CONSTRUCTION SPECIFICATION FOR CRACK REPAIR - CONCRETE

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932.01 SCOPE

This specification covers the requirements for the pressure injection, routing, and sealing of cracks in concrete for the purpose of structural rehabilitation and water seepage control.

932.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 920 Deck Joint Assemblies, Preformed Seals, Joint Fillers, Joint Seals, Joint Sealing Compounds, and Waterstops – Structures
OPSS 929 Abrasive Blast Cleaning - Concrete Construction

Ontario Provincial Standard Specifications, Material

OPSS 1212 Hot Poured Rubberized Asphalt Joint Sealing Compound
OPSS 1302 Water
OPSS 1350 Concrete - Materials and Production

ASTM International

C881 / C881M - 15	Epoxy-Resin Based Bonding Systems for Concrete
C920 - 18	Elastomeric Joint Sealants
D4285 - 83(2018)	Test Method for Indicating Oil or Water in Compressed Air

932.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Active Crack means a crack in concrete with plane surfaces that are in a state of movement relative to each other.

Crack Depth means the distance that the crack extends from the injection surface into the concrete to the point where the crack is 0.10 mm wide.

Effective Injection Pressure means the fluid grout pressure at point of entry at the injection port. This shall be calculated as gauge pressure minus head losses in injection system.

Flushing means removing debris from the crack section by means of air or a liquid under pressure.

Gauge Pressure means the actual fluid grout pressure reading on the pump gauge.

Injection Port means a mechanical device that is firmly connected into the crack section for the purpose of providing access into a crack for the grouting material.

Passive Crack means a concrete crack in concrete with plane surfaces that are not moving relative to each other.

Payment Adjustment Factor means a multiplier applied to the unit Contract price to determine the actual unit payment price.

Plural Component Pump means a grout pump that separately delivers the grout material components separately to a common static mixer.

Pot Life means the period of time after mixing during which a bonding system or mixture containing it retains sufficient workability for proper use.

Refusal Criteria means zero flow of grout at the proposed effective pressure for a duration of five minutes.

Regulated Operating Pressure means the maximum pressure, measured at the pump discharge, that the pump is capable of producing.

932.04 DESIGN AND SUBMISSION REQUIREMENTS

932.04.01 Submissions

932.04.01.01 Crack Repair Work Plan

A copy of the crack repair work plan shall be submitted to the Contract Administrator at least seven Days prior to the commencement of the work.

The crack repair work plan shall bear the seal and signature of an Engineer and include at least the following information.

a) A description of the method of repair, including the following minimum information:

   i. Summary of material and method selection for each crack repair type.
   ii. Proposed effective injection pressure.
   iii. Surface finishing.
   iv. Location, size, spacing and type of injection ports.
   v. Surface treatment of the concrete prior to surface sealing.
   vi. Method of storing and handling grouts, cleaning solvents, and waste materials.

b) A list of the materials to be used for surface sealing and repair, including the following minimum information:

   i. Material specifications.
   ii. Product data sheets with test data.
   iii. Material safety data sheets.
   iv. Pot life of the components to be used based on a sample size of 200 ml at 5 °C and 20 °C.
   v. ASTM Type, Grade and Class (applicable for epoxy-resin based bonding systems)

c) A list of the equipment and accessories to be used including the following minimum information:

   i. The operating pressure of each component.
   ii. The type of injection port and means of closure.

932.05 MATERIALS

932.05.01 Grout

932.05.01.01 General

Material used for crack injection shall be polyurethane resins for active cracks and epoxy resins for passive cracks.

Polyurethane and epoxy grout shall prevent the penetration of water and shall fill at least 80% of the depth of the crack using the proposed equipment and method of repair at the ambient and substrate temperatures existing at the time of grouting.

Polyurethane and epoxy grout shall have sufficient pot life to ensure it remains workable throughout the duration of its application and is compatible with the procedures outlined in the submitted crack repair work plan.

932.05.01.02 Epoxy Resin

Epoxy resin shall be according to ASTM C881, Type IV, Grade I, Class B and C.

932.05.01.03 Polyurethane Resin

Polyurethane resin shall be 100% solids, hydrophobic and be suitable for the range of temperatures at the time of repair.

932.05.02 Joint Sealing Compounds

932.05.02.01 Hot-Poured Rubberized Joint Sealing Compound

The hot-poured rubberized joint sealing compound shall be according to OPSS 1212.

932.05.02.02 Cold-Applied Joint Sealing Compound

Cold-applied joint sealing compound shall be according to ASTM C920, Type S or M, Grade NS, Class 25, Use T and M. Type M sealant shall be used where the depth of a chase is greater than 15 mm or the manufacturer's recommended depth for Type S sealant, whichever is less. Where the cold sealing compound is visible after completion of the work a grey colour material shall be used.

932.05.03 Water

Water shall be according to OPSS 1302.

932.06 EQUIPMENT

932.06.01 Gauges

In addition to the calibrated gauges required for use with the pumps and with the injection hose, additional gauges shall be available on site to replace those that malfunction.

Certificates of calibration from an organization accredited by the Standards Council of Canada shall be supplied for each gauge certifying that the gauges are capable of measuring the pressure within a tolerance of ± 5 kPa.

932.06.02 Pumps

Equipment used for pressure injection shall be suitable for the intended use and compatible with the grout.

Pumps shall be positive displacement type and shall be capable of delivering a minimum of two litres of grout per minute.

Pumps shall be capable of developing a maximum regulated operating pressure at least equal to twice the effective pressure.

Pumps shall be equipped with a calibrated gauge and shall be capable of accurately maintaining an effective operating pressure of 50 kPa or less.

Plural component pumps shall be used when multicomponent solution grouts are used.

Hand cartridge pumps shall not be used unless the volume of crack repair is less than one litre of resin for 100 m^2 of gross repair area.

932.06.03 Mixers

932.06.03.01 Static In-Line Mixers

Static in-line mixers shall produce a homogeneous grout and shall be sized to accommodate the minimum and maximum anticipated flow rates.

Static mixers shall have the manufacturer's plate attached showing the following mixer information:

a) Size.

b) Type.

c) Maximum operating pressure.

932.06.03.02 Agitating Mixer

Agitating mixers shall have a power driven paddle mixing head and produce a homogeneous component. The speed of the mixers shall be variable to a maximum of 500 rpm.

932.06.04 Injection Hoses

Injection hoses shall have a rated working pressure equal to or greater than the maximum pump operating pressure and shall be equipped with a calibrated gauge at the injection port end.

932.06.05 Injection Ports

Injection ports shall be removable or non-metallic insert type units. The pressure capacity of the injection ports shall be at least equal to the maximum operating pressure of the pump. All injection ports shall be equipped with a shut-off valve or other mechanical means of closure under pressure.

932.06.06 Air Compressor

Compressed air shall be free from oil and water when tested according to ASTM D4285.

932.06.07 Drills

Drilling of the injection holes shall be performed using a rotary percussion or rotary diamond type drill. Percussion drilling equipment shall not be used for drilling holes greater than 26 mm diameter and holes within 150 mm of any edge of concrete.

Only holes less than or equal to 26 mm in diameter shall be drilled within 50 mm of any free edge of concrete.

932.06.08 Routing Equipment

Routing equipment shall be any of the following:

a) Concrete router.

b) Hand-held grinding wheel or a multi-bladed cut-off saw equipped with abrasive or diamond blades.

c) Multi-bladed floor saw cutting equipment equipped with diamond blades.

932.07 CONSTRUCTION

932.07.01 General

Installation of all accessories and material shall be according to the manufacturer's recommendations and as specified in the submitted work plan.

Work shall only proceed when the temperature of the concrete is greater than or equal to 5 °C.

932.07.02 Access

Access shall be provided to facilitate:

a) Performance of work.

b) Inspection and measurement of the work by the Contract Administrator.

932.07.03 Crack Identification

Prior to commencement of the work, the cracks requiring repair, as identified by the Contract Administrator, shall be numbered, physically marked as to their extent and measured in the presence of the Contract Administrator.

This information shall be recorded and a copy submitted to the Contract Administrator.

932.07.04 Crack Injection

932.07.04.01 Drilling for Injection Ports

Holes for injection ports shall be drilled:

a) Perpendicular to the concrete surface and located directly on top of the crack.

b) On each side of the crack at a 45-degree angle to the surface of the concrete.

c) Per the manufacturer's recommendations.

The spacing of the injection ports shall not exceed 200 mm. The size and depth of the injection holes shall be according to the manufacturer's recommendations. Injection ports shall be inserted into the holes and sealed.

Prior to installation of the injection ports each hole shall be individually cleaned of all deleterious material by an air-water blast to completely remove all drill cuttings from the hole.

932.07.04.02 Cleaning and Flushing

After the injection ports have been inserted, cracks shall be flushed with an air-water mixture or an alternating water and air flush to remove all deleterious material prior to the injection of grout. The flushing material shall be injected through the injection port and continued until it exudes from the adjacent injection port and the crack is thoroughly cleaned. This flushing shall proceed from one end of the crack to the other.

A final flush shall be made with air only to remove all of the free water.

932.07.04.03 Surface Preparation and Sealing

Surface opening of the cracks shall be sealed prior to injection.

The surface of the concrete shall be mechanically cleaned for a distance of 25 mm each side of the crack sections to prepare a clean substrate for bonding of the surface sealing compound. The surface preparation and sealing shall be as recommended by the manufacturer of the surface sealing material.

The surface sealing material shall completely confine the injection grout to the crack section with only the injection ports providing access. The surface sealing material shall withstand the maximum injection pressure without developing leakage along the crack section.

Surface sealing of passive cracks shall not commence until at least one hour after the final air flush.

932.07.04.04 Injection of Grout

932.07.04.04.01 General

Grout shall be pressure injected. Injection of grout shall proceed from the injection port at the lowest elevation of the crack and continue upwards along the crack on an injection port to injection port basis without interruption to the other end of the crack. The injection nozzle shall not be moved to the adjacent injection port until grout is showing at the next higher adjacent injection port or refusal criteria is met.

While under pressure, each injection port shall be sealed immediately after completion of injection of grout.

When a maximum operating pressure greater than 3 MPa is required to inject the grout, the injection operation shall cease until the Contractor determines why this operating pressure is required.

932.07.04.04.02 Monitoring

The volume of grout used within each five metres of crack length shall be recorded. The pump gauge pressure shall be recorded every 10 minutes. The volume of grout and pump pressure shall be related to the crack location.

The records shall indicate crack location and number, injection port spacing, operating pressure and confirmation of grout showing or refusal. A copy of the recorded information shall be submitted to the Contract Administrator at the end of each Day.

932.07.04.04.03 Effective Injection Pressure

When calculating the effective pressure, the head losses shall be determined prior to commencement of injection.

Head losses shall be determined in the presence of the Contract Administrator by performing a pressure flow test, through the equipment, for each equipment configuration used.

932.07.04.04.04 Ratio Test

Plural component injection equipment proportioning shall be verified in the presence of the Contract Administrator by measuring the volume output of material in the pressure lines at least once for each two hours of operation.

When deviation from the manufacturer’s specified proportioning ratio exceeds 5%, immediate adjustment or replacement of the equipment is required.

932.07.04.04.05 Pot Life Determination

Prior to commencing the grouting operation, a sample shall be taken from the material containers on site and manually proportioned to the specified component ratio in the presence of the Contract Administrator. The total sample size shall be 200 ml, and the same size container shall be used for each sample taken.

The temperature of the material at the time of mixing and the pot life of the mixed material shall be recorded.

The proportions of materials and pot life shall conform to those specified in the original submissions.

An additional sample shall be taken from the end of the injection hose and a further pot life determination performed.

During grouting material samples shall be taken on a frequency of at least one per hour of operation and the pot life recorded.

Deviation from the proportions and pot life specified shall result in immediate discontinuance of use of the material.

All records shall be submitted to the Contract Administrator at the end of each working day.

932.07.04.05 Surface Finishing

Surface finishing shall not proceed until the curing period, as specified by the material supplier, has elapsed. Surface finishing shall consist of removal of the injection ports and the surface sealant flush with the original concrete surface. Core holes and holes left after the removal of injection ports shall be filled with a cement-based non-shrink grout after the surface sealant has been removed.

Where the crack is not completely filled to the injection surface, the crack shall be filled with a compatible material acceptable to the Contract Administrator. The material shall be applied according to the manufacturer's recommendations.

932.07.04.06 Coring

A 50 mm diameter test core shall be taken for each completed ten-metre increment of injected crack at locations specified by the Contract Administrator until satisfactory control is established. The ten-metre increment is the length of a continuous crack or a cumulative measurement of cracks of lesser length. The depth of the test core shall be the full depth of the crack but not greater than 500 mm.

Prior to establishing satisfactory control, test cores shall be taken within two hours after injection, at locations specified by the Contract Administrator.

Satisfactory control is established when three consecutive test cores meet acceptance criteria without payment adjustments as defined in the Acceptance and Rejection clause. If payment adjustments are required, test cores shall continue to be extracted for each completed ten-metre increment of injected crack until three consecutive cores are accepted without payment adjustment.

After satisfactory control has been established, test cores shall be taken for each Day or each completed 50 m increment, whichever is more. If a test core indicates payment adjustments or when there are changes in the material or procedure, testing shall resume on ten-metre increments of injected crack until satisfactory control is re-established.

Reinforcement and other embedded material shall be avoided while coring, and the Contractor shall use a covermeter capable of detecting the type(s) of reinforcement and embedded material in the element prior to coring.

All cores shall be taken in the presence of the Contract Administrator and shall be submitted to the Contract Administrator after coring. Similar coring shall be done to check remedial work.

932.07.04.07 Filling of Core Holes

Filling of core holes shall be according to OPSS 1350.

932.07.05 Routing and Sealing Cracks

Cracks shall be routed to create a chase and then filled with a sealant.

The depth to width ratio of the chase shall be 1H:1V with the crack located within the middle third of the chase. The width of the chase shall be 15 mm ± 5 mm.

The chase shall be abrasive blast cleaned according to OPSS 929. Abrasive blast cleaned areas shall have the subsequent treatment applied within 36 hours or shall be reblasted.

Immediately prior to placing the bond breaker, the chase shall be blasted with compressed air to remove all dust, dirt, and loose material.

A bond breaker compatible with the joint sealing compound and concrete shall be placed at the bottom of the chase.

Joint sealing compound shall be placed in the chase flush with the adjacent concrete surface unless it is subjected to vehicular traffic, in which case, it shall be recessed 2 mm ± 1 mm.

Hot-poured rubberized joint sealing compounds shall only be used on horizontal surfaces. Cold-applied joint sealing compounds shall only be used on vertical surfaces or on horizontal surfaces that are not to be waterproofed. Cold-applied joint sealing compound shall be installed according to the manufacturer's recommendations. Hot-poured rubberized joint sealing compound shall be installed according to OPSS 920.

932.07.06 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

932.08 QUALITY ASSURANCE

932.08.01 General

When the repair operation is complete, the Contract Administrator shall inspect the work to determine if the completed work contains defects.

932.08.02 Crack Injection

The 50 mm diameter test cores shall be examined for the percentage of the crack depth filled.

932.08.03 Ratio Test

The proportioning ratio of the injection material shall not deviate more than 5% from the manufacturer's specified proportioning ratio stated in the work plan.

932.08.04 Pot Life

The proportion of material and pot life shall not deviate from that specified by the manufacturer in the work plan.

932.08.05 Acceptance or Rejection

The Contract Administrator shall accept or reject material on the basis of the ratio testing and pot life determination results.

Crack injection shall be accepted or rejected on the basis of the percentage of crack depth filled as determined by evaluating the test core taken in each increment.

Rejection of the increment length of crack represented by the test core shall be applied during the entire grouting operation.

Where 90% or more of the crack depth is filled in the test core, the increment of crack length represented by the core shall be accepted.

Where 80 to 89% of the crack depth is filled in the test core, the work shall be accepted and a payment adjustment shall be applied to increment length of crack represented by that core.

Where less than 80% of the crack depth is filled in the test core, the ten-metre increment of crack length represented by the core shall be rejectable. An immediate review and adjustment of the method of injection shall be completed. The method of repair shall be submitted to the Contract Administrator prior to the commencement of the work. The increments represented by the failed test cores shall be repaired such that at least 80% of the crack depth is filled at no addition cost to the Owner.

932.09 MEASUREMENT FOR PAYMENT

932.09.01 Actual Measurement

932.09.01.01 Crack Injection

Measurement of crack injection shall be by length in metres of the accepted injected cracks. The total length shall be the sum of individual increments represented by the accepted test cores taken within each increment. Cracks filled to less than 80% of the crack depth shall not be measured for payment.

932.09.01.02 Routing and Sealing

Measurement of routing and sealing shall be by length in metres.

932.10 BASIS OF PAYMENT

932.10.01 Crack Injection - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment, and Material to do the work.

There shall be 100% payment of the Contract price where 90% or more of the crack depth is filled. There shall be no payment where less than 80% of the crack depth is filled.

There shall be a payment adjustment of the unit Contract price for each increment of crack filled to between 80% and 89% of the crack depth.

$Pa = [100 - (89-D) \times 2] \div 100$

Where: Pa = payment adjustment factor
D = percentage of the crack depth filled, rounded to the nearest 0.1%.

and: $89 \geq D \geq 80$

932.10.02 Routing and Sealing-Hot-Poured Rubberized Joint Sealing Compound-Item
Routing and Sealing-Cold-Applied Joint Sealing Compound - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.