Designation: ~~D6572 – 20~~ D6572 – 21

Standard Test Methods for Determining Dispersive Characteristics of Clayey Soils by the Crumb Test[1]

This standard is issued under the fixed designation D6572; 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 Two test methods are provided to give a qualitative indication of the natural dispersive characteristics of clayey soils: Method A and Method B.

1.1.1 *Method A*—Procedure for Natural Soil Crumbs described in 10.1.

1.1.2 *Method B*—Procedure for Remolded Soil Crumbs described in 10.2.

1.2 The crumb test, while a good, quick indication of dispersive soil, should usually be run in conjunction with a pinhole test and a double hydrometer test, Test Methods D4647/D4647M and D4221, respectively. Since this test method may not identify all dispersive clay soils, other tests such as, pinhole dispersion (Test Methods D4647/D4647M), double hydrometer (Test Method D4221) and the analysis of pore water extraction (Test Methods D4542) may be performed individually or used together to help verify dispersion.

1.3 The crumb test has some limitations in its usefulness as an indicator of dispersive soil. A dispersive soil may sometimes give a non-dispersive reaction in the crumb test. Soils containing kaolinite with known field dispersion problems, have shown non-dispersive reactions in the crumb test (**1**).[2] However, if the crumb test indicates dispersion, the soil is probably dispersive.

1.4 These test methods are applicable only to soils where the position of the plasticity index versus liquid limit plots (Test Methods D4318) falls on or above the "A" line (Practice D2487) and more than 12 % of the soil fraction is finer than 2-μm as determined in accordance with Test Method D7928.

1.5 Oven-dried soil should not be used to prepare crumb test specimens, as irreversible changes could occur to the soil pore-water physicochemical properties responsible for dispersion (**2**).

NOTE 1—In some cases, the results of the pinhole, crumb, and double-hydrometer test methods may disagree. The crumb test is a better indicator of dispersive soils than of non-dispersive soils (**3**).

1.6 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

[1] These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.06 on Physical-Chemical Interactions of Soil and Rock

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

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

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

1.7.1 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.

1.8 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1193 Specification for Reagent Water
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4221 Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4542 Test Methods for Pore Water Extraction and Determination of the Soluble Salt Content of Soils by Refractometer
D4647/D4647M Test Methods for Identification and Classification of Dispersive Clay Soils by the Pinhole Test
D6026 Practice for Using Significant Digits in Geotechnical Data
D7928 Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
E1 Specification for ASTM Liquid-in-Glass Thermometers
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dispersive clays, n*—soils that deflocculate easily and rapidly without significant mechanical assistance, in water of low-salt concentration.

3.2.1.1 *Discussion*—
Such soils usually have a high proportion of their adsorptive capacity saturated with sodium cations although adsorbed lithium and magnesium may also play a role (**4**). Such soils also generally have a high shrink-swell potential, have low resistance to erosion, and have low permeability in an intact state.

4. Summary of Test Method

4.1 A cube of remolded soil with approximately 15 ± 5 mm on each side (about the size of a single die in a pair of dice) or a natural soil crumb of approximately similar volume is placed on the bottom of a 300-mL container containing 250 mL of Type IV or distilled water.

[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.

4.2 The temperature of the water is recorded and visual determinations of the dispersion grade are made and recorded at 2 min ± 15 s, 1 h ± 8 min, and 6 h ± 45 min. Determination of grade is based on the formation, extent, and turbidity of a dense "cloud" or halo of colloidal-sized particles extending from the soil crumb.

4.3 Determinations consist of: Grade 1 (Non-Dispersive), Grade 2 (Intermediate), Grade 3 (Dispersive), and Grade 4 (Highly Dispersive).

5. Significance and Use

5.1 The crumb test provides a simple, quick method for field or laboratory identification of a dispersive clayey soil. The internal erosion failures of a number of homogeneous earth dams, erosion along channel or canal banks, and rainfall erosion of earthen structures have been attributed to colloidal erosion along cracks or other flow channels formed in masses of dispersive clay (**5**).

5.2 The crumb test, as originally developed by Emerson (**6**), was called the aggregate coherence test and had seven different categories of soil-water reactions. Sherard (**5**) later simplified the test by combining some soil-water reactions so that only four categories, or grades, of soil dispersion are observed during the test. The crumb test is a relatively accurate positive indicator of the presence of dispersive properties in a soil. The crumb test, however, is not a completely reliable negative indicator that soils are not dispersive. The crumb test can seldom be relied upon as a sole test method for determining the presence of dispersive clays. The double-hydrometer test (Test Method D4221) and pinhole test (Test Method D4647/D4647M) are test methods that provide valuable additional insight into the probable dispersive behavior of clay soils.

NOTE 2—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 standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depends on several factors; Practice D3740 provides a means of evaluating some of those factors.

6. Interferences

6.1 Oven-dried soil shall not be used in performing the crumb test as irreversible changes could occur to the soil pore-water physicochemical properties responsible for dispersion (**2**).

6.2 The use of water other than Type IV in accordance with Specification D1193, can interfere with dispersion of the colloidal clay particles.

6.3 The cube or crumb shall be carefully placed directly on the bottom of the dish when submerging the crumb. Dropping the crumb from the water surface can cause excessive slaking and may result in erroneous interpretation of the dispersion grade.

6.4 Jarring or moving the soil specimen or container once the test method has begun can cause excessive turbidity and may result in erroneous interpretation of the dispersion grade.

6.5 The use of a single, natural, irregular-shaped soil crumb may result in a specimen that is not representative of the total sample. Therefore, several crumb test specimens should be selected to make sure that representative test results are obtained. The total number of test specimens should be determined during the test program and will depend on the degree of agreement of individual test results.

7. Apparatus

7.1 *Specimen Container*—A white or clear, non-porous, glass or equivalent inert container with a minimum capacity of 300 mL and having a flat bottom of at least 85-mm across. The container shall be large enough to allow for the specimen to be fully immersed when placed in the container.

7.2 *Thermometer*—0 to 50°C range, 0.1°C divisions, conforming to the requirements of Specification E1. Temperature measuring devices, such as RTDs, thermistors, or liquid-in-glass thermometers (for example, Specification E2251) conforming to Specification E1 and the temperature range and accuracy, may be used.

7.3 *Sieve(s)*—4.75 mm (No. 4) and 2.0 mm (No. 10) sieve, in accordance with Specification E11.

7.4 *Timing Device*—A clock, stopwatch, digital timer, or alike readable to 1 second or better.

7.5 *Camera (optional)*—A device capable of taking photographs.

8. Reagents

8.1 *Purity of Water*—Type IV water in accordance with Specification D1193 or distilled water with a pH between 5.5 and 7.0 ~~should~~shall be used for conducting the test methods and preparing remolded specimens. ~~Distilled~~ Type IV water is preferred.

9. Sampling

9.1 Obtain a representative, homogenous soil sample passing the 4.75 mm (No. 4) sieve. Depending on the percentage of coarse sand in the soil, approximately 25 to 75 g of soil is needed to perform a crumb test. If using Method A, more soil may be needed in order to make sure representative test results are obtained. Soil for the crumb test should be selected as soon as possible after obtaining the representative sample.

NOTE 3—Approximately 400 to 500 g of soil is needed to perform the crumb, pinhole, and double hydrometer tests.

9.1.1 Determine the water content of the representative sample prior to specimen(s) selection in accordance with Test Method D2216 and record to the nearest 0.1 %. Record the qualitative state used in the determination such as, in situ, as-received or air-dried. Preserve the representative sample at the in situ or as-received water content. Do not oven dry the representative sample, if needed, air drying is permissible.

10. Test ~~Specimen~~Specimens

10.1 *Method A—Natural Soil Crumbs:*

10.1.1 Select one or more natural, irregularly shaped, soil crumbs from the representative sample with an abundance of aggregated soil lumps suitable for crumb test specimens. This soil crumb should be approximately the same volume as a cube with 15 ± 5 mm on each side (about the size of a single die of a pair of dice). If no one crumb is equivalent to this size cube, a series of smaller cubes can be used. The crumb volume should not be less than equivalent to a cube with 7 ± 3 mm on each side. Record the test specimen identification information and begin the test as soon as practicable after obtaining the test specimen(s).

10.1.2 Use of natural soil crumbs may result in a specimen that is not representative of the total sample; therefore, it is recommended that several crumb specimens be tested to make sure the total sample is represented. The number chosen is dependent on the homogeneity of the total sample.

10.2 *Test Method B—Remolded Soil Crumbs:*

10.2.1 Process the representative sample over a 2.0 mm (No. 10) sieve and retain the soil passing the 2.0 mm (No. 10) sieve.

10.2.2 Prepare a test specimen from the soil passing the 2.0 mm (No. 10) sieve by lightly compressing the moist soil into a cube approximately 15 ± 5 mm on each side. Use the thumbs and index finger to gently form the cube. Record the test specimen identification information and begin the test as soon as practicable after obtaining the test specimen(s).

10.3 If the crumb test is performed in conjunction with the pinhole test (Test Method D4647/D4647M), the cube can be prepared from soil cured to the ~~moisture~~water content desired for compacting the pinhole specimen. Alternatively, air-dried soil or soil at the natural ~~moisture~~ water content can be passed through a 2.0 mm (No. 10) sieve and formed into the cube. If additional ~~moisture~~water is needed to form the cube, Type IV or distilled water can be added until the cube can be formed. Record the addition and type of water.

11. Procedure

11.1 For either Method, place the specimen container on a horizontal working surface, which will be relatively free of vibration for the next 6 h ± 45 min.

11.2 Pour approximately 250 mL of Type IV or distilled water into the container and allow the water temperature to equalize to 21 ± 6°C. This temperature shall be maintained throughout the test.

11.3 Verify the water temperature has equalized prior to placing the specimen in the water. Record the temperature to the nearest 0.1°C.

11.4 Record the specimen container identification along with the test specimen that is placed in that container.

NOTE 4—Placing the container(s) on the top edge of the test form facilitates easy identification of a number of specimens and reduces the potential for misidentification.

11.5 Carefully place the specimen in the water and gently release it only after placing it directly on the bottom of the container. Do not move or vibrate the container or stir the water from specimen placement until the end of this test.

11.6 Record the time of specimen placement and start the timing device.

11.7 As the soil crumb begins to absorb water, observe the tendency for colloidal-sized particles to deflocculate and go into suspension.

NOTE 5—The colloidal-sized particles are visible in the form of a dense "cloud" or halo that extends from the soil crumb. The extent and turbidity of the suspended clay particle "cloud" is visually interpreted. The colloidal "cloud" is influenced by soil color; that is, dark soils produce a darker, more distinctly visible "cloud."

11.8 Determine and record the dispersion grade, in accordance with the following criteria (refer to Fig. 1), and temperature at 2 min ± 15 s, 1 hour ± 8 min, and 6 hours ± 45 min. Be careful to submerge the thermometer bulb without touching or disturbing the test specimen.

11.8.1 *Grade 1 (Non-dispersive)*—No reaction; the soil may crumble, slake, diffuse, and spread out, but there is no turbid water created by colloids suspended in the water. All particles settle during the first hour.

11.8.2 *Grade 2 (Intermediate)*—Slight reaction; Grade 2 is the transition grade. A faint, barely visible colloidal suspension causes turbid water near portions of the soil crumb surface. If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only one small area, assign Grade 1.

11.8.3 *Grade 3 (Dispersive)*—Moderate reaction; an easily visible cloud of suspended clay colloids is seen around the outside of the soil crumb surface. The cloud may extend up to 10 mm away from the soil crumb mass along the bottom of the dish.

11.8.4 *Grade 4 (Highly Dispersive)*—Strong reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of the dish. Occasionally, the soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb and the colloidal suspension. Often, the colloidal suspension is easily visible on the sides of the dish.

11.9 If a permanent record is desired, photograph the test specimen after the 6 hours ± 45 min reading.

12. Interpretation of Results

12.1 Use the following criteria to classify crumb test results:

12.1.1 *Grade 1*—Nondispersive.

12.1.2 *Grade 2*—Intermediate.

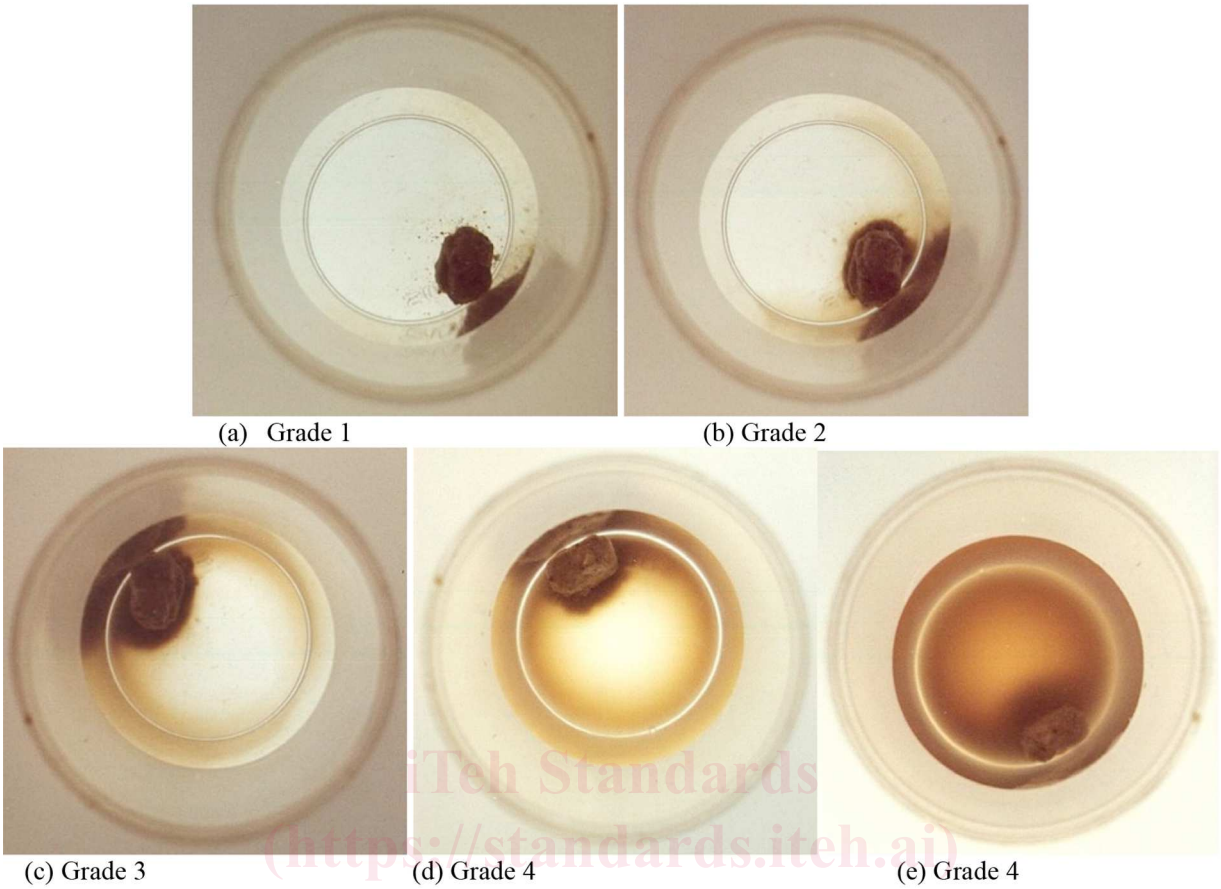

FIG. 1 Soil Crumb Specimens and Assigned Dispersion Grades (7)

12.1.3 *Grade 3*—Dispersive.

12.1.4 *Grade 4*—Highly Dispersive.

12.2 If the dispersive grade changed during the test, the 1 hour ± 8 min reading is normally used for the overall test evaluation. However, if the grade changes from 2 to 3 or from 3 to 4 between the 1 hour ± 8 min and 6 hours ± 45 min readings, use the 6 hours ± 45 min reading.

13. Report: Test Data Sheet(s)/Form(s)

13.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s) as given below, is covered in 1.7 and Practice D6026.

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

13.2.1 Identification of the soil being tested, such as the project identification, boring number, sample number, and depth.

13.2.2 Visual estimated classification of the soil type and color.

13.2.3 Test number, if any, testing dates and the name or initials of the person who performed the test.

13.3 Record as a minimum the following test specimen data:

13.3.1 Method used, A or B.

13.3.2 Water content of the sample in % and the qualitative state (in situ, as-received, or air-dried).

13.3.3 If any additional water was added to form the cube and type of water added, (Method B).

13.3.4 Test Specimen identification.

13.3.5 Specimen container identification, if any.

13.3.6 Type of water used for testing: distilled or Type IV.

13.3.7 Initial temperature of the water.

13.3.8 Start time of the test (hh:mm:ss).

13.3.9 Grade number, temperature, and time readings.

13.3.10 Dispersive classification of the test specimen(s): nondispersive, intermediate, dispersive, or highly dispersive.

13.3.11 If desired, photographs of the test specimen(s) taken at the different time readings or just at the 6 hours ± 45 min reading.

14. Precision and Bias

14.1 *Precision*—Test data on precision is not presented due to the nature of the soil materials tested by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. Also, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation.

14.1.1 Subcommittee D18.06 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

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

15. Keywords

15.1 clay (dispersive); colloidal erodibility; crumb test; dispersibility; dispersion; dispersive clays; erosion

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE TEST DATA SHEET/FORM

X1.1 *General*—Two example data sheets are presented. Fig. X1.1 presents a blank data sheet that may be used to record the crumb test data. This data sheet was designed to accommodate one sample with multiple specimens; therefore there is only one water content value representing the single sample. In some instances it may be necessary or reasonable to take additional water content determinations. Those additional water content values should also be recorded. Fig. X1.2 presents a completed example test data sheet.