ITEM 583.0401--09 – PERMANENT AND ARCHITECTURAL FINISHED SHOTCRETE WALL SURFACES

DESCRIPTION

This work shall consist of shotcreting a structural permanent soil nail wall, and the architectural rock surface finish .as shown in the Contract Documents, using the wet shotcrete application process. Also included under this specification are drainage, excavation and embankment, turf establishment, and soil erosion and sediment control activities necessary to complete the shotcrete work of this specification

MATERIALS

Materials used in this work shall conform to the following requirements:

Excavation and Embankment	203-2
Soil Erosion and Sediment Control	209-2
Turf Establishment	610-2.03
Portland Cement, Types 1 or 2	701-01
Blended Portland Cement	701-03
Coarse Aggregate	703-02
Concrete Sand	703-07
Premoulded joint filler	705-07, color matched per Contract Documents
PVC Plastic Drain Pipe System (schedule 80)	706-15
Fibers for Concrete Reinforcement	711-01
Quilted Covers (for curing)	711-02
Plastic Coated Fiber Blankets	711-03
Membrane Curing Compound	711-05, white pigmented only
Admixtures	711-08
Microsilica	711-11
Calcium nitrite based corrosion inhibitors	711-13
Water	712-01
Penetrating type protective sealers	717-03
Underdrain Filter Material (Type I)	733-20
Geotextiles	737-01
Geotextile Drainage	737-01C
Prefabricated Composite Structural Drains	737-04
Hydration Control Admixture	ASTM C494, Type S
Expansion Bolt Anchor	GSA FF-S-325, Group III, Type 1 or Group VIII, Type 1
Hook Bolts Inserted in Expansion Bolt Anchors	ASTM F568 Class 4.6
Carbon-Steel Fiber	ASTM A820 Type II

Concrete Penetrating Stain materials shall be a single component, waterbased, thermoplastic acrylic emulsion which carries its color and water repellent protection into the shotcrete. All concrete stain shall be of the same batch and lot and shall be delivered to the application site in original sealed containers clearly labeled with the manufacturer's name, brand name, type of material, batch and lot numbers and color. The finished color of the penetrating stain treated areas shall closely represent the natural rock surface in the area of this work, or as directed by the Engineer.

The concrete penetrating stain shall comply with New York State Laws regulating the use of volatile organic compounds and solvents.

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SHOTCRETE

General

The Contractor shall design the wet shotcrete mixtures for in accordance with ASTM C1116. Separate mixtures shall be designed for permanent structural shotcrete facing and for the sculpted architectural shotcrete carving layer. Both mixtures shall meet the material performance specification requirement using aggregate, microsilica, air-entrainment, and fibers. Permanent structural shotcrete shall include a corrosion inhibitor and use carbon steel fibers. The sculpted architectural shotcrete carving layer shall include macro synthetic fibers. Corrosion inhibitor will not be required in the architectural mix.

Separate shotcrete mixture designs will be developed for permanent structural shotcrete and architectural sculpted shotcrete. Wet shotcrete mixtures shall be produced in accordance with Sections 501-2.03, 2.04, 3.02, and 3.03. The maximum 90 minute limit will be implemented for wet shotcrete after the addition of water to the mixture for all shotcrete mixes for the permanent structural and architectural sculpted walls, unless an approved Hydration Control Admixture is added to the shotcrete mixture and approved as part of the mixture design by the Director, Materials Bureau. Hydration Control Admixtures are not to be confused with a retarder, which only slow the hydration of the shotcrete. Materials added to the mixture during placement, at the nozzle, shall be done so to provide a uniform mixture. A High Performance Rheology Modifier and Mix stabilizer may be used with approval of the Director, Materials Bureau. If planned to be used, these supplementary materials must be included in the mixture design and trial batches.

Minimum total cementitious content shall be 480kg per cubic meter. Microsilica shall be included at 6-10% by weight of cement content. Class F fly ash, when required for the mitigation of ASR potential, shall be included at 15-20% by weight of cement.

Maximum water to cementitious (w/cm) ratio shall be 0.40. Water shall only be added for slump control on site without exceeding the maximum w/cm ratio. Adjustments to slump when the maximum w/cm ratio has been met shall be done using High-Range or Mid-Range water reducers on site following a procedure approved by the Regional Materials Engineer.

Air content shall be 8% - 11% as sampled from delivery vehicles. In-place air content shall be 4% - 8%.

Coarse aggregate content shall be 318kg to 363kg per cubic meter. Maximum size and gradation shall be determined by the contractor and provided in the mixture design and trial batches.

Fibers shall be included for each shotcrete mix per the following unless otherwise approved by the Engineer. Fibers for permanent structural shotcrete shall be:

- carbon-steel fiber meeting the requirements of ASTM A820 Type II, plain carbon steel, end-deformed, slit-sheet fiber meeting minimum strength requirements of ASTM A 820. Fiber length shall be 35 mm (± 10 %), with an aspect ratio of 57 (± 10 %).
- Fibers shall be loose, clean and free of oils, glue, metallic or other coatings that interfere with bond. Store fibers in a dry location in their original containers to prevent corrosion, exposure to chlorides, dirt, grease or other contaminants.
- Use 30kg of steel fiber per cubic meter of shotcrete or as determined by the Structural design.

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Corrosion inhibitors shall have a minimum dosage rate of 12 liters per cubic meter unless higher rates are recommended by the supplier.

Fibers for sculpted architectural shotcrete carving layer shall be:

- Macro Synthetic fibers.
- Fiber shall be a synergistic combination of a twisted-bundle non-fibrillating monofilament and a fibrillating network fiber system and shall be made of 100% virgin materials in the form of fully-oriented copolymer/polypropylene, gray in color. Length shall be 38mm.
- Use a dosage rate of 0.2% to 2.0% by volume of concrete (1.8 kg/m^3 to 18 kg/m^3).

The shotcrete may be modified at the nozzle with a non-chloride alkali free accelerator for placements greater than 2 inches thick. Liquid alkali free accelerators are a high performance shotcrete accelerator for use in the wet-mix spraying process. It is a liquid additive whose dosage can be varied to the desired setting and hardening times. All admixtures shall conform to the requirements of 711-08. Admixtures added to the shotcrete at the nozzle shall also meet the requirements of ASTM C1141. All admixtures shall be identified and submitted with the shotcrete mixture designs. The dosage pumps shall comply with the manufacturer's recommendations and be included with the submittal. Only alkali free accelerator types will be allowed. The Specific Gravity of any accelerator will range between 1.31 to 1.42 and the pH of the material will range between 2.2 to 3.0

Store all materials above 10°C during cold weather months and below 38°C during hot weather months.

Testing and Performance Requirements.

Shotcrete Mixture: Produce trial batches, perform sampling and testing per the table below, to qualify each proposed mixture. Provide the Engineer with test results at least 14 days prior to the start of shotcrete work as follows:

Test	Test method	Age	Requirements
Air content (plastic)	ASTM C231	---	8% - 11%
Compressive Strength	ASTM C1604	7, 14, and 28 days	31 MPa, 38 MPa and 48 MPa (min) respectively
Flexural strength	ASTM C1609	14 and 28 days	4.8 MPa and 6.9 MPa (min) respectively
Rapid Chloride Permeability	ASTM C1202	28 days	1500 Coulombs (min)
Residual Flexural Strength[1]	ASTM C1399	14 days	0.8 MPa

Note 1 – ASTM C 1399 testing applies to sculpted shotcrete mixture only

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Nozzlemen prequalification: Each Nozzlemen shall perform trial placements to prove ability to place shotcrete that achieves the following characteristics. The contractor shall provide sampling as necessary and provide samples to the Department for testing.

Test	Test method	Age	Requirements
Air content (hardened)	NYSDOT TM 501-08P		4% - 8%
Compressive Strength	ASTM C1604	7, 14 and 28 days	31 MPa, 38 MPa and 48 MPa (min) respectively
Flexural Strength[2]	ASTM C78	14 and 28 days	4.8 MPa and 6.9 MPa (min) respectively
Bond Pull-off Strength	ASTM C1583	28 days	1.0 MPa avg[3] (min)

Note 2 – flexure test performed using ASTM C78 irrespective of fibers in the shotcrete mixtures
Note 3 - no individual test shall be less than 0.7 MPa

Production Testing, Frequency, and Performance Requirements: All shotcrete work shall meet the following performance characteristics when tested at the designated frequencies. Frequencies may be reduced by the Engineer. Samples shall be produced by the contractor under supervision of the Engineer, and provided to the Engineer for testing at the appropriate intervals.

Test	Test method	Age	Requirements	Frequency
Air content (plastic)	ASTM C231	---	8% - 11%	1 time per day min, every 38 m3 thereafter
Air content (hardened)	NYSDOT TM 501-08P		4% - 8%	1 time per day min, every 38 m3 thereafter
Compressive Strength	ASTM C1604 using 50mm cores	14 days	38 MPa (min)	1 time per day min, every 38 m3 thereafter
Flexural Strength[2]	ASTM C78	7 and 28 days	31 MPa / 48 MPa (min)	Every 190 m3 min
Bond Pull-off Strength[4]	ASTM C1583	28 days	1.0 MPa avg (min)	

Note 2 – flexure test performed using ASTM C78 irrespective of fibers in the shotcrete mixtures
Note 3 - no individual test shall be less than 0.7 MPa
Note 4 – frequency shall be determined by the Engineer based on hammer sounding results.

Equipment

Batching and Mixing Equipment: Shotcrete mixtures provided from a ready-mix concrete facility shall be produced per the approved mixture design and according to Sections 501-2.03, 2.04A, 2.04B, 3.02 and 3.03. Any small on-site mixing equipment shall be capable of thoroughly mixing the materials in sufficient quantity to maintain placing continuity. On-site batching and mixing shall be performed following a Quality Control Plan developed by the contractor and approved by the Engineer.

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Air Supply: Equipment shall be able to supply clean, dry, air for all parts of the work and simultaneous operation of a blowpipe. The air supply system must contain a moisture and oil trap to prevent contamination of the shotcrete material or existing surface.

Delivery Equipment: Only pneumatic-feed type delivery equipment will be allowed. Positive displacement type of equipment with hydraulic powered pistons (similar to conventional concrete piston pumps), with compressed air added at the discharge nozzle (Minimum 10.2CM/min) is preferred. Actual equipment used for the work will be accepted based on qualification testing. The shotcrete delivery equipment must be capable of delivering a steady stream of uniformly mixed material to the discharge nozzle at the proper velocity with the rate of discharge. Use a high velocity wet nozzle capable of injecting accelerator into the air stream. The nozzle shall be equipped with an air ring for injecting compressed air into the material flow. Wet-Mix Auxiliary Shotcrete dosing pumps, if used, shall have the ability to pump alkali free accelerators as per the manufacturer's data sheet. Auxiliary shotcrete equipment shall be provided as needed to complete the work.

CONSTRUCTION DETAILS

SUBMITTALS

The Contractor will submit to the Engineer those items listed within the Wet Shotcrete Processes and the Artificial Rock Sculpting requirements for review and approval.

Wet Shotcrete Process

- Qualifications of the Shotcrete Crew, with their work description such as foreman or the person in charge of running the project daily, Nozzlemen, leadman, finishers, laborers
- Copy of the Nozzlemen's ACI Certificates, wallet cards for the wet process application, with picture ID for verification.
- Material safety data sheets (MSDS) for all materials used in the preparation and placement of shotcrete wall.
- Safety program including Personal Protective Equipment (PPE) for the crew with safety harnesses for anyone working in lifts or crane basket, safety glasses, ear protection, dust respirators (minimum double rubber band paper dust mask N-95 rated), work lights for work if shooting at dusk.
- Quality Control Plan for surface preparation, shotcrete placement, and control of work to include but not limited to:
    - abrasive blasting of any exposed / corroded steel members including studded plates.
    - Surface preparation including high-pressure blasting cleaning of all existing surfaces prior to structural shotcrete placement, removal of curing compound from previously placed shotcrete, and methods to achieve saturated surface dry conditioning prior to any shotcrete placement.
    - proposed shotcrete equipment for the Wet process, including the size of the air compressor, backup equipment as well (volume/minute Rating).
    - Material mix design and test results from test panels shot and cored using ASTM C1604M and ASTM C 1140M on permanent structural shotcrete with, air entrainment, migrating corrosion inhibitor mix with the steel fibers Flexural test results for steel fibers using ASTM C1609M, residual strength for macro synthetic fibers using ASTM C 1399M using molded specimens. The submittal shall contain the extended working times for the ounces added to the proposed shotcrete/concrete mix submitted for this project.

This will allow for longer working times of the shotcrete material without hydrating.
  - Procedure for the shotcrete shooting sequence
  - Plan to protect adjacent surfaces during shooting
  - Plan to match existing shotcrete surface grades, edges, and corners.
  - Plan to remove any and all material sloughs, sags, roll over onto existing surfaces to be in compliance with this specification
  - Details on how the edges of the wall (new to old) are to be cleaned and finished roughen for the next application.
  - Proposed plan and details on forming and implementing the expansion joint detail as shown in the Contract Documents.
  - Proposed plan and detail on wall contraction joint details as shown in the Contract Documents.
  - Proposed plan on how to minimize the entrapment of rebound
  - Shotcrete curing
  - Detail procedures for pressure washing the entire wall surface, removal of the curing compound from the wall (after the 7 day cure), prepare the wall surface for the architectural layer of shotcrete.
- Details of proposed methods for control and disposal of waste materials, demolition, blasting grits and shotcrete/concrete debris.

Sculpted Architectural Shotcrete Carving Process

- A signed statement of experience certifying that the specialty contractor is an established business with a minimum of five (5) years of experience and indicate in detail experience in successfully constructing 1) textured artificial rockwork and earthwork, 2) natural earth and rock formations. Submit qualifications to the Regional Landscape Architect (RLA) for approval 45 days prior to the sculpting production work. Potential specialty contractors shall submit the following for approval by the RLA: limited to:
  - Photographic proof and reference material for evaluation experience and ability to perform, including photographs to show the contractor's capabilities to construct artificial earth and rock formations, outcrops, and earth cuts, natural earth and rock formations, and also including a list of completed projects and references which demonstrate these capabilities. These projects and photographs of projects must have been the work of those craftsman and artist proposed for this work.
  - Full documentation of the crew, including resumes of lead personnel and final texturing and finish experts, (et al) lists of specific personnel to be used, and details of each listed person's experience and abilities to perform all phases of construction to the RLA's satisfaction. Provide a Lead Sculptor to supervise the work and the application of final color. At a minimum the Lead Sculptor must have **5** years' experience in large-scale aesthetic finish production work, such as murals, artificial rock-scapes or similar. The Lead Sculptor's resume must show a minimum of five (**5**) years' experience in the management of project crews, as well as experience in coordination with other trades in the completion of simulated exhibitory fabrication projects. The Lead Sculptor will be responsible for consistency of aesthetic finish between different crews and consistency of overall finished appearance throughout the project.
- Submit to the RLA for approval layout drawings defining the proposed zones of different simulated geological formations a minimum of thirty days before the sculpting production work starts. Vary the relief of the finished surface and amplitude of texture to depths no less than of

those simulated geologic rock types noted on the plans.

PRECONSTRUCTION TESTING AND MOCK-UP

Prior to the start of any work, the contractor shall perform a trial batch for each shotcrete mixture, have testing performed on samples by an independent laboratory, and shall provide the Engineer with test results at least 14 days prior to the start of shotcrete pre-construction trial work. The trial batch production and sampling shall be witnessed by the Department and duplicate samples will be provided to the Department by the contractor.

Upon acceptance of the shotcrete mixtures, the contractor shall perform a pre-construction trial used to qualify the Nozzlemen proposed to work on the project. Any Nozzleman that has not been pre-qualified will not be permitted to apply shotcrete on the project.

The contractor shall produce pre-construction trial mock-up panels, using all the planned labor, equipment, materials, and procedures proposed for actual shotcrete wall construction. The trial will be used to determine the acceptability of the equipment and contractor's expertise to produce shotcrete conforming to the project specifications using the proposed materials and approved mixtures. Acceptance of the pre-construction trial results by the Department is required prior to the start of the wet Shotcrete application on the project. Two mock-up panels will be produced for each shotcrete mix per nozzleman. Panels will be shot for the positions expected to be encountered for the work. Mock-up panels shall be 1.0 m^2 and of a thickness matching the finished permanent structural shotcrete wall. One mock-up panel will include the Nelson stud plates, #19 grade 420 MPa reinforcing bars, as per the details in the Contract Documents, at the design thickness, steel fibered shotcrete mix. After setting, one panel shall be broken open in the presence of and a manner approved by the Engineer, to verify reinforcement embedment. If voids are present, additional trial panels shall be shot until results acceptable to the Engineer are achieved. Small non-interconnected voids will not constitute failure. The second mock-up panel will not require Nelson stud plates or reinforcing, will be shot using the steel fibered shotcrete mix and will have the finished surface roughened for bonding of the sculpted architectural shotcrete carving layer to be applied after the 7 day curing time has been met.

Permanent structural shotcrete work may progress on the project by each nozzleman approved by the above qualification testing.

A sculpted, non structural architectural shotcrete carving layer mix shall be applied to the non-reinforced mock-up panel. Each work crew is required to demonstrate the sculpting procedures. After the sculpted architectural shotcrete carving layer has cured 28 days, 3 bond pull-off tests shall be performed by the contractor's independent laboratory with results provided to the Engineer.

To qualify the sculpted architectural shotcrete carving process, a mock-up area shall be produced by the contractor. This sculpted architectural mock up shall be 6.6m high by 3m wide and may be applied on a surface that will be disposed of after trial or alternatively, the contractor may perform mock up work at an in-place location acceptable to the Engineer. When completed any disposable mock-ups shall meet the safety requirements for supporting the mass. Foundations and other means and methods to support and stabilize the mock-ups are the responsibility of the contractor. If mock-ups are applied on the permanent structural shotcrete and are deemed acceptable it will become part of the permanent work. If unacceptable, the contractor shall remove and replace unacceptable work to the satisfaction of the Engineer. Demonstrate continuity of sculpting procedures across expansion joints and across joints.

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To qualify the staining and sealing process, the contractor, after mock-up panel shotcrete is complete, including the sculpted architectural shotcrete carving layer, shall clean the carved surface and prepared it for staining and sealing as per the manufacturer's specifications. Apply the color based on the developed coloration scheme and manufacturer's recommendation. Each work crew is required to demonstrate their color application techniques consistent with the mock-up.

After the color application technique, color scheme and sealer application shall be submitted by the Lead Sculptor to the Regional Landscape Architect (RLA). A maximum of 3 mock-ups may be required to address the aesthetic requirements determined by the Regional Landscape Architect. Once a finished mock-up is acceptable to the RLA, production work on the project may proceed using the mock-up as the quality standard. All production work utilizing the accepted surface features, color application techniques, and color schemes depicted on the mockup(s) shall meet the same quality standards that are visible on the mock-up(s).

EXCAVATION AND EMBANKMENT
All the provisions of Section 203-3 shall apply for any work required on the plans or as directed by the Engineer.

SOIL EROSION AND SEDIMENT CONTROL.
All the provisions of Section 209-3 shall apply.

DRAINAGE
Install and secure all elements of the wall drainage network as shown on the Contract Documents. Secure the geocomposite drainage strips tightly to the excavation face to prevent shotcrete from contaminating the ground side of the geotextile. Geocomposite drainage strips shall be continuous. Splices to the geocomposite drainage strips shall be made with a 305mm minimum overlap such that the flow of water is not impeded. Install all elements of the drainage network, exclusive of the wall footing drains, prior to shotcreting. Clean the face of the excavation, and other surfaces to be shotcreted, of loose material, mud, rebound, overspray, or other foreign matter that could prevent or reduce shotcrete bond prior to shotcreting. Remove material that loosens as shotcrete is applied.

After completion of the sculpting process, drain pipes used for weeps shall be cut off flush with the finished shotcrete surface.

CONCRETE REMOVAL
Remove all unsound previously installed construction facing shotcrete and replace with new shotcrete prior to constructing permanent structural shotcrete. Repaired areas shall be cured and achieve the necessary compressive strength as determined by the Engineer prior to placing permanent structural shotcrete.

Remove concrete from any marked areas in a sequential manner, as directed by the Engineer. Do not remove excessive depths or amounts of concrete from a given area, which could damage the structure.

Remove any and all loose material from the proposed permanent soil nail wall.

Pressure wash all previously installed construction facing shotcrete with a turbo tip or spin jet head and

minimum of 35 MPa. Pressure wash the entire receiving surface to remove any loose concrete material. If any chipping of the temporary shotcrete is needed the chipped shotcrete surface will need to be pressure washed to remove any loose fractured shotcrete.

SURFACE PREPARATION

Prepare previously installed construction facing surfaces to receive shotcrete. Sandblast all soil nail plates, rust stains, and surfaces exhibiting white leaching. Pressure wash by high pressure water blasting the entire shotcrete/concrete surface with a turbo tip or spin jet head using a minimum of 35 MPa pressure to remove laitance from the bonding surface. Pressure wash any exposed epoxy coated reinforcing.

After the surface preparation has been accepted, every effort should be made to thoroughly wet the surface and all porous surfaces to be in contact with new shotcrete for 12 hours to bring the shotcrete/concrete surface to a Saturated Surface dry (SSD) condition prior to application of wet shotcrete. This may be accomplished by continuous wetting with soaker hoses or the use of burlap/burlene/etc... where moisture can be maintained. If in the opinion of the Engineer conditions or the situation prohibits this then the surfaces should be wetted for as long as possible. Surfaces must be wetted by a means acceptable to the Engineer using potable water. The Contractor shall remove any puddles of free standing water with oil-free compressed air, and protect the surfaces from drying, so the existing shotcrete/concrete remains in a clean, SSD condition until placement of the new shotcrete.

Prepared shotcrete/concrete surfaces will be examined and approved by the Engineer, before installation of new permanent structural shotcrete.

REINFORCING

Securely tie reinforcing steel bars to the nelson studded plates and at the intersecting bars to minimize vibration and movement. Avoid formation of knots of tie wire, which could interfere with proper shotcrete encasement of reinforcing steel. Tie reinforcing steel to avoid multiple laps or other congestion. All splices of reinforcing bars shall utilize the noncontact lap splice method with a clearance of 50 mm between bars. All #19 bar splices will be lapped 661 mm. The contractor will submit a means and methods for connecting the 2-#19 bars while leaving a 50mm noncontact splice. Any anchors used to tighten the reinforcing steel from vibrating shall be submitted for approval to keep the reinforcing steel from vibrating during the shooting process.

SHOTCRETE APPLICATION

Weather Limitations

All the provisions of Section 583-3.03A shall apply. Terminate shotcrete application if the ambient temperature rises above 38°C**.** Wind protection and sun shades will be implemented during hot weather days and windy days.

Placement

- Construction testing:
    - Compressive strength testing shall performed using samples from construction test panel shot using shotcrete from the middle of the first load of each day and for each 38 cubic meters of shotcrete placed thereafter. Material panels will be shot in a vertical position near the wall area shot for the day. Cure test panels in the same manner as the wall. Test panels shall be produced in accordance with 583-3.03C.1. After 7 days of on-site curing,

test panels shall be delivered to the Regional Materials Engineer.

- 50mm diameter core samples taken from the shotcrete test panels shall be tested by NYSDOT Laboratories for compressive strengths in accordance with ASTM C 1604M. Compressive strength tests will be performed for 14 day results to verify strength.
- Test panels for saw cutting of flexural beams shall be prepared according to ASTM C1140 at the frequency of every 190 m3 min per Nozzlemen. The panels will be cured and sawed by the Contractor and the beams will be provided to the Engineer. NYSDOT Laboratories will test the beams according to ASTM C78 to verify they meet 4.8 MPa at 14 days.
- If the minimum 14 day compressive strengths of 38 MPa are met, and the 14 day flexural test minimum of 4.8 MPa has been met the daily frequency of test panel's maybe adjusted by the engineer/inspector. In case of a panel failure or low breaks, the engineer/inspector may add additional panels or beams for back up or take cores and beams from the in-place shotcrete work to determine the compressive and flexural strengths of the material.

- Placement procedures:
  - Implement alignment control to establish control over line and grade and ensure that the minimum specified shotcrete thickness and cover to reinforcing steel and nelson studs are maintained. Verify that the coverage over the soil nail plates meet the drawing requirements.
  - Accomplish alignment control by means of devices such as shooting wires, guide strips, depth gauges or forms. Submit the proposed means of alignment control to the engineer for review and approval.
  - Guide strips and forms are to be of such dimensions and installation configuration that they do not impede the ability of the Nozzlemen to produce uniform, dense, properly consolidated shotcrete. Installations, which entrap rebound or form sand pockets or voids, shall require the use of a blowpipe to remove the excess material prior to shooting.
  - Formwork for the coping shall be installed and supported to prevent any vibration during shooting. For near horizontal areas like the coping, take the rubber tip off and pump the shotcrete mix into the form while lightly vibrating the material to prevent trapping excess rebound in the coping.
  - Place shotcrete using labor, equipment, materials, and procedures established in the accepted Quality Control Plan and per the trial placement mock-ups.
  - Do not apply corrosion inhibitor shotcrete mix to any dry surface or a surface with free standing water.
  - Cut out any voids, sags or other defects from the pneumatic applied shotcrete while still plastic and re-shoot. Otherwise make good any defects in the hardened shotcrete using light duty chipping hammers followed by water blasting to remove bruised harden shotcrete.
  - Protect all adjacent shotcrete surfaces from build-up of rebound, overspray and shotcrete trimmings. Remove any excess shotcrete buildup outside of the specified shooting areas. Leave the adjacent surface in a clean condition after completion of the work, free from contamination by excess shotcrete, shotcrete trimmings, rebound, overspray or slurry from shotcrete cleaning operations.
  - When stopping for the day the edge of the in-place shotcrete surface must be roughened to allow for good bond of the next layer of shotcrete. Do not featheredge. Produce a long tapered edge roughened at a 45° angle so to make a full depth construction joint.

- Immediately after placement, protect all shotcrete from premature drying, excessive hot or cold temperatures, and mechanical injury until shotcrete has been finished and curing has commenced.

Finishing

- Permanent Structural Shotcrete
  - Trim shotcrete with a cutting rod or other suitable device to the specified line and Grade as stated in the drawings.
  - Roughen the surface as appropriate to provide necessary bond for the sculpted architectural shotcrete carving layer. Surface roughness shall have a profile of at least 3 peak to valley measurements of 5mm in a 150 mm length, or at least 4 peak to valley measurements of 4 mm in a 150mm length.
- Sculpted Architectural Shotcrete Carving Layer
  - The permanent shotcrete facing shall be sculpted and carved in such a way that the finished surface closely resembles the appearance, texture and features of the mock-up panel(s) and existing rock. The sculpting shall be in such a way that the finished work will have a slope so that water cannot be trapped or puddle on the wall face.
  - After completion of the sculpting process, drain pipes used as weeps shall be cut flush with the finished surface.

Curing

Curing shall be in accordance with 555-3.08, Curing, and the following modifications:

- All curing covers shall be pre-wet and kept wet during the entire curing period in a manner satisfactory to the Engineer.
- Curing compounds shall be applied twice. The second application shall be done when the first application has become tacky. The second application shall be done at a right angle to the first application. The rate of each application shall be that given in 555-3.08A.
- Apply the approved liquid curing compound to all freshly place shotcrete after the desired surface finish has been achieved for both the permanent soil nail wall and the architectural sculpted rock.
- Curing Compounds will be used as concrete curing method over water curing to prevent surface shrinkage cracks and not to damage the surface finish.
- Curing Compounds to be used on Shotcrete shall be cured for a minimum of seven days prior to the next operation.

Staining and Sealing

Prior to staining, all permanently exposed shotcrete surfaces shall be prepared according to the staining manufacturers recommendations. Surfaces to be stained shall be pressure washed, clean, dry and free from dust, curing agents, oil, grease, efflorescence and any other contaminants that could prevent proper adhesion. In addition, glazed or glossy surfaces must be mechanically abraded to remove gloss to allow adhesion.

Prior to any staining operations, the contractor shall be required to complete a test staining program for color acceptance and surface area coverage. The test panel will be constructed at a location on site as approved by the Engineer. The finished color of the penetrating stain treated areas shall closely represent the natural rock surface in the area of this work, or as directed by the Engineer. The Contractor shall apply the stain according to the manufacturer's recommendations. The stain test sample must be

submitted to and approved by the Engineer prior to ordering the complete stain batch. When approved, the sample areas shall serve as a standard of acceptance for all further work.

Accompanying the sample shall be the manufacturer's literature which shall include materials specifications, physical properties, including ASTM test methods utilized, manufacturer's recommended application rates for the various surface textures and porosity, current application instructions, and Material Safety Data Sheets. The Contractor must comply with all safety instructions during all applications.

All permanently exposed shotcrete surfaces shall be stained, to match the previously approved coloring of the sample mockup panel.

At the time of stain application, both the shotcrete surface and the air temperature must be between 10°C and 32°C. Stain shall not be applied unless weather conditions will permit complete drying of material prior to rain, fog, dew or temperatures beyond the prescribed limits. Areas not to receive stain shall be masked.

Shotcrete staining shall consist of applying a minimum of two separate applications of at least two stain colors to all sculpted shotcrete (architectural surface treatment) such that the sculpted wall face demonstrates individual color variations and character to match that of the visual standard panel or approved mockup. Staining shall only be performed to surfaces that have been approved by the engineer.

Prior to use, the stain shall be thoroughly mixed using the appropriate mechanical means and shall be mixed during application operations as required to maintain uniformity.

The concrete penetrating stain shall be applied by a combination of hand wiping, spraying, sponging, brush painting, ragging or other methods approved by the Engineer, with as many layers and patterns necessary to achieve believable coloration within stones and natural random variation from stone to stone.

Damaged and Defective Shotcrete

The Department has the authority to accept or reject the shotcrete, which does not conform to the project specifications. The shotcrete may be rejected either during the application process, or on the basis of tests from test panels or the completed work.

Deficiencies observed during the wet shotcrete application process, such as, but not limited to the following, constitute a removal and replacement of the shotcrete at no cost to the state:

- Failure to properly control and remove build-up of overspray and rebound
- Incomplete consolidation of shotcrete around reinforcing steel
- Incorporation of sand lenses, excessive voids, delaminations, sags or sloughing
- Failure to apply the shotcrete to the required line and grade and Tolerance
- Failure to apply shotcrete material within the allowed time (90 minutes for wet shotcrete mix) unless a hydration control admixture was added to the load for extra time, the contractor will have to submit the dosage rates and extended times for the mix prior to placement. Higher temperatures may require a larger dosage of HCA than submitted. This will have to be coordinated by the shooting crew, inspector and the ready mix plant.

Whenever possible, perform remedial work to correct deficiencies while the shotcrete is still in the plastic

state.

If delaminations are found between the permanent structural wall and the architectural carving later or at the construction joint areas, the work shall be considered deficient, and will be removed and replaced to the satisfaction of the engineer, at no cost to the state. Conduct bond pull-off tests on 28 day strength cured shotcrete material in accordance with ASTM C1583 at the designated locations and a frequency selected by the Engineer. The average of a set of three bond pull off strength tests must exceed 1 MPa, with no individual result less than 0.7MPa. If these test results pass the specified criteria, the work will be considered acceptable with respect to bond. If the bond-pull off strength result fails to exceed 0.7MPa due to the substrate failing before the shotcrete, the test is not considered a failure. Only tests that did not exceed 1 MPA and did not show substrate failure did not meet the specified criteria, the work will be rejected and the Contractor must implement a remediation program to correct the deficiency at no extra cost to the NYSDOT. In the event that the adhesive fails during a pull off test for any reason, a new test will be performed at a new location

Hardened shotcrete, which is identified as being deficient, must be removed. Care shall be taken to prevent damage to reinforcing steel bars or anchors and adjacent sound shotcrete. Any embedment's that are adjacent to sound shotcrete and damaged during the shotcrete removal process are to be removed and replaced at no extra cost to the NYSDOT.

All prepared repair areas are to be inspected and approved by the Engineer/Inspector prior to the placement of any repair. Repair shotcrete is to be placed, finished, cured and protected in the same manner specified for shotcrete work.

All repairs and tests for non-conforming shotcrete are to be completed at no extra cost to the Department.

TURF ESTABLISHMENT
All the provisions of Section 610-3 and contract documents shall apply.

METHOD OF MEASUREMENT
Permanent and Architectural Finished Shotcrete wall surfaces will be measured by the square meter of the plane projection of the finished sculpted surface area. The total quantity of this item will be measured to the nearest square meter.

BASIS OF PAYMENT
The unit price bid per square meter shall include the cost of all labor, equipment and materials including but not limited to all steel reinforcing (including cutting and or bending existing reinforcing to fit the coping details), excavation & embankment, turf establishment, soil erosion & sediment controls, wall drainage network, all sampling, testing and coring requirements assigned to the contractor, premolded joint filler, polyethylene bond breaker strip, joint sealant, exterior surface finish, visual mock-ups, staining of applied sculpted face, staining of existing benches, installation and staining of coping and sealer application of all shotcrete areas. The unit price bid per square meter shall also include, but not be limited to the following:

PERMANENT STRUCTURAL SHOTCRETE FACING:
The cost of all temporary scaffolding, manlifts, selective demolition, materials, equipment, labor, tools, and incidentals required to accomplish work, access, preconstruction mockups test panels, supply, mixing

and application of pneumatic shotcrete, making of daily test panels, removal of defective materials, clean-up of the area and disposal of construction debris, waste and water, control of standing water (dewatering), waste shotcrete and rebound, maintaining and cleaning of the existing roadway, and parapet walls. Any Work Zone Traffic Control will also be included.

SCULPTED ARCHITECTURAL SHOTCRETE FACE LAYER

The cost of all labor, equipment and materials including, but not limited to fibers, admixtures, shotcrete mix, installation of sculpted architectural shotcrete, clean-up of the area and disposal of construction debris, waste and water, control of standing water (dewatering), waste shotcrete and rebound, maintaining and cleaning of the existing roadway, and parapet walls.

All items mentioned in section will be included in the square meter price. Progress payments will be made at the following percents when processes are completed and accepted; 40% when Permanent Structural Shotcrete Facing has been completed, 50% when Sculpted Architectural Shotcrete Face Layer has been completed, 10% when work has been completed to the satisfaction of the Engineer. Work Zone Traffic Control