TENDER DOCUMENTS

SUBSECTION 6.35
INJECTION

TABLE OF CONTENTS

PAGE

SUBSECTION 6.35 INJECTION

6.35.1 GENERAL

6.35.1.1 This subsection sets out the requirements related to crack injection work under this Contract.

6.35.1.2 Any specific requirements related to crack injection work covered by this Contract are set out in Section 4 *Special Technical Conditions*.

6.35.2 REFERENCE STANDARDS

6.35.2.1 The **Contractor** shall perform all crack injection work in accordance with the requirements of the following standards and documents to which the provisions of the Contract are added:

6.35.2.1.1 (ASTM) ASTM International

- ASTM C881/C881M-02 *Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete*.

6.35.2.1.2 (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 A23.3-04 *Design of Concrete Structures*.

6.35.2.1.3 (MTQ) Ministère des Transports du Québec

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

6.35.3 MATERIALS

6.35.3.1 INJECTION PRODUCT

6.35.3.1.1 The injection product shall be durable, require no maintenance or protection, provide superior weather and ozone resistance, and be strong and stable in fluctuating temperatures.

6.35.3.1.2 The injection product shall be prepared and applied according to the manufacturer's instructions and the injection program checked and approved by the Engineer.

6.35.3.1.3 Several types of injection product may be used depending on the size, cause, activeness of the crack and whether or not any water is present. Any materials which the **Contractor** is required to use under this Contract are identified in Section 4 *Special Technical Conditions*.

6.35.3.1.4 Epoxy resin

6.35.3.1.4.1 Unless otherwise indicated in the *Special Technical Conditions*, the injection product used to repair cracks up to 3.5 mm wide shall be a Type 1 or Type 4 epoxy resin conforming to standard ASTM C881/C881M and shall be suitable for filling cracks according to the technical data sheet for the product.

6.35.3.1.5 Cement mortar

6.35.3.1.5.1 Unless otherwise indicated in the *Special Technical Conditions*, the injection product used to repair wide cracks (more than 3.5 mm wide) may be microfine Portland cement-based mortar. One acceptable product is Rheorem 900 from Master Builders Technologies.

6.35.3.2 CRACK CLEANER

6.35.3.2.1 The cleaner shall be a phosphoric acid-based liquid designed to dissolve laitance, calcium deposits and other contaminants on concrete.

6.35.3.2.2 The cleaner shall be compatible with the injection product used.

6.35.3.3 SEALANT

6.35.3.3.1 If required by Section 4 *Special Technical Conditions*, the sealant used when injecting cracks shall be an adhesive gel with a low modulus of elasticity consisting of two (2) part 100% solid epoxy resin with no slump or a cement powder mixed with water. The sealant shall be compatible with the injection product and pressure used and shall be completely watertight.

6.35.4 INSPECTION AND STORAGE

6.35.4.1 All products referred to in article 6.35.3 *Materials* shall be delivered to the site in hermetically sealed original containers bearing a label that includes the following information:

6.35.4.1.1 manufacturer’s name;

6.35.4.1.2 brand;

6.35.4.1.3 type;

6.35.4.1.4 mixing and application instructions.

6.35.4.2 The injection product shall be stored as recommended by the manufacturer.

6.35.5 EQUIPMENT AND TOOLS

6.35.5.1 GENERAL

6.35.5.1.1 Injectors, feed pumps, tanks, pressure gauges, mixers, injection hoses, sealers and other equipment required to carry out injection work shall be clean, in good condition and of the proper capacity and power for the types of cracks to be injected and the type of injection materials selected. Pressure gauges shall be installed at pump discharge points.

6.35.5.1.2 The conformity of the injection equipment used by the **Contractor** shall be validated by the supplier of the injection and sealing products to ensure that it is adequate and recommended for the products being used. The **Contractor** shall submit a copy of the written certification to the Engineer prior to the start of work.

6.35.5.2 FEED PUMP

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

6.35.5.2.2 Every feed pump shall have a pressure switch to control the maximum pressure at the outlet. The pump shall have a regulating valve at the injection end to release the pressure.

6.35.5.3 MIXERS

6.35.5.3.1 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 paddles to produce an even mix.

6.35.5.4 INJECTION HOSES

6.35.5.4.1 The rated pressure capacity of the injection hoses shall at least match the maximum rated pumping pressure. A calibrated pressure gauge shall be mounted at the end of the injection nozzle.

6.35.5.5 OBTURATORS

6.35.5.5.1 Obturators shall be equipped with leak-proof shutoff valves.

6.35.5.5.2 Obturators shall comprise removable or non-metal inserts. The pressure capacity of obturators shall be at least equal to the maximum rated pressure of the pump.

6.35.6 EXECUTION

6.35.6.1 QUALIFICATIONS OF THE CONTRACTOR

6.35.6.1.1 The **Contractor** shall have at least five (5) continuous years of recent pertinent experience in the field of crack injection work similar to the work to be performed under this Contract.

6.35.6.1.2 The **Contractor** shall submit with its bid the number of years of experience it has in the field of crack injection and a list of at least five (5) similar projects it has carried out in the past five (5) years. The list shall include the location, the date, the method, the names of the manufacturers of the products used, the clients and proof of acceptance of the work.

6.35.6.1.3 Workers assigned to injection work shall have at least five (5) years of pertinent experience in injecting cracks in concrete.

6.35.6.2 PLANNING OF WORK

6.35.6.2.1 The Engineer will work with the **Contractor** to determine the lengths of cracks to be repaired and will mark the cracks with paint.

6.35.6.2.2 At least fourteen (14) days prior to the start of work, the **Contractor** shall submit the following information to the Engineer for examination and comments:

6.35.6.2.2.1 the technical data sheets for the crack cleaner, the injection product and the sealant; the products must be approved by the Engineer before they are delivered to the work site;

6.35.6.2.2.2 the crack repair method indicated by the manufacturer of the injection products;

6.35.6.2.2.3 a drawing showing the orientation of the cracks for injection points and the spacing between them.

6.35.6.2.3 The **Contractor** shall conduct a flow and pressure test on each configuration of equipment with the Engineer present in order to determine the following elements, and shall submit the test results to the Engineer in writing:

6.35.6.2.3.1 pressure loss and calculation of the actual pressure prior to starting injection work;

6.35.6.2.3.2 the maximum pressure to be used, taking into account structural stability and any other consideration related to the equipment and the injection methods used;

6.35.6.2.3.3 the rejection pressure and duration, taking into account the penetration depth required (maximum pre-set pressure maintained for two (2) minutes on a given injection point);

6.35.6.2.3.4 the actual injection pressure, taking injection line and distributor pressure losses into account; the **Contractor** shall install a pressure gauge on the distributor near the injection hole and monitor the work closely to ensure that the injection does not damage the existing concrete.

6.35.6.2.4 The **Contractor** is responsible for ensuring that product application tolerances and limits are complied with, more specifically mixing temperature and time.

6.35.6.3 DRILLING HOLES

6.35.6.3.1 The **Contractor** shall obtain authorization from the Engineer to drill injection holes.

6.35.6.3.2 The **Contractor** shall drill holes for the injection tubes based on the injection drawing reviewed by the Engineer.

6.35.6.3.3 Holes shall be 50 mm to 100 mm deep and oriented according to the crack slope drawings.

6.35.6.3.4 Spacing shall be determined based on the type of injection product, the width of the cracks and the injection depth. The maximum distance between injection holes is specified in Section 4 *Special Technical Conditions*.

6.35.6.3.5 Injection holes shall be drilled on both sides of the crack at an angle of 45^{o} degrees or less to the surface of the concrete. The holes shall be made to pass through the middle of the crack. The size of the holes is determined by the size of the obturator used.

6.35.6.3.6 The **Contractor** shall drill injection holes using a diamond bit and rotary or rotary hammer drill. The **Contractor** shall not use a hammer drill for holes within 150 mm of the edge of a concrete structure.

6.35.6.3.7 The **Contractor** shall clean each hole in order to remove all drilling debris.

6.35.6.4 CLEANING, SURFACE PREPARATION AND SEALING

6.35.6.4.1 The inside of the cracks shall be cleaned to the Engineer's satisfaction and as directed by the manufacturer of the injection products using air or water blasting or a combination thereof to remove any loose particles or foreign matter.

6.35.6.4.2 The **Contractor** shall check during cleaning to ensure that the injection holes pass through the cracks. The Engineer may ask the **Contractor** to rinse the cracks with coloured water. This process shall be done with the Engineer present. Any holes which, when the cracks are cleaned or a water test is performed, are shown to not pass through the cracks shall be remade using a different pattern. As well, additional holes shall be made if two (2) adjacent holes are shown by water testing to not meet.

6.35.6.4.3 Water injection tests shall be conducted with the Engineer present.

6.35.6.4.4 If required by Section 4 *Special Technical Conditions*, the **Contractor** shall seal the surface of the cracks before injection begins. The **Contractor** shall use abrasive blasting to clean the surface of the concrete over a width of 75 mm on either side of the cracks so that the sealing compound gets a good bite. Surface deposits shall be removed using mechanical equipment. The surface shall be prepared and the sealant applied as recommended by the manufacturer of the sealant.

6.35.6.4.5 The surface sealant shall keep the injection product in the cracks.

6.35.6.4.6 Preparation of the cracks shall be approved by the Engineer before the sealant is applied.

6.35.6.5 INJECTION

6.35.6.5.1 Cracks injection shall be done with the Engineer present. No payment will be made for any injection work done without the Engineer present.

6.35.6.5.2 The injection material shall be mixed and injected according to the manufacturer's instructions and the requirements of these specifications.

6.35.6.5.3 The **Contractor** shall ensure that the injection tubes remain in place during the work.

6.35.6.5.4 Injection shall start at the lowest level of the cracks and move uninterrupted from one obturator to the next to the other end of the cracks. The **Contractor** shall not move the injection nozzle toward the next obturator until the injection product is visible at that obturator or the rejection criteria are met.

6.35.6.5.5 The Engineer may call for the injection pressure to be reduced at any time if it appears to be too high. Unless otherwise indicated in the *Special Technical Conditions*, the injection pressure shall never exceed 8 MPa (1,160 psi) for a product with a viscosity of 150 ±25 cps.

6.35.6.5.6 The **Contractor** shall use a grinder to remove the injection tubes and sealant and shall seal the holes following injection to the satisfaction of the Engineer.

6.35.6.5.7 In cold weather, the **Contractor** shall install a heating system in order to keep the temperature of the injection product and the surfaces adjacent to the cracks in the range specified by the manufacturer.

6.35.7 QUALITY CONTROL

6.35.7.1 GENERAL

6.35.7.1.1 The **Contractor** is responsible for performing all tests and taking all readings and measurements required to ensure quality control of its injection work and crack sealing.

6.35.7.1.2 The **Contractor** shall carry out the following controls and measurements on site, including but not limited to:

6.35.7.1.2.1 temperature measurement of sealing and injection materials, ambient air, the substrate of the concrete to be injected, and mixes inside the tanks and mixers;

6.35.7.1.2.2 calibration of the injection equipment for injection;

6.35.7.1.2.3 measurement of injection pressure and time;

6.35.7.1.2.4 sampling for laboratory tests and on-site measurements;

6.35.7.1.2.5 any other measurement required for quality control or by the Engineer.

6.35.7.1.3 The **Owner** will have the following tests performed by an independent laboratory and will assume the associated costs:

6.35.7.1.3.1 “Shore D” hardness measurement and compression strength of microfine Portland cement-based mortar samples taken during injection;

6.35.7.1.3.1.1 for that purpose, the **Contractor** shall take a minimum of six (6) samples per injection session at its expense; the samples may be taken in containers similar to 35 mm film canisters or canisters of an equivalent size.

6.35.7.2 INJECTION REPORT

6.35.7.2.1 The **Contractor** shall record in an injection report the quantity of injection product used per linear metre length of crack and the pumping pressure indicated by the pressure gauge at ten (10) minute intervals and shall record the location of the corresponding cracks. The report shall indicate the number of cracks, the location of each crack and the space between obturators, and shall specify whether any injection product escaped during injection.

6.35.7.3 MIX TEST

6.35.7.3.1 The **Contractor** shall, with the Engineer present, check whether the multi-component injection equipment is delivering the desired mix of ingredients. To that end, the **Contractor** shall measure the quantity of material exiting the injection hoses at least once for every two (2) hours of operation. Any discrepancy greater than 5% relative to the mix recommended by the manufacturer shall be corrected immediately by making an appropriate adjustment or replacing the material.

6.35.7.4 APPLICATION LIFE

6.35.7.4.1 Prior to the start of injection, the **Contractor** shall take a sample of the injection product from the containers on site with the Engineer present. The **Contractor** shall measure and mix the ingredients manually based on the prescribed proportions. 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 and the application life of the mixed product.

6.35.7.4.2 The **Contractor** shall take an additional sample at the end of the injection hose to validate the application life.

6.35.7.4.3 During application of the injection product, the **Contractor** shall take samples of the product at least once per hour of operation and record the application life of the mixed product.

6.35.7.4.4 Any discrepancy relative to the prescribed proportions and application life will result in immediate rejection of the product and the piece of concrete.

6.35.7.4.5 At the end of each workday, the **Contractor** shall provide the Engineer with all the recorded information.

6.35.7.4.6 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 submitted to the Engineer at the end of each workday.

END OF SUBSECTION