Construction Specification 54—Boring and Jacking

1. Scope
The work consists of furnishing and installing a steel casing by boring and jacking and furnishing and installing cellular concrete in the space between the steel casing and the earth.

2. Material
Admixtures must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete. If air-entraining cement is used, any additional air-entraining admixture must be of the same type as that in the cement.

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.

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

Steel casing and fittings must be new and conform to the requirements of Material Specification 554, Steel Pipe. Special fittings and appurtenances that are incorporated into the work must be of the same material as the casing. The wall thickness of the casing must be sufficient to withstand jacking pressures and preclude deformation of the casing. As a minimum, the casing wall must have a thickness of a half inch. Each end of each section of casing must be uniformly square to the axis of the casing.

Water 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. Non-potable water must conform to the requirements of ASTM C1602.

Welding electrodes must conform to the requirements of Material Specification 581, Metal.

3. Terminology
For the purpose of this specification the following definitions and terms apply:

annular space—The space between the steel casing and the earth.

Auger boring system—A boring system that includes: a track, boring machine, steel casing pipe, mechanical steering head, cutting head and augers. There are two types of auger boring systems: guided and non-guided. A guided boring system utilizes a pre-advanced pilot pipe to guide the auger.

Bi-directional steering head—A mechanical steering head capable of controlling both line and grade as the casing is being jacked through the earth.

Bore pit—An excavated pit containing the track and boring machine.

Boring machine—Equipment that provides the horizontal thrust and rotational power needed to bore and jack a casing through earth, typically mounted on rails in the bore pit.

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—A steel pipe installed by boring and jacking into which a carrier pipe will be 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—A period when the average daily ambient temperature is less than 40 degrees Fahrenheit for three consecutive days and the air temperature is not greater than 50 degrees Fahrenheit for more than half of any 24-hour period.

cutting head—A device attached to the lead auger that can protrude, sit flush, or sit within the casing.

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.

grade monitoring system—A system that allows continuous monitoring of the grade of the leading edge of a casing.

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

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 approval for its specified use.

leading edge band—A steel band affixed to the leading edge of a mechanical steering head or steel casing. The diameter of the leading edge band is slightly larger than that of the casing.

mechanical steering head—A short section of casing pipe affixed to the leading end of the casing, used to control the vertical and/or horizontal position of the leading end.

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

pre-foamed 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.

pre-pumped cellular concrete—Cellular concrete at the mixer before it is pumped through the grout line.

sonde—A device affixed to a mechanical steering head that allows for monitoring horizontal alignment.

thrust-reaction structure—A temporary structure constructed at the back of the bore pit designed to withstand large jacking forces required to push the casing pipe through the earth.

tunnel boring machine (TBM) attachment—An attachment that has a cutting head that is self-powered separate from the boring machine.

tunnel boring machine system—A boring system that includes: a track, boring machine, casing pipe, and tunnel boring machine attachment.
**wet density**—The unit weight of the job mix in its plastic state, also referred to as the as-cast density or the plastic density.

**wing cutters**—Appendages on the cutting head that will open to increase the cutting diameter when turned in one direction and close when turned in the opposite direction.

### 4. Submittals
At least 14 days before beginning the boring and jacking operation, furnish the engineer a written plan for the boring and jacking operation and a written plan for the grouting operation. Include evidence satisfactory to the engineer that the planned operations and materials conform to this specification and that the work will be performed by a contractor having experience with similar work. Boring and jacking must be conducted by an experienced contractor having bored and jacked a minimum of 2,000 feet of 42-inch or larger diameter conduit. 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.

The plans must be signed and stamped by a qualified registered professional engineer (PE) who is registered in the State where the operation will occur. The PE shall be responsible for the design and selection of materials for the casing pipe in accordance with this specification. Casing pipe must not be delivered to the site prior to acceptance of a professional engineering sealed certification of the pipe materials by the engineer.

The boring and jacking plan must address pipe materials to be installed; any investigation required to avoid buried utilities; bore pit excavation, dewatering, and shoring; equipment setup, including foundation and thrust reaction structure; planned staging and stockpile area locations; casing section lengths; and joining of casing sections. It must also include the method of monitoring and maintaining the specified casing line and grade.

The grouting operation plan must plan for complete filling of the annular space within 24 hours of casing installation. Include a cellular concrete mix design report with a statement of all materials to be incorporated into the mix, the mix proportions, and evidence that the materials and the mix meet specification requirements. Provide results of ASTM C232 for bleeding, ASTM C495 for compressive strength, and wet density as specified in section 9. Include a detailed description of the mechanisms that will be used for producing and conveying the job mix into the annular space. Address the installation of bulkheads, vents, grout nipples, and any other materials and equipment necessary to maintain pressure and flow of the mix. Include a plan for confined space entry or permit-required confined space entry, as applicable, as defined in OSHA 1910. Once approved by the engineer, the statement of materials and proportions will constitute the job mix. Any change to the job mix must be approved by the engineer.

Obtain the engineer’s concurrence prior to making a change to the boring and jacking plan or the grouting operation plan.

During the boring and jacking operation, furnish the engineer a written record of the grade of the leading edge of the casing at 20-foot intervals. When horizontal control is specified, the record must show both line and grade of the leading edge of the casing at 20-foot intervals.

During the grouting operation, furnish the engineer a batch ticket or record of the mix ingredients and proportions including all admixtures. Include the time of batching of any materials batched offsite and the time the load was discharged.

Report 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 with the record of grade and line, as applicable, of the leading edge of the casing at 20-foot intervals and all test results. Include location, date, and time of sampling and testing with all density values. Described corrective actions, including but not limited to mix proportion adjustments, adjustments in foam generation, and pumping pressure adjustments. Include the results of oven-dry density and 28-day compressive strength tests made and reported in accordance with ASTM C495.
5. **Design of job mix**

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

The mix must contain 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. **Installing the casing**

Casing installation must begin until measures are in place to ensure the grouting operation will begin immediately after the casing is installed and be completed within 24 hours.

Use an auger boring machine, tunnel boring machine, or hand tools to excavate soil as the casing is jacked through the earth. A guided-boring system must not be used. Sluicing and jetting with water as a means of soil cutting is prohibited. Bentonite slurry, drilling fluids, or other lubricants must not be used.

The bore pit must be of sufficient size to allow for a safe operation and to perform the work as specified. Use sumps or other dewatering measures to remove standing water at all times during the boring and jacking operation. Design and manage the bore pit floor and thrust-reaction structure to maintain equipment alignment throughout the operation. The floor and thrust-reaction structure must be non-yielding. All operations must comply with OSHA and all state and local safety standards. Leave the bore pit and all temporary works in place, as necessary, to install the carrier pipe after the boring and jacking operation is completed.

The outside diameter of the leading edge band must not be greater than the outside diameter of the casing plus two times the casing wall thickness.

Continuously monitor grade during the boring and jacking operation and monitor alignment when required in section 11.

Auger boring systems must be steered by a mechanical steering head. If horizontal alignment is required in section 11, employ a bi-directional steering head. Attach to the leading auger a cutting head with wing cutters that protrudes just ahead of the leading edge of the steering head.

The bore diameter must equal or exceed the outside diameter of the casing by no more than 1 inch.

Ensure each end of each section of casing is square to the casing axis. Measure the length of each section of casing to facilitate accurate monitoring of the location of the leading edge of the casing at all times throughout the boring and jacking operation.

Weld the sections of casing to conform to AWWA Standard C206 for single welded butt joints. The weld must be continuous and watertight for the full pipe circumference.

Install a pair of grout nipples in the casing at intervals not exceeding 40 feet. For each set of nipples, install one 30 degrees left and one 30 degrees right of the apex of the casing. Install a single nipple in the apex of the casing midway between pairs of nipples. Install the first and last grout nipple sets approximately 10 feet from the ends of the casing. All grout nipples must contain an operable valve, cap, or plug that will not leak when subjected to the maximum allowable grouting pressure.

Install a bulkhead at each end of the casing to contain the job mix within the annular space for the specified hold period at the specified hold pressure. Mount a pressure hose and gauge on the lowest bulkhead. Position the pressure gauge to measure grout pressure within one foot of the elevation of the bulkhead's lowest point. Provide sufficient length of pressure hose to extend the gauge beyond backfill that may be required on the bulkhead.
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 will not leak when subjected to the maximum allowable grouting pressure. Design vents to be extended above backfill that may be required on the bulkhead.

Equip all pressure gauges with a gauge saver.

7. 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 on site 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 pre-foamed grout with the neat-cement grout. A concrete drum mixer must not be used for mixing foam or a foaming agent into the job mix.

If an inline rotor—stator mixer is used for incorporating pre-foamed 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 pre-pumped wet density of the job mix.

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

8. Grouting
Begin grouting immediately after the casing installation and completely fill the annular space with cellular concrete within 24 hours. 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 pre-pumped wet density.

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

Sample cellular concrete after it has been pumped through the annular space. The initial sample must be from a grout nipple immediately upstream of the point of injection. If the sample density is within the specified limits, the grout nipple(s) at the sample location may be closed and pumping may continue without changing the point of injection. Cellular concrete may be pumped for any distance from the injection point as long as the maximum specified grouting pressure is not exceeded and the density requirements are met. Move the point of injection upstream if grouting pressure approaches the maximum specified pressure or the sampled cellular concrete fails to meet density requirements. Continue sampling and testing throughout the grouting process to verify that grout density is maintained as specified.

Control grouting pressure to alleviate any distress noted in the embankment or any leakage or signs of potential bulkhead failure. Cease grouting and immediately notify the engineer at the first sign of any distress in the embankment or bulkhead such as cracking, bulging, or leaking grout. After the engineer’s concurrence, implement measures to alleviate the distress prior to continuing the grouting operation. If a leak cannot be fixed, cease grouting until the job mix has set.

With both vents and all grout nipple valves open, begin pumping the job mix through a grout nipple in the downstream bulkhead or through a grout nipple closest to the downstream end of the casing. Monitor pressure at the connected grout nipple and at the pressure gauge located in the bulkhead. Unless otherwise specified in section 11, the maximum pressure must not exceed 4 pounds per square inch at either location. Close the downstream vent and any grout nipple valve when the mix begins flowing from the vent or valve. Ensure that each grout nipple remains open until the mix is observed flowing from the nipple. As the pressure reading at either gauge approaches the maximum allowable pressure, move the point of grout deployment upstream. If the pressure reading at either
gauge continues to be near the maximum allowable pressure, cease grouting until the in-place mix has sufficiently set so that grouting pressure is reduced by at least 1 psi below the maximum allowable pressure. Continue the process of moving the grout line discharge upstream until the mix flows from the upstream vent. Close the vent and maintain the specified pressure for the hold period.

If it is necessary to cease grouting to limit grout pressure, install a pressure gauge at the lowest grout nipple that will be subjected to fluid pressure whenever grouting resumes.

**Hold period**—With all vents and unconnected grout nipples closed, maintain 2 to 4 pounds per square inch pressure on the closed system for a minimum of 5 minutes. Continually monitor the pressure during this period to verify a minimum of 2 pounds per square inch is maintained. After the hold period, close the last grout nipple and keep all valves and bulkheads closed for a minimum period of 24 hours or until the job mix is set.

**Determining if the job mix has set**—Fill a container having a minimum volume of 0.2 cubic foot with cellular concrete discharged from the grout line. Seal the container to prevent drying or evaporation and store it away from sunlight inside the casing. The mix will have set when it will not flow from the open container.

**Cold weather**—The job mix must not be conveyed and pumped into the annular space during cold weather unless it is insulated from exposure to freezing temperatures and 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.

**9. Monitoring and testing**
Employ a sonde transmitter and locator, theodolite, or laser monitoring system if monitoring of horizontal alignment is specified in section 11.

Monitor the embankment and bulkheads during the boring and jacking and grouting operations for any signs of distress such as settlement, bulging, cracking, and leaking of cellular concrete at a bulkhead.

Use a cylindrical container of known weight and volume to monitor the wet density of pre-pumped and pumped cellular concrete. The container must be at least 0.2 cubic foot in volume and made of non-absorbent 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 pounds. Compute and record the wet density to the nearest 0.5 pound per cubic foot.

Test pre-pumped 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 pre-pumped 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 six initial strength specimens from the grout line discharge immediately prior to making the first grout nipple connection. Obtain six final strength test specimens immediately prior to making the last grout nipple connection. Test specimens for 28-day compressive strength and oven-dry density according to ASTM C495.

**10. Measurement and payment**
**Method 1**—The length of installed casing must be measured and payment made at the contract unit price for each linear foot of casing installed.
**Method 2**—Payment will be made at the contract lump sum price.

**Method 1 and 2**—Payment will constitute full compensation for all labor, equipment, materials, and all other items necessary and incidental to the completion of the work including that of the grouting operation.

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 11 of this specification.

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