Designation: ~~D7830/D7830M – 13~~ D7830/D7830M – 14

Standard Test Method for In-Place Density (Unit Weight) and Water Content of Soil Using an Electromagnetic Soil Density Gauge[1]

This standard is issued under the fixed designation D7830/D7830M; 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~~ Scope*

1.1 This test method covers the procedures for determining in-place properties of non-frozen, unbound soil and soil aggregate mixtures such as total density, gravimetric water content and relative compaction by measuring the ~~electromagnetic~~intrinsic impedance of the compacted soil.

1.1.1 The method and device described in this test method are intended for in-process quality control of earthwork projects. Site or material characterization is not an intended result.

1.2 *Units*—The values stated in either SI units or inch-pound units [given in brackets] 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.

1.2.1 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 in this standard.

1.2.2 In the engineering profession, it is customary practice to use, interchangeably, units representing both mass and force, unless dynamic calculations are involved. This implicitly combines two separate systems of units, that is, the absolute system and the gravimetric system. It is undesirable to combine the use of two separate systems within a single standard. The use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft^3 should not be regarded as nonconformance with this standard.

1.3 All observed and calculated values shall conform to the Guide for Significant Digits and Rounding established in Practice D6026.

1.3.1 The procedures used to specify how data is collected, recorded, and calculated in this standard are regarded as industry standard. In addition, they are representative of the significant digits that should generally 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; and it is common practice to increase or decrease the number of significant digits of reported data commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in the analysis methods for engineering design.

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.*

NOTE 1—ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

2. Referenced Documents

2.1 *ASTM Standards*:[2]

D422 Test Method for Particle-Size Analysis of Soils

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))

[1] This test method is 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.

Current edition approved ~~Feb. 1, 2013~~. Published ~~April 2013~~November 2014. ~~DOI: 10.1520/D7830-13.~~Originally approved in 2013. Last previous edition approved in 2013 as D7830 – 13. DOI:10.1520/D7830_D7830M–14.

[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.

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

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
D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method
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
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating
D4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
D7382 Test Methods for Determination of Maximum Dry Unit Weight and Water Content Range for Effective Compaction of Granular Soils Using a Vibrating Hammer
D4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
D4959 Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating
D6026 Practice for Using Significant Digits in Geotechnical Data
D6938 Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *Other Referenced Documents:*

"Development of a Non-Nuclear Soil Density Gauge to Eliminate the Need for Nuclear Density Gauges"[3]

3. Terminology

3.1 ~~*Definitions*~~—*Definitions:*

3.1.1 See Terminology D653 for general definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *impedance, n*—a measure of opposition to alternating current (AC).

3.2.2 *impedance spectroscopy, n*—a method that measures the electromagnetic properties of a medium as a function of frequency.

4. Summary of Test Method

4.1 The total or wet density and gravimetric water content of soil and soil-aggregate are correlated to empirical data using an electromagnetic impedance spectroscopy device. Electromagnetic properties of the soil are determined at specific frequencies by measuring the changes in the electromagnetic field. A function is generated that describes the relationship between electrical properties over a range of frequencies. That function is compared to an empirical model and other calibration checks to determine water content and density.

4.2 This method employs electromagnetic impedance spectroscopy to determine the volumetric water content and wet density. The measurement spectrum is made up of frequencies ranging from 30 kHz to 50 MHz.

4.3 Properties such as dry density, gravimetric water content and relative compaction are calculated from the total density and the volumetric water content.

5. Significance and Use

5.1 The method described determines wet density and gravimetric water content by correlating complex impedance measurement data to an empirically developed model. The empirical model is generated by comparing the electrical properties of typical soils encountered in civil construction projects to their wet densities and gravimetric water contents determined by other accepted methods.

5.2 The test method described is useful as a rapid, non-destructive technique for determining the in-place total density and gravimetric water content of soil and soil-aggregate mixtures and the determination of dry density.

5.3 This method may be used for quality control and acceptance of compacted soil and soil-aggregate mixtures as used in construction and also for research and development. The non-destructive nature allows for repetitive measurements at a single test location and statistical analysis of the results.

NOTE 2—The quality of the result produced by this standard test method is dependent on the competence of the personnel performing it, and the

[3] Prepared for The Department of Homeland Security under contract No. HSHQDC-07-C-00080. Dated October 31, 2008. Available from the U.S. Department of Homeland Security, Washington, D.C. 20528, http://www.dhs.gov.

suitability of the equipment and facilities used. Agencies that meet the requirements of Practice D3740 are generally considered capable of competent and objective sampling/testing/inspection, and the like. Users of this standard 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 evaluation some of those factors.

6. Interferences

6.1 Anomalies in the test material with electrical impedance properties significantly different from construction soils and aggregate evaluated during soil model development, such as metal objects or organic material, may affect the accuracy of the test method.

6.2 Chemical and mineralogical composition may affect the results of a test. Examples of materials that may impact the results include but are not limited to, quarried materials containing higher concentrations of iron, volcanic rock, and materials that have significant fractions of cemented particles, organic soils, recycled materials or materials containing asphalt, portland cement, lime, fly ash, or other stabilizing modifiers. In most cases the effect may be satisfactorily addressed by following the Calibration Procedure in Section 7.

6.3 A significant increase in the conductivity of the pore water such as from ground water that may contain significant salt deposits or contaminants. In most cases the effect may be satisfactorily addressed by following the Calibration Procedure in Section 7.

6.4 This test method applies only to non-frozen soil. The electrical properties of soil change with temperature. Generally, testing should be limited to soil temperatures above 10°C [50°F] and below 40°C [104°F]. Effects of temperature on electrical properties of soils also depend on soil type. Clayey soils are more temperature sensitive than sandy soils. Accuracy of measurements improves when the temperature of soil is close to the temperature used in the model calibration. Calibration for temperature effects should be done when soil temperatures differ by more than 10°C [18°F] from model calibration temperatures. Calibration Procedures are given in Section 7.

6.5 The accuracy of the results obtained by this test method may be influenced by poor or incorrect placement of the device on the soil being tested. Non-homogeneous soils, non-uniform surface texture, large air voids that may be present may decrease the precision of the results. Correct placement of the soil gauge is important to the quality of the electrical measurements collected by the device.

6.6 Oversized particles in the measurement volume may cause an error in water content and/or density results. Where lack of uniformity in the soil is suspected due to layering, aggregates, or voids, the test site should be excavated and visually examined to determine if the material is representative of the in-situ material in general and if an oversize correction is required in accordance with Practice D4718.

6.7 Variation from actual values may increase for soil material that is significantly drier or wetter than optimum water content as determined using Test Methods D698 or D1557. Variation from actual values may increase for soil material that is compacted to less than 80 % of the maximum dry density as determined using Test Methods D698 or D1557.

6.8 Attempts to measure unknown in-place soils with a soil model that was generated from a limited range of ~~wet~~ density or water content values, or both, may result in density and water content errors.

6.9 Strong electromagnetic fields such as those generated by high tension power lines may interfere with the device operation.

6.10 For a circular sensor 280 mm [11 in.] in diameter, the typical maximum measured volume is approximately 0.0034 m^3 [0.12 ft^3]. The actual measured volume is indeterminate and varies with the plate diameter, sensor configuration, and material being tested. Results are typically influenced more by the density and water content of the material near the surface.

7. Apparatus[4,5]

7.1 *Electromagnetic Soil Density Gauge*—A device capable of generating an electromagnetic field and measuring the differential voltage change between two electrodes. An example of the device is shown in Fig. 1 and a sensor schematic section and approximate electrical fields that sense the soil is shown in Fig. 2. While the exact details of construction of the apparatus may vary, the system shall consist of:

7.1.1 Electronic circuitry to provide power and signal conditioning to the sensor and to provide the data acquisition and display functions. The circuitry shall be designed to perform a calibration of the unit over a range of conditions and materials expected in the field.

7.1.2 Internal circuitry suitable for displaying individual measurements to allow operators to record the results.

[4] The sole source of supply of the TransTech Soil Density Gauge (SDG) apparatus known to the committee at this time is TransTech Systems, Inc. 1594 State Street, Schenectady, NY. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[5] The Electromagnetic Soil Density Gauge is covered by a patent (patent no.: US 7,219,024 B2). Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.