

SECTION 027207
REHABILITATION OF MANHOLES AND WET WELLS
WITH SHOTCRETE AND WATERPROOFING (S-74)

1. SCOPE - SHOTCRETING

The work covered by these specifications consists of furnishing all labor, equipment, materials, and performing all operations in connection with the rehabilitation of manholes with shotcrete and waterproofing, complete in strict accordance with these specifications and the applicable drawings and subject to the terms and conditions of the contract.

1.1 Shotcrete:

1.1.1 Shotcreting shall conform to all requirements of "Specifications for Materials, Proportioning, and Application of Shotcrete (ACI-506.2-77)" published by the American Concrete Institute, Detroit, Michigan, except as modified by these specifications.

1.1.2 Steel reinforcement shall be incorporated in the shotcrete as required and shall be furnished, bent, set and placed in accordance with the provisions of these specifications.

1.1.3 The purpose of this specification is to obtain a dense and durable concrete having the specified strength.

1.2 Composition:

1.2.1 Shotcrete shall be composed of Portland Cement, aggregate and water so proportioned as to produce a concrete suitable for pneumatic application.

1.3 Strength Requirements:

1.3.1 Concrete ingredients shall be selected, proportioned in such a manner as will produce concrete which will be extremely strong, dense and resistant to weathering and abrasion. Concrete shall have a minimum 28-day strength of 4,000 psi.

1.4 Materials:

1.4.1 Portland Cement

1.4.1.1 Cement shall be Portland Cement conforming to all of the requirements of the American Society for Testing Materials Standard Specifications, Latest Serial Designation C150 for Portland Cement, Type I.

1.4.1.2 When weighed in the conventional manner, Portland Cement shall weigh not less than 94 pounds per cubic foot.

1.4.2 Fine Aggregate

1.4.2.1 Fine aggregate shall be natural siliceous sand consisting of hard, clean, strong, durable and uncoated particles, conforming to the requirements of American Society for Testing Materials Standard Specifications, Latest Serial Designation C33 for Concrete Aggregates.

1.4.2.2 Fine aggregate shall not contain less than 3% nor more than 6% of moisture.

1.4.2.3 Fine aggregate shall be evenly graded from fine to coarse and shall be within the following limits:

Passing No.	3/8 sieve	- 100%
Passing No.	4 sieve	- 95% to 100%
Passing No.	8 sieve	- 80% to 100%
Passing No.	16 sieve	- 50% to 85%
Passing No.	30 sieve	- 25% to 60%
Passing No.	50 sieve	- 10% to 30%
Passing No.	100 sieve	- 2% to 10%

1.4.3 Water

1.4.3.1 Water used in mixing at the nozzle shall be fresh, clean, and free from injurious amounts of oil, acid, alkali, vegetable, sewage and/or organic matter. Water shall be considered as weighing 8.33 pounds per gallon.

1.4.4 Reinforcement

1.4.4.1 Reinforcement bars shall conform to the latest requirements of ASTM Standard Specifications, Serial Designation A 615 for Deformed Billet Steel Bars for Concrete

Reinforcement. Unless shown otherwise on the plans, all bars shall be Grade 40.

1.4.4.2 Steel mesh reinforcement shall be electrically welded, cold drawn, mild steel fabric conforming to the latest requirements of ASTM Standard Specifications, Serial Designation A 185 for Welded Steel Wire Fabric for Concrete Reinforcement. Mesh can be fabricated from cold-drawn steel wire conforming to the requirements of the latest ASTM Standard Specifications, Serial Designation A 82. Unless otherwise shown on the plans, mesh shall be 2 x 2 - W0.9 x W0.9 galvanized welded wire fabric.

1.4.5 Storage of Materials

1.4.5.1 Cement shall be stored with adequate provisions for the prevention of absorption of moisture. It shall be stored in a manner that will permit easy access for inspection and identification of each shipment.

1.4.5.2 Aggregate shall be stockpiled at points selected to provide maximum drainage and to prevent the inclusion of any foreign material during rehandling.

1.4.5.3 On delivery to the site of the work, the steel reinforcement shall be carefully bundled, tagged and stored so the bars for any position in the work may be readily identified. All reinforcing steel shall be stored on approved material above the ground.

1.5 Sampling and Testing Cement and Aggregate

1.5.1 The Contractor shall determine the source, kind and quality of the cement and aggregates to be used in the work well in advance of the time scheduled for starting the work and, when so directed, shall submit such information for approval before starting shotcrete operations.

1.5.2 The cost of testing cement and aggregates shall be borne by the City. Certified test reports and certificates, when so directed, shall be submitted in duplicate to the Engineer and to such other agencies or persons as he may designate.

1.5.3 Where cement and aggregate suppliers maintain regular recognized testing services, certified copies of such tests shall be submitted to the Engineer. However, in any case of doubt as to the accuracy and/or adequacy of such tests, the Owner may require that cement and aggregates be tested by a recognized commercial testing laboratory which has been selected by the Contractor and approved by the Owner. The testing laboratory shall then test the cement and aggregates and prepare written reports showing the results of such tests on each shipment. The laboratory shall also certify that the materials covered by the report comply in all respects with these specifications.

1.5.4 No cement or aggregate which fails to meet the requirements of these specifications shall be incorporated into the work.

1.6 Surface Preparation

1.6.1 Unsound materials of construction and all coated, scaly, or unsound material shall be removed by chipping with pneumatic hammers and chisels to sound surface; all cracks and cavities shall be chipped to such formation that their sides form approximately a 45-degree angle to the exposed surface for at least one (1) inch in depth. All areas to receive pneumatic concrete shall be cleaned by flushing or scouring with water and compressed air jets to assure removal of all loose particles. All areas of existing surfaces shall be given a wet sandblasting with the shotcrete equipment and the air pressure at the cement gun shall not be less than 50 psi or hydroblast @ min. 6000 psi.

A caustic wash comprised of sodium hydroxide solution at a ratio of one quart of 50% Sodium Hydroxide Solution to 100 gallons of water shall be applied to all surfaces. The mixing, application, and removal of the solution shall be done with caution to avoid contact with body and in a workmanlike manner. The solution shall remain on the surface for at least 15 minutes. Once the solution has been washed completely off, the surface shall be allowed to dry before application of replacement materials.

1.6.2 To insure perfect bond, the newly chipped, sandblasted, and washed surface shall be thoroughly moistened with water prior to application of shotcrete. In no instance shall shotcrete be applied in an area where free running water exists.

1.7 Proportioning

1.7.1 Prior to start of shotcreting, the Contractor shall submit to the Engineer the recommended mix as a ratio of cement to aggregate. Recommended mix shall be on the basis of test data from prior experience and capable of producing the required 4,000 psi compressive strength. Provided data submitted is adequate, no further testing of recommended mix will be required.

1.7.2 The Contractor shall provide all equipment necessary to control the actual amounts of all materials entering into the concrete. The types of equipment and methods used for measuring materials shall be subject to approval.

1.8 Mixing

1.8.1 Shotcrete shall be thoroughly mixed by machine and then passed through a sieve to remove all large particles before placing in hopper of the cement gun. The mixture shall not be permitted to become damp. Each batch should be entirely discharged before recharging is begun. The mixer shall be cleaned thoroughly enough to remove all adherent materials from the mixing vanes and from the drum at regular intervals.

1.8.2 Water shall not be added to the mix before it enters the cement gun. Quantities of water shall be controlled by a valve at the nozzle of the gun. Water content shall be adjusted as required for proper placement, but shall in no case exceed four gallons of water per sack of cement, including the water contained in the aggregate.

1.8.3 Remixing or tempering shall not be permitted. Mixed material that has stood 45 minutes without being used shall be discarded. Rebound materials shall not be reused.

1.9 Application

1.9.1 Shotcrete shall not be placed on a frozen surface nor during freezing weather. Shotcrete shall not be placed when it is anticipated that the temperature during the following 24 hours will drop below 32 degrees Fahrenheit.

1.9.2 Sequence of application may be from bottom to top or vice versa if rebound is properly removed.

1.9.3 Corners shall be filled first. "Shooting" shall be from an angle as near perpendicular to the surface as practicable, with the nozzle held approximately 3 feet from the work (except in confined control). If the flow of material at the nozzle is not uniform and slugs, sand spots, or wet sloughs result, the nozzleman shall direct the nozzle away from the work until the faulty conditions are corrected. Such defects shall be replaced as the work progresses.

1.9.4 Shotcreting shall be suspended if:

- (1) Air velocity separates the cement from the sand at the nozzle.
- (2) Temperature approaches freezing and the newly placed shotcrete cannot be protected.

1.9.5 Shotcrete shall be applied in one or more layers to such total thickness as required to restore the area as detailed over the original lines of the adjoining surface, unless otherwise specified. All cavities, depressions, washouts, and similar failures shall be rebuilt to original lines by use of shotcrete reinforced with wire mesh; where the cavity exceeds 4 inches in depth, a layer of mesh shall be used for each 3 inches of depth of shotcrete. However, in no case shall wire mesh be placed behind existing reinforcement.

1.9.6 The time interval between successive layers in sloping, vertical or overhanging work must be sufficient to allow initial but not final set to develop. At the time the initial set is developing, the surface shall be cleaned to remove the thin film of laitance in order to provide a perfect bond with succeeding applications.

1.10 Construction Joints

1.10.1 Construction joints or day's work joints shall be sloped off to a thin, clean, regular edge, preferably at a 45-degree slope. Before placing the adjoining work, the slope portion and adjacent shotcrete shall be thoroughly cleaned as necessary, then moistened and scoured with an air jet.

1.11 Surface Finish

1.11.1 Nozzleman shall bring the shotcrete to an even plane and to well-formed corners by working up to ground wires or other guides, using somewhat lower placing velocity than normal.

1.11.2 After the body coat has been placed, the surface shall be trued with a thin-edge screed to remove high areas and expose low areas. Low areas shall be properly filled with concrete to insure a true, flat surface.

1.11.3 After the concrete surface has been trued, the entire surface shall be given a flashcoat finish unless a special type finish is specified on the drawings.

1.11.4 Thicknesses: The minimum thickness of the shotcrete shall be 1-inch over all surfaces.

1.12 Curing

1.12.1 Curing shall be in accordance with either paragraph 3.7.1(d) or paragraph 3.7.5 of ACI 506.2-77 depending upon atmospheric condition.

1.13 Adjacent Surface Protection

1.13.1 During progress of the work, where appearance is important, adjacent areas or grounds which may be permanently discolored, stained, or otherwise damaged by dust and rebound, shall be adequately protected and, if contacted, shall be cleaned by early scraping, brushing or washing as the surroundings permit.

1.14 Inspection

1.14.1 Because of the importance of workmanship affecting the quality of the shotcrete, shotcrete continual inspection during placing shall be maintained. Any imperfections discovered shall be cut out and replaced with sound material.

1.15 Equipment

1.15.1 Cement Gun

1.15.1.1 The mixing and delivering equipment shall be either the vertical double chamber type or rotary type. The upper chamber of the double chamber type shall receive and pressurize the dry mix and deliver it to the lower chamber. The lower chamber shall force the pressurized mix into the delivery hose by means of a feed wheel. The type of feeder utilized should be of sufficient capacity that the lower chamber may continuously furnish all required material to the delivery hose while the upper chamber receives the recharge. The rotary type cement gun shall have an enlarged hopper to feed material into a rotating-multiported cylinder. Material shall fall by gravity into a port which shall then be rotated to a position in which the material is expelled by air into a moving stream of air. All equipment must be kept in good

repair. The interior of drums, feed gearing and valves shall be cleaned as often as necessary (at least once every 8-hour shift) to prevent material from caking on critical parts.

15.2 Nozzle

1.15.2.1 Nozzle shall be the premixing type with perforated water feed ring inside the nozzle. The maximum length of material hose for the application of shotcrete shall be approximately 150 feet although it shall be permissible to use as much as 800 feet of material hose if the supply air pressure measured at the cement gun is increased to maintain proper velocity. The following table gives requirements for compressor size, hose size, and air pressure using 150 feet of material hose:

TABLE I

<u>Comp.Cap</u> <u>cfm</u>	<u>Max. Hose</u> <u>Dia. In.</u>	<u>Max. Size</u> <u>Nozzle In.</u>	<u>Min Air</u> <u>Press. psi</u>
365	1-5/8	1-5/8	60
600	2	2	80
750	2-1/2	1-1/2	90

For each 25 feet of material hose used in excess of 150 feet, the required air pressure shall be increased by 5 psi.

1.15.3 Air Compressor

1.15.3.1 Any standard type of compressor shall be satisfactory if it is of sufficient capacity to provide, without interruption, the pressures and volume of air necessary for the longest hose delivery. The air compressor capacity determinations shall include allowances made for the air consumed in blowing rebound, cleaning, reinforcing, and for incidental uses. Compressor equipment shall be of such capacity so as to insure air pressures at the special mixer capable of producing the required material velocities.

1.15.4 Water Supply

1.15.4.1 The water pressure at the discharge nozzle should be sufficiently greater than the operating air pressure to assure the water is intimately mixed with the other materials. If the line water pressure is inadequate, a water pump or pressurized tank shall be introduced into the line. The water pressure shall be uniformly steady (nonpulsating).

1.16 Qualifications

1.16.1 Foremen, Nozzlemen, Gunmen, Reboundmen

1.16.1.1 Before employment on the project, above workmen must satisfy the Engineer that each has done satisfactory work in similar capacities elsewhere for a sufficient period of time to be fully qualified to properly perform the work in accordance with the requirements of the related specifications.

1.16.2 Foremen

1.16.2.1 Foreman shall have had at least 4 years experience on similar work.

1.16.3 Nozzlemen

1.16.3.1 Nozzlemen shall be qualified workmen, having had at least 2 years experience in similar work, and it shall be his responsibility to:

1. Insure all surfaces to be shot and clean and free of laitance or loose material, using air and air-and-water blast from the nozzle as required.
2. Insure the operating air pressure is uniform and provides proper nozzle velocity for good compaction.
3. Regulates the water content so the mix will be plastic enough to give good compaction and a low percentage of rebound but still enough not to sag.
4. Hold the nozzle at the proper distance and as nearly normal to the surface as the type work will permit, to secure maximum compaction with minimum rebound.
5. Follow a sequence routine that will fill corners with sound shotcrete and encase reinforcement without porous material behind the steel, using the maximum practicable layer thickness.
6. Determine necessary operating procedures for placement in close quarters, extended distances or around unusual obstructions where placement velocities and mix consistency must be adjusted.
7. Direct the crew when to start and stop the flow of materials, and stop the work when material is not arriving uniformly at the nozzle.
8. Insure sand or slough pockets are cut out for replacement.
9. Bring the shotcrete to finished lines in a neat and workmanlike manner.

1.16.4 Gunman

1.16.4.1 Gunman shall operate the special pneumatic mixer and direct the work of the mixer crew. Utilizing his experience, he shall maintain proper pressure on the cement gun to insure the necessary nozzle velocity. He shall further see that the material fed to the nozzle is uniform.

2. WATERPROOFING

When indicated on drawings and upon completion of the shotcreting operations, two coats of Drycon (Grey and white), as manufactured by IPA Systems of Philadelphia, PA, shall be applied to the interior surfaces of the manholes. Minimum thickness of each coat shall be 1/16 inch. Alternate waterproofing materials shall be submitted to the Engineer for approval prior to commencing manhole rehabilitation work.

3. MEASUREMENT AND PAYMENT

Unless included in the proposal as a bid item, manhole and wetwell rehabilitation shall not be measured and paid but shall be subsidiary to other work.