

DATE: July 13, 2011

TO: MAG Specification and Details Committee Members

FROM: Brian Gallimore, Materials Working Group/AGC

RE: Section 309 – Lime Slurry Stabilizing

PURPOSE: Section 309 needed to be modified to include the use of hydrated lime and not just be a slurry spec. Allow the spec to be used for soil modifications.

REVISIONS:

- a) Revise title to include soil modification
- b) Add mix design criteria
- c) Add additional testing procedures
- d) Specify equipment to be used to spread material more accurately
- e) Be non-specific on compaction equipment
- f) Payment for lime materials

**SECTION 309**

**LIME ~~SLURRY~~ STABILIZATION OR MODIFICATION OF SUBGRADE**

**309.1 DESCRIPTION:**

This section shall consist of constructing a mixture of soil, lime and water for the stabilization or modification of subgrade soils, ~~or base materials~~. The work shall be performed in conformity with the lines, grades thickness, and typical cross sections shown on the plans.

Lime Stabilization involves improving soil conditions as defined within this specification. Lime Modification can be allowed by the Engineer in the event only limited soil improvement is required.

**309.2 MATERIALS:**

**309.2.1 Soil or Subgrade:** For Lime Stabilization applications, ~~The~~ soil or subgrade material used for this work shall consist of materials on the site or imported and shall be free of roots, sod, weeds and stones larger than 3 inches and have a Plasticity Index (PI) greater than 10, when tested in accordance with AASHTO T-89 & T-90. For Lime Modification applications, the allowable soil or subgrade properties will be determined by the Engineer.

**309.2.2 Quicklime and Hydrated Lime:** Lime used to manufacture the commercial lime slurry specified herein, shall be either quick lime or hydrated lime and shall conform to the requirements of ASTM C-977. ~~Lime may only be used in the production of a lime slurry. The direct use of dry hydrated lime or quicklime to the soil material is strictly prohibited.~~ All lime shall come from a single source. If a source change is requested, a new mix design shall be submitted using lime from the proposed new source. The new design must be approved by the Engineer prior to use.

**309.2.3 Commercial Lime Slurry:** Commercial lime slurry shall be a pumpable suspension of solids in water. The water or liquid portion of the slurry shall not contain dissolved material in sufficient quantity naturally injurious or objectionable for the purpose intended. The solids portion of the mixture, when considered on the basis of solids content, shall consist principally of hydrated lime of a quality and fineness sufficient to meet the following requirements as to chemical composition and residue.

(A) Chemical Composition: The solids content of the lime slurry shall consist of a minimum of 90% by weight, of calcium and magnesium oxides (CaO and MgO), as determined by ASTM C-25.

(B) Residue: The percent by weight of residue retained in the solids content of lime slurry shall conform to the following requirements:

Residue retained on a No. 6 sieve	Max.	0.2%
Residue retained on a No. 30 sieve	Max	4.0%

(C) Grade: Commercial lime slurry shall conform to a dry solids content as approved by the Engineer.

A certificate of compliance and a field summary of lime slurry produced shall be provided to the Engineer for each load of slurry.

**309.2.4 Water:** Water used for mixing or curing shall be reasonable clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. Water shall be tested in accordance with and shall meet the suggested requirements of AASHTO T-26. Water known to be of potable quality may be used without test.

### 309.3 COMPOSITION:

**309.3.1 Lime Slurry:** Lime ~~slurry~~ shall be applied at the mix design rate for the depth of subgrade stabilization or modification shown on the plans or requested by the Engineer.

**309.3.2 Mix Design:** Before commencing lime treatment work, the Contractor shall submit for approval by the Engineer, a proposed mix design. The proposed mix design shall be prepared by a testing laboratory under the direction and control of a registered Professional Engineer. The mix design shall be determined using the soils or subgrade material to be stabilized or modified and lime from the proposed supplier and shall determine the following:

- (a) Percent of lime and rate of application of quicklime or lime slurry in the treated soil or subgrade material to meet the design specifications.
- (b) Optimum water content during mixing, curing and compaction.
- (c) Gradation of in-situ mixture after treatment.
- (d) Additional mixing or equipment requirements.
- (e) Sulfate content. The sulfate content of the subgrade soil shall be determined by ARIZ 733, AASHTO T290, or ASTM C1580. This result will be reported in the design. The sulfate content will allow the mix designer to recommend the appropriate mellowing time.
- (f) Mellowing time requirements to provide the contractor with the appropriate time frames for the lime reaction with the soil to be effective, if needed.

For Stabilization applications, the mix design shall comply with the following requirements:

- (a) pH: Minimum 12.4 after compaction of initial mixing with lime at ambient temperature, in accordance with Eades-Grimm pH test method (ASTM C977 APPENDIX or ASTM D6276).
- (b) Plasticity Index: Less than 3, per AASHTO T-89 & T-90.
- (c) Swell Potential: One (1) percent or less vertical expansion of an air dried soil when inundated with water and allowed to swell at a confined pressure of 60 psf. Maximum expansive potential (%) of 1.0. The maximum expansive potential shall be determined on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at approximately 2% below optimum moisture content. The sample should be confined under a 100 psf surcharge and submerged/inundated.
- (d) Hydrated Lime Content: The design engineer shall specify/designate the mMinimum 5.0 percentage of lime by dry weight of the combined lime/soil mixture to accomplish/satisfy the criteria above. The percentage of cementlime specified shall also be sufficient to overcome/allow for expected variations during the mixing process, per ASTM D-3155.
- (e) Unconfined Compressive Strength: Minimum 160 psi in five days curing at 100°F. when tested in accordance with ASTM D-1633 Method A or an alternate compressive strength method approved by the Engineer.

For Soil Modification purposes only, the mix design shall specify the minimum amount of quicklime or Hydratedhydrated lime slurry required to meet the desired improved soil properties.

**309.3.3 Tolerance:** At final Compaction, the lime and water content for each course of subgrade treatment shall conform to the approved mix design with the following tolerance:

<u>Material</u>	<u>Tolerance</u>
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Lime	+0.5% of design, (ASTM C-114)
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Water	<del>+4%, -0% of</del> Optimum <u>to optimum +4%</u> , (ASTM D-698)
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### 309.4 CONSTRUCTION:

**309.4.1 General:** It is the primary requirement of this specification to secure a completed subgrade containing a uniform lime mixture, free from loose segregated areas, of uniform density and moisture content, well bound for its full depth, and with a smooth surface suitable for placing subsequent courses.

Prior to beginning any lime ~~slurry~~-stabilization or modification, the subgrade shall be constructed and brought to grade and shall be shaped to conform to the typical sections, lines and grades as shown on the plans.

When the design requires treatment to a depth greater than 12 inches, the subgrade soil shall be treated in equal layers. The top layer(s) of soil shall be removed and stockpiled. The lower layer of soil to be treated shall then be treated and allowed to cure in place. After final mixing, the lower layer shall be compacted in maximum 12 inch thick compacted lifts. The stockpiled soil shall then be placed, treated, mixed and compacted in successive maximum 12 inch thick compacted lifts.

**309.4.2 Weather Limitation:** Lime ~~slurry~~-treated subgrade shall not be constructed if the atmospheric ambient temperature is below 40° F. or when conditions indicate that temperatures may fall below 40° F. within 24 hours.

**309.4.3 Equipment:** Contractor shall provide all equipment necessary to complete the work including grading and scarifying equipment, a spreader of the lime, ~~slurry (gravity feed spreader, will not be permitted)~~, mixing and pulverizing equipment, sheepsfoot and pneumatic rollers, sprinkling equipment and trucks. Gravity feed or tailgate spreading, defined as not having automatic controls, will not be permitted. The spreader shall demonstrate the ability to maintain a consistent spread rate over variable travel speeds. When using dry hydrate to make slurry, agitators are mandatory in distributor trucks. All equipment used for this work is subject to approval by the Engineer.

**309.4.4 Application:** Lime ~~slurry~~ shall be spread only on that area where the mixing operation can be completed during the same working day. ~~The application and mixing of lime with the soil shall be accomplished by the methods hereinafter described as Slurry Placing.~~

309.4.4.1 Dry Hydrated Lime or Dry Quicklime Application: Hydrated lime or quicklime shall only be applied by approved spreader trucks equipped with operating dust collectors to minimize dust issues while loading. Additionally, dust control measures must be observed during the spreading and soil mixing of dry lime.

309.4.4.2 Slurry Application: ~~Slurry Placing:~~ Lime slurry shall be mixed in a portable mixing unit and spread with trucks equipped with an approved distribution system as a slurry. Commercial lime slurry shall be applied at ~~the~~with a lime percentage determined by the mix design, not less than specified herein. ~~The distribution of lime slurry shall be attained by successive passes over a measured section of subgrade until the proper amount of lime has been spread, as determined in the job mix design. The rate of application shall be verified using the methods outlined by ASTM D-3155.~~ The contractor shall provide the Engineer with the daily production quantities for the lime slurry.

**Thickness:** The thickness of the lime ~~slurry~~-treated subgrade shall be determined by visual inspection and/or by depth tests taken at intervals so that each test shall represent no more than 1000 square yards per layer. If more than one layer, the method used to remove material to determine the depth of lime treatment may be by shovel and/or pick, coring or other method approved by the Engineer. Phenolphthalein solution shall be used to detect the presence of lime. When the grade deficiency is more than 1 inch, the Contractor shall correct such areas in a manner satisfactory to the Engineer. Contractor shall replace, at no cost to the Agency, the material where depth tests are taken.

No traffic other than the mixing equipment will be allowed to pass over the spread of lime slurry until after completion of mixing.

The Engineer reserves the right to vary the rate of application of lime from the specified application rates during the progress of construction as necessary to maintain a pH of the lime/soil mixture above 12.04 and the desired characteristics of the treated subgrade.

**309.4.5 Mixing:** The full depth of the treated subgrade shall be mixed with an approved mixing machine. The use of disc plows or blades are strictly prohibited except in areas specified by the engineer. To insure a complete chemical reaction of the lime and soil or subgrade, water shall be used as required to maintain a minimum moisture content 4% above the optimum prior to beginning compaction and held at optimum to +4% of 0-4% above optimum during compaction. During the interval of time between application and mixing, lime that has been applied, unmixed and exposed to the open air for 10 hours or more will not be accepted.

After mixing and prior to compaction, clay lumps shall meet the following criteria:

	<u>Percent</u>
Minimum of clay lumps passing 1-1/2 inch sieve	100
Minimum of clay lumps passing No. 4 sieve	60

**309.4.6 Compaction:** Compaction of the mixture shall begin after final mixing and shall be accomplished in accordance with the design specifications. ~~Sheepsfoot or segmented wheel rollers shall be used during initial compaction. Steel wheel or pneumatic tired rollers shall be used only during final compaction.~~ Areas inaccessible to conventional rolling equipment rollers shall be compacted to the required density by methods approved by the Engineer.

The material shall be aerated or watered as necessary to provide and maintain required moisture content. The field density of the compacted mixture shall be at least 95 percent of the maximum wet density at optimum to +4% of 0-4% above optimum moisture content. A composite of untreated soil or subgrade materials from a minimum of five (5) random locations, per soil type, within the area to be stabilized shall be used to determine the maximum wet density and optimum moisture content in accordance with ASTM D-558. The in-place ~~field compacted field~~ density shall be determined in accordance with ASTM D-1556, ASTM D-2167 or ASTM D-69382922. The adjustment for rock larger than the no. 4 sieve shall be performed in accordance with ARIZ 227c.

After each section is completed, tests will be made by the Engineer. If the material fails to meet the density requirements, it shall be reworked to meet requirements.

If pumping subgrade should become evident at any time prior to paving, the Engineer may require proof rolling with a pneumatic-tire roller or other approved equipment in order to identify the limits of the unacceptable area. The proof rolling will be performed at no additional cost to the Contracting Agency.

All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing material as required, and reshaping and recompacting. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereupon or the work is accepted. Compaction and finishing shall be done in such a manner as to produce a smooth dense surface free of compaction planes, cracks, ridges or loose materials.

Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion, shall be smooth and shall conform with the typical section shown on the plans and to the established lines and grades. Should the material, due to any reason or cause, lose the required stability, density, and finish before the next course is placed or the work is accepted, it shall be recompacted and refinished at no cost to the Agency.

**309.4.7 Finishing and Curing:** After the final layer or course of lime treated subgrade has been compacted, it shall be brought to the required lines and grades in accordance with the plans. The completed section shall then be finished by rolling with a pneumatic or other suitable roller.

~~The final~~Each layer of lime treated subgrade shall be maintained in a moist condition until the next layer of pavement structure is placed. If required, a fog seal for curing, in compliance with MAG Section 333, shall be furnished and applied to the surface of the final layer of the lime stabilized material as soon as possible after the completion of final rolling and before the temperature falls below 40° F. Curing seal shall be applied at a rate between 0.10 and 0.20 gallons per square yard of surface. The exact rate will be determined d by the Engineer.

After curing begins, all traffic, except necessary construction equipment shall be kept off the lime stabilized subgrade for a minimum of 7 days or until the final pavement structure layer(s) are placed. As an alternative, the contractor may place a loose lift of aggregate base course over the curing subgrade. The aggregate base course should be kept moist during the curing process.

**309.4.8 Maintenance:** The Contractor shall maintain, at his/her own expense, the entire lime ~~slurry~~ treated subgrade in good condition from the start of work until all the work has been completed, cured and accepted by the Engineer.

### **309.5 MEASUREMENT:**

The quantity of lime slurry treated soils shall be measured by the square yard, measured in place, treated, compacted, to the proper depth, and accepted.

The quantity of curing seal shall be measured by the ton.

### **309.6 PAYMENT:**

The lime ~~slurry~~ treated soils measured as provided above, will be paid for at the contract price per square yard, which price shall be full compensation for the item complete, as herein described and specified.

The Owner or Engineer reserves the option to pay for the lime separately. Should this option be chosen, the lime treated soils measured as provided above will be paid for at the contract price per square yard which shall include full compensation for the item less lime, as herein described and specified. The Lime materials will be paid for by the contract price per ton based on hydrated lime. If quicklime is used there will be an additional pay factor of 1.3 applied to determine the actual amount of hydrated lime placed.

Payment for curing seal will be by the ton, based on the rate of application as requested by the Engineer.