Designation: D4829 – 11

Standard Test Method for Expansion Index of Soils[1]

This standard is issued under the fixed designation D4829; 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 allows for determination of expansion potential of soils when inundated with distilled water.[2]

1.2 This test method provides a simple yet sensitive method for evaluation of expansion potential of soils for practical engineering applications using an index parameter.

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

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

1.4.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.5 *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:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2435 Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading

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

D3877 Test Methods for One-Dimensional Expansion, Shrinkage, and Uplift Pressure of Soil-Lime Mixtures

D4546 Test Methods for One-Dimensional Swell or Collapse of Cohesive Soils

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D6026 Practice for Using Significant Digits in Geotechnical Data

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E145 Specification for Gravity-Convection and Forced-Ventilation Ovens

3. Terminology

3.1 For common definitions of other terms used in this Test Method, refer to Terminology D653.

3.2 *Definitions:*

3.2.1 *scarification*—scratching the surface of a compacted layer to facilitate bonding with the next layer to avoid potential separation between compacted layers.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *expansion index (EI), n*—1000 times the difference between final and initial height of the specimen divided by the initial height.

4. Summary of Test Method

4.1 A specimen is prepared by compacting a test soil into a metal ring at a degree of saturation of 50 ± 2 %. The specimen and the ring are then placed in a consolidometer. A vertical confining pressure of 6.9 kPa (1 lbf/in.^{2}) is applied to the specimen and the specimen is then inundated with distilled water. The deformation of the specimen is recorded for 24 h or until the rate of deformation becomes less than 0.005 mm/h (0.0002 in./h), whichever occurs first. A minimum recording time of 3 h is required.

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Strength and Compressibility of Soils.

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[2] Refer to Anderson, J. N., and Lade, P. V., "The Expansion Index Test," *Geotechnical Testing Journal*, Vol 4, No. 2, ASTM, 1981, pp. 58–67.

[3] 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.

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

5. Significance and Use

5.1 The expansion index, *EI*, provides an indication of swelling potential of a soil.

5.2 The *EI* test is not used to duplicate any particular field conditions such as soil density, water content, loading, in-place soil structure, or soil water chemistry. However, consistent test conditions are used in preparation of compacted specimens such that direct correlation of data can be made.

NOTE 1—Qualitative classification of potential expansion in a soil based on *EI* is provided in Table 1.

NOTE 2—Notwithstanding the statements on precision and bias contained in this test method: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies which meet the criteria of Practice D3740 are generally considered capable of competent testing. Users of this test method are cautioned that compliance with Practice D3740 does not ensure reliable testing. Reliable testing depends on several factors; Practice D3740 provides a means of evaluating some of those factors.

5.3 The measurement of the magnitude of one-dimensional wetting-induced swell or collapse (hydrocompression) under different vertical (axial) pressures, as well as the magnitude of swell pressure and the magnitude of free swell, and also the determination of data for stress-induced compression following wetting-induced swell or collapse are covered by Test Methods D4546.

6. Apparatus

6.1 *Mold*—The mold shall be cylindrical in shape, made of metal, and shall have the capacity and dimensions indicated in Fig. 1. The mold shall have a detachable collar inscribed with a mark 50.8 mm (2.00 in.) above the base. The lower section of the mold is designed to retain a removable stainless steel ring 25.4 mm (1 in.) in height, 101.9 mm (4.01 in.) in internal diameter, and not less than 3.10 mm (0.120 in.) in wall thickness.

6.2 *Rammer*—A metal rammer with a circular face with a diameter of 50.8 mm (2.00 in.) and a mass of 2.5 kg (5.5 lbm) shall be used. The rammer shall be equipped with a suitable arrangement to control height of drop to a free fall of 304.8 mm ± 1.3mm (12 in. ± 0.05 in.) over the top of the soil to be compacted. See Test Methods D698 for further specification of a suitable rammer.

6.3 *Balance*—A balance of at least 1000 g capacity meeting the requirements of Guide D4753, Class GP2.

6.4 *Drying Oven*—A thermostatically controlled drying oven (specified in Specification E145) capable of maintaining a temperature of 110 ± 5°C (230 ± 9°F) for drying water content samples.

TABLE 1 Classification of Potential Expansion of Soils Using *EI*

Expansion Index, *EI*	Potential Expansion
0–20	Very Low
21–50	Low
51–90	Medium
91–130	High
>130	Very High

6.5 *Straight Edge*—Steel straight edge at least 150 mm (6 in.) in length with one beveled edge.

6.6 *Sieves*—A 4.75-mm (No. 4) sieve conforming to the requirements of Specification E11.

6.7 *Mixing Tools*—Miscellaneous tools such as mixing pans, spoons, trowels, spatula, a suitable mechanical device, and so forth for thoroughly mixing the sample of soil with water.

6.8 *Loading Device*—A consolidometer or equivalent loading device as described in Test Methods D2435 for supporting and submerging the specimen, for applying a vertical load, and for measuring the change in height of the specimen. The consolidometer ring must be as specified in 6.1.

6.9 *Porous Disks*—The disks shall be smooth ground and fine enough (Note 3) to minimize intrusion of soil into the disks. The disk shall reduce false displacements caused by seating of the specimen against the surface of the disk. Such displacements are significant, especially if displacements and applied vertical pressures are small.

NOTE 3—A suitable pore size is 10 µm.

6.9.1 Porous disks shall be air dry.

6.9.2 Porous disks shall have a close fit to the consolidometer ring to avoid extrusion or punching. Suitable disk dimensions are 12.7 mm ± 0.13 mm (0.50 in. ± 0.005 in.) in height and 101.5 mm ± 0.13 mm (3.995 in. ± 0.005 in.) in diameter or as described in 6.3 of Test Methods D2435.

7. Sample Preparation

7.1 *Preparation for Sieving*—If the soil sample is damp when received from the field, dry it until it becomes friable using a trowel. Air drying or oven drying at temperatures below 60°C (140°F) may be used. Thoroughly break up the aggregations in a manner such that the natural size of individual particles is not reduced.

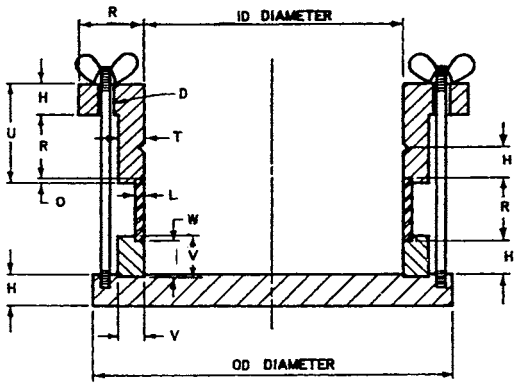
NOTE 4—If particles larger than 6.35 mm (0.25 in.) are potentially expansive, such as particles of claystone, shale, or weathered volcanic rock, they may be broken down so as to pass the 4.75-mm (No. 4) sieve if this is consistent with use of the soil.

7.2 *Sieving*—Sieve an adequate quantity of the representative soil using the 4.75-mm (No. 4) sieve. Record the percentage of coarse material retained on the 4.75-mm (No. 4) sieve and discard.

7.3 *Sample*—Select a representative sample of the soil with a mass of approximately 1 kg (2 lbm) or more prepared using the guidelines in 7.1 and 7.2.

8. Specimen Preparation

8.1 *Water Content*—Thoroughly mix the selected representative sample with sufficient distilled water to bring the soil to a water content that has a corresponding degree of saturation of 50 ± 2 % in the compacted condition. After mixing, take a representative sample of the material for determination of the water content and seal the remainder of the soil in a close-fitting airtight container for a period of at least 16 h. Weigh the moisture sample immediately, and dry in an oven at 110 ± 5°C (230 ± 9°F) for at least 12 h, or in accordance with Test Methods D2216, to a constant mass. The water content sample



Letter	in.	Tolerances (in.)	mm	Tolerances (mm)
ID	4.010	± 0.005	101.9	± 0.1
OD	6.00	± 1.01	152.4	± 0.2
H	0.50	± 0.01	12.7	± 0.2
D (Hole)	7/32	+ 1/64	5.5	+ 0.2
U	1.625	± 0.01	41.3	±0.2
T	0.325	± 0.01	9.5	± 0.2
O	0.125	± 0.004	3.2	± 0.1
R	1.00	± 0.01	25.4	± 0.2
W	0.563	± 0.004	14.3	± 0.1
V	0.688	± 0.01	17.5	± 0.2
L	0.120	± 0.000	3.05	± 0.0

FIG. 1 Mold with Ring for Compaction of Specimen for Expansion Index Test

shall have a mass of at least 100 g conforming with Test Methods D2216. The water content of the trimmings shall be determined in accordance with Test Methods D2216 using a resolution of 0.1 % or better.

8.2 *Specimen Compaction*—Prepare a specimen by compacting the cured soil in the 101.9-mm (4.01-in.) diameter mold in two equal layers to give a total compacted depth of 50.8 mm (2 in.). Compact each layer by 15 uniformly distributed blows of the rammer dropping free from a height of 305 mm ± 2.5 mm (12 in. ± 0.1 in.) above the top of the soil when a sleeve type rammer is used, or from 305 mm ± 2.5 mm (12 in. ± 0.1 in.) above the approximate elevation of each finally compacted layer when a stationary mounted type of rammer is used. Scarify the first compacted layer before adding material for the second layer using a knife or other suitable object. During compaction rest the mold on a uniform rigid foundation, such as provided by a cube of concrete with a mass not less than 90 kg (200 lb).

8.3 *Specimen Trimming*—Following compaction, remove the upper and lower portions of the mold from the inner ring and carefully trim the specimen flush with the top and bottom of the ring with a straight edge.

8.4 *Specimen Height*—Determine the initial height of the specimen H_1, with a resolution of 0.03 mm (0.001 in.) similar to the procedure in Section 7 of Test Methods D3877 or assume equal to the height of the specimen ring.

8.5 *Degree of Saturation*—Calculate the water content in accordance with Test Methods D2216 and the dry unit weight in accordance with Section 11 of Test Methods D698. Determine the degree of saturation using the equation provided below. If the degree of saturation is not within 50 ± 2 %, prepare another specimen. Adjust the water content of the new specimen based on the calculated degree of saturation and prepare the specimen in accordance with 8.1-8.4 to achieve a degree of saturation 50 ± 2 %. Increase the water content if the degree of saturation is less than 50% and decrease the water content if the degree of saturation is higher than 50 %.

$$S = \frac{wG_s\gamma_d}{G_s\gamma_w - \gamma_d} \quad (1)$$

where:

S = degree of saturation, %
w = water content, %,
G_s = specific gravity, use 2.7 unless the specific gravity is known to be less than 2.6 or more than 2.8,
γ_w = unit weight of water, 9.79 kN/m^3 (62.3 lbf/ft^3) at 20°C (68°F), and
γ_d = dry unit weight of compacted soil specimen, kN/m^3 (lbf/ft^3).

Use the resolution provided in 8.1 for w. Use a resolution of 0.1 kN/m^3 (0.1 lbf/ft^3) or better for γ_d.

NOTE 5—This standard test method assumes a specific gravity of 2.7, which is typical of soil minerals commonly used for compaction. In addition, using an assumed specific gravity value of 2.7 will result in a maximum error of 4 % in the calculated degree of saturation, provided the actual specific gravity is between 2.6 and 2.8. These small errors in saturation with mineral type will cause systematic and small changes in the *EI* that are considered equally important to variations caused when determining the specific gravity using Test Methods D854.

9. Procedure

9.1 Place the compacted soil specimen in the ring of a consolidometer or equivalent loading device with air-dried porous disks placed at the top and bottom ends of the specimen. Subject the specimen to a total pressure of 6.9 kPa (1 lbf/in.^{2}), including the weight of the upper porous disk and any unbalanced weight of the loading machine. Allow the specimen to compress under this pressure for a period of 10 min. Subsequent to this initial compression period, obtain the initial reading ($D1$) on the consolidometer dial indicator with a resolution of 0.03 mm (0.001 in.) or better.

9.2 Inundate the specimen with distilled water, obtaining periodic dial indicator readings, in accordance with Test Methods D2435, for a period of 24 h or until the rate of expansion becomes less than 0.005 mm/h (0.0002 in./h). However, in no case shall the sample be inundated and readings taken for less than 3 h.

9.3 Remove the specimen from the loading machine after the final reading (D_2) obtained with a resolution of 0.03 mm (0.001 in.) or better and determine the change in height ΔH as the difference between the initial and final reading of the dial indicator. Determine the specimen mass to the nearest 0.1 g (2.2×10^{-4} lbm).

10. Calculation and Report

10.1 *Calculation*—Calculate the expansion index, *EI*, as follows:

$$EI = \frac{\Delta H}{H_1} \cdot 1000 \qquad (2)$$

where:

ΔH = change in height, $D_2 - D_1$, mm,
H_1 = initial height, mm,
D_1 = initial dial reading, mm, and
D_2 = final dial reading, mm.

Use the resolutions provided in 8.4, 9.1, and 9.3 for H1, D1, and D2, respectively.

10.2 Record as a minimum the following general information (data):

10.2.1 Sample/specimen identifying information, such as Project No., Boring No., Sample No., Depth, and so forth.

10.2.2 Any special selection and preparation process, such as breaking down large particles of claystone, shale, volcanic rock, and so forth.

10.3 Record as a minimum the following specimen data:

10.3.1 The initial height (use a resolution of 0.03 mm (0.001 in.) or better).

10.3.2 The initial water content (nearest 0.1 %).

10.3.3 The initial dry unit weight (use a resolution of 0.1 kN/m^3 (0.1 lbf/ft^3) or better).

10.3.4 The initial degree of saturation (use three significant digits).

10.4 Record as a minimum the following expansion test data:

10.4.1 The initial and final dial readings (use a resolution of 0.03 mm (0.001 in.) or better).

10.4.2 The final water content (nearest 0.1 %).

10.4.3 Report the *EI* to the nearest whole number. If the initial specimen height is greater than the final specimen height, report the expansion index as zero.

11. Precision and Bias

11.1 *Interlaboratory Test Program*—An interlaboratory test program using three different soil samples was performed by 14 geotechnical firms in the Los Angeles and Orange Counties of California (Table 2).

NOTE 6—The data in Table 2 was obtained using a version of the standard that allowed the specimen to be prepared within a 40 to 60 % saturation range, then further allowed interpreting the *EI* corresponding to a saturation of 50 %, if necessary, by use of an equation.

11.1.1 *Precision*—The repeatability limit (within laboratory) cannot be determined from the data from the referenced study because the participating laboratories did not perform replicate tests on each soil sample. Subcommittee D18.05 is seeking pertinent data from the users of this test method.

11.1.1.1 The reproducibility (between laboratories) can be determined from the reference study. The standard deviation (1s limit) and the difference two-standard-deviation limit (d2s limit) are presented in Table 2 (there is a 95 % probability that two properly conducted tests performed by different laboratories will differ by less than the d2s limit).

11.2 *Bias*—There is no acceptable reference value for this test method, therefore, bias cannot be determined.

12. Keywords

12.1 clays; expansive soils; index tests; laboratory tests; soil moisture; swelling soils

TABLE 2 Results of Interlaboratory Test Program

Average Expansion Index	Standard Deviation (1 s limit)	Difference Two-Standard-Deviation Limit (d2s limit)
56	11	30
76	14	39
77	18	50

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this test method since the last issue, D4829–08a, that may impact the use of this test method. (Approved November 1, 2011)

(*1*) Revised Sections 1 and 5 to remove the word "compacted" as a descriptor for the type of soils to which the method is applicable.

(*2*) Added new 5.3 to refer the user to Test Methods D4546 for quantitative results due to swelling.