



**SPECIAL PROVISIONS
FOR
TUNNEL GROUTING**

**Woodbury County
IM-NHS-029-6(257)147--03-97**

**Effective Date
March 18, 2014**

THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

120152.01 DESCRIPTION.

A. Summary.

Requirements for contact grouting, replacement grouting, compaction grouting, and consolidation grouting around tunnels.

B. References.

American Society for Testing and Materials (ASTM).

- C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete

120152.02 MATERIALS.

A. Construction Materials.

1. Portland Cement: ASTM C 150, Type I/II.
2. Bentonite: API Specification 13A, high swelling montmorillonite, capable of mixing with water to form a stable homogeneous suspension.
3. Sand: Clean, natural silica sand, graded such that all of the material passes the No. 20 sieve and not more than 20% passes the No. 200 sieve.
4. Fluidifier: A compound possessing such characteristics that it will tend to hold the solid constituents in suspension, and is compatible with the cement and water used in the mix. Fluidifier shall not contaminate the groundwater. Acceptable fluidifiers are calcium ligno-sulfonate and sodium ligno-sulfonate, that contain a shrinkage compensator.
5. Chemical Grout: Composed of base material, reactant, water, and accelerator if required.

Use a base material, catalyst, activator, inhibitor, buffer, or soluble additive that are compatible with each other and with the soil and groundwater. Use chemically stable gel that does not render surrounding groundwater nonpotable. Use a compound chemically stable within the service life of the project.

6. Water: Potable and complying with ASTM C 94.
7. Grout Mixes:
 - a. Contact grout: A cement-based grout containing between 2% and 4% bentonite with a 7 day unconfined compressive strength of at least 500 psi minimum per ASTM C 39 and shrinkage less than 5%. Add sand to the mix for voids larger than 2 inches.
 - b. Compaction Grout: A base material with the gradation of silty sand, with not less than 3 cubic feet of cement per cubic yard of grout, and water as necessary to achieve a pumpable mix with not more than a 2 inch slump with a compressive strength of at least 500 psi. Use a base material consisting of not less than 20% and not more than 30% passing the No. 200 sieve.
 - c. Consolidation Grout: Per the manufacturer's specifications for application to the ground conditions. Minimum unconfined compressive strength of grouted soil: 50 psi.
 - d. Replacement Grout: Cement based grout with a minimum compressive strength of 200 psi.

B. Grouting Equipment.

1. Use equipment for mixing and injecting grout that is suitable for grouting service, capable of satisfactorily mixing and agitating the grout and forcing it into the grout holes in a continuous flow, at the required pressures. Maintain equipment in operating condition at all times to reduce breakdowns during operations.
2. Use hose for pressure grouting having a diameter sufficient to deliver the required flow and capable of withstanding the required pressure.
3. Use a mixer or proportioning pump of a type and capacity appropriate for the grout mix being used and for the production requirements. Provide suitable meters or other devices for accurate measurement of the ingredients being mixed.
4. Provide suitable agitator tanks for the type of grout being used.
5. Provide properly designed pressure gauges with suitable range and calibration at the grout pump and on the hookup at the collar of the hole being grouted.
6. Where it is necessary to maintain pressure or to prevent unset grout from backflow or seepage from the collar of the grout injection hole, provide suitable stop valves at the collar of the hole.
7. Provide means for accurate determination of the amount of grout injected.
8. Furnish one or more accurately calibrated, high-precision pressure gauges for use in periodic checking of the accuracy of all gauges used in grouting.
9. Provide a grout plant capable of supplying, mixing, stirring, and pumping the grout at pressures up to 100 psi for contact grouting, consolidation and replacement grouting. For compaction grouting, the minimum capability of the pumping equipment shall be 1,000 psi.

10. Provide a cement grout mixer shall have two mixing tanks. Install the water supply system so that water can be metered into each tank. Water meters shall read in tenths of a cubic foot. Mixing shall be achieved by constant rapid circulation of grout. The equipment shall be such that all grout is constantly circulated or agitated between the time it is mixed and the time it is injected into the hole.
11. Arrange the cement grout mixer to discharge grout into a tank or sump fitted with a mechanical agitator.
12. At all times during grouting operations, provide functioning pressure and volume meters and gauges of suitable size and design on all grout lines and have a spare set of meters and gauges on the job site. Calibrate water meters so that one gauge division represents no more than 0.1 cubic foot. Provide calibration of all meters and gauges at least once per month or at the direction of the Engineer. No grouting shall be permitted unless these requirements are met.
13. Provide a suitable water connection on the intake of the grout pump to facilitate flushing of the system and injection of water into the grout holes.

120152.03 CONSTRUCTION.

A. Submittals.

Submit the following for each type of grouting to be performed.

1. Proposed mix proportions, data on physical and chemical properties of grout, cure times, performance record, and samples.
2. Narrative and dimensioned sketches showing grouting equipment, procedures, and sequences for each type of grouting. Include information for each structure or utility to be protected or restored. Include catalog cuts and sketches as appropriate.
3. Details of monitoring system, schedule and relationship to tunnel excavation.
4. Locations and sizes of grout holes and ports.
5. Proposed injection pressures.
6. Qualifications of grout supervisor.
7. Details of grouting equipment, facilities and assembly.
8. Submit for record: weekly records listing location, depth and diameter of each grout hole, quantity pumped in each grout hole, grout mix details (including admixtures, variations and reasons for changes), grouting pressures and rates of pumping. Maintain all records for duration of construction.

B. Definitions.

1. **Compaction Grouting:** Compaction grouting is the injection of seams or bulbs of grout into the soil under high pressure to re-compact soil loosened by construction activities.
2. **Consolidation Grouting:** Consolidation grouting is the injection of ultrafine, micro-fine cement or chemical grouts into permeable soils in order to improve their stability or to reduce their permeability.

3. **Contact Grouting:** Contact grouting is the injection of grout between the initial support and the ground or jacked carrier pipe and the ground. Grouting between carrier pipe and initial support is not backfill grouting and is specified in Special Provisions for Tunneling with Initial Support.
4. **Replacement Grouting:** Replacement grouting is the injection of grout to fill voids caused by loss of ground during construction.
5. **Backfill Grouting:** Grouting between the carrier pipe and initial support. Backfill grouting is specified in Special Provisions for Tunneling with Initial Support.
6. **Void:** Space created by overcutting or lost ground that is filled with air, water or slurry and has a volume greater than 1 cubic foot.

C. Quality Assurance.

1. Design, plan, and perform grouting by, or under the supervision of, an experienced reputable individual or firm, regularly engaged in the type of work involved for at least 3 years.
2. Demonstrate the adequacy of proposed grouting methods and equipment before work proceeds.

D. General.

1. Keep equipment and lines clean to maintain efficiency. Use grouting equipment of a suitable configuration to accomplish this.
2. Verify the locations of utilities, house connections, vaults and other buried structures before installing grout pipes.
3. Obtain all permits and permissions necessary.
4. Complete consolidation grouting prior to tunneling at appropriate receiving and jacking pit portals extending out 5 feet from the earth retaining structure and at least 2 feet around all sides of the tunnel as indicated in the plans.
5. Demonstrate to the Engineer that the consolidation grouting efforts yielded desired results as indicated in the specifications prior to commencing tunneling.

E. Contact Grouting.

1. **General.**
 - a. Contact grout outside jacked carrier pipe with a diameter of 36 inches or more within 72 hours of completion of tunneling.
 - b. Contact grout to fill and voids over 1 cubic foot in volume within 24 hours of identification.
 - c. Grout pressure at the injection point shall not exceed 0.6 psi per foot of depth unless approved by the Engineer. Monitor ground movements for heave and cease or modify grouting if movements approach or exceed specified limits.
 - d. Conduct contact grouting in such a manner as to completely displace the jacking lubricant, reconsolidate loose soils, and ensure that all voids between the ground and initial support; ground and casing pipe; or ground and jacked carrier pipe are filled with grout.

- e. Conduct contact grouting by manifold grouting using at least four separate lines pumping concurrently from one or more pumps when grouting jacked pipe. Use one or more lines when grouting initial support. Hook up all lines to adjacent grout holes. Pump the first hole to completion and leave the valve at the packer open to hold the pressure. Then pump the second hole to completion and so on until all lines have been used. At this time, disconnect the hose leading to the first packer after closing the valve and move ahead to the next grout hole in sequence and pump. Repeat this process continuously along the tunnel until grouting is complete or terminated at the end of shift.
- f. After the grouting of a hole is finished, maintain the pressure by means of a valve or other approved device until the grout has set to the extent that it will be retained in the grout hole.
- g. Remove packer and stop valve assemblies as soon as cement grout has attained its final set and no longer tends to flow or seep from the injection point.
- h. Pump grout at pressures to ensure complete filling, but without damage to initial support or pipe.
- i. Pump contact grout into all grout holes.
- j. When grouting is complete, clean out the open hole and install a watertight plug manufactured by the pipe supplier. In RCP, fill the hole to a depth of at least five inches with nonshrink grout and finish flush with the interior concrete lining.

F. Compaction Grouting.

1. General.

- a. Compaction grouting for control of surface settlements, other utilities and structures is required only if the tunneling methods do not keep settlement within limits specified in Special Provisions for Instrumentation, Monitoring and Settlement Control or acceptable limits. Unless otherwise specified, acceptable limits will keep all structures and surfaces in such relation to their undisturbed position as to avoid any damage, disturbance to drainage patterns or loss of useful life. Be prepared to perform the compaction grouting or replacement grouting if ground control procedures do not prove effective in controlling settlement.
- b. Design and monitor grout pipe installations to ensure that grout bulbs are at least four feet from the outside of the tunnel excavation. Monitor the tunnel system during grouting operations in the vicinity to ensure that excessive deflections do not occur. Cease grouting or modify pressures if movements, including heave, approach or exceed specified limits.
- c. Before work begins, coordinate the work with the owner of the structure or utility to be supported or restored to correct elevation. Notify the Engineer as to the date, time and location of any meetings so that he may attend.
- d. Maintain vehicular and pedestrian access in the vicinity of the work; restore areas affected by the work to their pre-existing condition; locate, protect, support and maintain in service without interrupting any utility, facilities, structures, equipment and chattels of the owner of any structure potentially affected by the work.

2. Method.

- a. Install grout pipes flush with existing surfaces in any public right-of-way.
- b. Maintain continuous observation of the roadway, utility, or structure to be protected as specified in Special Provisions for Instrumentation, Monitoring and Settlement Control. Begin grouting operations as soon as any deflection greater than specified or unacceptable deflection is noted.
- c. Maintain continuous observation during restoration to elevation of any roadway, structure, or utility in order to terminate and secure the work in timely fashion.
- d. Establish and maintain effective and immediate communications between the tunnel and surface monitoring crews and the grouting crew.

G. Consolidation Grouting.

1. General.

- a. Inject consolidation grout into areas shown on the plans or listed herein.
- b. Consolidation grouting is required for the full length of tunnel section for all alignments that are capable of being grouted.
- c. Perform consolidation grouting if required for face control and ground water isolation at the following times:
 - 1) Tunnels: At least 5 feet ahead of tunnel face, with a minimum of a 1 foot overlap between grouted zones that have set.
 - 2) Do not advance the tunnel into the grouted zone until the grout has set.
- d. Grout pressure at the injection point in the ground shall not exceed 0.6 psi per foot of depth unless approved by the Engineer.
- e. Consolidation grouted zones around the tunnels shall consist of a minimum 2 foot thick zone in the top 270 degrees of the tunnel.
- f. At the Contractor's discretion, use consolidation grout in areas to avoid unwanted deflections of structures and surfaces, limit or prevent runs of unconsolidated material, and to control groundwater flow.

2. Method.

- a. Install grout pipes from the pits, tunnel, or ground surface. Obtain property owner permission before installing grout pipes from the ground surface.
- b. Select the grout design for viscosity, gel time, ultimate strength of the grouted material and other factors relevant to the specific use.
- c. Grouted zone shall attain a minimum unconfined compressive strength of 50 psi before tunneling advances into the grouted zone. Drill into the grouted zone in at least three locations for each grout section and demonstrate to the Engineer that the grout has permeated and set.

H. Replacement Grouting.

1. Conduct replacement grouting to fill all voids that exist between the tunnel and other structures or the ground surface.
2. Fill void with grout as soon as practically possible.
3. Conduct replacement grouting by placing grout from the surface or from within the tunnel. Fill the void as quickly as possible, using appropriate equipment to achieve this end. Complete void filling under pressure with compaction grouting techniques to compact the adjacent soil and to minimize future settlements. Voids may have to be grouted several times to ensure proper filling and compaction of the adjacent soil.
4. After the void has been grouted, observe it until the tunnel heading has advanced sufficiently to ensure that the void does not propagate. Fill any observed enlargement of voids immediately.
5. If the void extends from the tunnel to the surface, fill the first two feet of void against the tunnel with a coarse aggregate to prevent point loadings.
6. If the void is filled from the surface, clean the work areas and adjacent work areas and restore them to their pre-existing condition immediately after grouting is finished.

I. Grout Hole Filling.

Clean out and fill grout holes with nonshrink grout and finish flush with the interior lining or initial support. Repair interior pipe lining or coating per the lining or coating manufacturer's recommendations.

J. Field Quality Control.

The Engineer may request up to ten inspection holes at no extra cost to the Contracting Authority to determine the completeness of contact grouting. Drill holes in grout through grout holes at locations selected by the Engineer. The holes shall have a minimum diameter of 1.5 inches. If a void is found, the inspection hole will be used as a grout hole. Place grout to fill the void. Holes that encounter voids will not be counted against the inspection hole allowance.

K. Testing and Inspection.

The ITL shall sample and test all cement grouts for compressive strength per the Standard Specifications. Take samples of each grouting operation daily.

L. Clean Up.

1. During grouting work, provide for proper disposal of waste and wastewater. Remove waste grout resulting from grouting operations.
2. The work will not be certified for final acceptance until the surface work areas have been cleaned and restored to their pre-existing condition or better, and the interior surface of the tunnel lining has been finished flush and properly cleaned to the satisfaction of the Engineer.

M. Abandonment of Grout Pipes.

Fill grout pipes with grout and cut ends of grout pipes one foot minimum below surrounding grade or as required by the authorities having jurisdiction.

120152.04 METHOD OF MEASUREMENT.

Tunnel Grouting will not be measured for payment.

120152.05 BASIS OF PAYMENT.

Tunnel Grouting is incidental to trenchless technique used and will not be paid for separately.