TENDER DOCUMENTS

SUBSECTION 6.36
PRESTRESSING

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SUBSECTION 6.36 PRESTRESSING

6.36.1 GENERAL

6.36.1.1 This subsection describes the requirements relating to the fabrication of prestressed girders, prestressing by post-tensioning of the deck slabs as well as strengthening of prestressed girders or foundation units by adding post-tensioning work covered by this Contract.

6.36.1.2 Any specific requirements pertaining to the prestressing work covered by this Contract are set out on the drawings and in Section 4 *Special Technical Conditions*.

6.36.1.3 The requirements relating to demolition work are described in subsection 6.21 *Demolition and Removal.*

6.36.1.4 The requirements relating to reinforcing steel are described in subsection 6.31 *Concrete Reinforcement.*

6.36.1.5 The requirements relating to formwork are described in subsection 6.32 *Formwork*.

6.36.1.6 The requirements relating to concreting are described in subsection 6.33 *Cast-in-Place Concrete*.

6.36.1.7 The requirements relating to waterproofing are described in subsection 6.37 *Miscellaneous Products for Concrete Work.*

6.36.1.8 The requirements relating to steelwork are described in subsection 6.41 *Steelwork.*

6.36.2 MEASUREMENT UNITS

6.36.2.1 The measurement units and respective symbols thereof used in this subsection are described as follows:

Measurement unit	Designation	Symbol
angle, plan	degree	º
angle, plan	radian	rad
stress, pressure	kilopascal	kPa
stress, pressure	megapascal	MPa
length	millimeter	mm
temperature	Celsius degree	°C

6.36.3 REFERENCE STANDARDS

6.36.3.1 All work relating to prestressing shall be carried out in accordance with standard CAN/CSA S6, with the recommendations with respect to prestressed concrete published by the *Canadian Precast/Prestressed Concrete Institute* (CPCI), as well as with the recommendations prepared by the ACI-ASCE's Joint Committee 423.

6.36.3.2 The **Contractor** shall carry out all prestressed concrete work (by pre-tensioning or post-tensioning) in accordance with the following standards and documents to which the provisions of this Contract are added:

6.36.3.2.1 (ASTM) ASTM International:

- ASTM A123/A123M *Standard Specifications for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*;
- ASTM A143/A143M *Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement*;
- ASTM A307 *Standard Specification for Carbon Steel Bolts, Studs and Threaded Rod 60 000 PSI Tensile Strength*;
- ASTM A325 *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*;
- ASTM A416/A416M *Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete*;
- ASTM A421/A421M *Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete*;
- ASTM A722/A722M *Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete;*
- ASTM C109/C109M *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)*;
- ASTM C939 *Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method);*
- ASTM C1064/C1064M *Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.*

6.36.3.2.2 (CSA) Canadian Standards Association:

- CAN/CSA-A23.1/A23.2 *Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete*;
- CAN/CSA A23.4 *Precast Concrete – Materials and Construction*;
- CAN/CSA G40.20/G40.21 *General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel*;
- CAN/CSA S6 *Canadian Highway Bridge Design Code*;
- CAN/CSA W59 *Welded Steel Construction (Metal Arc Welding)*.

6.36.3.2.3 (MTQ) Ministère des Transportsdu Québec:

- MTQ – *Cahier des charges et devis généraux* (CCDG) – *Construction et réparation*;
- MTQ – *Normes – Ouvrages routiers* – Tome VII *Matériaux* :
    - Norme 3901 *Coulis cimentaires*.

6.36.4 FABRICATION OF PRESTRESSED CONCRETE GIRDERS

6.36.4.1 MATERIALS

6.36.4.1.1 The **Contractor** is responsible for the selection of the products used and performance thereof once implemented.

6.36.4.1.2 The **Contractor** may, with the prior written authorization from the Engineer, make such changes to the materials or construction details that it deems required.

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

6.36.4.1.4 Prestressing reinforcement

6.36.4.1.4.1 Unless otherwise indicated on the drawings, the prestressing reinforcement used shall be 1860 MPa grade low-relaxation strands meeting the requirements of standards ASTM A416/A416M and ASTM A421/A421M.

6.36.4.1.4.2 For each delivery and at least fourteen (14) days prior to the tensioning of the prestressing reinforcement, the **Contractor** shall, for each production batch, provide the Engineer with a certificate of conformity containing, without however being limited to, the following information:

6.36.4.1.4.2.1 the name of the prestressing reinforcement manufacturer;

6.36.4.1.4.2.2 the diameter, caliber, category and Low Relaxation (LR) identification of the relaxation type;

6.36.4.1.4.2.3 the stress-strain diagram;

6.36.4.1.4.2.4 the certificate on the ultimate strength and elastic modulus;

6.36.4.1.4.2.5 the spool number corresponding to the production batch number.

6.36.4.1.4.3 Any steel received that is not identified will be rejected.

6.36.4.1.4.4 When a delivery control is carried out by the **Owner**, the sample collection will consist of two (2) 1500 mm strands per production batch.

6.36.4.1.4.5 For the prestressing cables manufactured outside the worksite, the **Contractor** shall replace, on worksite, the strands on which a sample is collected.

6.36.4.2 EXECUTION OF WORK

6.36.4.2.1 Fabrication of the girders

6.36.4.2.1.1 The **Contractor** or sub-contractor thereof shall have a recognized prestressed concrete plant that comprises a permanent building in which the prestressed concrete structural elements are fabricated by means of permanently installed equipment. The ambient temperature inside the building shall be maintained at or above 10°C.

6.36.4.2.1.2 The prestressed concrete girders shall comply with the drawings.

6.36.4.2.1.3 The precast prestressed concrete girders shall be fabricated in accordance with standard CAN/CSA A23.4.

6.36.4.2.1.4 The length of each girder indicated on the drawings shall be checked on site by the **Contractor** prior to undertaking the fabrication of the girders.

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

6.36.4.2.1.6 The camber of each new girder 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 deck concrete slab, the profile of the girder is identical that of the adjacent girders.

6.36.4.2.1.7 In determining the initial length required for the girders, the **Contractor** shall take into account the shrinkage due to drying and the other effects due to prestressing in order that the final length of the girders complies with the lengths measured on site.

6.36.4.2.1.8 The girders shall comprise at least two (2) lifting elements or devices integrated into the concrete; there shall be at least one at each end of every girder used as lifting points to enable the handling thereof.

6.36.4.2.1.9 For the important fabrication stages, such as the tensioning of the strands or cables and concreting, the **Contractor** may not proceed with a subsequent stage of the fabrication before the necessary inspection and test reports as well as the other required documents have been checked and accepted by the Engineer.

6.36.4.2.1.10 Every girder end shall be clearly marked with the identification number, in accordance with the indications on the shop drawings.

6.36.4.2.1.11 The concreting and curing of the girders shall meet the requirements of standard CAN/CSA-A23.1 and the ambient temperature shall be maintained at or above 10°C from the start of concreting.

6.36.4.2.1.12 The requirements for dimensional tolerances are specified in Article 15.6.4.4.5 *Tolérances dimensionnelles* of the CCDG.

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

6.36.4.2.1.14 The requirements for defective strands are specified in Article 15.6.4.4.3 *Armature et torons* of the CCDG.

6.36.4.2.2 Waterproofing of the girders

6.36.4.2.2.1 Once the concrete is fully cured, the **Contractor** shall apply, to all surfaces of the girders, two (2) coats of a penetrating sealer (siloxane) that meets the requirements of subsection 6.37 *Miscellaneous Products for Concrete Work* of this specifications, and in accordance to the manufacturer's recommendations.

6.36.4.3 HANDLING AND STORAGE

6.36.4.3.1 The handling and storage of the girders shall meet the requirements of Article 15.6.4.5 *Manutention et entreposage* of the CCDG.

6.36.4.3.2 The spools of strands shall be stored so as to protect them from moisture or from any nearby source of potential degradation.

6.36.4.3.3 The girders shall be stored so as to prevent any deformation and other damage, as well as any damage to the waterproofing products.

6.36.4.3.4 Within seven (7) days of the date of the Notice of Contract, the **Contractor** shall provide the Engineer, for review, with the details of the precautions and requirements related to the handling and transportation of the precast girders.

6.36.4.3.5 The **Contractor** shall deliver the precast girders to the site designated by the **Owner** and in accordance with the indications on the drawings, on land belonging to the **Owner** and located in the Greater Montreal area.

6.36.4.4 QUALITY CONTROL

6.36.4.4.1 In addition to the quality control process to be carried out by the **Contractor**, the fabrication of the girders and tensioning of the strands will also be checked by an external firm retained by the **Owner**. The **Owner** will bear the cost of these independent checks. The **Contractor** shall collaborate with the firm retained by the **Owner** in order to facilitate the supervision work.

6.36.4.4.2 The **Contractor** shall, before taking corrective measures, report to the Engineer in writing any defect in the fabrication of the girders. The corrective measures shall be authorized by the Engineer.

6.36.4.4.3 The **Contractor** shall allow and facilitate the on-site check, by the Engineer, of the tensioning of the strands, failing which the work will be deemed defective.

6.36.5 STRENGTHENING OF PRESTRESSED GIRDERS 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 For the anchor blocks, unless otherwise indicated on the drawings, the **Contractor** shall use new high strength steel bars having a nominal ultimate strength of 1030 MPa and compliant with standard ASTM A722/A722M.

6.36.5.1.1.2 For each high strength steel bars delivery and at least fourteen (14) days prior to the tensioning of the prestressing reinforcement, the **Contractor** shall, for each production batch, provide the Engineer with a certificate of conformity containing the following information, without however being limited thereto:

6.36.5.1.1.2.1 the name of the prestressing reinforcement manufacturer;

6.36.5.1.1.2.2 the nominal diameter and the grade;

6.36.5.1.1.2.3 the stress-strain diagram;

6.36.5.1.1.2.4 the certificate on the ultimate strength and elastic modulus;

6.36.5.1.1.2.5 the production batch number.

6.36.5.1.1.3 Any steel received that is not identified will be rejected.

6.36.5.1.1.4 When a delivery control is carried out by the **Owner**, the sample collection will consist of two (2) 1500 mm bars per production batch.

6.36.5.1.1.5 For the prestressing cables manufactured outside the worksite, the **Contractor** shall replace, on worksite, the strands on which a sample is collected.

6.36.5.1.2 Sheathed and greased strands

6.36.5.1.2.1 Unless otherwise indicated on the drawings, all post-tensioning steel strands shall be 1860 MPa grade low-relaxation strands in accordance with 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 Engineer with the results of tests carried out by a Canadian laboratory that is a member of the *Association des firmes de génie-conseil - Québec* (*AFG*) showing that the physical and chemical properties are compliant.

6.36.5.1.2.3 The composition of the prestressing cables, the number of single strands, the diameters and the number of wires shall be as indicated on the drawings.

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 execute joints or make splices in the strands.

6.36.5.1.3 Anchor heads, anchor cones and isolation casings

6.36.5.1.3.1 The 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 The anchor cones and related materials at each end of the steel cables shall be of the type recommended by the anchor head manufacturer and shall be accepted 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 The new isolation casings shall be compatible with the anchor plates to which they will be fixed.

6.36.5.1.4 Sheaths

6.36.5.1.4.1 The sheaths for high strength steel bars shall be made of galvanized steel.

6.36.5.1.4.2 The sheaths for post-tensioning strands shall be *Fusolene* smooth-walled high-density polyethylene (HDPE) pipes manufactured by Plasti-Drain Ltée or equivalent authorized by the Engineer. They shall be equipped with appropriate sleeve fittings and adaptors so that they can be connected as recommended by the manufacturer.

6.36.5.1.4.3 The HDPE pipes shall be resistant to the effects of ultraviolet radiation and capable of withstanding pressures of at least 1000 kPa.

6.36.5.1.4.4 Unless otherwise indicated on the drawings, all sheath fittings (splices) shall be merged.

6.36.5.1.4.5 Each strand individual sheath shall be made of *Shell Polypropylene HMA 6100* polypropylene (PP) manufactured by Shell Chemicals or equivalent authorized by the Engineer.

6.36.5.1.5 Grease

6.36.5.1.5.1 The grease used shall meet the corrosion protection standards for agressive environments as specified by the Post-Tensioning Institute (PTI), and shall be the product *Visconorust PT1000* manufactured by Viscosity Oil or equivalent authorized by the Engineer.

6.36.5.1.6 Injection grout for prestressed concrete girders

6.36.5.1.6.1 At least fourteen (14) days prior to the date scheduled for the start of injection work, the **Contractor** shall submit to the Engineer, for review, the technical data sheet of the bagged injection grout or, in the case of grout prepared on worksite, representative samples of the cement and plasticizer it proposes to use. No injection work will be permitted without the prior authorization of the grout mix formula by the Engineer.

6.36.5.1.6.2 The injection grout used shall meet the resistance requirements such as the properties, fluidity, bleeding time and free expansion stipulated in MTQ standard 3901.

6.36.5.1.6.3 The compressive strength of the grout is determined using 50 mm cube samples stored and tested in accordance with standard CAN/CSA A23.2-1B *Determining the Fluid Grout Properties.* The tests are carried out by the Owner's Laboratory, at the **Owner**'s expense.

6.36.5.1.6.4 The grout prepared on worksite shall consist of the following:

6.36.5.1.6.4.1 a type GU cement;

6.36.5.1.6.4.2 an expandable plasticizer, the product *Intraplast-N* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer and used in the proportions recommended by the manufacturer;

6.36.5.1.6.4.3 the amount of water needed to obtain the minimum water/cement ratio, which shall be 0.4 and produce the compressive strength indicated on the drawings;

6.36.5.1.6.4.4 an air content of 5% to 7%.

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

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 supply new height- and width-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 as indicated on the drawings.

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

6.36.5.1.7.4 The welds shall meet the requirements of standard CSA W59.

6.36.5.1.7.5 The high-strength bolts and the nuts and washers shall be galvanized and shall comply with standard ASTM A325.

6.36.5.1.7.6 The U-bolts shall be new, galvanized and 10 mm in diameter and shall comply with standard ASTM A307.

6.36.5.1.7.7 All components of the external post-tensioning supports shall be hot dip galvanized in accordance with standard ASTM A123/A123M.

6.36.5.1.7.8 After tensioning is complete, the **Contractor** shall touch up by applying two (2) coats on all surfaces whose galvanizing has been damaged, including the portion of the unused and exposed threads. The touch-up material shall be submitted to the Engineer for review.

6.36.5.2 INSPECTION AND STORAGE

6.36.5.2.1 The **Contractor** shall ensure that all materials constituting the post-tensioning cables are unloaded and stored with utmost care and protected against any aggression (including, without limitation, direct contact with the ground, adverse weather conditions and condensation).

6.36.5.2.2 In particular, the sheathed and greased strands shall be adequately protected until they are coated with grout.

6.36.5.2.3 The Engineer may refuse to allow the use of any material that he deems damaged or unsuitable for its intended use.

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 dial pressure gauge at least 150 mm in diameter, and each jack-pressure gauge set shall be accompanied by a certified calibration graph establishing the ratio between the readings and the force of the two movements, upward and downward, of the piston.

6.36.5.3.3 Grout mixer

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

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

6.36.5.3.4 Grout pump

6.36.5.3.4.1 The grout shall be injected using a progressive cavity pump equipped with a pressure gauge and a flow sensor.

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

6.36.5.4 EXECUTION OF WORK

6.36.5.4.1 Work planning

6.36.5.4.1.1 At least fourteen (14) days prior to the start of work, the **Contractor** shall provide the Engineer, for review, with the technical data sheets and a sample of each of the following materials: single strand, steel strand, high strength steel bar, anchoring devices and grease. The samples shall be accompanied by two (2) 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 to the Engineer, for review, the drawings of the sheath supports.

6.36.5.4.1.2 The **Contractor** shall not start the fabrication or installation of the post-tensioning elements before having obtained 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 to the Engineer, for review, the system details, namely the drawings, design notes as well as any other technical information relating to the system that it proposes to use for the post-tensioning, including, without however being limited to:

6.36.5.4.1.3.1 the contemplated tensioning method and sequence;

6.36.5.4.1.3.2 the complete specifications;

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

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

6.36.5.4.1.3.5 the tension forces;

6.36.5.4.1.3.6 the elongation calculations;

6.36.5.4.1.3.7 the losses;

6.36.5.4.1.3.8 the grout injection equipment and materials;

6.36.5.4.1.3.9 the details of the HDPE pipes and air outlet ports;

6.36.5.4.1.3.10 any other relevant data relating to the post-tensioning work.

6.36.5.4.1.4 Prior to drilling in the girders including the upper cap, the stiffeners and the diaphragms, the **Contractor** shall submit to the Engineer, for review, its survey of the passive reinforcement and existing prestressing reinforcement as well as its proposed drilling location. The **Contractor**'s survey shall include the coordinates (x, y, z) and comprise a single reference system for all surveyed elements.

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

6.36.5.4.3 Within twenty-four (24) hours of each demolition operation, the **Contractor** shall notify the Engineer so that the latter conducts a survey of the deterioration of the prestressing sheaths, cables and wires in the demolished or drilled areas and shall provide the labour and equipment needed to continue the demolition in the locations where the Engineer may deem it necessary to complete his survey.

6.36.5.4.4 The creation of exploratory openings in the girder concrete shall be carried out in the presence of the Engineer.

6.36.5.4.5 After conducting an on-site assessment of the damage to the existing cables in the prestressed girders, the Engineer will determine the type of work required to strengthen the girders.

6.36.5.4.6 The Engineer will determine the tension in each new external post-tensioning cable based on the extent of damage to the existing cables and on the adjacent girder existing cambers. The **Contractor** shall provide both its surveyor and the Engineer access to the adjacent girders in order to allow for the survey of the adjacent girder camber and to follow the increase of the camber of the girder that is the subject of the post-tensioning. The **Contractor** shall take into consideration, in the preparation of its method and the sequence contemplated for the tensioning, the procedure of control of the additional external post-tensioning.

6.36.5.4.7 Construction of the new the anchor blocks

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

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

6.36.5.4.7.3 Holes shall be drilled in the girder flanges to allow the placement of the galvanized reinforcing steel and high strength steel bars as indicated on the drawings and in the location survey of the existing steel elements.

6.36.5.4.7.4 The holes for the reinforcing steel bars and high strength steel bars shall not be diamond drilled. The **Contractor** shall use a template for that purpose. If a reinforcing bar or prestressing cable is intercepted, the **Contractor** shall stop drilling and notify the Engineer to obtain his guidance. Where applicable, the hole shall be re-drilled at the **Contractor**'s expense.

6.36.5.4.7.5 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 sketch showing the location of the drilled holes.

6.36.5.4.7.6 Saw cuts shall be executed in order to delineate the area to be demolished for the construction of the new anchor blocks in accordance with subsection 6.21 *Demolition and Removal*.

6.36.5.4.7.7 The existing membrane on the girders shall be removed at the locations of the new anchor blocks and sheath supports.

6.36.5.4.7.8 All the concrete surfaces of the existing flanges that will come into contact with the new anchor block concrete shall be demolished to a depth of 50 mm. The **Contractor** shall take note that the concrete in that location is usually sound and encumbered with reinforcing steel, hardware and prestressing cables, thus difficult to demolish.

6.36.5.4.7.9 The demolition of the concrete of the girder faces shall meet the requirements of subsection 6.21 *Demolition and Removal* and the indications on the drawings.

6.36.5.4.7.10 The high strength steel bars, as well as the sheaths, cones, plates, casings and anchor accessories shall be implemented.

6.36.5.4.7.11 The **Contractor** shall supply and install the galvanized reinforcing steel for the anchor blocks.

6.36.5.4.7.12 The placement of the reinforcing steel shall meet the requirements of subsection 6.31 *Concrete Reinforcement* and the instructions on the drawings.

6.36.5.4.7.13 The anchor block formwork shall be fabricated so as to comply with the concreting phases indicated on the drawings.

6.36.5.4.7.14 The formwork shall meet the requirements of subsection 6.32 *Formwork* and the indications on the drawings.

6.36.5.4.7.15 The **Contractor** shall supply and place the anchor block first-phase and second-phase concrete.

6.36.5.4.7.16 Unless otherwise indicated on the drawings, the anchor block first-phase and second-phase concrete shall have a nominal strength of 50 MPa.

6.36.5.4.7.17 The surface preparation for the second-phase concreting shall be carried out by means of abrasive blasting and water blast cleaning in accordance with subsection 6.21 *Demolition and Removal*.

6.36.5.4.7.18 The concreting shall meet the requirements of subsection *6.33 Cast-in-Place Concrete* and the indications on the drawings.

6.36.5.4.8 Placement and tensioning

6.36.5.4.8.1 Every tensioning operation shall be supervised, at all times on the worksite, by an engineer of the **Contractor** who is a member of the *Ordre des ingénieurs du Québec* (*OIQ*) and has at least ten (10) years of relevant experience in the field of strengthening by post-tensioning. If this requirement is not met, the **Contractor** will not be allowed to proceed with the strengthening by post-tensioning.

6.36.5.4.8.2 The tensioning of the new steel strands and high strength steel bars shall be carried out by persons who have at least five (5) years of relevant experience in that field. A proof of the competency of the proposed persons shall be submitted to the Engineer prior to the start of post-tensioning work.

6.36.5.4.8.3 The compressive strength of the anchor block first-phase concrete at the time of tensioning of the high strength steel bars and of the strands shall not be less than 25 MPa unless otherwise indicated on the drawings.

6.36.5.4.8.4 The strength of the anchor block concrete prior to tensioning shall, if required by the Engineer, be confirmed by destructive testing.

6.36.5.4.8.5 The **Contractor** shall carry out the tensioning as directed by the prestressing material manufacturer. This work shall be carried out in the presence of the **Contractor**'s engineer.

6.36.5.4.8.6 The high strength steel bars shall be tensioned according to the values indicated on the drawings or as directed by the Engineer.

6.36.5.4.8.7 The **Contractor** shall insert the sheathed and greased strands into the HDPE sheaths and anchor assemblies and fix the sheaths on the steel supports next to the girder flanges as indicated on the drawings.

6.36.5.4.8.8 The sheath supports for longitudinal post-tensioning and the temporary supports shall be installed so as to limit the deflection of the HDPE sheaths to 3 mm between the supports during grout injection. The permanent supports shall be installed according to the spacing shown on the drawings. The temporary support method shall be submitted to the Engineer for review.

6.36.5.4.8.9 The supports shall be positioned so that the strands are centered in the new sheaths.

6.36.5.4.8.10 The **Contractor** shall provide for a tensioning sequence that comprises a gradual tensioning of the strands, one at a time, alternating on either side of the girders and starting on the side where the concrete deterioration is the most severe. The maximum permissible difference in tension between the cables on the upstream side of the girder and those on the downstream side will be assessed by the Engineer before tensioning begins and after the extent of deterioration of the existing cables has thereby been analysed. The **Contractor** shall await instructions from the Engineer before proceeding with the tensioning of the new cables.

6.36.5.4.8.11 The **Contractor** shall exert the tension so that the jack has the same axis as that of the strand being tensioned.

6.36.5.4.8.12 The steel strands shall be tensioned according to the values indicated on the drawings. 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 he has assessed the damage to the existing cables.

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

6.36.5.4.8.14 The isolation casings shall be fully injected with grease after tensioning is complete.

6.36.5.4.9 Grout injection

6.36.5.4.9.1 The **Contractor** shall protect the sheathed and greased strands and high strength steel bars by injecting grout over the entire length of the sheaths in accordance with Article 6.8.7 *Grout* of standard CAN/CSA A23.1.

6.36.5.4.9.2 The tensioning of the post-tensioning elements shall be completed prior to the grout injection.

6.36.5.4.9.3 No injection work will be permitted until the grout mix formula has been previously reviewed by the Engineer.

6.36.5.4.9.4 The **Contractor** shall install injection tubes and vents (air outlet ports) to prevent air entrapment in the sheaths.

6.36.5.4.9.5 The steel shall be free of any dirt, rust, oil, grease or other deleterious substances when it is coated with grout.

6.36.5.4.9.6 The injection shall always be carried out starting at the lower end of the sheaths in order to prevent the risk of air entrapment.

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

6.36.5.4.9.8 The time lapse between the mixing and pumping of the grout shall not exceed forty (40) minutes.

6.36.5.4.9.9 The grout temperature at the time of injection shall not be below 16°C or above 27°C.

6.36.5.4.9.10 If the injection work cannot maintain the unidirectional flow, the **Contractor** shall thoroughly clean out the HDPE pipes and the sheaths immediately in accordance with Article 6.8.7 *Grout* of standard CAN/CSA A23.1.

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

6.36.5.4.10 Second-phase concreting and waterproofing membrane

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

6.36.5.4.10.2 The surface of the exterior anchor blocks shall be covered with a waterproofing membrane as indicated on the drawings and in accordance with 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 worksite improvisation.

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

6.36.5.5.3 The **Contractor** shall provide the Engineer with the cable elongation values and indicate the maximum permissible 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 jack pressure gauge by comparing it to another pressure gauge mounted on the system.

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

6.36.5.5.6 The tension in the steels shall be determined by measuring the elongation thereof, continuously checked by means of the jack pressure gauge.

6.36.5.5.7 The **Contractor** shall determine the error at the zero point of the jack's traction by taking a few direct readings of the elongation of the steels at the jack. These readings shall subsequently be plotted on a diagram and connected to each other by a line. The extension of that line to the point of interception with the horizontal axis makes it possible to estimate that error.

6.36.5.5.8 The **Contractor** shall apply tension and limit it so as to obtain an effective prestressing force compliant with the values indicated on the drawings and, where applicable, by the Engineer.

6.36.5.5.9 The post-tensioning elongation surveys, tensile stress readings at the jack pressure gauge and cable slip shall be accepted 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, member of the OIQ, shall be sent to the Engineer at the end of the work.

6.36.6 STRENGTHENING OF THE PIER CAPS BY ADDING POST-TENSIONING

6.36.6.1 This article specifies the requirements for the addition of prestressing on pier caps.

6.36.6.2 MATERIALS

6.36.6.2.1 The **Contractor** is responsible for the selection of the products used and performance thereof once implemented.

6.36.6.2.2 Following a joint inspection of the structural elements by the prestressing **Contractor**'s engineer and the Engineer, the **Contractor** may, with the prior written authorization from the Engineer, make such changes to the materials or installation details that it deems required.

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

6.36.6.2.4 High strength steel bars

6.36.6.2.4.1 The high strength steel bars shall be galvanized, 1030 MPa grade and compliant with standard ASTM A722/A722M, and shall be the product *DYWIDAG* manufactured by DSI or equivalent authorized by the Engineer.

6.36.6.2.4.2 All high strength steel bars of every delivery to the worksite by the supplier shall have an individual lot number and bear a label so that each lot, as well as the delivery date, may be identified accurately. Any steel received that is not identified will be rejected.

6.36.6.2.4.3 The high strength steel bars, their washers, nuts and other accessories shall be galvanized in accordance with standards ASTM A123/A123M, ASTM A143/A143M and ASTM A722/A722M and the manufacturer's recommendations.

6.36.6.2.5 Welded sleeves, conical nuts, washers and other accessories

6.36.6.2.5.1 The welded sleeves shall be the product *DYWIDAG* or equivalent authorized by the Engineer and shall be installed so that the post-tensioned steel cannot twist or loop or be damaged in any other way.

6.36.6.2.5.2 The conical nuts and the washers, plates and related materials at the pull end of the bars shall be of the type recommended by the high strength steel bar manufacturer and accepted by the Engineer.

6.36.6.2.5.3 The welded sleeves, the conical nuts and the washers, plates and other accessories shall be hot dip galvanized in accordance with standard ASTM A123/A123M and with the manufacturer's recommendations.

6.36.6.2.6 Sheaths

6.36.6.2.6.1 The sheaths for post-tensioning high strength steel bars shall be the product *Fusolene* smooth-walled HDPE pipes manufactured by Plasti-Drain Ltée or equivalent authorized by the Engineer. They shall be equipped with appropriate sleeve fittings and adaptors so that they can be connected as recommended by the manufacturer.

6.36.6.2.6.2 The sheaths shall be resistant to the effects of ultraviolet radiation and capable of withstanding pressures of at least 1000 kPa.

6.36.6.2.6.3 All sheath connections and splices shall be fused.

6.36.6.2.7 Injection grout

6.36.6.2.7.1 The injection grout used shall comply with Article 6.36.5.1.6 *Injection Grout for Prestressed Concrete Girders.*

6.36.6.2.8 External post-tensioning sheath supports

6.36.6.2.8.1 The sheath supports shall comply with Article 6.36.5.1.7 *External Post-Tensioning Sheath Supports*.

6.36.6.3 INSPECTION AND STORAGE

6.36.6.3.1 The bars shall be stored so as to prevent any deformation and deterioration such as corrosion pits.

6.36.6.3.2 The **Contractor** shall facilitate the verification of the condition of the bars or strands prior to implementation thereof.

6.36.6.3.3 The bars shall, at the time of implementation, be clean, free of oil, grease or rust. They shall be cut by grinding and not with a torch. All bars in poor condition shall be replaced at the **Contractor**'s expense.

6.36.6.4 EQUIPMENT AND TOOLS

6.36.6.4.1 All equipment used for tensioning and grout injection shall comply with Article 6.36.5.3 *Equipment and Tools*.

6.36.6.5 EXECUTION OF WORK

6.36.6.5.1 Fourteen (14) days prior to implementing the post-tensioning, the **Contractor** shall submit to the Engineer, for review, a tensioning procedure representing the installation and the tensioning technical sheets, specifying the equipment, the tensioning method and sequence and the provisions concerning the safety of the personnel.

6.36.6.5.2 The tension shall be measured using the jack pressure gauge and be such that the tension following the anchor return is 680 MPa. The applied tension shall be checked by measuring the elongation of the bars. The assumptions on the anchor return shall be checked by measuring the elongation of the bars during the tensioning, in increments of 10%, up to the maximum tension before the anchor return and after the anchor withdrawal. The difference in the prestressing forces obtained by the two (2) measurements shall not be greater than 5%. If the difference is greater than 5%, the **Contractor** shall have the corrective measures thereby proposed accepted by the Engineer. The Engineer may change the tension value prior to the tensioning of the bars or request a re-tensioning in function of the observed anchor returns.

6.36.6.5.3 After final tensioning, the bars shall be cut by grinding and covered with two (2) layers of one of the cold galvanizing products specified in Article 6.41.6.5 *Repair after galvanizing* of subsection 6.41 *Steelworks*.

6.36.6.6 GROUT INJECTION

6.36.6.6.1 The **Contractor** shall protect the high strength steel bars by injecting grout over the entire length of the sheaths.

6.36.6.6.2 The tensioning of the post-tensioning elements shall be completed prior to the grout injection.

6.36.6.6.3 No injection work will be permitted until the grout mix formula has been previously reviewed by the Engineer.

6.36.6.6.4 The **Contractor** shall install injection tubes and vents to prevent air entrapment in the sheaths.

6.36.6.6.5 The steel shall be free of any dirt, rust, oil, grease or other deleterious substances when it is coated with grout.

6.36.6.6.6 The injection shall always be carried out starting at the lower end of the sheaths in order to prevent the risk of air entrapment.

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

6.36.6.6.8 The time lapse between the mixing and pumping of the grout shall not exceed forty (40) minutes.

6.36.6.6.9 The grout temperature at the time of injection shall not be below 16°C or above 27°C.

6.36.6.6.10 If the injection work cannot maintain the unidirectional flow, the **Contractor** shall thoroughly clean out the HDPE sheaths immediately in accordance with Article 6.8.7 *Grout* of standard CAN/CSA A23.1.

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

6.36.7 STRENGTHENING OF THE UPPER PORTION OF THE PIERS BY POST-TENSIONING

6.36.7.1 MATERIALS

6.36.7.1.1 High strength steel bars

6.36.7.1.1.1 The **Contractor** shall use new high strength steel bars having a nominal ultimate strength of 1030 MPa and compliant with standards ASTM A722/A722M and CAN/CSA S6. All nuts, washers and other accessories shall also be supplied by the steel bar manufacturer. The bar bearing plates shall be 300W grade steel and compliant with standard CAN/CSA G40.21.

6.36.7.1.1.2 Each lot of high strength steel bars delivered to the worksite shall have an individual lot number and bear a label so as to allow the traceability through the certificates from the steel mill from which it originates. Any steel received that is not identified will be rejected.

6.36.7.1.2 Injection grout

6.36.7.1.2.1 At least fourteen (14) days prior to the date scheduled for the start of injection work, the **Contractor** shall submit to the Engineer, for review, representative samples of the cement and plasticizer it proposes to use. No injection work will be permitted without the prior authorization of the grout mix formula by the Engineer.

6.36.7.1.2.2 The injection grout shall comply with MTQ standard 3901 and have the following properties:

Properties	Test Methods	Requirements
Minimum compressive strength	CAN/CSA A23.2-1B	20.0 MPa at 7 days 35.0 MPa at 28 days
Fluidity	ASTM C939 ASTM C939 modified[1]	> 12 sec. and < 35 sec. > 9 sec. and < 20 sec.
Temperature	ASTM C1064/C1064M	5ºC < T < 30ºC

[1] Contrary to the requirements of standard ASTM C939, the cone is completely filled with grout and the measured time is that corresponding to the flow of a first liter of grout.

6.36.7.1.2.3 The grout products meeting the requirements for the purpose of this Contract are the following:

- *Euco Cable Grout PTX* manufactured by Euclid Canada Inc.;
- *MASTERFLOW 1205* manufactured by BASF;
- *Sikagrout 300 PT* manufactured by Sika Canada Inc.;
- Any other equivalent product authorized by the Engineer.

6.36.7.1.3 Leveling grout

6.36.7.1.3.1 At least fourteen (14) days prior to the date scheduled for the start of injection work, the **Contractor** shall submit to the Engineer, for review, representative samples of the leveling grout it proposes to use. No injection work will be permitted without the prior authorization of the leveling grout mix formula by the Engineer.

6.36.7.1.3.2 The leveling grout shall be the product *Sikagrout 212* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer.

6.36.7.1.4 Filler concrete

6.36.7.1.4.1 The anchoring niches shall be concreted after the prestressing grout injection.

6.36.7.1.4.2 The anchoring niche filler concrete shall be bagged self-consolidating, the product *Sikacrete-08 SCC* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer.

6.36.7.2 INSPECTION AND STORAGE

6.36.7.2.1 The high strength steel bars and accessories thereof shall be protected against corrosion and other damages during handling, transportation, storage and implementation.

6.36.7.2.2 The Engineer may refuse to allow the use of any material that he deems damaged or unsuitable for its intended use.

6.36.7.3 EQUIPMENT AND TOOLS

6.36.7.3.1 All equipment used for demolition, tensioning and grout injection shall comply with Article 6.36.5.3 *Equipment and Tools.*

6.36.7.4 EXECUTION OF WORK

6.36.7.4.1 Work planning

6.36.7.4.1.1 At least fourteen (14) days prior to the start of the work covered by this subsection, the **Contractor** shall submit to the Engineer, for review, the workshop drawings and the procedure for the installation of the high strength steel bars, anchoring devices, bearing plates, nuts, and all parts and fittings needed to carry out the work including, without however being limited to:

6.36.7.4.1.1.1 the contemplated tensioning method and sequence;

6.36.7.4.1.1.2 the technical specifications of materials and equipment;

6.36.7.4.1.1.3 the details of the steel post-tensioning elements, reinforcing steel and high strength steel bars;

6.36.7.4.1.1.4 the anchoring devices;

6.36.7.4.1.1.5 the tension forces;

6.36.7.4.1.1.6 the elongation calculations;

6.36.7.4.1.1.7 the losses;

6.36.7.4.1.1.8 the grout injection equipment and materials;

6.36.7.4.1.1.9 the details of the air outlet ports;

6.36.7.4.1.1.10 any other relevant data relating to the work.

6.36.7.4.1.2 At least seven (7) days prior to the start of drilling, the **Contractor** shall provide the Engineer, for review, with a plan showing the location of the high strength steel bars.

6.36.7.4.1.3 All design notes, procedures and other documents shall be signed by the **Contractor**'s engineer who is a member of the OIQ.

6.36.7.4.1.4 The **Contractor** shall not start the fabrication or installation of the post-tensioning elements before having obtained authorization from the Engineer.

6.36.7.4.2 Demolition of the niches

6.36.7.4.2.1 The **Contractor** shall, prior to undertaking the demolition of the niches, have moved the drains as described in subsection 6.21 *Demolition and Removal*.

6.36.7.4.2.2 The demolition of the niches shall meet the requirements of subsection 6.21 *Demolition and Removal.*

6.36.7.4.3 Drilling

6.36.7.4.3.1 At least fourteen (14) days prior to the start of the drilling work, the **Contractor** shall submit to the Engineer the detailed description of the drilling method and procedure, specifying the type of equipment used, the type of drilling carried out, the drill hole cleaning procedures, the materials used, accompanied by the technical data sheets thereof, the sketching necessary for understanding and any other information deemed necessary or required by the Engineer.

6.36.7.4.3.2 The **Contractor** is responsible for the drilling method used.

6.36.7.4.3.3 The **Contractor** shall drill the holes with a diamond core drill.

6.36.7.4.3.4 The inclination of each hole shall have a maximum deviation of ± 2° relative to the horizontality indicated on the drawings. The permissible deviations for the drill holes are restricted, in all directions, to 2% of the drilled length relative to the theoretical position of the holes.

6.36.7.4.3.5 Following drilling, the Engineer will check inside the hole to ensure that no damage has been done to the elements in place.

6.36.7.4.4 Placement and tensioning

6.36.7.4.4.1 Every tensioning operation shall be supervised, at all times on the worksite, by the **Contractor**'s engineer member of the OIQ and has at least ten (10) years of relevant experience in the field of strengthening by post-tensioning. In case of failure to comply with this requirement, the **Contractor** will not be allowed to proceed with the tensioning work.

6.36.7.4.4.2 The **Contractor** shall notify the Engineer at least twenty-four (24) hours prior to inserting the bars into the drill holes in order for him to inspect the bars to ensure that the bars, the protection against corrosion and the accessories meet the requirements indicated on the drawings and in the specifications, the design notes and the manufacturer's recommendations. The bars that do not meet the requirements will be declared non-compliant. Where applicable, the non-compliances shall be corrected or the non-compliant bar shall be replaced, all at the **Contractor**'s expense.

6.36.7.4.4.3 The use of mechanical, pneumatic or hydraulic hammers is not authorized for the placement of the anchor bars in the drill holes. If the anchor bar cannot be inserted into the hole by gravity or thrust, the bar shall be removed and the drill hole shall be cleaned.

6.36.7.4.4.4 The tensioning of the high strength steel bars shall be carried out by persons having at least five (5) years of relevant experience in that field. A proof of competency of the proposed personnel shall be submitted to the Engineer before the start of work.

6.36.7.4.4.5 The **Contractor** shall carry out the tensioning in accordance with the prestressing material manufacturer's recommendations. This work shall be carried out in the presence of the **Contractor**'s engineer.

6.36.7.4.4.6 The **Contractor** shall tension the high strength steel bars when the compressive strength of the leveling grout has reached at least 25 MPa.

6.36.7.4.5 Grout injection

6.36.7.4.5.1 The **Contractor** shall protect the high strength steel bars by injecting grout over the entire length of the drill holes.

6.36.7.4.5.2 The tensioning of the high strength steel bars shall be completed prior to the grout injection.

6.36.7.4.5.3 No injection work will be permitted until the grout mix formula has been previously reviewed by the Engineer.

6.36.7.4.5.4 The **Contractor** shall use steel plates having injection ports at one end of the rigid bars and vent ports, air outlet ports, at the other end to prevent air entrapment in the drill holes.

6.36.7.4.5.5 The steel shall be free of any dirt, rust, oil, grease or other deleterious substances when it is coated with grout.

6.36.7.4.5.6 The grout shall be mixed by volume so that the time elapsed between mixing and pumping thereof does not exceed the lesser of the limit specified by the plasticizer manufacturer and forty (40) minutes. The **Contractor** shall not mix a second batch of a same volume of grout.

6.36.7.4.5.7 The grout temperature at the time of injection shall not be below 16°C or above 27°C.

6.36.7.4.5.8 If the injection work cannot maintain the unidirectional flow, the **Contractor** shall thoroughly clean out the holes immediately in accordance with Article 6.8.7 *Grout* of standard CAN/CSA A23.1.

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

6.36.7.5 QUALITY CONTROL

6.36.7.5.1 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 worksite improvisation.

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

6.36.7.5.3 At least fourteen (14) days prior to the tension work, the **Contractor** shall provide the Engineer with the high strength steel bar elongation values and indicate the maximum permissible 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.

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

6.36.7.5.5 The permissible deviation relative to the prescribed post-tensioning force shall not exceed 5%.

6.36.7.5.6 The tension in the steel bars shall be determined by measuring the elongation thereof, and continuously double-checked by means of the jack pressure gauge.

6.36.7.5.7 The **Contractor** shall apply tension and limit it so as to obtain an effective prestressing force compliant with that indicated the drawings.

6.36.7.5.8 The post-tensioning elongation surveys, tensile stress readings at the jack pressure gauge and high strength steel bar slip shall be accepted by the Engineer.

6.36.7.5.9 A copy of the tensioning report signed by the **Contractor**'s engineer, member of the OIQ, shall be sent to the Engineer at the end of the tensioning work.

6.36.8 PRESTRESSING BY POST-TENSIONING OF THE DECK SLABS

6.36.8.1 MATERIALS

6.36.8.1.1 The **Contractor** is responsible for the selection of the products used and performance thereof once implemented.

6.36.8.1.2 Following a joint inspection of the structural elements by the **Contractor**'s engineer specialized in prestressing and the Engineer, the **Contractor** may, with the prior written authorization from the Engineer, make such changes to the materials or installation details that it deems required.

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

6.36.8.1.4 Prestressing reinforcement

6.36.8.1.4.1 Sheathed and greased strands

6.36.8.1.4.1.1 Unless otherwise indicated on the drawings, all post-tensioning steel strands shall be 1860 MPa grade low-relaxation strands compliant with standards ASTM A416/A416M and ASTM A421/A421M.

6.36.8.1.4.1.2 All prestressing cables of every delivery to the worksite by the supplier shall have an individual lot number and bear a label so that each lot, as well as the delivery date, may be identified accurately. Any steel received that is not identified will be rejected.

6.36.8.1.4.1.3 If the source of the strands is neither Canadian nor American, the **Contractor** shall provide the Engineer with the results of tests carried out by a Canadian laboratory, member of *AFG*, showing that the physical and chemical properties are compliant.

6.36.8.1.4.1.4 The composition of the prestressing cables, namely the number of strands and diameter thereof, shall be as indicated on the drawings.

6.36.8.1.4.1.5 The **Contractor** shall not execute joints or make splices in the strands.

6.36.8.1.4.2 Anchor heads and cones

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

6.36.8.1.4.2.2 The anchor cones and related materials at each end of the steel cables shall be of the type recommended by the anchor head manufacturer and shall be accepted by the Engineer.

6.36.8.1.4.3 Sheaths

6.36.8.1.4.3.1 The sheaths for post-tensioning strands shall be *Fusolene* smooth-walled HDPE pipes manufactured by Plasti-Drain Ltée or equivalent authorized by the Engineer. They shall be equipped with appropriate sleeve fittings and adaptors so that they can be connected as recommended by the manufacturer.

6.36.8.1.4.3.2 The HDPE pipes shall be capable of withstanding pressures of at least 1000 kPa.

6.36.8.1.4.3.3 All sheath connections and splices shall be fused.

6.36.8.1.4.4 Injection grout

6.36.8.1.4.4.1 At least fourteen (14) days prior to the date scheduled for the start of injection work, the **Contractor** shall submit to the Engineer, for review, representative samples of the cement and plasticizer it proposes to use. No injection work will be permitted without the prior authorization of the grout mix formula by the Engineer.

6.36.8.1.4.4.2 The injection grout used shall meet the requirements stipulated in MTQ standard 3901.

6.36.8.1.4.4.3 The compressive strength of the grout shall be superior to 20 MPa after seven (7) days and at 35 MPa after twenty-eight (28) days. The compressive strength shall be determined using 50 mm cube samples stored and tested in accordance with standard ASTM C109/C109M. Tests will be carried out by the Owner's Laboratory, at the **Owner**'s expense.

6.36.8.1.4.4.4 The grout shall consist of the following:

6.36.8.1.4.4.4.1 a type GU cement;

6.36.8.1.4.4.4.2 an expandable plasticizer, the product *Intraplast-N* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer and used in the proportions recommended by the manufacturer;

6.36.8.1.4.4.4.3 the amount of water needed to obtain the minimum water/cement ratio, which shall be 0.4 and produce the compressive strengths specified in paragraph 6.36.8.1.4.4.3;

6.36.8.1.4.4.4.4 an air content of 5 to 7%.

6.36.8.1.4.4.5 The **Contractor** shall not incorporate calcium chloride into the grout or any admixture containing calcium chloride.

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

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

6.36.8.1.4.4.8 At the time of initial set, within approximately three (3) hours, the grout shall expand by 8% relative to the initial volume thereof.

6.36.8.2 INSPECTION AND STORAGE

6.36.8.2.1 The **Contractor** shall ensure that all materials constituting the post-tensioning cables are unloaded and stored with utmost care and protected against any aggression including, without limitation, direct contact with the ground, adverse weather conditions and condensation.

6.36.8.2.2 In particular, the sheathed and greased strands shall be adequately protected until they are coated with grout.

6.36.8.2.3 The Engineer may refuse to allow the use of any material that he deems damaged or unsuitable for its intended use.

6.36.8.3 EQUIPMENT AND TOOLS

6.36.8.3.1 All equipment used for tensioning and grout injection shall comply with Article 6.36.5.3 *Equipment and Tools*.

6.36.8.4 EXECUTION OF WORK

6.36.8.4.1 Work planning

6.36.8.4.1.1 At least fourteen (14) days prior to the start of work, the **Contractor** shall provide the Engineer, for review, with the technical data sheets and one sample of each of the following materials: single strand, high strength steel bar, anchoring devices and grease. The samples shall be accompanied by two (2) 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 to the Engineer, for review, the drawings showing the tensioning sequence and grout injection method.

6.36.8.4.1.2 The **Contractor** shall not start the fabrication or installation of the post-tensioning elements before having obtained authorization from the Engineer.

6.36.8.4.1.3 At least fourteen (14) days prior to the start of post-tensioning work, the **Contractor** shall submit to the Engineer, for review, the system details, namely the drawings, design notes as well as any other technical information relating to the system that the **Contractor** proposes to use for the post-tensioning, including, without however being limited to:

6.36.8.4.1.3.1 the contemplated tensioning method and sequence;

6.36.8.4.1.3.2 the complete specifications;

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

6.36.8.4.1.3.4 the anchoring devices (anchor head and cone);

6.36.8.4.1.3.5 the tension forces;

6.36.8.4.1.3.6 the elongation calculations;

6.36.8.4.1.3.7 the losses;

6.36.8.4.1.3.8 the grout injection equipment and materials;

6.36.8.4.1.3.9 the details of the HDPE pipes and air outlet ports;

6.36.8.4.1.3.10 any other relevant data relating to the post-tensioning work.

6.36.8.4.2 Placement and tensioning

6.36.8.4.2.1 Every tensioning operation shall be supervised, at all times on the worksite, by an engineer who is a member of the OIQ and has at least ten (10) years of relevant experience in the field of post-tensioning. If this requirement is not met, the **Contractor** will not be allowed to proceed with the post-tensioning work.

6.36.8.4.2.2 The tensioning of the new steel strands and high strength steel bars shall be carried out by persons having at least five (5) years of relevant experience in that field. A proof of competency of the proposed personnel shall be submitted to the Engineer prior to the start of post-tensioning work.

6.36.8.4.2.3 The **Contractor** shall carry out the tensioning in accordance with the prestressing material manufacturer's recommendations. This work shall be carried out in the presence of the **Contractor**'s engineer.

6.36.8.4.2.4 The anchoring devices shall be positioned so that the strands are centered in the sheaths.

6.36.8.4.2.5 The **Contractor** shall provide for a tensioning sequence that comprises an alternating gradual tensioning of the strands located on either side of the elements to be prestressed.

6.36.8.4.2.6 The **Contractor** shall exert the tension so that the jack has the same axis as that of the strand being tensioned.

6.36.8.4.2.7 The **Contractor** shall proceed with the tensioning the steel strands according to the values indicated on the drawings. In all cases, the tensioning values shall be validated by the Engineer prior to the start of work.

6.36.8.4.3 Grout injection

6.36.8.4.3.1 The **Contractor** shall protect the sheathed and greased strands by injecting grout over the entire length of the sheaths.

6.36.8.4.3.2 The tensioning of the post-tensioning elements shall be completed prior to the grout injection.

6.36.8.4.3.3 No injection work will be permitted until the grout mix formula has been previously reviewed by the Engineer.

6.36.8.4.3.4 The **Contractor** shall install injection tubes and vents to prevent air entrapment in the sheaths.

6.36.8.4.3.5 The injection shall always be carried out starting at the lower end of the sheaths in order to prevent the risk of air entrapment.

6.36.8.4.3.6 The strands shall be free of any dirt, rust, oil, grease or other deleterious substances when it is coated with grout.

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

6.36.8.4.3.8 The time lapse between the mixing and pumping of the grout shall not exceed forty (40) minutes.

6.36.8.4.3.9 The grout temperature at the time of injection shall not be below 16°C or above 27°C.

6.36.8.4.3.10 If the injection work cannot maintain the unidirectional flow, the **Contractor** shall thoroughly clean out the HDPE pipes and the sheaths immediately in accordance with Article 6.8.7 *Grout* of standard CAN/CSA A23.1.

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

6.36.8.4.4 Sealing

6.36.8.4.4.1 After the final tensioning, the prestressing reinforcement shall be cut by grinding and entirely coated with concrete.

6.36.8.4.4.2 All niches shall be filled with concrete of the same type as that used for the slab.

6.36.8.4.4.3 The sealer concrete shall cover the anchors over a thickness of 75 mm.

6.36.8.4.4.4 The sealing of the anchors shall be carried out within seven (7) days of grout injection.

6.36.8.4.4.5 After a minimum period of twenty-four (24) hours of the end of injection, the vents and drains for which no sealing is provided for on the drawings shall be cut to a minimum depth of 25 mm without however exceeding 50 mm.

6.36.8.4.4.6 The holes left by the removal of the vents and drains shall be filled according to the requirements of subsection 6.32 *Formwork* for the removal of the formwork bracket plastic cones.

6.36.8.5 QUALITY CONTROL

6.36.8.5.1 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 worksite improvisation.

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

6.36.8.5.3 At least fourteen (14) days prior to the tensioning work, the **Contractor** shall provide the Engineer with the cable elongation values and indicate the maximum permissible tensioning force. The **Contractor**'s engineer shall record the actual steel elongation values of the strands and steel bars, the pressure exerted by the jacks and any tension loss at the anchors, if any.

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

6.36.8.5.5 The permissible deviation relative to the prescribed post-tensioning force shall not exceed 5%.

6.36.8.5.6 The tension in the steels shall be determined by measuring the elongation thereof, continuously checked by means of the jack pressure gauge.

6.36.8.5.7 The **Contractor** shall determine the error at the zero point of the jack's traction by taking a few direct readings of the elongation of the steels at the jack. These readings shall subsequently be plotted on a diagram and connected to each other by a line. The extension of that line to the point of interception with the horizontal axis makes it possible to estimate that error.

6.36.8.5.8 The **Contractor** shall apply tension and limit it so as to obtain an effective prestressing force compliant with the drawings.

6.36.8.5.9 The post-tensioning elongation surveys, tensile stress readings at the jack pressure gauge and cable slip shall be accepted by the Engineer.

6.36.8.5.10 A copy of the tensioning report signed by the **Contractor**'s engineer, member of the OIQ, shall be sent to the Engineer at the end of the work.

END OF SUBSECTION