Designation: D 5102 – 96

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

This standard is issued under the fixed designation D 5102; 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. Cored specimens of soil-lime should be tested in accordance with Test Methods D 2166.

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 Two alternative procedures are provided:

1.2.1 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.

1.2.2 Procedure B describes procedures for preparing and testing compacted soil-lime specimens using Test Methods D 698 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. Results of unconfined compressive strength tests using Procedure B should not be directly compared to those obtained using Procedure A.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3.1 The use of balances or scales to record pounds of mass (lbm) or to record density in pounds of mass per cubic foot (lbm/ft^3) should not be regarded as nonconformance with this test method.

1.4 *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 limitations prior to use.* For specific precautionary statements, see Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*

C 51 Definitions of Terms Relating to Lime and Limestone (As Used by the Industry)[2]

C 977 Specification for Quicklime and Hydrated Lime for Soil Stabilization[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[3]

D 2166 Test Methods for Unconfined Compressive Strength of Cohesive Soil[3]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[3]

D 3551 Method for Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer[3]

D 3740 Practice for the Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock Used in Engineering Design and Construction[3]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[3]

3. Terminology

3.1 *Definitions:*

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

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[2] *Annual Book of ASTM Standards*, Vol 04.01.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

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

3.1.1 Refer to Terminology D 653 for terms relating to soil and Definitions C 51 for terms relating to lime and limestone.

3.1.2 *Definitions of Terms Specific to This Standard*:

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

3.1.4 *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 the maximum axial load attained per unit area or the load per unit area at 5 % axial strain, whichever occurs first during performance of a test.

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, 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.

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 hydrated lime [$Ca(OH)_2$] or monohydrated dolomitic lime [$Ca(OH)_2 + MgO$] are used. 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 D 3740. 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 D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with D 3740 does not, in itself, ensure reliable testing. Reliable testing depends on many factors; Practice D 3740 provides a means of evaluating some of these factors.

6. Apparatus

6.1 *Balance or Scale*:

6.1.1 *Procedure B*, a balance or scale for determining the mass of soil, lime, and water, having a minimum capacity of 20 kg and meeting the requirements of Specification D 4753 for a balance of 1-g readability.

6.1.2 *Procedure A*, a balance or scale, for preparing test specimens for Procedure A and for determining water content, having a minimum capacity of 1000 g and meeting the requirements of Specification D 4753 for a balance of 0.1-g readability.

6.2 *Specimen Dimension Measurement Devices*, dial comparators, calipers, circumferential tape or other suitable devices for measuring the height and diameter of the specimen within 0.1 % of the measured dimension.

6.3 *Specimen Molds*:

6.3.1 *Procedure A*, molds having sufficient capacity to provide specimens with length-to-diameter ratios between 2.00 and 2.50. Molds 50 ± 0.2 mm (2.0 ± 0.01 in.) in diameter by 125 ± 0.2 mm (5.0 ± 0.01 in.) high or 50± 0.2 mm (2.0 ± 0.01 in.) in diameter by 100 ± 0.2 mm (4 ± 0.01 in.) high are commonly used. Split molds may be used. The mold shall have an extension collar assembly made of rigid metal and constructed so it can be securely attached to and detached from the mold.

6.3.2 *Procedure B*, molds with extension collars conforming to the requirements of Method D 698.

6.4 *Tamping Rod or Compaction Hammer*, tamping rod or compaction hammer suitable for mold size and preparation of specimen at desired unit weight.

6.5 *Test Specimen Extruder*—An extruder is required if split molds are not used. The device shall consist of a piston, jack, and frame or similar equipment suitable for extruding specimens from the mold.

6.6 *Containers*, suitable plastic airtight, moistureproof containers for sealing and storing specimens after compaction. The containers should be rigid to protect the specimens from disturbance during handling.

6.7 *Miscellaneous Equipment*, tools such as spatulas, knives, straightedge, trowels, scoops, etc., for use in preparing specimens.

6.8 *Temperature Controlled Room or Cabinet*, a room or cabinet capable of maintaining a temperature of 23.0 ± 1.7°C (73.4 ± 3.0°F) for curing soil-lime specimens. A moist room can be used but is not required.

6.9 *Timer*, a timing device to indicate the elapsed testing time to the nearest second for establishing the rate of strain application prescribed in 13.2.

6.10 *Compression Device and Load Indicator*—The compression device may be any device with sufficient capacity and control to provide the constant strain rate prescribed in 13.2. The device shall be equipped so the compressive load is applied to the specimen without producing eccentric loading conditions. When the compression device is set to advance at a specified rate, the actual rate shall not deviate from the