SP00396 (2018 Specifications: 0~~6~~9-01-20) ***(This Section requires SP02001, SP02040, SP02050 and SP02690. Requires SP02510 when reinforcement is required. Requires SP02415 when PVC pipe is required)***

SECTION 00396 - SHOTCRETE SLOPE STABILIZATION

(Follow all instructions. If there are no instructions above a subsection, paragraph, sentence, or bullet, then include it in the project. The specifications may be modified to include project specific specifications, but all additions, deletions, or modifications must be sent to the ODOT Technical Resource and State Specifications Engineer for review and approval.)

Replace Section 00396 of the Standard Specifications with the following Section 00396:

Description

00396.00 Scope - This Work consists of constructing pneumatically applied shotcrete stabilization blankets onto slope surfaces at locations shown or where directed.

00396.01 Definitions:

Cementitious Materials - As defined in 02001.02

Dry-Mix Shotcrete - Shotcrete process in which all dry constituents except accelerator and water are mixed before introduction into the delivery hose. Compressed air is used to deliver the dry mix through the hose. Water is added under pressure in the nozzle body, where it is mixed thoroughly with the dry constituents before the mixture is jetted from the nozzle onto the substrate.

Fiber Reinforced Shotcrete - Shotcrete containing steel fiber or synthetic polymer fiber reinforcing complying with ASTM C1116/1116M.

Nozzle Operator - A worker trained to manipulate the nozzle (also referred to as the “gun”) to control consistency in the dry-mix process, and to control final placement of the concrete mix on the substrate.

Predampening - In the dry-mix process, the controlled addition of water to the Aggregates or premixed shotcrete Materials during batching to adjust the moisture content of the shotcrete mixture before introduction into the nozzle.

Rebound - Shotcrete or shotcrete constituents that fail to adhere to the substrate.

Shotcrete - A method used to place concrete onto a surface at high velocity. The concrete mix contains admixtures and additives as necessary to provide a quick setting time, high early strength, and satisfactory adhesion to the substrate.

Substrate - The surface on which shotcrete is placed.

Wet-Mix Shotcrete - Shotcrete process in which all constituents, except accelerator, are mixed before introduction into the delivery hose. Compressed air and accelerator are added to the mixture at the nozzle, in such a way that the quantity can be properly regulated.

00396.02 Submittals:

(a) Qualifications - Provide personnel experience documentation showing compliance with 00396.30.

(b) Product Data - Submit according to 00150.37, at least 28 Calendar Days before the preconstruction conference, a proposed mix design according to the requirements of this Section and 02001.15 as appropriate for shotcrete. Include strength test and air entrainment test results. Include all proposed additives, including but not limited to air entrainment additives, accelerators, and curing agents.

(c) Work Plan - Submit a detailed work plan according to 00150.37 at least 28 Calendar Days before the preconstruction conference. Include the following:

- Proposed process and Equipment for shotcrete application
- Sequence of the Work
- Material storage and handling procedures
- Methods for sampling and testing the shotcrete
- If steel fibers or synthetic polymer fibers are required, the process for blending them into the shotcrete mix

Materials

00396.10 Materials - Furnish Materials meeting the following requirements:

Bar Reinforcement 02510.10
Cement (Type I or II) 02010.10
Chemical Admixtures 02040
Coarse Aggregate 02690.20
Curing Materials 02050.10
Fine Aggregate 02690.30
Non-Epoxy Grout 02080.20
PVC Pipe 02415.50
Water 02020
Welded Wire Fabric 02510.40

00396.11 Prepackaged Product - Premixed and prepackaged concrete products, with or without steel fibers or synthetic polymer fibers, manufactured as a shotcrete product may be used for site-mixed shotcrete if the Materials meet these Specifications and if approved.

00396.12 Aggregates - Combined Fine Aggregates and Coarse Aggregates shall meet the following grading requirements as determined by AASHTO T 27:

Percent Passing

Sieve Size	(by Weight)
1/2"	100
3/8"	90 - 100
No. 4	70 - 85
No. 8	50 - 70
No. 16	35 - 55
No. 30	20 - 35
No. 50	8 - 20
No. 100	2 - 10

00396.13 Steel Fiber Reinforcement - If steel fiber reinforced shotcrete is required, the steel fibers shall:

- be between 1/2 and 1 1/2 inches long.
- meet the requirements of ASTM A820 Type 1, Deformed.
- have a length-to-diameter ratio of less than 80.
- have a minimum tensile strength of 160,000 psi.

Only steel fibers manufactured specifically for use in shotcrete applications will be allowed. The steel fiber content shall not be less than 100 pounds per cubic yard of shotcrete.

00396.14 Synthetic Polymer Fiber Reinforcement - If synthetic polymer fiber reinforced shotcrete is required, the synthetic polymer fibers shall:

- be between 1/2 and 3 inches long.
- meet the requirements of ASTM C1116 Type III.
- have a minimum diameter of 0.012 inch.
- have a minimum tensile strength of 75,000 psi.

Only synthetic polymer fibers manufactured specifically for use in shotcrete applications will be allowed. The proportion of synthetic polymer fibers in the mix shall follow the fiber manufacturer's recommendations.

00396.15 Shotcrete Mix Requirements - Determine the exact proportions both by weight and by volume of cementitious Materials, Fine Aggregate, Coarse Aggregate, fiber reinforcement (if any), admixtures, and water, subject to the Engineer's approval. Shotcrete shall meet the following minimum requirements:

- Maximum water-cement ratio of 0.45
- Entrained air content meeting the requirements of 02001.20(b) for the proposed maximum aggregate size and the intended exposure

00396.16 Acceptance Sampling and Testing:

(a) General:

(1) Test Panels - Prepare shotcrete test panels on vertically supported open-face forms. The forms shall:

- have internal dimensions of at least 24 by 24 by 5 inches.
- be rigid, nonabsorbent, and nonreactive with cement.

Place the shotcrete in the forms using the same shotcrete mix, air pressure, water pressure, and nozzle tip that will be used in the production shotcrete. Protect the panels for at least 24 hours or until final set has taken place.

(2) Preproduction Testing - Prior to beginning production shotcrete operations, prepare and test at least two test panels for each mix design. Cure the test panels in a manner appropriate to the anticipated field conditions. Before starting production Work, provide to the Engineer compressive strength test results showing that the mixture meets the minimum strength requirements. Do not begin production shotcrete Work until satisfactory test results are obtained.

(3) Production Testing - During shotcrete operations prepare, in the presence of the Engineer, a minimum of one test panel for each 50 cubic yards placed, but no fewer than one test panel daily for each nozzle operator plus one test panel shot whenever the nozzle Equipment is changed. Cure the production test panels under the same conditions as the production shotcrete. Identify each production test panel with the daily Work area reported according to 00396.46.

(b) Compressive Strength Tests:

(1) Compressive Test Cores - Obtain 3-inch diameter test cores from the cured shotcrete test panels prepared according to 00396.16(a)(1) and 00396.16(a)(2). Collect core samples a minimum of 4 inches from the edge of the concrete in the test form. Test core samples for compressive strength according to AASHTO T 22 within 24 hours of coring.

(2) Shotcrete Compressive Strength - The shotcrete cores shall attain 2,500 psi compressive strength at 7 Calendar Days.

(c) Shotcrete Quality - Submit a visual description of each core. Include details concerning the presence of voids, sand pockets, laminations, and other deficiencies. The visual quality of the cores shall not be lower than Grade 2 according to shotcrete grading requirements of ACI 506.2.

(d) Failure of Shotcrete - If a shotcrete section represented by any test panel is deficient in any of the criteria specified in 00396.16(b) or 00396.16(c), provide remedy as directed at no additional cost to the Agency. Remedies may include, but are not limited to, the application of additional shotcrete to the deficient area or removal and replacement of the deficient section.

Equipment

00396.20 General - Provide mixing Equipment capable of thoroughly mixing the Materials in sufficient quantity to maintain uniform and continuous application.

00396.21 Pump System - The pump system that conveys premixed shotcrete constituents shall deliver a uniform and continuous flow of Material, without segregation or loss of constituents.

00396.22 Air Compressor - Furnish air compressor(s) capable of providing:

- a supply of clean air adequate for maintaining sufficient nozzle velocity for all parts of the Work and for the simultaneous operation of a blow-pipe for clearing away rebound; and
- a minimum of 250 cubic feet of air per minute per operating nozzle.

00396.23 Dry-Mix Delivery Equipment - Furnish dry-mix delivery Equipment capable of discharging the cement/Aggregate mixture into the delivery hose and delivering a continuous stream of uniformly mixed Material to the discharge nozzle. Equip the discharge nozzle with a manually operated water injection system (water ring) for directing an even distribution of water through the cement/Aggregate mixture. The water valve shall be capable of ready adjustment to vary the quantity of water, and shall be convenient to the nozzle operator. Provide greater water pressure than the operating air pressure at the discharge nozzle to ensure that the water is thoroughly mixed with the other Materials. Use steady, nonpulsating water pressure. Regularly inspect and replace Equipment parts, especially the nozzle liner and water ring, as necessary or as directed.

When using the dry-mix process, furnish and use predampening Equipment.

00396.24 Wet-Mix Delivery Equipment - Wet-mix delivery Equipment shall be capable of discharging the premixed Materials into the delivery hose and delivering a continuous stream of uniformly mixed Material to the discharge nozzle. Follow the manufacturer's recommendations on the type and size of nozzle to be used, and on cleaning, inspection, and maintenance of the Equipment.

Labor

00396.30 Personnel Qualifications - At least 7 Calendar Days before beginning shotcrete Work, provide written evidence that the on-site supervisor, nozzle operator, and delivery Equipment operator have performed satisfactory Work in similar capacities elsewhere for a sufficient length of time to be fully qualified to perform their duties.

The on-site supervisor shall have not less than 2 years of full-time experience as a shotcrete nozzle operator.

All nozzle operators shall have current certification by the American Concrete Institute for wet-mix or dry-mix vertical placement of shotcrete, as appropriate to the proposed mixing process.

The nozzle operator and delivery Equipment operator shall each have at least 1 year of full-time experience on similar applications with the same type of Equipment as proposed for the Project. Before starting shotcrete Work, the nozzle operator shall, in the presence of the Engineer, demonstrate the ability to apply shotcrete on a test panel according to 00396.16. Visual quality of core samples from test panels shall meet requirements of 00396.16(c).

Before being allowed to place shotcrete in permanent construction, each nozzle operator shall make one satisfactory test panel for each mix used during the course of the Work.

The nozzle operator shall be assisted by a helper, able to operate a blow-pipe for the purpose of keeping the work area free of rebound.

Construction

00396.40 Surface Preparation - Before applying shotcrete to Rock surfaces, remove all loose material and vegetation and clean the surface with air, water jets or other approved means. Use air jets to remove loose material from Soil surfaces.

Do not place shotcrete on any surface that is frozen or spongy, or where there is free water. Dampen the surface before applying shotcrete.

00396.41 Shotcrete Blanket Thickness Control - Control shotcrete blanket thickness by installing noncorrosive pins, nails or other gauging devices normal to the face of the substrate so that they protrude the required shotcrete thickness outside the face. Place the pins on a maximum 5-foot square pattern. When welded wire fabric reinforcement is used, place at least a 1-inch cover of shotcrete over the wire fabric.

00396.42 Anchor Bars - Clean and blow clear all drilled holes before installing the anchor bars. Completely fill drilled holes with non-epoxy grout, using a grout tube extending to the bottom of the hole.

00396.43 Welded Wire Fabric - Place welded wire fabric as shown or directed. Overlap sheets at least 8 inches and secure with tie wire.

00396.44 Weep Holes - Install weep holes as shown or directed. Do not drill holes larger than 3 inches in diameter. Install the PVC drain pipe before applying shotcrete. Extend the end of the pipe 1 to 3 inches beyond the final slope face. Protect pipe ends during shotcreting, and clear weep hole drain pipes after shotcrete is placed.

00396.45 Batching and Mixing Shotcrete:

(a) Dry-Mix Process - Batch the cement/Aggregate mix by weight or volume. Predampen the dry-mix after it flows out of the packaging but before it flows into the main hopper in order to ensure that the premixed constituents will flow at a uniform rate. Do not use predampened cement/Aggregate mix in the Work if it is allowed to stand more than 45 minutes.

(b) Wet-Mix Process - Batch and mix wet-mix shotcrete according to ASTM C94.

(c) Fiber Reinforcement - Demonstrate the procedure for adding fibers to the shotcrete in the field and obtain the Engineer's approval before beginning production Work. If fibers are added to the dry or wet mix on-site, use a screen having a mesh of 1 1/2 to 2 1/2 inches to prevent fiber balls from entering the shotcrete line, unless it is demonstrated that fiber balls can be prevented without a screen. Do not add fibers to the dry or wet mix at a rate faster than can be blended with the other constituents without forming balls or clumps. If bulk fibers show a tendency to tangle together, pass them through a vibrating screen or sift them into the mix so they enter it as individual elements and not as clumps.

00396.46 Shotcrete Application - Apply shotcrete from the lower portion of the area to the top so rebound does not accumulate on the area still to be covered. Hold the nozzle approximately perpendicular to the working face, and at a distance that minimizes rebound and maximizes compaction. Shotcrete shall emerge from the nozzle in a uniform and continuous flow. When, for any reason, the flow becomes intermittent, divert the nozzle from the Work until uniform and continuous flow resumes. A nozzle operator's helper, equipped with blow-pipe, shall attend the nozzle operator at all times during shotcrete placement to keep the Work area free of rebound.

Do not work rebound material into the finished product. Do not salvage rebound or include it in later batches.

Suspend placement operations if:

- high wind prevents the nozzle operator from properly applying the material;
- the ambient temperature is below 40 °F; or
- rain or other external factors wash cement out of the freshly placed material or cause sloughs in the work.

Taper construction joints over a distance of at least 12 inches to a thin edge. Thoroughly wet the surface of such joints before any adjacent section of shotcrete is placed. Do not make square construction joints.

Report daily, in writing, the quantity and limits of shotcrete applied on each day of shotcrete operations. Identify in these reports the production samples collected according to 00396.16(b) for each reported Work area.

If shotcrete containing steel fibers is applied in areas accessible to the public, apply a minimum 1/2-inch thick finish coat of shotcrete without steel fibers to protect the public from injury by brushing against the fibers.

Remove dummy areas, sags, and other defects and replace with a new layer, at no additional cost to the Agency. Replace any damaged fabric reinforcement with lapped and tied wire fabric.

Allow previous layers of shotcrete to take initial set before applying additional layers. Remove all loose Material before applying additional layers.

00396.48 Finishing and Curing - Leave the shotcrete surface with a natural "gun" finish.

Apply Type 2, white-pigmented curing compound to the shotcrete immediately after application. Keep shotcrete surfaces from freezing for at least 7 Calendar Days after application. Before placing subsequent shotcrete, remove all curing compound in contact with exposed welded wire fabric, anchor bars or previous shotcrete surfaces by sandblasting.

Measurement

00396.80 Measurement - The quantities of shotcrete will be measured on the area basis. Measurement will be of the finished shotcrete surface area.

Payment

00396.90 Payment - The accepted quantities of shotcrete will be paid for at the Contract unit price, per square yard, for the item "Shotcrete Slope Stabilization".

Payment will be payment in full for furnishing and placing all Materials, and for furnishing all Equipment, labor, and Incidentals necessary to complete the Work as specified.