Designation: D5030/D5030M – 21

Standard Test Methods for Density of In-Place Soil and Rock Materials by the Water Replacement Method in a Test Pit[1]

This standard is issued under the fixed designation D5030/D5030M; 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 These test methods cover the determination of the in-place density of soil and rock materials using water to fill a lined test pit to determine the volume of the test pit. The use of the word "rock" in these test methods is used to imply that the material being tested will typically only contain particles larger than 3 in. [75 mm].

1.2 These test methods are best suited for test pits with a volume between approximately 3 and 100 ft^3 [0.08 and 3 m^3]. In general, the materials tested would have maximum particle sizes over 5 in. [125 mm]. These test methods may be used for larger sized excavations if desirable.

1.2.1 This procedure is usually performed using circular metal templates with inside diameters of 3 ft [0.9 m] or more. Other shapes or materials may be used providing they meet the requirements of these test methods and the guidelines given in Annex A1 for the minimum volume of the test pit.

1.2.2 Test Method D4914 may be used as an alternative method. Its use, however, is usually only practical for volume determination of test pits between approximately 1 and 6 ft^3 [0.03 and 0.2 m^3].

1.2.3 Test Method D1556 or Test Method D2167 is usually used to determine the volume of test holes smaller than 1 ft^3 [0.03 m^3].

1.3 The two procedures are described as follows:

1.3.1 *Procedure A*—In-Place Density and Density of Total Material (Section 12).

1.3.2 *Procedure B*—In-Place Density and Density of Control Fraction (Section 13).

1.4 *Selection of Procedure:*

1.4.1 Procedure A is used when the in-place density of the total material is to be determined. Procedure A can also be used to determine percent compaction or percent relative density when the maximum particle size present in the in-place material being tested does not exceed the maximum particle size allowed in the laboratory compaction test (Test Methods D698, D1557, D4253, D4254, and D7382). For Test Methods D698 and D1557 only, the density determined in the laboratory compaction test may be corrected for larger particle sizes in accordance with, and subject to the limitations of, Practice D4718.

1.4.2 Procedure B is used when percent compaction or percent relative density is to be determined and the in-place material contains particles larger than the maximum particle size allowed in the laboratory compaction test methods previously described or when Practice D4718 is not applicable for the laboratory compaction test method. Then, the material is considered to consist of two fractions, or portions. The material obtained from the in-place density test is physically divided into a control fraction and an oversize fraction based on a designated sieve size. The density of the control fraction is calculated and compared with the density(ies) established by the laboratory compaction test method(s).

1.4.3 Often, the control fraction is the minus No. 4 [4.75-mm] sieve size material for cohesive or nonfree-draining materials and the minus 3-in. [75-mm] sieve size material for cohesionless, free-draining materials. While other sizes may be used for the control fraction such as ⅜, ¾-in. [9.5, 19-mm], these test methods have been prepared using only the No. 4 [4.75-mm] and the 3-in. [75-mm] sieve sizes for clarity.

1.5 Any soil and rock material can be tested, provided that the material being tested has sufficient cohesion or particle attraction to maintain stable side walls during excavation of the test pit and through completion of this test. It should also be firm enough not to deform or slough due to the minor pressures exerted while digging the hole and filling it with water.

1.6 These test methods are generally limited to material in an unsaturated or partially saturated condition above the ground water table and is not recommended for materials that are soft or friable (crumble easily) or in a moisture condition such that water seeps into the excavated hole. The accuracy of the test may be affected for materials that deform easily or that may undergo volume change in the excavated hole from standing or walking near the hole while performing the test.

1.7 *Units*—The values stated in either inch-pound units or SI units [presented in brackets] are to be regarded separately as standard. The values stated in each system may not be exact

[1] These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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

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.

1.7.1 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 slug unit is not given, unless dynamic ($F = ma$) calculations are involved.

1.7.2 In the engineering profession, it is customary practice to use, interchangeably, units representing both mass and force, unless dynamic calculations ($F = ma$) are involved. This implicitly combines two separate systems of units, that is, the absolute system and the gravimetric system. It is scientifically undesirable to combine the use of two separate systems within a single standard. These test methods have been written using inch-pound units (absolute system) where the pound (lbm) represents a unit of mass; however, conversions are given in the SI system. The use of balances or scales recording pounds of weight (lbf), or the recording of density in lbf/ft^3 should not be regarded as nonconformance with this standard.

1.8 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this test method.

1.8.1 The procedures used to specify how data are collected, recorded or calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering data.

1.9 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement, see Section 9.

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C127 Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate

C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying

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))

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

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

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

D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density

D4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

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

D4914 Test Methods for Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit

D6026 Practice for Using Significant Digits in Geotechnical Data

D7382 Test Methods for Determination of Maximum Dry Unit Weight of Granular Soils Using a Vibrating Hammer

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

F2362 Specification for Temperature Monitoring Equipment

3. Terminology

3.1 For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *control fraction, n*—the portion of a soil sample consisting of particles smaller than a designated sieve size.

3.2.1.1 *Discussion*—This fraction is used to compare in-place densities with densities obtained from standard laboratory compaction test methods. The control sieve size depends on the laboratory test used.

3.2.2 *oversize particles, n*—the portion of a soil sample consisting of the particles larger than a designated sieve size.

3.2.2.1 *Discussion*—This designated sieve size is often the same sieve size used to determine the control fraction.

4. Summary of Test Method

4.1 The ground surface at the test location is prepared and a template (metal ring) is placed and fixed into position. A liner is laid in the template and the volume of the space between a selected level within the template and the ground surface is

[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.

determined by filling the space with water. The mass or the volume of the water required to fill the template to the selected level is determined and the water and liner removed. Material from within the boundaries of the template is excavated, forming a pit. A liner is placed in the test pit and template, water is poured into the pit and template up to the selected level; the mass or volume of the water within the pit and template and, subsequently, the volume of the hole are determined. The wet density of the in-place material is calculated from the mass of material removed and the measured volume of the test pit. The water content of the material is determined, and the dry density of the in-place material is calculated.

4.2 The density of a control fraction of the material can be determined by subtracting the mass and volume of any oversize particles from the initial values and recalculating the density.

5. Significance and Use

5.1 These test methods can be used to determine the in-place density of compacted soil and rock materials in construction of earth embankments, road fills, and structure backfill. For construction control, the test methods can be used as the basis for acceptance of material compacted to a specified density or to a percentage of a maximum density determined by a standard laboratory compaction test method such as determined from Test Methods D698 or D1557, subject to the limitations discussed in 1.4.

5.2 These test methods can be used to determine in-place density of natural soil deposits, aggregates, soil mixtures, or other similar material.

NOTE 1—The quality of the result produced by these test methods are dependent on the competence of the personnel performing them and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of these test methods are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Interferences

6.1 Because it is possible to observe lower densities in soil and rock materials created by particle interference (see Practice D4718), the percent compaction of the control fraction should not be assumed to represent the percent compaction of the total material in the field.

6.2 A very careful assessment must be made as to whether or not the volume determined is representative of the in-place condition when this test method is used for clean, relatively uniform-sized particles 3 in. [75 mm] and larger. The disturbance during excavation, due to lack of cohesion, and the void spaces between particles spanned by the liner may affect the measurement of the volume of the test pit.

7. Apparatus

7.1 *Balance or Scale,* having a capacity and readability appropriate to the mass and procedural techniques for the specific test pit dimensions within the range of 3 to 100 ft^3 [0.08 to 3 m^3] volume and meeting the requirements of Specification D4753.

7.2 *Balance or Scale,* a balance (or scale) to determine water content of minus No. 4 material having a minimum capacity of about 2 lbm [1000 g] and meeting the requirements of Specification D4753 for a balance of 0.001 lb [0.1 g] readability.

7.3 *Drying Oven,* thermostatically controlled, preferably of the forced-draft type, and capable of maintaining a uniform temperature of 110 ± 5°C throughout the drying chamber, in accordance with Test Methods D2216.

7.4 *Sieves,* No. 4 sieve [4.75-mm] and 3-in. [75-mm], conforming to the requirements of Specification E11.

7.5 *Thermometer,* use of electrical thermocouples or thermoresistive devices (Specification F2362) are required with readability to four significant digits.

7.6 *Metal Template,* a circular template to serve as a pattern for the excavation. Template dimensions, shapes, and material may vary according to the size of the test pit to be excavated. The template must be rigid enough not to deflect or bend.

NOTE 2—The template shown in Fig. 1 represents a design that has been found suitable for this purpose.

7.6.1 Since it may be difficult to place the template exactly level on the soil surface, particularly with 6-ft [1.8-m] and larger diameter rings, the height of the template should accommodate a slope of approximately 5 %. Since the water level is kept below the top of the template during testing, it is not necessary that the template be level. The top of the ring must be high enough to prevent any loss of water due to wave action caused by wind.

7.7 *Liners*—Material used to line the excavation and retain the test water should be approximately 4 to 6 mil [100 to 150 µm] thick. Two pieces, each large enough to line the test pit prior to and after excavation, with about 3 ft [1 m] extending beyond the outside of the template in both cases. Any type of

FIG. 1 A 6-ft [1.8-m] Diameter Metal Ring for Determining In-Place Density