

## SPECIFICATION SECTION 07400 – PRESTRESSED CONCRETE

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## **SPECIFICATION SECTION 07400 - PRESTRESSED CONCRETE AND PRESTRESSING**

### **1. DESCRIPTION**

- a) This Specification Section prescribes the construction of Prestressed Concrete structures and Prestressed Concrete portions of composite structures in conformity with the design, lines, grades, and dimensions shown on the Drawings or as may be established by the Engineer in accordance with this and other relevant Specification Sections.
- b) The work shall include the supply and installation of any items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.
- c) The work includes the manufacture, transportation and storage of beams and structural members of precast concrete prestressed by either pretensioning or post tensioning methods. It shall also include the installation of all precast prestressed members.

### **2. MATERIAL REQUIREMENTS**

#### **2.1 Reference Standards**

The most recent edition of the following Standards shall be applied to the Works covered by this Specification Section.

Vietnamese Standard:

22TCN 272-05	Specification Standard for Bridge Design
22TCN 247-98	Specification for Construction and Acceptance of Prestressed Girder
TCVN 9114:2012	Precast Prestressed Concrete Products - Technical Requirements and Acceptance
22TCN 267-2000	Anchor for Prestressed Concrete T13; T15 & D13; D15

International Standard:

ASTMA416M	Steel Strand, Un-coated Seven Wire Stress Relieved
Grade270	Strand for Pre-stressed Concrete.
AASHTO M235	Epoxy Resin Adhesives

#### **2.2 Material for Prestressed Concrete**

##### **2.2.1 General Requirement**

All materials to be furnished and used but not covered in this Specification Section shall conform to the requirements stipulated in other applicable Specification Sections.

### 2.2.2 Prestressing Steel

- a) High tensile steel strand with low relaxation shall be weld free and stress relieved after stranding and shall conform to the requirements of ASTM A416M-Grade 270 or equivalent steel strand, uncoated seven wire stress relieved strand for Prestressed Concrete
- b) Testing of prestressing reinforcement shall be in accordance with the requirements of the ASTM Specifications for the type of system intended to be used or subject to approval by the Engineer.

Table 1 – Stress Limits for Prestressing Tendons

Condition	Tendon Type		
	Stress Relieved Strand and Plain High Strength Bars	Low Relaxation Strand	Deformed High Strength Bars
Pre tensioning			
Immediately prior to transfer ( $f_{pt} + \Delta f_{pES}$ )	$0.7 f_{pu}$	$0.75 f_{pu}$	-
At service limit state after all losses ( $f_{pe}$ )	$0.80 f_{py}$	$0.80 f_{py}$	$0.80 f_{py}$
Post tensioning			
Prior to seating-short-term $f_s$ may be allowed	$0.90 f_{py}$	$0.90 f_{py}$	$0.90 f_{py}$
At anchorages and couplers immediately after anchor set ( $f_{pt} + \Delta f_{pES} + \Delta f_{pA}$ )	$0.70 f_{pu}$	$0.70 f_{pu}$	$0.70 f_{pu}$
At end of the seating loss zone immediately after anchor set ( $f_{pt} + \Delta f_{pES} + \Delta f_{pA}$ )	$0.70 f_{pu}$	$0.74 f_{pu}$	$0.70 f_{pu}$
At serviceability limit state after losses ( $f_{pe}$ )	$0.80 f_{py}$	$0.8 f_{py}$	$0.80 f_{py}$

Source: 22 TCN 272-05

$f_{pu}$  – Specified tensile strength of prestressing steel (Mpa)

$f_{py}$  – Yield strength of prestressing steel (Mpa)

### 2.2.3 Anchorages for Post Tensioning

- a) All anchorage assemblies shall be subject to the approval of the Engineer in according with Vietnamese Standard 22TCN267-2000.
- b) All post tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices. The Contractor shall submit information and details, including test certifications for by the Engineer.
- c) End anchorage devices (stress and dead anchors) shall be designed and manufactured for the types of tendons to be used. They shall have a previous service record of performance and durability when used on

similar type work.

- d) All anchorage devices for post tensioning shall be capable of holding the prestressing steel at a load of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.
- e) It is the responsibility of the Contractor to design reinforcement, which takes cognisance of the bursting force produced by the particular shape and design of the anchorages.
- f) All exposed steel parts shall be protected from corrosion. All threaded parts and fittings shall be protected by greased wrappings or plugs until used. Anchorages shall be kept free from dirt, mortar, loose rust or other deleterious materials. Damaged anchorage parts shall not be used.

#### 2.2.4 Ducts (Sheath)

- a) Ducting for internal tendons shall be fully compatible with the proposed prestressing system. The ducts shall be fabricated from corrugated galvanized sheet steel or semi rigid conduit.
- b) Minimum duct thickness shall be as follows:
  - i) 0.45mm for duct diameter less than or equal to 67 mm
  - ii) 0.6mm for duct diameter greater than 67 mm
  - iii) 0.25mm for bar tendons
- c) Ducts shall have grouting connections at each end and shall have vent/drains at all intermediate high and low points, subject to the approval of the Engineer.

#### 2.2.5 Grout for Ducts

Unless otherwise specified in other prevailing Specification Sections or subject to approval by the Engineer as a result of grouting trials the grout shall:

- a) Consist only of ordinary Portland cement (PC40,PC50 with chloride and sulphate contents of less than 0.5%) water and expansive admixtures approved by the Engineer and used in accordance with the manufacturer's instructions,
- b) Have a water to cement ratio as low as possible consistent with the necessary workability, and under no circumstances shall the water/cement ratio 0.34 – 0.38 (without admixture  $\leq 0.4$ ; with admixture  $\leq 0.38$ )
- c) Contain no admixtures containing chlorides, nitrates or similar electrolytic conducting materials.

#### 2.2.6 Concrete

- a) Concrete shall be of the class indicated on the Drawings and shall conform with the requirements of Specification Section 07100 Concrete

and Concrete Structures and the requirements specified below unless otherwise stated on the Drawings or as may be required by the Engineer.

- b) The maximum size of aggregate for use in the manufacture of Prestressed Concrete shall be 25 millimeters.
- c) The main properties of concrete such as compressive strength at 28 days, Modulus of Elasticity (Young Modulus), and other properties that were used for the detailed design shall be confirmed by testing of samples of the approved mix design. The Contractor shall perform the tests in accordance with the appropriate standards, or as may be required by the Engineer.

#### 2.2.7 Submittals

Prior to the submission of shop and working drawings the Contractor shall prepare a schedule of the Works covered by this Specification Section for submission to the Engineer. Upon approval of the schedule by the Engineer, the Contractor shall prepare, check and submit detailed shop and working drawings together with the calculations, formwork, falsework etc to the Engineer for his review and approval for the items listed below or as directed by the Engineer well before superstructure construction is programmed to start. The shop and working drawings shall be checked by a qualified professional engineer who shall confirm the adequacy and safety of the proposed details by certifying and stamping the shop and working drawings. Concrete shall not be cast prior to the Engineer's approval on the Contractor's submittals. The Contractor shall provide, inter alia:

- a) Geometry Control Plan

Detailed procedures and methods for controlling the geometry at every stage of construction.

- b) Temporary Works

Temporary fixing/stabilizing method of the supports and closures during erection operations;

Travelling forms, suspended falsework or scaffolding, girder erection gantries;

Formwork and falsework;

Dimensions and complete descriptions of all devices, joints, bearings, and anchorages not specified or detailed in this Specification Section.

- c) Prestressing

Method and timing of the insertion of prestressing cables;

Post tensioning or pre tensioning hardware, jointing, jacking, grouting equipment, and men and materials of any kind;

Vertical alignment and deflection control measures with calculations of precamber by prestressing forces, loads, temperature range and effects of creep and shrinkage of concrete.

d) Grouting

Statement for grouting of ducts.

e) Casting and curing

Detailed casting manual describing all the activities in a step by step procedure;

Methods of controlling deflection to ensure the accuracy of alignment of the completed superstructure.

f) Anchorage Zone

Calculations and shop drawings for the reinforcing details.

g) Erection of members

Equipment for all machinery, devices, labor and material which are to be used for erection

Methods of tie down and closure of superstructures during erection.

h) Deck Slab

Fabrication and installation methods for concrete formwork;

Placing methods of cast insitu slab on the formwork.

### **3. CONSTRUCTION REQUIREMENTS**

#### **3.1 General**

- a) The Contractor shall assign an experienced technician, skilled in the operation of prestressing systems, who shall supervise the work being performed in compliance with this Specification Section and to the satisfaction of the Engineer.
- b) The Contractor shall provide all equipment necessary for construction and prestressing. The equipment shall be of a currently manufactured model, and shall be in good working condition. A prestressing system approved by the Engineer shall be used. If hydraulic jacks are used they shall be equipped with accurate pressure gauges. The operation of jacks and gauges shall be calibrated and a graph or table showing the calibration shall be provided to the Engineer. Should other types of jacks be used, calibrated proving rings or other devices shall be furnished so that the jacking forces may be accurately known.
- c) The requirements for concrete construction in Specification Section 07100 Concrete and Concrete Structures shall be complied with, except as

may be modified in this Specification Section. Prestressed Concrete members shall be stressed, placed and cured at shops, manufacturing plants and locations where the fabrication of such members can be properly inspected and controlled and approved by the Engineer.

- d) Vertical alignment and girder lengths shown on the Drawings represent dimensions at the time of final creep. Deflection criteria for girders shall be in accordance with Vietnamese Standard 22 TCN 272-05. Longitudinal deflections may be rectified by an appropriate approved method.
- e) The Contractor shall submit to the Engineer a method statement for Prestressed Concrete for approval

## **3.2 Sampling and Testing**

### **3.2.1 Grouting Trials**

- a) Where full scale trials are required they shall begin at least 21 days before the planned commencement of the fixing of ducts for prestressing in the Permanent Works unless otherwise specified in the Contract.
- b) The trials shall incorporate all relevant details of ducts, vents, duct supports, prestressing anchorages and couplers, prestressing strands and grout inlets and outlets. Tendons shall be sufficiently tensioned such that the strands within the duct take up a representative alignment. All systems, methods and materials shall be those proposed for the Permanent Works and shall have been submitted to the Engineer as part of the Contractor's detailed method statement.
- c) Grouting shall be carried out in accordance with the requirements of Clause 3.6.2 of this Specification Section, and the following information shall be recorded:
  - Fluidity of the grouting using a flow cone;
  - Results of bleeding tests;
  - Compressive strength of the grout;
  - Temperature of the grout at the point of injection;
  - Shade temperature;
  - Grouting pressure close to the point of injection;
  - Type of any admixture and results of control tests carried out by the manufacturer to demonstrate its properties including those at appropriate hydration temperatures; and
  - Results of a visual inspection for detection of leakage.
- d) The arrangement of ducting, end plates injection and outlet connections shown on the Drawings shall be rigidly supported and an actual or simulated bar tendon inserted but not stressed.

- e) After the grout strength has reached 17 Mpa, at least three samples, each one of 1 meter long, shall be cut from the grouted duct at the locations chosen by the Engineer. Each of the samples shall be sectioned longitudinally by cutting with a high speed abrasive cutting wheel, friction saw or similar. The sectioned samples shall be delivered to the Engineer, who will assess the acceptability of the grouting trials particularly in respect of the presence and location of any voids in the samples.
- f) If the presence and location of voids are deemed to be unacceptable, the Contractor shall amend the properties of the grout and/or grouting procedures and carry out further trials, until an acceptable result is obtained.
- g) Before commencing grouting trials the Contractor shall submit to the Engineer details of the proposed ducting, method of support and calculations substantiating that the ducting and any surrounding supporting material will withstand the grouting pressure used during the trials.

#### 3.2.2 Site Flow Tests

Fluidity of the grout shall be tested on Site at the time of mixing using the marsh cone test to ensure practicality of pumping and minimize the risk of blockage during grouting operation. A target flow time of 10-15 seconds shall be achieved.

#### 3.2.3 Testing of Precast Prestressed Members

Where required by the Engineer, one or more beams may be subjected to a loading test. The Contractor shall obtain the prior approval of the Engineer for the detailed arrangements for testing.

### 3.3 Placing Steel

All steel reinforcement shall be accurately placed in the position shown on the Drawings and rigidly held in place during placing and setting of the concrete. Distance from the forms shall be maintained by stays, formwork spacers, ties, hangers, or other approved support. Formwork spacers for holding units from contact with the forms shall be of approved material, shape and dimensions. Layers of reinforcement shall be separated by suitable wire spacers. Wooden blocks shall not be used.

### 3.4 Post Tensioning Method

- a) Post tensioning shall be carried out in accordance with an approved method and in the presence of the Engineer unless permission has been

obtained to the contrary.

- b) Immediately before tensioning the Contractor shall prove that all tendons are free to move in the ducts.
- c) Each anchorage device shall be set square to the line of action of the corresponding post tensioning tendon and shall be securely fixed in position and gradient to prevent movement during the placing and compaction of concrete.
- d) Except where dead end anchorages are cast in the concrete, tendons shall not be installed until just prior to stressing. Tendons shall be pulled or pushed through the duct in such a manner as to avoid damage to either the tendon or the duct.
- e) Unless approved otherwise concrete shall not be stressed until 2 test cylinders taken from it have attained a compressive strength of not less than 80% of the specified 28 day strength as shown by standard specimens cured in a similar fashion to the element unless specifically noted otherwise on the Drawings. The test cylinders shall be cured in conditions similar to the concrete to which they relate and in a manner approved by the Engineer.
- f) Where members consist of jointed elements the strength of transfer of the jointing material shall be at least equivalent to the specified strength of the members.
- g) The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Engineer. Allowance shall be made for the friction in the jack and anchorage for pull in of the tendon during anchorage.
- h) The tendons shall be stressed at a gradual and steady rate until the required extension and tendon load are reached or are approved by the Engineer. The sequence of stressing shall be as shown on the Drawings or directed by the Engineer.
- i) The force in the tendons shall be obtained from readings on a load cell or pressure gauge incorporated in the equipment and the extension of the tendons measured. The extension of the tendons under the approved total forces shall be within the limits given below of the agreed calculated extension.

Transverse Tendons for Segments:	±10% average for one tendon
	± 7% for average of one segment
Longitudinal Tendons for Segments	± 5%
All other Tendons	± 5%

- j) If the measured extensions are not within the specified tolerance then the Contractor shall submit to the Engineer his method of rectifying the discrepancy.
- k) When the prestressing force has been applied to the satisfaction of the Engineer the tendons shall be anchored. The force exerted by the tensioning apparatus shall then be decreased gradually and steadily so as to avoid shock to the tendon or anchorage.
- l) Full records shall be kept of all tensioning operations including measured extensions, pressure gauge or load cell readings and draw-in at anchorage. Copies of records shall be supplied to the Engineer within 24 hours of each tensioning operation.
- m) Unless otherwise agreed by the Engineer, tendons shall not be cut less than 2 days after stressing.

### **3.5 Grouting**

#### **3.6.1 Plant for Grouting**

- a) The grout mixer shall produce a grout of colloidal consistency. The grout injector shall be capable of continuous operation with a sensibly constant pressure up to 0.70 N/mm<sup>2</sup> and shall include a system of circulating or agitating the grout whilst actual grouting is not in progress. All baffles to the pump shall be fitted with 1.18 mm sieve strainers.
- b) The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a nozzle that can be locked off without loss of pressure in the duct.
- c) The pressure gauges shall be calibrated before they are first used in the Works, and thereafter as required by the Engineer. All equipment shall be thoroughly cleaned and washed with clean water at least once every 3 hours during the grouting operations and at the end of use for each day.
- d) During the grouting operation, the Contractor shall provide adequate flushing out plant to facilitate complete removal of the grout in the event of a breakdown of the grouting equipment or other disruption before the grouting operation has been completed.

#### **3.5.2 Grouting of Ducts and Sheathing**

- a) Grouting trials shall be undertaken when directed by the Engineer. Prior to using the grout in any trial or in the works the Contractor shall submit a detailed method statement for grouting procedures covering proposed materials, sheathing, anchorage and vent alignment equipment, and quality control to the Engineer for his approval.
- b) All ducts shall be thoroughly cleaned out by means of flushing with water

and/or water/compressed air.

- c) Grouting of ducts shall be carried out as soon as it is technically practicable but not more than 4 weeks after the tendons inside the ducts have been stressed and the Engineer's permission to commence grouting has been obtained. If due to the requirements of the stressing procedure, tendons cannot be grouted within 4 weeks the sheathing shall be sealed to protect the tendons from corrosion.
- d) Injection shall be continuous and slow enough to avoid producing segregation of the grout. The method of injecting grout shall ensure complete filling of the ducts and complete surrounding of the steel. Grout shall be allowed to flow from the free end of the duct until its consistency is equivalent to that of the grout injected. The opening shall then be firmly closed. Any air vents shall be closed in a similar manner one after the other in the direction of flow. The injection tubes shall then be sealed off under pressure until the grout has set.
- e) The filled ducts shall not be subjected to shock or vibration within 1 day of grouting. Not less than 2 days after grouting the level of grout in the injection and vent tubes shall be inspected and made good as necessary.
- f) The Contractor shall keep full records of grouting including the date when each duct was grouted, the proportion of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer within 3 days of completing grouting.

### **3.6 Protection of Prestressing Anchorages**

- a) As soon as possible after tensioning and grouting are completed, exposed end anchorages, strands and other metal accessories shall be cleaned of rust, misplaced mortar, grout and other such materials.
- b) Immediately following the cleaning operation the entire surface of the anchorage recess and all exposed metal shall be thoroughly dried and uniformly coated with an epoxy bonding agent conforming to AASHTO M235 Class III in accordance with the manufacturer's recommendations.
- c) The anchorage recess shall then be filled with an approved non shrinkage mortar. The mortar shall not contain aluminum powder, iron particles, chlorides, sulphates, fluorides or nitrates.
- d) Where the protection will form part of the exposed works the anchorage recess shall be filled with concrete of the same quality and color as that of the adjacent concrete and shall be applied and cured in accordance with this Specification Section or as may be required by the Engineer.
- e) Exposed surfaces of anchorages not in an anchorage recess shall be

coated for corrosion protection with a coal tar epoxy or equivalent as approved by the Engineer. Prior to coating all surfaces shall be wire brushed to remove all loose rust, mill scale or other deleterious substances and the surfaces cleaned with a suitable solvent to remove oil and grease.

### **3.7 Curing**

#### **3.7.1 General**

Except as specified herein or otherwise approved, wet (water) curing shall be provided in compliance with the requirements in Specification Section 07100 - Concrete and Concrete Structures. If the Contractor elects to cure by any other method the method and details shall be subject to the approval of the Engineer.

#### **3.7.2 Steam Curing**

A steam curing process complying with the following conditions may be used as an alternative of water curing, if proposed by the Contractor and subsequently approved by the Engineer.

- a) The casting bed for any unit cured with steam shall be completely enclosed to prevent steam from escaping and exclude the outside atmosphere.
- b) Two to four hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made. If retarding admixtures have been used, the duration before application of the steam shall be increased to four to six hours.
- c) Water curing methods shall be used from the time the concrete is placed until steam is first applied.
- d) The steam shall have a relative humidity of 100% to prevent loss of moisture and to provide moisture for proper hydration of the cement.
- e) Steam shall not be directly applied to the concrete. During the application of the steam, the ambient air temperature shall increase at a rate not exceeding 22°C per hour until the maximum temperature is reached and shall be held until the concrete has reached the desired strength.
- f) In discontinuing the steam application, the ambient air temperature shall not decrease at a rate exceeding 22°C per hour until the temperature has reached 10°C above the temperature of the air to which the concrete will be exposed.
- g) The maximum curing temperature shall be from 60°C to 67°C.

### **3.8 Handling, Transport and Storage**

- a) Precast Prestressed Concrete shall not be moved from the casting position

or transported until the concrete has attained a compressive strength of 90% of the specified 28 day strength.

- b) Extreme care shall be exercised in handling and moving concrete members.
- c) Precast girders and slabs shall be transported in an upright position, shock shall be avoided and the points of support and directions of the reactions with respect to the members shall be approximately the same during transport and storage as when the members is in its final position. If the Contractor deems it expedient to transport or store precast prestressed units in other positions than this, it shall be done at his own risk after notifying the Engineer of his intention to do so. Any unit considered by the Engineer to have become substandard shall be rejected.

### **3.9 Marking of Precast Members**

Each precast member shall be uniquely and permanently marked so as to show its type and date of casting.

### **3.10 Erection of Precast Girders**

- a) Confirmation of position.

Prior to the erection of the beams the Contractor shall survey the positions of the supporting columns and confirm with the Engineer on the positions, both horizontal and vertical, of the supports.

The Contractor shall, at his own expense, make all necessary adjustments to the bearing seating and beam length to ensure that completed decks are true to line and level.

Any proposed deviation of beam length from that given in the Drawings shall be agreed by the Engineer before the girder is cast.

- b) Erection

The Contractor shall submit a full method statement for his proposed methods for lifting and placing girders in their permanent position. The method statement shall be submitted to the Engineer for his approval within one month of the commencement date of the Works.

The method statement shall particularly include but not be limited to the use of lifting and transfer gantries supported on the new structure and particular locations such as the start of erection from the embankment. The method statement shall include full details of the equipment to be used to handle girders and to incorporate them into the structure. The method statement shall be accompanied by full structural calculations and appropriate Working Drawings for each stage of the procedure. The calculation shall be consistent with the trial construction and shall be considered for all the combinations of

loads arising during construction and actual conditions at the Site, particularly the wind load and the conditions of natural ground. The Contractor shall carry out all additional soils investigation necessary to confirm his assumptions concerning the nature of the existing ground. The calculations and drawings shall be certified and stamped by a qualified structural engineer experienced in the preparation of such details.

The details shall include consideration of the effect of each stage of the procedure on the completed Permanent Works on which the gantry is to be mounted and operated. The procedures for lifting and transferring the beams into position and the order of erection of the beams be appropriate for the eccentricity of loading on the completed permanent works (supporting piers and the foundations) is minimized.

When girders are being placed in position they shall be braced against overturning before being released by the crane or other lifting devices.

Girders shall be firmly secured from moving laterally during the placing of insitu concrete at a later stage.

The lifting and placing of girders will not be permitted to commence until such time as the Contractor's method statement, calculations and Shop and Working Drawings have been reviewed and approved by the Engineer.

### 3.11 Tolerances for Prestressed Concrete Structures

The tolerances listed in Table 2 are the allowable deviations for Prestressed Concrete structures. These tolerances will be included in assessments for the acceptance of work.

Table 2 Acceptable Tolerances of Prestressed Concrete Structures

Description	Tolerance (mm)
Length	$\pm 10$
Height	+15; 0
Width of girder flange	+20; -10
Width of girder web	$\pm 5$
Thickness of girder flange	+10; -5
Centroid of tendons	$\pm 5$
Compressive Strength	Refer to Section 07100
Curvature of the girder from the longitudinal center line (plan view)	$\leq 10$
Camber	$\pm 5$

Source: Vietnamese Standard 22TCN 247-98

### 3.12 Testing Frequencies

Testing frequencies shall be accordance with Vietnamese Standard: TCVN

9114:2012; 22TCN 247-98 or other international standard subject equivalence being demonstrated by the Contractor and the satisfaction of the Engineer of the Vietnamese standard shall apply:

1) Precast Prestressed Concrete Products

Item	Test Description	Reference Article	Remarks
a	Material testing & preparation work before construction: (for material & quarries approval)		
	+ Cement	Article 4.1.1	
	+ Quality of aggregate for concrete	Article 4.1.2	
	+ Water for concrete	Article 4.1.3	
	+ Others requirement index for concrete chloride ion, additive cement	Article 4.15 ; 4.2	
	+ Reinforcement for precast prestressed concrete		
B	During construction period:		
	Strength concrete requirement	Article 4.3	
	Precast concrete anchor	Article 4.5	
	Tensioning requirement	Article 4.6	
	Construction tolerance	Article 4.7; 4.8; 4.9	
C	After construction period: (For acceptance of construction works)	Article 5	

Source: Vietnamese Standard TCVN 9114:2012: Precast Prestressed Concrete Products – Technical Requirement and Acceptance

2) Prestressed Concrete Beam

Item	Test Description	Reference Article	Remark
A	Material testing & preparation work before construction: (for material & quarries approval)		
	+ Cement	Article 2.1	
	+ Sand	Article 2.2	
	+ Quality of aggregate for concrete	Article 2.3	
	+ Water for concrete	Article 2.4	
	+ Others requirement index for concrete : additive cement	Article 2.5	
	+ Reinforcement for precast prestressed concrete	Article 2.6; 2.7	
	+ Conduit	Article 2.8	
	+ Lubrication in conduit	Article 2.9	
	+ Tensioning	Article 2.10	
	+ Epoxy liquid	Article 2.11	
B	During construction period:		
	Construction for reinforcement & precast prestressed reinforcement	Chapter III	
	Tightening of steel wire ropes bed, formwork, falsework	Chapter IV	
	Tightening of steel wire ropes work	Chapter V (include pretensioning method &	

		post tensioning method)	
	Beam casting & finishing	Chapter VI	
C	After construction period: (For acceptance of construction works)	Chapter VII	

Source: Vietnamese Standard 22TCN 247-98: Standard for construction and Acceptance PC Beam.

#### 4. MEASUREMENT AND PAYMENT

##### 4.1 Method of Measurement

Prestressed Precast Members:

- a) The quantity of prestressed precast concrete “I” girders shall be measured for payment according to the number of precast Prestressed Concrete “I” girders of each length/type shown on the Drawings; fabricated, hauled, erected and installed in place and accepted by the Engineer.
- b) The Prestressed Concrete and Prestressing provisions, material requirements and construction requirements identified in this Specification Section shall be measured for payment in pay items 07400-01, 07400-02, 07400-03, 07400-04 and 07400-05.
- c) Any Prestressed Concrete and Prestressing Works not specifically identified in this Specification Section but which are necessary for the performance of the Works shall be deemed to be included in pay items 07400-01, 07400-02, 07400-03, 07400-04 and 07400-05.

Cast Insitu Post Tensioned Members:

- d) Cast insitu post tensioned concrete members shall be measured for payment according to (1) the number of cubic meters of concrete, (2) the weight of reinforcing steel and (3) the weight of tendons respectively in accordance with the Drawings and accepted by the Engineer.
- e) The tendons shall be measured for payment in metric tonnes according to the length of the tendon between the outside faces of the applicable concrete members.
- f) Measurement and payment for concrete and reinforcing steel in void slab beams is included in other Sections of this Specification.
- g) The Prestressed Concrete and Prestressing provisions, material requirements and construction requirements identified in this Specification Section pertaining to tendons shall be measured for payment in pay items 07400-09 and 07400-13.
- h) Any Prestressed Concrete and Prestressing Works not specifically identified in this Specification Section but which are necessary for the performance of the Works shall be deemed to be included in pay items 07400-09 and 07400-13.

## 4.2 Basis of Payment

- a) The work under this Specification Section shall be paid for in accordance with the applicable unit prices as indicated in the Bill of Quantities and given below. Payment shall constitute full compensation for performing the requirements of the Contract for the item of work as specified including furnishing all necessary labor, materials, tools, equipment, incidentals and tests.
- b) Payment for each prestressed precast member shall include, inter alia, the: concrete, reinforcement and prestressing steel, tendons, inserts, formwork, precast concrete planks, couplers, box outs, transport, lifting girders, launching girders and any other material or incidental work contained in or attached to the above members and shall include the work of tensioning, grouting, anchorages, ducts and all required testing. Payment will be made through pay items 07400-01, 07400-02, 07400-03, 07400-04 and 07400-05.
- c) Payment of tendons in post tensioned void slab beams is included in this Specification Section through pay items 07400-09 and 07400-13 and shall include the work of tensioning, grouting, anchorages, ducts and all required testing.
- d) Payment for the cast insitu post tensioned concrete void slab beams is included in the applicable pay items in Specification Section 07100 - Concrete and Concrete Structures for concrete and in Specification Section 07500 - Reinforcing Steel for reinforcement. Formwork, precast concrete planks, couplers, box outs, chairs, spacers, tying wire and any other materials or incidental work contained in or attached to the above members is deemed included in the aforementioned pay items.
- e) The Contractor shall be responsible for additional costs for the repairing/additional works.
- f) The provision of design and certifications shall be deemed to be included in the relevant Contract unit prices

Pay Item	Description	Unit
<b>07400</b>	<b>Prestressed Concrete</b>	
07400-01	Prestressed Concrete I Girder (L=21m)	no.
07400-02	Prestressed Concrete I Girder (L=24m)	no.
07400-03	Prestressed Concrete I Girder (L=27m)	no.
07400-04	Prestressed Concrete I Girder (L=30m)	no.
07400-05	Prestressed Concrete I Girder (L=33m)	no.
07400-09	Internal Prestressing Tendons - Type 3T15.2	ton
07400-13	Internal Prestressing Tendons - Type 12T15.2	ton