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Standard Test Method for
STRESS WAVE ENERGY MEASUREMENT FOR DYNAMIC PENETROMETER TESTING SYSTEMS[1]

This standard is issued under the fixed designation D 4633; 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 describes the procedure for measuring that part of the drive weight (hammer) kinetic energy that enters the penetrometer connector rod column during dynamic (hammer impact) penetrometer testing of soil.

1.2 This test method has particular application to the comparative evaluation of hammer systems, and, to a lesser degree of accuracy, hammer-operator systems, that are used for the penetration testing of soils.

1.3 This test method applies to penetrometers driven from above the ground surface. It is not intended for use with down-hole hammers.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are provided for information only.

1.5 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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. Terminology

2.1 *Descriptions of Terms Specific to This Standard:*

2.1.1 *connector rods*—the drill rods that connect the drive weight system above the ground surface to the penetrometer below the surface.

2.1.2 *engineer*—the engineer, geologist, or other responsible professional, or their representative.

2.1.3 *load cell*—any instrument placed around, on, or within a continuous column of penetrometer connector rods for the purpose of sensing that part of the drive weight (hammer) kinetic energy that is transmitted into the penetrometer connector rods.

NOTE 1—Some hammer energy is lost at impact during the transfer of kinetic energy in the hammer to compression wave energy in the penetrometer connector rods. This impact-transfer loss can vary significantly with the shape of the hammer or the anvil, or both, with the mass of the anvil, and with the properties of any impact cushion at the anvil.

2.1.4 *penetrometer*—any sampler, cone, blade, or other instrument placed at the bottom of the connector rods where the penetration resistance in (hammer blows/penetration distance) is used as an index to one or more soil engineering properties.

2.1.5 *processing instrument*—an instrument which receives the signal from the load cell after a hammer blow and processes it to produce computed E_i or ER_i values (see 2.2.2 and 2.2.3).

2.1.6 *string-cut drop*—supporting a hammer on a string at a stipulated distance above the anvil and cutting the string to obtain an unimpeded hammer drop.

2.2 *Symbols:*

2.2.1 E^*—the nominal kinetic energy in a drive weight of stipulated mass after a gravitational free fall from a stipulated fall height (the Newtonian kinetic energy at impact).

2.2.2 E_i—the energy content of the initial (first) compression wave that is produced by a hammer impact.

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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2.2.3 $ER_i = (E_i/E^*)\ 100\ \%$—measured stress wave energy ratio.

2.2.4 L—length between the hammer impact surface and the bottom of the penetrometer.

2.2.5 L'—length between the load cell and the bottom of the penetrometer.

2.2.6 $\Delta L = L - L'$.

3. Significance and Use

3.1 Various types of driven penetrometers are used to evaluate in situ the engineering behavior of soils. The penetration resistance of soil to a particular driven penetrometer depends not only upon the mass of the hammer and the soil characteristics, but upon the continuity and geometry of system components and upon system operation factors that contribute resistance to free-fall of the drive weight. Some penetration testing systems are only standardized with respect to the configuration of the penetrometer and the mass of the drive weight. The stress wave integration procedure is a method of evaluating variations from differences in system geometry and operation.

3.2 The incremental penetration of a penetrometer from a hammer blow is directly related to the magnitude of the irregularly shaped force pulse within the first compressive wave from that blow. A processing instrument integrates the forces within the time limits of the first compressive pulse or wave (idealized example in Fig. 1) thus computing the stress wave energy of the primary force pulse. The integrated stress wave energy, therefore, provides an approximate measure of the effective driving force.

3.3 The integrated stress wave method has particular application to evaluation of hammer systems that are used for penetration testing of soils. There is an approximate, linear relationship between the incremental advance of a driven soil penetrometer and the stress wave energy that enters the penetrometer connector rods. Therefore, there is also an approximate inverse relationship between the penetration resistance (in hammer blows per unit length of soil penetration) and the stress wave energy, E_i (or ER_i).

3.4 Stress wave measurements may be used to evaluate both operator-dependent cathead and rope-hammer drop systems and the relatively operator-independent mechanized systems. When operator-dependent hammer systems are tested, the possible inability of the operator to reproduce environmental influences must be considered.

3.5 This test method has been found useful for such purposes as:

3.5.1 Comparing the dynamic penetration resistances produced by different equipment or operators performing the same type of test at a project.

3.5.2 Comparing project penetration resistance with similar design reference data.

3.5.3 An organization performing internal evaluations of their hammer-operator-rig combinations.

3.5.4 The training of dynamic penetration system operators.

3.5.5 Demonstrating the relative importance of equipment or operator variables.

3.5.6 Aiding the design of penetrometer drive systems.

3.5.7 Documenting data for regulatory agencies.

3.5.8 Developing a conversion between different types of dynamic penetration tests.

4. Apparatus

4.1 *Load Cell, Processing Instrument, and Digital Timer*—The engineer may use any suitable apparatus that measures E_i or ER_i within the required accuracy of ±2 %. Such apparatus usually consists of a load cell, processing instrument, and digital timer.

4.2 *Oscilloscope*—An oscilloscope can be a useful adjunct, and a digital oscilloscope hooked to a computer can act as a combination instrument and timer.

5. Procedure

5.1 Connect the load cell to the penetrometer connector rods no closer than 2.0 ft (0.6 m) to the base of the anvil. Use load cell adaptors that minimize abrupt changes in cross-sectional area with respect to the penetrometer connector rods. The cross-section of the rods above and below the load cell must be the same for a distance of at least 1.0 ft (0.3 m) in both directions.

5.2 Follow the processing instrument manufacturer's calibration procedures to ensure the load cell and processing instrument are operating properly. Match the processing instrument setting to the type rod used above and below the load cell.

5.2.1 If the instrument cannot be preset to the