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Standard Test Method for Measurement of Collapse Potential of Soils[1]

This standard is issued under the fixed designation D 5333; 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 determination of the magnitude of one-dimensional collapse that occurs when unsaturated soils are inundated with fluid.

1.2 This test method may be used to determine the magnitude of potential collapse that may occur for a given vertical (axial) stress and an index for rating the potential for collapse.

1.3 This test method specifies the technique for specimen preparation, apparatus, and procedure for quantifying the amount of height change associated with collapse and procedures for reporting test results.

1.4 The procedures given in this test method are applicable to both undisturbed and remolded specimens.

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

1.6 *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[2]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[2]

D 2435 Test Method for One-Dimensional Consolidation Properties of Soils[2]

D 4829 Test Method for Expansion Index of Soils[2]

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *collapse*—decrease in height of a confined soil following wetting at a constant applied vertical stress. A collapsible soil may withstand relatively large applied vertical stress with small settlement while at a low water content, but this soil will exhibit settlement (that could be large) after wetting with no additional increase in stress. Large applied vertical stress is not necessary for collapse.

3.2.2 *collapse index* (I_e), percent—relative magnitude of collapse determined at 200 kPa (2 tsf) and calculated using (Eq 1).

3.2.3 *collapse potential* (I_c), percent—relative magnitude of soil collapse determined at any stress level as follows:

$$I_c = \left[\frac{d_f - d_o}{h_o} - \frac{d_i - d_o}{h_o}\right]100 = \left[\frac{d_f - d_i}{h_o}\right]100 \tag{1}$$

where:

d = dial reading, mm (in.),
d_o = dial reading at seating stress, mm (in.),
h_o = initial specimen height, mm (in.),
d_f = dial reading at the appropriate stress level after wetting, mm (in.),
d_i = dial reading at the appropriate stress level before wetting, mm (in.),
$(d_f - d_o)/h_o$ = strain at the appropriate stress level after wetting, and
$(d_i - d_o)/h_o$ = strain at the appropriate stress level before wetting.

Eq 1 may be rewritten in terms of void ratio:

$$I_c = \frac{\Delta e}{1 + e_o} \cdot 100 \tag{2}$$

where:

Δe = change in void ratio resulting from wetting, and
e_o = initial void ratio.

or, since the test is conducted as a one-dimensional test:

$$I_c = \frac{\Delta h}{h_o} \cdot 100 \tag{3}$$

where:

Δh = change in specimen height resulting from wetting, mm (in.) and
h_o = initial specimen height, mm (in.).

4. Summary of Test Method

4.1 The test method consists of placing a soil specimen at natural water content in a consolidometer, applying a predetermined applied vertical stress to the specimen and inundating the specimen with fluid to induce the potential collapse in the soil specimen. The fluid should be distilled water when evaluating the collapse index, I_e. The fluid may simulate pore water of the specimen or other field condition as necessary

[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.

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

when evaluating collapse potential, I_c.

5. Significance and Use

5.1 Collapsible soils occur widely in the United States and worldwide. Collapsible soils are typified by low values of dry unit weight and natural water content. Engineering works founded on collapsible soils may be damaged by sudden and often large induced settlements when these soils are saturated after construction. Predicting collapse potential is important to the design of many engineering structures.

5.2 Collapse potential, I_c, is used to estimate settlement that may occur in a soil layer at a particular site. I_c is determined from (Eq 1) using a predetermined applied vertical stress and fluids applied to a soil specimen taken from the soil layer. Settlement of a soil layer for the applied vertical stress is obtained by multiplying I_c by $H/100$ where H is the thickness of the soil layer.

5.2.1 Procedures for estimating potential for collapse are uncertain because no single criterion can be applied to all collapsible soils. For example, some soils may swell after fluid is added to the specimen until sufficient vertical stress has been applied. Collapse may then occur after additional vertical stress is applied. This test method may be used to determine the collapse potential, I_c, of soil at a particular vertical stress or the collapse index, I_e, at an applied vertical stress of 200 kPa (2 tsf). I_c for smaller applied vertical stress may be estimated assuming that the soil does not swell after inundation at smaller applied vertical stress.

5.2.2 Amount of settlement depends on the extent of the wetting front and availability of water, which can rarely be predicted prior to collapse.

5.3 The collapse index, I_e, is used to measure a basic index property of soil.

5.3.1 I_e is comparable to the expansion index as measured in accordance with Test Method D 4829, and is used to describe the degree of collapse that a particular soil will exhibit under specified conditions.

5.3.2 I_e is not intended to duplicate any particular field conditions such as loading, in-place soil structure, or soil water chemistry. The test procedure maintains constant test conditions allowing direct correlation of data between organizations and direct investigation of a particular aspect of soil behavior.

5.3.3 I_e is classified in Table 1.

6. Apparatus

6.1 Apparatus shall conform to Test Method D 2435.

6.2 Porous stones shall be air-dried to preclude increases in water content of the specimen through capillarity.

7. Specimen Preparation

7.1 Specimens may be remolded or compacted or taken from undisturbed soil samples. Prepare undisturbed specimens in accordance with guidelines of Test Method D 2435.

7.2 Use relatively undisturbed specimens to determine collapse potential, I_c. Since collapsible soils are sensitive to sampling methods using fluids, samples shall be taken using dry methods. Successful dry sampling methods include the double tube auger and hand carved block samples.

TABLE 1 Classification of Collapse Index, I_e

Degree of Collapse	Collapse Index I_e, %
None	0
Slight	0.1 to 2.0
Moderate	2.1 to 6.0
Moderately severe	6.1 to 10.0
Severe	>10

8. Calibration

8.1 Assemble and calibrate the consolidometer in accordance with Test Method D 2435.

9. Soil Parameters

9.1 Soil parameters such as natural water content, mass, volume, specific gravity, liquid and plastic limits, and particle size distribution may be determined following general guidance in Test Method D 2435. The natural and final water content shall be determined in accordance with Test Method D 2216.

10. Procedure

10.1 Conduct the test in accordance with Test Method D 2435, except as follows:

10.1.1 Place the specimen in the loading device immediately after determining the initial wet mass and height of the specimen following compaction or trimming. Enclose the specimen ring, filter paper, if any, and porous stones as soon as possible with a loose fitting plastic membrane, moist paper towel, or aluminum foil to minimize change in specimen water content and volume due to evaporation. Then apply a seating stress of 5 kPa (0.05 tsf). Within 5 min of applying the seating stress, apply load increments each hour at natural water content until the appropriate vertical stress is applied to the soil. Load increments should be 12, 25, 50, 100, 200, etc. kPa (0.12, 0.25, 0.5, 1, 2 tsf). Record the deformation before each load increment is applied.

NOTE 1—The duration between load increments prior to wetting is limited to 1 h to prevent excessive evaporation of moisture from the specimen that would cause erratic results.

10.2 The stress to be applied to the soil prior to wetting depends on whether I_c or I_e is to be determined as appropriate for the design situation.

10.3 Inundate the specimen with fluid 1 h after loading to the appropriate vertical stress and after recording the deformation or dial reading. Record deformation versus time at approximately 0.1, 0.25, 0.5, 1, 2, 4, 8, 15, 30 min and 1, 2, 4, 8, and 24 h or as according to Test Method D 2435 after adding fluid.

NOTE 2—In soils with high permeability, collapse may occur rapidly and time dependency may be difficult to measure.

10.3.1 Fluid shall be distilled-deionized water to determine I_e.

10.3.2 Use fluids appropriate for various site conditions or anticipated changes in groundwater characteristics to determine I_c. These fluids shall be described in the report.

10.4 Add fluid to allow for specimen wetting from the bottom only, so that air will not be trapped in the specimen.

10.5 The duration of the load increment following inundation shall be overnight or until primary consolidation according to Test Method D 2435 has been completed.

10.6 Additional vertical stress may be placed on the specimen in increments according to Test Method D 2435 as needed or until the slope of the deformation versus stress level curve is obtained. Record deformation versus time as in 10.3. Leave each load increment on overnight or until primary consolidation has been completed.

11. Report

11.1 Report the following information:

11.1.1 Identification and description of the test specimen, including whether the specimen is undisturbed, remolded, or prepared in other ways,

11.1.2 Initial and final water content and dry unit weight,

11.1.3 Specimen dimensions,

11.1.4 Description of consolidometer,

11.1.5 Applied vertical stress at inundation, and

11.1.6 Percent compression or strain of the specimen at each applied vertical stress prior to inundation.

11.2 The data shall be plotted strain versus logarithm of the applied vertical stress. Void ratio may be used instead of strain if specific gravity is determined:

11.2.1 Fig. 1 is an illustration of data from results of a test for measuring collapse potential. I_c is calculated for the applied vertical stress of 100 kPa (1 tsf) by (Eq 1):

$$I_c = (9.6 - 1.5) = 8.1 \tag{4}$$

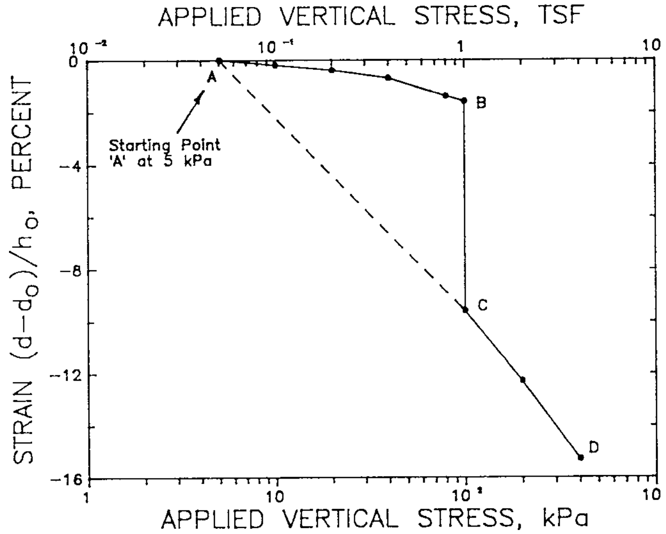
where point C is at 9.6 % strain and Point B is at 1.5 % strain. Potential settlement of a soil layer 3 m (10 ft) thick with this collapse potential is 8.1·3/100 = 0.24 m (0.81 ft).

11.2.2 Collapse potential may be estimated for applied vertical stress less than 100 kPa (1 tsf) by calculating the difference in strain between the inundated (dotted) and uninundated curves. For example, collapse potential at 40 kPa (0.4 tsf) is:

$$I_c = (6.8 - 0.8) = 6.0 \tag{5}$$

Settlement of the soil layer is 6.0·3/100 = 0.18 m (0.6 ft).

11.3 All departures from these procedures including special loading sequences, special specimen preparation procedures, special specimen dimensions, and special wetting fluid.



d = dial reading, mm (in.)
d_o = dial reading at seating stress, mm (in.)
h_o = initial specimen height, mm (in.)

NOTE 1—$(d - d_o)/h_o$ is multiplied by 100 to obtain percent.

FIG. 1 Example Compression Curve of the Collapse Potential Test

11.4 Collapse index, I_e, or collapse potential, I_c, whichever is applicable as defined in Section 3.

12. Precision and Bias

12.1 Data are being evaluated to determine the precision of this test method. In addition, Subcommittee 18.05 is seeking pertinent data from users of the test method.

12.2 There is no accepted reference value for this test method, therefore, bias cannot be determined.

13. Keywords

13.1 collapse; collapse index; collapse potential; compressibility; consolidation; soil