Designation: D5102 – 09

Standard Test Methods for Unconfined Compressive Strength of Compacted Soil-Lime Mixtures[1]

This standard is issued under the fixed designation D5102; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers procedures for preparing, curing, and testing laboratory-compacted specimens of soil-lime and other lime-treated materials (Note 1) for determining unconfined compressive strength. This test method can be used for specimens prepared at the maximum unit weight and optimum water content, or for specimens prepared at other target unit weight and water content levels. Other applications are given in Section 5 on Significance and Use.

NOTE 1—Lime-based products other than commercial quicklime and hydrated lime are also used in the lime treatment of fine-grained cohesive soils. Lime kiln dust (LKD) is collected from the kiln exhaust gases by cyclone, electrostatic, or baghouse-type collection systems. Some lime producers hydrate various blends of LKD plus quicklime to produce a lime-based product.

1.2 Cored specimens of soil-lime should be tested in accordance with Test Methods D2166.

1.3 Two alternative procedures are provided:

1.3.1 Procedure A describes procedures for preparing and testing compacted soil-lime specimens having height-to-diameter ratios between 2.00 and 2.50. This test method provides the standard measure of compressive strength.

1.3.2 Procedure B describes procedures for preparing and testing compacted soil-lime specimens using Test Methods D698 compaction equipment and molds commonly available in most soil testing laboratories. Procedure B is considered to provide relative measures of individual specimens in a suite of test specimens rather than standard compressive strength values. Because of the lesser height-to-diameter ratio (1.15) of the cylinders, compressive strength determined by Procedure B will normally be greater than that by Procedure A.

1.3.3 Results of unconfined compressive strength tests using Procedure B should not be directly compared to those obtained using Procedure A.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.4.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.5 Lime is not an effective stabilizing agent for all soils. Some soil components such as sulfates, phosphates, organics, etc. can adversely affect soil-lime reactions and may affect the test results using this method.

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.6.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The rationalized slug unit is not given, unless dynamic (F = ma) calculations are involved.

1.6.2 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two separate systems of units; that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording density in lbm/ft^3 shall not be regarded as non-conformance with this standard.

[1] These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization With Admixtures.

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***A Summary of Changes section appears at the end of this standard**

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.* For specific precautionary statements, see Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C51 Terminology Relating to Lime and Limestone (as used by the Industry)

C977 Specification for Quicklime and Hydrated Lime for Soil Stabilization

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D2166 Test Method for Unconfined Compressive Strength of Cohesive Soil

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D3551 Practice for Laboratory Preparation of Soil-Lime Mixtures Using Mechanical Mixer

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology D653 for terms relating to soil and Definitions C51 for terms relating to lime and limestone.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lime content*—the ratio, expressed as a percentage, of (*a*) the dry (as received/packaged) mass of lime to (*b*) the dry mass of soil.

3.2.2 *unconfined compressive strength of soil-lime (q_u)*—the compressive stress at which an unconfined cylindrical specimen of soil-lime will fail in an axial compression test. In this test method, unconfined compressive strength is either the maximum axial load/force attained per unit area or the load/force per unit area at 5 % axial strain, whichever occurs first during performance of a test.

3.2.3 *carbonation*—partial or complete transformation of calcium hydroxide or magnesium hydroxide (or both) to carbonate phases due to reaction with carbon dioxide. Carbonation may take place during manufacture and storage of lime, laboratory mixing, curing and testing of soil-lime mixtures, construction, and service. Carbonation will reduce the effectiveness of the lime in producing desired soil-lime reactions.

3.2.4 See Section 7 on Reagents and Materials.

4. Summary of Test Method

4.1 Dependent on design criteria, a predetermined number of compacted soil-lime specimens are prepared for each specified lime content, unit weight, and water content so unconfined compression testing can be performed on laboratory cured specimens of specified ages. In many instances, single or preferably duplicate specimens are tested following a 28 and 90-day curing period at room temperature. In some cases, however, a curing period of 7 days at room temperature or accelerated curing conditions may be necessary.

4.2 The amount of soil, lime, and water required for the specimen is determined. The soil-lime-water mixture is compacted in a mold to the desired initial specimen conditions (moist/dry unit weight and molding water content).

4.3 After removal from the mold, specimens are cured for a specified number of days.

4.4 Following the curing period, the soil-lime specimens are loaded in compression to failure. Maximum load or load at 5 % axial strain is used to calculate unconfined compressive strength.

5. Significance and Use

5.1 Compression testing of soil-lime specimens is performed to determine unconfined compressive strength of the cured soil-lime-water mixture to determine the suitability of the mixture for uses such as in pavement bases and subbases, stabilized subgrades, and structural fills.

5.2 Compressive strength data are used in soil-lime mix design procedures: (*a*) to determine if a soil will achieve a significant strength increase with the addition of lime; (*b*) to group soil-lime mixtures into strength classes; (*c*) to study the effects of variables such as lime percentage, unit weight, water content, curing time, curing temperature, etc.; and (*d*) to estimate other engineering properties of soil-lime mixtures.

5.3 Lime is generally classified as calcitic or dolomitic. Usually in soil stabilization, high-calcium lime [CaO] or dolomitic lime [CaO + MgO] are used. The lime is transformed from oxide to hydroxide form [[$Ca(OH)_2$ or [$Ca(OH)_2$ + $Mg(OH)_2$]] by the addition of water in the soil, a slurry tank, or at a manufacturing facility. Lime may increase the strength of cohesive soil. The type of lime in combination with soil type influences the resulting compressive strength.

NOTE 2—The agency performing this test method can be evaluated in accordance with Practice D3740. Not withstanding statements on precision and bias contained in this method: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facility used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not, in itself, ensure reliable testing. Reliable testing depends on many factors; Practice D3740 provides a

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.