand, per shipment, with a minimum of one sample of every ten reels delivered.

b. For anchorage assemblies: Two samples of each size, per manufacturer, per heat of steel.

One of each of the samples furnished to represent a lot will be tested. The remaining sample(s), properly identified and tagged, will be stored by the Engineer for future testing in the event of loss or failure of the component represented to meet minimum strength requirements. For acceptance of the lot represented, test results must show that 100% of the guaranteed ultimate tensile strength has been met.

3. Lots and Identification: A lot is that parcel of components as described herein. All strands from each manufacturer 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. Submit records to the Engineer identifying assigned lot numbers with the heat, coil or reel of material represented. All unidentified pre-stressing steel, anchorage assemblies or bar couplers received at the site will be rejected. Also, loss of positive identification of these items at any time will be cause for rejection.

4. Release of Materials: 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.

PROTECTION OF PRESTRESSING STEEL AND HARDWARE

All prestressing steel shall be protected against physical damage or rust at all times (from time of manufacturer to grouting or encasing in concrete). Prestressing steel that has sustained physical damage at any time shall be rejected. Prestressing hardware shall be protected from rust and corrosion at all times (from time of manufacturer until completion of the project).

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. A corrosion inhibitor shall not be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of Federal Specification MIL-P-3420. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

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.

Prestressing steel shall be stored and handled in a manner which will protect it from physical damage or contamination at all times from manufacture until grouted in place. Prestressing steel shall not be dragged on abrasive surfaces during fabrication and installation. Damaged, abraded, or contaminated prestressing steel shall be rejected.

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

At the time the prestressing steel is installed in the work, it shall be free from rust, loose mill scale, dirt, paint, oil, grease or other deleterious material. Removal of tightly adhering mill scale will not be required. Prestressing steel which has experienced rusting to the extent that all evidence of it cannot be removed by wiping with a clean rag shall be subject to rejection.

The Contractor shall install, stress, and grout the tendons in less than a seven consecutive calendar day time period. If the period time between installation and stressing of the prestressing steel and grouting of the tendon will exceed seven consecutive calendar days, the prestressing steel shall be completely removed from the duct and inspected for corrosion by the Engineer. If corrosion other than light surface rust (which can be completely removed by rubbing) is found, the existing pulled strand will be replaced with new strand.

Projecting ends of prestressing steel shall be wrapped continuously in plastic sheeting and sealed using waterproof tape. The plastic sheeting shall extend to the anchorage opening. The anchor shall be sealed with plastic sheeting and waterproof tape sufficient to prevent water intrusion. All grout ports and vents shall be closed or temporarily plugged. All duct connections shall be sealed. The tendons are not to be installed in the ducts prior to or during placement of the deck panels or the grouting of the shear keys.

PLACING CONCRETE

Precautions: Exercise great care when placing and consolidating concrete so as not to displace or damage any of the post-tensioning ducts, anchorage assemblies, splices and connections, reinforcement or other embedment. Reference Section 1, Precast Post-Tensioned Slab Panel Construction, for additional information.

POST-TENSIONING OPERATIONS

A. **General:** Do not apply post-tensioning forces until the concrete has attained the specified compressive strength as determined by cylinder tests.

B. Installing Tendons:

Push or pull post-tensioning strands through the ducts to make up a tendon using methods which will not snag on any lips or joints in the ducts. Strands which are pushed should be rounded off at the end of the strand or fitted with a smooth protective cap. During the installation of the post-tensioning strand into the duct, the strand shall not be intentionally rotated by any mechanical device.

Alternatively, strands may be assembled to form the tendon and pulled through the duct using a special steel wire sock (“Chinese finger”) or other device attached to the end. The ends of the strands may not be welded together for this purpose. Round the end of the preassembled tendon for smooth passage through the duct. Cut strands using an abrasive saw or equal. Flame cutting is not allowed.

C. **Stressing Strands:** Tension all strands with hydraulic jacks so that the post-tensioning force is not less than that required by the contract documents, and on the approved shop drawings.

1) **Maximum Stress at Jacking:** The maximum temporary stress (jacking stress) in the post-tensioning strands shall not exceed 80% of its specified minimum ultimate tensile strength.

2) Do not overstress tendons to achieve the expected elongation.

3) **Initial and Permanent Stresses:** The post-tensioning strands shall be anchored at initial stresses that will result in the long term retention of permanent stresses or forces of no less than those shown on the contract documents, and on the approved shop drawings. The initial stress at the anchorages after anchor set shall not exceed 70% of the specified ultimate tensile strength of the post-tensioning strands.

4) Permanent stress and permanent force are the stress and force remaining in the post-tensioning strands after all losses, including long term creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, losses in the post-tensioning strands from the sequence of stressing, friction and unintentional wobble of the strands, anchor set, friction in the anchorages and all other losses peculiar to the post-tensioning system.

D. **Stressing Equipment:** Only use equipment furnished by the manufacturer of the post-tensioning system (strands, hardware, anchorages, etc.).

1) Stressing Jacks and Gauges: Each jack shall be equipped with a pressure gauge for determining the jacking pressure. The pressure gauge shall have an accurately reading dial at least 6 inch in diameter.

2) Calibration of Jacks and Gauges: Within 30 days of use, each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position it will be in at the final jacking force. Calibration shall be done when the jack is connected to the equipment (pumps and gauges) in the identical configuration as will be used on the job site, e.g. with the same length hydraulic lines. Initial calibration of the jacks and gauges shall be performed by an independent laboratory using a proven load cell. For each jack and gauge unit used on the project, furnish certified calibration charts from the independent laboratory prior to stressing the first tendon. The jack and its gauge shall be used together in the field.

Certified calibration shall be made at the start of the work, or as requested by the Engineer. Calibrations subsequent to the initial calibration with a load cell may be accomplished by the use of a master gauge. Supply the master gauge to the Engineer in a protective waterproof container capable of protecting the calibration of the master gauge during shipment to a laboratory. Provide a quick-attach coupler next to the permanent gauge in the hydraulic lines to enable quick and easy installation of the master gauge to verify the permanent gauge readings. The master gauge will be calibrated by and remain in the possession of the Engineer for the duration of the project.

Any jack repair, such as replacing seals or changing the length of the hydraulic lines, is cause for recalibration using a load cell.

No extra compensation will be allowed for the initial or subsequent calibrations or for the use and required calibrations of the master gauge.

E. **Stressing of Tendons:** After the concrete panel are of the age and strength as specified on the plans, ensure that the forces being applied to the tendon and the elongation of the post-tensioning tendon can be measured at all times. A permanent record shall be kept of guage pressure and elongations at all times and shall be submitted to the Engineer.

All tendons shall be tensioned to a preliminary force as necessary to eliminate any take-up in the tensioning system before elongation readings are started. This preliminary force shall be between 5 and 25 percent of the final jacking force. The initial force shall be measured by a dynamometer or by other approved method, so that its amount can be used as a check against elongation as computed and as measured. Each strand shall be marked prior to final stressing to permit measurement of elongation and to ensure that all anchor wedges set properly.

Elongations shall be measured to the nearest 1/16 inch.

Dead end elongations shall be checked against the values as shown on the approved shop drawings.

Tendons shall be tensioned by jacking at each end of the tendon. Tendons shall not be pulled simultaneously by jacks at each end.

For the required strand force, the observed elongation shall agree within 5% of the theoretical elongation or the entire operation shall be checked and the source of error determined and remedied to the satisfaction of the Engineer before proceeding further. Do not overstress the tendon to achieve the theoretical elongation.

Friction: The plans were prepared based on assumed friction coefficient, wooble and anchor set as shown on the plans. The post-tensioning forces shown are for jacking forces. Submit calculations and show a typical strand force diagram, after friction and anchor set losses, on the shop drawings based upon the expected actual coefficients and values for the post-tensioning system to be used. Show these coefficients and values on the shop drawings.

If, in the opinion of the Engineer, the actual friction significantly varies from the expected friction, revise post-tensioning operations so the final tendon force is in agreement with the plans.

F. **Cutting of Post-Tensioning Strands:** Cut post-tensioning strands by an abrasive saw within 3/4inch to 1 1/2 inch away from the plan location. Flame cutting of post-tensioning strands shall not be used.

GROUTING OPERATIONS

A. General: All grouting operations shall be carried out by workers that have received instructional training and under the direct supervision during grouting operations of personnel that must be ASBI certified grout technician and have at least three years of experience on previous projects involving grouting of similar type and magnitude. Grouting shall be performed under the immediate control of a grouting supervisor skilled in the various aspects of grouting. The grouting supervisor must be ASBI certified grout technician and have experience at least four previous and satisfactorily completed projects. This person shall be named and shall furnish proof of experience as requested by the engineer.

Submit a grouting operation plan for approval at least 45 days in advance of any scheduled grouting operations. Written approval of the grouting operation plan by the Engineer is required before any grouting of the permanent structure takes place.

At a minimum, provide the following items in the grouting operation plan:

1. Provide names, training and experience records for the grouting crew and the Supervisor in conformance with this Specification.
2. Type, quantity, and brand of materials used in grouting including all certifications required.

3. type of equipment furnished, including capacity in relation to demand and working condition, as well as back-up equipment and spare parts;
4. general grouting procedure;
5. Control of grout fluidity on site flow testing and adjustments.
6. duct repair procedures;
7. method(s) for sealing ducts at all connections, vents, splices, etc.;
8. method to be used to control the rate of flow within ducts;
9. theoretical grout volume calculations per tendon;
10. types and locations of inlet and outlet pipes;
11. means of sealing and protecting ducts and tendons prior to grouting;
12. duct cleaning methods prior to grouting;
13. mixing and pumping procedures;
14. direction of grouting;
15. sequence of use of the inlets and outlet pipes;
16. procedures for handling blockages, including flushing of ducts;
17. method(s) to inspect behind anchorages;
18. procedures for post grouting repair of any grout voids detected in the post-tensioning System.
19. Samples of Contractor QC forms that are to be signed daily by the grouting Supervisor;

Before grouting operations begin, a joint meeting of the Contractor, grouting crew, grout manufacturer's field representative and the Engineer will be conducted to discuss the grouting operation plan, required testing, corrective procedures and any other issues requested by the Engineer.

The time between the first installation of the prestressing steel in the duct and the completion of the stressing and grouting operations will not exceed seven calendar days. Any light surface corrosion forming during this period of time will not be a cause for rejection of the prestressing steel.

When stressing has been completed and the stressed tendons have been accepted by the Engineer, grout the annular space between the bars and the duct.

B. Equipment: Use a colloidal grout mixer and pump capable of continuous mechanical mixing and producing a grout free of lumps and undispersed cement. Use equipment able to pump mixed grout in a manner complying with all the provisions specified herein. Provide accessory equipment that will provide for accurate solid and liquid measures necessary to batch all materials.

Use positive displacement type grout pumps able to produce an outlet pressure of at least 145 psi, with seals adequate to prevent oil, air or other foreign substances entering into the grout and to prevent loss of grout or water. Place a pressure gauge having a full scale reading of no more than 300 psi at some point in the grout line between the pumping outlet and the duct inlet.

The grouting equipment must contain a screen having clear openings of 0.125 inch [3.35 mm] maximum size to screen the grout prior to its introduction into the grout pump. If using grout with an thixotropic admixture, a screen opening of 0.1875 inch (4.75 mm) is satisfactory. Ensure that this screen is easily accessible for inspection and cleaning. Utilize a gravity feed to the pump inlet from a the mixer and/or a hopper attached to and directly over it. If utilized, keep the hopper at least partially full at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct. It shall be fitted with an agitator to keep the grout moving continuously before it is pumped into the duct. Under normal conditions, the grout equipment must be capable of continuously grouting the longest tendon on the project in not more than 20 minutes.

C. Mixing: Mix the grout in accordance with the manufacturer's instructions and the approved grouting plan using a colloidal mixer to obtain a homogeneous mixture. Perform a fluidity test on the mixed grout, in accordance with Section 3, Post-Tensioning Grout prior to beginning the injection process. Do not begin the grouting process until the proper grout properties have been obtained.

Meet the specified target flow rates. No water shall be added to the grout to modify its consoistency after the initial mixing operation is complete

D. Grout Injection: Open all grout vents and high point vent openings before grouting starts. Provide injection and ejection vents with positive shut-offs. Allow grout to flow from the first vent after the injection vent until any residual flushing water, if allowed, or entrapped air has been removed, then closes that vent. Close remaining vents in sequence in the same manner. Maintain a continuous flow of grout at a rate not to exceed 30 feet of duct per minute.

Do not allow the pumping pressure at the injection vent to exceed 145 psi for oval ducts nor 250 psi for circular ducts, however; normal operations shall be performed at approximately 75 psi. If the actual grouting pressure exceeds the maximum allowed, close the injection vent and inject the grout at the next vent which has been, or is ready to be, closed as long as a one way flow is maintained. Do not inject grout into a succeeding vent from which grout has not yet flowed.

Pump grout through the duct and continuously waste at the ejection vent until no visible slugs of water or air are ejected. Perform a fluidity test, in accordance with Section 3, Post-Tensioning Grout, 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 Section 3, Post-Tensioning Grout. If the grout efflux time is not acceptable, discharge additional grout from the discharge outlet. Test grout efflux time. Continue this cycle until an acceptable grout fluidity is achieved. Ensure that the tendon duct 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.

E. Temperature Restrictions: The temperature of the concrete shall be 40º F or higher from the time of grouting until job cured 2 inch cubes of grout reach a minimum compressive strength of 800 psi. Grout shall not be above 90ºF during mixing or pumping. If necessary, cool the mixing water.

F. Finishing: Do not remove or open valves, caps and vent pipes until the grout has set. Remove the ends of steel vents at least flush with the concrete surface to receive a topping after the grout has set. Remove ends of plastic vents to the surface of the concrete 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 concrete anchorage blockouts and the like. Miscellaneous materials include paper, tie wire, duct tape, etc.

PROTECTION OF END ANCHORAGES

After grouting has been completed for a minimum of 72 hours, remove the permanent non-metallic grout cap covering the wedge plate to check for voids and probe, through vents or other devices, behind anchorages and grouted pockets for the presence of voids in the presence of the Engineer. Do not fill any voids or begin activities to protect the end anchorage prior to inspection by the Engineer. Upon inspection by the Engineer, fill any voids detected using methods approved by the Engineer. Within 54 hours after grout cap inspection, clean exposed areas of end anchorages and other metal accessories of rust, misplaced mortar, grout and other such materials. Immediately following the cleaning operation, install tight fitting forms and hold in place securely against the previously placed concrete. Fill the void between the form and the anchorage with an epoxy grout meeting the requirements of API (American Petroleum Institute) Specification 610-Appendix L, 1995 to protect the anchorage. .

BASIS OF PAYMENT

No separate measurement and payment will be made for furnishing, installing and post-tensioning of the strands, ducts and anchorage hardware.

The cost of this work will be included in the pay item for Precast Post-Tensioned Slab Panels.