



Soils - Use of Lime during Construction

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GEOTECHNICAL GUIDELINES FOR THE USE OF LIME DURING CONSTRUCTION

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(Note: This policy was jointly developed by Fairfax, Loudoun and Prince William Counties. The formatting from Fairfax County's original Lime Policy has been maintained for uniformity.)



PART X 4-0X00 USE OF LIME FOR DRYING, MODIFICATION AND STABILIZATION

4-0X01 Applicability and Restrictions

1. Part X presents geotechnical guidelines and minimum requirements for the design and construction of projects using lime for drying, modification and stabilization of soil. The following definitions apply to this geotechnical guideline:

A. *Active Zone or Zone of Seasonal Fluctuation* is the zone under and around a structure where the soil's moisture content is appreciably affected by climatic conditions and environmental factors. For building footings the Active Zone extends up to a minimum of 4 feet below the exterior finish grade, or 2 feet below the bottom of the footing, whichever is deeper. For pavements, the Active Zone extends to 4 feet below the finished pavement surface.

B. *Authority Having Jurisdiction (AHJ)* is the local jurisdiction issuing this policy.

C. *Expansive Soil within the Active Zone* is defined by the International Building Code as:

"Soils meeting all four of the following provisions shall be considered expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D 4318.
2. More than 10 percent of the soil particles pass a No. 200 sieve (75 µm), determined in accordance with ASTM D 422.
3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.
4. Expansion Index greater than 20, determined in accordance with ASTM D 4829."

D. *Mellowing* is the textural change of soil due to the phenomenon of cation exchange followed by flocculation and agglomeration due to the chemical reaction between lime and clay soil particles.

E. *Soil Drying* is a rapid decrease in soil moisture content due to the chemical reaction between water in the soil and lime and is limited to non-expansive soil.

F. *Soil Modification* is a reduction in soil plasticity, increase in optimum moisture content, decrease in maximum dry density, and improved compactability due to the chemical reaction between soil and lime. Soil Modification shall not be considered permanent.

G. *Soil Stabilization* is a permanent reduction in soil plasticity or expansion index so the soil is not expansive, and permanent strength gain occurs through pozzolanic reaction due to the chemical reaction between soil and lime.

H. *Lime* is quicklime or hydrated lime meeting the requirements of ASTM C 977, "Standard Specification for Quicklime and Hydrated Lime for Soil Stabilization."



2. Soil Drying is limited to the soil that meets the standards of suitable structural fill material as established by the VDOT Road and Bridge Specifications, Virginia Uniform Statewide Building Code, the AHJ's site construction standards, and project documents approved by the AHJ. For Soil Drying a separate geotechnical study or report is not required to be submitted to the AHJ; however, notice in writing shall be given to the AHJ prior to the use of lime for Soil Drying.
3. Soil Modification is limited to soils that are below the Active Zone. For Soil Modification, a geotechnical study or report shall be submitted to and approved by the AHJ. The lime modified soils below the Active Zone shall have a Plasticity Index (PI) of 20 or less.
4. Stabilization of expansive soils by mixing or blending with dry or slurry lime may be considered for various engineering applications requiring the placement of structural or engineered fill within the Active Zone. For Soil Stabilization, a geotechnical study or report shall be submitted to and approved by the AHJ.
5. Lime storage, handling and mixing shall not allow airborne dust particles to leave the property. Additionally, lime storage, handling and mixing shall not occur where occupied structures or areas of public use are within 300 feet, unless the contractor can demonstrate, to the satisfaction of the AHJ that the construction techniques will not allow visible airborne dust particles to drift over the occupied structures or areas of public use.
6. The AHJ may require that regardless of location, adjoining property owner notices must be served on all properties adjoining the lime project site. A minimum of five adjoining properties must be served with notices at the time of geotechnical report submission. The format of such notices shall be approved by the AHJ.
7. Each proposal to use lime shall be reviewed and approved on a case by case basis by the AHJ, except when lime is used for Soil Drying, in which case a written notice shall be given to the AHJ prior to the use of lime for Soil Drying.
8. Lime stabilization shall not be used if the soluble sulfate content by weight in the expansive soils exceeds 5,000 parts per million. The soluble sulfate content in soils to be stabilized shall be determined in accordance with AASHTO T290.
9. Strength gain due to the pozzolanic reaction of lime treated soils shall not be included in the design of slopes.
10. Strength gain due to the pozzolanic reaction of lime treated soils, Soil Stabilization, will only be recognized in pavement design in the following manner: The Thickness Index shall be determined based on the CBR values in accordance with VTM-8 of the natural subgrade soils prior to stabilization. Only the top 8 inches of the stabilized soil may be considered as part of the pavement structure necessary to achieve the required Thickness Index.
11. Soil modified or stabilized by lime shall not be used as backfill for basement



walls and retaining walls unless approved otherwise by the AHJ.

12. Lime modification and lime stabilization will not be permitted when the soil, aggregate or the surface on which the lime treated soil is to be placed is frozen, and manipulation (i.e. mixing) shall not be started until the surface is free of frost. Lime modification shall not start until the temperature of the soil to be treated with lime is at least 35 degrees F. Lime stabilization shall not start until the air temperature at the project site is at least 40 degrees F.

13. All lime stabilization within the VDOT Right-of-Way shall be completed in accordance with the current VDOT Road and Bridge Specifications and this policy. If there is a conflict between the current VDOT Road and Bridge Specifications and this policy, the most restrictive requirement applies.

14. Lime shall not be used in Storm Water Management facilities.

4-0X02 Expansive Soil Determination

1. The geotechnical engineer shall use the properties identified in Section 4.0X01.C to evaluate the volume change of potentially expansive soils. These tests shall be performed on representative samples from each soil mapping unit deemed potentially expansive soils impacting the proposed construction.

2. All laboratory test data, interpretations and supporting graphs shall be included in the geotechnical report.



4-0X03 Mixture Design for Lime Stabilization of Soil

1. The appropriate lime content for field application shall be determined in accordance with the National Lime Association (NLA) Technical Brief, *Mixture Design and Testing Procedures for Lime Stabilized Soil*, October 2006 (attached) with the following amendments:

A. Organic Content – The soil proposed to be stabilized shall be natural inorganic soil as defined by ASTM D 2487 and shall contain no more than two percent (2%) organic material by dry weight as determined by ASTM D 2974. The intentional mixing of organic material with natural inorganic soil is not permitted.

B. Expansion Index (EI) Testing Procedures – In accordance with the Virginia Uniform Statewide Building Code ASTM D 4829 shall be used for EI Testing.

C. Lime used to perform the laboratory tests shall be of the same type, grade, and consistency as the lime to be used for field application.

D. Validation testing for the prescribed minimum amount of lime determined for stabilization of soil:

- 1) Determine the Expansive Index (EI) of the cured specimens using a minimum of two duplicate tests conducted in accordance with ASTM D 4829. The EI shall be equal to or less than 20 in order for lime stabilization to be considered as effective in controlling soil expansion; or
- 2) Determine the Plasticity Index (PI) of material from the cured specimens in accordance with ASTM 4318. The PI shall be less than 15 in order for lime stabilization to be considered as effective in controlling soil expansion.

E. To allow for variations in the soil properties in the field, increase the required minimum lime content as determined by the above procedures by at least 0.5 percent by dry weight and use this value as the design lime content.

F. Maps, boring logs and laboratory test data and their interpretations (including analysis; plots; the location of each of the proposed lime mix designs including the depth and lateral extent of the proposed lime stabilization; and conclusions) must be included in the geotechnical report.



4-0X04 Treatment Requirements for Lime Stabilization of Soil

1. The minimum depth and lateral extent of treatment specified below shall be used in the absence of engineering analyses and/or controlled experiments or pilot studies substantiating the adequacy of alternative treatment depths and areas. If vegetation is to be established, it shall be planted in non-stabilized soil in accordance with standard landscaping practices.

A. Fills: The depth and extent of treatment shall conform to the minimum requirements specified below for the specific engineered structure to be supported by the fill.

B. Building Pads: When lime stabilization is used, the depth of stabilization shall extend through the active zone. The lime stabilization shall extend at least five (5) feet beyond the projected perimeter of the building's or structure's footing/foundation.

C. Backfill behind Basement Walls and Retaining Walls: Lime modified and lime stabilized soils shall not be placed as backfill behind basement walls and retaining walls, unless approved otherwise by the AHJ.

D. Backfill for Utility Trenches: Lime modified and lime stabilized soils may be used to backfill utility trenches.

E. Roadway and Parking Lot Subgrades: In fill areas, the depth of stabilization shall be at least 4 feet below the finished pavement surface. In cut areas, the depth of stabilization shall extend to at least 2 feet below the subgrade elevation. The lime stabilization shall extend at least 2 feet beyond the proposed edges of the pavement, shoulders and sidewalks.

If lime stabilized soils are to be used in the determination of the Thickness Index for the pavement design, the stabilized soil shall have a minimum unconfined compressive strength of 150 psi when prepared and tested in accordance with VTM-11. The required pavement Thickness Index shall be determined based on the CBR values in accordance VTM-8 of the natural subgrade soils prior to stabilization. Only the top 8 inches of the stabilized soil may be considered as part of the pavement structure necessary to achieve the required Thickness Index.

2. Alternative treatment depths and areas may be used provided their adequacy is satisfactorily demonstrated and pursuant to obtaining approval from the AHJ. All supporting data, logic, rationale, assumptions, field control procedures and conclusions shall be thoroughly documented in the geotechnical report.

A. The geotechnical engineer shall evaluate the variation of the swell potential and swell pressure with depth for the expansive soils encountered at a particular site.

B. Swell tests shall be conducted on disturbed or undisturbed soil samples or both depending on the requirements of the particular application. These tests shall be conducted in accordance with ASTM Test Method D 4546 (Method B), ASTM D 4829



and/or other testing methods approved by the AHJ. The tests shall take into account field conditions, including but not limited to: moisture variation, compacted densities, and surcharge loads.

C. Based on pilot studies, the geotechnical engineer may recommend alternative treatment for the depth and lateral extent to which treatment should extend in order to achieve the desired performance or required design parameters, such as allowable differential movement and swelling pressures.

4-0X05 Health and Safety Precautions for Soil Treatment with Lime

1. Various types of lime can be used in a dry or slurry form for soil treatment. Care must be taken during construction to avoid skin and eye burns, especially if quicklime is used. Water shall be applied and mixing operations shall be started immediately after spreading lime in order to avoid or minimize unnecessary exposure.

2. The contractor shall be responsible for controlling fugitive dust due to lime application, on and off the project limits. Dry lime shall not be delivered, spread or mixed when wind or other conditions allow lime dust to leave the construction site. In the event that lime leaves or appears likely to leave the construction site - as determined from visual observation - the contractor shall immediately cease operations. Operations shall not be resumed until working conditions are suitable or alternate construction techniques are employed to ensure that lime dust does not leave the construction site.

3. Water runoff from any project site must be controlled by the contractor. Lime must not be allowed to flow with water runoff to any surface water body on or off a project site or onto an adjacent site.

4. The AHJ may require that a Health and Safety Plan be called for in the project specifications. The health and safety plan shall include, but not be limited to, the identification of precautions for exposure to lime, associated operations and products, protocols for ensuring adherence to the plan requirements, and emergency medical treatment available on and near the job site. The Health and Safety Plan shall be prepared by a competent professional for the contractor. If required by the AHJ, a copy of the Health and Safety Plan shall be provided to the AHJ.



4-0X06 Lime Stabilization Specifications

1. Lime stabilization shall be accomplished according to a set of specifications prepared by the Registered Design Professional of Record (RDPR) registered in the Commonwealth of Virginia, which shall include a Field Quality Control Plan meeting the minimum requirements of Sections 4-0X01, 4-0X04 and 4-0X07. These specifications shall be submitted to the AHJ for review and approval. If the RDPR is not the Geotechnical Engineer of Record (GER) for project, the GER shall provide a certification to the AHJ indicating that they have reviewed the specifications prepared by the RDPR and concur with the specifications, findings and recommendations.
2. The specifications shall describe the work, identify suitable material (lime, water, etc.) requirements, identify the type of equipment for mixing, describe the contractor's experience and address at a minimum, the following construction methods: soil preparation; lime spreading; mixing and watering; mellowing; and compaction and finishing.

4-0X07 Field Quality Control for Lime Modification and Stabilization of Soil

1. Field quality control must be provided on every project where lime modification and lime stabilization is used and shall be monitored under the direction of the RDPR, qualified and experienced in soil and foundation engineering. Daily written documentation of all monitoring activities, including, but not limited to, field observations, construction equipment, source, type, grade and consistency of lime, sampling and test locations, test results and supporting measurements, etc., shall be maintained and readily available at the project field office and be made available to the AHJ upon request.
2. At a minimum, the following elements shall be included in the Field Quality Control Plan which shall be submitted to the AHJ for review prior to approval of the Site Plan. (Where required, random sampling, measurement and testing locations, and random locations shall be determined in accordance with ASTM Standard D 3665.)
 - A. Depth of Lime Treatment. The depth of treatment shall be investigated for every application by digging test holes and spraying a non-hazardous color sensitive indicator solution on the treated soil exposed on the sides of the test holes. If lime is present in the soil, it should react with the indicator solution and cause a change in color to develop. For subgrade stabilization applications, one (1) test hole is required per 3,000 square foot area of treated soil. A minimum of three (3) test holes are required for any subgrade stabilization application. The test holes shall be randomly located. The minimum number of test holes required is on a per layer (lift) basis when mixing is accomplished in-place by a traveling mixer. When lime-soil mixing is accomplished using a stationary mixer, the minimum number of test holes required may be based on the surface area of the total thickness of lime stabilized soil.



B. Lateral Extent of Lime Treatment. Prior to stabilizing an area, the limits of lime treatment shall be established in the field by a survey. The extent of the treated areas will be identified by the geotechnical engineer and the field surveys shall be conducted by a professional land surveyor or registered design professional registered in the Commonwealth of Virginia. In addition, test holes used to check the depth of treatment shall also be used to verify the lateral extent of treatment.

C. Dry Lime Spread Rate. The spread rate of dry lime shall be determined or measured for every lift in terms of pounds of lime per unit area of surface. If lime is applied in bags, the spread rate can be determined from: the number of bags used, the weight of lime per bag, and the area being treated. If lime is applied in bulk via mechanical means, a one-square-yard piece of canvas or other suitable material shall be placed on the ground at random locations at least once per day during continuous operation, and the weight of lime spread on it measured after lime application is completed. A minimum of three (3) measurements shall be conducted for bulk applications, with one (1) test being conducted at the start of spreading lime.

D. Spread Rate of Lime-Slurry Composition. The spread rate of lime-slurry over a known (measured) area can be based on the lime solids content. The amount of lime solids in a lime-slurry mixture can be determined by measuring the specific gravity of the slurry. The specific gravity shall be determined via hydrometer test in accordance with ASTM D 422. Alternative methods to measure the specific gravity of lime slurry may be proposed to the AHJ for review and approval. A minimum of one (1) test shall be conducted for every 2,500 gallons of slurry mix or portion thereof. Samples must be taken at random locations after slurry spreading begins.

E. Mellowing and Pulverization. A minimum duration of 24 hours is required for mellowing, unless laboratory studies show that the PI is reduced to less than 15 in a shorter period of time. Tests shall be conducted in the field to assure proper pulverization after mellowing and prior to final placement or compaction. The lime treated material must be mixed until 100 percent of it, exclusive of the coarse aggregate, passes the 1-inch sieve and a minimum of 60 percent of it, exclusive of the coarse aggregate, passes the U.S. Number 4 sieve. If the lime stabilization is completed in two (2) days or less, three (3) tests shall be conducted, with one (1) test being conducted at the start of operations. If the lime stabilization is completed in more than 2 days, at least one (1) test per lift shall be conducted each day during continuous operation.

F. Testing Prior to Final Compaction. The maximum allowable loose lift thickness is 8 inches. After pulverization and prior to final compaction, samples from random locations within each lift shall be taken for pH (ASTM D 6276) and PI (ASTM D 4318) or EI (ASTM D 4829) determinations. One (1) soil sample shall be taken and tested for every 1,000 cubic yards of stabilized soil with a minimum of one (1) soil sample per day from each lift of stabilized soil. However, if the test results indicate the work is not in



compliance with the approved specifications, the AHJ may require a greater testing frequency. The pH determination shall not be less than a pH of 12.2 and no more than 10% of pH determinations shall be less than a pH of 12.3. Field pH testing is not required for lime modified soil.

G. Compaction Characteristics. For every type of expansive soil to be modified or stabilized at the job site, laboratory moisture density curves must be determined for a mixture of that soil with the design lime content. The laboratory compaction tests shall be conducted in accordance with ASTM Test Method D 698. The compaction in the field shall be monitored based on the laboratory moisture-density test results. One (1) field density test shall be conducted per 10,000 square foot area of each compacted lift, with a minimum of three (3) tests per lift. Tests shall be made at random locations within each lift. Field density tests shall be conducted in accordance with ASTM Standard D 2922 or ASTM D 1556 or a combination of the two standards. Since the moisture-density relationships change with time during curing, testing for field moisture-density characteristics must be conducted as soon as the compaction of the mixture has been completed.

H. Other Engineering Characteristics. Other field tests may be appropriate to demonstrate the quality control or verify the anticipated performance of the lime-treated material for the particular application. The type, purpose, frequency, and location of all other field tests shall be documented in the quality control plan.

I. The RDPR shall compile a summary report of all site observations and testing performed on a daily basis and submit signed and sealed reports to the AHJ within 5 business days. All technicians performing work within the VDOT Right-of-Way shall obtain certification through VDOT, and certification by any other agency is not acceptable.



4-0X08 Quality Assurance

1. Quality assurance shall be provided by the Geotechnical Engineer of Record (GER) on every project where lime treatment is used, and shall include at a minimum, a weekly audit of field quality control activities and a final written summary report.

A. The final report shall be signed and sealed by the GER and shall include, but not be limited to: a summary of all monitoring data; audit results; steps taken to correct any deficiencies or items not in compliance with the specifications and Field Quality Control Plan; a statement indicating whether or not lime modification or stabilization for all applications of the subject project has been performed in accordance with the specifications and Field Quality Control Plan; a recommendation for any work to be completed prior to the release of performance bonds and/or the issuance of residential or non-residential use permits; and all supporting data.

B. The audits and final summary report shall be conducted and prepared under the direction of a Virginia registered design professional, specializing in soil and foundation engineering.

C. The final summary report shall be submitted to the AHJ for review prior to the release of performance bonds and/or the issuance of the Certificate of Occupancy related to the subject project.

Attachment/Hyperlink:

- [National Lime Association \(NLA\) Technical Brief, *Mixture Design and Testing Procedures for Lime Stabilized Soil*, October 2006](#)