CEMENT AND LIME STABILIZATION OF SUBGRADE SOILS
(07-12-07)  DB5 R21

General

The Design-Build Team shall be responsible for the following:

1. Performing all laboratory tests in a laboratory certified by the AMRL / NCDOT Laboratory Proficiency Program
2. Sampling Sub-grade soils
3. Conducting Laboratory tests to determine:
   a. Soil classifications
   b. Moisture-density relationships
   c. Quantity of lime or cement required to achieve specified strengths
4. Designating areas to be stabilized by either lime or cement and the required rates of application
5. Conducting field tests to determine unconfined compressive strength

Sampling

The Design-Build Team shall take soil samples, after the project has been graded to within 2 inches of final sub-grade elevation. The Design-Build Team shall sample the top 8 inches at a minimum frequency of one sample per 1,000 feet, per each lane, for classification tests; and one sample per 3,000 feet, per each lane, for moisture density tests and lime or cement mix design tests. Additional samples shall be taken to ensure that all the predominant soil types, limits of distribution of these soils and different site conditions have been represented.

Classification Tests

The Design-Build Team shall perform the following tests to determine AASHTO classifications of different soils in accordance with AASHTO specifications as modified by NCDOT. Copies of these modified procedures can be obtained from Materials and Test Unit’s Soils Laboratory.

<table>
<thead>
<tr>
<th>TEST</th>
<th>AASHTO DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Preparation of Disturbed Soils</td>
<td>T-87</td>
</tr>
<tr>
<td>Particle Size Analysis of Soils</td>
<td>T-88</td>
</tr>
<tr>
<td>Determining the Liquid Limit of Soils</td>
<td>T-89</td>
</tr>
<tr>
<td>Determining the Plastic Limit and Plasticity Index of Soils</td>
<td>T-90</td>
</tr>
</tbody>
</table>
Moisture Density Test

Based on the criteria set in Table 2, below, the Design-Build Team shall perform the Moisture Density Tests, using either lime or cement. The Design-Build Team shall use 10% cement by weight in soil cement and 4% lime by weight, in soil-lime mixtures. The Design-Build Team shall conduct the tests in accordance with AASHTO T-99, and T-134 for soil-lime and soil-cement mixtures, respectively. In each case, The Design-Build Team shall determine the maximum dry density and optimum moisture content.

### TABLE 2

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent passing #200 Sieve</td>
<td>35 Max</td>
<td>36 Min</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>40 Max</td>
<td>41 Min</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>10 Max</td>
<td>25 Min</td>
</tr>
</tbody>
</table>

The Design-Build Team shall use cement for all soils meeting criteria in Column A and lime for all soils meeting criteria in Column B. The Design-Build Team may choose either lime or cement for all soils not meeting all criteria in either Column A or B.

**DETERMINING THE APPLICATION RATES FOR SOIL-CEMENT AND SOIL-LIME MIXTURES**

**Soil-Cement Mixtures**

For soil-cement mixtures, the Design-Build Team shall be required to do the following:

- Make specimens at optimum moisture content using a quantity of cement in the range of 5 to 12 percent by weight.

- Compact the specimens to a minimum density of 95% of maximum dry density obtained using AASHTO T 134.

- Make a minimum of 2 specimens for each selected cement rate.

- Cure the specimens for 7 days in a moist room maintained at a temperature of 73°F ±2.7° and a humidity of 100%. At the end of the curing period, immerse the specimens in water for 4 hours.
• After immersion, test the specimens in unconfined compression in accordance with ASTM D 1633.

• Report the maximum strength obtained and the corresponding percent strain.

• Select the rate of cement that provides a minimum unconfined compressive strength of 200 psi and a maximum of 400 psi.

**Soil-Lime Mixtures**

For soil-lime mixtures, the Design-Build Team shall be required to do the following:

• Make specimens at optimum moisture content using a quantity of lime in the range of 3.5 to 6.5 percent by weight.

• Compact specimens to a minimum density of 95% of maximum dry density obtained by AASHTO T99.

• Make a minimum of two specimens for each selected lime rate.

• Cure the specimens in sealed plastic bags for 48 hours in an oven at a temperature of 118 °F. Do not immerse the specimens in water at the end of the curing period.

• Test the specimens in unconfined compression in accordance with AASHTO T 208. Report the maximum strength obtained and the corresponding percent strain.

• Select the rate of lime that provides a minimum unconfined compressive strength of 60 psi.

**Submittals for Review and Approval Prior to Construction**

The Design-Build Team shall adhere to the following submittal guidelines:

• Submit all laboratory test results for review.

• Submit a sketch in plan view showing areas of the project to be stabilized by either lime or cement and application rates for each stabilizer.

• Submit any other documentation that supports the Design-Build Team’s recommendations.

**Construction of Lime Treated Subgrade**

The Design-Build Team shall construct the lime treated sub-grade as specified in Section 501 of the North Carolina Department of Transportation 2006 *Standard Specifications for Roads and Structures* with the following exceptions:
**Subsection 501-4 Equipment**
Contractor’s equipment will not require engineer's approval.

**Subsection 501-8 (A) General**
Paragraph #1 is not applicable to this project.

**Subsection 501-9 (B) Preliminary Curing**
Amend as follows: Allow a minimum of 2 days and a maximum of 4 days for preliminary curing.

**Subsection 501-10 Compacting, Shaping, and Finishing**
Last paragraph is not applicable.

**Subsection 501-11 Thickness**
Last two paragraphs are not applicable.

**Subsection 501-15 Method of Measurement**
The entire sub-sections are not applicable.

**Subsection 501-16 Basis of Payment**
The entire sub-section is not applicable.

**Construction of Cement Treated Subgrade**

The Design-Build Team shall construct the soil cement sub-grade as specified in section 542 of the North Carolina Department of Transportation 2006 *Standard Specifications for Roads and Structures*, with the following exceptions:

**Subsection 542-4 Equipment**
Contractor’s equipment will not require Engineer’s approval.

**Subsection 542-7 Application of Cement**
First paragraph is not applicable.

**Subsection 542-11 Thickness**
Paragraphs 2 and 3 are not applicable.

**Subsection 542-16 Method of Measurement**
This entire sub-section is not applicable.

**Subsection 542-17 Basis of Payment**
This entire sub-section is not applicable.
Unconfined Compressive Strength

The Design-Build Team shall allow a minimum of seven days curing before testing for strength.

The lime-stabilized subgrades shall be tested using Dynamic Cone Penetrometer (DCP) in accordance with Quality Assurance Testing of Lime-Treated Soils Utilizing the Dynamic Cone Penetrometer, Test Method #1-2005. The Design-Build Team shall adhere to the testing equipment requirements and procedures as outlined in Dynamic Cone Penetrometer Testing for Subgrade Stability except that the minimum penetration depth shall be eight inches. Upon request, a copy of the aforementioned documents can be obtained from the NCDOT Geotechnical Engineering Unit. The required unconfined compressive strength for lime shall be 60 psi, which corresponds to a penetration per blow of approximately 0.5 inches of the Dynamic Cone Penetrometer.

For cement-stabilized subgrades, the Design-Build Team shall make field specimens, cure them for seven days and test them in the laboratory. The minimum and maximum required unconfined compressive strength for soil cement shall be 200 psi and 400 psi, respectively.

Submittals for Review During Construction

The Design-Build Team shall submit the unconfined compressive strength and dynamic cone penetrometer test results for review and acceptance.

EMBANKMENT MONITORING

Monitoring

Settlement gauges shall be installed before any fill is placed. Settlement gauge elevations are to be surveyed weekly by the Design-Build Team. The initial elevation of the settlement gauge plate (at the top of the plate) shall be determined at the time of installation along with the embankment elevation. When new sections of pipe are added, elevations shall be recorded at the top of existing pipe and at the top of the new pipe. This is to take into account interim settlement, variable pipe lengths and thread lengths in coupling. Results of settlement gauge readings shall be forwarded to NCDOT Geotechnical Engineering Unit along with the letter by the prequalified geotechnical firm releasing the embankment from the waiting period.

Settlement Gauges

Settlement plates consisting of wood or metal shall be placed on a level surface near natural ground as shown in the plans developed by the Design-Build Team. Extend the 2½" Ø metal pipe by adding pipe sections at threaded couplings as the embankment is progressed. Make sure