



Designation: D2844 – 07

Standard Test Method for Resistance *R*-Value and Expansion Pressure of Compacted Soils¹

This standard is issued under the fixed designation D2844; 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 covers the procedure for testing both treated and untreated laboratory compacted soils or aggregates with the stabilometer and expansion pressure devices to obtain results indicative of performance when placed in the base, subbase, or subgrade of a road subjected to traffic.

1.2 The values stated in SI units are to be regarded as the standard. However, use of equipment manufactured to be readable in inch-pound units only should not be considered as non-conformance to the test method. Many stabilometers and expansion pressure devices are manufactured to be readable in inch-pound units only.

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.3.1 For purposes of comparing measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal or significant digits in the specified limits.

1.3.2 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should 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 analytical 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.*

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, 2007. Published March 2007. Originally approved in 1969. Last previous edition approved in 2001 as D 2844 – 01^{ε1}. DOI: 10.1520/D2844-07.

2. Referenced Documents

2.1 ASTM Standards:²

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D6026 Practice for Using Significant Digits in Geotechnical Data

E4 Practices for Force Verification of Testing Machines

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 AASHTO Documents:

T 190 Test Method for Resistance *R*-Value and Expansion Pressure of Compacted Soils³

2.3 ASTM Adjuncts:⁴

Exudation Device

Expansion Pressure Apparatus

Stabilometer

3. Terminology

3.1 For definitions of terms in this test method, refer to Terminology D653.

4. Significance and Use

4.1 This test method is used to measure the potential strength of subgrade, subbase, and base course materials for use in road and airfield pavements. The *R*-value is used by

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.

³ Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

⁴ Copies of detailed drawings of the apparatus shown in Figs. 4 (1 drawing), 6 (4 drawings), 7 and 8 (7 drawings) are available at a nominal cost from ASTM International Headquarters. Request Adjunct Nos. ADJD284401, ADJD284402, and ADJD284403, respectively.

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

some agencies as criteria for acceptance of aggregates for base course and bituminous courses.

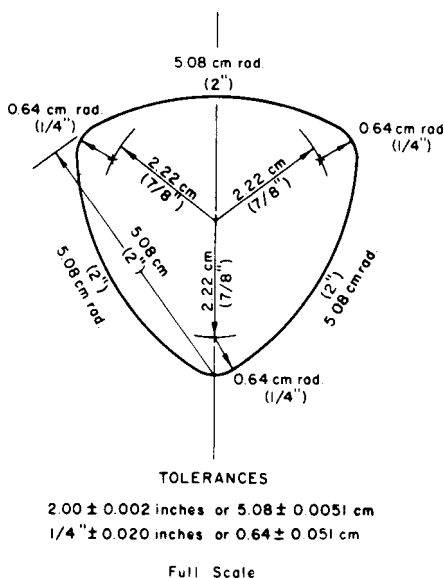


FIG. 1 Tamper Shoe for Kneading Compactor

4.2 The expansion pressure testing has been used in conjunction with the R-value test to determine cover requirements (thickness) and construction controls to reduce pavement distortion from expansive subgrade soils.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this test method are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

5. Apparatus

5.1 *Kneading Compactor*, capable of applying an average contact pressure of 2410 ± 110 kPa (350 ± 16 psi) to the tamper foot shown in Fig. 1 and with provisions for maintaining this pressure during changes in sample height. The load-time trace shall be free of “chatter” or evidence of impact-associated changes in slope. The rise time for application of foot pressure, in the range from 240 to 2070 kPa (35 to 300 psi), shall not be less than 0.07 nor more than 0.20 s. The dwell time, measured at 300 psi foot pressure, shall not be less than 0.15 nor more than 0.45 s. The pressure-release or removal time shall not be greater than 0.60 s.

5.1.1 The compactor shall include a counter or timer for measuring the number of tamps applied to a specimen and a mold holder, for use in compacting specimens, that rotates equally between tamps to give 5 to 7 tamps per revolution of the mold. The holder shall firmly restrain the mold during compaction. The base of the mold holder shall have a metal plate 100.8 (3 31/32 in mm) in diameter and 12.7 mm (0.5 in.) high to which is cemented a rubber disk having a diameter of 100.0 mm (3 15/16 in.) and a height of 3.2 mm. (1/8 in.). The plate shall be an integral part of the base of the mold holder. The

compactor shall also include a trough for feeding the sample into the mold in 20 increments (Fig. 2). Troughs with a semicircular cross section of 39 cm^2 (6 in.³) in area and 50.8 cm (20 in.) long have proven satisfactory.

5.2 *Compression Testing Machine*, with a minimum capacity of 45 kN (10 000 lbf) and satisfying the requirements of Practices E4.

5.3 *Mold*, 101.6 ± 0.05 mm (4 ± 0.002 in.) inside diameter by 127 ± 0.20 mm (5 ± 0.008 in.) high. (See Fig. 3 for surface roughness.)

5.4 *Rubber Disks*, 100 mm (3 15/16 in.) in diameter by 3 mm (1/8 in.) thick and having a durometer hardness of 60 ± 15.

5.5 *Metal Follower*, solid-walled, metal specimen follower 100.33 ± 0.13 mm (3.95 ± 0.005 in.) in outside diameter by 127 mm (5 in.) long.

5.6 *Exudation Device*, as shown in Fig. 4.⁴

5.7 *Phosphor Bronze Disk*, as shown in Fig. 5.

5.8 *Filter Paper*, 100 mm in diameter and .15 mm (0.006 in.) thick, smooth surface, medium filtering speed, medium retention.

5.9 *Filter Paper*, 110 mm in diameter and .15 mm (0.006 in.) thick, creped surface, medium-fast filtering speed, medium retention.

5.10 *Expansion-Pressure Device*, with accessories as shown in Fig. 6.⁴ There should be at least three of these devices for each sample to be tested within a day’s time.

5.11 *Deflection Gage*, with divisions of 0.002 mm (0.0001 in.) and an allen wrench as shown in Fig. 6.

5.12 *Stabilometer*, with accessories, as shown in Fig. 7 and Fig. 8.⁴

5.13 *Standard Metal Specimen*, 101.60 mm. (4 in) in outside diameter by 152.2 mm (6 in.) high as shown in Fig. 8.

5.14 *Balance*, 5000-g capacity, accurate to 1 g.

5.15 *Sieves*, 25.0 mm (1 in.), 19.0 mm (3/4 in.) and 4.75 mm (No. 4) conforming to the requirements of Specification E11.

5.16 *Miscellaneous Equipment*, including mixing pans, spoons, spatulas, and gallon cans with close-fitting lids.

6. Soil Preparation

6.1 Remove any coatings from coarse aggregate and break clay lumps to pass the 4.75-mm (No. 4) sieve.

6.2 Adjust the soil gradation when some of the material is retained on the 19.0-mm (3/4-in.) sieve. When 75 % or more passes the 19.0mm (3/4-in.) sieve, use that part of the sample passing the 19.0mm (3/4-in.) sieve. If less than 75 % of the sample passes the 1-in. sieve use that part of the sample passing the 25.0-mm (1-in.) sieve.

7. Preparation of Soil Specimens

7.1 Thoroughly mix four 1200-g samples of soil with the amount of water estimated to equal one half to two thirds of the water required to produce saturation as defined in 7.3 and 7.4. Place the samples in covered containers and allow them to stand overnight. Just prior to compaction, mix the samples with the final amount of water required to produce saturation. The first sample is used as a pilot specimen to assist in determining the final amount of water required.

7.2 Weigh out enough material to fabricate a compacted sample 101.6 mm (4 in.) in diameter by 63 mm (2.5 in.) high.

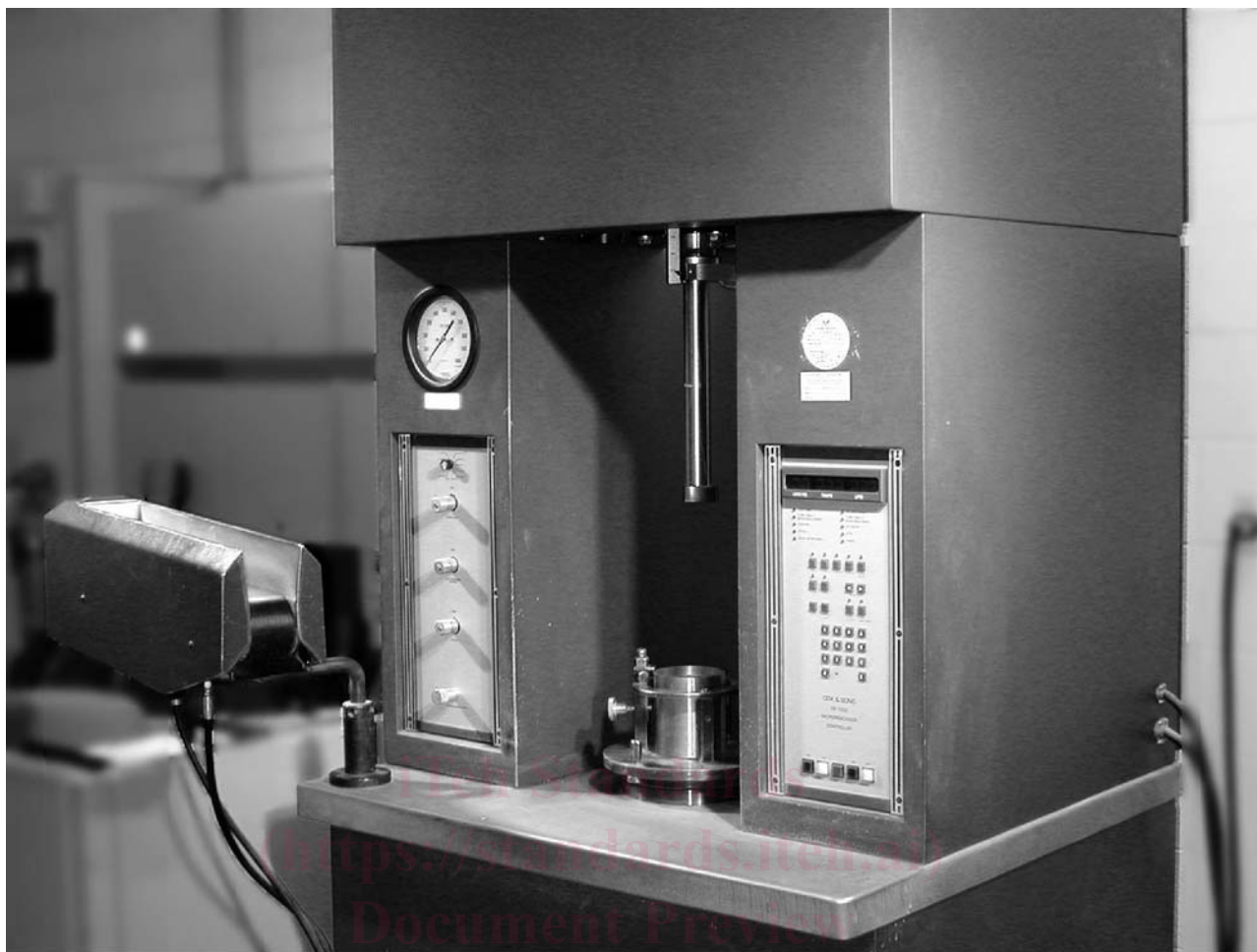


FIG. 2 Compactor with Sample Feed Trough

ASTM D2844-07

Compacted specimens having heights from 62 to 65 mm (2.45 to 2.55 in.) are acceptable. Compact the soil into the mold by means of the kneading compactor as follows: Place the mold in the mold holder which has a rubber disk, 100 mm (3 15/16 in.) in diameter and 3 mm (1/8 in.) thick, cemented to the plate. Adjust the mold for approximately 3-mm (1/8-in.) clearance between the lower edge of the mold and base of the mold holder. Spread the sample along the length of the trough. With the compactor-foot pressure set at 1720 ± 170 kPa (250 ± 25 psi), feed 76 mm (3 in.) of the soil from the trough into the mold. Redistribute the sample remaining in trough as needed to feed the balance of the soil into the mold in 20 equal increments with one application of the ram after each increment. Allow 10 additional tamps to level the soil, then place a rubber disk on top of the specimen. Apply 100 additional tamps with a foot pressure of 2410 kPa (350 psi). Stop compacting the soil at any time before 100 tamps if water appears around the bottom of the mold.

NOTE 2—Use lower compaction pressures when necessary to limit penetration of the ram into the soil to not greater than 6 mm (1/4 in.).

7.3 Remove the mold containing the compacted specimen from the compactor. Level the tamped surface by hand tamping with a 38-mm (1.5-in.) diameter rod. Place a phosphor-bronze disk on the tamped surface of the soil and place a filter paper

on top of the bronze disk. Invert the mold and place it on the exudation device so that the filter paper is on the bottom. Place the solid walled, metal specimen follower into the mold. Using the compression testing machine, apply a uniformly increasing pressure to the soil at the rate of 8900 N(2000 lbf)/min. Water should be exuded from the soil at 2070 kPa (300 psi) as evidence that enough moisture is present to produce saturation. Stop the loading and record the exudation pressure to the nearest 10 kPa (1 psi) when either five of the six outer lights on the exudation pressure device are lighted or three outer lights are lighted and free water is visible around the bottom of the mold. Do not exceed a exudation pressure of 5520 kPa (800 psi).

7.4 Mold at least two more specimens with different amounts of moisture so that a range of exudation pressures from 690 to 5520 kPa (100 to 800 psi) (Note 3) is obtained which brackets the 2070 kPa (300 psi) value. For some high volume-change soils, additional specimens having exudation pressures lower than 100 psi may be necessary to obtain expansion pressures that are low enough to provide a suitable range of data for a complete expansion pressure analysis of the soil.

NOTE 3—Occasionally, material from very plastic, clay-test specimens will extrude from under the mold and around the follower ram during the

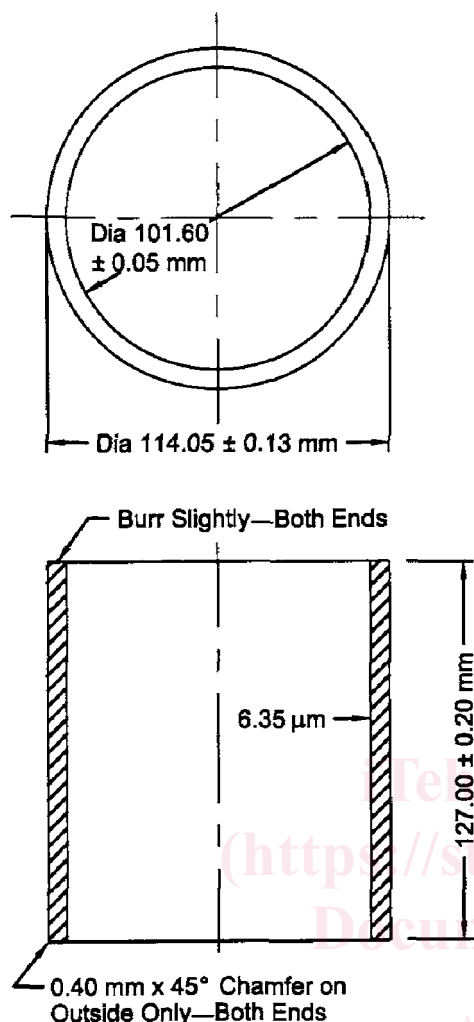


FIG. 3 Mold

NOTE 1—Inside roughness is obtained by smooth machining inside to required diameter of 101.6 ± 0.05 mm (4.000 ± 0.002 in.) followed on final operation with a boring tool bit ground to a 90° point with sharp point ground flat measuring 0.025 to 0.075 mm (0.001 to 0.003 in.) across. Depth of cut is 0.050mm (0.002 in.) with 0.25mm (0.010 in.) feed using sulfur-based oil coolant.

loading operation. If this occurs when the 5520-kPa(800-psi) point is reached and fewer than five lights are lighted, the soil should be reported as less than 5 R-value. Coarse granular materials and clean sands may require the use of paper baskets to permit testing.

8. Calibration of Expansion-Pressure Apparatus

8.1 Calibrate the spring-steel bar of the expansion-pressure device (Fig. 6) by applying upward measured loads at the center of the bar and measuring the respective deflections of the bar with the deflection dial indicator.

8.2 The steel spring bar is considered in calibration when the measured deflections are within the following tolerances:

Applied Load	Dial Reading, in. (mm)
3.75 (8)	0.055 ± 0.005 (0.0021 ± 0.0002)
7.50 (16)	0.110 ± 0.005 (0.0042 ± 0.0002)
11.25 (24)	0.165 ± 0.005 (0.0063 ± 0.0002)
15.00 (32)	0.220 ± 0.005 (0.0084 ± 0.0002)

8.3 If the deflection dial indicator does not check the above readings, loosen the top frame bar and adjust the position of the shims, between the frame and the spring steel bar, until the required readings are obtained.

NOTE 4—Some models of the expansion-pressure apparatus have set screw adjustments in lieu of shims.

9. Expansion-Pressure Testing

9.1 Allow the test specimen to rebound in a covered mold for at least 30 min after determination of the exudation pressure.

9.2 Place deflection dial indicator in position on the expansion-pressure device with the single-bearing end of the gage base resting on the adjustment ring.

9.3 Using an allen wrench, raise or lower the adjustment plug until the deflection dial indicator measures 0.025 mm (– 1.0010 in.). The deflection dial indicator will read 00.229 mm. (0090 in.).

9.4 Place the perforated disk with stem firmly on the face of the compacted specimen in the mold and place the mold in the expansion-pressure device after placing creped surface filter paper on the turntable.

9.5 Seat the perforated disk firmly on the specimen with pressure applied by the fingers. Raise the turntable on the expansion device until the deflection dial indicator reads zero. If the device was properly adjusted, according to 7.3, this will apply the preset surcharge deflection of 0.025 mm (0.0010 in.).

9.6 Rotate the specimen height measuring device toward the base of the turntable until it rests on the outer edge of the turntable.

9.7 Record the height of the specimen as indicated to the nearest 2.5 mm (0.1 in.).

9.8 Put approximately 200 mL of water into the mold and allow pressure from expansion of the specimen to develop for 16 to 24 h.

NOTE 5—Do not leave a test specimen unconfined by the expansion-pressure device while there is free water on top of the specimen in the mold.

9.9 Read the deflection of the calibrated spring steel bar to 0.002 mm (0.0001 in.). When the deflection is greater than 0.254 mm (0.010 in.), the expansion-pressure device should be recalibrated before using again.

9.10 Determine the expansion pressure, *P*, as follows:

$$P = kd$$

where:

k = spring constant of steel bar calculated from calibration of the expansion-pressure apparatus and expressed in kPa/0.025 mm (or psi/0.0010 in.), and,

d = deflection shown by deflection dial indicator, mm (in.).

10. Adjustment of Stabilometer

10.1 Adjust the bronze nut on the stabilometer stage base so that the top of the stage is 89 mm (3 ½ in.) below the bottom of the upper tapered ring of the stabilometer. Perform all tests at this setting.



FIG. 4 Exudation-Indicator Device

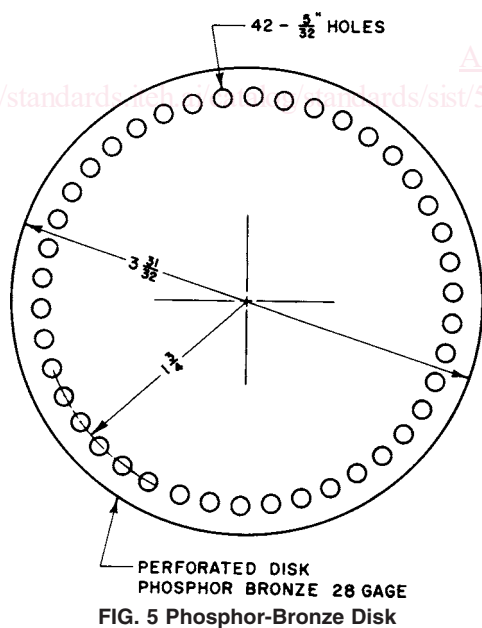


FIG. 5 Phosphor-Bronze Disk

10.2 Adjust the amount of air in the stabilometer cell so that 2 ± 0.05 turns of the pump handle increases the liquid pressure from 34 to 690 kPa (5 to 100 psi) with the standard metal specimen in the stabilometer chamber.

11. Resistance-Value Testing of Specimens

11.1 After testing for expansion pressure, pour water off the top of the specimen (Note 6) and place the mold with the specimen on top of the stabilometer. Place the follower on top of the specimen and force the specimen from the mold into the stabilometer. Remove the now empty mold from the stabilometer assembly. Lower the testing machine head until it just engages the follower.

NOTE 6—If all the water has drained through the specimen, add water to the top and allow to stand for 15 min. Pour off any excess water and continue test.

11.2 Apply a horizontal pressure of 34 kPa (5 psi) to the specimen by means of the displacement pump then apply a vertical load using a uniform rate of movement of 1.3 mm (0.05 in.)/min.

11.3 Record the horizontal pressure when the vertical load is 8900 N (2000 lbf) and stop loading. Reduce the vertical load to 4450 N (1000 lbf). With the displacement pump, adjust the horizontal pressure down 27 kPa (4 psi) then bring up to 34 kPa (5 psi).

NOTE 7—This will result in a further reduction in the applied load, and should be ignored.

11.4 Turn the stabilometer pump handle at approximately two turns per second and measure the number of turns of the pump handle (using the turns-displacement dial indicator on

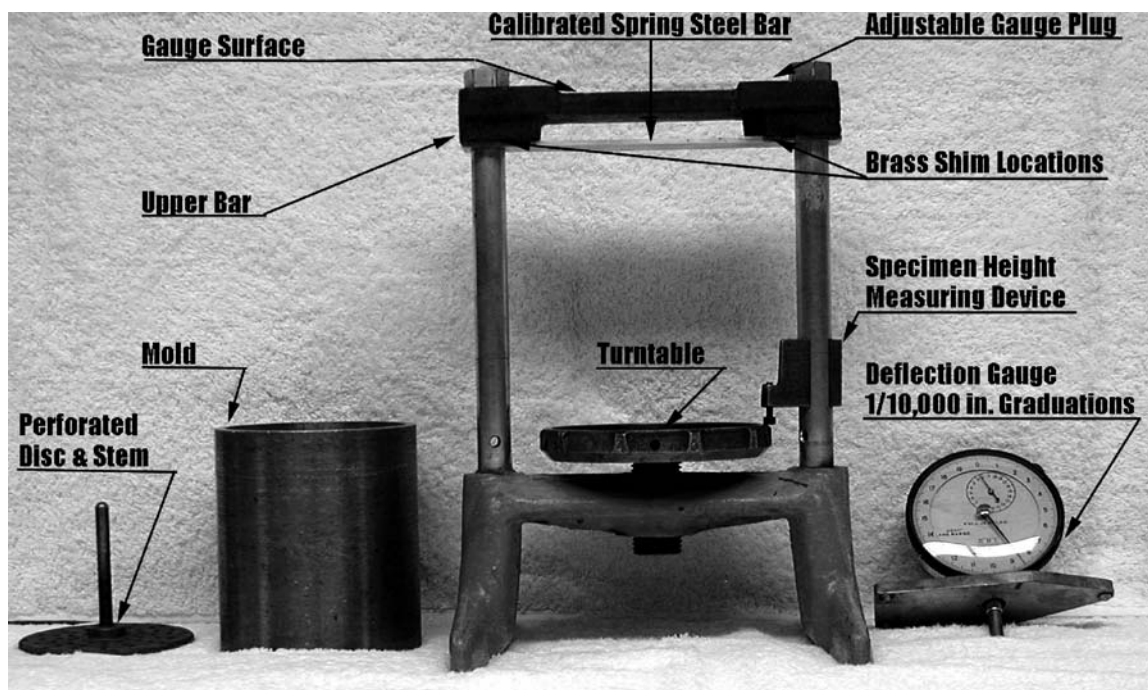


FIG. 6 Expansion-Pressure Device and Accessories

the stabilometer) to raise the horizontal pressure from 34 to 690 kPa (5 to 100 psi). This is the turns displacement, D , of the specimen.

11.5 Determine the resistance, R , as follows:

$$R = 100 - [100/(2.5/D)(1100/P_h - 1) + 1] \text{ for SI units}$$

$$R = 100 - [100/(2.5/D)(160/P_h - 1) + 1] \text{ for U.S. customary units}$$

where:

P_h = horizontal pressure, kPa (psi), and

D = number of turns, displacement dial indicator reading.

This is the R -value for specimens with compacted heights from 62 to 65 mm (2.45 to 2.55 in.). If the height of the specimen is between 58 and 62 mm or 65 and 68 mm (2.3 and 2.45 in. or 2.55 and 2.7 in., respectively) use the chart (Fig. 9) for correcting R -values to a specimen height of 63 mm (2.5 in.).

NOTE 8—If the R -value is desired at a specific exudation pressure, for example, 2070 kPa (300 psi), within the range of pressures measured in tests of the three specimens, it is convenient to construct a graph of R -value versus exudation pressure and interpolate.

12. Precision and Bias

12.1 Bias statements are not applicable to this test method.

12.2 The estimates of precision for this test method listed in Table 1 are based on the analysis of data from 13 pairs of AMRL soil reference samples. Participating laboratories were asked to perform AASHTO Test Method T 190, which is equivalent to ASTM Test Method D2844, at an exudation pressure of 300 psi. More than 100 paired test results from 16 to 23 laboratories were analyzed. Estimates of test precision for R -values greater than 50 have not been developed.

13. Keywords

13.1 acceptance tests; base course; bearing capacities; compaction; dynamic bearing capacity; expansion; expansive soils; flexible pavements; foundations; highway loads; inspection; kneading compaction; laboratory tests; materials tests; pavement design; resistance value; specifications; stability; stabilometer; subbase; subbase strength; subgrade; subgrade reaction; subgrade stability; trafficability