

# TECHNICAL SPECIFICATIONS SHALLOW SOIL MIXING CONSTRUCTION

## (In-Place Wall, In-Situ Stabilization, In-Situ Fixation, pH Adjustment of Soil)

(This technical specification is to be used to guide the writer in the contract requirements for Shallow Soil Mixing (SSM) 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. Optional subsections are denoted by \*. Parenthetic remarks ( ) are included when appropriate to provide the writer with additional, nonessential information. Most [ ] and \* are used to include SSM designs which go beyond the standard design and may include addition of proprietary additives, injection of air for vapor phase extraction of organics. All [ ], ( ), and \* should be filled in or omitted from the writer's specification.)

### SCOPE OF WORK

This section of the specifications includes the minimum requirements for the SSM (in-situ stabilization, in-situ fixation, pH adjustment of soil) and related work as indicated on the drawings and as hereinafter specified. The work consists of furnishing all plant, labor, equipment, and materials and performing all operations as required to construct the SSM (in-place wall, in-situ stabilization treatment, in-situ fixation).

### Reference Standards

Following is a list of Standards which will be referenced in this Specification.. Such referenced Standards shall be considered part of these Specifications as if fully repeated herein.

<u>REFERENCE</u>	<u>TITLE OF DESCRIPTION</u>
ASTM C 39 (UCS)	Unconfined Compressive Strength
ASTM C 150	Portland Cement
ASTM D 5084	Permeability
ASTM D 4380	Density

## Definitions and Abbreviations

### ASTM - American Standards of Testing Materials

Grout - a stable colloidal mixture of water and Type I Portland Cement. (Type of cement may be specified if other than Type I.) [Additional materials such as, bentonite, clay, attapulgite clay, lime, dilute acids, fly ash retarding agents and quick setting agents may be added.]

Owner - The Owner referenced herein is  
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Owners' Representative - A person or firm designated in the contract to act on behalf of the Owner in the execution of these specifications.

Shallow Soil Mixing - A soil improvement technique used to construct in-place walls or to treat soils in-situ to maximum depth of 30 feet. This is accomplished with a series of overlapping stabilized soil columns (typically 4-12 ft. in diameter). The stabilized soil columns are formed by a crane mounted drill attachment which turns a single shaft large diameter auger head which consists of two or more cutting edges and mixing blades. As the auger head is advanced into the soil, grout is pumped through hollow drill shaft and injected into the soil at the pilot bit. The cutting edges and mixing blades blend the soil and grout with a shearing motion. When the design depth is reached the auger head is raised to expose the mixing blades at the surface and then allowed to readvance to the bottom.

Once the shaft is completed, another column is drilled using a specified pattern of overlapping columns so what is left behind is a series of interlinked columns having the following (property/properties): improved bearing capacity, or shear strength, immobilized contaminants, neutralized soil and when reinforced, able to withstand differential soil and hydrostatic loading.

Work Area - A relatively level and stable surface of compacted fill and/or excavated earth from which the SSM unit can begin work from.

### Qualifications of Contractor

- A. Six jobs soil mixing (SSM).
- B. Three jobs soil mixing environmental (SSM).

In particular, a SSM specialist shall be submitted and approved by the Owners' Representative to supervise the construction, and quality control. The name

and qualifications of the contractor (or specialty subcontractor) shall be submitted with the bid.

### SSM [In-Place Wall, etc.]

The SSM [In-Place Wall, etc.] shall be constructed to the lines and grades and cross sections as indicated on the drawings. The SSM shall have essentially vertical columns having a nominal width of \_\_\_\_\_ feet and shall extend through the over burden to a minimum specified depth of \_\_\_\_\_ feet. The completed SSM [In-Place Wall, etc.] shall be a homogeneous mixture of grout and the \_\_\_\_\_ types of in-situ soils. Mixing is to be accomplished by the number of shaft revolutions, penetration rate and the amount of grout injected. [A \_\_\_\_\_ description of overburden through which the SSM [In-Place Wall, etc.] is to be drilled is presented in the boring logs listed in Appendix \_\_\_\_\_ ].

## **SUBMITTALS**

### Qualifications

The contractor shall be a specialist in the construction of SSM [In-Place Walls, etc.].

The contractor shall submit evidence and references of similar projects. Project descriptions shall include depth, width, and length of the area as well as a description of the type of reagents used for the construction, soil conditions and any difficulties encountered in construction. (Project descriptions should be submitted with the bid.)

The SSM Superintendent shall be knowledgeable and experienced in soil improvement waste stabilization construction using SSM techniques. This experience shall include, but not necessarily be limited to: 1) the use and control of SSM advancement and injection of grout in SSM construction; 2) methods required to properly mix the grout (and additives, as required); 3) laying out the proper shaft drilling patterns; 4) knowledge of construction equipment and material; and 5) routine field quality assurance/quality control testing.

The Superintendent shall control the mixing of the grout, SSM rate of advancement and the grout injection rate. The Superintendent shall supervise and ensure that the SSM shafts have been properly mixed and interconnected. The credentials of the SSM Superintendent shall be submitted at least one week prior to the start of the SSM [In-Place Wall, etc.] construction.

### Work Plan

The contractor shall submit a preconstruction work plan for approval by the Owners' Representative at least \_\_\_\_ days prior to the start of work under this section. The work plan shall include the following items:

**Schedule:** A schedule in sufficient detail to identify the major segments of the work. Starting and ending dates for all major work items shall be clearly identified.

**SSM Construction Method:** A detailed description of the methods of construction which shall include the column construction methods, grout mixing and monitoring, rate of advancement, percent overlap of shafts and the minimum gallons [based on proposed cement to water ratio] of grout per shaft.

**Equipment:** A list of major equipment by type and capacity which shall include crane, grout mixer, drilling attachment, auger [diameter] support, and transport equipment.

### Quality Control

The quality control plan shall be submitted along with the work plan.

The plan shall include a list of test methods and minimum standards with which to gauge the quality of the work during construction including grout density, depth measurements, densities of mixed materials, penetrometer testing of mixed materials and UCS testing.

The plan shall address the physical properties and manufacturers stated properties for all permanent materials including manufacturer's certifications of quality, mill certificates, gradation test data, etc.

The plan shall state when all quality control data will be submitted to the Owner and the correction procedures to be employed in the case of substandard results.

## **MATERIALS REQUIREMENTS**

### Grout

The material added to the soil will be water based grout. The purpose of the grout is to 1) assist in loosening the soil for penetration and mixing, 2) (lower permeability, aid in structural support, treat in-situ soils, fixate in-situ contaminants). The grout will be premixed in batch or continuous mix plants which combine materials in predetermined proportions.

## Water

Fresh water, free of excessive amounts of deleterious substances that adversely affect the properties of the grout shall be used to manufacture grout. Potential water sources shall be tested prior to or during the pilot study by the contractor prior to beginning the SSM construction to assure that the water is of suitable characteristics for grout preparation. It is the responsibility of the contractor that the grout resulting from the water shall always meet the standard of this Specification. (If the Owner has an onsite water source, information as to the available gpm of the source, location of source and the chemical characteristics of the water (i.e., pH, chlorides, hardness, total organic carbon (TOC) should be provided).

## Cement

Cement used in preparing a grout shall conform to ASTM Designation C-150 "Requirements for Portland Type I-II Cement". The cement shall be adequately protected from moisture and contamination while in transit. Cement shall be stored in a silo or other appropriate bulk storage container, storage of cement in bags is not acceptable. Reclaimed cement or cement containing lumps or deleterious matter shall not be used.

## Bentonite [Optional]

[Bentonite used in preparing slurry shall be pulverized (powder or granular) premium grade sodium cation montmorillonite.]

## Additives [Optional]

[Admixtures of softening agents, dispersants, retarders or plugging or bridging agents may be added to the water or the grout to permit efficient use of materials and proper workability of the grout. However, no additives shall be used except as approved by the Owners' Representative.]

## Proprietary Chemicals [Optional]

[Shall be approved by the Owners' Representative based on initial bench scale testing.]

## **EQUIPMENT**

### General

The Contractor shall furnish the necessary plant and equipment for construction of the facilities shown on the contract documents. The equipment shall be of the type and capacity to complete the work in an efficient manner and shall be maintained in operable condition at all times.

### Grout Mixing Plant

The Contractor shall provide a grout mixing plant containing the necessary equipment for preparing the grout including a high-shear/high speed colloidal mixer capable of producing a stable grout mixture. Pumps, valves, volumetric feeders, flow controllers/meter, hoses and other equipment shall be provided as required to adequately supply grout to the SSM equipment.

Dry materials used in the grout mixing shall be stored in silos and fed via a calibrated rotary valve [screw feeder] to the colloidal mixer(s) for agitation and circulation.

The precise arrangements and sequence of mixing shall be based on the results of the design mix program. Other dry ingredient proportions shall be batch or continuously mixed by weight to a predetermined final density. A maximum holding time of three hours will be enforced for the grout.

Calibration of mixing components shall be done at the beginning of the project and monthly thereafter. The screw feeders or rotary valve shall be calibrated against time to deliver a predetermined weight. Water shall be controlled by flow meter and/or by the volume level indicators in the colloidal mixer. The specific gravity of the grout shall be determined during the design mix program for double checking grout proportions. Grout volumes from the mixing plant shall be monitored by a flow meter capable of measuring liquids, containing high solids or other acceptable method.

### SSM

The SSM rig shall consist of a single shaft auger head capable of creating a column with a minimum thickness of \_\_\_\_\_ feet and achieving a maximum depth of \_\_\_\_\_. The auger head shall have a bottom discharge capability for grout. The cutting blades and mixing blades shall be configured so that they are capable of blending in-situ soils and grout into a homogeneous mixture.

The power source for driving the mixing shafts shall be sufficient to maintain required RPM and penetration rate from a stopped position at the depth specified.

## Environmental Control Equipment [Optional]

[Environmental control equipment shall consist of the following: bag houses, hoods, large diameter casings, activated carbon canisters and/or vapor condensers to regulate and reduce the amount of potentially toxic emissions while drilling.]

## **EXECUTION OF WORK**

### General

The SSM [In-Place Wall, etc.] shall be constructed to the elevations, lines, grades and cross sections shown on the drawings and in accordance with these specifications unless otherwise directed by the Owners' Representative.

### Horizontal Alignment

The SSM [In-Place Wall, etc.] shall be carefully staked out prior to beginning construction. The SSM [In-Place Wall, etc.] is advanced by overlapping and alternating primary and secondary shifts so that there are no areas left untreated or unstabilized. Placement of shafts shall be controlled by the use of a template or other approved means to gage the distance between shafts. The shaft locations shall be set according to surveyed reference points.

### Vertical Alignment

Maintaining verticality will be accomplished by observing the angle of the Kelly bar as it advances downward.

### Mixing Shaft Speed

The mixing shaft speed (RPMs) shall be adjusted to accommodate a constant rate of mixing and shaft penetration based on the degree of drilling difficulty.

### Penetration Rate

The penetration rate shall be adequate to ensure proper mixing and achieve the projected production rates.

## Grout Take

The grout take (or injection rate) per vertical foot of column will be adjusted to the requirements of the design mix. Positive displacement pumps will be used to transfer the grout from the mix plant to the SSM rig.

The rate of application may be controlled and monitored by any of the following three methods. First, the positive displacement grout pumps will be calibrated according to real site conditions to produce a time vs. flow correlation. By adjusting the pump output to the penetration rate a present grout take can be achieved. Second, the transfer pumps will deliver grout to the SSM rig where a return line can be adjusted to bleed off any overflow back to the overflowed plant. Third, Flow Meter controller. Typically, the application rate can be successfully controlled by experienced operators once the pattern of operation is established.

Generally, the injection rate will be 100 percent while the auger is moving downward.

Inevitably some variations of the grout take will occasionally occur to the field conditions. However, the overall minimum application rate to each shaft can be monitored, calculated and controlled. Additional mixing will be used when necessary to evenly distribute the grout through the entire column. The injection of grout to each column will be monitored, checked by calculation and recorded.

## Obstruction/Mixing Shaft Refusal

If obstructions including, but not limited to, boulder(s) or timber, old drums are encountered which effectively stops the penetration of the auger, the column shall be completed in accordance with the specifications and remedial measures will be taken at the Owners' account.

## Soil Mixing Structural Requirements [Optional]

[The soil mix shall achieve the following minimum structural characteristics:

1. Unconfined Compressive Strength (UCS) of \_\_\_\_\_ at 7 days and \_\_\_\_\_ at 28 days.]

## Remixing [Optional]

[In the event the soil mix has not achieved the specified structural requirements at 7 days, the Contractor shall determine if site conditions have changed.]

## **QUALITY CONTROL**

The contractor shall be responsible to ensure that all work is performed to the standards established, herein, subject to review and inspection by the Owner. All quality control records, routine tests, observations, and measurements shall be available for inspection by the Owners' Representative. The Owner shall bear the cost of all specified tests.

### Preconstruction Design Mix

Prior to construction, a mix design program shall be conducted to determine the design mix ingredients, sequence of mixing, grout properties and soil mix properties. The basic guiding principal for the laboratory mix program is to strive to accurately model expected field results. [Appendix \_\_\_\_\_ presents the results of a mix design study performed for the representative soil types found at the site. Presentation of the data from this study in no way relieves the Contractor of the responsibility to verify to his satisfaction that the results are accurate.]

### Submittals

The Contractor shall make timely submittals of all information required by Section 2.0 to the Owners' Representative. The Owner may review and approve these submittals.

### Materials

The Contractor shall submit data, tests, manufacturers' certificates, etc. to document the compliance of all materials to these specifications.

**Cement:** The supplier shall provide a certificate which compiles with ASTM C 150 for each truckload of material delivered to the site.

**Water:** The water shall be tested for those parameters listed in Section 3.2 prior to construction to confirm that it is suitable for use in the SSM construction.

**Grout:** Based on the mix design program, field testing of the grout properties shall be submitted for approval. Grout control may be performed by one or a combination of the following tests:

- Unit Weight by Mud Balance Method.

### Mixed Soil [Waste]

**Sampling -** Samples of the mixed soil [waste] will be taken each day, one set per shift. These samples shall be taken with a special sampling tool at the

bottom and middle of the shaft; and a third sample shall be collected at the top, immediately following installation. Sufficient sample shall be collected at each depth to make up three molds. The soil [waste] mix shall be placed in suitable molds, rodded to remove trapped air pockets and then placed in a plastic bag that contains sufficient moisture to keep the mixture damp. [After the initial set, a dead weight load may be imposed on the sample to model the stress from earth pressures.]

Laboratory Testing - Samples shall be transported to an independent geotechnical laboratory for testing once the samples have sufficient strength so as to not adversely affect the properties. At the end of seven days, curing one sample from each shift's daily production shall be tested for the following:

1. Unconfined Compressive Strength, ASTM C-39

At the end of twenty-eight days a second sample shall be selected for testing using the same list of tests above. All test results shall be reported to the Owners' Representative as soon as they become available from the laboratory.

#### SSM [In-Place Wall, etc.] Measurement

The Contractor shall make measurements of each column depth at the completion of the mixing. All measurements shall be taken from the tip of the cutting teeth to a predetermined set of marks on the auger shaft/Kelly bar. The Contractor shall maintain onsite an as-built profile of the SSM area.

#### Records

The Contractor shall maintain records for all testing, measurements, observations, and inspections. Quality Control Reports shall be submitted to the Owners' Representative each day [or at the end of each shift] on a form acceptable to the Owner. These reports shall list all test results, measurements, and observations made and/or received by the Contractor for that day.

#### Owner Quality Control

The Owner reserves the right to perform additional tests, using his own forces, on the SSM area. The Owner's testing will in no way relieve the Contractor of the responsibility to perform the tests as specified in the above sections and to meet this specification.

## **MEASUREMENT**

The SSM [In-Place Wall, etc.] area shall be measured by the effective column surface area times the depth of the column (cubic yards). All measurements shall be approved by the Owners' Representative daily.

## **PAYMENT**

Payment for the SSM [In-Place Wall, etc.] shall be made at the contract unit prices for the SSM area. The price shall include all costs for mixing of the grout and soil, quality assurance testing, record keeping, and daily cleanup. No separate payment will be made for other items incidental to the construction.