



# **Winton Hill Railway Trail**

## **Rock Cut Stabilization**

Bermuda

### **Annex C**

### **Specifications**

Date: October 16, 2017

Project No. 90-05-76



## Part 1 GENERAL

### 1.1 Related Sections

- .1 Section 01010 – General Requirements

### 1.2 Requirements

- .1 Unit prices may be used to vary Contract Price when authorised by Owner's Representative.

### 1.3 Conditions of Unit Prices

- .1 Unit price quantities will be checked and measured by Owner's Representative.
- .2 Unit prices entered on Tender Form will remain in force until Substantial Completion and issuance of Interim Certificate of Completion.

### 1.4 Unit Prices

#### .1 Mobilization / Demobilization - Lump Sum

- .1 Terms and Payment: Lump Sum (LS).
- .2 This Item includes: 50% of Lump Sum Contract Price for Mobilization and Demobilization to be paid when mobilization to site is complete. The remainder of the Lump Sum Price for Mobilization and Demobilization to be paid when work is complete and all materials, equipment and facilities are removed from site and site cleaned and left in condition to the satisfaction of the Owner's Representative and all other Agencies having Jurisdiction.

#### .2 Rock Anchors - Unit Price

- .1 Unit of Measurement: Install 25 mm diameter rock anchor (per m), and perform load test on each anchor.
- .2 This item includes: The unit price for installation of each 25 mm diameter rock anchor including all labour, materials, equipment, and site access necessary to complete the work. The unit price also includes performing load tests on new rock anchors.
- .3 The number of rock anchors specified in the specifications may change after scaling operations.
- .4 The number of rock anchors to be load tested will be determined by the Owner's Representative.
- .5 Rock anchors will be installed at locations designated by the Owner's Representative.
- .6 Payment for rock anchor installation and testing will be made at the Contract Unit Prices per rock anchor for 25 mm anchors and performing load testing which



shall be full compensation for supplying all material, labour and equipment to execute the work as specified.

.3 Rock Scaling - Unit Price

- .1 Unit of Measurement: Per square meter of area scaled
- .2 This item includes: Unit price per square meter area scaled
- .3 Payment for Scaling will be made at the Contract Unit Prices per square meter of area scaled, which shall be full compensation for supplying all material, labour and equipment to execute the work as specified.
- .4 Disposal and clean-up of materials from rock scaling, trimming, and excavation of existing fallen materials in the work areas is not part of this unit price.

END OF SECTION



## Part 1 GENERAL

### 1.1 Utilities and Services

- .1 Existing underground services are known to exist within the site.
- .2 The Contractor is responsible for locating and protecting these and any possible other services within the works area.

### 1.2 Setting Out Stations

- .1 The Ministry of Public Works will establish sufficient survey stations for the Contractor to undertake the works.

### 1.3 Setting out and Dimensions

- .1 The Contractor shall be solely responsible for the accurate setting out of the works and shall employ a qualified surveyor whenever necessary. Any damages which may be incurred as a result of the incorrect setting out of the works shall be the responsibility of the Contractor.
- .2 The Contractor shall be responsible for the maintenance of all bench marks on the site.
- .3 The Contractor shall provide accurate locations for all rock anchors installed.

### 1.4 Use Of Site

- .1 Limit use of site to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated. Confine construction and operations to within the boundary shown on drawings.
- .2 Keep driveways and entrances serving all adjacent premises and public property clear and available to the public, owners, owner's employees, guests, and both service and emergency vehicles at all times. These areas shall not be used for parking or storage of materials.

### 1.5 Working Hours

- .1 Normal working hours shall be Monday to Saturday 8.00am through to 6.00pm and Sunday working shall not be permitted.

END OF SECTION



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## Part 1 GENERAL

### 1.1 Requirements Included

- .1 Works schedule
- .2 Cash flow forecast
- .3 Work Plans
- .4 Traffic Control Plan
- .5 Quality Control Plan
- .6 Health and Safety Plan
- .7 Product data
- .8 Samples

### 1.2 Administrative

- .1 Provide to Engineer for review the submittals specified. Submit with reasonable promptness and in an orderly sequence so as to not cause delay in the Work. Failure to submit in ample time is not considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default will be allowed.
- .2 Do not proceed with Work affected by the submittal until review is complete.
- .3 Review submittals prior to submission to the Engineer. This review represents that necessary requirements have been determined and verified, or will be, and that each submittal has been checked and co-ordinated with the requirements of the Work and Contract Documents. Submittals not stamped, signed, dated and identified as to the specific project will be returned without being examined and will be considered rejected.
- .4 Contractor's responsibility for errors and omission in submission is not relieved by Engineer review of submittals.
- .5 Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved by Engineer review.
- .6 Keep one review copy of each submission on Site.

### 1.3 Works Schedule

- .1 Prepare schedule in the form of a horizontal bar chart in electronic Microsoft Project format. If other equivalent critical-path scheduling software is used, provide the Engineer with a copy of the software.
- .2 Provide a separate bar for each trade or operation. Show proposed progress of all activities for main work items and sub trades of Contract. Where applicable, indicate labour, Works crews, plant and equipment to be employed.



- .3 No progress payments will be approved until a schedule acceptable to the Engineer is received.

#### 1.4 Work Plans

- .1 Provide Work Plan for each key activity, as requested by Engineer, to show methods and general methodology for carrying out the Work. Relate Work Plan to activities shown on Works Schedule.
- .2 Work Plans shall identify, among other things:
- Sequencing of works
  - Access details
  - Temporary works
  - Temporary staging
  - Events affecting traffic, both road and marine
  - Events requiring work at night if necessary.
  - Tasks involving lifting, hoisting, and/or specified crane set-ups.
  - Methods to ensure appropriate environmental protection including containment and disposal of lead paint debris.
  - Safety procedures for dealing with lead based paints.
  - Safety procedures for working at height, over water, and in confined spaces.
  - Other key tasks as requested by the Engineer.
- .3 Work plans must include, where necessary, drawings and calculations.

#### 1.5 Traffic Control Plan

- .1 Submit a Traffic Control Plan, per Section 01570.

#### 1.6 Quality Control Plan

- .1 Submit a Quality Control Plan, per Section 01400.

### Part 2 PRODUCTS

- .1 None

### Part 3 EXECUTION

- .1 None



**GOVERNMENT OF BERMUDA**

Ministry of Public Works

Works and Engineering

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Section 01200 – Project Meetings

Project No. 90-05-76

Winton Hill Railway Trail Rock Cut Stabilization

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END OF SECTION



## Part 1 GENERAL

### 1.1 Required Submittals

- .1 The Contractor shall submit the following documents to the Engineers Representative:
  - .1 Schedule of Work
  - .2 Construction Method Statements
  - .3 Construction Safety and Health Risk Assessments
  - .4 Contractor Level 1 and level 3 IRATA certifications
  - .5 Environmental Method Statements
  - .6 Samples
  - .7 Certificates

### 1.2 Administration

- .1 Provide to the Engineer for review the submittals specified. Submit with reasonable promptness and in an orderly sequence so as to not cause delay in the Work. Failure to submit in ample time is not considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default will be allowed.
- .2 Do not proceed with Work affected by the submittal until review is complete.
- .3 Review submittals prior to submission to the Engineer. This review represents that necessary requirements have been determined and verified, or will be, and that each submittal has been checked and coordinated with the requirements of the Work and Contract Documents. Submittals not stamped, signed, dated and identified as to the specific project will be returned without being examined and will be considered rejected.
- .4 Verify that field measurements and affected adjacent Work are coordinated.
- .5 Contractor's responsibility for errors and omission in submission is not relieved by Engineer review of submittals.
- .6 Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved by Engineer review.
- .7 Keep one review copy of each submission on Site.

### 1.3 Schedule of Work

- .1 Prepare schedule in the form of a linked bar chart. All events, activities and constraints shall be numbered and shall be given a title. Details to be given for each event, activity or constraint should include:





- .1 its title
- .2 its scheduled start and finish dates
- .3 its duration
- .4 any relevant “must” start or finish dates
- .2 Provide a separate bar for each event, activity, operation or constraint, show proposed progress of all activities. Where applicable, indicate labour, construction crews, plant and equipment to be employed.
- .3 The key milestones in the construction process shall also be identified. Schedule milestones will include but not be limited to the following:
  - .1 Start of construction
  - .2 Placement of orders for critical equipment items
  - .3 Delivery dates (to site) for critical equipment items
  - .4 Final handover (final completion)
- .4 Revise and resubmit schedule every two weeks to reflect actual progress of the Works.
- .5 With schedule updates, provide written explanations to Engineer as to why previously reviewed schedule is not being met (if applicable).
- .6 Show changes in operations proposed (if required), to complete construction works within Contract Time.
- .7 No progress payments will be approved until receipt of schedule updates acceptable to the Engineer.

#### **1.4 Method Statements**

- .1 Provide Method Statement for each key activity and additionally as requested by Engineer, to show construction methods, equipment and general methodology for carrying out the Work. Relate Method Statement to activities shown on Construction Schedule.
- .2 Method Statements shall identify, among other things:
  - .1 Sequencing of works
  - .2 Methods to ensure appropriate environmental protection
  - .3 Other key tasks as specified in the Contract Documents, and/or as requested by the Engineer.

#### **1.5 Shop Drawings and Product Data**



- .1 The term “shop drawings” means drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are to be provided by the Contractor to illustrate details of any portion of the Work including temporary access platforms.
- .2 Indicate materials, methods of Work and attachment or anchorage, erection, diagrams, connections, explanatory notes and other information necessary for completion of Work.
- .3 Adjustments made on shop drawings by the Engineer are not intended to change the Contract Amount. If adjustments affect the value of Work, state such in writing to the Engineer prior to proceeding with the Work.
- .4 Make such changes in shop drawings as the Engineer may require, consistent with Contract Documents. When resubmitting, notify the Engineer in writing of any revisions other than those requested.
- .5 Submit two (2) copies of product data sheets or brochures for requirements requested in specification Section and as the Engineer may reasonably request.
- .6 Submit two (2) prints of shop drawings for each requirement requested in specification Sections and as the Engineer may reasonably request. Engineer will return one print marked as follows:
  - .1 “REVIEWED” - Make and distribute additional copies as required for own execution of the Work.
  - .2 “REVIEWED AS MODIFIED” - Drawings will be marked “REVIEWED AS MODIFIED” when the Engineer requires revision or correction to the details shown on the drawing, but does not require resubmission of the drawing. This procedure will not relieve the Contractor of responsibility for errors or omissions in the shop drawings or of responsibility for meeting all requirements of the Contract. Revise the drawing as noted, and make and distribute additional copies as required for own execution of the Work.
  - .3 “REVISE & RESUBMIT” - Make the necessary revisions and resubmit revised drawings for review. Show the drawing number of the first such revised drawing and show the latest revision number applicable to the drawing by adding a suffix to the drawing numbers as – “REV. 1”, “REV .2”, etc.
  - .4 “NOT REVIEWED” - This notation indicates when the Engineer has not reviewed the drawing. It may also be used in combination with the notation to revise and resubmit the drawing where the Engineer lacks sufficient information to complete his review and required to resubmit the drawing for review after revision.
- .7 Use only those shop drawings on the work that bear the “REVIEWED” or “REVIEWED AS MODIFIED” notation.
- .8 Do not revise shop drawings marked “REVIEWED” unless resubmitted to the Engineer for further review.



- .9 Catalogue pages or drawings applicable to an entire family or range of equipment or materials will not be accepted as shop drawings unless they are clearly marked to show the pertinent data for the particular materials.
- .10 Submissions that are illegible or unclear will not be accepted and they will be returned to the Contractor unreviewed.
- .11 Submit all submissions under cover of a transmittal listing the individual items in the submission, and indicating whether or not they are revisions to a previous submission.
- .12 Owner may deduct, from payments due to Contractor, costs of additional Engineering work incurred if correct shop drawings are not submitted after one review by Engineer.
- .13 Review by the Engineer is for the sole purpose of ascertaining conformance with the general design concept. This review does not mean that the Engineer approves the detail design inherent in the shop drawings, responsibility for such remains with the Contractor, and such review does not relieve the Contractor of his responsibility for errors or omissions in the shop drawings or of his responsibility for meeting all requirements of the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job-site, for information that pertains solely to fabrication processes or to techniques of Work and installation and for co-ordination of the work of all sub-trades.

## 1.6 Samples

- .1 Submit for review samples as requested in respective specification Sections. Label samples as to origin and intended use in the Work.
- .2 Deliver samples prepaid to Engineer's or testing company's business address as directed.
- .3 Notify the Engineer in writing, at the time of submission, of deviations in samples from requirements of Contract Documents.
- .4 Adjustments made on samples by the Engineer are not intended to change the Contract Amount. If adjustments affect the value of Work, state such in writing to the Engineer prior to proceeding with the Work.
- .5 Make changes in samples which the Engineer may require, consistent with Contract Documents.

## 1.7 Certificates

- .1 Submit certificates of insurances within 10 days after award of Contract and before any work begins at the Site.

END OF SECTION



## **Part 1 GENERAL**

### **1.1 Environmental Measures**

- .1 Meet or exceed the requirements of all Bermuda environmental legislation and regulations, including all amendments up to project date provided that in any case of conflict or discrepancy, the more stringent requirements shall apply.

## **Part 2 EXECUTION**

### **2.1 Fires**

- .1 Fires and burning of rubbish on site will not be permitted.

### **2.2 Disposal of Rubbish and Waste Materials**

- .1 Collect all rubbish and waste material and dispose of in accordance with the latest editions of the Ministry of Public Works Waste Management Plan.

### **2.3 Environmental Protection**

- .1 When, in the opinion of Engineer, negligence of Contractor results in damage or destruction of local flora and or fauna, or other environmental or aesthetic features beyond work areas as shown on contract drawings, the Contractor shall be responsible, at his expense, for complete restoration including replacement to satisfaction of Engineer.

### **2.4 Pollution Control**

- .1 Control emissions from equipment and plant to Bermuda authorities' emission requirements.
- .2 Prevent extraneous materials from contaminating air, land or water, by vacuum, temporary enclosures, screens, traps or other devices.
- .3 Spills of deleterious substances should be immediately contained and cleaned up in accordance with provincial regulatory accordance with provincial regulatory requirements. Spills should be reported forthwith to the Engineer.

### **2.5 Storage And Handling Of Fuels And Dangerous Fluids**

- .1 Locate fuel storage facility a minimum of 100 m from any water body in an area approved by the Engineer and construct impermeable dykes so that any spillage is contained.
- .2 Prevent spillage of gasoline, diesel fuel and other oil products into the water and on land. Clean up spills promptly at own cost in accordance with Bermuda regulatory requirements. Report any fuel spills immediately to Engineer.
- .3 Proper use of primers, grouts, bonding adhesives and other hazardous substances will be undertaken to prevent their entry into the water. Substances are to be stored and



mixed on protected surfaces away from site to prevent their entry into waterways and contamination of soils.

- .4 Collect and dispose of used oil filter cartridges and other products of equipment maintenance at industrial waste facility to satisfaction of Engineer.

END OF SECTION



## Part 1 GENERAL

### 1.1 Related Sections

- .1 Section 01300 - Submittals

### 1.2 Description

- .1 This section outlines the requirements for the rock scaling, rock removal operations.

### 1.3 Definitions

- .1 Scaling / Rock Removal: Consists of the removal of loose and unstable rock fragments, rock pieces, rock blocks, rock masses, soil and rock layers, by equipment and methods approved by the Owner's Representative from exposed bedrock surfaces.
- .2 Scaling Crew: Experienced scaling crew consists of a supervising scaling foreman and a minimum of two (2) rock scalars.
- .3 Manual Scaling/Removal: Scaling consists of the removal of loose soil, rock, and overburden from behind the crest of the slope, the slope face, and benches on the slope. Scaling shall be done by hand working from a fall restraint or work positioning system (i.e. manlift or telescopic crane) and using suitable hand tools and powered equipment. Scaling also includes felling and removal of trees and brush, and pulling down larger rocks with wire rope attached to equipment on the road.
- .4 Mechanical Scaling/Removal: Mechanical Scaling consists of the removal of loose soil, rock, trees and bushes, on above or below the slope using a long-reach excavator with toothed bucket or with attached scaling chains.

### 1.4 Measurement Procedures

- .1 Scaling and rock removal will be measured based on the area scaled.
- .2 Payment for scaling and rock removal will be made at the Contract Unit Price per square meter, which shall be full compensation for supplying all material, labour, and equipment to execute the work as specified.
- .3 Protection of infrastructure shall be considered incidental to scaling and rock removal and all other unit price work items.
- .4 Repair or replacement of all infrastructure damaged by scaling and rock removal operations, to the satisfaction of the Owner's Representative, shall be at the Contractors cost.

### 1.5 Method of Measurement

- .1 Payment quantities shall be based on the 2D measurement of the square meter of area scaled. Area of scaling and rock removal to be paid for will be determined from the dimensions as per the project specifications. Irregularities in the rock face must be accounted for in the quantities, as no additional measurement will be made for payment.



## 1.6 Basis of Payment

- .1 Payment for Scaling will be made at the Contract Unit Price per square meter covered for Scaling and Rock Removal and shall include full compensation for furnishing all labour, materials, tools, equipment, and incidentals for doing all the work involved in scaling and rock removal, as shown on the plans, as specified in the contract documents and as directed by Owner's Representative.

## 1.7 Action and Informational Submittals

- .1 Submit submittals in accordance with Section 01300 - Submittal Procedures.

## 1.8 Requirements

- .1 The Contractor shall provide an experienced scaling crew that consists of a supervising scaling foreman with at least three (3) years' experience, a minimum of two (2) rock scalers with at least two (2) years' experience each scaling on slopes similar to the project site conditions, within the last five (5) years. The scaling crew size shall be maintained at all times until the completion of all work.
- .2 In view of the rock slope heights at the project site, it has been assumed that scaling crews will be working from ropes at heights. Each scaling person working from ropes at heights must have a minimum of Level 1 Industrial Rope Access Trade Association (IRATA) training or approved equivalent. In addition, a Level 3 IRATA or approved equivalent supervisor must be onsite at all times.
- .3 Where scaling activities may impact upon any existing infrastructure the Contractor shall provide protective measures as detailed in the Contractor's Work Plan/Procedure, prior to commencing scaling. Protective measures shall include but not be limited to; padding material placed on the roadway, blasting mats, temporary rock berms or barriers, and temporary removal of signs, guardrail and similar infrastructure. The Contractor shall be completely responsible for all damage that is a result of its scaling or other operations.
- .4 The Contractor shall have hand tools and equipment available on site such that scaling can be carried out using the most appropriate and effective tools and methods for any given situation.

## Part 2 PRODUCTS

### 2.1 Materials

- .1 None

### 2.2 Qualified Rock Stabilization Companies

- .1 The following list is a selection of potential Qualified Rock Stabilization Companies that may be able to assist with this work. This list is presented to assist the Bidders in locating suitable sub-contractors. This list is not all inclusive and Bidders are not required to use any of these Companies. Other suitably qualified rock stabilization companies are welcome to be included in the Tender.



- .2 Potential Rock Stabilization Companies (alphabetical order);
  - .1 BAT Construction Ltd, 10230 Dallas Dr., Kamloops, British Columbia, Canada, 1-250-573-1222, <http://www.batconstruction.com/>
  - .2 Cimota Inc, 170 rue de Rotterdam, Saint-Augstin-de-Desmaures, Quebec, Canada, 1-418-878-3234, Patrick Girouz, [pgiroux@cimota.qc.ca](mailto:pgiroux@cimota.qc.ca)  
<http://cimota.qc.ca/>
  - .3 GeoStabilization International, 543 31 Road, Grand Junction, Colorado, 81502 USA, 1-855-579-0536, <http://www.geostabilization.com/>
  - .4 Hi-Tech Rockfall Construction Inc, Forest Grove, Oregon, USA, 1-800-505-3155, <http://www.hitechrockfall.com/>

### Part 3 EXECUTION

#### 3.1 Scaling

- .1 Rock slope scaling and removal shall include the areas of the site identified on the site plans or on site by the Owner's Representative.
- .2 Thoroughly scale the rock slope to remove all loose soil, rock, and overburden from the slope face within 5 m of the crest of the slope.
- .3 All scaling operations must be completed from the top and proceeding downwards.
- .4 The Contractor is to assess the appropriateness of the methods in order to safely and effectively carry out the scaling and removal operations. Prior to initiation of the work, the Contractor must advise the Owner's Representative in writing, or otherwise agreed, of how the Contractor intends to complete operations and must obtain Owner's Representative approval.
- .5 Prior to proposing or initiating mechanical scaling operations, the rock slope (or area considered) must be manually scaled. If mechanical scaling is employed, manually scale the slope afterwards to remove any remaining loose material. Areas proposed for mechanical scaling must be approved by Owner's Representative.
- .6 On slopes that require both scaling and anchoring, complete the scaling operation in a particular area prior to rock anchoring in that same area unless otherwise directed by the Owner's Representative.
- .7 All scaling and removal operations are to be conducted under full time inspection of Owner's Representative and completed to the satisfaction of the Owner's Representative. The extent of scaling and removal in all areas and suitability of equipment being used will require the approval of Owner's Representative.
- .8 The Contractor shall be responsible for public safety during scaling operations. One lane of traffic must remain open at all times.
- .9 Scaled material is considered waste material and must be disposed of offsite in accordance with applicable regulations. Disposal of the scaled materials shall be carried out by Others.





- .10 Comply with all safety requirements during the scaling operation.
- .11 Notify Owner's Representative 48 hours prior to scaling operations for inspection of scaled work surface. Owner's Representative may request the Contractor to do further work which the Owner's Representative deems necessary.

### **3.2 Protection**

- .1 Work in coordination and cooperation with Others to prevent damage to surroundings and injury to persons.
- .2 Repair or replacement of all infrastructure wilfully damaged by scaling operations, to the satisfaction of the Owner's Representative, shall be at the Contractors cost.

END OF SECTION



## Part 1 GENERAL

### 1.1 Related Sections

- .1 Section 01010 – General Requirements
- .2 Section 01300 - Submittals
- .3 Section 02270 – Slope Protection and Erosion Control

### 1.2 REFERENCES

- .1 Prestressed Rock and Soil Anchors by the Post-Tensioning Institute (PTI), 2014.

### 1.3 DESCRIPTION

- .1 This section outlines the requirements for the provision and installation of rock anchors.
- .2 Rock anchors may be installed in areas identified in the field by the Owner's Representative following scaling activities.
- .3 The number of rock anchors required will depend upon the conditions encountered and the conditions of the rock slope following scaling. There are no assurances regarding the actual number of rock anchors to be used for this project – i.e. the final number of rock anchors may vary from zero (0) to fifty (50).

### 1.4 MEASUREMENT PROCEDURES

- .1 See Instruction to Bidders.
- .2 Payment quantities shall be determined as per project specifications. Quantities of rock anchors to be paid for will be based on the number of anchors installed and associated lengths.

### 1.5 BASIS OF PAYMENT

- .1 The contract price paid per rock anchor shall include full compensation for furnishing all labour, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing rock anchors, complete in place, as shown on the plans, as specified in the contract documents and as directed by the Owner's Representative.

### 1.6 SUBMITTALS

- .1 Submit in accordance with Section 01300 Submittals.
- .2 The Contractor shall submit a detailed method statement for controlling and monitoring the drilling angle and alignment of anchors before commencing anchor installation.
- .3 Rock Anchor Installation Procedure: Prior to ordering Rock Anchor materials, the Contractor shall submit a Rock Anchor Installation Procedure for review by the Project Manager. The Installation Procedure shall include product information from the anchor



hardware and grout manufacturers including their recommended installation procedures, drilling equipment and hole diameter, grouting and tensioning procedures, calibration certificate(s) for rock anchor testing equipment, and similar information.

- .4 Product Data: Submit manufacturer's instructions, printed product literature and data sheets for rock anchors and include product characteristics, performance criteria, physical size, finish and limitations.
- .5 Maintain field drilling records for each rock anchor, including date/time, location of bedrock, overall drilling conditions making specific notes on any weathered or water zones encountered, drilled length of tie-back and rock embedded length.
- .6 Maintain grout installation records for each rock anchor, including, date/time, amount of grout used and Specific Gravity of each grout batch.
- .7 Provide Owner's Representative with a daily copy of field records.

## Part 2 PRODUCTS

### 2.1 MATERIALS

- .1 Anchors shall be 25 mm diameter, grade 1030 MPa, with all accessories (caps, centralizers, couplers, bearing plates, wedge washers, nuts, etc.) required to complete the work as detailed on the plans and to the manufacturer's specifications.
- .2 Anchor lengths and design loads will vary depending upon the site conditions and the anchor requirements noted following scaling operations. Rock anchors may consist of the following lengths: 3 m and 6m.
- .3 Each rock anchor shall have a 200 mm by 200 mm by 25 mm galvanized face plate, galvanized bevelled hardened steel washers (minimum 2 per anchor) and a galvanized hexagonal nut.
- .4 Rock anchor installations will utilize grout consisting of a non-expansive, non-shrink grout. Grout shall have a minimum compressive strength of 35 MPa at 3 days and 50 MPa at 28 days. The grout shall have non-shrink properties.
- .5 The anchor shall be provided with Class I, encapsulated tendon, double corrosion protection according to the recommendation for Prestressed Rock and Soil Anchors publication.
- .6 The rock anchor shall be a two-stage grouted anchor with the free length of the anchor fully grouted after tensioning and lock-off. PVC or other bond breakers on the free length shall not be permitted.
- .7 Each item of the rock anchor system shall be Hot-Dip Galvanized conforming to ASTM A123 or ASTM A153 wherever applicable.

## Part 3 EXECUTION



### 3.1 EXAMINATION

- .1 Visually inspect substrate in presence of Owner's Representative.
- .2 Inform Owner's Representative of unacceptable conditions immediately upon discovery.
- .3 Proceed with installation only after unacceptable conditions have been remedied and receipt of written approval to proceed from Owner's Representative.

### 3.2 INSTALLATION

- .1 Anchor hole drilling, anchor installation, grouting, pre-stressing and related activities shall be carried out only under the supervision of experienced geotechnical personnel.
- .2 Procedures and equipment used for drilling holes in rock, preparing, installing, grouting, and tensioning rock anchors shall be in strict accordance with the manufacturer's specifications to ensure the required design anchorage is achieved.
- .3 Discrepancies between the manufacturer's specifications and those presented within this specification should be reviewed and approved by the Owner's Representative.
- .4 Provide appropriate drilling platform or equivalent for drilling, installation, and testing of rock anchors on the slopes.
- .5 Anchor the drilling platform adequately to ensure the safety of the workmen and the satisfactory performance of the work during the drilling, installation, and testing of the rock anchors.
- .6 Where required, prepare the rock surface for uniform loading from the bearing plate during post tensioning.
- .7 Anchor hole diameters shall be minimum of 100 mm, or as per manufacture specifications.
- .8 Rock anchors shall be installed with sufficient thread exposed to accept a plate and nut to facilitate tensioning and testing.
- .9 Temporary casing should be provided as required to stabilize drill hole sidewalls.
- .10 Use commercially manufactured centralizers at intervals not greater than 3 meters to keep the bar centred in the hole. Ensure centralizers do not interfere with tremie tube and are sized appropriately for anchor diameters.
- .11 Anchor holes shall be grouted within 48 hours of the hole being drilled.
- .12 Anchor hole depth shall be approved by Owner's Representative before anchor installation.
- .13 Couplers (if required) shall be installed in a manner which will ensure that they can transfer the required anchor loads.
- .14 Grout shall be tremied into the lowest elevation of the anchor hole without interruption.
- .15 Grout sampling and testing will be carried out by a certified testing consultant appointed



by Owner's Representative.

- .16 After grout is cured to at least 35 MPa, anchors shall be tension tested and locked off in accordance with the Post Tensioning Institute (PTI 2014) method for proof testing rock anchors. Performance load tests as per PTI will be performed on select new and existing anchors, as per Owner's Representative direction. Design loads and lock off loads are as shown on the drawings.
- .17 The rock anchor shall be a two-stage grouted anchor with the free length of the anchor fully grouted after tensioning and lock-off.
- .18 In order to confirm the anchorage methods, products, and procedures proposed by the contractor, the Contractor at his expense shall supply all equipment and assist the Owner's Representative conduct rock anchor pull 'performance testing' on the first three rock anchors and a minimum of 3% of the remaining rock anchors in accordance with the Post Tensioning Institute (PTI 2014) Standard Methods. Additional performance testing will be requested at the discretion of Owner's Representative if any rock anchors do not pass testing requirements.
- .19 All other rock anchors shall be pull 'proof' tested, after grout is cured at least 35 MPa, anchors shall be tension tested and locked off in accordance with PTI method for proof testing rock anchors. Design loads and lock off loads are as per project specifications
- .20 Failed rock anchors shall be removed and reinstalled by the contractor at his expense.

### **3.3 DEFECTIVE ROCK ANCHORS**

- .1 If rock anchors are deemed to be defective by the Owner's Representative then contractor must remediate and reinstall anchors at own cost with methods approved in writing from Project Manager.

END OF SECTION



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## Part 1 GENERAL

### 1.1 SCOPE OF WORK

- .1 This Section specifies providing shotcrete in select section of Winton Hill Railway Trail, Bermuda.

### 1.2 DEFINITIONS

- .1 Shotcrete: Portland cement concrete or mortar conveyed through a hose and pneumatically projected at high velocity onto a surface to achieve compaction.
- .2 Steel fiber: Discrete, hard drawn, bent steel fibers uniformly distributed in shotcrete to improve shrinkage crack resistance and the flexural capacity of shotcrete.
- .3 Defective shotcrete: Shotcrete that does not meet requirements of specifications or contract plans, including shotcrete that does not meet strength requirements, or which lacks uniformity, exhibits segregation, honeycombing, or lamination, shows significant cracking, contains dry patches or sand pockets, is hollow, or does not meet the project requirements.
- .4 Corrective Shotcrete: Shotcrete used to replace defective shotcrete.
- .5 Wet Mix Process: Mixture of cement and aggregates being supplied to the nozzle readily batched with water and admixtures.
- .6 Rebound: Shotcrete constituents that fail to adhere to the surface to which shotcrete is being applied.
- .7 Void filling shotcrete or dental concrete: Void filling shotcrete or dental concrete to be placed at localized deep cavities where structural shotcrete is not feasible. The location to be determined in the field.
- .8 Test panel: Minimum face dimensions of face panel during field trial shall be 750 mm x 750mm and a nominal depth of 100 mm to evaluate mix design and quality of placement. Shoot test panels in a vertical orientation. During construction, reduced test panel face dimensions shall be minimum 400 mm x 400 mm and minimum depth of 125 mm. Nozzleman prequalification test panel shall include the welded wire mesh at mid-depth of the test panel.
- .9 Engineer: Qualified engineer providing on-site representation on behalf of the Engineer-of-Record.

### 1.3 QUALITY ASSURANCE

- .1 Codes, Regulations, Reference Standards and Specifications using latest versions, if date not given:
  - .1 ACI 305. "Guide to Hot Weather Concreting"
  - .2 ACI 506.1R "Guide to Fiber Reinforced Shotcrete"
  - .3 ACI 506.2 "Specifications for Materials, Proportioning, and Application of Shotcrete"
  - .4 ACI 506.4 "Guide for the Evaluation of Shotcrete"



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- .5 ACI CP-60 (2009): Craftsman Workbook for ACI Certification of Shotcrete Nozzleman”
  - .6 ASTM A185. “Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete”
  - .7 ASTM A820. “Standard Specification for Steel Fibers for Fiber-Reinforced Concrete”
  - .8 ASTM C31. “Standard Practice for Making and Curing Concrete Test Specimens in the Field”
  - .9 ASTM C33. “Standard Specification for Concrete Aggregates”
  - .10 ASTM C39. “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”
  - .11 ASTM C94. “Standard Specification for Ready Mixed Concrete”
  - .12 ASTM C150. “Standard Specification for Portland Cement”
  - .13 ASTM C192. “Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory”
  - .14 ASTM C266. “Standard Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles”
  - .15 ASTM C231. “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method”
  - .16 ASTM C494. “Standard Specification for Chemical Admixtures for Concrete”
  - .17 ASTM C1064. “Standard Test Method for Temperature of Freshly Mixed Hydraulic Cement Concrete”
  - .18 ASTM C1077. “Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for laboratory Evaluation”
  - .19 ASTM C1116. “Standard Specification for Fiber-Reinforced Concrete”
  - .20 ASTM C1140. “Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels”
  - .21 ASTM C1141. “Standard Specification for Admixtures for Shotcrete”
  - .22 ASTM C1240. “Standard Specification for Silica Fume used in Cementitious Mixtures”
  - .23 ASTM C1385. “Standard Practice for Sampling Materials for Shotcrete”
  - .24 ASTM C1480. “Standard Specification for Packaged, Pre Blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete Application”
  - .25 ASTM C1604. “Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete”
  - .26 ASTM D1785. “Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, 120”
  - .2 Qualifications of Applicator:
    - .1 Have work performed by experienced personnel regularly engaged in shotcrete application.
    - .2 Employ qualified shotcrete applicators (nozzlemen) who have had previous experience and training in plain and steel fiber reinforced shotcrete application on at least three comparable projects. Perform work under immediate supervision of



foreman with at least five years experience. Have each shotcrete applicator demonstrate, for approval, acceptable proficiency in uniformity of application of shotcrete to vertical test panels before beginning production work on soil and rock cut surfaces. Nozzleman should be ACI CP-60 certified or approved equivalent.

- .3 Uniformity of Materials:
  - .1 For production shotcrete application, use same cement, aggregate and water proportions used in approved test areas and unit tests.
  - .2 Minor adjustments are permitted subject to prior approval by the Engineer. Specified strengths shall be maintained.
- .4 Mix Design and Testing Prior to Production
  - .1 Develop shotcrete mix by independent commercial laboratory compatibility tests and field trials as specified.
  - .2 Perform compatibility tests to determine cements and additives to be used in the field trial mixes. Determine initial and final set for additive concentrations of varying percentages of cement content by weight contemplated for use in the work.
  - .3 Make laboratory and field trial mixes with ingredients identical to those proposed for use in the work.
  - .4 To ascertain compatibility of ingredients and optimum proportions, develop shotcrete mix having strength and characteristics necessary for actual application.
  - .5 Accelerating Admixture:
    - .1 Use approved accelerating admixture to develop quick set as follows:
      - .1 Time of initial setting: Two minutes maximum.
      - .2 Time of final setting: Six minutes maximum
    - .2 Sodium silicate admixtures shall not be used.
    - .3 Determine time of setting in accordance with ASTM C266 with the following additional requirements.
      - .1 Add manufacturer's recommended dosage of accelerator to cement in preparation of a batch, together with water to produce water- cement ratio in varying percentages expected to be used in actual shotcrete application.
      - .2 Use minimum possible time interval to attain proper mixing without disturbing initial set of paste.
      - .3 Additional modifications to accommodate quick-set accelerators: as approved by the Engineer.
  - .6 Standard Concrete Cylinder Testing:
    - .1 Choose materials and proportions so that three cast cylinders 100 mm by 200 mm made with no additive shall achieve average minimum strength of 35 MPa psi at 28 days with Type I/ II cement conforming to ASTM C150. Cast cylinders in accordance with ASTM C192 and test in accordance with ASTM C39. Cast and test three cylinders minimum for each combination of materials proposed.





- .2 Provide laboratory trial batch records demonstrating the concrete mixture follows the specified requirements.
- .7 Shotcrete Field Trial (Pre-Qualification):
  - .1 After completion and approval of laboratory tests, make field trials (Test Panels) using selected mixes to accommodate capability of equipment, workmanship and material under field conditions prior to actual application of shotcrete. Notify for examination by Engineer prior to shotcrete placement.
  - .2 Make field application of each mix selected for field trial on at least three vertical test panels to simulate construction conditions.
  - .3 Apply shotcrete onto test panels with minimum dimensions of 750 mm by 750 mm and of average thickness of shotcrete, nominal 200 mm in accordance with ASTM C1140.
  - .4 Cure test panels in accordance with ASTM C31.
  - .5 From each test panel, obtain three (3) test specimens within 24 hours after shooting. Preparation for testing specimens shall comply with ASTM C1140. Note: For sawed cubes, compressive strengths shall be multiplied by a correction factor of 0.85 to obtain equivalent strength of drilled cores.
  - .6 Average three cores from each panel to comprise one test.
  - .7 Perform field trial work in the presence of the Engineer.
  - .8 Test specimens cored or sawed from the panels for compliance with the specified compressive strength in accordance with ASTM C1604. The required compressive strength development for shotcrete shall be 8 MPa psi (24 hours), 25 MPa (7 days), and 35 MPa (28 days).
  - .9 Nozzleman prequalification test panel shall be cored to intersect embedded steel to ensure consistency of application and no voids behind embedment.
- .8 Testing Agency Qualifications:
  - .1 An independent testing agency, acceptable to the Ministry of Public Works, Government of Bermuda, qualified according to ASTM C1077.
- .9 Acceptance of test - Consider the compressive strength adequate if the average of the three test specimen exceeds 85 percent of the specified compressive strength and no single core is less than 75 percent of the specified compressive strength.
- .10 If the initial prequalification test panel is rejected, a second panel may be shot and tested. If this panel is acceptable, work may proceed. If the second panel is not acceptable, the contractor shall change procedures, mixture proportions, nozzlemen, or shotcrete equipment as necessary before repeating the preconstruction testing. Do not proceed with work until preconstruction test results are satisfactory to Engineer.

## 1.4 SUBMITTALS

- .1 Prior to commencement of shotcrete operations, submit the following for Engineer approval.



- .1 Submit data showing compliance with requirements specified in this Submittal section. Where available, submit material safety data sheets (MSDS) for all materials.
- .2 Submit shotcrete mixture proportions. Submittals shall show constituent proportions by mass in the case of batching by weight or proportions by volume in the case of volumetric batching. For prepackaged materials meeting ASTM C1480, submit suppliers' technical data showing compliance with requirements.
- .3 Submit compressive strength test results.
- .4 Submit water-cementitious materials ratio (w/cm).
- .5 Submit admixture types, brand names, producers, manufacturer's technical data sheets describing technical properties and performance in shotcrete and showing compatibility with the project cementitious materials.
- .6 Submit cementitious materials types, mill certificates showing manufacturing location, and compliance with applicable ASTM standards.
- .7 Submit aggregate source, producers' names, gradations, specific gravities, compliance with ASTM C33, and evidence that this data is not more than 1 year old.
- .8 Submit qualifications and experience of the proposed workers including the supervisor, nozzle men, and crew. Submit evidence of ACI certification of nozzle men proposed for the work.
- .9 Submit proof of experience for the contractor and the shotcrete crew foreman to include at least three projects of similar size and complexity. Proof shall include a description of previous project's size; density of reinforcing materials; volume of shotcrete placed; and the name, address, and current phone number of person(s) representing the owner or architect/engineer.
- .10 Submit fiber material, length, and fiber content.
- .11 Submit curing materials and curing procedures for shotcrete.
- .12 Submit name of proposed contractor's testing agency and documentation of the agency's certification to ASTM C1077.
- .13 Remedial Plan for the defective shotcrete: The remedial plan shall include remediation for the possibility where the shotcrete does not meet the required compressive strength and the shotcrete cannot be removed and replaced.
- .14 Submit proposed color and texture patterns for final architectural finishes.

## **1.5 PRODUCT DELIVERY, STORAGE AND HANDLING**

- .1 Deliver, store, and handle materials, in accordance with manufacturer's written instructions, to prevent contamination, segregation, corrosion or damage. Store and protect liquid admixtures as required to prevent evaporation.

## **Part 2 PRODUCTS**

### **2.1 MATERIALS**

- .1 Portland Cement: ASTM C150 Type I/II.
  - .1 Alkali content not to exceed 0.6 percent.



- .2 Aggregates: uniformly well graded and not exhibiting extremes of gradations, in accordance with ASTM C33.
  - .1 Maximum aggregate size: No. 67.
- .3 Water: water shall be potable.
- .4 Accelerating Admixtures: ASTM C1141, with the following additional requirements:
  - .1 Containing less than 0.10% by mass water-soluble chlorides or materials corrosive to steel nor those which can cause other detrimental effects such as cracking or spalling as determined by test method in accordance with ASTM D512.
  - .2 In accordance with reference standard or documented history of demonstrable satisfactory performance in mix of similar proportions.
  - .3 Manufactures: TamShot 90 AF or approved equivalent.
- .5 Steel Fiber: ASTM A820, discrete, hard drawn, galvanized bent steel fibers uniformly distributed in shotcrete. Fiber shall have bent or deformed ends. Minimum dosage of steel fiber is 20 kg/ Cu Meter of shotcrete.
- .6 Steel-Welded Wire Fabric (a.k.a. Welded Wire Mesh): ASTM A185, plain, cold drawn, galvanized. Welded wire fabric shall be used in conjunction with structural shotcrete for retained slopes and may be used as part of surface protection measures at locations of adverse features in rock cut slopes.
- .7 Reinforcement Support: Provide ties and other devices for spacing, supporting, and fastening reinforcing against existing substrate, as required.
- .8 Drain Holes:
  - .1 All drain holes shall be fitted with a Perforated Pipe.
  - .2 Pipe. ASTM D1785, Schedule 40 PVC solid and perforated wall; cell Classification 12454-B or 12354-C, wall thickness SDR 35, with solvent weld or elastomeric joints.
- .9 Shotcrete thickness indicator pins: Provide thickness measuring pins to gauge layer thickness and surface plane.

## 2.2 PROPORTIONING

- .1 Proportion shotcrete in compliance with ACI 506.2 – Fiber Reinforcing Concrete.
- .2 As an option, add three to four percent (by weight of cement) silica fume to minimize rebound.

## 2.3 BATCHING, MIXING AND DELIVERY

- .1 Batch, mix, and deliver shotcrete in accordance with ACI 506.2 Ready Mix Concrete and Fiber reinforced concrete as applicable.



## Part 3

### EXECUTION

#### 3.1 CONTROL OF WATER

- .1 Prior to shotcrete application, control ground water inflows and seepage to prevent dissolution of cement and fine aggregates in fresh shotcrete. Control water by appropriate and approved methods as specified in Section 3.2.

#### 3.2 WALL DRAINAGE NETWORK

- .1 Install and secure all elements of the stabilization / drainage network as shown on the Drawings and manufacturer's recommendation.

#### 3.3 PREPARATION OF SUBSTRATE SURFACES

- .1 Rock Surface - Remove loose material, mud, or other foreign material that will inhibit bonding. Clean surface prior to shotcrete placement. Dampen surface in accordance with that described in 3.4.
- .2 Shotcrete Surface - Remove all deteriorated, loose, unsound material or contaminants that will inhibit bonding. Receiving surface shall be dampened and allowed to dry to a saturated surface-dry (SSD) condition just prior to shotcrete application. Chip surfaces to receive shotcrete to remove offsets causing abrupt changes in thickness. Roughen receiving surfaces that have been saw-cut,
- .3 After cleaning, keep surfaces moist until shotcrete is applied.

#### 3.4 SHOTCRETE APPLICATION

- .1 Provide pins to establish thickness and surface planes. Install thickness measuring pins to provide field thickness control.
- .2 Pneumatically applied mortar or concrete (shotcrete) must be applied by personal with direct experience with shotcrete application.
- .3 Grout consistency can be varied as needed to allow penetration into the small void.
- .4 Grout shall be mixed with a mechanical or centrifugal mixer and will be used within 30 min after mixing.
- .5 Rock surfaces must be thoroughly cleaned and wetted prior to grout placement.
- .6 Hold nozzle at one to three feet from surface and position so that stream of flowing material is applied as nearly as possible at right angles to surface to be covered. Place shotcrete from bottom up unless it can be demonstrated that other methods will work successfully.
- .7 Maintain steady nozzle motion as layer is built up to thickness shown and specified.
- .8 Apply shotcrete of uniform consistency to maximize binding, cohesion and density, to minimize rebound and segregation, and to prevent sagging of applied shotcrete.
- .9 Acceptable shotcrete consists of dense, uniform concrete without segregation or discernible weakness of bond between layers and accomplished without reuse of rebound. Note: Within soil nail portion of permanent retained soil slope walls, install WWF as shown on the Drawings.



- .10 Shotcrete shall be ceased if shotcrete does not meet specified standard and compressive strength.
- .11 Hot-Weather Shotcreting: Mix, place, and protect shotcrete according to ACI 305R when hot-weather conditions and high temperatures would seriously impair quality and strength of shotcrete and as follows:
  - .1 Cool ingredients by chilling water and/or replacing water with ice before mixing to maintain shotcrete temperature at time of placement below 32°C.
  - .2 Lower temperature of reinforcing steel and receiving surfaces below 38°C before shotcreting by atomized fog spray.
- .12 Intermediate Surfaces:
  - .1 When applying more than one layer of shotcrete, use a cutting rod, brush with a stiff bristle, or other suitable equipment to remove all loose material, overspray, laitance, or other material that may compromise the bond of the subsequent layer of shotcrete. Conduct removal immediately after shotcrete reaches initial set.
  - .2 Allow shotcrete to stiffen sufficiently before applying subsequent layers. If shotcrete has hardened, clean the surface of all loose material, laitance, overspray, or other material that may compromise the bond of subsequent layers. Bring the surface to a saturated surface-dry condition at the time of application of the next layer of shotcrete.

### 3.5 SEQUENCE OF OPERATIONS

- .1 Apply shotcrete lining in accordance with the sequences indicated on drawings and the following requirements:
  - .1 Minimum thickness of shotcrete layer at any point as shown on drawings and specified. Use adequate thickness indicators.

### 3.6 CONSTRUCTION JOINT

- .1 Taper construction joints at approximately 45 degrees from receiving surface. Form joints by cutting plastic shotcrete. Roughen shotcrete in the joint face while it is still plastic.

### 3.7 FINISH

- .1 Final architectural finish to be selected based on styles and color determined by the Owner (See section 1.4 A.15).

### 3.8 CURING

- .1 When the daily mean temperature is above 5°C, curing shall be continuous for a minimum of 7 consecutive days or for the time necessary to attain 70 percent of the specified compressive.
- .2 Unless otherwise specified, complete moist curing by one of the following methods:
  - .1 Ponding or continuous sprinkling for a minimum of 7 days.
  - .2 Covering with an absorptive mat or sand that is kept continuously wet.



- .3 Use of curing compounds. Apply twice the coverage (double the application rate) recommended by manufacturer.
- .3 Do not use natural curing in lieu of that specified in this section unless the relative humidity of the air in contact with the shotcrete remains at or above 85 percent and such curing is authorized by Engineer.

### 3.9 DEFECTIVE SHOTCRETE

- .1 All shotcrete which lacks uniformity or exhibits segregation, low strength, honeycombing or laminations shall be regarded as defective.
- .2 Explore and identify potential causes of defective shotcrete, i.e. batch mix problems and/or improper placement, etc.
- .3 Remove and replace, or otherwise correct, all defective shotcrete as directed at no cost to IFA.

### 3.10 VOID FILLING SHOTCRETE OR DENTAL CONCRETE

- .1 Where deemed necessary, void filling shotcrete or dental concrete shall be used to fill local voids and surface irregularities. Where shotcrete is used, each layer of shotcrete used to fill the void shall have maximum thickness of  $\pm 200$  mm.
- .2 Shotcrete or Dental concrete shall have a minimum compressive strength of 20 MPa in 28 days.
- .3 Thoroughly clean and moisten rock surface to saturated surface dry conditions prior to placement.
- .4 Procedures to fill overhangs must prevent the formation of air pockets and the head of the placed concrete must be higher than the upper surface of the overhang.
- .5 Void filling shotcrete or dental concrete must be allowed to set for 72 hours prior to application of the structural shotcrete layer.
- .6 Rock surfaces must be thoroughly cleaned and wetted to saturated surface dry conditions prior to void filling shotcrete or dental concrete placement.

### 3.11 JOBSITE CONDITIONS AND SAFETY

- .1 Alkali hydroxides and other chemicals contained in shotcrete admixtures are moderately toxic and can cause skin and respiratory Irritation. Adequate safety measures shall be taken as required in the Contractor's health and safety plan.

### 3.12 CONTRACTOR QUALITY CONTROL - 4.1 FIELD QUALITY CONTROL

- .1 Testing During Construction:
  - .1 Engage a qualified independent commercial testing agency, certified to ASTM C1077, to sample materials, visually grade cores, perform tests, and submit reports during shotcreting.
  - .2 *Test samples*—Sample shotcrete in accordance with ASTM C1385. The contractor is responsible for the curing and protection of test panels on site prior to the time that they are transported to the testing agency's laboratory.
  - .3 *Compressive strength samples*—Obtain test specimens from job-site test panels.



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- .4 *Temperature of shotcrete mixture*—Determine the temperature of the mixture using material sampled prior to discharge into the pump for wet-mix shotcrete. Testing shall be completed in accordance with ASTM C1064,
  - .5 Test Panels:
    - .1 Construct a test panel for each mixture, each nozzleman, and each work day or for every 40 m<sup>3</sup> placed, whichever results in the most panels. The face dimensions of a panel shall be a minimum of 400 mm X 400 mm. and the depth a minimum of 150 mm. Shoot test panels in a vertical orientation.
    - .2 Condition test panels in accordance with ASTM C1140 until transported to the testing agency's laboratory.
    - .3 Obtain test specimens from test panels using procedures outlined in ASTM C1140. Cores shall be a nominal 75 mm. diameter,
    - .4 Test shotcrete specimens for compliance in accordance with ASTM C1604 for compressive strength at 24 hours, 7 days and 28 days.
  - .6 *Reporting of quality assurance test results*—Provide copies of any test results generated for quality control to the contractor, Engineer, and IFA for review.
  - .7 Additional specimens will be required upon failure of original cores. Should additional specimens show acceptable strength, the work will be accepted. If additional specimens show unacceptable strength, the work will be rejected. Furnish additional specimens as directed.
- .2 Acceptance
    - .1 Strength of shotcrete shall be considered satisfactory when the mean compressive strength of each set of 3 cores equals or exceeds 85 percent of the specified compressive strength, with no individual core less than 75 percent of the specified compressive strength.
  - .3 Minimum specified compressive strength of shotcrete is 35 MPa at 28 days.

**END OF SECTION**