

SECTION 02203

IN-SITU SOIL MIXING SOLIDIFICATION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Specified:

1. The Contractor shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to solidify soils in-place using the soil mixing method.
2. Implement soil mixing program in accordance with this Section.

B. Related Work Specified Elsewhere:

1. Section 02201, Earthwork.

1.02 APPLICABLE CODES, STANDARDS, AND SPECIFICATIONS

A. American Petroleum Institute (API):

1. 13A, Specification for Drilling Fluids Materials.

B. ASTM International (ASTM):

1. C150/C150M, Standard Specification for Portland Cement.
2. C989/C989M, Standard Specification for Slag Cement for Use in Concrete and Mortars.
3. D1632, Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory.
4. D1633, Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders.
5. D5084, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

1.03 SUBMITTALS

A. Soil Mixing Work Plan: Provide, as a single submittal, the following information:

1. Summary of Contractor's experience performing soil mixing using the methods and equipment proposed for this Project. Describe at least three recent soil mixing projects (with similar equipment and site conditions) by the Contractor's Site Supervisor, Foreman, and Mixing Operator. If Contractor proposes to subcontract a portion or all of the soil mixing Work, provide Subcontractor qualifications consistent with this paragraph.

2. Soil Mix Design:
 - a. Contractor may propose a mix design based on the successful mix designs presented in the *ISS Bench-Scale Treatability Study Report* (ISS Report; ARCADIS 2011) included in the Supplemental Information Attachment. As presented in the ISS Report, ISS Mix Designs 3, 4 and 6 each met the performance criteria of this Section.
 - b. List of materials, and proportions of each, for the selected soil mix design, including water requirements. Provide data sheets, test results, certifications, and mill reports to qualify the materials for the proposed soil mix design. Note that the mix designs testing per the ISS Report used a 1:1 water to cement ratio for each of the mix designs. Contractor shall confirm adequate in-situ water is available for in-situ solidification (ISS) reagent hydration and have a contingency provision if adequate in-situ water is not available.
 - c. Calculations showing in-situ volume and weight of untreated soil in each soil mixing cell, including overlap areas between adjacent cells.
 - d. For each soil mixing cell, calculations showing the quantity of each material required as a percentage of the total weight of untreated soil.
 - e. Volume expansion (swelling) of solidified soils based on water content of grout (if used) and/or estimated volume of groundwater within each soil mixing cell.
3. List of equipment, including cut sheet and technical details for each.
4. Detailed description of the methods and sequence of construction.
5. Shop Drawings:
 - a. Site layout drawing showing the proposed storage location(s) for materials and equipment.
 - b. ISS layout drawing showing the location and dimensions of each soil mixing cell within the ISS area, including dimensions of overlap between adjacent cells.
6. Revised design for Contractor's excavation protection system (EPS) that reflects Contractor's intended methods and sequence of construction. Revised design shall be stamped and signed by a Professional Engineer licensed and registered in New York State.
7. Quality Assurance/Quality Control Plan:
 - a. Procedures for measuring and proportioning materials for soil mix design.
 - b. Specific delivery and mixing methods to ensure proper in-situ proportions are achieved.
 - c. Procedures for verifying and documenting the final limits of soil mixing in each cell.
 - d. Procedures for collecting samples of mixed soils.
8. Schedule: Estimated production rate expressed as volume of soil mixing per day and schedule for completing soil mixing Work.

- B. Daily Soil Mixing Reports: Submit the following information for each day soil mixing is performed:
 - 1. Soil mixing cell(s) completed.
 - 2. Mix proportions (percent by weight of each material) and total weight of each dry reagent used. If reagents are added in the form of a liquid grout, provide mix proportions (percent by weight of each material), grout injection rate, and total volume of grout used.
 - 3. Unforeseen Site conditions encountered.
 - 4. Modifications to or deviations from Contractor's approved Soil Mixing Work Plan or this Section.
 - 5. Quality assurance/quality control activities performed.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store dry reagents in closed water-proof containers.
- B. Materials and equipment shall be stored in locations approved by Owner so as not to endanger the Work, and so that easy access may be had at all times to all parts of the Work area.
- C. Special precautions shall be taken to permit access at all times to fire hydrants, fire alarm boxes, driveways, and other points where access may involve the safety and welfare of the general public.

1.05 SCHEDULING

- A. Anticipate and schedule Site Work, including excavation, soil mixing, and backfilling to accommodate quality control testing by Engineer.

1.06 PERFORMANCE CRITERIA

- A. Soil mixing program shall achieve the following criteria throughout the ISS area:
 - 1. Strength: Between 50 and 500 pounds per square inch (psi) at 28 days, as determined by ASTM D1633.
 - 2. Hydraulic Conductivity: Less than 1×10^{-6} centimeters per second (cm/sec) at 28 days, as determined by ASTM D5084.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Portland Cement: Type I/II Portland cement conforming to the chemical and physical requirements of those respective types as specified in ASTM C150.
- B. Water: Clean, potable water free from oil, salts, acid, strong alkalis, vegetable matter, and other impurities that would have an adverse effect on the soil solidification process.

C. Mineral Admixtures:

1. Bentonite: Hydrogel® by Wyo-Ben, Inc. or approved equal meeting API 13A, Section 9 specifications.
2. Slag Cement: NewCem® by Lafarge North America, Inc. or approved equal meeting ASTM C989 Grade 120 specifications.

2.02 MIXES

- A. Materials for selected soil mix design shall be proportioned by Contractor on the basis of laboratory trial mixtures presented in the ISS Report to produce a cohesive and non-segregating mixture.

2.03 EQUIPMENT

- A. Batch Plant: If used, Contractor's batch plant shall consist of purpose-built mixers, volumetric screw feeders, flow controllers, storage tanks, silos, transfer pumps, valves, hoses, supply lines, and incidentals as needed to store, proportion, mix, and deliver grout or dry reagents to soil mixing equipment at necessary pressure and flow rate.
- B. Soil Mixing Equipment: Soil mixing equipment shall be selected by Contractor on the basis of field experience, Contractor's intended mixing method, subsurface conditions to be encountered at the Site, and other related factors. If wet mixing methods are to be used, equipment shall provide adequate pressure and flow rate, and a means of measuring both, such that grout is delivered at a constant rate throughout each soil mixing cell.

PART 3 – EXECUTION

3.01 PREPARATION

- A. Excavate existing Site soils in ISS area to approximately elevation 421.5 feet in accordance with the Contract Documents and Contractor's approved Soil Mixing Work Plan.
- B. Layout soil mixing cells within ISS area through survey in accordance with Contractor's approved Soil Mixing Work Plan before initiating soil mixing Work.

3.02 SOIL MIXING

- A. Comply with sequencing requirements of Contractor's approved Soil Mixing Work Plan.
- B. Evenly distribute reagents throughout each soil mixing cell and thoroughly blend with existing Site soils as required to achieve a homogeneous mixture between elevations 421.5 feet and 416.5 feet.
- C. Provide sufficient overlap between adjacent soil mixing cells to ensure the complete solidification of soils within the ISS area.
- D. Placement of fill material over completed cells may proceed once mixed soils achieve a minimum strength of 50 psi, as determined by field or laboratory testing of representative samples.

3.03 SITE QUALITY CONTROL

- A. Equipment Calibration: Calibrate mixing equipment in accordance with manufacturer's specifications at the beginning of the Project and on a monthly basis thereafter until soil mixing Work is complete.
- B. Site Records: Document and record the following for each soil mixing cell:
 - 1. Start and end time of soil mixing.
 - 2. Mix proportions (percent by weight of each material) and total weight of each dry reagent used. If reagents are added in the form of a liquid grout, document mix proportions (percent by weight of each material), grout injection rate, and total volume of grout used.
 - 3. Final horizontal and vertical limits of soil mixing.
 - 4. Summary of visual observations during mixing activities.
- C. Quality Control Testing During Construction:
 - 1. Collect wet samples of freshly-mixed soil from within the ISS area at locations to be selected by Engineer. Engineer will visually inspect samples to assess homogeneity and consistency with other soil mixing cells, and will prepare and submit test specimens for laboratory testing on a daily basis during soil mixing Work. Contractor shall be responsible for re-mixing cells that have not been thoroughly mixed, or that appear visibly inconsistent with other soil mixing cells, as determined by Engineer.
 - 2. On the first day of soil mixing each week, Engineer will prepare and submit for testing a minimum of five test specimens as follows:
 - a. Strength Testing (ASTM D1633): One specimen will be tested at seven days, and two specimens will be tested at 28 days.
 - b. Hydraulic Conductivity Testing (ASTM D5084): One specimen will be tested at seven days, and one specimen will be tested at 28 days.
 - 3. For each remaining day of soil mixing during the week, Engineer will prepare and submit for testing a minimum of three test specimens as follows:
 - a. Strength Testing (ASTM D1633): Two specimens will be tested at 28 days.
 - b. Hydraulic Conductivity Testing (ASTM D5084): One specimen will be tested at 28 days.
 - 4. Additional test specimens may be submitted by Engineer and held at the laboratory for potential future testing.

D. Evaluation of Site Quality Control Test Results:

1. Test results for laboratory-cured cylinders will be acceptable if the following criteria are met:
 - a. Strength Test Results: All 28-day test results within design criteria specified in Paragraph 1.06.A.1 of this Section.
 - b. Hydraulic Conductivity Test Results: All 28-day test results less than design criteria specified in Paragraph 1.06.A.2 of this Section.

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