2012 Purdue Road School

Chemical Use for Subgrade Modification of Soils

Athar Khan, M.S., P.E., Manager
Office of Geotechnical Services
Geotechnical Issues

Overview:

- Key Items of Standard Specifications

Sections:

- 203,
- 207,
- 215,
- 913
Section 203.09

• Added Requirement for Embankment Soils:

**Soils shall not be used if**

• Max. Dry Density < 90 pcf ---- AASHTO T-99
• Ca or Mg carbonate > 7% ---- ITM 508
• Loss on ignition > 7% ------- AASHTO T-267
As written in the Standard Specifications Book, Glossary of Terms:

101.62 Subgrade. The upper portion of a roadbed upon which the pavement structure and shoulders are constructed.
SUBBASE

EMBANKMENT

SUBGRADE

PAVEMENT
Section 207

Section 207.03

Soils requirements for subgrade:

**Soils shall not be used in subgrade if**

Max Dry Density < 100 pcf-----------------------------AASHTO T-99
Liquid Limit > 50----------------------------------------AASHTO T-89
Loss on Ignition > 3%-----------------------------------AASHTO T-267
Ca or Mg Carbonate > 3%--------------------------------ITM-508
Subgrade Treatment

The subgrade shall be constructed uniformly transversely across the width of the pavement including the shoulders or curbs unless shown otherwise on the plans.
# Design Criteria for Subgrade Treatment Types (NEW)

<table>
<thead>
<tr>
<th>Traffic Volume (A.A.D.T.)</th>
<th>Subgrade Type</th>
<th>Construction Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 3000 V.P.D.</td>
<td>Type I</td>
<td>Realignment  (New Road Construction)</td>
<td>Fill Area</td>
</tr>
<tr>
<td></td>
<td>Type IA</td>
<td>Reconstruction (Existing Alignment)</td>
<td>Fill/Cut/at-grade</td>
</tr>
<tr>
<td></td>
<td>Type IB</td>
<td>Realignment and Reconstruction</td>
<td>Fill/Cut/at-grade</td>
</tr>
<tr>
<td></td>
<td>Type IC</td>
<td>Realignment and Reconstruction</td>
<td>Fill/Cut/at-grade</td>
</tr>
<tr>
<td>&lt; 3000 V.P.D.</td>
<td>Type II</td>
<td>Realignment  (New Road Construction)</td>
<td>Fill Area</td>
</tr>
<tr>
<td>&gt; 500 V.P.D.</td>
<td>Type IIIA</td>
<td>Reconstruction (Existing Alignment)</td>
<td>Fill/Cut/at-grade</td>
</tr>
<tr>
<td>&lt; 500 V.P.D.</td>
<td>Type III</td>
<td>Realignment  (New Road Construction)</td>
<td>Fill area</td>
</tr>
<tr>
<td></td>
<td>Type IIIIA</td>
<td>Reconstruction (Existing Alignment)</td>
<td>Fill/Cut/at-grade</td>
</tr>
<tr>
<td>≥ 3000 V.P.D.</td>
<td>Type IV</td>
<td>Urban Area, Shallow Utilities, etc.</td>
<td>or use Type IB with Slurry</td>
</tr>
<tr>
<td>---</td>
<td>Type V</td>
<td>Trails on Abandoned-Railroad Corridor</td>
<td>At-grade/cut</td>
</tr>
</tbody>
</table>
How To Achieve Subgrade Treatment

1. Chemical - Lime, lime by-products, cement, fly ash, or a combination

2. Mechanical - Undercut and replacement with compacted aggregate

3. Moisture - Density Control

4. Partial undercut and replacement with geosynthetic reinforced aggregate
New Options

#1 Chemical Modification Option
- Pavement
- 14 inches in-place Chemical Modification

#2 Mechanical Option
- Pavement
- Excavation and replacement with compacted aggregate
- 12 inches

#3 Moisture-density Control Option
- Pavement
- Compaction
- 24 inches

#4 Geosynthetic Reinforced Aggregate Option
- Pavement
- Compacted Aggregate
- Geogrid
- 9 inches
Section 207

Section 207.04

Type I

1. 14 in. chemical soil modification, (16 in. under Old Spec.)

2. 12 in. of the subgrade excavated and replaced with coarse aggregate No. 53, or by

3. 24 in. of soil compacted to density and moisture requirements.
Pavement Replacement

- Pavement
- Subgrade
UN-MODIFIED SUBGRADE

RUTTING
24 inches Subgrade Treatment Using (Type I) Moisture-Density

First excavate, and re-compact in lifts to 100% (AASHTO T-99)

Subgrade

18 inches

6 inches compaction in-place to 100% (AASHTO T-99)
24 inches Subgrade Treatment Using (Type I) Moisture-Density (Con’t.)

Pavement

Subgrade

6 inches

6 inches

6 inches

6 inches

6 inches
Moisture problems under first lift of base that sat for several weeks
R-27265 (SR 28) Moisture problems under first lift of base that sat for several weeks
1. 14 in. chemical soil modification, (16 in. under Old Spec.)
2. 12 in. of the subgrade excavated and replaced with coarse Aggregate No. 53.
Section 207.04 (Con’t.)

Type 1B

1. 14 in. chemical soil modification, (16 in. under Old Spec.)
Chemically Modified Subgrade
109th Ave Subgrade Treatment using Cement for 6% Organics
109th Ave Subgrade Treatment using Cement for 6% Organics
Section 207.02- Materials

Materials shall be in accordance with the following:

**Chemical Modifiers**

*Cement By-Products*---------913.05
   Fly Ash----------------------901.02
*Lime*------------------------913.04(b)
*Portland Cement, Type 1*-----901.01(b)
*Coarse Aggregate, Class D or Higher, Size No. 11, 12, 53, or 73*-----904
   Geogrid, Type I------------918.05(a)
*Water*----------------------913.01

*Note: On hold until more information is collected. (see Construction Memorandum dated 8/24/11.)*
Section 207 (Con’t.)

Section 207.04 (Con’t.)

Type 1C (New Item)

1. 12 in. of the subgrade excavated and replaced with coarse Aggregate No. 53
Pictures of the SR 127 (Exit 154) ramp area on NB I69. Picture 1 shows the solid ground on the north end; the others show the severe rutting that occurred after we drove a triaxle over the area.
Pictures of the SR 127 (Exit 154) ramp area on NB I69. Photos showing the severe rutting that occurred after we drove a triaxle over the area.
Section 207 (Con’t.)

Section 207.04 (Con’t.)

Type II

1. 8 in. chemical soil modification,
2. 6 in. of the subgrade excavated and replaced with coarse Aggregate No. 53,
3. 12 in. of soil compacted to density and moisture requirements.
Section 207 (Con’t.)

Section 207.04 (Con’t.)

Type II A

1. 8 in. chemical soil modification
2. 6 in. of the subgrade excavated and replaced with coarse Aggregate No. 53.

8 in. Chemical Soil Modification  
6 in. Coarse Aggregate No. 53
Section 207 (Con’t.)

Section 207.04 (Con’t.)

Type III

1. 6 in. of soil compacted to the density and moisture requirements

2. 6 in. of subgrade excavated and replaced with coarse Aggregate No. 53.
1. 6 in. of subgrade excavated and replaced with coarse Aggregate No. 53.
1. 9 in. of the subgrade excavated and replaced with coarse Aggregate No. 53 on geogrid.
It was recommended that type IV subgrade treatment be used.

- Geogrid with 9” of No. 53 aggregate placed on top of the geogrid
Rutting After Type IV Subgrade Treatment
Since we could not achieve the Type IV subgrade treatment, the following correction was used (Change Order).

The new plan would be to excavate 18” and use as follows:
- 6-8” of No.2 riprap in the bottom.
- 1-2” layer of No. 53 aggregate to choke the riprap.
- Geogrid
- 9” No. 53 aggregate to grade
Water standing at bottom of excavated depth
Layout of No. 2 stone, No. 53 aggregate and geogrid
SR23 Subgrade Treatment Using Cement Slurry
Subgrade Treatment for Trails on Abandoned-Railroad Corridor

1. 3 in. of the subgrade excavated and replaced with 3 in. coarse Aggregate No. 53.
Section 215.02

Materials

Soils containing...

1. Ca and Mg carbonate > 6% by dry weight----ITM-508
2. Loss on Ignition > 6% by dry weight---------AASHTO T-267
3. Max Dry Den. < 95 pcf------------------------AASHTO T-99
4. Soluble sulfate content >1000 ppm----------AASHTO T-290*

*Note: Current Spec shows AASHTO T-289

Shall not be used
Testing and Mix Design Requirements

1. The geotechnical consultant shall include the tests and recommendations, Chemical modifier shall be from the Department’s list of approved source,

2. Hydrated lime, Quick Lime or Portland Cement based mixed design shall be submitted to the engineer,

3. Fly Ash, Lime by-products, or any combination of chemical modifiers based mixed design shall also be submitted to the Office of Geotechnical Services for approval at least 5 business days prior to the use,

4. If cement is recommended, a price adjustment will be made in accordance with 215.11.
Contractor’s Submittals for the Chemical Soils Modification shall include the following:

1. Soils gradation --------------------------AASHTO T-88, T-89
2. Liquid and Plastic Limit ------------------AASHTO T-90
3. Moisture and Density test ---------------AASHTO T-99
4. Loss on Ignition -------------------------AASHTO T-267
5. Cal and Mg carbonate test ---------------ITM-508
6. Sulfate test -----------------------------AASHTO T 290*

(*Note: Typo error- in Std Spec’s showing as T-289)
Contractor’s Submittals for the Chemical Soils Modification shall include the following (Con’t):

7. Soils – lime reactivity: Soils testing data showing the strength gain of 50 psi of soil-lime mixture over the natural soils in accordance with AASHTO T-208.

8. Determine the optimum lime content.

9. Moisture and Density of Lime-soil mixture shall be in accordance with AASHTO T-99.

10. Cement-soils reactivity: Test Data of cement-soils mixture showing strength gain of 100 psi over the natural soils should be in accordance with AASHTO T-208.

Section 215.07

Spreading of Chemical Modifier

1. When soils are either A6 and/or A7, scarification and diskling is required.
2. The chemical modifier shall be spread uniformly.
3. When mixed design requires two modifiers, mechanical mixing is required prior to spreading.
4. Perform in-ground mixing of the chemicals and soils after spreading.
5. Avoid long exposure of the chemical after spreading.
Section 215.08

Mixing

1. Soils chemicals shall be mixed thoroughly.

2. 100% should pass No. 1 sieve.

3. 60% shall pass No. 4 sieve.

4. Moisture shall be at or over OMC based AASHTO T-99 of chemical soils mixture. **Recommending additional moisture tests after 24 hours.**

5. The mixing depth shall be 8 in. or 14 in. deep (as specified).
Section 215.09 - Compaction

• Acceptance testing shall be performed with a Dynamic Cone Penetrometer (DCP) in accordance with ASTM D-6951. The chemically modified soil lift shall meet the following requirements for compaction:

1. A minimum DCP blow count of 17 for the top 6 in. of a 14 in. lift
2. A minimum DCP blow count of 16 for the bottom 8 in. of a 14 in. lift
3. A minimum DCP blow count of 20 for an 8 in. lift
4. A minimum of 1 passing test for each 1,500 ft of chemically modified soil for each two-lane pavement

*Suggestion: Terminate DCP test at 25 blow counts even if DCP does not penetrate to a specified depth of 6 or 8 in. in Cement-modified soils.
Section 215.09 – Compaction (Con’t.)

DCP - Dynamic Cone Penetrometer

- Handle
- 8 kg (17.6 lb) Hammer
- Drop Height 575 mm (22.6"
- Drive Anvil
- Graduated Stem 1000 mm (40"
- Variable
- 16 mm ø (5/8"
- Steel Rod
- Cone
- 60° Cone Angle
- 20 mm ø (13/16"

(continued)
Section 913.04

Lime

(b) Lime for Soil Modification

Hydrated lime, quicklime, or a lime by-product used for soil modification shall be approved in accordance with ITM-806, Procedure P.

Contact Materials Management Office for the List of Approved Sources.
Other Acceptable or Future Testing Devices

1. Light Weight Deflectometer (LWD)
2. Proposing Changes - Sulfate Test Method (Up Coming in the Future)
3. Intelligent Compaction (IC) (Up Coming in the Future)
Alternate Compaction Testing

Lightweight Deflectometer (LWD)

LWD---- this is an acceptable device using Special Provision for Chemically Modified Subgrade Compaction.
Questions?