CONSTRUCTION SPECIFICATION FOR ROCK STABILIZATION

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203.01 SCOPE

This specification covers the requirements for the stabilization of a rock face or mass using a combination of rock bolts, shotcrete or concrete buttresses or both.

203.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

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

203.01.02 Appendices Significance and Use

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.

203.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-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 931	Structure Rehabilitation - Shotcrete

Ontario Provincial Standard Specifications, Material

OPSS 1440	Steel Reinforcement for Concrete

ASTM International

A 123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A 820-90	Standard Specification for Steel Fibers for Fiber-Reinforced Concrete
C 33	Standard Specification for Concrete Aggregates
C 42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C 150	Standard Specification for Portland Cement

Others

ACI 506.2-77	Specification for Materials, Proportioning and Application of Shotcrete ISRM (International Society for Rock Mechanics) Suggested Method for Rock Anchorage Testing

203.03 DEFINITIONS

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

Basal Plane means a planar discontinuity within a rock mass along which one portion of the mass could slide over another.

Nozzle Operator means as defined in OPSS 931.

Rock Bolting means the pinning of a rock block or rock mass in-situ using grouted steel bars.

203.04 DESIGN AND SUBMISSION REQUIREMENTS

203.04.01 Submission Requirements

203.04.01.01 Rock Bolting

The following information shall be submitted to the Contract Administrator for information purposes a minimum of 2 weeks prior to starting the work:

a) The name and statement of experience of the persons or firm responsible for installing the rock bolts.

b) The name of the firm supplying the rock bolts.

c) The name of the firm supplying the resin cartridge.

d) The type, set time and dimensions of the resin cartridge, the drill hole diameter, and the installation methodology to be used.

e) The mill certificates for the rock bolts to be used.

f) The type of grout, the drill hole diameter, and installation methodology for grouted rock bolts.

203.04.01.02 Shotcreting

A list of equipment and accessories to be used including the information below shall be submitted to the Contract Administrator a minimum of 2 weeks for information purposes prior to the application of shotcrete:

a) Equipment type and capacity.

b) Nozzle type and size.

c) Continuous feed predampener details.

d) List of additives to be used along with the name of the supplier.

203.05 MATERIALS

203.05.01 Rock Bolts

Rock bolts shall be a minimum 25M reinforcing steel bars according to OPSS 1440 with a minimum yield strength of 400 MPa and a minimum length of 3.0 m, unless specified elsewhere in the Contract Documents. Rock bolts shall be fully threaded bars or bars threaded at one end and provided with a faceplate of at least 100 x 100 mm in area with a nut and beveled or spherical washers as recommended by the manufacturer. All rock bolt components shall be hot-dip galvanized according to ASTM A123.

203.05.01.01 Anchoring Agent for Rock Bolts

The anchoring agent for rock bolts shall be supplied in cartridges containing an polyester resin with a catalyst that has a maximum nominal gel time of 15 minutes. Fully cured anchoring agent shall have a minimum compressive strength of 50 MPa and a minimum tensile strength of 15 MPa. Resin with an expired shelf life shall not be used.

203.05.01.02 Grout

The grout cube for high early strength grout shall be at least 20 MPa at 7 Days and 30 MPa at 28 Days. The type of cement used shall be suitable for the required use of the grout. Accelerators shall not be used. The grout shall bleed less than 2% when allowed to stand for 1 hour.

203.05.01.03 Grout Tubes

Grout tubes shall have an adequate inside diameter to enable the grout to be pumped to the bottom of the drill hole. They shall be able to withstand a pressure of 1 MPa.

203.05.02 Rock Shotcrete

Shotcrete for rock face stabilization shall consist of the following:

a) Normal Portland cement: 18% - 21% by weight of dry components according to ASTM C150.

b) Silica fume: 10% - 15% by weight of Portland cement containing a minimum of 90% SiO_2 and having a proven record of performance when used in shotcrete.

c) Aggregate: Gradation No.2 in ACI 506.2-77 having a well-graded distribution with maximum size of 10 mm and according to ASTM C33.

d) Steel Fibre Reinforcement: Quantity as recommended by the supplier and quality according to ASTM 820 or Owner-approved equivalent.

e) Water: Clean and free of substances which may be harmful or corrosive to concrete or steel; the ratio of water to total cementitious material shall be in the range of 0.35 to 0.45:1 and in sufficient quantity to provide good placement characteristics.

f) Additives as required to achieve optimum strength and placement characteristics.

g) Hardened shotcrete at 7 Days shall have a minimum compressive strength of 30 MPa.

203.05.02.01 Pipe for Rock Drains

Rock drains shall consist of slotted polyvinyl chloride (PVC) pipe according to ASTM D1784 and have a minimum internal diameter of 19 to 25 mm, inclusive.

203.06 EQUIPMENT

203.06.01 Shotcreting

203.06.01.01 Compressor - Air Blasting

The compressor for air blasting shall have a minimum capacity of 14.2 m^3/min or 500 cfm. The compressed air shall be free from oil and other contaminants.

203.06.01.02 Hand Finishing Equipment

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

203.06.01.03 Mixing Process

The dry mix process shall be used.

A continuous feed predampener capable of bringing the dry bagged material to a consistent and suitable moisture content shall be operated at sufficient capacity to allow the 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 required velocity.

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 ensure that the liquid is thoroughly mixed with the other materials. The liquid pressure shall be uniform.

203.07 CONSTRUCTION

203.07.01 Rock Bolting

Holes for rock bolts shall be drilled at the diameter recommended by the resin supplier for the sizes of the rock bolts and cartridges at the locations as specified in the Contract Documents. For grouted rock bolts, holes shall be drilled as specified in the Contract Documents.

Holes shall be drilled in a direction angled downward in order to connect the basal planes and to a depth such that when the rock bolt is fully inserted it protrudes 70 + 20 mm from the rock or shotcrete surface.

The drill holes shall be thoroughly cleaned with compressed air prior to the installation of a polyester resin anchoring agent or grout. The holes shall be filled with anchoring agent or grout to ensure complete encapsulation of the rock bolt and an adequate bond length along the full length of the drill hole while allowing some overflow.

Centralizers shall be maintained in position during installation.

Rock bolts shall be installed according to the resin supplier's installation instructions or as specified in the Contract Drawings. For the resin anchor, during the insertion of the rock bolt in the hole, the bolt shall be steadily rotated by means of a pneumatic tool and suitable coupling attached to the threaded end of the bolt according to the resin manufacturer recommendations. The rotation shall be continued after the bolt has been inserted for a further 15 seconds or according to the recommendations of the resin manufacturer and the bolt shall then be maintained in position until the resin has hardened.

After the rock bolts are fully inserted into the drill holes in a vertical or inclined rock face, the bolts shall be maintained in position to prevent any further loss of resin while the anchoring agent is setting.

Grout shall be pumped or poured through the grout tube until the hole is filled.

The face plate, washer and nut shall be pneumatically fastened to the rock bolts at angles of less than 30 degrees from the perpendicular in order to provide full contact of the faceplate with the rock or shotcrete bearing surface and nominal tensioning of the bolt.

Rock bolts in holes that are not completely filled with anchoring agent or which protrude from the hole by an amount greater or less than the length specified shall not be accepted and shall be replaced at a location as close to the original bolt as possible.

Corrosion protection shall be applied to all exposed surfaces not already protected.

203.07.01.01 Testing of Rock Bolts

Rock bolt tests shall be conducted as specified in the Contract Documents to demonstrate the performance of the rock bolts by axial pull tests using a calibrated hollow hydraulic jack.

The rock bolt pull testing shall be carried out according to the International Society for Rock Mechanics (ISRM) standard methods for proof tests in the presence of the Contract Administrator. The axial tensioning equipment shall consist of a hollow plunger type hydraulic jack with a minimum capacity of 200 kN, a hydraulic pump, pressure gauges, displacement gauges capable of measuring displacements of 0.0025 cm, and all necessary accessory items for carrying out rock bolt performance tests. Rock bolts that fail to meet the test criteria shall be reinstalled and tested at no additional cost to the Owner.

203.07.02 Rock Shotcreting

203.07.02.01 Operational Constraints

The Contract Administrator shall be notified of the intent to apply shotcrete a minimum of 3 Business Days prior to the commencement of the shotcreting operation.

The application of shotcrete shall not proceed until the rock surface has been properly prepared according to this specification and verified by the Contract Administrator.

Shotcreting shall not be carried out when the air temperature or the existing rock surface temperature is below 10 °C, or is likely to fall below 10 °C, or is above 30 °C, or likely to rise above 30°C throughout the duration of the shotcreting operation, unless protection is provided according to the Contractor's submitted plan.

Shotcreting operations shall be suspended during weather conditions that may adversely affect the quality of the work.

203.07.02.02 Approval of Nozzle Operator

Shotcreting shall be carried out by a nozzle operator who has been certified by participation in the MTO Shotcrete Nozzleman Certification Program and who is on the list of approved nozzle operators for the current construction season.

203.07.02.03 Placing

To ensure that a full bond is developed with the shotcrete, all rock surfaces against which shotcrete is to be placed shall be clean, solid and free from loose or unsound fragments, vegetation or other organic materials, and any foreign substances or other debris.

Immediately prior to wetting the rock surface, all dust and loose material shall be removed 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 rock surface using compressed air.

All necessary measures shall be taken during shotcrete application to guard against damage, including damage to passing vehicles which may be caused by excessive rebounding of shotcrete material.

Shotcrete shall be placed to create a minimum 75 mm thick and an average 100 mm thick layer to stabilize fractured rock and support rock overhangs at the locations as specified in the Contract Documents.

During the application of the shotcrete, a steady continuous flow of shotcrete shall be maintained. Any pre-dampened 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 work area as the work proceeds. Rebound or waste material shall not be worked back into construction or salvaged and re-used.

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

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

203.07.02.04 Testing of Rock Shotcrete

Testing of shotcrete shall be according to ASTM C42. If necessary, thicknesses shall be confirmed by core drilling. The minimum number of cores taken will be 1 for every 50 square metres of shotcrete placed at locations selected by the Contract Administrator.

A minimum of 5 test panels shall be constructed during the work as directed by the Contract Administrator. Specimens from the panels may be tested by the Contract Administrator to determine compliance with this specification.

When the shotcrete has gained sufficient strength and within 36 hours after its placement, all designated in-place shotcrete in both the initial and subsequent shotcreted layers shall be tested in the presence of the Contract Administrator. The testing shall consist of hammering at 300 mm centres to detect any hollow sounding areas.

Areas of shotcrete that are determined by the Contract Administrator to be inadequately bonded or cracked or any area of shotcrete where porous, rebound material, cracks, or sagging are present in cores that are taken within those areas shall be removed and replaced until adequate shotcrete quality and bonding has been achieved. Rehabilitation by other methods shall only be undertaken with the written approval of the Contract Administrator.

203.07.03 Rock Drains

When drain holes are specified in the Contract Documents, the holes shall be drilled to depths of 3.0 m at an inclination of approximately 10 degrees above the horizontal and throughout the shotcrete layer at 2.0 to 3.0 m centres.

The drain holes shall then be lined with tightly-fitting PVC pipe that protrudes approximately 25 to 75 mm outside of the shotcreted face.

203.07.04 Concrete Buttress

Rock cavities shall be filled with reinforced concrete at locations as specified in the Contract Documents.

All work shall be according to OPSS 904.

Concrete shall be 30 MPa at 28 Days.

Dowels into the rock shall be installed into the existing rock base on a grid pattern and to depths as specified in the Contract Drawings.

Reinforcing steel shall be according to OPSS 905.

The resultant concrete face shall be a smooth surface.

203.07.05 Management of Excess Material

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

203.09 MEASUREMENT FOR PAYMENT

203.09.01 Actual Measurement

203.09.01.01 Rock Bolting

For measurement purposes, a count shall be made of the number of rock bolts installed.

203.09.01.02 Rock Shotcrete

Measurement shall be by area in square metres of shotcrete and shall only include those areas that have an average thickness of 100 mm and a minimum thickness of 75 mm.

203.09.01.03 Rock Drains

For measurement purposes, a count shall be made of the number of rock drains installed.

203.09.01.04 Concrete Buttress

Measurement shall be by volume in cubic metres of the reinforced concrete placed.

203.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clauses under Actual Measurement.

203.10 BASIS OF PAYMENT

203.10.01 Rock Drains - Items
Concrete Buttress - 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.

203.10.02 Rock Shotcreting - Item
Rock Bolting - 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.

Replacement of unacceptable rock bolts and rock shotcreting shall be carried out at no additional cost to the Owner.

Appendix 203-A, November 2014
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

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.