

# Construction Specification 85—Conduit Slip-Lining

## 1. Scope

The work consists of furnishing and installing a carrier pipe in a casing and installing cellular concrete in the annular space between the carrier pipe and casing.

## 2. Material

**Admixtures** must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete. If air-entraining cement is used, use the same type of air-entraining admixture as in the cement.

**Concrete culvert pipe** must conform to the requirements of Material Specification 542, Concrete Culvert Pipe.

**Corrugated polyethylene pipe and fittings** must conform to the material requirements as outlined in Material Specification 548, Corrugated Polyethylene Pipe.

**Cushioning material** must be made from polychloroprene (neoprene) with a Shore A Durometer of 60 meeting ASTM Classification D2000 M2BC514 and be supplied with the manufacturer's or supplier's name and the Shore A hardness.

**Fly ash** must conform to the requirements of Material Specification 532, Supplementary Cementitious Materials, for the specified class.

**Foaming agents** must conform to the requirements of ASTM C869.

**Plastic pipe, fittings, and gaskets** must conform to the requirements of Material Specification 547, Plastic Pipe.

**Portland cement** must conform to the requirements of Material Specification 531, Portland Cement, for the specified type.

**Reinforced concrete pressure pipe, fittings, and accessories** must conform to the requirements of Material Specification 541, Reinforced Concrete Pressure Pipe.

**Water reducing and/or retarding admixtures** must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

**Water used for the job mix** must be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter or other deleterious substances. Potable water may be used without testing. Nonpotable water must conform to the requirements of ASTM C1602.

## 3. Terminology

The following definitions and terms apply to this specification:

**annular space**—The space between the casing and the carrier pipe.

**bulkhead**—A form, seal, or other apparatus installed to contain cellular concrete in the annular space.

**carrier pipe**—A conduit installed inside a casing for the purpose of carrying water.

**casing**—An existing pipe into which the carrier pipe is installed.

**cellular concrete**—A lightweight concrete having a homogeneous void or cell structure, made with a foaming agent, that may contain typical concrete admixtures or supplementary cementitious materials such as fly ash; synonymous with grout.

**cold weather**—The condition that exists when the air temperature is less than 40 degrees Fahrenheit for three consecutive days and the average daily temperature is not greater than 50 degrees Fahrenheit for more than one half of any 24-hour period.

**engineer**—The person responsible to the contracting officer or owner for verifying the technical adequacy of the work.

**gauge saver**—A device installed between a grout line and a pressure gauge to prevent cellular concrete from entering the gauge.

**grout line**—Equipment through which the cellular concrete is pumped to the point of deployment.

**grouting operation**—The installation of cellular concrete.

**hot weather**—Any combination of high temperatures, low relative humidity, high winds, and solar radiation that impairs the quality of freshly mixed or hardened cellular concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise resulting in detrimental results.

**inline rotor--stator mixer**—A type of high shear mixer that can be installed in a grout line and used to combine foam or a foaming additive with neat-cement grout.

**job mix**—A cellular concrete mix that has been designed to comply with this specification and has the engineer's concurrence for its specified use.

**neat-cement grout**—A mixture of Portland cement and water that may contain admixtures or a supplementary cementitious material such as fly ash.

**nonrigid pipe**—Pipe that is flexible and tends to deform when subjected to relatively low loads as compared to loads necessary to deform a rigid pipe. Examples of non-rigid pipe are plastic and corrugated plastic pipes and thin-walled corrugated metal pipe.

**prefoamed grout**—A mixture of Portland cement, water, and a foaming agent that may contain additives or a supplementary cementitious material such as fly ash.

**pumped cellular concrete**—Cellular concrete at or beyond the point of grout line discharge.

**prepumped cellular concrete**—Cellular concrete at the mixer before it is pumped through the grout line.

**rigid pipe**—Pipe that is inflexible and can support relatively large loads. Examples of rigid pipe are concrete, steel, and thick-walled corrugated metal pipe.

**slick line**—Steel tubing that is affixed to the inside wall of the casing or outside of the carrier pipe. Cellular concrete is pumped through each slick line from the downstream bulkhead to the point of deployment.

#### 4. Submittals

No later than 14 days before beginning the slip-lining operation, the contractor must furnish the engineer a written operation plan containing details of how the planned operations and materials conform to this specification. The plan must:

- explain the method for conveying the carrier pipe to the point of insertion into the casing
- describe joining the sections of carrier pipe
- describe how the carrier pipe will be slipped through the casing
- detail the bridging and blocking that will be used to maintain the specified carrier pipe grade and clearance

- explain the grouting operation including the number and diameter of slick lines, if applicable, and where they will terminate
- address the installation of bulkheads, vents, and any other materials and equipment necessary to maintain pressure and flow of the mix
- describe the mechanisms to be used for producing and conveying the job mix into the annular space

The plan must include the cellular concrete mix design containing:

- a statement of the materials, including all admixtures, and the mix proportions
- documentation that the materials and the mix meet specification requirements
- results of ASTM C232 for bleeding and ASTM C495 for compressive strength
- results of wet density tests

Include a statement documenting the experience of the contractor. The cellular foam grout must be installed by a contractor having completed a minimum of 10 cellular concrete installations that are similar in nature to that specified.

During the grouting operation, furnish the engineer a record of the mix ingredients and proportions including all admixtures. Include the time of batching and the time the load was discharged.

Report the results of onsite testing of cellular concrete density and temperature to the engineer at the time of testing.

Submit a final written report to the engineer which includes all test results. Include the time of sampling and testing with all density values. Describe all corrective actions, including but not limited to mix proportion adjustments, adjustments in foam generation, and pumping pressure in correlation with test results. Include the results of dry density and 28-day compressive strength tests made according to ASTM C495.

## **5. Design of job mix**

Proportion the mix according to recommendations of the manufacturer of the foaming admixture.

Use Portland cement and a pozzolan such as fly ash with the amount of pozzolan ranging from 25 to 50 percent of the volume of cementitious materials.

Control the water/cementitious materials ratio so that bleeding does not occur.

The job mix must have a wet density ranging from 40 to 70 pounds per cubic feet.

The job mix 28-day compressive strength must equal or exceed 200 pounds per square inch.

## **6. Preparing the casing and carrier pipe**

Clean the casing of all sediment and debris and flushed with water prior to installing the carrier pipe. The quality of the water will must be such that no residue remains in the casing after flushing. Remove all standing water from within the casing prior to grouting.

Clean the exterior surface of the carrier pipe just prior to installation, if necessary, to remove any substance that could interfere with its ability to bond to cellular concrete.

## **7. Installing the carrier pipe**

Install the carrier pipe to comply with Construction Specification 41, 42, 44, or 45, as applicable.

Join and push or pull the carrier pipe in a manner that will not damage the pipe or casing. For carrier pipe with articulating bell and spigot joints, install one-half- to three-quarter-inch thick cushioning material as described in section 2 between each bell shoulder and spigot face.

Bridge and block the carrier pipe to maintain positive grade from upstream to downstream with a minimum one inch clearance between the carrier pipe and the casing. Use wood, plastic, or metal skids and blocks configured so the flow of the job mix is not obstructed and it can fill the entire annular space. Secure blocks and skids in a manner that will not alter or damage the casing or carrier pipe and remain firmly affixed during the carrier pipe installation.

If filling the carrier pipe with water is necessary to secure the carrier pipe within the casing during grouting, water leaking into the casing will not be allowed.

Install a bulkhead at each end of the annular space to contain the cellular concrete. Install one primary and at least one backup grout nipple with working valves in the downstream bulkhead. Install slick lines as needed to control grouting pressure. The bulkheads must contain the cellular concrete for the hold period specified at the specified hold pressure.

Install a vent near the top of each bulkhead. Vents must have a diameter equal to or exceeding half the diameter of any grout line and must contain a valve, cap, or plug that does not leak.

Attach a pressure gage to the downstream bulkhead located so that it will measure grout pressure at an elevation within one foot of the lowest part of the bulkhead. Attach a pressure gage to the grout line near the outlet end of the grout line. All pressure gages must be equipped with a gage saver.

## **8. Mixers and mixing**

Cellular concrete production must comply with requirements set forth by the manufacturer of the foaming admixture and this specification.

Neat-cement grout to be used in the production of the job mix may be batched and mixed onsite or batched and mixed elsewhere and transported to the site. Use a high-speed paddle or high-shear mixer to mix the foaming agent or prefoamed grout with the neat-cement grout. A concrete drum mixer must not be used for adding foam or a foaming agent to the job mix.

If an inline rotor-stator mixer is used for incorporating prefoamed grout into the neat-cement grout, install a point of discharge with a valve just beyond the inline mixer for the purpose of sampling and measuring the prepumped wet density of the job mix.

The prepumped wet density of the job mix must not vary more than 5 pounds per cubic foot throughout the grouting operation.

## **9. Grouting**

Pump the job mix into the annular space within 90 minutes after the introduction of the cement to the mix. The operation must consistently deliver the job mix as rapidly as practical at pressures at or below the specified maximum. Maintain cellular concrete density within 40 to 70 pounds per cubic foot at all times and locations, varying no more than 5 pounds per cubic foot and remaining within 5 pounds per cubic foot of the prepumped wet density.

Pump the job mix with progressive cavity pumps, positive displacement pumps, eccentric screw pumps, eccentric cavity pumps, peristaltic pumps, or other nonpulsing pumps. Piston pumps and other pumps which subject the mix to pulsing pressures must not be used.

Control grouting pressure to avoid damage to the casing and carrier pipe. Make provisions to avoid potential dangers associated with blown lines or bulkheads or pressure induced disjoints of the casing or carrier pipe.

With both vents open, pump the job mix into a grout nipple in the downstream bulkhead. Close the downstream vent when cellular concrete begins flowing from the vent.

Cellular concrete may be conveyed the entire length of the pipe from the bulkhead provided the whole annular space is filled and the pressure at any point does not exceed the maximum pressure specified in section 13 or specified below for nonrigid carrier pipes.

For nonrigid carrier pipes, control grouting pressure as necessary to avoid deflecting or deforming the carrier pipe. Pressure must not exceed 4 pounds per square inch for nonrigid carrier pipes. Carrier pipe wall deflection must be less than one-half inch in any direction.

If the job mix cannot be deployed to the entire annular space without exceeding the specified maximum pressure or without damaging the bulkheads, carrier pipe, or casing, discharge the job mix at multiple points along the annular space. Where discharging at multiple points is necessary, begin grouting by pumping into the shortest slick line and proceeding to the next shortest slick line, repeating the process to completely fill the annular space while controlling grout pressure and avoiding damage.

With both vents, slick lines (where applicable), and all disconnected grout nipples closed, maintain 2 to 4 pounds per square inch pressure on the closed system for a minimum of 5 minutes, then close the connected grout nipple and disconnect the grout line. Leave the bulkheads in place for a minimum period of 24 hours after the hold period or until the job mix has set as determined below.

**Determining if the job mix has set**—After the annular space is completely filled, fill a watertight non-absorbent container with cellular concrete discharged from the grout line. The container must have a minimum volume of 0.2 cubic feet and minimum dimension of 6 inches. Seal the container to prevent drying or evaporation and store it on site away from sunlight. Do not store the container in an enclosed space or at a location where it is exposed to heat. The mix is set when it will not flow from the open container.

**Cold weather**—Do not pump the job mix into the annular space during cold weather unless it is insulated or otherwise prevented from freezing for a period of 24 hours after setting. The temperature of the mix must not be less than 40 degrees Fahrenheit at the time of pumping into the annular space.

**Hot weather**—In hot weather or under conditions contributing to quick stiffening of the mix, pump the mix within 45 minutes of adding the cement to the mix. The engineer may allow a longer time, provided the setting time of the mix is increased a corresponding amount by the addition of an approved set-retarding admixture. The temperature of the mix must not exceed 90 degrees Fahrenheit at the time of pumping into the annular space.

## 10. Monitoring and testing

Monitor bulkheads during the grouting operation for any signs of distress such as bulging, cracking, and leaking of cellular concrete.

Use a cylindrical container of known weight and volume to monitor the wet density of prepumped and pumped cellular concrete. The container must be at least 0.2 cubic feet in volume and made of nonabsorbent material. Tap the sides of the container by hand or rubber mallet while collecting a representative sample of cellular concrete. Overfill the container and screed excess concrete with a sawing motion using a glass, acrylic, or metal strike-off plate. Clean excess concrete from the container exterior and weigh the sample with a scale accurate to 0.1 pound. Compute and record the wet density to the nearest 0.5 pounds per cubic foot.

Test prepumped wet density at the beginning of cellular concrete production and test pumped wet density prior to connecting the grout line to any grout nipple. Test prepumped and pumped wet density at least every 30 minutes during the grouting operation, when there are visually noticeable changes in the cellular concrete, and after corrective actions to adjust the density.

Test the mix for bleeding according to ASTM C232.

Prepare strength test specimens according to ASTM C495. Obtain 6 initial strength specimens from the grout line discharge immediately prior to making the first grout nipple connection. Obtain 6 final strength test specimens immediately after the annular space has been filled. Test specimens for 28-day compressive strength and oven-dry density according to ASTM C495.

**11. Removal of temporary works**

Remove all temporary works such as the bore pit including the backstop and shoring from the site. Fill or otherwise treat the bore pit as specified in section 13.

**12. Measurement and payment**

Payment for conduit slip-lining will be made at the contract lump sum price and will constitute full compensation for all labor, equipment, materials, and all other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 13 of this specification.

**13. Items of work and construction details**