



**INSTALLATION SPECIFICATION - STRUCTURE
PROTECTION AND REHABILITATION USING
CEMENTITIOUS LINING MATERIALS**



QUADEX SEWER STRUCTURE RESTORATION MATERIALS INSTALLATION SPECIFICATION FOR RESTORATION USING QUADEX REHABILITATION MATERIALS

1.0 General

These specifications are intended to set a standard of quality and design for the application of cementitious used in the rehabilitation of sanitary sewer structures.

2.0 DEFINITIONS

The term "approved" shall mean that the proposed material shall meet or exceed each of the performance criteria set forth in this specification. Manufacturers and vendors of various name brand materials must submit proof that any proposed material will meet the guidelines and requirements of this specification. Material approvals shall be made by the engineer no less than two weeks prior to bid date.

3.0 APPROVED MATERIALS

3.1 Infiltration Control

All fast setting materials furnished shall be designed to be applied in dry powder form, with no prior mixing of water, directly to active leaks under hydrostatic pressure in manholes or related structures. Materials shall consist of rapid setting cements, siliceous aggregates, and various accelerating agents. Material shall not contain chlorides, gypsum, or metallic particles. Approved infiltration control material shall be Quadex Quad-Plug as manufactured by Quadex, Inc.

A. Specifications: Infiltration Control Materials

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- a. Compressive Strength (ASTM C109)
30 mins: 1850 psi
- b. Bond Strength (ASTM C321)
28-Day: >80 psi
- c. Set Time 30 seconds

3.2 Invert Repair and Patching

All material furnished shall be designed to fill large voids in structure walls and to repair or reconstruct inverts where no hydrostatic pressure exists. Material shall consist of rapid setting cements, NSG aggregates, and various accelerating agents. Material shall not contain chlorides, gypsum, or metallic particles. Approved invert repair and patching material shall be Quadex Hyperform as manufactured by Quadex, Inc.

Approved material shall exhibit the following minimum physical properties:

- a. Compressive Strength (ASTM C109)
30 mins: >1200 psi
1 hour: >2500 psi
1 day: >4000 psi
- b. Bond Strength (ASTM C882)
28-Day: >3000 psi
- c. Shrinkage (ASTM C666)
0%

3.3 Cementitious Lining Materials

All cementitious lining materials shall be specifically designed for the rehabilitation of manholes and other related wastewater structures. Liner materials shall be cement based, poly-fiber reinforced, shrinkage compensated, and enhanced with chemical admixtures and siliceous aggregates. Liner materials shall be mixed with water per manufacturer's written specifications and applied using equipment specifically designed for either low-pressure spray or centrifugal spin casting application of cement mortars. All cement liner materials must be capable of a placement thickness of ½" to 4" in a one pass monolithic application.

A. Portland cement

Portland cement materials shall be manufactured from Type II Portland cement and enhanced with silica fume and high-density chemically stable aggregates. Materials must resist corrosion when placed in an environment capable of producing a maximum substrate pH level of 3.0. Approved material shall be Quadex QM-1s Restore as manufactured by Quadex, Inc., or "pre-approved" equal.

Approved material shall exhibit the following 28-day minimum physical properties:

- a. Compressive Strength (ASTM C109)
>10,000 psi
- b. Flexural Strength (ASTM C293)
>1,250 psi



- c. Bond Strength (ASTM C882)
>2,500 psi
- d. Permeability (AASHTO T-277)
Not to exceed 350 coulombs
- e. Freeze-Thaw (ASTM C666)
No damage in minimum 300 cycles
- f. Material Wet Density
Minimum 127 +/-5 PCF

B. Calcium Aluminate

Calcium Aluminate materials shall be manufactured from 100% pure calcium-aluminate cement and enhanced with silica fume and high-density chemically stable aggregates. Materials must resist corrosion when placed in an environment capable of producing a maximum substrate pH level of 2.0. Approved material shall be Quadex Aluminaliner as manufactured by Quadex, Inc., or "pre-approved" equal.

Approved material shall exhibit the following 28-day minimum physical properties:

- a. Compressive Strength (ASTM C109)
>9,000 psi
- b. Flexural Strength (ASTM C293)
>1,600 psi
- c. Bond Strength (ASTM C882)
>2,500 psi
- d. Permeability (AASHTO T-277)
Not to exceed 350 coulombs
- e. Freeze-Thaw (ASTM C666)
No damage in minimum 300 cycles
- f. Material Wet Density
Minimum 127 +/-5 PC

C. Calcium Aluminate

Calcium Aluminate materials shall be manufactured from 100% pure calcium-aluminate cement and enhanced with calcium aluminate aggregates. Materials must resist corrosion when placed in an environment capable of producing a maximum substrate pH level of 2.0. Approved material shall be Quadex Aluminaliner PF as manufactured by Quadex, Inc., or "pre-approved" equal.

Approved material shall exhibit the following 28-day minimum physical properties:

- a. Compressive Strength (ASTM C109)
>9,000 psi
- b. Flexural Strength (ASTM C293)
>1,600 psi
- c. Bond Strength (ASTM C882)
>2,500 psi
- d. Permeability (AASHTO T-277)
Not to exceed 350 coulombs
- e. Freeze-Thaw (ASTM C666)
No damage in minimum 300 cycles
- f. Material Wet Density
Minimum 127 +/-5 PC

4.0 CEMENTITIOUS REHABILITATION

4.1 Structure Cleaning and Preparation

The floor and interior walls of the structure shall be thoroughly cleaned and made free of all foreign materials including dirt, grit, roots, grease, sludge and all debris or material that may be attached to the wall or bottom of the manhole.

- a. High pressure water blasting with a minimum of 3500psi shall be used to clean free all foreign material within the structure.
- b. When grease and oil are present within the structure, an approved detergent or muriatic acid shall be used integrally with the high pressure cleaning water.
- c. All materials resulting from the cleaning of the structure shall be removed prior to application of the cement based coating.
- d. All loose or defective brick, grout, ledges, steps and protruding ledges shall be removed to provide an even surface prior to application of cement based coating.

4.2 Sealing Active Leaks

The work consists of hand applying a dry quick-setting cementitious mix designed to instantly stop running water or seepage in all types of concrete and masonry structures. The applicator shall apply material in accordance with manufacturer's recommendations and following specifications.



- a. The area to be repaired must be clean and free of all debris per the guidelines set forth.
- b. Once cleaned, prepare crack or hole by chipping out loose material to a minimum depth and width of ¼ inch.
- c. With gloved hand, place a generous amount of the dry quick-setting cementitious material to the active leak, with a smooth fast motion, maintaining external pressure for 30 seconds, repeat until leak is stopped.
- d. Proper application should not require any special mixing of product or special curing requirements after application.

4.3 Invert Repair and Patching

The work consists of hand mixing and applying a rapid setting, high early strength, non-shrink patching material to fill all large voids and repair inverts prior to spray lining of the structure. For manhole invert repairs, flow must be temporarily restricted by inflatable or mechanical plugs prior to cleaning.

- a. The area to be repaired must be cleaned and free of all debris per the guidelines set forth.
- b. Mix water shall be clean potable water and require no additives or admixtures for use with cementitious patching materials.
- c. Cementitious material shall be mixed in a mortar tub or 5-gallon pail with water per manufacturer's specifications. Material should be mixed in small quantities, to avoid setting prior to placement in voids or inverts.
- d. Once mixed to proper consistency, the materials shall be applied to the invert or void areas by hand or trowel. In invert applications, care should be taken to not apply excessive material in the channel, which could restrict flow. Once applied, materials should be smoothed either by hand or trowel in order to facilitate flow.
- e. Flows in inverts can be reestablished within 30 minutes of material placement.

4.4 Application of Cementitious Liner

The work consists of spray applying and/or centrifugally spin-casting a cementitious based liner to the inside of the existing structure. The necessary equipment and application methods to apply the cementitious based liner materials shall be only as approved by the material manufacturer.

- a. Material shall be mixed with water in accordance with manufacturer's specifications. Once mixed to proper consistency, the materials shall be pumped via a rotor-stator style progressive cavity pump through a material plaster hose for delivery to the appropriate and / or selected application device.
- b. Spray application of the cementitious material.
 - a. Material hose shall be coupled to a low-velocity spray application nozzle. Pumping of the material shall commence and the mortar shall be atomized by the introduction of air at the nozzle, creating a low-velocity spray pattern for material application.
 - b. Spraying shall be performed by starting at the bottom of the structure and progressing up the wall to the corbel and chimney areas.
 - c. Material shall be applied to a specified uniform minimum thickness no less than ½-inch. Material shall be applied to the bench area in such a manner as to provide for proper drainage without ponding.
- c. Centrifugal application of the cementitious material. Spin-cast unit shall be approved by the material manufacturer and be driven only by a direct current (DC) motor with a minimum speed of 2,500 rpm. Motor torque shall be sufficient to apply lining materials evenly within a minimum 8 foot diameter structure.
 - a. Material hose shall be coupled to the spin-cast unit. The spin-cast unit shall then be positioned within the center of the manhole at either the top of the manhole chimney or the lowest point corresponding to the junction of the manhole bench and walls.



- b. The spin-cast unit shall then be initialized, and pumping of the material shall commence. As the mortar begins to be centrifugally cast evenly around the interior of the structure, the rotating applicator head shall be raised and/or lowered at a controlled retrieval speed conducive to providing a uniform material thickness on the structure walls.
- c. Controlled multiple passes are then made until the specified minimum finished thickness is attained. If the procedure is interrupted for any reason, simply arrest the retrieval of the applicator head until flows are recommenced.
- d. Material thickness may be verified at any point with a depth gauge and shall be no less than a uniform ½-inch. If additional material is required at any level, the spin-cast unit shall be placed at that level and application shall recommence until that area is thickened.
- d. Material shall be applied only when the structure is in a damp state, with no visible water dripping or running over the walls.
- e. The low-velocity spray nozzle may be used in conjunction with the spin-cast unit to facilitate uniform application of the mortar material to irregularities in the contour of the structure walls and bench areas.
- f. When applying materials to open air structures, special precautions shall be taken to ensure proper curing. When recommended by the manufacturer, the contractor shall perform the following:
 - a. Prior to applying materials contractor shall subject the structure to a water spray for a minimum of 24 hours to ensure substrate is fully saturated.
 - b. Contractor shall avoid spraying portions of the structure that are subjected to direct sunlight.
 - c. When directed by the manufacturer, contractor shall apply Quadex Quad Cure curing agent to the surface of all applied and finished materials. (Calcium Aluminate cements only)
 - d. Contractor shall cover place a sheet of 4-6 mil plastic sheeting between frame and cover to prevent any moisture loss.
 - g. Troweling of materials shall begin immediately following the spray application. Initial troweling shall be in an upward motion, to compress the material into any voids within the structure walls. Precautions should be taken not to overtrowel.
 - h. Once troweling has been completed the applied liner shall be brushed to remove trowel marks and to break up the latent surface brought about by trowelling. Brushing should be in the horizontal plane and as with troweling do not over work the lining material.
 - i. Curing will take place once the structure cover has been replaced. It is important that the structure lid/ cover is replaced no more than 10 minutes after troweling is complete to avoid moisture loss in the material due to sunlight and winds. When low flow conditions exist within the structure additional measures may be required such as placing plastic sheeting underneath the lid/cover.
 - j. Material shall not be applied during freezing weather conditions. Material shall not be placed when the ambient temperature is 37 degrees Fahrenheit and falling or when the temperature is anticipated to fall below 32 degrees Fahrenheit within 24 hours.

5.0 QUALITY CONTROL – CEMENT

The quality and performance of the material and the workmanship of the applicator shall be maintained by one or more of the following measures to be determined and specified by the engineer or owner.

5.1 Visual Inspection

All structures will be visually inspected for cracks, bug holes, and unfinished surfaces.

5.2 Performance Testing

A. Vacuum Testing

All pipes entering the manhole should be plugged, taking care to securely place the plug from being drawn into the manhole. A vacuum pump apparatus shall be placed onto the manhole ring and sealed to the structure in accordance with the pump manufacturers' recommendations. A vacuum pump of ten (10) inches of mercury shall be drawn and the



vacuum pump shut off. With the pressure relief valves closed, the time shall be measured for the vacuum to drop to (9) inches. The following are minimum allowable test times for manhole acceptance at the specified vacuum drop.

Manhole Depth (Feet)	Time (Seconds)		
	48" Diameter	60" Diameter	72" Diameter
4	10	13	16
8	20	26	32
12	30	39	48
16	40	52	64
20	50	65	80
24	60	78	96

For each additional
2 ft. depth add:

5	6.5	8
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6.0 WARRANTY

Product manufacturers shall warrant all materials to be free of defects, product design, and workmanship for a period of one year from date of purchase. Manufacturer will provide replacement materials for any product proven to be defective when applied in accordance with manufacturer's recommendations. Manufacturer's obligation shall be limited solely to product replacement.

B. Material Testing

One 2 x 2 inch sample cube shall be taken for every 56 bags of material used. Samples shall be sprayed from nozzle, identified, and sent to an independent test laboratory for compression strength testing as described in ASTM C-109 and shall have a minimum average of the strengths set forth in Section 3.3.