Designation: D 425 – 88 (Reapproved 1994)

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Centrifuge Moisture Equivalent of Soils[1]

This standard is issued under the fixed designation D 425; 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.

ε[1] NOTE—Paragraph 6.1 was changed editorially in September 1988.

1. Scope

1.1 This test method covers the determination of the moisture equivalent of soil in the laboratory by means of a centrifuge technique.

1.2 This test method is limited to disturbed specimens of coarse-grained soils having fines of low plasticity such as SP, SW, SC-SM, or SM soils. The test is limited to soils passing the 2.00-mm sieve or that fraction of a soil passing a 2.00-mm sieve.

NOTE 1—Test Method D 3152 or Test Method D 2325 should be used to evaluate the capillary-moisture relations of fine-grained soils and coarse-grained soils having fines of medium to high plasticity, undisturbed soils, and soils at specific desired units weights.

1.3 The test method is temperature-dependent, and consistent comparable results can be obtained only if the tests are performed under a constant-temperature condition.

1.4 The values stated in SI units are to be regarded as the standard.

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:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

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

D 2325 Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus[2]

D 3152 Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-Membrane Apparatus[2]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

3. Terminology

3.1 All definitions are in accordance with Terminology D 653. Terms of particular significance are as follows:

3.2 *capillary fringe zone*—the zone above the free water elevation in which water is held by capillary action.

3.3 *centrifuge moisture equivalent*—the water content of a soil after it has been saturated with water and then subjected for one hour to a centrifugal force equal to 1000 times that of gravity.

3.4 *specific retention*—the ratio of the volume of water that cannot be drained from a saturated soil under the action of force of gravity to the total volume of voids.

3.5 *water-holding capacity*—the smallest value to which the water content of soil or rock can be reduced by gravity drainage.

4. Summary of Test Method

4.1 The centrifuge moisture equivalent of soils is determined by initially air-drying the soil, selecting two 5-g test specimens, thoroughly soaking each test specimen, and then determining the water content of each specimen after it has been centrifuged for 1 h at a force equal to 1000 times that of gravity at a controlled temperature of 20 ± 1°C.

5. Significance and Use

5.1 Not all water contained in a saturated soil can be removed by gravity drainage. The amount of water retained after gravity drainage is usually expressed as water holding capacity or specific retention. It varies with time, and with the particle-size distribution and plasticity of the soil (in general, increasing in value with increasing plasticity index).

5.2 In general, the centrifuge moisture equivalent is based on the theory of applying a centrifugal force great enough to reduce the capillary fringe zone enough that it can be ignored without introducing much error, even in small specimens, and yet not so great as to withdraw a large proportion of the water

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

Current edition approved May 27, 1988. Published July 1988. Originally published as D 425 – 35 T. Last previous edition D 425 – 79[ε1].

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

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

that is held securely above the capillary fringe. For example, if a soil will hold water 100 mm by capillarity acting against gravity, the soil will theoretically be able to hold the water only 0.1 mm against a centrifugal force that is 1000 times greater than the force of gravity. It has been determined that for at least medium-textured soils (sandy to silty particle-size distribution) the centrifuge moisture equivalent approximates the water holding capacity and when combined with the bulk density can be used to calculate an approximate specific retention and specific yield. These properties when combined with porosity can be used to estimate aquifer storage coefficient.

6. Apparatus

6.1 *Centrifuge*—A centrifuge of such a size and so driven that a force equal to 1000 times the force of gravity may be exerted on the center of gravity of the soil specimen for 1 h. The centrifuge chamber shall be capable of maintaining a controlled temperature of 20 ± 1°C. The revolutions per minute, *N*, required to provide a centrifugal force of 1000 times gravity is determined from the equation:

$$N = \sqrt{\frac{RCF}{0.0000111\ rm}} \tag{1}$$

where:

N = revolutions per minute,
RCF = relative centrifugal force (1000),
r = radius of rotation to center of gravity of the test specimen, cm, and
m = mass of the body, taken as unity.

For normal equipment installation, *N* will equal approximately 2300 rpm.

6.2 *Gooch Crucible*—A procelain Gooch crucible having a perforated bottom, a capacity of approximately 25 mL, and a diameter at bottom of about 20 mm (Fig. 1). Crucibles should be numbered and paired in such a way that their masses meet the requirements of the manufacturer of the centrifuge.

6.3 *Babcock Trunnion Cups*—At least one pair of centrifuge cups with caps and with a crucible holder for supporting the Gooch crucible above the bottom of the cup (Fig. 1). The holder shall have sufficient clearance to fit fully within the cup and short support the cup in such a manner that the water ejected during the centrifuging operation does not come in contact with the crucible and soil. Cups and crucible holders should be balanced in pairs opposite each other in the centrifuge and should be numbered in pairs (for example, 1, 1A, 2, 2A, etc.).

6.4 *Filter Paper*—A circular piece of filter paper just large enough to cover the inside bottom of the Gooch crucible.

NOTE 2—Filter papers may be purchased already cut to size from a

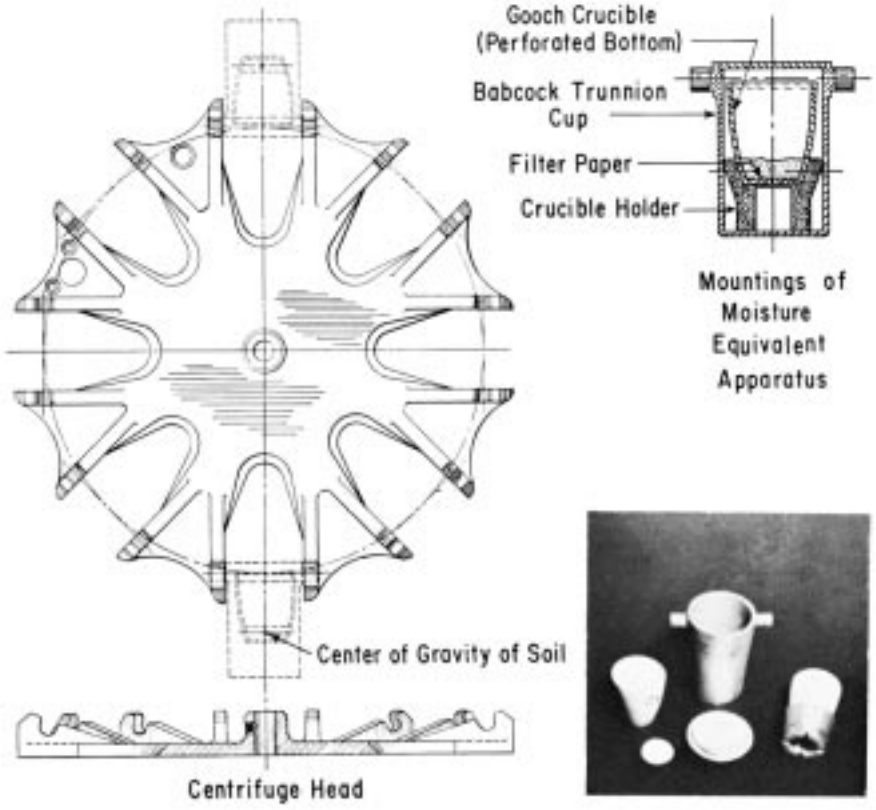

FIG. 1 Crucible, Trunnion Cup, and Cup Holder

scientific supply company. A medium speed, high wet strength (hardened) paper is recommended.

6.5 *Balance*—A balance having a readability of 0.01 g, and accurate to ±0.03 g.

NOTE 3—For additional information on balances refer to Specification D 4753.

6.6 *Humidifier*—A desiccator cabinet or large desiccator jar with water in the lower half works satisfactorily. The desiccator plate should be covered with hardware cloth on which to set the crucibles and soil specimens.

6.7 *Oven*—A thermostatically controlled drying oven, preferably of the forced-draft type, capable of maintaining a uniform temperature of 110 ± 5°C throughout.

6.8 *Water Content Containers*—Suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, and cleaning. Containers shall have close-fitting lids to prevent loss of moisture from the soil before initial weighing and to prevent absorption of moisture from the atmosphere following oven drying and before final weighing. One container is needed for each water content determination. Containers should be 60 to 90-mL capacity.

NOTE 4—It is recommended that the containers be numbered in pairs to coincide with the crucible numbers.

6.9 *Mortar and Pestle*—A mortar and rubber-covered pestle suitable for breaking up the aggregations of soil particles.

6.10 *Sieve*—2.00-mm (No. 10) sieve conforming to Specification E 11. A sieve bottom pan and lid are also highly desirable for facilitating specimen preparation.

7. Test Specimen

7.1 Expose the soil sample, as received, to the air at room temperature until dried thoroughly. Break up the aggregations thoroughly in the mortar with a rubber-covered pestle. Dry sieve this material on a 2.00-mm sieve.

NOTE 5—If the sample, as received, has a mass much greater than required to perform this test, the sample can be thoroughly mixed and a sample weighing about 50 g split out for air drying.

7.2 Take two 5-g specimens from the material passing the 2.00-mm sieve after it has been thoroughly mixed. The crucibles should be numbered and paired in such a way that the masses of the crucibles and contents meet the requirements of the manufacturer of the centrifuge.

8. Procedure

8.1 Place the specimens loosely but evenly in the paired Gooch crucibles, in which previously has been placed a piece of wet filter paper that just covers the bottom of each crucible. Place the crucible in a pan of distilled or demineralized water of a depth at least 5 mm greater than the height of soil in the cup and allow the soil to take up water until "saturated." Eight hours or overnight usually is satisfactory, as indicated by the presence of free water covering the surface of the soil. Place the crucible and specimen in the humidifier to drain for at least 12 h to ensure uniform distribution of moisture throughout the soil mass. Pour or siphon off any water standing above the surface of the specimens and place the crucibles in the centrifuge cups fitted as described in 6.2. Place the paired crucibles in the centrifuge cups opposite each other in the centrifuge.

8.2 Control the centrifuge at a temperature 20 ± 1°C. Bring the centrifuge to the required speed within 5 min by five successive equal steps of the rheostat, with 1 min at each step. Maintain the centrifuge for 60 min at a constant speed which, for the diameter head used, will exert a centrifugal force 1000 times the force of gravity upon the center of gravity of the test specimen. Following this period of centrifuging at required speed, allow the centrifuge to come to rest with as little braking as possible, but not to exceed a 5-min time interval.

8.3 When water is observed on the top of the soil after centrifuging, the soil is said to have water-logged. The centrifuge moisture equivalent is not considered to be valid for this material and the report should be so noted.

8.4 Immediately after centrifuging, transfer soil from the crucibles to the water content containers as quickly as possible to minimize moisture loss; it is not necessary to remove all of the soil from the crucibles. Then determine the water content of each specimen in accordance with Method D 2216.

8.5 A copy of a sample data sheet is shown in Fig. 2. Any data sheet can be used, provided the form contains all the required data.

9. Calculation

9.1 Calculate the centrifuge moisture equivalent as the average of the water contents of the two specimens.

10. Report

10.1 The report shall include the following:

10.1.1 Identification of sample (material) being tested, by boring number, sample number, test number, etc.

10.1.2 Average centrifuge moisture equivalent of the specimen to the nearest 1 %. If the specimen was water-logged, the report should state that the centrifuge moisture equivalent was not valid for the soil tested.

10.1.3 Indication of which test specimen, if any, was water-logged.

11. Precision and Bias

11.1 *Precision*—Information on the precision of this test method is being gathered.[4]

12. Keywords

12.1 centrifuge moisture equivalent; specific retention; specific yield, storage capacity; water holding capacity

[4] For a discussion of variables which affect the results of this test, see Johnson, A. I., Prill, R. C., and Morris, D. A., "Specific Yield–Column Drainage and Centrifuge Moisture Content," U.S. Geological Survey Water Supply Paper 1662-A, 1963.

(1) Laboratory Sample No.								
(2) Container No.								
(3) Weight of container + wet sample (W_{cws}), g								
(4) Weight of container + dry sample (W_{cs}), g								
(5) Weight of moisture (W_w), g (3 - 4)								
(6) Weight of container (W_c), g								
(7) Weight of dry sample, (W_s), g (4 - 6)								
(8) Moisture Equivalent (w_{cme}), % (5 ÷ 7) x 100								
(9) Average Moisture Equivalent (w_{cme}) , %								

Date and Name: Analyzed_____ Computed_____ Checked_____
Remarks: _____

(1) Laboratory Sample No.								
(2) Container No.								
(3) Weight of container + wet sample (W_{cws}), g								
(4) Weight of container + dry sample (W_{cs}), g								
(5) Weight of moisture (W_w), g (3 - 4)								
(6) Weight of container (W_c), g								
(7) Weight of dry sample, (W_s), g (4 - 6)								
(8) Moisture Equivalent (w_{cme}), % (5 ÷ 7) x 100								
(9) Average Moisture Equivalent (w_{cme}) , %								

Date and Name: Analyzed_____ Computed_____ Checked_____
Remarks: _____

FIG. 2 Centrifuge Moisture Equivalent Sample Data Sheet

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