

**APPENDIX C**  
**CEMENT-MODIFIED SOIL**  
**SPECIFICATION**

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

### CEMENT-MODIFIED SOIL

#### PART 1 - GENERAL

##### 1.1. DESCRIPTION

- A. This work includes constructing a subgrade mixture of existing soils and Portland cement. Construct according to these Specifications and conform to the lines, grades, and typical sections shown on the plans.

##### 1.2. REFERENCES

- A. The following is a list of standards which may be referenced in this section.
- B. ASTM C150, Specification for Portland Cement (AASHTO M 85).
- C. ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft<sup>3</sup>).
- D. ASTM 2487, Classification of Soil for Engineering Purposes (USCS).
- E. ASTM D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil Aggregate by Nuclear Methods (Shallow Depth).
- F. AASHTO T272-10, Standard Method of Test for Family of Curves – One Point Method (Modified Proctor).
- G. When density is determined by nuclear method, the equipment shall be calibrated on soils from site. Take all safety precautions and obey all regulations governing the use of radioactive materials.

##### 1.3. DEFINITIONS

- A. Suitable Material: Material meeting the Unified Soil Classification soil types SM, SC, and CL with percent fines passing the No. 200 sieve greater than 25 and plasticity index (PI) more than 10. The soil/aggregate shall not contain roots, topsoil, or any material deleterious to its reaction with cement. Also, soils designated as suitable for their intended use by the Engineer.
- B. The water used in construction must be from a potable source.

##### 1.4. MIX DESIGN AND SAMPLING

- A. The Mix Design must be completed by an accredited materials laboratory approved by the A/E Construction Manager.
  - 1. All sampling, testing, proportioning and documentation shall be completed by the approved laboratory.
  - 2. All samples must be taken from previously undeveloped soils.
  - 3. The Portland cement used in the design process must be submitted to, and approved by, the A/E Construction Manager prior to beginning the design process.

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

4. The Contractor shall submit a mix design package indicating the proposed mix design meets the requirements of this specification to the A/E Construction Manager at least three weeks prior to construction.
- B. In-place samples of the road structure shall be taken as follows:
1. At a minimum frequency of 400 feet per lane.
  2. Lane sample locations must alternate to achieve a sample every 200 lane-feet.
  3. Each sample shall contain at least 20 lbs. (14kg) of proportionally blended material from the roadway.
  4. Additional samples may be needed to represent material changes and/or problem areas. Additional samples shall be taken at the Contractor's discretion or as directed by the A/E Construction Manager.

### 1.5. QUALITY CONTROL

- A. Test strip
1. Contractor shall construct a continuous test strip of no less than 2,000 sf within the project area.
    - a. Test strip must be tested in accordance with this specification in no less than 4 locations to confirm the density and permeability of the test strip.
    - b. If the average of the 4 test locations does not meet the requirements for density and or permeability the Contractor must adjust the mix proportions accordingly.
- B. The Owner's Testing and Inspection Agency shall check work as it progresses. When material furnished or work performed by the Contractor fails to conform to specifications, the must promptly notify the Contractor and the A/E Construction Manager. The Owner's Testing and Inspection Agency will, as a minimum perform the following:
1. Perform one-point proctors in sufficient quantity to verify testing.
  2. Conduct density Owner's Testing and Inspecting Agency and permeability tests in sufficient quantity to ascertain the work being performed complies with these specifications. The following minimum schedule shall be adhered to for fill conditions:
    - a. One every 4,000 square feet, or fraction thereof, plus
    - b. Areas where degree of compaction or permeability are in question.
  3. The Owner's Testing and Inspecting Agency shall submit formal reports of all density and permeability tests and retests to the A/E Construction Manager. The reports shall be furnished to the A/E Construction Manager within one working day of completion of the required tests. Such tests and submittals shall not relieve the Contractor from any of his contractual obligations and he shall be responsible for ensuring that his work is maintained to the required quality.
    - a. Date of the test and date submitted.

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

- b. Location and sketch of test by station, coordinate and elevation.
  - c. Wet weight, moisture content and dry weight of field sample.
  - d. One-point proctor data.
  - e. Permeability at sample location.
  - f. Maximum dry density and moisture content of the lab sample that best match the field samples in color, texture, grain size and maximum dry density.
  - g. Ratio of field dry density to maximum lab dry density expressed as a percent.
  - h. Permeability.
  - i. Comments concerning the field density or permeability passing or failing the specified requirements.
  - j. Comments about re-compaction or mix adjustments if required.
4. Moisture Control: Perform moisture sampling in soils being worked to ascertain compliance with these specifications.
  5. Observations: Make observations of the work on each site visit and record observations in formal report.
- C. Report Test Results: All test results shall be submitted to the A/E Construction Manager. Work sheets reflecting the days testing activities with calculations shall be delivered to the A/E Construction Manager by the beginning of the next workday. Formal typed reports shall then be submitted to the A/E Construction Manager.
  - D. Maintain Records: Complete records of test observations shall be maintained. Records will include, but not limited to, proof-rolling, detailed locations and results of tests, observations, and undercuts. These records shall be submitted to the A/E Construction Manager with accompanying as-builts at the end of the project.
  - E. Upon completion of project, submit drawings detailing locations of all density tests including pertinent supporting data such as proof-rolling, undercuts, one-point Proctor verifications, and any other data relating to soils work performed on the project site.

## PART 2 – PRODUCTS

### 2.1. GENERAL:

- A. Material meeting the Unified Soil Classification soil types SM, SC, and CL with percent fines passing the No. 200 sieve greater than 25 and plasticity index (PI) more than 10. The soil/aggregate shall not contain roots and other organic matter, topsoil, or any material deleterious to its reaction with cement. Also, soils designated as suitable for their intended use by the Engineer.

### 2.2. WATER

- A. Water to be used in construction must be from a potable source.

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

### 2.3. PORTLAND CEMENT

- A. Portland Cement shall meet the requirements on AASHTO M 85.
- B. Portland cement shall be Types I or II.
- C. Ensure that the Portland cement concrete meets the low alkali and false set requirements of AASHTO M 85.
- D. Do not use cement that is damaged, partially set, lumpy, or caked.
- E. Do not mix or store different brands or types of cement together. Do not mix or store the same brand of cement from different mills together.

### PART 3 - EXECUTION

#### 3.1. GENERAL

- A. Weather Limitations
  - 1. Mix and place cement only when the weather permits the course/layer to be finished without interruption in the time specified.
  - 2. Begin mixing only when the air temperature is above 40°F in the shade and rising.
  - 3. Ensure that the temperature of the soil to be used in the mixture is above 50°F.
  - 4. Interruption of Work: If the work is interrupted for more than two hours after cement has been added, or if a completed lift is rained upon within 24 hours of completion, remove and replace the affected portion at no additional cost to the Owner.

#### 3.2. EQUIPMENT

- A. In-Place Mixing
  - 1. Use a cyclone-type spreader or its equivalent to spread the cement uniformly across the coverage area and capable of metering the spread rate being placed.
  - 2. Use a rotary type mixer with sufficient tines which produces a uniform and homogenous blend of materials. The use of disk harrows will not be allowed for the mixed-in-place soil-cement base construction method. Mixer shall be inspected by the Engineer daily and tines with more than 25% wear must be replaced.

#### 3.3. CONSTRUCTION

- A. In-Place Mixing
  - 1. The addition of Portland cement to modified existing soil conditions is in addition to dewatering requirements specified elsewhere within the Project Manual.
  - 2. Soil: Move and spread the soil uniformly to the proper depth to obtain the specified thickness.
  - 3. Pulverization

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

- a. Loosen and pulverize roadbed materials to the width and depth to be stabilized without disturbing or damaging the underlying subgrade.
  - b. Continue pulverizing until 100 percent of material can pass through a 1-1/2 in. sieve, and until at least 80 percent of the soil, excluding any stone or gravel, can pass through a No. 4 sieve.
  - c. Remove all roots, sod, and rocks that exceed 3 in. (75 mm) in diameter.
  - d. Remove all other harmful materials.
4. Cement:
- a. Portland cement shall be applied at the rate specified in the approved mix design.
  - b. Uniformly spread the required amount of Portland cement with a cyclone-type mechanical spreader or its equivalent.
  - c. Apply the Portland cement at a rate that ensures the pounds spread are within  $\pm 10$  percent of the amount specified. Furnish a square-yard cloth, scales and personnel for checking the spread rate of cement placed.
  - d. Apply cement on days when wind will not interfere with spreading.
  - e. If the cement content is below the 10 percent limit in the mixing area, add additional cement to bring the affected area within the tolerance specified and recalibrate the mechanical spreader's spread rate.
  - f. Regulate operations to limit the application of cement to sections small enough so that all of the compacting and finishing operations can be completed within the required time limits.
  - g. Pass only spreading and mixing equipment over the spread cement. Operate this equipment so that it does not displace cement.
  - h. Replace damaged cement at no additional cost to the Owner when damage is caused by:
    - 1) Hydration due to rain, before or during mixing operations.
    - 2) Spreading procedures contrary to the requirements mentioned above.
    - 3) Displacement by the Contractor's equipment or other traffic.
5. Mixing
- a. Begin mixing as soon as practical after the cement is spread and continue until a homogeneous and uniform mixture is produced. Make multiple passes as required. If the equipment does not produce a homogeneous and uniform mixture meeting these specifications, make any necessary changes to the satisfaction of the A/E Construction Manager.
6. Spreading
- a. Use an approved mixture spreader to obtain the specified thickness. Spread the mixture the full width of the area to be covered.

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

- b. Ensure that trucks and other construction equipment, including motor graders, do not travel over the material until compaction equipment has made initial passes over the mixture.
  - c. Ensure that less than 30 minutes elapse between the placement of cement-treated material in adjacent lanes at any location, unless longitudinal joints are specified.
7. Thickness of Course:
- a. Compact the cement-modified soil in maximum lifts (thickness) of 12-inches unless otherwise directed by the A/E Construction Manager
8. Compacting
- a. Limits
    - 1) Compact stabilized soil to a minimum of 98 percent of the specified theoretical density.
    - 2) Complete compaction within 2 hours.
    - 3) Complete all operations in four hours, from adding cement to finishing the surface.
  - b. Additional Compaction Requirements
    - 1) Do not perform vibratory compaction on materials more than 1-1/2 hours old, measured from the time the cement was added to the mixture.
    - 2) Loosened material accumulated during this process is considered waste and is to be removed from the Project.
    - 3) Use a pneumatic-tired roller to roll the finished surface until the surface is smooth, closely knit, free from cracks, and in conformance with the proper line, grade, and cross-section.
    - 4) At any place inaccessible to the roller, secure the required compaction with mechanical tampers approved by the Engineer. The same compaction requirements stated in the above subsection apply.
9. Open to Traffic
- a. Correct any failures caused by construction traffic at no additional cost to the Owner.
10. Protection of Courses
- a. Maintain the work until it has sufficiently cured and is ready to resume following courses or the next pavement course. This preservation action does not relieve the Contractor of his responsibility to maintain the work until final acceptance.

### 3.4. TESTING

- A. Allow mixture to cure a minimum of three days (or as directed by the A/E Construction Manager) before testing.

## SECTION 312000.5 – CEMENT-MODIFIED SOIL

- B. Compact to a minimum 98 percent maximum dry density (Modified Proctor) in accordance with ASTM D1557.
- C. Core samples must have a maximum permeability of  $1 \times 10^{-5}$  cm/second.
- D. Areas failing to pass the minimum density requirement shall be remixed with additional cement, as directed by the A/E Construction Manager, reconstructed, and tested in accordance with this specification.
- E. Areas failing to pass the maximum permeability requirement shall be remixed with additional cement and/or clayey soils, as directed by the A/E Construction Manager, reconstructed, and tested in accordance with this specification.

### PART 4 – MEASUREMENT AND PAYMENT

#### 4.1. MEASUREMENT AND PAYMENT

- A. No separate payment will be made for work described in this Section. Work described herein is considered subsidiary to each applicable bid item.

**END OF SECTION**



SECTION 312000.5 – CEMENT-MODIFIED SOIL

**THIS PAGE INTENTIONALLY LEFT BLANK**