

**GUIDE
TECHNICAL SPECIFICATIONS
JET GROUTING
SOIICRETE STABILIZATION**

(This technical specification is to be used to guide the writer in the contract requirements for Soilcrete Stabilization via Jet Grouting construction for a specific site. Included are _____ to be filled in with project specific data. Also included are [] which denote options to be considered for specific design requirements. Parenthetic remarks () are included when appropriate to provide the writer with additional, non-essential information.)

(NOTE: Jet Grouting is the process of creating soilcrete in situ with stabilizing fluids or grout mix delivered at high pressure though nozzle(s) at the end of a monitor inserted into a borehole. The soilcrete is created by the erosion of the soil by the high pressure injected grout or fluids. A jet grout column is created by injecting the fluids at high pressure, rotating, and lifting the monitor a constant rate. The soil is eroded and mixed with the fluids or grout and forms cementitious grout column. Typical applications include sludge stabilization, groundwater barrier walls, soil improvement, foundation improvement, and other ground treatment.)

1.0 SCOPE OF WORK

This section of the specifications includes requirements for the Jet Grouting and related work as indicated on the drawings and as hereinafter specified. The work consists of furnishing all plant, labor, equipment, and materials and of performing all operations as required to construct the soilcrete stabilization via Jet Grouting Method.

1.1. Reference Standards

Following is a list of standards that will be referenced in this specification. Such referenced standards shall be considered part of these specifications as if fully repeated herein.

REFERENCE	TITLE OR DESCRIPTION
API Spec 13A	API Specification for Oil-Well Drilling-Fluid Materials
API RP 13B-1	API Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids
ASTM C 138	Test Method for Unit Weight of Concrete
ASTM D 422	Particle-Size Analysis of Soils
ASTM D 1140	Materials Finer than No. 200 Sieve
ASTM D 4318	Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4380	Density of Bentonite Slurries
ASTM D 5084	Hydraulic Conductivity Using a Flexible Wall Permeameter

Jet Grout Soilcrete Stabilization

1.2. Abbreviations and Definitions

A. API - American Petroleum Institute

B. ASTM - American Society for Testing and Materials

C. Owner - The Owner as referred to herein is _____.

D. Owner's Representative - The Owner's Representative or the Engineer is _____ (or individuals) designated by the Owner to act on its behalf in the execution of these specifications.

E. Jet Grouting - Jet Grouting is the process of creating soilcrete in situ with stabilizing fluids or grout mix delivered at high pressure through nozzle(s) at the end of a monitor inserted into a borehole. The soilcrete is created by the erosion of the soil by the high pressure injected grout or fluids. A jet grout column is created by injecting the fluids at high pressure, rotating, and lifting the monitor at a constant rate. The soil is eroded and mixed with the fluids or grout and forms cementitious grout column. Typical applications include sludge stabilization, groundwater barrier walls, soil improvement, foundation improvement, and other ground treatment.)

F. Soilcrete – the result from binding of the in-situ soils with a cementing agent or grout to form a blend of soils & grout to meet a specific standard of strength or permeability.

G. Monitor – A fluid drill pipe designed to deliver the elements of the Jet Grouting process. The monitor has one or more injection points. The nozzle(s) injects the fluid at high velocity into the soil to mix it with the slurry or grout.

H. Jet Grout Column – A cylindrical mass of soilcrete formed from the Jet grout Process.

I. Jet Grout Specialist - An individual who has had proven and successful experience in jet grout construction and is knowledgeable of: (1) the proper methods employed (2) the use, testing and control of the specified grout, (3) construction equipment, (5) testing for grout mixing quality control.

1.3. Submittals

the following information shall be submitted at least [4 weeks] prior to construction.

1.3.1. Qualifications of Contractor

The Contractor will designate the organization responsible for the Jet Grouting work (the Jet Grouting Contractor). This organization may be the Contractor's own company, a specialty subcontractor or an organization providing technical assistance to the Contractor to do the work. In any case, the Jet Grout Contractor shall submit evidence that it is experienced and competent to construct in-situ soilcrete via Jet Grouting. The Jet Grouting Contractor shall have at least [three] years of prior experience in successful completion of Jet grouting projects. This evidence will insure that the Contractor will have sufficient competent experienced personnel to carry out the operations specified.

In particular, a Jet Grout specialist shall supervise the construction, grout preparation, and quality control. The Jet Grout specialist shall have at least [five] years of experience and [five] or more projects in successful construction of Jet Grouting.

Jet Grout Soilcrete Stabilization

The company name, key contact, and qualifications of the Contractor's off-site laboratory shall be submitted. The laboratory will have previous experience with soilcrete materials, experienced laboratory technicians, and flexible wall permeability testing equipment.

1.3.2. Work Plan

The Contractor shall submit a detailed operating plan describing his proposed construction equipment, procedures, and schedules. This shall include, but not be limited to, the Contractor's plan for:

- A.** Coordinating the construction, maintenance and removal of working platforms, mixing pads, and haul roads with the Owner, general contractor or other contractors on site.
- B.** Equipment set-up and site use layout including storage areas, haul roads and work platform dimensions.
- C.** Equipment specifications including: capability of jet grout rig; and specifications of grout mixing equipment.
- D.** Grouting Plan outlining the spacing, location, depth, and quantity of grout to achieve the specified criteria. Grout hole locations shall be dimensionally referenced to the contract drawings. Including the geometry of the finished columns, size and overlap.
- E.** Jet Grouting Procedures- method of drilling, jet grouting (i.e. single, double, triple, jet systems). Fluid injection pressure(s), rotational speed and withdraw rate for jet grouting through the soil strata.
- F.** Material properties, sources, and (manufacturer's) certificates of quality.
- G.** Control of drainage, spills, wastes, etc.
- H.** Clean-up, spoils disposal, grout disposal
- I.** Monitoring Plan- A ground movement monitoring plan to measure vertical movements or heave/settlement of utilities, structures, and roadways in the vicinity of the jet grouting operations.

1.3.3. Quality Control Plan

The Contractor shall submit a quality control plan with details on personnel, responsibilities, inspections, and organization for insuring the quality of construction required by these specifications. The plan shall provide a table listing testing methods, frequencies, and minimum acceptable values. The plan shall explain the methods and locations for obtaining samples for testing and reporting schedules. Copies of quality control forms shall be submitted for review and approval.

1.3.4. Bar Chart Schedule and Sequence of Operations

The Contractor shall submit a detailed schedule and sequence of operations in a bar chart format. The submittal shall include a description of the schedule including typical working hours and days; sequence of operations; and maintenance schedule.

Jet Grout Soilcrete Stabilization

1.3.5. Design Mix

(This section would be included if a pre-construction laboratory design mix program is required to determine appropriate materials and material proportions for the required jet grout performance. In the case of contaminated sites, a compatibility-testing program may also be required. Sometimes this work is completed by others in advance of the project and can be provided to the Contractor)

[The following specific information shall be submitted prior to the start of jet grout operations:]

- A. [Sampling Plan. A description of the methods and locations of all samples used in the design mix testing.] (Generally, test borings and/or test pits are used to obtain soils samples. Mixing water, [leachate,] bentonite clay, and cement.)
- B. [Compatibility testing program report, including the results of chemical desiccation test, applicable permeability tests, and compressive strength testing.]
- C. [Laboratory design mix and trial mix reports, including proportions, density, bentonite or cement content, moisture content, gradations, [Atterberg limits,] and hydraulic conductivity and/or compressive strength on at least four [4] samples of the proposed design mix. (Note: laboratory testing may require two to four weeks to complete, or more depending on the number and complexity of tests required.)]
- D. [Source and properties of all materials (water, bentonite, cement, on site soils, borrow soils, and any admixtures.)]

(Due to the time and uncertainty in laboratory testing, it is often advised that the owner or Engineer subcontract this work to an experienced technical advisor early in the project schedule to avoid delays and uncertainty in construction)

1.4. Reports

the following information shall be submitted to the Engineer on a regular schedule during the progress of the work. Daily reports shall be submitted by [noon of the day following the date of the report]. Laboratory test results shall be submitted within [36 hours] of receipt of the report from the laboratory. Final reports shall be submitted within [two weeks] of the completion of work.

1.4.1. As-Built Profile

a record of column constructed including the depth, key, and location obtained each morning and evening. The information shall be used to generate an as-built column profile, as constructed.

1.4.2. Grout Mix

a record of plant-mixed grout slurry quantities, proportions, properties, and admixtures made during construction. Adjustments to the slurry mixture shall be noted.

1.4.3. Quality Control Data

A record of quality control samples, tests and test results.

2.0 MATERIALS

Jet Grout Soilcrete Stabilization

2.1 Jet Grout Slurry

The Grout Slurry shall consist of a stable homogeneous mixture of cement/bentonite in water and shall be controlled in accordance with the most current API Recommended Practice 13B-1, and the following requirements:

A. If bentonite slurry is used, the slurry shall be a mixture of not less than [2%] bentonite in water. Additional bentonite or admixtures may be required depending on the hardness and temperature of the water and the quality of the bentonite. The slurry shall have properties as described in Table 1 (Alternatively, [The Contractor may use bentonite or other additives as required to suspend cement particles and control viscosity of the mixed grout.])

B. For cement grout, properties should include a calculated design density and a planned viscosity

2.2 Bentonite

Bentonite used in preparing slurry shall be pulverized (powder or granular) premium grade sodium-cation montmorillonite and shall meet the most current API Standard 13A, Section 4. The yield of the bentonite shall be [90] barrels per ton.

2.3 Cement

Cement used in preparing grout shall conform to ASTM C150, Portland Type I or II or ASTM C989, Ground Granular Blast Furnace Slag or a mixture of both.

2.4 Water

Fresh water, free of excessive amounts of deleterious substances that adversely affect the properties of the grout shall be used to manufacture grout/ slurry. The water shall be potable, clean and free from sewage, oil, acid, alkali, salts and organic materials. It is the responsibility of the Contractor that the grout/slurry resulting from the water shall always meet the standards of this specification.

2.5 Admixtures

For Bentonite Slurry, admixtures of the type used in the control of oil-field drilling slurries such as softening agents, dispersants, retarder or plugging or bridging agents may be added to the water or the slurry to permit efficient use of bentonite and proper workability of the slurry. The Engineer shall be advised of all additives used.

3.0 Jet Grouting

A. Jet Grouting shall be performed in accordance with the approved grout injection area layout scheme to achieve the following acceptance criteria in the in situ soil within the work area:

B. Use the same equipment, materials, and procedures as those determined in the test program to give satisfactory results to perform production Jet Grouting for underpinning and excavation support.

Jet Grout Soilcrete Stabilization

C. Install soilcrete columns, ensuring that continuous spoil return up the borehole annulus is achieved during all work.

3.1 [Test Section]

Construct a test section evaluate the contractor's proposed methods and the grout mix's ability to produce soilcrete columns meeting the depth, diameter, overlapping and material property requirements shown and specified herein. Construct the test section of the jet-grouted soilcrete columns/panels in a location near the proposed Jet Grouting area approved by the Engineer, prior to starting Jet Grouting production work at the site.

The effectiveness of the Jet Grouting will be verified as follows:

The Owner may retain a soil testing firm or ask the Jet Grouting contractor to perform the in situ testing as directed by the Owner's engineer. Test sections will be performed before and during production work, as follows:

A. Test section locations will be agreed upon and located within the treatment area. A test section shall consist of a single module comprised of at least three grout injection points. Tests will be performed at the center of the module prior to and after grouting. Spacing and diameter of elements shall be proposed by the Jet Grouting contractor.

B. All testing to determine specification compliance will be provided by an independent testing agency retained by the Owner. Regardless of the method selected, the same test method shall be utilized both before and after the soil improvement work in order to provide the most accurate assessment of the degree of improvement obtained.

C. The method of installation of the test section shall comply with this specification and shall be performed using the same grout line sizes, drilling and grouting equipment and procedures as that to be used for production work.

D. Prior to commencement of production grouting, _____ test sections shall be performed. If the pre-production test sections indicate that the required ground improvement has not been achieved, the grouting contractor shall revise the procedures in the Work Plan and re-test.

4.0 EQUIPMENT

4.1 General

A. All equipment used for drilling boreholes; lowering, raising and rotating jet monitors; mixing grout; supplying pressurized grout and air-water to jet monitors; and jet monitors used to perform the seepage barrier shall have proven performance records for use in Jet Grouting work.

B. Spare parts and equipment shall be available on site to maintain Jet Grouting equipment in satisfactory operation condition at all times during execution of the Jet Grouting work.

4.2 Drilling equipment

Use drilling equipment of a type and capacity suitable for drilling required hole diameters and depths, and lowering, raising, and rotating jet grout monitors to the depths and at the rates required to perform the work as shown on the Contract Drawings and as specified herein.

4.3 Jet Grouting Monitors

Jet Grout Soilcrete Stabilization

Use Jet Grouting monitors having capacity suitable for producing soilcrete columns in the work site soil types identified in the Geotechnical Reports, and of the size and depth shown on the Contract Drawings and as specified herein.

4.3 Batching Plant

The grout/slurry batching plant shall include the necessary equipment including a high shear mixer capable of producing homogeneous mixtures of cement/bentonite in water, pumps, valves, hoses, supply lines, and all other equipment as required to adequately supply slurry to the jet grout rig. All grout/slurry for use shall be prepared using a suitable mixer. Mixing of water and cement/bentonite shall continue until the resulting grout/slurry is homogeneous.

5.0 EXECUTION OF THE WORK

5.1 General Requirements

A. Jet Grouting may consist of a single jet (grout injection only), double jet (grout air injection, or triple jet (water, air and grout injection) systems. Any of these systems will be acceptable, providing the performance requirements of these Specifications are met.

B. The jet grouting operations for installation of trial columns and production columns must conform to the approved Jet Grouting Plan.

C. The Contractor shall familiarize himself with sites, in particular, with location of the above ground utilities (e.g., overhead telephone and power lines) that might affect his operations. Due to the high concentration of utilities at the Project site, it is anticipated that that Contractor will be required to install a significant number of the jet grout columns at an angle to avoid conflicts with utilities.

D. Expose all near-surface utilities in the vicinity of their jet grouting operations to ensure that the drill-rig does not penetrate these utilities.

E. Maintain good control of the jet grouting process in regard to spoil return so as to minimize or eliminate ground heave.

F. At all times during and at completion of jet grouting operations, the site shall be thoroughly cleaned of all debris, water, return floe and spilled material. The contractor shall dispose of all such waste materials in a manner acceptable to all agencies having jurisdiction.

G. Prevent any and all material from entering storm drains or other drainage courses, or leaving the site via runoff.

H. Comply with applicable requirements of all regulatory authorities having jurisdiction.

I. Comply with the traffic maintenance requirements.

5.2 Jet Grouting

A. Jet grout columns shall be installed at locations where jet grouting is indicated on the Drawings (i.e. jet grouting area) to create a fully grouted zone meeting the performance requirements.

Jet Grout Soilcrete Stabilization

B. Create soilcrete columns by jet grouting process from the bottom to the top of the grout area as shown on the Drawings. The bottom of the jet grout area is defined. The top of the jet grout area is to be determined by the Contractor, meeting the approval of the Engineer.

C. Grouting for an individual jet grout column shall be continuous and without interruption

6.0 CLEAN-UP

At completion of daily Jet Grouting operations, thoroughly clean site and dispose of all spoil debris, water, and spilled material. Spoil stockpiling overnight is permitted prior to transfer to a predetermined waste or fill location

8.0 QUALITY CONTROL

The Contractor shall maintain his own quality control for the cutoff wall construction under the direction of a qualified geotechnical engineer. Testing requirements are specified herein.

8.1 Jet Grouting Operations

Monitoring and logging of Jet Grouting operations for both test areas and production work shall be done by the Field Quality Control Representative

Any jet grout hole lost or damaged as the result of mechanical failure of equipment, inadequacy of grout or water supplies, or improper drilling or injection procedures shall be backfilled with cement grout and replaced by another hole, drilled and injected by the Contractor at no additional cost to the Owner.

Grout injection and monitor rotation and extraction rates shall be sufficient to produce grout columns meeting the diameter, depth, overlap, and material property requirements specified herein.

Proportion and inject grout mix so that the soilcrete column produced meets the requirements listed in Table 1

Equipment for mixing, holding, and pumping grout shall be in a secure location and shall be operated to minimize spillage of material. No material will be allowed to enter storm drains or other drainage courses.

Daily records shall be maintained by the grouting contractor and submitted to the Owner's representative.

Ensure continuous spoil return during all Jet Grouting operations. The grouting contractor will monitor nearby structures and utilities.

8.2 Materials

A. Bentonite: Certificate of Compliance with the specification shall be obtained from the manufacturer for each shipment of bentonite delivered to the site.

B. Cement: Certificate of Compliance with the specification shall be obtained from the

Jet Grout Soilcrete Stabilization

manufacturer for each shipment of bentonite delivered to the site.

C. Water: Water for slurry mixing shall be tested once each [change in water source].

D. Fresh Slurry: A complete series of tests shall be conducted from the mixer or tank containing fresh grout slurry ready for introduction in the trench at least twice per shift

8.3 Field Testing

(Either or both types of QC sampling may be used.)

A. Coring Sample Method- Perform continuous coring of the jet grouted mass at [4] locations. The core holes shall be drilled from the surface after the jet grout had had sufficient opportunity to set. Backfill core holes with cementitious, non-shrink grout upon completion. The exact locations of the core holes will be determined by the Engineer in the field.

B. Wet Sample Method- Wet samples of the in-situ soilcrete materials shall be obtained with the in-situ sampler. The samples shall be taken prior to the soilcrete being allowed to cure in-situ. The wet samples shall be placed in molds (ASTM D4832) and allowed to cure. Note the location, depth, and column of wet sample. Wet samples will be obtained for every [1000] lin ft of column formed

The following requirements apply to both types of samples:

1. The soilcrete samples shall be placed in boxes and properly labeled to indicate the depth and columns from which the sample originates.
2. The samples shall be wrapped in plastic film (e.g., clear plastic wrap) to prevent moisture loss.
3. The samples shall be stored in a cool, dry location (preferably in a climate controlled trailer on site the day that they drilled). Wet samples shall be stored in moisture controlled atmosphere to be allowed to cure and stabilize for shipping to a laboratory for testing.
4. The samples shall not be allowed to freeze.
5. The Contractor will make the samples accessible to the engineer for viewing.
6. The Engineer reserves the right to select a small amount of samples for compressive strength testing.

Strength by wet sampling/cast molds to meet the requirements listed in Table 1

Strength by core sampling to meet the requirements listed in Table 1

8.4 Quality Control Testing Equipment

A. The field laboratory shall be equipped with the following equipment, at a minimum:

1. Marsh funnel and cup – 2 sets
2. Mud balance – 2 sets
4. pH tape – 1 set

Jet Grout Soilcrete Stabilization

B. A qualified off-site laboratory shall be engaged to perform the tests listed below. Samples shall be delivered to the laboratory on an expedited schedule and test results shall be reported the same week as the samples are received.

1. Permeability of Jet-grouted materials by ASTM D5084
2. Unconfined Compressive Strength by ASTM 1633

8.5 Permeability Measurements

Flexible wall permeability tests shall be conducted on samples of the backfill to determine compliance with these specifications. Samples of the SB backfill shall be obtained [from the mixing area] and sent to the off site laboratory for testing. The test parameters shall be as follows:

- A. Average Effective Confining Stress = [10] psi.
- B. Hydraulic Gradient = [<30]
- C. Permeate = [site groundwater]

[Permeability tests may also be performed on site, using an approved fixed wall apparatus. The fixed wall test is a filter press modified to operate at 1 to 10 psi. Test results from the fixed wall test must be reduced by a factor to be equivalent to flexible wall tests. The fixed wall tests must be compared to flexible wall tests performed during the pre-construction design mix to determine appropriate testing time and test parameters as well the reduction factor. Fixed wall tests may be performed except that for every 5 fixed wall tests, at least one flexible wall test shall be performed.]

8.6 Documentation

Results of all tests performed shall be recorded on forms acceptable to the Engineer and signed by the Jet Grout Specialist. These forms will be available to the Engineer at all times for his inspection. Copies of all quality control documents will be submitted daily to the Engineer for his verification.

An as-built profile drawing shall be continuously maintained by the Contractor. The profile shall indicate the extent of treatment at the end of each working day. The daily profile shall be drawn in an electronic format or by hand, as directed by the Engineer.

9.0 MEASUREMENT AND PAYMENT

Payment for the Jet Grouting shall be made at the contract price. Such price shall include all costs for the construction and completion of the jet grouting. No separate payment will be made for materials, equipment, slurry, records or quality control. Final acceptance of the treatment area will be based on meeting all the requirements of the grout injection locations and installation under the Contractor-proposed grout injection point layout scheme, and any required secondary grouting within the limits indicated as requiring Jet Grouting on _____ drawing nos _____ .

1. Jet Grouting:

Jet Grout Soilcrete Stabilization

- a. Mobilization: A lump sum payment as noted below will be made to the Contractor upon mobilization of the jet grouting equipment to the jet grouting area indicated on the Drawings, with the approval of the Engineer. Mobilization will be considered to be complete once the jet grout column has been installed.
- b. Drill Holes: measurement for payment will be made for the length of hole drilled from the ground surface to the depth of the bottom of the hole.
- c. Jet grout columns: measurement for payment will be made for the length from the depth where jetting commences to the depth where jetting is terminated.
- d. Coring of jet grout columns: measurement for payment will be made for the length of jet grout column cored exclusive of any drilling in the soil above the jet grout columns.