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CONSTRUCTION SPECIFICATION FOR STRUCTURE REHABILITATION - SHOTCRETE

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931.01 SCOPE

This specification covers the requirements for concrete structure rehabilitation using normal and silica fume shotcrete.

931.01.01 Specification Significance and Use

This specification is written as a municipal-oriented specification. Municipal-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of many municipalities in Ontario.

Use of this specification or any other specification shall be according to the Contract Documents.

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

931.02**REFERENCES**

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

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

Ontario Provincial Standard Specifications, Construction

OPSS 904	Concrete Structures
OPSS 905	Steel Reinforcement for Concrete
OPSS 919	Formwork and Falsework
OPSS 928	Structure Rehabilitation - Concrete Removal
OPSS 929	Abrasive Blast Cleaning - Concrete Construction
OPSS 932	Crack Repair - Concrete

Ontario Provincial Standard Specifications, Material:

OPSS 1002	Aggregates - Concrete
OPSS 1301	Cementing Materials
OPSS 1302	Water
OPSS 1306	Burlap
OPSS 1315	White Pigmented Curing Compounds for Concrete

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:

LS-430	Method of Test for Bond Strength by Tensile Load
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CSA Standards

A23.2-14C- 09 Obtaining and Testing Drilled Cores for Compressive Strength Testing*

* [Part of A23.1-09/A23.2-09 Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

ASTM International

A123/A123M-12 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A153/A153M-09 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A185/A185M-07 Steel Welded Wire Reinforcement, Plain, for Concrete

C1202-10 Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

931.03 DEFINITIONS

For the purpose of this specification the following definitions apply:

Cold Weather means those conditions when the air temperature is at or below 10° C. It is also considered to exist when the air temperature is at or is likely to fall below 10° C within 96 hours after concrete placement. Temperature refers to shade air temperature.

Dry-Mix Shotcrete means shotcrete in which the mixing water is added at the nozzle.

Hot Weather means those conditions when the air temperature is at or above 28 °C. It is also considered to exist when the air temperature is at or is likely to rise above 28 °C within 24 hours after concrete placement. Temperature refers to shade air temperature.

Nozzle Operator means the worker on the shotcrete crew who manipulates the nozzle, controls consistency with the dry process, and controls final placement of the material.

Rehabilitation means any modification, alteration, or improvement to a structure or its components that is designed to correct defects or deficiencies.

Structure means any bridge, culvert, tunnel, retaining wall, wharf, dock, guide way, or any part thereof.

Wet-Mix Shotcrete means shotcrete in which all of the ingredients, including water, are mixed before introduction into the delivery hose. Compressed air is introduced to the material flow at the nozzle.

931.04 DESIGN AND SUBMISSION REQUIREMENTS

931.04.01 Submission Requirements

931.04.01.01 Mix Design

The mix proportions and the name of the supplier of the prebagged shotcrete mix shall be forwarded to the Contract Administrator for review at least 14 Days prior to the application of shotcrete.

In addition, the Contractor shall submit with the mix design the following:

- a) A certificate from the cement supplier stating that the cement is certified to be free from early stiffening tendencies according to the requirements of OPSS 1301.
- b) Performance test data from the manufacturer of the prebagged material, or test data from another contract, verifying that the material meets the requirements of this specification.

All supporting test data shall not be more than 12 months old at the time the mix design was submitted to the Contract Administrator.

931.04.01.02 Shotcrete Equipment

A list of equipment and accessories to be used, including the following information, shall be submitted to the Contract Administrator at least 14 Days prior to the application of shotcrete:

- a) Equipment type and capacity.
- b) Nozzle type and size.
- c) Continuous feed predampener details, only when the dry mix process is used.

931.04.01.03 Nozzle Operator

The names of the nozzle operators and proof of their qualification shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of the shotcreting operation.

931.04.01.04 Cold Weather Protection

Details of the method to be used in the production of the shotcrete to control the shotcrete temperature shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of the shotcreting operation in cold weather. The submission shall be accompanied by samples of insulation, if requested by the Contract Administrator, and shall contain the following information:

- a) Weather conditions for which the description applies.
- b) Type of insulation, metric "R" value, and number of layers to be used.
- c) Description of housing and heating.
- d) Method of withdrawal of protection to avoid sudden temperature change in the shotcrete.
- e) Method of ensuring cold weather protection measures are maintained and effective when work requiring adjustment to the protective measure is being performed.

931.04.01.05 Hot Weather Shotcreting

A description of the method to be used in the production of the shotcrete to control the shotcrete temperature shall be submitted to the Contract Administrator 14 Days prior to the application of shotcrete in hot weather.

931.04.01.06 Curing

A description of the methods to be used for fog-misting and curing, including equipment and procedures, shall be submitted to the Contract Administrator 14 Days prior to the application of shotcrete.

931.04.01.07 Return of Submissions

Two copies of each submission shall be returned as one of the following:

- a) Stamped with the wording: Reviewed. In this case, work can commence on receipt of the drawings by the Contractor.

- b) Stamped with the wording: Reviewed as Noted. In this case, work can start on receipt of the reviewed submission by the Contractor. The submission shall be updated as noted and shall be sealed and signed by the design Engineer and the design-checking Engineer stating the submission has been revised according to the noted comments.
- c) Showing only required changes. In this case, the submission shall be updated as required and the submission process repeated.

931.05 MATERIALS

931.05.01 Anchors

Anchors for the attachment of the welded steel wire fabric to the concrete surface shall be galvanized according to ASTM A153/A153M and be of adequate length and strength to resist a pull-out force of 1.0 kN.

931.05.02 Burlap

Burlap shall be according to OPSS 1306.

931.05.03 Cementing Material

Cementing material shall be according to OPSS 1301.

931.05.04 Curing Compound

Curing compound shall be according to OPSS 1315.

931.05.05 Fine Aggregate

Fine aggregate shall be according to OPSS 1002.

931.05.06 Formwork

Formwork shall be according to OPSS 919.

931.05.07 Proprietary Patching Materials

Proprietary patching materials shall be as specified in the Contract Documents.

931.05.08 Shotcrete

931.05.08.01 General

The shotcrete mix shall be supplied prebagged. The prebagged mix shall contain cementing materials and fine aggregate. The bags shall be maintained in a dry condition up to the time of its use and shall be stored within a temperature range of 5 to 30 °C. Any bags that contain lumps of pre-hydrated shotcrete or appear to be frozen or otherwise damaged shall not be used in the Contract.

Each bag shall be stamped with the name of the manufacturer, mix identification, and date of packaging. The prebagged mix shall be used within 3 months of packaging.

931.05.08.02 Normal Shotcrete

The shotcrete shall have a minimum 28-Day compressive strength of 30 MPa. The water to cement ratio, by mass, shall not be greater than 0.35 when the wet mix process is used.

931.05.08.03 Silica Fume Shotcrete

The silica fume shotcrete shall have a minimum 28-Day compressive strength of 35 MPa and maximum rapid chloride permeability at 28 Days of 1,000 coulombs. The shotcrete mix shall contain 8% silica fume by mass of total cementing materials.

931.05.09 Tie Wire

Coated tie wire according to OPSS 905 shall be used.

931.05.10 Water

Water shall be according to OPSS 1302.

931.05.11 Welded Steel Wire Fabric

Welded steel wire fabric shall be welded galvanized steel of 51 x 51 mm, MW 5.5 x MW 5.5, and shall be according to ASTM A185/A185M. Galvanizing shall be according to ASTM A123/A123M.

931.06 EQUIPMENT

931.06.01 Compressor - Air Blasting

The compressor for air blasting shall have a minimum capacity of 3.5 m³/min. The compressed air shall be free from oil and other contaminants.

931.06.02 Fog Misting Equipment

The Contractor shall provide fog misting equipment for curing of the shotcrete. Fog misting equipment shall include at least one hand held portable unit.

931.06.03 Hand Finishing Equipment

Where hand finishing is required, only magnesium, wood, or sponge rubber floats shall be used.

931.06.04 Mixers

931.06.04.01 Dry Mix Process

A continuous feed predampener shall be used. The predampening equipment shall be capable of bringing the dry bagged material to consistent and suitable moisture content and shall operate at sufficient capacity to allow work to proceed without delays.

The delivery equipment shall be capable of discharging the mixture into the delivery hose at a rate sufficient to ensure a continuous smooth stream of uniformly mixed shotcrete mixture being delivered to the nozzle, at the velocity required.

The discharge nozzle shall be equipped with a manually operated water injection system, for directing an even distribution of liquid through the mixture. The liquid valve shall be capable of ready adjustment to vary the quantity of liquid and shall be convenient for the nozzle operator. The nozzle shall be capable of delivering a conical discharge stream with uniform appearance throughout. The liquid pressure at the discharge nozzle shall be sufficiently greater than the operating air pressure to assure that the liquid is thoroughly mixed with the other materials. The liquid pressure shall be uniform.

931.06.04.02 Wet Mix Process

The mixing equipment shall be capable of thoroughly mixing the specified materials in sufficient quantity to maintain continuous placing. The delivery equipment shall be capable of delivering the pre-mixed materials accurately, uniformly, and continuously through the delivery hose.

The wet mix process shall not be used for silica fume shotcrete.

931.06.05 Straight Edge

The straight edge shall be 1.0 m long, commercially made, and metal.

931.07 CONSTRUCTION

931.07.01 General

Typical locations and areas of repair are as specified in the Contract Documents; however, the actual locations and extent of repair shall be as determined during the layout of the repair areas according to OPSS 928 and as directed by the Contract Administrator.

931.07.02 Operational Constraints

The Contract Administrator shall be notified of the intent to apply shotcrete 3 Business Days prior to the commencement of the shotcreting operation. The application of shotcrete shall not proceed until the concrete surface preparation has been completed according to this specification and verified by the Contract Administrator.

Prior to shotcreting, the Contractor shall demonstrate to the Contract Administrator that the substrate temperatures meet the requirements specified in the Contract Documents by measuring and recording the substrate temperatures using a contact thermometer or infrared thermometer.

Shotcreting shall not be carried out when the air temperature or existing concrete surface temperature is below 10 °C or is likely to fall below 10 °C, or is above 28 °C or likely to rise above 28 °C throughout the duration of the shotcreting operation, unless protection is provided in accordance with the Contractor's submitted plan.

The air in contact with the repaired surfaces shall be maintained at temperatures above 10 °C for at least 96 hours after the application of shotcrete. The use of unvented heaters shall be prohibited.

Shotcreting operations shall be suspended during adverse weather conditions, unless protection is provided.

Prior to seasonal shutdown, operations shall be scheduled in such a manner to ensure that the shotcreting operations are completed in all areas where concrete removal has commenced. No steel reinforcement shall be left exposed during seasonal shutdown.

931.07.03 Access to Work Areas, Work Platform, and Scaffolding

Adequate access shall be provided to facilitate inspection and measurement by the Contract Administrator.

931.07.04 Surface Preparation

All concrete surfaces against which shotcrete is to be placed shall be clean, solid, and free from loose or unsound fragments, coatings, and any other foreign substances or debris, and shall be sufficiently rough to ensure that a full bond is developed with the new shotcrete.

All existing concrete surfaces to be covered by shotcrete shall be uniformly roughened by means of scabbling, chipping, or bush hammering. A surface profile of 5 ± 2 mm shall be achieved by exposing the aggregates across the entire surface.

All concrete surfaces, including areas 50 mm beyond the perimeter of the removal area and existing steel reinforcement to receive shotcrete, shall be abrasive blast cleaned according to OPSS 929 prior to installation of welded steel wire fabric.

Abrasive blast cleaned areas shall have shotcrete applied within 36 hours or shall be reblasted. In areas requiring reblasting, the Contractor shall remove the welded steel wire fabric prior to abrasive blast cleaning and reinstall the wire fabric.

Immediately prior to wetting the concrete, all dust and loose material shall be removed from the prepared surface of the repair area by using compressed air.

The area to be shotcreted shall be maintained in a wet condition for a period of 2 hours prior to the application of the shotcrete. Prior to the shotcreting operation, excess water shall be removed from the surface using compressed air.

931.07.05 Placement of Welded Steel Wire Fabric

When welded steel wire fabric is specified in the Contract Documents, it shall not be installed until after the concrete surface and exposed steel reinforcement in the repair area have been abrasive blast cleaned. The wire fabric shall not be abrasive blast cleaned at any time.

The Contractor shall install wire fabric in all repair areas greater than 0.1 m² that have a minimum dimension of 200 mm. The wire fabric shall be securely fastened to the exposed steel reinforcement by ties placed no further than 300 mm apart in a grid pattern. When the exposed steel reinforcement is not capable of providing rigid support for the wire fabric, anchors shall be used to support the wire fabric.

When there is no exposed steel reinforcement, the wire fabric shall be fastened to the concrete with anchors placed no further than 300 mm apart in a grid pattern. The minimum clearance between the wire fabric and the existing concrete shall be 20 mm.

The wire fabric shall be installed flat, tight, and at locations shown in the Contract Documents using spacers and anchors. The edges of adjoining wire fabric sheets shall be overlapped by one wire spacing plus 50 mm. The wire fabric shall be kept clean of any substance that may reduce the bond of the shotcrete to the wire surface.

931.07.06 Approval of Nozzle Operator

Shotcreting shall be carried out by a nozzle operator who has been certified by participation in the MTO Shotcrete Nozzlemen Certification Program.

931.07.07**Placing**

Prior to the application of shotcrete, the Contractor shall protect all structural components not receiving shotcrete and appurtenances from the shotcreting operation. Repair areas being prepared to receive shotcrete shall also be protected.

When practical, shotcrete shall be placed without the use of formwork. When the requirements of this specification cannot otherwise be met, formwork may be used and shall be according to OPSS 919. Formwork shall be adequately braced against excessive vibration and constructed to permit the escape of air and rebound during the shotcreting operation.

During the application of shotcrete, a steady continuous flow of shotcrete shall be maintained. Any predampened mixture that is not used within one half hour, shall not be incorporated into the work.

Shotcrete shall be applied so that there is no sagging or separation of the material in place. All rebound material shall be removed from the repair area as the work proceeds. Rebound or waste material shall not be worked back into construction or salvaged and re-used.

The concrete surface surrounding the repair area shall be cleaned immediately after the application of shotcrete using suitable hand tools.

When shotcrete in a repair area cannot be applied in a single operation or delays are experienced, moist curing by means of continuous fog mist shall be applied according to the curing requirements of this specification. If the previous layer has hardened, the surface of the shotcrete shall be thoroughly cleaned of any laitance by wire brushing and wetted prior to application of an additional layer of shotcrete.

The shotcrete shall be placed level or slightly above the level of the original concrete surface to provide a minimum of 50 mm cover to the welded steel wire fabric or reinforcing steel, unless otherwise specified in the Contract Documents.

At the end of the shotcreting operation, the shotcrete shall be terminated at a 1H:1V slope. Before placing an adjacent section, this sloped portion shall be thoroughly cleaned by wire brushing any laitance and wetted.

The total required depth of shotcrete shall be placed within the same working day.

931.07.08**Finishing**

Unless otherwise specified in the Contract Documents, when the final layer of shotcrete has attained its initial set, the surface of the shotcrete shall be finished with hand finishing equipment.

When tested with a straight edge, the maximum gap between the straight edge and any point on the surface shall be 6 mm.

931.07.09**Curing**

Shotcrete shall be initially moist cured by continuous fog mist for a minimum period of 24 hours. The curing shall commence as soon as the fog mist can be applied without deforming the surface of the shotcrete. When an area of fresh shotcrete is exposed to direct sunlight or to wind, the curing shall be applied immediately after the final application of shotcrete in that area.

After the initial 24 hour fog misting period, moist curing shall continue for an additional period of 72 hours by means of fog mist or wet burlap.

When wet burlap is used, the burlap shall be placed in a manner to ensure that it is in full contact with the surface of the shotcrete for the full duration of the curing period. The curing with burlap and water shall be according to OPSS 904.

Immediately after removal of moist curing, the shotcrete surface shall be coated with a curing compound according to OPSS 904.

931.07.10 Cold Weather Protection

931.07.10.01 General

The Contractor shall protect the shotcrete during cold weather. The protection system shall be designed for the worst conditions that can be reasonably anticipated from local weather records, forecasts, site conditions and past experience for the time period during which the protection is required.

931.07.10.02 Control of Temperature

During cold weather, the Contractor shall for a minimum period of seven days following the shotcrete operation, monitor and control the temperature of the shotcrete to ensure that the temperature does not fall below 10 °C. The Contractor shall take measures to ensure that the shotcrete temperature remains within the acceptable limits.

The Contractor shall supply thermocouples, wires, and digital temperature indicators with an accuracy of $\pm 0.5^{\circ}\text{C}$ to monitor the shade air temperature and shotcrete temperature. The digital temperature indicators shall be left in place or provided upon request to the Contract Administrator to facilitate additional readings for verification purposes.

Thermocouples shall be embedded near the shotcrete surface at a minimum of two locations for each day of shotcreting, as directed by the Contract Administrator.

For cold weather conditions, protection of concrete shall at least be according to Table 1.

931.07.10.03 Temperature Records

The Contractor shall record the shade air temperature and shotcrete temperature at a minimum frequency of once every four hours for the first 24 hours after the shotcreting operation and then once every eight hours for the remainder of the curing and protection period and during the removal of the cold weather protection.

The Contractor shall provide the Contract Administrator with the necessary access to the location and equipment to verify temperature readings.

Temperature records shall be forwarded to the Contract Administrator at the end of every day. At the end of the cold weather protection period, the Contractor shall submit to the Contract Administrator a complete temperature record consisting of a summary of the recorded temperatures and a graphical plot of temperature vs. time.

931.07.11 Coring and Testing

931.07.11.01 General

The cores shall be obtained according to CSA A23.2-14C at random locations specified by the Contract Administrator. The Contractor shall locate all steel reinforcement in the area, prior to taking any cores, to avoid cutting steel reinforcement.

Testing shall not be required on a structure when the total measured vertical area of shotcrete on a structure is less than 20 m² or the total measured horizontal area of shotcrete on a structure is less than 20 m².

931.07.11.02 Lot and Sublot Size

A lot shall consist of the total quantity of normal shotcrete or silica fume shotcrete in the Contract Documents. Each lot shall be divided into sublots of approximately equal size and not greater than 100 m². Separate sublots are required for vertical and horizontal repairs. Separate sublots are required for individual structures.

The Contract Administrator shall determine the sublot size after discussion with the Contractor and prior to the commencement of the shotcreting operation.

931.07.11.03 Compressive Strength

The Contractor shall be responsible for all aspects of coring, storage, and transportation of cores to determine compressive strength.

For evaluation of compressive strength testing, the Contractor shall remove four cores from the hardened shotcrete when the shotcrete is between 7 to 10 Days of age, for each sublot. The cores shall be 75 mm in diameter and at least 100 mm long. Cores may contain wire fabric but shall not contain reinforcing steel.

The Contractor shall deliver the cores to the designated quality assurance laboratory as specified in the Contract Documents. The cores shall be tested according to CSA A23.2-14C at 28 Days of age. The forms on which the field data for the cores is recorded shall be submitted to the laboratory with the shotcrete cores. Test results shall be recorded on forms acceptable to the Owner and forwarded to the Contract Administrator within 4 Days from the date of testing.

931.07.11.04 Tensile Bond Strength

The minimum tensile bond strength of the shotcrete shall be 1.0 MPa.

The tensile bond strength testing shall be carried out by the Contractor, in the presence of the Contract Administrator, on 3 in-situ cores taken within one metre of each other for each sublot. The testing shall be carried out by technicians employed by a laboratory acceptable to the Owner.

The cores shall be 100 mm in diameter and extend into the parent concrete to the depth specified in MTO LS-430. The testing shall be according to MTO LS-430 and shall be carried out when the shotcrete is 7 to 10 Days of age. The equipment used to measure the tensile bond strength shall be equipped with a maximum load indicator.

The Contractor shall ensure that the epoxy adhesive is cured according to the manufacturer's recommendations prior to carrying out the test. If failure occurs in the epoxy adhesive and the specified strength of 1.0 MPa has not been reached, the test shall be repeated within 300 mm of the original core location. Retesting is not required when the specified strength of 1.0 MPa has been achieved.

After the tensile bond strength testing is completed, the cores shall be extracted for the full depth of the coring to demonstrate to the Contract Administrator that the depth of coring was adequate.

All individual tensile bond strength results obtained by the Contractor and average shall be recorded on forms acceptable to the Owner and forwarded to the Contract Administrator within 4 Business Days of the date of testing.

931.07.11.05 Rapid Chloride Permeability - Silica Fume Shotcrete

For evaluation of rapid chloride permeability, the Contractor shall remove cores from the hardened silica fume-shotcrete and test cores according to ASTM C1202. Testing shall be carried out by a laboratory that is acceptable to the Owner.

Two cores, 100 mm in diameter and at least 75 mm long, shall be removed from each subplot, when the silica fume shotcrete is 7 to 10 Days of age. The portion of the core to be tested shall contain no reinforcing steel, welded wire steel fabric, or other embedments.

Cores shall be delivered in a plastic bag sealed to avoid loss of moisture, to a laboratory acceptable to the Owner, within 24 hours of coring. The cores shall be stored at a temperature of 23 ± 2 °C in a moist condition until time of testing. A 10 mm thick slice shall be cut from the top of each core before testing. Testing shall be carried out according to ASTM C1202 when the shotcrete is 28 to 32 Days of age.

Rapid chloride permeability results obtained by the Contractor shall be recorded and forwarded to the Contract Administrator within 37 Days of application of shotcrete. Rapid chloride permeability core samples and original test record shall be retained by the Contractor until final completion of the Contract and shall be provided to the Contract Administrator, upon request.

931.07.11.06 Filling of Core Holes

All remnants of cores, including ones that remain in place, shall be completely removed and core holes filled immediately after coring. Prior to filling, the inside surfaces of each core hole shall be cleaned of all laitance and other debris from the coring operation by wire brushing. The core holes shall be cleaned using compressed air, pre-wetted, and filled with a proprietary patching material. The patching material shall be comparable to the surrounding concrete in terms of strength and permeability. The patching material shall be mixed and cured according to the manufacturer's recommendations. The patch shall be finished flush with the surface of the concrete and all excess material removed.

931.07.12 Remedial Work

If plastic shotcrete is rejected by the Contract Administrator, the Contractor shall stop the work and take all necessary measures to correct deficiencies while the shotcrete is in the plastic state.

The Contractor shall notify the Contract Administrator in writing immediately if any of the defects or conditions listed in the Quality Assurance section are present in the Work with an explanation of the cause and extent of the deficiencies. These areas shall be repaired by the Contractor.

A proposal for the remedial work for the above defects and conditions shall be submitted to the Contract Administrator for review. The Contractor shall not proceed with repairs until approval of the proposal has been received.

The Contractor shall repair all cracks greater than or equal to 0.3 mm after the curing period has elapsed. Repair of cracks shall be according to OPSS 932. If the linear measurement of cracks greater than or equal to 0.3 mm in width per square metre is 2 m or greater, the entire shotcrete in the repair area shall be removed and replaced.

931.07.13 Management of Excess Material

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

931.08 **QUALITY ASSURANCE**

931.08.01 **Inspection**

931.08.01.01 **During Shotcrete Application**

The Contract Administrator shall inspect the plastic shotcrete during the application process and shall reject all or a portion of the work based on the presence of one or more of the defects identified below:

- a) Failure to properly control and remove build-up of overspray and rebound.
- b) Incomplete consolidation around steel reinforcement and anchors.
- c) Excessive shotcrete rebound.
- d) Incorporation of sand lenses, excessive voids, delaminations, sags, and sloughing.
- e) Failure to apply shotcrete to the required line, grade, and tolerance.

931.08.01.02 **Completed Work**

The Contract Administrator shall inspect the completed work to determine if the work contains any of the following:

- a) Debonding or hollow-sounding areas.
- b) Porous or rebound material visible in cores.
- c) Areas that have visibly sagged in cores.
- d) Cracks.

931.08.02 **Acceptance or Rejection**

The Contract Administrator shall have the authority to accept or reject shotcrete that does not conform to the Contract requirements, either during the shotcrete application process or on the basis of the completed work, or if any of the defects identified in the Inspection subsection are identified in any of the cores extracted.

931.08.02.01 **Normal Shotcrete**

For normal shotcrete, the Contract Administrator shall reject all or a portion of the lot based on the presence of one or more of the defects identified in the Inspection subsection or one or more of the following conditions:

- a) Average compressive strength less than 30 MPa.
- b) An individual compressive strength result more than 3.5 MPa below the specified strength.
- c) Average tensile bond strength less than 0.6 MPa.
- d) Any work that does not conform to the requirements of this specification.

931.08.02.02 Silica Fume Shotcrete

For silica fume shotcrete, the Contract Administrator shall reject all or a portion of the lot based on the presence of one or more of the defects identified in the Inspection subsection or one or more of the following conditions:

- a) Average compressive strength less than 35 MPa.
- b) An individual compressive strength result more than 3.5 MPa below the specified strength.
- c) Average tensile bond strength less than 0.6 MPa.
- d) Average rapid chloride permeability greater than 2,500 coulombs.
- e) Any work that is not according to the requirements of this specification.

931.09 MEASUREMENT FOR PAYMENT

931.09.01 Actual Measurement

**931.09.01.01 Normal Shotcrete
 Silica Fume Shotcrete**

Measurement shall be by volume in cubic metres of the concrete removed according to the Measurement for Payment section of OPSS 928, except when the existing cover to steel reinforcement is less than 50 mm, the depth used in calculating the volume shall be adjusted by adding the difference between the 50 mm required and the existing cover.

No measurement shall be made for areas of shotcrete that were removed according to the Remedial Work subsection.

No measurement shall be made for shotcrete required to patch areas of concrete removal when the removal was not approved by the Contract Administrator.

931.10 BASIS OF PAYMENT

**931.10.01 Normal Shotcrete - Item
 Silica Fume Shotcrete - 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, including abrasive blast cleaning of the concrete surfaces.

Payment for the work of abrasive blast cleaning of steel reinforcement shall be according to OPSS 929.

When the Contract does not contain a separate tender item for providing access to the work, the Contract price for the shotcrete items requiring the access shall include full compensation for all labour, Equipment, and Material to do the work.

TABLE 1
Minimum Cold Weather Protective Measures

Anticipated Minimum Air Temperature °C	Protective Measure Thickness of New Shotcrete < 0.25 m
+10 to 0	PM2
-1 to -10	PM4
-11 to - 20	PM5
Less than - 20	PM5
Maximum Allowable Drop in Concrete Temperature/24 hours	15 °C

Notes:

A. Protective Measures:

- PM2 - Cover concrete with insulation having an R-Value of 0.67.
- PM3 - Cover concrete with insulation having an R-Value of 1.33.
- PM4 - Cover concrete with insulation having an R-Value of 2.00.
- PM5 - House and heat as specified in the Housing and Heating clause of OPSS 904.

B. All R-Values are metric.

C. The conversion factor from metric to imperial units is:

Metric R-Value x 5.678 = Imperial R-Value.

**Appendix 931-A, November 2020
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS**

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

The designer should specify the following in the Contract Documents:

- Proprietary patching materials. (931.05.07)
- Location of the quality assurance laboratory. (931.07.11.03)

The designer should determine if the following is required and, if so, specify it in the Contract Documents:

- Welded steel wire fabric. (931.07.05)

The wire fabric shall not be used in repair areas on which a cathodic protection system is to be installed.

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Related Ontario Provincial Standard Drawings

No information provided here.