Designation: D 1558 – 99

Standard Test Method for Moisture Content Penetration Resistance Relationships of Fine-Grained Soils[1]

This standard is issued under the fixed designation D 1558; 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 is for establishing the moisture-penetration resistance relationships of fine-grained soils as determined by the soil penetrometer.

1.2 The values stated in inch-pound units are to be regarded as the standard.

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:*

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft^3(600 kN·m/m^3)

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[3]

D 3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[3]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Testing Soil, Rock, and Related Construction Materials[3]

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *penetration resistance curve (proctor penetration curve)*—the curve showing the relationship between 1 the penetration resistance and 2 the water content.

3.1.2 All other terms and definitions are in accordance with Terminology D 653.

4. Significance and Use

4.1 This test method is used with Methods A and B of Test Method D 698 to develop relationships between moisture content, density, and penetration resistance. These relationships are used with a previously prepared family of moisture-penetration curves as a rapid field test to determine the approximate amount of moisture in the soil.

NOTE 1—When a penetration-resistance measurement of material in place is compared at a given moisture content with penetration-density curves prepared at a specified compactive effort, an approximate check of compaction (density) may be obtained.

4.2 Penetration resistance determinations are not reliable for very dry molded soil specimens or very granular soils.

NOTE 2—Notwithstanding the statements on Precision and bias contained in this Standard: The precision of this test method is dependent on the compentence of the personnel performing it and the suitability of the equipment and the facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on many factors; Practice D 3740 provides a means of evaluating some of those factors.

5. Apparatus

5.1 *Moisture-Density Apparatus*, conforming to the requirements prescribed in Test Method D 698.

5.2 *Soil Penetrometer*—A soil penetrometer (Fig. 1) consisting of a special spring dynamometer with pressure-indicating scale on the stem of the handle. The pressure scale shall be graduated to 90 lbf in 2-lbf divisions with a line encircling the stem at each 10-lbf interval, or graduated to 181 N in 9.8 N divisions with a line encircling the stem at each 5-kg interval. A sliding ring on the stem shall indicate the maximum pressure obtained in the test.

5.3 *Set of Penetrometer Needles*—Each penetrometer needle (Fig. 1) shall consist of a shank with a head of known end area. The set of interchangeable needles shall include the sizes given in Table 1. The needle shank shall have graduations

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

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

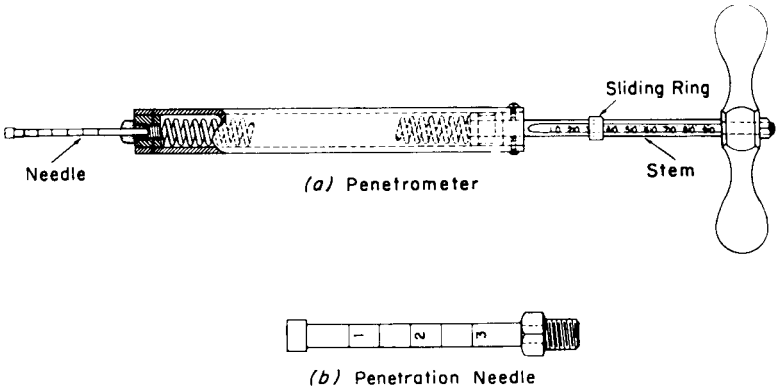

FIG. 1 Soil Penetrometer

TABLE 1 Sizes For Interchangeable Needles

Size (area),									
in.^{2}	1	¾	½	⅓	⅕	1/10	1/20	1/30	1/40
(cm^2)	(6.45)	(4.84)	(3.23)	(2.15)	(1.29)	(0.65)	(0.32)	(0.22)	(0.16)
End diameter,									
in.	1.124	0.976	0.796	0.651	0.505	0.357	0.252	0.206	0.178
(mm)	(28.55)	(24.79)	(20.22)	(16.54)	(12.83)	(9.07)	(6.40)	(5.23)	(4.52)

inscribed at intervals of ½ in. (10 mm) to indicate the depth of penetration, and shall have a length of not less than 4 in. (100 mm), excluding the threaded portion. Needles should not be used when they have been worn so as to reduce the flat-end area by 5 %.

5.4 *Balance or Scale*—A direct reading platform balance (or scale) having a minimum capacity of least 90 lb (181 N) and meeting the requirements of Specification D 4753 with a readability of ±0.10 lb (49 mN).

6. Sample

6.1 Prepare the sample in accordance with either Method A or B of Test Method D 698. After preparation, the fraction passing the No. 4 (4.75-mm) sieve shall have at least 20 % passing the No. 200 (75-µm) sieve.

7. Calibration

7.1 The penetrometer may be calibrated by measuring the load applied by means of a platform scale. Apply loading manually using the needle directly on the scale so that the spring compresses at a rate of approximately ½ in. (10 mm) per second to ⅓ of the full range of the penetrometer scale. Read the loading on the platform scale. Repeat the test at ⅔ and the full range of the penetrometer scale. The difference, if any, between the penetrometer and the scale or balance should not exceed 2 lbf (8.89 N). For ease in calibration it is recommended that the 1 in.^{2} (64.5 mm^2) needle be used.

7.2 The penetrometer should be cleaned, lubricated, and calibrated on a regular basis. The penetrometer should be stored in a clean location or case, with no compression on the spring.

8. Procedure

8.1 Compact the soil in the moisture-density mold in accordance with the procedure described in Method A or B of Test Methods D 698.

8.2 Determine the resistance of the soil to penetration by use of the soil penetrometer with attached needle of known end area. The needle used shall be of such size that the readings obtained will be between 20 and 80 on the decimal scale or 10 and 40 on the metric scale. Place the mold containing the soil specimen on a smooth space between the feet of the operator. The operator shall hold the penetrometer in a vertical position and shall control the rate of penetration by steadying the arms against the front of the legs at the same time applying pressure to the penetrometer handle (Note 2). Penetrate the soil specimen at the rate of 0.5 in. (13 mm)/s for a distance of not less than 3 in. (76 mm). Place the penetration needle away from the edge of the mold (approximately four times the needle diameter), near the center, and space the individual penetrations so as not to interfere with one another. Penetrate the soil specimen not less than three times and use the average of the readings.

NOTE 3—With some large penetrometers it is difficult to use the device in the manner discussed in 8.2. Therefore, the operator should hold the penetrometer in a comfortable vertical position that yields a steady rate of pressure application.

8.3 Determine the penetration resistance on each molded soil specimen as described in 8.2.

9. Calculation

9.1 Multiply the average penetrometer reading, as determined in 8.2, by the reciprocal of the end area of the penetration needle and record the resulting value as the penetration resistance of the soil expressed in pounds-force per square inch or kilopascals. Calculate the moisture content of the soil in accordance with Test Method D 2216.

10. Moisture-Penetration Resistance Relationship

10.1 Plot the penetration-resistance values and the corresponding moisture contents (as calculated in accordance with Section 9) on the same graph sheet with the corresponding moisture-density relations data (as provided in Test Method

D 698). Plot the moisture-penetration resistance data immediately above the moisture-density data, using the same moisture content scale for both sets of data. The moisture-penetration resistance relationship curve shall be established by not less than three determinations.

11. Precision and Bias

11.1 The precision of this test method has been determined based on a limited amount of data. This data was derivied from a round robin study of four labortories using an ML soil with an average penetration resistance of 1440 psi. Single operator standard deviations of 78, with an acceptable range of 219 for two results, and multilaboratory standard deviations of 566, with an acceptable range of 1586 were determined in accordance with Practice C 670 and calculated in accordance with Practice E 691.

11.2 Subcommittee D18.08 is seeking pertinent data from users of this test method on precision.

12. Keywords

12.1 backfills; base courses; compaction; compaction control; compaction curves; control; density; embankments; field control; field laboratories; field tests; fine grained soils; inspection; laboratory test; maximum dry density; moisture; moisture content; moisture control; penetration resistance; soil tests

SUMMARY OF CHANGES

In accordance with Committee D-18 policy, this section identifies the location of changes to this standard since the last edition (1994) that may impact the use of this standard.

(*1*) Added Specification D 4753 to Section 2.
(*2*) Added new Section 3 on Terminology. Added this definition for usability from Terminology D 653.
(*3*) Renumbered sections to reflect new Section 3.
(*4*) Revised 5.2 to reflect pound-force versus pound.
(*5*) Revised 5.4 to reflect requirements of Specification D 4753.
(*6*) Revised 7.1 to reflect pound-force and to express metric equivalent as newtons.
(*7*) Added 7.2 concerning cleaning, storage, and calibration frequency.
(*8*) Added Summary of Changes.