

TENDER DOCUMENTS

SUBSECTION 6.35 INJECTION

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SUBSECTION 6.35 INJECTION

6.35.1 GENERAL

- 6.35.1.1 This subsection describes the requirements relating to crack injection work covered by this Contract.
- 6.35.1.2 Any specific requirements pertaining to crack injection work covered by this Contract are set out on the plans and in Section 4 *Special Technical Conditions*.

6.35.2 MEASUREMENT UNITS

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

| Measurement Unit | Designation | Symbol |
|------------------|--------------------|--------|
| length | meter | m |
| length | millimeter | mm |
| length | micrometer | µm |
| stress, pressure | megapascal | MPa |
| volume | milliliter | mL |
| viscosity | millipascal-second | mPa·s |
| temperature | Celsius degree | °C |
| angle plan | degree | ° |

6.35.3 REFERENCE STANDARDS

- 6.35.3.1 The Contractor shall perform all crack injection work in accordance with the following standards and documents to which the provisions of this Contract are added:
- 6.35.3.1.1 (ASTM) ASTM International:
- ASTM C881/C881M *Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete*.
- 6.35.3.1.2 (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-A23.3 *Design of Concrete Structures*.
- 6.35.3.1.3 (MTQ) Ministère des Transports du Québec:
- MTQ – *Cahier des charges et devis généraux (CCDG) – Construction et réparation*.

6.35.4 MATERIALS

6.35.4.1 INJECTION PRODUCT

6.35.4.1.1 The injection product shall be durable, require no maintenance and no protective measures, provide superior resistance to weather and ozone exposures and show good resistance and stability to low and high temperature cycles.

6.35.4.1.2 The injection product shall be prepared and applied in accordance with the manufacturer's instructions and with the injection program of the Contractor, checked and approved by the Engineer.

6.35.4.1.3 Several types of injection products may be used depending on the size and origin of the crack, on whether or not any water is present and on the required treatment. The type of resin, if any, that the Contractor is required to use under this Contract is indicated on the plans.

6.35.4.1.4 Epoxy resin

6.35.4.1.4.1 The epoxy resin shall be used for the structural repairs of cracks narrower than 6 mm.

6.35.4.1.4.2 The epoxy resin shall be a Type I or IV, Grade-1, Class C and comply with standard ASTM C881/C881M.

6.35.4.1.4.3 The mixed epoxy resin shall have a viscosity of approximately 200 mPa·s \pm 10 mPa·s, at 23°C.

6.35.4.1.4.4 The epoxy resin shall be moisture insensitive.

6.35.4.1.4.5 The epoxy resin shall be the product *Sikadur 52* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer.

6.35.4.1.5 Polyurethane resin

6.35.4.1.5.1 The polyurethane resin shall be used for the permanent sealing of cracks wider than 0.2 mm.

6.35.4.1.5.2 The polyurethane resin shall be Type MDI, 100 % solids and have a reaction time that can be managed by adding a set accelerator.

6.35.4.1.5.3 The polyurethane resin shall meet the following performance criteria, without being limited thereto:

6.35.4.1.5.3.1 low toxicity;

6.35.4.1.5.3.2 no shrinkage after the reaction;

- 6.35.4.1.5.3.3 resistance to freeze-thaw cycles;
- 6.35.4.1.5.3.4 resistance to wetting and drying cycles;
- 6.35.4.1.5.3.5 resistance to low thermal movements.
- 6.35.4.1.5.4 The single-component or two-component polyurethane resin shall have a viscosity between 200 to 350 mPa·s at 23°C.
- 6.35.4.1.5.5 The polyurethane resin shall be the product *SikaFix PU LV* manufactured by Sika Canada Inc. or *Concresive 1250 IUG*, manufactured by BASF or equivalent authorized by the Engineer.
- 6.35.4.1.6 Cement grout
 - 6.35.4.1.6.1 The cement grout shall be used to fill cracks larger than 6 mm and voids that require a large volume of grout.
 - 6.35.4.1.6.2 The cement grout shall have a fineness which, according to the Blaine test, is greater than 625 m²/kg.
 - 6.35.4.1.6.3 The grading of the cement grout shall comply with the specifications indicated in the following table:

| Particle size | % Passing |
|---------------|-----------|
| 40 µm | 100 |
| 30 µm | 98 |
| 20 µm | 97 |
| 15 µm | 94 |
| 10 µm | 77 |
| 5 µm | 44 |
| 2 µm | 16 |

- 6.35.4.1.6.4 The cement grout shall be the product *MasterRoc MP 650* manufactured by BASF or equivalent authorized by the Engineer.
- 6.35.4.1.7 The Contractor remains responsible for the selection of the injection product to use and for the performance thereof once applied.
- 6.35.4.2 CRACK CLEANER
 - 6.35.4.2.1 The cleaner shall be a phosphoric acid-based liquid designed to dissolve laitance, limestone and other contaminants on concrete.
 - 6.35.4.2.2 The cleaner shall be compatible with the injection product used.

6.35.4.3 SEALANT

- 6.35.4.3.1 The sealant used for crack injection shall be a low modulus of elasticity adhesive gel consisting of two components, 100 % solids epoxy resin with no slump, or a cementitious powder mixed with water. The sealant shall be compatible with the injection product, withstand the injection pressures used and be completely watertight.
- 6.35.4.3.2 The epoxy adhesive shall be the product *Sikadur 31 Hi-Mod Gel* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer.
- 6.35.4.3.3 A cement grout shall be used to seal cracks larger than 6 mm when cement grout injection is indicated on the plans.

6.35.5 INSPECTION AND STORAGE

- 6.35.5.1 All products identified in Article 6.35.3 *Materials* shall be delivered to the worksite in their original sealed containers bearing a label containing the following information:
- 6.35.5.1.1 the name of the manufacturer;
- 6.35.5.1.2 the brand;
- 6.35.5.1.3 the type;
- 6.35.5.1.4 the mixing and application instructions.
- 6.35.5.2 The injection product shall be stored in accordance with the manufacturer's recommendations.

6.35.6 EQUIPMENT AND TOOLS

6.35.6.1 GENERAL

- 6.35.6.1.1 The injection equipment, displacement pumps, tanks, pressure gauges, mixers, injection tubes, plugs and other equipment required to carry out the injection work shall be clean, in good condition and shall have the proper capacity and power for the type of cracks to be injected and the type of injection materials selected. The pressure gauges shall be installed at the pump discharge point.
- 6.35.6.1.2 The conformity of the injection equipment used by the Contractor shall be validated by the injection and sealing product supplier to ensure that they are adequate and recommended for the products used. The Contractor shall submit a copy of this written certification to the Engineer prior to the start of injection work.

6.35.6.2 DISPLACEMENT PUMP

6.35.6.2.1 The Contractor shall use displacement pumps designed for multi-component injection products when that type of product is used. The use of handheld guns is not permitted.

6.35.6.2.2 Every displacement pump shall be equipped with a pressure switch to control the maximum pressure at the outlet of the pump. The pump shall be equipped with a regulating valve at the injection point to release the pressure.

6.35.6.3 MIXERS

6.35.6.3.1 Stationary in-line mixers shall ensure the production of a homogeneous injection product and shall have sufficient capacity to generate the anticipated minimum and maximum flow rates. The agitator mixer shall be motorized and equipped with mixing paddles allowing the production of a homogeneous mix.

6.35.6.4 INJECTION TUBES

6.35.6.4.1 The operating pressure capacity of the injection tubes shall, to a minimum, correspond to the maximum pumping operating pressure. A calibrated pressure gauge shall be mounted at the end of the injection nozzle.

6.35.6.5 PLUGS

6.35.6.5.1 Mechanical plug

6.35.6.5.1.1 The mechanical plug shall be installed in a hole that has been previously drilled in the concrete.

6.35.6.5.1.2 The mechanical plug shall be used for low-pressure and high-pressure injections.

6.35.6.5.1.3 When used to inject epoxy or polyurethane resin, the mechanical plug shall be equipped with a tight shut-off valve.

6.35.6.5.1.4 The mechanical plug shall be equipped with a restraint system capable of withstanding the pump injection pressure while ensuring the perimetric sealing thereof.

6.35.6.5.2 Surface plug

6.35.6.5.2.1 The surface plug shall be used when it is not feasible to drill the concrete or when the injection pressure is low.

6.35.6.5.2.2 The surface plug shall be equipped with a tight shut-off valve.

6.35.6.5.3 The surface plug shall mainly be used for epoxy resin injections.

6.35.7 EXECUTION OF WORK

6.35.7.1 QUALIFICATIONS OF THE CONTRACTOR

6.35.7.1.1 The Contractor shall have a minimum of five (5) continuous years of recent relevant experience in the field of crack injection work similar to the work required under this Contract.

6.35.7.1.2 The workers assigned to the injection work shall have a minimum of five (5) years of relevant experience in concrete crack injection work.

6.35.7.2 WORK PLANNING

6.35.7.2.1 The Engineer will, together with the Contractor, determine the lengths of the cracks to be repaired and mark them with paint.

6.35.7.2.2 At least fourteen (14) days prior to the start of work, the Contractor shall submit to the Engineer, for review, the work plan containing the following information:

6.35.7.2.2.1 the technical data sheets on the crack cleaner, injection product and sealant used. The products shall be authorized by the Engineer prior to delivery thereof at the worksite;

6.35.7.2.2.2 the technical data sheets on the injection equipment;

6.35.7.2.2.3 the model and serial number of the pressure gauge as well as calibration certificate thereof issued within the last twelve (12) months;

6.35.7.2.2.4 the recommended crack injection method from the injection product manufacturer;

6.35.7.2.2.5 the name of the person in charge of injection work expected to be present on site;

6.35.7.2.2.6 the list of five (5) similar projects that the above-mentioned person has supervised within the previous five (5) years;

6.35.7.2.2.7 a plan showing the orientation of the cracks, the position of the injection points and the spacing between them.

6.35.7.2.3 The Contractor shall conduct, in the presence of the Engineer, a flow and pressure test on each equipment configuration in order to determine the elements described below, and shall submit to the Engineer, in writing, the test results thereto related:

6.35.7.2.3.1 the pressure loss and the calculation of the effective pressure prior to undertaking the injection work;

6.35.7.2.3.2 the maximum pressure to be used in function of the structural stability or of any other consideration related to the equipment and injection methods used;

- 6.35.7.2.3.3 the rejection pressure and duration thereof in function of the penetration to be obtained (maximum pre-set pressure maintained for two (2) minutes on a given injection point);
- 6.35.7.2.3.4 the actual injection pressure, in function of the pressure losses through the injections lines and through the distributor. To that end, the Contractor shall install a pressure gauge on the distributor, near the hole to be injected, and monitor the structure closely to ensure that the injection work does not damage the structure.
- 6.35.7.2.4 The Contractor is responsible for ensuring that the implementation tolerances and application of the product limits are respected, more specifically the mixing temperature and time.

6.35.7.3 INSTALLATION OF THE PLUGS

6.35.7.3.1 Mechanical plug

- 6.35.7.3.1.1 The Contractor shall obtain authorization from the Engineer to drill the holes for the installation of the mechanical plugs.
- 6.35.7.3.1.2 The Contractor shall drill holes for the installation of the mechanical plugs according to the injection plan reviewed by the Engineer.
- 6.35.7.3.1.3 The holes shall be 50 mm to 100 mm deep and oriented according to the crack slope plans.
- 6.35.7.3.1.4 The spacing shall be determined in function of the type of injection product used, of the crack width and of the depth of injection. The maximum distance between the injection holes shall correspond to the thickness of the element to be injected without however exceeding 400 mm.
 - 6.35.7.3.1.4.1 The first and last plugs shall be installed at a distance which, relative to the end of the crack, corresponds to half the spacing prescribed for the other plugs.
 - 6.35.7.3.1.4.2 A minimum of two (2) plugs shall be installed for each crack.
- 6.35.7.3.1.5 The injection holes shall be drilled on both sides of the crack at an angle less than or equal to 45° relative to the concrete element surface. These holes shall be oriented in such a way as to pass through the middle of the crack. The size of the holes shall be determined in function of the size of the plugs used.
- 6.35.7.3.1.6 The Contractor shall drill the injection holes using a diamond drill operated by rotation or by rotation and percussion. The Contractor shall not use a hammer drill for holes located within 150 mm of the edge of a concrete structure.
- 6.35.7.3.1.7 The Contractor shall subsequently clean each hole in order to remove all drilling debris.

- 6.35.7.3.1.8 The plugs shall be driven deep into the drilled hole so as to avoid any breakage in the concrete around the drilled hole when tightening the plugs.
- 6.35.7.3.1.9 The Contractor shall ensure not to damage the existing post-tensioning cables when drilling the holes for the injection.
- 6.35.7.3.2 Surface plug
- 6.35.7.3.2.1 The surface plugs shall be installed at the same time as the application of the sealant.
- 6.35.7.3.2.2 Following the cleaning of the concrete surface adjacent to the crack by abrasive blasting, the plugs shall be installed astride the crack in a 3 mm thick layer of sealant.
- 6.35.7.3.2.3 The Contractor shall ensure that the injection duct is not blocked by the sealant by inserting a nail into the duct after having installed the plug. The nail shall be removed after the sealant has cured.
- 6.35.7.4 CLEANING, SURFACE PREPARATION AND SEALING
- 6.35.7.4.1 The inside of cracks shall be cleaned to the satisfaction of the Engineer and according to the injection product manufacturer so as to remove any foreign and loose matter, either by means of air blasting or high-pressure water blasting or a combination of the two (2) methods.
- 6.35.7.4.2 The Contractor shall check during the cleaning, to ensure that the injection holes properly intercept the cracks. The Engineer may require the Contractor to rinse the cracks with coloured water. This step shall be carried out in the presence of the Engineer. Any holes that do not intercept the cracks during cleaning thereof or when the water tests are conducted shall be remade according to a different pattern. Moreover, additional holes shall be drilled if, during the water testing, two (2) adjacent plugs do not communicate.
- 6.35.7.4.3 The water injection tests shall be conducted in the presence of the Engineer.
- 6.35.7.4.4 The Contractor shall seal the crack opening in surface prior to undertaking the injection. The Contractor shall clean the concrete surface by means of abrasive blasting, over a width of 75 mm on either side of the crack, in order for the sealing compound to bond well. The surface deposits shall be removed by means of mechanical equipment. The preparation and surface application of the sealant shall comply with the sealant manufacturer's recommendations.
- 6.35.7.4.5 The surface sealant shall confine the injection product in the crack and be applied in sufficient thickness to withstand the injection pressure.
- 6.35.7.4.6 The crack preparation shall be accepted by the Engineer prior to applying the sealant.

6.35.7.5 INJECTION

- 6.35.7.5.1 The crack injection shall be carried out in the presence of the Engineer. Any injection work carried out without the Engineer being present will not be paid.
- 6.35.7.5.2 The injection material shall be mixed and injected in accordance with the manufacturer's recommendations and with the requirements of these specifications.
 - 6.35.7.5.2.1 The addition of solvents, thinners, or other matter to the injection product is prohibited.
- 6.35.7.5.3 The Contractor shall ensure that the plugs remain in place during the injection work.
- 6.35.7.5.4 The injection shall start at the lowest level of the crack and progress from one plug to the next, without interruption, up to the end of the crack. The Contractor shall not move the injection nozzle toward the next plug before the injection product appears at that plug or when the rejection criteria are met.
- 6.35.7.5.5 The Engineer may, at any time, request that the injection pressure be reduced if it seems excessive. Unless otherwise indicated on the plans, the injection pressure shall, however, never exceed 8 MPa for a product with a viscosity of 150 ± 25 mPa·s.
- 6.35.7.5.6 Where indicated on the plans, the Contractor shall remove, by grinding, all the injection tubes and sealant material and, after the injection, it shall seal the holes, to the satisfaction of the Engineer.
- 6.35.7.5.7 In cold weather, the Contractor shall install a heating system in order to maintain the temperature of the injection product and surfaces adjacent to the cracks within the ranges specified by the manufacturer.
- 6.35.7.5.8 When the Contractor notes that an abnormally high volume of resin is injected into the crack, it shall immediately stop the injection work and notify the Engineer thereof.

6.35.8 QUALITY CONTROL

6.35.8.1 GENERAL

- 6.35.8.1.1 The Contractor is responsible for conducting all the tests and for taking all the readings and measurements required to ensure the quality control of its injection and crack sealing work.
- 6.35.8.1.2 The Contractor shall carry out the injection work in the presence of the Engineer.

- 6.35.8.1.3 The Contractor shall carry out, without however being limited to, the following controls and measurements on the worksite:
- 6.35.8.1.3.1 the temperature measurements of the sealing and injection materials, ambient air, concrete substrate to be injected, mixes inside the tanks and mixers;
 - 6.35.8.1.3.2 the calibration of the injection equipment, for the injection;
 - 6.35.8.1.3.3 the measurements of the injection pressure and time;
 - 6.35.8.1.3.4 the collection of the samples for the tests to be conducted by a laboratory, member of the Association des firmes de genie-conseil - Québec (AFG), and on-worksite measurements;
 - 6.35.8.1.3.5 any other measurements or tests required to ensure the quality control of the work or required by the Engineer.
- 6.35.8.1.4 The following tests will be conducted by the Owner's Laboratory, at the Owner's expense:
- 6.35.8.1.4.1 Shore D hardness measurements and compressive strength of the microfine Portland cement-based grout samples collected during injection;
 - 6.35.8.1.4.1.1 To this end, the Contractor shall collect, at its expense, a minimum of six (6) samples per injection session. The samples may be collected in containers type 35 mm film canisters or other equivalent format.
- 6.35.8.2 INJECTION REPORT
- 6.35.8.2.1 The Contractor shall, in an injection report, record the quantity of injection product used per 1 m long crack as well as the pumping pressure indicated by the pressure gauge, at ten (10) minute intervals, also indicating the location of the corresponding cracks. The report shall indicate the number of cracks, the location of each crack and the spacing between the plugs, in addition to specifying whether any injection product escaped during injection.
- 6.35.8.3 DOSAGE TEST
- 6.35.8.3.1 The Contractor shall check, in the presence of the Engineer, whether the multi-component injection equipment provides the desired dosage. To do so, the Contractor shall measure the quantity of material coming out of the injection tubes at least once every two (2) hours of operation. Any deviation greater than 5 % relative to the dosage prescribed by the manufacturer shall be rectified immediately through appropriate adjustment or replacement of the equipment.

6.35.8.4 OPERATIONAL LIFE

- 6.35.8.4.1 Prior to starting the injection of the injection product, the Contractor shall collect, from the containers on site and in the presence of the Engineer, a sample of the injection grout. The Contractor shall measure and mix the ingredients manually, according to the prescribed proportions indicated on the plans. The total volume of the sample shall be 200 mL. Each sample shall be placed in a container of equal size. The Contractor shall record the temperature of the product at the time of mixing as well as the operational life of the mixed product.
- 6.35.8.4.2 The Contractor shall collect an additional sample at the outlet of the injection tube to validate the operational life.
- 6.35.8.4.3 During application of the injection product, the Contractor shall collect samples of the product at least once every hour of operation and record the operational life of the mixed product.
- 6.35.8.4.4 Any deviation relative to the prescribed proportions and operational life will result in the immediate rejection of the product and of the piece of concrete.
- 6.35.8.4.5 At the end of each working day, the Contractor shall submit to the Engineer all the recorded information in a format that has been previously authorized by the Engineer.
- 6.35.8.4.6 The Contractor shall inform the Engineer of all test results, measurements and controls throughout the duration of the work and shall record them in the daily injection logbook, a copy of which shall be given to the Engineer at the end of each working day.

END OF SUBSECTION