Amend Section 628 – Shotcrete to read as follows:

## "SECTION 628 – SHOTCRETE

**628.01 Description.** This work includes furnishing all materials and labor required for placing and securing geocomposite drainage material, weep holes, reinforcing steel, shotcrete for the initial facing (flashcoat) and permanent facing, sculpturing and staining of the exposed concrete surface, and nail head bearing plates and nuts for the soil nail retaining walls shown on the Plans. The work also includes any preparatory trimming and cleaning of soil/rock surfaces and shotcrete cold joints to receive new shotcrete.

**628.02 Materials.** All admixtures and materials for shotcrete shall conform to sheet S0.1 General Notes 4(B) on the Plans and Subsection 601.02 Materials.

Materials shall be delivered, stored and handled to prevent contamination, segregation, corrosion or damage. Store liquid admixtures to prevent evaporation and freezing.

Geocomposite drain strips shall be provided in rolls wrapped with a protective covering and stored in a manner that protects the fabric from mud, dirt, dust, debris, and shotcrete rebound. Protective wrapping shall not be removed until immediately before the geotextile or drain strip is installed. Extended exposure to ultra-violet light shall be avoided. Each roll of geotextile or drain strip in the shipment shall be labeled to identify the production run.

**628.03 Construction Submittals. No shotcreting shall be performed until the following submittals are accepted by the Engineer.** At least 30 days before the planned start of shotcrete placement, submit 8 copies of the following information, in writing, to the Engineer for review and acceptance:

**(A)** Written documentation of the finisher's and nozzlemen's qualifications including proof of ACI certification (if applicable)

**(B)** Proposed methods of shotcrete placement and of controlling and maintaining facing alignment and location and shotcrete thickness.

**(C)** Shotcrete mix design including:

**(1)** Type of Portland cement.

**(2)** Aggregate source and gradation.

**(3)** Proportion of mix by weight and water-cement ratio.

**(4)** Proposed admixtures, manufacturer, dosage, and technical literature.

**(5)** Previous strength test results for the proposed shotcrete mix completed within one year of the start of shotcreteing may be submitted for initial verification of the required compressive strengths at start of production work.

**(D)** Certificates of Compliance, manufacturers' engineering data and installation instructions for the drainage geotextile, geocomposite drain strip, drain grate and accessories.

## 628.04 Construction Requirements

**(A) General.** Use either the dry mix or the wet mix process of shotcreting as follows:

**(1) Dry Mix Process.**

**(a)** Mix the cement and damp fine aggregates thoroughly.

**(b)** Feed the cement-fine aggregate mixture into a special mechanical feeder(gun) or other accepted delivery equipment.

**(c)** Meter the mixture into a delivery hose by a feed well or distributor.

**(d)** Convey this mixture by compressed air through the delivery hose to a special nozzle. Fit the nozzle with a perforated manifold that the Contractor can introduce the water under pressure and intimately mix with the other ingredients.

**(e)** Jet the mortar from the nozzle at high velocity onto the surface that the Contractor will shotcrete.

**(2) Wet Mix Process.**

**(a)** Mix the ingredients specified in Subsection 628.04(A)(1)-Dry Mix Process including water thoroughly.

**(b)** Introduce the mortar into the chamber of the delivery equipment.

**(c)** Meter the mortar into the delivery hose and convey the mortar by compressed air or other means to a nozzle.

**(d)** Inject additional air at the nozzle to increase the velocity and improve the gunning pattern.

**(e)** Jet the mortar from the nozzle at high velocity onto the surface that the Contractor will shotcrete.

**(B) Equipment.** Submit the manufacturer's specifications and operation instructions for the equipment that will be used on the project for acceptance by the Engineer. Operate the equipment according to the manufacturer's recommendations.

The Contractor may do proportioning of the mortar ingredients, except water, either volumetrically or by weight. Apply the water as specified above. The Engineer will not permit batches requiring fractional sacks unless the Contractor weighs the cement. Use the batches of the mixture within the time requirements specified in Section 601 – Structural Concrete.

**(1) Dry Mix Process.** Mix the ingredients thoroughly with mixing equipment so the Contractor can coat the fine aggregate particles with cement. Provide mixing equipment for the continuous application of the mortar.

The moisture content of the fine aggregate shall be such that the fine aggregate-cement mixture shall flow at a uniform rate (without slugs) through the delivery hose. The optimum moisture content shall depend on the delivery equipment used, but shall be between 3% and 6%.

Discharge the fine aggregate-cement mixture into the delivery hose under close control. Deliver a continuous, smooth stream of uniformly mixed material at the proper velocity to the discharge nozzle.

Equip the discharge nozzle with a manually operated water injection system (water ring) for directing and even distribution of water through the fine aggregate-cement mixture. The water valve shall be readily adjustable in varying the quantity of water, and shall be convenient to the person handling the nozzle.

Deliver a conical discharge stream of uniform appearance. Distortion of this stream or nonuniform appearance shall be cause to stop the work until the Contractor has corrected the situation.

Maintain a supply of clean air adequate for providing sufficient nozzle velocity for parts of the work and for the simultaneous operation of a blow pipe for clearing away rebound.

The water pressure at the discharge nozzle shall be greater than the operating air pressure to assure that the water shall

intimately mix with the other materials. If the water line pressure is inadequate, use a water pump to increase and get the required pressure. The water pressure shall be non-pulsating.

**(2) Wet Mix Process.** The wet mix delivery equipment shall be of a design and size that has produced good results in similar work. The wet mix process shall have the capacity to deliver the pre-mixed materials accurately, uniformly and continuously through the delivery hose. Follow the manufacturer's recommendations as to:

**(a)** the type and size of nozzle,

**(b)** cleaning the equipment,

**(c)** inspecting the equipment and

**(d)** maintaining the equipment.

The air compressor shall conform to Subsection 628.04(B)(1) – Dry Mix Process.

**(C) Qualification.** The shotcrete contractor shall be capable of performing the work specified herein and shall have the following minimum experience requirements below.

The workers handling the nozzle employed for the work shall be competent operators with at least two years of experience in this type of work. The person handling the nozzle may be an apprentice with at least 6 months of experience. The foreman in charge shall have at least two years of experience handling the nozzle.

**(D) Alignment Control.** Surfaces that the Contractor will shotcrete shall conform to the dimensions shown in the contract or ordered by the Engineer. The surfaces shall not contain free moisture but shall be sufficiently damp to prevent absorption. Install adequate ground wires as guides to establish the thickness and surfaces of the shotcrete build-up. The wires shall be taut and true to line at all times during the operation.

**(E) Surface Preparation.** Clean the face of the excavation and other surfaces to be shotcreted of loose materials, mud, rebound, overspray or other foreign matter that could prevent or reduce shotcrete bond. Protect adjacent surfaces for overspray during shooting. Avoid loosening, cracking, or shattering the ground during excavation and cleaning. Remove any surface material which is so loosened or damaged to a sufficient depth to provide a base that is suitable to receive the shotcrete. Remove material that loosens as the shotcrete is applied. Cost of additional shotcrete is incidental to the work. Divert water flow and

remove standing water so that the shotcrete placement will not be detrimentally affected by standing water.

**(F) Gunning.** Apply the shotcrete from the lower part of the area upwards to prevent accumulation of rebound. Orient nozzle at a distance and approximately perpendicular to the working face so that rebound will be minimal and compaction will be maximized. Pay special attention to encapsulating reinforcement. Care shall be taken while encasing reinforcing steel and mesh to keep the front face of the reinforcement clean during shooting operations, so that shotcrete builds up from behind, to encase the reinforcement and prevent voids and sand pockets from forming.

Allow each layer ample time to set. Each layer shall be free of rebound material before applying the next layer. If final set has taken place, wet down the area before the next application.

If high winds prevent the person handling the nozzle from making proper application of the mortar or if rain occurs causing washing out of the cement or sloughing of the mortar, the Engineer will suspend gunning.

**(G) Rebound.** Remove rebound. The Engineer will not allow rebound to become a part of the work.

**(H) Construction Joints.** Form construction joints by tampering to a thin edge over a distance of about 12 inches. Clean the construction joint thoroughly and wet the construction joint before the subsequent application of shotcrete.

**(I) Finishing.**

**(1)** The surface finish of the shotcrete construction facing shall be sculpted as shown on contract drawings. Finish the surface with proper floats and steel trowels. Round the exposed edges with an edging tool. Control joints shall be tooled to specified radius as shown on plans. The pattern shall match the existing sculpted rock finish at the adjacent work site, Mile Post 5.00 to 5.16.

**(2) Staining of Exposed Shotcrete Surfaces.** All exposed shotcrete surfaces shall be stained with a penetrating liquid stain that produces permanent color in the shotcrete surfaces. The stain shall be a water based formulation of hydrochloric acid and metallic salts that creates a reaction within the shotcrete substrate. The reaction should slightly etch the shotcrete to provide deep and permanent color penetration. Stain data shall be submitted to the Engineer for approval.

The shotcrete surface must be uniformly cleaned, cured and dried as required by the stain manufacturer before applying the stain. The shotcrete shall be cured for a minimum of 28 days and any membrane curing compounds must be completely removed and surface shall be thoroughly rinsed. Pressure washing may be necessary to clean the concrete surfaces. Acid wash shall not be used to clean the concrete surfaces.

Adjacent areas and vegetation shall be protected during the preparation and application of the stain.

Prior to constructing the permanent shotcrete wall, the Contractor shall produce a 3 feet by 3 feet test specimen for approval by the Engineer at no increase in contract price and contract time. Test specimen shall be sculpted and stained by the Contractor to experiment with the colors, application method, and finishing techniques. Multiple applications to the shotcrete surfaces may be required to produce the required color.

**(J) Curing.** Curing shall be by curing compound as shown in contract drawings.

**(K) Control Testing.**

**(1) Preconstruction Testing.** When required by the Engineer, the Contractor shall furnish three unreinforced and three reinforced test panels, at least 30 inches square with the same thickness as in the structure, but not less than 3 inches thick. Reinforcing for the test panels shall be of the same size and spacing required for the work. The Contractor shall make test panels to represent actual job conditions.

Test nonreinforced specimens for conformance to specified physical properties in accordance with ASTM C 1140. The Engineer will visually grade reinforced specimens for conformance to specified core grade as specified in Subsection 628.03(K)(2) – Shotcrete Core Grades.

Allow only nozzle operators with test panel mean core grade less than or equal to 2.5 to place job shotcrete. Require nozzle operator to shoot second test panel if first test panel is rejected. If nozzle operator's second mean core grade is greater than 2.5, do not permit that nozzle operator to shoot on the project.

**(2) Shotcrete Core Grades.**

**(a) Grade 1.** Shotcrete specimens are solid; there are no laminations, sandy areas or voids. Small air voids with maximum diameter or 1/8 inch and maximum length of ¼ inch are normal and acceptable. Sand pockets or voids behind continuous reinforcing steel are unacceptable. The surface against the form or bond plane shall be sound, without sandy texture or voids.

**(b) Grade 2.** Shotcrete specimens shall have no more than two laminations or sandy areas with dimensions not to exceed 1/8 inch thick by 1 inch long. The height, width, and depth of voids shall not exceed 3/8 inch. Porous areas behind reinforcing steel shall not exceed ½ inch in any direction except along length of reinforcing steel. The surface against the form or bond plane shall be sound, without sandy texture or voids.

**(c) Grade 3.** Shotcrete specimens shall have no more than two laminations or sandy areas with dimensions exceeding 3/16 inch thick by 1-1/4 inches long, or one major void, sand pocket, or lamination containing loosely bonded sand not to exceed 5/8 inch thick and 1-1/4 inches in width. The surface against the form or bond plane may be sandy, with voids containing overspray to a depth of 1/16 inch.

**(d) Grade 4.** Core shall meet, in general, requirements of Grade 3 cores, but may have two major flaws such as described for Grade 3, or may have one flaw with maximum dimension of 1 inch perpendicular to the face of the core, with maximum width of 1-1/2 inches. The end of the core that was shot against the form may be sandy, with voids containing overspray to a depth of 1/8 inch.

**(e) Grade 5.** Core that does not meet criteria of core grades 1 through 4, by being of poorer quality, shall be classified as Grade 5.

**(f)** Determine grade by computing the mean of a minimum of three test specimens. Accept mean grade of 2.5 or less. Reject individual shotcrete cores with grade of greater than 3.

**(g)** The above core grades are based on cores with surface area of 50 square inches. For cores with greater or lesser area than 50 square inches, adjust allowable flaws relative to 50 square inches.

**(3) Evaluation of In-Place Shotcrete.** Remove and replace shotcrete that is delaminated, exhibits laminatins, voids, or sand pockets exceeding limits for specified grade of shotcrete. Remove and replace shotcrete that does not comply with specified material properties.

Repair core holes in accordance with ACI 301 Chapter 9. Do not fill holes by shooting.

**(4) Acceptance.** The Engineer will accept shotcrete work that meets requirements of the contract documents. The Engineer will accept shotcrete work that has previously failed to meet one or more requirements, but which has been repaired to meet requirements of the contract documents.

Shotcrete work that fails to meet one or more requirements and that cannot be brought into compliance will be evaluated for acceptance by the Engineer. Modifications may be required to ensure remaining work complies with requirements of the contract documents.

**(L) Geocomposite Drain Strips.** Install geocomposite drain strips centered between the columns of nails as shown on the Plans. The drain strips shall be at least 24 inches wide and placed with the geotextile side against the ground. Secure the strips to the excavation face and prevent shotcrete from contaminating the ground side of the geotextile. Drain strips shall be continuous vertically. Splices shall be made with a 24 inch minimum overlap such that the flow of water is not impeded. Repair damage to the geocomposite drain strip, which may interrupt the flow of water.

**(M) Connection Pipe and Weepholes.** Install connection pipes as shown on the plans. Connection pipes are lengths of solid PVC pipe installed to direct water from the geocomposite drain strips to the exposed face of the wall. Connect the connection pipes to the drain strips using prefabricated drain grates. Install the drain grate per the manufacturers recommendations. The joint between the drain grate and the drain strip and the discharge end of the connection pipe shall be sealed to prevent shotcrete intrusion.

**628.05 Method of Measurement.** The quantity to be paid for shotcrete is the quantity shown in the proposal schedule. The contract quantity will be adjusted for authorized changes that affect the quantity or for errors made in computing this quantity. If there is evidence that a quantity specified as a contract

quantity is incorrect, submit calculations, drawings, or other evidence indicating why the quantity is in error and request, in writing, that the quantity be adjusted.

The Engineer will not measure additional shotcrete required to complete the job. The Contractor shall anticipate and include in his/her bid substantial excavation overbreak and subsequent backfill with shotcrete at the face of the excavation due to the cobbly and rocky nature of the subsurface materials at the soil nail retaining wall locations.

**628.06 Basis of Payment.** The engineer will pay for the accepted shotcrete at the contract unit price per pay unit, as shown in the proposal schedule. Payment will be full compensation for the work prescribed in this section and the contract documents.

The prices includes full compensation for providing proper shotcrete facing alignment and thickness control; furnishing and installing admixtures, reinforcing steel and reinforcement wire holding devices; bearing plates and nuts, test panels, all wall drainage materials including geocomposite drain strips, connection pipes, drain grates, fittings, all sampling, testing, sculpturing and staining, and reporting required; and furnishing labor, material tools, equipment, and incidents necessary to complete the work.

The Engineer will make payment under:

| **Pay Item** | **Pay Unit** |
|---|---|
| Shotcrete | Square Yards |

**1)** 30% of the contract bid price upon submitting an acceptable shotcreting plan, a job-mix formula acceptable to the Engineer and preparing surface for shotcreting;

**2)** 25% of the contract bid price upon installing the intial layer of shotcrete;

**3)** 35% of the contract bid price upon installing the final layer of shotcrete, and completion of sculpturing and staining;

**4)** 10% of the contract bid price upon completion of cleanup of shotcrete area.

The Engineer will not pay for additional shotcrete or cast-in-place concrete needed to fill voids created by irregularities in the cut face, excavation overbreak or inadvertent excavation beyond the plan final wall face excavation line or failure to construct the shotcrete construction facing to the specified line and grade tolerances. The Contractor shall anticipate substantial excavation overbreak and subsequent backfill with shotcrete at the face of the excavation due to the cobbly

and rocky nature of the subsurface materials at the soil nail retaining wall locations."

**END OF SECTION 628**