

## SECTION 628 - SHOTCRETE

**628.01 Description.** This work includes the pneumatic application of mortar according to the contract. \*|

**628.02 Materials.** Materials shall conform to the following: |

Portland Cement	701.01
Welded Wire Fabric Reinforcement	709.01(C)
Water	712.01

The Contractor may use admixtures with the acceptance of the Engineer. \*|  
The Contractor shall submit the type, quantity and manner of incorporation of \*|  
the admixtures for acceptance by the Engineer. \*|

Fine aggregate for shotcrete shall conform to ASTM C 33, except that the \*|  
maximum percentage for material passing the No. 100 sieve shall be fifteen \*|  
(15) percent. The Contractor shall require a minimum sand equivalent of sixty \*|  
(60) instead of the requirements for "Material finer than No. 200 sieve" \*|  
specified in Table I - Limits for Deleterious Substances in Fine Aggregate \*|  
for Concrete, therein.

The proportion of cement to fine aggregate shall be one (1) part of \*|  
portland cement to not more than four and a half (4-1/2) parts of fine \*|  
aggregate based on dry, loose volumes. The Contractor shall consider one (1) \*|  
sack of cement (94 pounds) to be one (1) cubic foot of loose volume. The \*|  
quantity of water incorporated shall be as specified with the process used.

**628.03 Construction Requirements.**

(A) **General.** The Contractor may use either the dry mix or the wet mix \*|  
-process of shotcreting as follows: \*|

(1) **Dry Mix Process.**

(a) The Contractor shall mix the cement and damp fine \*|  
aggregates thoroughly. \*|

(b) The Contractor shall feed the cement-fine aggregate \*|  
mixture into a special mechanical feeder (gun) or other \*|  
accepted delivery equipment. \*|

(c) The Contractor shall meter the mixture into a delivery \*|  
hose by a feed wheel or distributor. \*|

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

(e) The Contractor shall jet the mortar from the nozzle at \*  
 high velocity onto the surface that the Contractor will \*  
 shotcrete. \*

**(2) Wet Mix Process.**

(a) The Contractor shall mix the ingredients specified in \*  
 Subsection 628.03(A)(1) - Dry Mix Process including water \*  
 thoroughly. \*

(b) The Contractor shall introduce the mortar into the chamber \*  
 of the delivery equipment. \*

(c) The Contractor shall meter the mortar into the delivery \*  
 hose and convey the mortar by compressed air or other means to \*  
 a nozzle. \*

(d) The Contractor shall inject additional air at the nozzle \*  
 to increase the velocity and improve the gunning pattern. \*

(e) The Contractor shall jet the mortar from the nozzle at \*  
 high velocity onto the surface that the Contractor will \*  
 shotcrete. \*

**(B) Equipment.** The Contractor shall submit the equipment that the \*  
 Contractor will use on the project for acceptance by the Engineer. The \*  
 Contractor shall operate the equipment according to the manufacturer's \*  
 recommendations. The Contractor shall submit the manufacturer's \*  
 specifications and operating instructions to the Engineer. \*

The Contractor may do proportioning of the mortar ingredients, \*  
 except water, either volumetrically or by weighing. The Contractor shall \*  
 apply the water as specified above. The Engineer will not permit batches \*  
 requiring fractional sacks unless the Contractor weighs the cement. The \*  
 Contractor shall use the batches of the mixture within the time \*  
 requirements specified in Section 601 - Structural Concrete. \*

**(1) Dry Mix Process.** The Contractor shall mix the mixing equipment \*  
 mix the ingredients thoroughly so that the Contractor can coat the \*  
 fine aggregate particles with cement. The Contractor shall 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 three (3) to six (6) percent.

The Contractor shall discharge the fine aggregate-cement mixture into the delivery hose under close control. The Contractor shall deliver a continuous, smooth stream of uniformly mixed material at the proper velocity to the discharge nozzle. \*|

The Contractor shall equip the discharge nozzle with a manually operated water injection system (water ring) for directing an 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. \*|

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

The Contractor shall 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 line water pressure is inadequate, the Contractor shall 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. The Contractor shall follow the manufacturer's recommendations 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 628.03(B)(1) - Dry Mix Process.

(C) **Qualification.** The workers handling the nozzle employed for the work shall be competent operators with at least two (2) years of experience in this type of work. The person handling the nozzle may be an apprentice with at least six (6) months of experience. The foreman in charge shall have at least two (2) 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. The Contractor shall 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 times during the operation.

(E) **Gunning.** The Contractor shall construct the ditch lining in layers that shall not sag. The Contractor shall build each layer up by making several passes of jetted mortar over the specified surface. The Contractor shall jet the shotcrete from the nozzle in a continuous flow. If the flow become intermittent, the person handling the nozzle shall direct the flow away from the work until the flow again becomes constant.

In gunning walls, application of the mortar shall begin at the bottom. The Contractor shall build the first layer up to a thickness that shall embed the reinforcement and shall not sag. The Contractor shall remove slugs, sand spots and wet sloughs. The Contractor shall resurface the affected areas properly as the work progresses.

The Contractor shall allow each layer ample time to set. Each layer shall be free of rebound material before the Contractor applies the next layer. If final set has taken place, the Contractor shall 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.

(F) **Rebound.** The Contractor shall remove rebound. The Engineer will not allow rebound to become a part of the work.

(G) **Construction Joints.** The Contractor shall form construction joints by tapering to a thin edge over a distance of about twelve (12) inches. The Contractor shall clean the construction joint thoroughly and wet the construction joint before the subsequent application of shotcrete.

(H) **Finishing.** The surface finish of the ditch lining shall be the natural finish as applied. The Contractor shall finish the surface finish of gutters with proper floats and steel trowels. The Contractor shall round the exposed edges with an edging tool.

(I) **Preconstruction Testing.** When required by the Engineer for preconstruction testing, the Contractor shall furnish test panels at least thirty (30) inches square. The thickness should be the same as in the structure but not less than three (3) inches. Test panels shall simulate actual job conditions to mix design and shooting positions met. \*|  
 The Engineer may require that the Contractor reinforces the portions of \*|  
 test panels at the structure to check whether the Contractor gets sound \*|  
 shotcrete behind reinforcing steel. \*|

(J) **Control Testing.** When required by the Engineer, the Contractor shall furnish unreinforced test panels, at least twelve (12) inches square and three (3) inches thick. The Contractor shall make test panels \*|  
 to represent actual job conditions. \*|

**628.04 Method of Measurement.** The Engineer will measure the shotcrete by the \*|  
 cubic yard or square yard complete in place as specified in the proposal. The \*|  
 Engineer will compute the actual yardage within the neat lines and dimensions \*|  
 of the structure shown in the contract or ordered by the Engineer. |

The Engineer will measure reinforcing steel according to Section 602 - \*|  
 Reinforcing Steel.

**628.05 Basis of Payment.** The Engineer will pay for the accepted quantities \*|  
 of shotcrete at the contract unit price per cubic yard or square yard as \*|  
 specified in the proposal.

The price shall be full compensation for furnishing materials, tools, \*|  
 labors, equipment and incidentals necessary to complete the work. \*|

The Engineer will pay for the reinforcing steel according to Section \*|  
 602 - Reinforcing Steel. |

The Engineer will make payment under: \*|

-Pay Item	Pay Unit
Shotcrete for _____	Cubic Yard
Shotcrete for _____	Square Yard