# TENDER DOCUMENTS

# SUBSECTION 6.36
# PRESTRESSING

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## SUBSECTION 6.36 PRESTRESSING

### 6.36.1 GENERAL

6.36.1.1 This subsection sets out the requirements related to the fabrication of prestressed beams and the reinforcement of prestressed beams using post-tensioning.

6.36.1.2 Any specific requirements related to the fabrication of prestressed beams and the reinforcement of prestressed beams under this Contract are set out in Section 4 *Special Technical Conditions*.

6.36.1.3 The requirements related to demolition work are set out in subsection 6.21 *Demolition and Removal.*

6.36.1.4 The requirements related to reinforcing steel work are set out in subsection 6.31 *Reinforcing Steel for Concrete.*

6.36.1.5 The requirements related to formwork are set out in subsection 6.32 *Formwork*.

6.36.1.6 The requirements related to concreting are set out in subsection 6.33 *Cast-in-Place Concrete*.

6.36.1.7 The requirements related to waterproofing are set out in subsection 6.37 *Miscellaneous Products for Concrete Work.*

### 6.36.2 REFERENCE STANDARDS

6.36.2.1 All work related to prestressing shall be performed in conformity to standard CAN/CSA S6, the recommendations on prestressed concrete published by the *Canadian Precast/Prestressed Concrete Institute* (CPCI), and the recommendations drafted by the ACI-ASCE's Joint Committee 423.

6.36.2.2 The **Contractor** shall perform all prestressed concrete work (using pre- or post-tensioning) in conformity to the requirements of the following standards and documents to which the provisions of the Contract are added:

6.36.2.2.1 (ASTM) ASTM International

- ASTM A307-07b *Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength*;
- ASTM A325-07a *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*;
- ASTM A416/A416M-06 *Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete*;

- ASTM A421/A421M-05 *Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete*;
- ASTM A722/A722M-07 *Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete;*
- ASTM C109/C109M-07a *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)*.

6.36.2.2.2 (CSA) Canadian Standards Association

- CAN/CSA-A23.1-04/A23.2-04 *Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete*;
- CAN/CSA A23.4-05 *Precast Concrete – Materials and Construction*;
- CAN/CSA-G164-M92 (R2003) *Hot Dip Galvanizing of Irregularly Shaped Articles*;
- CAN/CSA S6-06 *Canadian Highway Bridge Design Code*;
- CSA G40.20-04/G40.21-04 *General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel*;
- CSA W59-03 *Welded Steel Construction (Metal Arc Welding)*.

6.36.2.2.3 (MTQ) Ministère des Transports du Québec

- MTQ – *Cahier des charges et devis généraux* (CCDG).

## 6.36.3 MATERIALS

6.36.3.1 The **Contractor** is responsible for choosing the materials used and for their performance once they are in place.

6.36.3.2 The **Owner** may reject any material that failed to meet the technical requirements on similar previous projects.

6.36.3.3 The **Contractor** may not make such changes to the materials or construction details as it deems necessary or desirable without first obtaining written authorization from the Engineer.

6.36.3.4 All materials shall be new and free of dirt, rust, oil, grease and any other deleterious material at all stages of the work.

6.36.3.5 PRESTRESSING REINFORCING STEEL

6.36.3.5.1 Unless otherwise indicated on the drawings or in the *Special Technical Conditions*, the prestressing reinforcing steel used shall be 1860 MPa low-relaxation strands conforming to the requirements of standards ASTM A416/A416M and ASTM A421/A421M.

6.36.3.5.2 All of the prestressing cables in each of the supplier's deliveries to the work site or the plant shall have an individual lot number and shall be labelled so as to permit accurate identification of each lot and the delivery date. Any steel that is delivered without identification will be rejected.

## 6.36.4 FABRICATION OF PRESTRESSED CONCRETE BEAMS

6.36.4.1 PERFORMANCE OF WORK

6.36.4.1.1 Fabrication of beams

6.36.4.1.1.1 The **Contractor** or its sub-contractor shall have a recognized prestressed concrete plant that includes a permanent building in which prestressed concrete structural elements are fabricated using permanent facilities. The air temperature inside the building shall be kept at 10°C or higher.

6.36.4.1.1.2 Prestressed concrete beams shall conform to the drawings and specifications.

6.36.4.1.1.3 Prefabricated prestressed concrete beams shall be fabricated in conformity to the provisions of standard CAN/CSA A23.4.

6.36.4.1.1.4 The length of each beam indicated on the drawings shall be checked on site by the **Contractor** before fabrication of the beams begins.

6.36.4.1.1.5 Where new beams are intended to replace existing beams, the **Contractor** shall do an on-site check of the current profile of the beams to be replaced and the profile of the adjacent beams in order to determine the camber required for the new beams.

6.36.4.1.1.6 The camber of each new beam shall be established so as to ensure that once it is in place and under the effects of prestressing, its own weight and the weight of the concrete deck slab, the profile of the new beam will match to suit the profile of the adjacent beams.

6.36.4.1.1.7 The **Contractor** shall take into account drying shrinkage and other effects due to prestressing in determining the initial length required for beams so that their final length suits to the length measured on site.

6.36.4.1.1.8 Beams shall include two (2) or more lifting devices cast into the concrete; there shall be at least one such device at each end of every beam to be used as a lifting point to permit handling of the beam.

6.36.4.1.1.9 For key steps in the fabrication process, such as tensioning of the strands or cables and concreting, the **Contractor** may not proceed with a subsequent step until the necessary inspection and test reports and other required documents have been received, checked and approved by the Engineer.

6.36.4.1.1.10 The ends of beams shall be clearly marked with the identification number indicated on the shop drawings. That number shall be written on the ends of the beams.

6.36.4.1.1.11 Concreting and curing of beams shall conform to standard CAN/CSA-A23.1 and shall meet the following requirement:

6.36.4.1.1.11.1 the air temperature shall be kept at 10°C or higher from the start of concreting.

6.36.4.1.1.12 The requirements for dimensional tolerances are the requirements set out in clause 15.6.4.4.5 *Tolérances dimensionnelles* of the CCDG.

6.36.4.1.1.13 The requirements for surface correction and finish are specified in clause 15.6.4.4.6 *Correction et fini des surfaces* of the CCDG.

6.36.4.1.1.14 The requirements pertaining to defective strands are specified in clause 15.6.4.4.3 *Armature et torons* of the CCDG.

6.36.4.1.1.15 Handling and storage of beams shall be carried out in conformity to the requirements of clause 15.6.4.5 *Manutention et entreposage* of the CCDG.

6.36.4.1.2 Waterproofing of beams

6.36.4.1.2.1 Once the concrete is fully cured, the **Contractor** shall apply to all surfaces of the beams two (2) coats of a penetrating sealer (siloxane) conforming to the requirements of subsection 6.37 *Miscellaneous Products for Concrete Work* of these specifications, according to the manufacturer's instructions.

6.36.4.2 HANDLING AND STORAGE

6.36.4.2.1 Handling and storage of beams shall conform to the requirements of clause 15.6.4.5 *Manutention et entreposage* of CCDG.

6.36.4.2.2 Spools of strand shall be stored so as to protect them from dampness and any nearby source of potential degradation.

6.36.4.2.3 Beams shall be stored so as to prevent any deformation or other damage and any damage to the waterproofing.

6.36.4.2.4 Within seven (7) days after the Contract award, the **Contractor** shall provide the Engineer with details of precautions and requirements related to the specific handling and transportation of beams fabricated under this Contract.

6.36.4.2.5 The **Contractor** shall deliver the prefabricated beams to the site designated by the **Owner** on the drawings and in the *Special Technical Conditions*, on the **Owner**'s property in the Greater Montreal region, Quebec.

6.36.4.3 QUALITY CONTROL

6.36.4.3.1 In addition to the quality control process to be implemented by the **Contractor**, the fabrication of beams and tensioning of strands will be subject to verficication by an external firm retained by the **Owner**. The **Owner** will cover the cost of these independent checks. The **Contractor** shall work with the firm retained by the **Owner** in order to facilitate the monitoring of work.

6.36.4.3.2 The **Contractor** shall report to the Engineer in writing any flaw or defect in the fabrication of beams before taking corrective measures. Corrective measures shall be authorized by the Engineer before implementation.

6.36.4.3.3 The **Contractor** shall permit and facilitate on-site verification by the **Owner**'s engineer of the tensioning of the strands, failing which the work shall be deemed defective.

## 6.36.5 REINFORCEMENT OF PRESTRESSED BEAMS BY ADDING EXTERNAL POST-TENSIONING

6.36.5.1 MATERIALS

6.36.5.1.1 High strength steel bars

6.36.5.1.1.1 Unless otherwise indicated on the drawings or in the *Special Technical Conditions,* the **Contractor** shall use for anchor blocks new high strength steel bars with a nominal ultimate strength of 1,030 MPa conforming to standard ASTM A722/A722M.

6.36.5.1.1.2 Each lot of high strength steel bars delivered to the work site shall have an individual lot number and shall be labelled so as to permit accurate identification of each lot at the site and the delivery date. Any steel that is delivered without identification will be rejected.

6.36.5.1.2 Sheathed and greased strands

6.36.5.1.2.1 Unless otherwise indicated on the drawings or in the *Special Technical Conditions,* all post-tensioning steel strands shall be grade 1,860 MPa low-relaxation strands conforming to standards ASTM A416/A416M and ASTM A421/A421M.

6.36.5.1.2.2 If the source of the strands is neither Canadian nor American, the **Contractor** shall provide the results of tests carried out by a Canadian laboratory showing that the physical and chemical properties conform.

6.36.5.1.2.3 The composition of the prestressing cables (number of single strands, diameters and number of wires) shall be as indicated on the drawings or in the *Special Technical Conditions*.

6.36.5.1.2.4 All strands shall be greased and covered at the factory with an individual polypropylene sheath.

6.36.5.1.2.5 The **Contractor** shall not join or splice strands.

6.36.5.1.3 Anchor heads, anchor cones and isolation casings

6.36.5.1.3.1 Anchor heads shall be installed so that the post-tensioned steel cannot twist or loop or be damaged in any other way.

6.36.5.1.3.2 Anchor cones and related materials at each end of the steel cables shall be of the type recommended by the manufacturer of the anchor heads and shall be approved by the Engineer.

6.36.5.1.3.3 The **Contractor** shall supply and install an isolation casing for the sheathed and greased cables behind the anchor plates and accessories.

6.36.5.1.3.4 New isolation casings shall be compatible with the anchor plates to which they are attached.

6.36.5.1.4 Sheaths

6.36.5.1.4.1 Sheaths for high strength steel bars shall be high-density polyethylene (HDPE) or galvanized steel pipe.

6.36.5.1.4.2 Sheaths for post-tensioning strands shall be Fusolene smooth-sided high-density polyethylene (HDPE) pipe from Plasti-Drain or an approved equivalent. They shall be equipped with proper sleeve connectors and adaptors so that they can be connected as recommended by the manufacturer.

6.36.5.1.4.3 High-density polyethylene (HDPE) pipes shall be resistant to ultraviolet radiation and capable of withstanding pressure of at least 1,000 kPa.

6.36.5.1.4.4 Unless otherwise indicated on the drawings or in the *Special Technical Conditions*, all connections (splices) between sheaths shall be fusionned.

6.36.5.1.4.5 The individual sheath for each strand shall be a Shell Polypropylene HMA 6100 sheath manufactured by Shell Chemicals or an equivalent approved by the Engineer.

6.36.5.1.5 Grease

6.36.5.1.5.1 The grease used shall conform to the corrosion protection standards for “severe environments” as specified by the Post-Tensioning Institute (PTI), such as Visconorust PT1000 from Viscosity Oil or an approved equivalent.

6.36.5.1.6 Injection grout for prestressed concrete beams

6.36.5.1.6.1 At least twenty-eight (28) days before the intended start date of injection work, the **Contractor** shall submit to the Engineer representative samples of the cement and superplasticizer it plans to use. No grouting will be permitted until the Engineer has approved the grout mix.

6.36.5.1.6.2 The injection grout used shall conform to the requirements set out in Quebec Department of Transport standard 3901 *Coulis cimentaires*.

6.36.5.1.6.3 The compressive strength of the grout shall not be less than 20 MPa after seven (7) days or less than 35 MPa after twenty-eight (28) days. It shall be determined using 50 mm cube samples stored and tested in accordance with ASTM Standard C109/C109M. The tests will be carried out by the **Owner**'s laboratory at the **Owner**'s expense.

6.36.5.1.6.4 The grout shall comprise the following:

6.36.5.1.6.4.1 Type GU cement;

6.36.5.1.6.4.2 an expanding superplasticizer, such as Intraplast-N manufactured by Sika or an equivalent approved by the Engineer, in proportions recommended by the manufacturer;

6.36.5.1.6.4.3 the amount of water needed to achieve a minimum water/cement ratio of 0.4 and to produce the specified compressive strength;

6.36.5.1.6.4.4 air content of 5% to 7%.

6.36.5.1.6.5 The **Contractor** shall not mix calcium chloride into the grout or any admixture containing calcium chloride.

6.36.5.1.6.6 The fluidity of the grout, determined by measuring the flow time of a specified volume of grout using the cone flow method, shall be between eighteen (18) and twenty-two (22) seconds.

6.36.5.1.6.7 After a period of fifteen (15) minutes at rest, there shall be no bleeding or segregation of the grout.

6.36.5.1.6.8 When it first sets, that is, in approximately three (3) hours, the grout should have expanded 8% over its initial volume.

6.36.5.1.7 Sheath supports for external post-tensioning

6.36.5.1.7.1 To add external post-tensioning, the **Contractor** shall provide new height-adjustable sheath supports made of galvanized angles.

6.36.5.1.7.2 The supports shall be fabricated so as to be compatible with the new sheaths and as indicated on the drawings.

6.36.5.1.7.3 The supports shall be fabricated from new 300W grade structural steel conforming to standard CSA G40.20/G40.21 or as indicated on the drawings.

6.36.5.1.7.4 Welds shall conform to standard CSA W59.

6.36.5.1.7.5 High-strength bolts, nuts and washers shall be galvanized and shall conform to standard ASTM A325.

6.36.5.1.7.6 U-bolts shall be new, galvanized and 10 mm in diameter and shall conform to standard ASTM A307.

6.36.5.1.7.7 All components of external post-tensioning supports shall be hot dip galvanized in conformity to standard CAN/CSA-G164.

6.36.5.1.7.8 After tensioning is complete, the **Contractor** shall touch up (with two (2) coats) any damaged galvanized steel surfaces, including unused and exposed threads. The touch-up material shall be submitted to the Engineer for review and comments.

6.36.5.2 INSPECTION AND STORAGE

6.36.5.2.1 The **Contractor** shall ensure that all materials used to make the post-tensioning cables are unloaded and stored with utmost care and protected against any adverse conditions (including, but not limited to, direct contact with the ground, inclement weather and condensation).

6.36.5.2.2 Specifically, sheathed and greased strands shall be properly protected until they are coated with grout.

6.36.5.2.3 The Engineer may refuse to allow the use of any material it deems to be damaged or unsuitable for the intended purpose.

6.36.5.3 EQUIPMENT AND TOOLS

6.36.5.3.1 All equipment used for tensioning and grout injection shall be submitted to the Engineer for review.

6.36.5.3.2 Jack

6.36.5.3.2.1 Each jack shall be equipped with a pressure gauge with a dial at least 150 mm in diameter, and each jack-pressure gauge set shall have a certified calibration display showing the relationship between readings and up and down forces of the piston.

6.36.5.3.3 Grout mixer

6.36.5.3.3.1 The mixer shall be a high-shear colloidal mixer with high-speed blades to shear and separate the cement particles so as to allow complete contact between particles and water.

6.36.5.3.3.2 The mixer used shall allow the grout to be agitated again prior to use.

6.36.5.3.4 Grout pump

6.36.5.3.4.1 Grout shall be injected using a progressive cavity pump equipped with a pressure gauge and a flow meter.

6.36.5.3.4.2 The equipment used to inject grout shall be capable of operating at a pressure of at least 700 kPa.

6.36.5.4 PERFORMANCE OF WORK

6.36.5.4.1 Planning

6.36.5.4.1.1 At least fourteen (14) days prior to the start of work, the **Contractor** shall provide the Engineer with technical data sheets for and a sample of each of the following materials: single strand, steel strand, high strength steel bar and anchors, and grease. The samples shall be accompanied by two copies of the mill test certificate and two (2) copies of the tension-elongation curves at no additional cost to the **Owner**. The **Contractor** shall also submit drawings of the sheath supports for review.

6.36.5.4.1.2 The **Contractor** shall not begin fabrication and installation of the post-tensioning elements before obtaining authorization from the Engineer.

6.36.5.4.1.3 At least fourteen (14) days prior to the start of post-tensioning work, the **Contractor** shall submit system details to the Engineer for review and comments, that is, drawings, design notes and any other technical information related to the system the **Contractor** plans to use for post-tensioning, including, but not limited to:

6.36.5.4.1.3.1 the planned tensioning method and sequence;

6.36.5.4.1.3.2 complete specifications;

6.36.5.4.1.3.3 details of steel post-tensioning elements (reinforcing steel, high strength steel bars, sheath supports);

6.36.5.4.1.3.4 anchoring devices (anchor head, anchor cone, isolation casing);

6.36.5.4.1.3.5 tensioning forces;

6.36.5.4.1.3.6 elongation calculations;

6.36.5.4.1.3.7 losses;

6.36.5.4.1.3.8 grouting equipment and materials;

6.36.5.4.1.3.9 details of HDPE pipes and air vents;

6.36.5.4.1.3.10 any other pertinent information related to post-tensioning.

6.36.5.4.2 The **Contractor** shall give the Engineer at least forty-eight (48) hours to conduct the initial survey of the corroded existing prestressed cables.

6.36.5.4.3 Within twenty-four (24) hours following each demolition operation, the **Contractor** shall notify the Engineer so that a condition survey of the extent of deterioration to the existing prestressing sheaths, cables and wires can be assessed in the demolished or drilled areas and shall provide the labour and equipment needed to proceed with demolition in areas where the Engineer determines that more concrete removal is needed in order to complete the survey.

6.36.5.4.4 After conducting an on-site assessment of the damage to the existing cables in the prestressed beams, the Engineer will determine the type and extent of work needed to reinforce the beams.

6.36.5.4.5 The Engineer will determine the tension in each of the new external post-tensioning cables based on the extent of damage to the existing cables.

6.36.5.4.6 Construction of new anchor blocks

6.36.5.4.6.1 The **Contractor** shall take such precautions as are necessary to avoid damaging existing post-tensioning elements when constructing new anchor blocks.

6.36.5.4.6.2 The **Contractor** shall locate, using a specialized device (pacometer, radar, etc.) and mark on the faces of beams the exact position of the existing reinforcing steel and prestressing sheaths prior to the start of demolition or drilling. The method used to locate post-tensioning elements shall be submitted to the Engineer for review.

6.36.5.4.6.3 The **Contractor** shall drill holes in the flanges and webs of the beams to allow the placement of galvanized reinforcing steel and high strength steel bars as indicated on the drawings and in the location survey of existing steel elements.

6.36.5.4.6.4 Holes for reinforcing steel bars and high strength steel bars shall not be diamond drilled. The **Contractor** shall use a template for this purpose. If a reinforcing bar or prestressing cable is encountered, the **Contractor** shall stop drilling and ask the Engineer for instructions. If necessary, the hole shall be re-drilled at the **Contractor**'s expense.

6.36.5.4.6.5 Once drilling is complete, the Engineer will check the inside of the hole to ensure that there has been no damage to the post-tensioning elements. The **Contractor** shall submit to the Engineer for review a drawing showing the location of the drill holes.

6.36.5.4.6.6 Make saw cuts in order to outline the area to be demolished for the construction of new anchor blocks.

6.36.5.4.6.7 Remove the existing membrane on the beams at the locations of the new anchor blocks and sheath supports.

6.36.5.4.6.8 Demolish to a depth of 50 mm all concrete surfaces of existing flanges that will come into contact with the concrete of the new anchor blocks. The concrete at these locations is usually sound and congested with reinforcing steel, hardware and prestressing cables, making it difficult for the **Contractor** to demolish.

6.36.5.4.6.9 Demolition of concrete on the faces of beams shall conform to subsection 6.21 *Demolition and Removal* and the instructions contained on the drawings.

6.36.5.4.6.10 Place high strength steel bars and sheaths, as well as anchor cones, plates, casings and accessories.

6.36.5.4.6.11 Supply and install galvanized reinforcing steel for anchor blocks.

6.36.5.4.6.12 Placement of reinforcing steel shall conform to subsection 6.31 *Reinforcing Steel for Concrete* and the instructions on the drawings.

6.36.5.4.6.13 Fabricate formwork for anchor blocks so as to comply with the phases of concreting shown on the drawings.

6.36.5.4.6.14 Formwork shall conform to subsection 6.32 *Formwork* and the instructions on the drawings.

6.36.5.4.6.15 Supply and place first-phase and second-phase concrete for anchor blocks.

6.36.5.4.6.16 First-phase and second-phase concrete for anchor blocks shall have a nominal strength of 50 MPa unless otherwise indicated in the *Special Technical Conditions.*

6.36.5.4.6.17 Surface preparation for second-phase concreting shall be carried out using abrasive blasting and water blast cleaning.

6.36.5.4.6.18 Concreting shall conform to subsection *6.33 Cast-in-Place Concrete* and the instructions on the drawings.

6.36.5.4.7 Placement and tensioning

6.36.5.4.7.1 All post-tensioning work shall be monitored on site at all times by an engineer who is a member in good standing of the *Ordre des ingénieurs du Québec* and has at least ten (10) years experience in the field of reinforcement by means of post-tensioning. If this requirement is not met, the **Contractor** may not proceed with post-tensioning.

6.36.5.4.7.2 Tensioning of new steel strands and high strength steel bars shall be carried out by qualified persons. Proof of the competency of the proposed persons shall be submitted to the Engineer prior to the start of post-tensioning work.

6.36.5.4.7.3 The compressive strength of the first-phase concrete of anchor blocks at the time of tensioning of the high strength steel bars and strands shall not be less than 25 MPa or shall conform to the value indicated in the *Special Technical Conditions*.

6.36.5.4.7.4 The strength of the concrete in the anchor blocks prior to tensioning shall be confirmed by destructive testing if required by the Engineer.

6.36.5.4.7.5 The **Contractor** shall carry out post-tensioning as directed by the manufacturer of the prestressing materials. The work shall be performed with the **Contractor**'s engineer present.

6.36.5.4.7.6 Tension the high strength steel bars according to the values indicated on the drawings or in the *Special Technical Conditions* or as directed by the Engineer.

6.36.5.4.7.7 The **Contractor** shall insert the sheathed and greased strands into the HDPE sheaths and anchor assemblies and attach the sheaths to the steel supports on both sides of the beam flanges as indicated on the drawings.

6.36.5.4.7.8 Sheath supports for longitudinal post-tensioning and temporary supports shall be installed so as to limit the deflection of the HDPE sheaths between supports to 3 mm during grouting. Permanent supports shall be placed according to the spacing shown on the drawings. The temporary support method shall be submitted to the Engineer for review.

6.36.5.4.7.9 Supports shall be positioned such that the strands are centred in the new sheaths.

6.36.5.4.7.10 The **Contractor** shall plan a tensioning sequence that includes alternating gradual tensioning of the strands on either side of the beams. The maximum allowable difference in tension between the cables on the upstream and downstream sides of the beam will be determined by the Engineer before tensioning begins and after the extent of deterioration of the existing cables has been analysed. The **Contractor** shall await instructions from the Engineer before tensioning any new cables.

6.36.5.4.7.11 The **Contractor** shall ensure that the jack is aligned with the strand being tensioned.

6.36.5.4.7.12 Tension steel strands according to the values indicated on the drawings or in the *Special Technical Conditions*. In all cases, the tensioning values shall be validated by the Engineer prior to the start of work. The final effective force per strand will be determined by the Engineer after the damage to the existing cables has been assessed.

6.36.5.4.7.13 Once the strands have been tensioned, the **Contractor** shall leave 450 mm of excess strand in the isolation casings to allow future re-tensioning.

6.36.5.4.7.14 Isolation casings shall be filled with grease after tensioning is complete.

6.36.5.4.8 Grouting

6.36.5.4.8.1 The **Contractor** shall inject grout over the entire length of the sheaths in order to protect the sheathed and greased strands and high strength steel bars.

6.36.5.4.8.2 Tensioning of post-tensioning elements shall be completed prior to grouting.

6.36.5.4.8.3 No grouting will be permitted until the Engineer has examined the grout mix.

6.36.5.4.8.4 The **Contractor** shall install injection tubes and air vents to prevent air from becoming trapped in the sheaths.

6.36.5.4.8.5 Steel shall be free of dirt, rust, oil, grease and other deleterious substances when it is grouted.

6.36.5.4.8.6 Injection shall always be carried out starting at the lower end of the sheath in order to prevent the risk of air entrapment.

6.36.5.4.8.7 The volume of grout mixed shall be such that the time elapsed between mixing and pumping does not exceed the limit specified by the manufacturer of the superplasticizer. The **Contractor** shall not mix a second batch of the same volume of grout.

6.36.5.4.8.8 The time lapse between mixing and pumping shall not exceed 40 minutes.

6.36.5.4.8.9 Grout temperature at the time of injection shall not be lower than 16°C or higher than 27°C.

6.36.5.4.8.10 If injection work is interrupted, the **Contractor** shall thoroughly clean out the HDPE pipes and sheaths immediately.

6.36.5.4.8.11 The **Contractor** shall have a reliable supply of water and high-pressure compressed air available at all times during grout injection.

6.36.5.4.9 Second-phase concreting and waterproofing membrane

6.36.5.4.9.1 The **Contractor** shall protect the ends of the sheathed and greased strands and high strength steel bars by placing second-phase concrete (sealer) as indicated on the drawings.

6.36.5.4.9.2 Cover the surface of the exterior anchor blocks with a waterproof membrane as indicated on the drawings and in conformity to subsection 6.37 *Miscellaneous Products for Concrete Work.*

6.36.5.5 QUALITY CONTROL

6.36.5.5.1 The **Contractor**'s engineer shall ensure that the details of the method reviewed by the Engineer are safely applied and that the integrity of the structure is not compromised by on-site improvisation.

6.36.5.5.2 The **Contractor** is responsible for conducting all tests and taking all readings and measurements required to ensure quality control of its tensioning work.

6.36.5.5.3 The **Contractor** shall provide the Engineer with cable elongation values and indicate the maximum allowable tensioning force. The **Contractor**'s engineer shall record the actual steel elongation values, the pressure exerted by the jacks and any tension loss at the anchors.

6.36.5.5.4 The **Contractor** shall periodically check the accuracy of the pressure gauge on the jack by comparing to another gauge mounted on the system.

6.36.5.5.5 The allowable difference relative to the prescribed post-tensioning force shall not exceed 5%.

6.36.5.5.6 The tension in the steel elements shall be determined by measuring their elongation continuously using the pressure gauge on the jack.

6.36.5.5.7 The **Contractor** shall determine the tension zero point error of the jack by taking several direct readings of the elongation of the steel at the jack. These readings shall then be plotted on a diagram and connected by a line. The zero point error is estimated by extrapolating that line to the point where it intersects the horizontal axis.

6.36.5.5.8 The **Contractor** shall apply tension and limit it so as to obtain an effective prestressing force that conforms to the drawings and the values specified by the Engineer.

6.36.5.5.9 The post-tensioning elongation surveys, tension readings at the pressure gauge on the jack and cable slip shall be approved by the Engineer before the work is accepted.

6.36.5.5.10 A copy of the tensioning report signed by the **Contractor**'s engineer shall be sent to the Engineer once the work is completed.

**END OF SUBSECTION**