



Designation: D4015 – 21

Standard Test Methods for Modulus and Damping of Soils by Fixed-Base Resonant Column Devices¹

This standard is issued under the fixed designation D4015; 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 shear modulus and shear damping as a function of shear strain amplitude for solid cylindrical specimens of soil in intact and reconstituted conditions by torsional vibration using resonant column devices. The vibration of the specimen may be superposed on a controlled static state of stress in the specimen. The vibration apparatus and specimen may be enclosed in a triaxial chamber and subjected to an all-around pressure and axial load. In addition, the specimen may be subjected to other controlled conditions (for example, pore-water pressure, degree of saturation, temperature). These test methods of modulus and damping determination are considered nondestructive when the shear strain amplitudes of vibration are less than $10^{-2} \%$ (10^{-4} in./in.), and many measurements may be made on the same specimen and with various states of static stress.

1.2 Two device configurations are covered by these test methods: Device Type 1 where a known torque is applied to the top of the specimen and the resulting rotational motion is measured at the top of the specimen, and Device Type 2 where an uncalibrated torque is applied to the top of the specimen and the torque transmitted through the specimen is measured by a torque transducer at the base of the specimen. For both types of devices, the torque is applied to the active end (usually top) of the specimen and the rotational motion also is measured at the active end of the specimen.

1.3 These test methods are limited to the determination of the shear modulus and shear damping, the necessary vibration, and specimen preparation procedures related to the vibration, etc., and do not cover the application, measurement, or control of the axial and lateral static normal stresses. The latter

procedures may be covered by, but are not limited to, Test Method D2850, D4767, or D7181.

1.4 *Significant Digits*—All recorded and calculated values shall conform to the guide for significant digits and rounding established in Practice D6026.

1.4.1 The procedures used to specify how data are collected/recorded and calculated in this standard are regarded as the 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 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 design.

1.4.2 Measurements made to more significant digits or better sensitivity than specified in this standard shall not be regarded a nonconformance with this standard.

1.5 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units, which are provided for information only and are not considered standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with these test methods.

1.5.1 The converted inch-pound units use the gravitational system of units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The converted slug unit is not given, unless dynamic ($F = ma$) calculations are involved.

1.5.2 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

¹ These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.09 on Cyclic and Dynamic Properties of Soils.

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

unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording density in lbm/ft³ shall not be regarded as nonconformance with this standard.

1.6 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.

1.7 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

- D653 Terminology Relating to Soil, Rock, and Contained Fluids
- D2166/D2166M 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
- D2850 Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils

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.

- 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
- D4767 Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
- D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
- D7181 Test Method for Consolidated Drained Triaxial Compression Test for Soils

3. Terminology

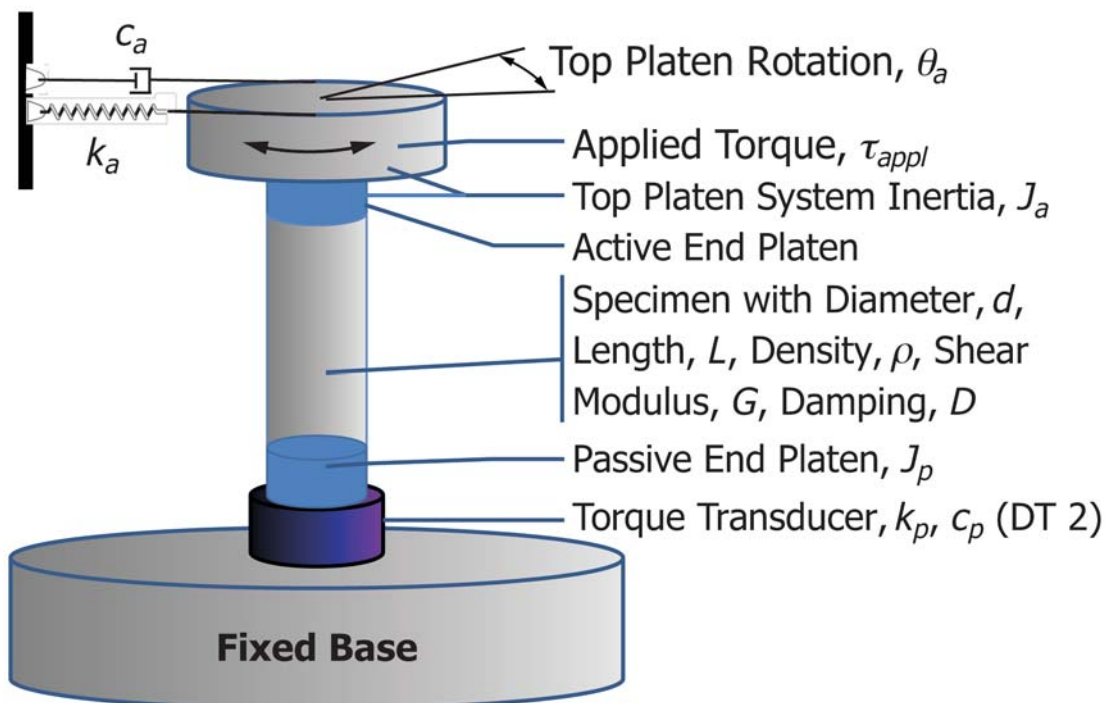
3.1 *Definitions*—For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *damping capacity D* [unitless, typically expressed in %], *n*—in resonant column systems, is related to the component of the dynamic shear modulus that lags the applied shear stress by 90° degrees.

3.2.2 *Device Type 1, DT1*, *n*—in resonant column systems, a resonant column system as shown in Fig. 1 where the passive end platen is directly connected to the Fixed Base (no torque transducer), a calibrated vibratory torque is applied to the active end, and rotation is measured at the active end.

3.2.2.1 *Discussion*—The vibration excitation device may incorporate springs and dashpots connected to the active-end platen, where the spring constants and viscous damping coefficients must be known. The rotational inertia of the active-end



For Device Type 1, no torque transducer is needed and the Passive End Platen is connected to the Fixed Base.

FIG. 1 Resonant-Column Schematic for Both Device Types 1 and 2