

SPECIFICATIONS FOR CAST-IN-PLACE
PRESTRESSED POST-TENSIONED CONCRETE

1044. 1. DESCRIPTION

The work will consist of placing reinforcing steel, mixing, placing and heating concrete and supplying movable deck hoarding in accordance with "Specifications for Reinforced Concrete", and "Specifications for Reinforced Concrete Deck Slabs, Rigid Frames, Approach Slabs, End Newel Posts, Curbs, Sidewalks and Medians", the installation of bearings, anchorages, ducts, void forms, high strength cables, post-tensioning of the cables, the grouting of the ducts, the supply of materials and the performance of all other incidental work as shown or described, or reasonably inferable from the plans and specifications.

1044. 3. SUPPLY OF MATERIALS

Material supply shall be as per Sections 3.1 and 3.2 of the "Specifications for Reinforced Concrete" and the following:

3.1 Material to be supplied by the Minister at the sources of supply specified in the Special Provisions:

- (i) Elastomeric bearings and their metal components
- (ii) High strength strand for cables.

3.2 Material to be supplied by the Contractor:

- (i) Anchorages
- (ii) High early strength cement and admixtures for grout
- (iii) Grout fittings
- (iv) Ducts, support accessories, couplers, air vents
- (v) Void Forms
- (vi) Other incidental materials as required by the plans or specifications.

1044. 7. CONSTRUCTION METHODS

7.1 Handling and Storage of Materials

7.1.1 Elastomeric Bearings

The elastomeric bearings and their metal components shall be stored clear of the ground in a storage shed until required for installation. Particular care shall be taken to prevent damage to the stainless steel surfaces of the bearings and the teflon coated bearing pads. The protective wrapping around the stainless steel surfaces and teflon coated bearing pads shall not be removed until immediately prior to the installation of the bearings or shall not be removed at all if so directed by the Engineer in the field.

7.1.2 Anchorages

The anchorages shall be stored clear of the ground in a storage shed until the anchorages or their components are required for installation. Care shall be taken to prevent damage to the high tensile steel anchorages and in particular the formation of nicks, bruises or other surface damage.

7.1.3 High Strength Strand

High strength strand shall be stored clear of the ground in a storage shed. The protective packing around the reeless packs shall not be removed until the strand is required for the fabrication of the cables. The high strength strand shall at all times be protected from corrosion and contamination by oil, dirt or other materials which may adversely affect the performance of the cables.

7.1.4 Ducts

Ducts, couplers and air vents shall be stored clear of the ground in a storage shed until required for installation. Care shall be taken to prevent damage to the ducts or their components, making sure that no change occurs in the cross-sectioned shape of the ducts and duct components.

7.1.5 Void Forms

Void forms shall be stored clear of the ground in a storage shed until the forms are required for installation. The void forms shall be handled with care in order to prevent weakening of the forms by physical damage.

7.1.6 Replacement of Damaged Materials

Material supplied by the Minister or the Contractor, which in the opinion of the Engineer has been damaged or otherwise rendered unusable by improper storage or handling by the Contractor, shall be replaced by the Contractor at the Contractor's expense.

7.2 Falsework

Notwithstanding the reference to the falsework having to be supported on piling as per Section 7.2 Falsework of the "Specifications for Reinforced Concrete", the use of steel scaffolding on mud sills will be permitted.

In the event that the Contractor elects to use steel scaffolding on mud sills, the Engineer will require that selected parts of the falsework be tested to the estimated dead load plus construction load in order to establish anticipated settlement. The Contractor shall provide the Engineer with all pertinent data required for the determination of the construction loads.

Unless there is a marked difference in the ground conditions under the structure, one test load will be required only for falsework supported on natural ground and one test load for falsework supported on fill.

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.2 Falsework (Cont'd)

The test loads shall not be carried out too far in advance of the concrete placing operations to preclude the possibility of a change in the state of the natural ground and fill from that at the time of the tests. In the event that a change in the state of the natural ground or fill does take place between the time of the test and concrete placing operations, the Engineer may require that the load test be repeated. The falsework shall be arranged to provide uniform bearing pressure from the mud sills to the supporting ground or fill to preclude the possibility of differential settlement of the falsework.

The field test loading of steel scaffolding on mud sills to establish anticipated settlement shall in no way relieve the Contractor of the requirement to have the falsework designed by a Registered Professional Engineer as called for in Section 7.2 Falsework of the "Specifications for Reinforced Concrete".

The cutting or stepping of the bridge slopes to facilitate the placing of mud sills shall be kept to a minimum, and the level surface required for placing the steel scaffolding shall be obtained by means of timber cribs. All cuts or steps in the slopes which may be permitted by the Engineer to facilitate the erection of falsework shall be backfilled to the original cross-section and compaction by the Contractor at his own expense after the removal of the falsework.

Where required by plans or Special Provisions, the Contractor shall provide openings in the falsework for highway or railway traffic to clearances as shown on the plans. The openings in the falsework shall be designed and constructed so that the falsework will be stable if subjected to impact by vehicles. No vehicles will be allowed through a falsework unless a properly designed and constructed opening is provided.

In addition to the requirements for falsework removal as stated in Sec. 7.2 of the "Specifications for Reinforced Concrete", the falsework shall not be removed until the Engineer is satisfied that the stressing operations have been satisfactorily carried out. All damage to the structure resulting from the removal of the falsework shall be repaired by the Contractor at his own expense to the satisfaction of the Engineer.

7.3 Forms

The forms for the bottom of the box girders or slabs shall be so constructed that 50 to 100 mm of the formwork around the bearings, deck drains, air vents, or similar projections below the bottom concrete surfaces, may be removed prior to the start of the stressing operations.

The inside forms for box girders shall be removed after concrete placing is complete except as follows. The Contractor will be allowed to leave in place the inside forms for the top slabs of box girders in those bays to which access is not possible after the casting of the top slabs. All other void forms may be left in place. The box girder top slab forms to be left in place shall be supported by means of adjustable hangers placed on or cast into the walls of the box girders.

7.4 Void Forms

New void forms shall be supplied by the Contractor and the use of weathered or partially decomposed forms will not be allowed. Unravalled ends of void forms shall be cut back to sound material.

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.4 Void Forms (Cont'd)

Void forms shall be accurately positioned and well secured within the forms for the post-tensioned slab. They shall be strong enough to withstand external pressures and uplift forces due to wet concrete without being distorted excessively and shall be held in place during the operations of placing and vibrating concrete so that their correct positions with respect to horizontal and vertical axes of the slab will be maintained.

All splices between void forms shall be steel banded on each side of the joint and well taped with waterproof tape.

Concrete shall be placed in a manner which will not displace the voids either longitudinally or laterally.

The void forms and retaining devices shall be tested to the satisfaction of the Engineer before being used in the construction. The test shall be carried out as often as necessary until the void forms, splices, end caps and anchors are found to perform properly. The test shall be made on two void forms, each form long enough to include one void splice if applicable and three void tie downs spaced at the same distances apart as the anchors to be used in the post-tensioned slab. One end of the void forms shall be encased and the other end open for visual inspection after the placing of concrete. The test section shall be fully representative of the proposed post-tensioned slab, with the void forms anchored and accurately positioned.

All retaining devices used to hold the void forms which may end up on the exposed concrete surfaces, shall be galvanized. The dimensional tolerances for the void forms shall be ± 3 mm and the tolerance for the position of the void forms in the post-tensioned slab shall be ± 3 mm transversely and 6 mm longitudinally.

The void forms shall be vented by means of 12 mm inside diameter plastic tubes located as shown on the plans or as directed by the Engineer. The joints between the void forms and the vents shall be taped well to prevent the entry of concrete into the voids and vents. The vents shall be cut off flush with the bottom surface of the slab after the forms have been removed.

7.5 Installation of Bearings

The bearings shall be placed in the positions indicated on the plans and the bearing components extending into the cast-in-place concrete shall be fixed securely to the forms to ensure that there is no displacement of the bearings or their components during the placing and vibrating of the concrete.

7.6 Experienced Personnel

The placing of voids, ducts, couplers and air vents, fabrication of cables, threading of cables, placing of anchorages, the stressing of cables and grouting of cables, shall be carried out under the continual supervision of experienced personnel. When required by the Engineer, the Contractor shall prove to the satisfaction of the Engineer that the supervisory personnel engaged for this work have adequate experience.

7.7 Placing of Ducts

The Contractor shall submit his proposed system for supporting the ducts to the Engineer for

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.7 Placing of Ducts (Cont'd)

The ducts shall be placed in the positions shown on the plans with a tolerance of 3 mm vertically and 6 mm horizontally.

The ducts shall be fixed securely in place and supported at a maximum spacing of 1.0 m to prevent horizontal or vertical displacements during the placing and vibrating of concrete. All duct couplers, air vents and duct connections to anchorages shall be taped well with waterproof tape to prevent the entry of concrete and moisture into the ducts. The ends of the ducts shall be plugged temporarily to prevent the entry of debris, or other material prior to the threading of cables. Vents shall be placed at all high points in the duct profile. Drainage outlets shall be placed at the low points whenever freezing temperatures are expected before the ducts are grouted, or when cold weather precautions are in effect. Vents and drainage outlets shall be 12 mm minimum inside diameter and their bottom ends are to terminate at recesses 25 mm deep by 50 mm square in the underside of the slab.

7.8 Placing of Anchorages

The anchorages shall be placed in the positions shown on the plans within a tolerance of 3 mm vertically and 6 mm horizontally, coaxial with the ducts. The anchorages shall be fastened securely to the forms to prevent horizontal or vertical displacement during the placing and vibrating of concrete. The joints between the forms and anchorages shall be taped to prevent leakage of concrete mortar.

7.9 Expansion Dams

A trial fitting of all expansion dams including anchor bolts will be required during placing of the reinforcing steel and ducts.

7.10 Placing and Vibrating of Concrete

The methods of placing and vibrating the concrete and in particular the height of concrete drop shall be such to ensure that the bearings, ducts, voids and anchorages are not damaged or disconnected.

7.11 Fabrication of Cables

The cables shall be fabricated either prior to or during the threading into the ducts. In the calculation of the quantities of the high strength strand supplied by the Minister, the following additional lengths were allowed for: 600 mm on each end for stressing plus 600 mm on one end for threading for a total of an additional 1800 mm per strand, or cable.

The cables fabricated prior to threading shall be fabricated in a shop equipped with a suitable floor which can be maintained free of oil, dirt or other materials which may adversely affect the performance of the cables. The fabricated cables shall be wound on reels of suitable diameter to prevent kinking and shall be stored off the ground in a storage shed until required for installation in the ducts. The coils containing the fabricated cables shall be wrapped with a layer of 100 um polyethylene or other protective materials.

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.11 Fabrication of Cables (Cont'd)

If the cables are fabricated on site during the threading, the space between the reeless packs and the ends of the ducts and the ground under the reeless packs shall be completely covered with a layer of 100 um polyethylene which shall be kept free at all times of oil, dirt or other materials which may adversely affect the performance of the cables. Whether the cables are fabricated prior to or during the threading, the reeless packs containing the high strength strand shall be positioned on proper stands fabricated as per the recommendations of the supplier of the high strength strand.

The maximum time duration that a length of strand may be exposed to atmospheric conditions before being threaded into a duct shall be 2 d.

The strands on the threading end of the cables shall be welded together and tapered as required to facilitate the threading and a proper size hook supplied by the Contractor shall be welded onto the threading end of each cable.

All strands or cables that: (a) develop injurious amounts of rust or other results of corrosion, (b) are contaminated by substances having a deleterious effect on the steel or concrete or on the bond strength of steel to concrete (c) sustain physical damage while in the care and control of the Contractor, shall be either replaced by the Engineer at the Contractor's cost, or cleaned to the satisfaction of the Engineer at the Contractor's cost.

7.12 Threading and Movement of Cables

The cables shall be threaded prior to the placing of concrete around the ducts or portions of the ducts.

Within 2 h of completion of concrete placing operations around ducts or portions of ducts, the cables within these ducts shall be moved once back and forth to prevent bonding due to any possible leakage in the ducts. This procedure shall be repeated again immediately prior to stressing of the cables to demonstrate that the cables are free and unbonded in the ducts.

7.13 Welding

The Contractor will not be allowed to weld to the ducts, or in the vicinity of the ducts or their components, high strength strands or cables and the anchorages, except as permitted by Section 7.11 Fabrication of Cables.

7.14 Stressing Equipment

The stressing equipment shall be compatible in all respects to the system of stressing shown on the plans.

The jack or jacks used to stress the cables shall be equipped with either a pressure gauge or a load cell for determining the jacking stress. The pressure gauge shall have an accurate reading dial at least 100 mm in diameter and each jack and its gauge shall be calibrated as a unit with the ram extended to the approximate position that it will be at the final jacking force. The load cell, if used, shall be calibrated and shall be provided with an indicator by means of which the prestressing force in the cables may be determined. The calibration of the jacks, gauges and load cells shall be done within 28 d prior to the jacks being used, and the

calibration certificate shall be supplied to the Engineer, at least 14 d prior to the start of stressing operations.

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.15 Stressing Calculations

The Contractor shall submit to the Engineer at least 14 d prior to the start of stressing operations, a set of stressing calculations prepared and sealed by Registered Professional Engineer.

The calculations shall be accompanied by jack and gauge or load cell calibration curves, and copies of stress-strain curves. The stress-strain curves for high strength strand will be supplied to the Contractor by the Department.

The submission of the stressing calculations to the Engineer shall in no way relieve the Contractor of the full responsibility for the success or failure of the stressing operations.

7.16 Stressing

The stressing operations shall not be started until the concrete has attained the required strength shown on the plans, as determined by the Engineer from cylinder breaks or other tests. The cables shall be stressed in the sequence and schedule shown on the plans. Every cable shall be stressed simultaneously from both ends except that in the case of a simple span, stressing of the cables alternately on each end will be allowed.

During stressing operations, no construction equipment or material will be permitted on the bridge deck, except for the equipment required for stressing.

The cables shall be so stressed that the jacking force in the cables shall not be less than the value shown on the plans. However, at no time shall the actual jacking force exceed the force corresponding to the calculated elongation by more than 5%. The final elongation of the cables shall not vary from the calculated elongation by more than 1% or 3mm, whichever is the smaller dimension. After the completion of the stressing operations, the ends of the anchorages shall be plugged temporarily to prevent the entry of debris and moisture into the ducts. The ends of the strands shall not be cut off before the Engineer is satisfied that the stressing of the cables has been completed satisfactorily and permits the ends of the strands to be cut off. Methods which might cause damage to the cables and anchorages shall not be employed for the cutting off of the strands.

7.17 Stressing Records

The Contractor shall supply to the Engineer a copy of the stressing records for each cable.

7.18 Grouting

The grouting of the cables shall be done as soon as possible after the stressing but not before the Engineer is satisfied that the stressing of the cables has been completed satisfactorily. Grout shall have a compressive strength of 35.0 MPa at 28 d, and shall consist of high early strength cement, admixtures and water.

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.18 Grouting (Cont'd)

The water-cement ratio shall be kept in the range of 0.45 to 0.55. The grout shall have between 3% to 5% entrained air and contain an expansive agent which is able to provide between 5% and 10% unrestrained expansion when used in the quantity recommended by the manufacturer. Admixtures shall not contain any chlorides, fluorides or nitrates and shall be subject to the approval of the Engineer. The grout shall be mixed in a colloidal grout mixer of the roller type or a high speed stirring mixer capable of operating from 1,800 to 2,900 r.p.m. The mixing shall be done at high speeds for 2 min. and shall be followed by slow agitation until the grout is used up.

Immediately prior to the grouting of each duct, compressed air shall be forced through the duct and air vents. The compressor shall be equipped to ensure that the air blown through the ducts is clean and in particular, oil free. During the forcing of air through the ducts and air vents, the Contractor shall inspect carefully each air vent and opposing end of the duct to ascertain that there is a free flow of air through each section of the duct. Closing of the low point drainage outlet will be allowed before grouting begins, but only after compressed air has been forced through the ducts.

From the mixer, the grout shall pass through a strainer into positive displacement grouting pumps provided with a recirculating device for use when the grout is not being injected.

Grouting shall be carried out quickly, with the filling of a given duct being completed within 30 min after the cement and water are first brought together. The grouting pressure shall be sufficiently high to cause a stream of grout to issue freely at the air vents and at the open end of the duct.

The Contractor shall supply and install grout fittings at the grouting anchorage and the open anchorage capable of maintaining the grout in the duct under pressure from the time that the duct has been filled with the grout until the grout is set.

Grout shall be pumped through the duct and ejected continuously at the air vents and open anchorage until no visible slugs of water or air are ejected. Every air vent shall be closed with the socket plug as soon as a steady stream of grout is evident at the air vent, starting with the air vent closest to the grouting end and proceeding progressively to the open anchorage. Once the air vents are closed and a steady stream of grout is evident at the open anchorage, the grout fitting of this anchorage then shall be closed and the pumping pressure shall be held for thirty seconds. The grout fitting of the grouting anchorage shall then be closed while maintaining this pressure. Where deemed advisable or convenient, the Contractor may be allowed to grout through the air vents on low points of the ducts providing that a procedure similar to that as outlined above is followed to ensure that the duct is properly filled.

After the grout has set, all grout fittings and air vents shall be cut off inside of the recesses and the recesses shall be filled with mortar mixed as specified in Section 7.19 of this Specification. Sufficient grout shall always be available so that each duct can be grouted completely in one operation. A generous allowance shall be made for wastage. If sufficient grout is not available to complete grouting of a duct, the grout already in the duct shall be forced out and the duct cleaned out completely with water and compressed air.

1044. 7. CONSTRUCTION METHODS (Cont'd)

7.19 Recesses

The Contractor shall fill the anchorage and air vent recesses with mortar after the grout has set. The mortar shall consist of water and one part of cement to three parts of clean, fine sand passed through a 6.7 mm sieve.

After 3 d curing, the ends of the concrete in the vicinity of the anchorage recesses shall be coated with two coats of asphalt waterproofing. The first asphalt coating shall be dried thoroughly before the second coat is applied.

The Contractor may, if he so chooses, fill the anchorage recesses prior to grouting of the ducts in order to facilitate the attachment of the grout fittings.

7.20 Extension of Heating

Where the terms of the contract call for the heating of the superstructure concrete and the scheduling is such that the stressing, grouting of ducts, and filling of recesses are required to be done under freezing conditions, the requirements of Section 7.16 Cold Weather Precautions of "Specifications for Reinforced Concrete" shall be extended as follows:

- (1) The air surrounding the fresh concrete shall be kept at a temperature of not less than 20° C for such additional time past the minimum of 4 d as may be required for the concrete to reach the required strength for stressing as shown on the plans.
- (2) The air surrounding the fresh concrete shall be kept at a temperature of not less than 10° C from the time that the concrete has reached the required strength for stressing until 24 h past the completion of grouting of ducts and the filling of recesses, reckoned from the time of completion of grouting of the last duct and the filling of the last recess. Where the filling of the anchorage recesses is completed after the grouting of ducts, local heating of the ends of the concrete slab will be permitted for the curing of the mortar.
- (3) The water for grout and mortar shall be heated to a temperature not exceeding 50° C. The temperature of the deposited grout shall not exceed 20° C.

1044. 9. METHOD OF MEASUREMENT

9.1 Bearings

Installation of bearings will be measured on a unit basis. The number to be paid for will be the total number of complete bearing assemblies installed.

9.2 Anchorages

Supplying and placing anchorages will be measured on a unit basis. The number to be paid for will be the total number of complete anchorages supplied and placed.

9.3 Ducts

Supplying and placing ducts will be measured on a lineal metre basis. The length to be paid for will be the total number of lineal metres of duct as determined from the plan dimensions. No allowance will be made for couplers, air vents and support accessories.

1044. 9. METHOD OF MEASUREMENT (Cont'd)

9.4 Cables

The fabrication, threading and stressing of cables will be measured on a mass basis. The total number of kilograms to be paid for will be the number of kilograms of high strength strand placed as determined from the plan length and the nominal mass of the strand as given in recognized handbooks. No allowance will be made for that part of the cable required for attachment to jacks or for threading of cables.

9.5 Void Forms

Supplying and placing void forms will be measured on a lineal metre basis. The length to be paid for will be the total number of lineal metres of void forms placed as determined from the plan dimensions. No allowance will be made for tie downs, air vents, and testing of the void forms and tie downs.

9.6 Grouting and Recess Filling

No measurement will be taken for grouting of cable ducts and filling of anchorage and air vent recesses, as this work will be paid for on a lump sum basis.

9.7 Extension of Heating

No measurement will be taken for extension of heating, as this work will be paid for on a lump sum basis.

1044. 11. BASIS OF PAYMENT

11.1 Bearings

Installation of bearings will be paid for at the Contract Unit Price for "Erection of Bearings", measured as specified herein, which price will be payment in full for performing all operations herein described for bearings and all other items incidental to the work included in this Specification.

11.2 Anchorages

Supplying and placing anchorages will be paid for at the Contract Unit Price for "Supplying and Placing Anchorages", measured as specified herein, which price will be payment in full for performing all operations for anchorages herein described and all other items incidental to the work included in this Specification.

11.3 Ducts

Supplying and placing ducts will be paid for at the Contract Unit Price for "Supplying and Placing Ducts", measured as specified herein, which price will be payment in full for performing all operations herein described for ducts and all other items incidental to the work included in this Specification.

1044. 11. BASIS OF PAYMENT (Cont'd)

11.4 Cables

Fabrication, threading and stressing of cables will be paid for at the Contract Unit Price for "Placing and Stressing Cables", measured as specified herein, which price will be payment in full for performing all operations herein described for cables and all other items incidental to the work included in this Specification.

11.5 Void Forms

Supplying and placing void forms will be paid for at the Contract Unit Price for "Supplying and Placing Void Forms", measured as specified herein, which price will be payment in full for performing all operations herein described for void forms and all other items incidental to the work included in this Specification.

11.6 Grouting and Recess Filling

Grouting and recess filling will be paid for at the Contract Lump Sum Price for "Grouting", measured as specified herein, which price will be payment in full for performing all operations herein described for grouting and all other items incidental to the work included in this Specification.

11.7 Extension of Heating

Extension of heating will be paid for at the Contract Lump Sum Price for "Extension of Heating", measured as specified herein, which price will be payment in full for performing all operations herein described for extending heating and all other items incidental to the work included in this Specification.