



Standard Test Methods for Modulus and Damping of Soils by the Resonant-Column Method¹

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1. Scope

1.1 These test methods cover the determination of shear modulus, shear damping, rod modulus (commonly referred to as Young's modulus), and rod damping for solid cylindrical specimens of soil in the undisturbed and remolded conditions by vibration using the resonant column. The vibration of the specimen may be superposed on a controlled ambient 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 strain amplitudes of vibration are less than 10^{-4} rad (10^{-4} in./in.), and many measurements may be made on the same specimen and with various states of ambient stress.

1.2 These test methods cover only the determination of the modulus and damping, the necessary vibration, and specimen preparation procedures related to the vibration, etc., and do not cover the application, measurement, or control of the ambient stress. The latter procedures may be covered by, but are not limited to, Test Methods D 2166 or D 2850.

1.3 *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.*

2. Referenced Documents

2.1 ASTM Standards:

- D 2166 Test Method for Unconfined Compressive Strength of Cohesive Soil²
- D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock²
- D 2850 Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression²

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 Soil Dynamics.

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² *Annual Book of ASTM Standards*, Vol 04.08.

D 4767 Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils²

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *ambient stress*—stresses applied to the specimen, during the test, that do not result from the vibration strains. These test methods do not cover the application and measurement of ambient stresses; however, the ambient stress at the time of measurement of the system resonant frequency and system damping shall be measured and recorded in accordance with the final section of the paper.

3.1.2 *apparatus model and constants*—the rigidity and mass distribution of the resonant column shall be as required in the following section in order for the resonant-column system to be accurately represented by the model shown in Fig. 1. The apparatus constants are the mass of the passive-end platen, M_P , including the mass of all attachments rigidly connected to it; the rotational inertia of the passive-end platen, J_P , including the rotational inertia of all attachments rigidly connected to it; similar mass, M_A , and rotational inertia, J_A , for the active-end platen and all attachments rigidly connected to it, such as portions of the vibration excitation device; the spring and damping constants for both longitudinal and torsional springs and dashpots (K_{SL} , K_{ST} , ADC_L , ADC_T); the apparatus resonant frequencies for longitudinal vibration, f_{oL} , and torsional vibration, f_{oT} ; the force/current constant, FCF , relating applied vibratory force to the current applied to the longitudinal excitation device; the torque/current constant, TCF , relating applied vibratory torque to the current applied to the torsional excitation device; and the motion transducer calibration factors (LCF_A , RCF_A , LCF_P , RCF_P) relating the transducer outputs to active- and passive-end longitudinal and rotational motion.

3.1.3 *moduli and damping capacities*—Young's modulus (herein called rod modulus), E , is determined from longitudinal vibration, and the shear modulus, G , is determined from torsional vibration. The rod and shear moduli shall be defined as the elastic moduli of a uniform, linearly viscoelastic (Voigt model) specimen of the same mass density and dimensions as the soil specimen necessary to produce a resonant column having the measured system resonant frequency and response due to a given vibratory force or torque input. The stress-strain relation for a steady-state vibration in the resonant column is a hysteresis loop. These moduli will correspond to the slope of a