Designation: D 4829 – 95

Standard Test Method for Expansion Index of Soils[1]

This standard is issued under the fixed designation D 4829; 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 provides an index to the expansion potential of compacted soils when inundated with distilled water.[2]

1.2 This test method controls variables that influence the expansive characteristics of soils and still retains a relatively simple test for practical engineering applications.

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

D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft lbf/ft^3(600 kN-m/m^3))[3]

D 854 Test Method for Specific Gravity of Soils[3]

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

D 2435 Test Method for One-Dimensional Consolidation Properties of Soils[3]

D 3877 Test Methods for One-Dimensional Expansion, Shrinkage, and Uplift Pressure of Soil-Lime Mixtures[3]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[3]

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

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]

3. Terminology

3.1 Refer to Terminology D 653 for standard definitions of terms. Additional terms are as follows:

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

4. Summary of Test Method

4.1 The specimen is compacted into a metal ring so that the degree of saturation is between 40 and 60 % and the specimen and the ring are placed in a consolidometer. A vertical confining pressure of 6.9 kPa (1 lbf/in.^{2}) is applied to the specimen and then the specimen is inundated with distilled water. The deformation of the specimen is recorded for 24 h or until the rate of deformation becomes less than 0.0005 mm/h (0.0002 in./h), whichever occurs first. A minimum recording time of 3 h is required.

5. Significance and Use

5.1 The expansion index, *EI*, is used to measure a basic index property of soil and therefore, the *EI* is comparable to other indices such as the liquid limit, plastic limit, and plasticity index of soils, as in Test Method D 4318.

5.2 The *EI* 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, the test procedure keeps all conditions constant allowing direct correlation of data between organizations. All organizations can benefit from these collective experiences.

5.3 The classification of a potentially expansive soil is based on the following table:

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

6. Apparatus

6.1 *Mold*—The mold shall be cylindrical in shape, made of metal, and have the capacity and dimensions indicated in Fig. 1. It shall have a detachable collar inscribed with a mark 5.08 mm (2.00 in.) above the base. The lower section of the mold is designed to retain a removable stainless steel ring 2.54 mm (1 in.) in height, 10.19 mm (4.01 in.) in internal diameter, and not less than 0.31 mm (0.120 in.) in wall thickness.

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Structural Properties of Soils.

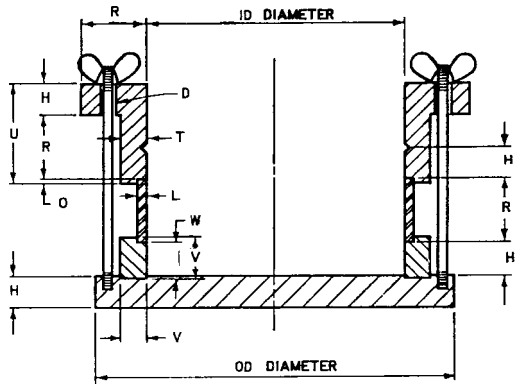
Current edition approved April 15, 1995. Published August 1995.

[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] *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.**



Letter	in.	mm
ID	4.01	101.9
OD	5½	139.7
H	½	12.7
D	7/32 Hole	5.6 Hole
U	1⅝	41.3
T	⅜	9.5
O	⅛	3.2
R	1	25.4
W	7/16	11.1
V	9/16	14.3
L	0.120	3.05

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

6.2 *Rammer*—A metal rammer having a 5.08 mm (2.00 in.) diameter circular face and weighing 2.5 kg (5.5 lbf) shall be equipped with a suitable arrangement to control height of drop to a free fall of 30.5 mm (12 in.) above the top of the soil. See Test Methods D 698 for specification of a suitable rammer.

6.3 *Balance*—A balance of at least 1000 g capacity meeting the requirments of Specification D 4753, Class GP2.

NOTE 1—For further information refer to Specification D 4753.

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

6.5 *Straight Edge*—Steel straight edge 30.5 mm (12 in.) in length and having one bevelled edge.

6.6 *Sieves*—A 4.75-mm (No. 4) sieve conforming to the requirements of Specification E 11.

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

6.8 *Loading Device*—A consolidometer or equivalent loading device as described in Test Method D 2435 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 to minimize intrusion of soil into the disks and shall reduce false displacements caused by seating of the specimen against the surface of porous disks (Note 2). Such displacements may be significant, especially if displacements and applied vertical pressures are small.

NOTE 2—A suitable pore size is 10 µm.

6.9.1 Porous disks shall be air dry.

6.9.2 Porous disks shall fit close to the consolidometer ring to avoid extrusion or punching. Suitable disk tolerances are described in 6.3 of Test Method D 2435.

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 under a trowel. Drying may be in air or by the use of drying apparatus, such that the temperature of the sample does not exceed 60°C (140°F). Then thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of individual particles.

NOTE 3—If particles larger than 0.6 mm (0.25 in.) are potentially expansive, such as 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 pulverized soil over 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 lbf) or more prepared as in 7.1 and 7.2.

8. Specimen Preparation

8.1 *Adjust Water Content*—Thoroughly mix the selected representative sample with sufficient distilled water to bring the soil to approximately optimum water content as determined in accordance with Test Method D 698. The actual test method need not be run, but experience and judgement should be used to estimate that water content. After mixing, take a representative sample of the material for moisture determination and seal the remainder of the soil in a close-fitting airtight container for a period of at least 16 h (or overnight). 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 Method D 2216, to a constant mass to determine water content. The moisture sample shall have a mass of at least 300 g (0.66 lbf).

8.2 *Specimen Molding*—Form a specimen by compacting the cured soil in the 10.19-mm (4.01-in.) diameter mold in two equal layers to give a total compacted depth of approximately 5.1 mm (2 in.). Compact each layer by 15 uniformly distributed blows of the rammer dropping free from a height of 30.5 mm (12 in.) above the top of the soil when a sleeve type rammer is used, or from 30.5 mm above the approximate elevation of each finally compacted layer when a stationary mounted type of rammer is used. 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 *Trim Specimen*—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 *Determine Initial Height*—Determine initial height of the specimen H_1 to within 0.05 mm (0.02 in.) similar to the procedure in 6.4 of Test Methods D 3877 or assume equal to the height of the specimen ring.

8.5 *Saturation*—Calculate the water content and dry unit

weight in accordance with Section 6 of Test Method D 698. Weigh the compacted specimen and determine the percent saturation. The percent saturation, *S*, may be determined as follows:

$$S = \frac{wG_s\alpha_d}{G_s\alpha_w - \alpha_d} \quad (1)$$

where:
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 (see Note 5),
α_w = unit weight of water, 9.8 kN/m^3 (62.4 lbf/ft^3), and
α_d = dry unit weight, kN/m^3 (lbf/ft^3).

NOTE 4—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. The corresponding maximum error in the Expansion Index calculated from 10.1.2 is 3.[2] An error of this magnitude is much less than the normal scatter obtained in these tests as indicated in 11.1. Refer to Test Method D 854 for measurement of specific gravity outside the given range.

8.6 *Adjust Water Content*—Adjust the water content to achieve a degree of saturation of 50 ± 1 %. If the degree of saturation is not between 49 and 51 %, then remove the soil from the mold and adjust the water content by adding water or air drying. Repeat the steps in 8.2, 8.3, 8.4, and 8.5 until the degree of saturation of the compacted specimen is between 49 and 51 %.

NOTE 5—Alternatively, the expansion index at 50 % saturation may be calculated from the measured index EI_{meas} of a single test at a saturation in the range of 40 to 60 % in 10.1.2.

9. Procedure

9.1 Place the soil specimen, which has been compacted in the 10.19-mm (4.01-in.) diameter ring, in a consolidometer or equivalent loading device with air dried porous disks at the top and bottom. Place on the specimen 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 consolidate under this pressure for a period of 10 min, after which time make the initial reading (D_1) on the consolidometer dial indicator to an accuracy of at least 0.003 mm (0.001 in.).

9.2 Inundate the specimen in distilled water, making periodic readings on the dial indicator for a period of 24 h or until the rate of expansion becomes less than 0.0005 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) 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.

10. Calculation and Report

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

$$EI_{meas} = \frac{\Delta H}{H_1}\cdot 1000 \quad (2)$$

TABLE 1

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

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

10.1.1 Report *EI* to the nearest whole number. If the initial specimen height is greater than the final specimen height, report the expansion index as zero. The molding water content, the final water content, and initial dry density of the specimen should accompany the expansion index in the complete presentation of results.

10.1.2 If the degree of saturation, *S*, is within the range from 40 to 60 %, the expansion index at 50 % saturation may be calculated from:

$$EI_{50} = EI_{meas} - (50 - S_{meas})\frac{65 + EI_{meas}}{220 - S_{meas}} \quad (3)$$

where:
EI_{meas} = measured expansion index corresponding to a degree of saturation,
S_{meas} = degree of saturation determined by the test, and
EI_{50} = estimate of the expansion index (*EI*).

Scatter in test data overshadows a maximum error of 1 % that may be introduced by the above calculation.[2]

10.2 The report should indicate if *EI* was determined from 10.1 by adjusting the water content to achieve a degree of saturation 50 ± 1 % or calculated from 10.1.2 using EI_{meas} for S_{meas} within 40 and 60 % saturation.

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.

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 1. (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

SUMMARY OF CHANGES

This section identifies the location of changes to this test method that have been incorporated since the last issue. Committee D-18 has highlighted those changes that affect the technical interpretation or use of this test method.

(1) The definition of weighted expansion index has been removed.

(2) The precision statement has been revised.