



# Standard Test Methods for Determining Dispersive Characteristics of Clayey Soils by the Crumb Test<sup>1</sup>

This standard is issued under the fixed designation D 6572; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 These test methods provide a qualitative indication of the natural dispersive characteristics of clayey soils.

1.2 These test methods are not applicable for soils with less than 12 % fraction finer than 0.005 mm and with a plasticity index less than or equal to 8.

1.3 The crumb test method has some limitations in its usefulness as an indicator of dispersive clay. A dispersive soil may sometimes give a nondispersive reaction in the crumb test. Soils containing kaolinite with known field dispersion problems have shown nondispersive reactions in the crumb test (1)<sup>2</sup>. However, if the crumb test indicates dispersion, the soil is probably dispersive.

1.4 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).

1.5 The crumb test method, while a good quick indication of dispersive clay, should usually be run in conjunction with a pinhole test and a double hydrometer test, Test Methods D 4647 and D 4221, respectively.

NOTE 1—In some cases, the results of the pinhole, crumb, and double-hydrometer test methods may disagree. Crumb test methods are a better indicator of dispersive clays than of nondispersive clays (3).

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 *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<sup>3</sup>

<sup>1</sup> 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.

Current edition approved June 10, 2000. Published August 2000.

<sup>2</sup> The boldface numbers in parentheses refer to the list of references at the end of this standard.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 04.08.

D 1193 Specification for Reagent Water<sup>4</sup>

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock<sup>3</sup>

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction<sup>3</sup>

D 4221 Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer<sup>3</sup>

D 4647 Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test<sup>3</sup>

E 1 Specification for ASTM Thermometers<sup>5</sup>

E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>6</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *dispersive clays*—soils that disperse (deflocculate) easily and rapidly without significant mechanical assistance in water of low-salt concentration.

3.1.1.1 *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.

3.2 For definitions of other terms used in these test methods, refer to Terminology D 653.

## 4. Summary of Test Method

4.1 A cube of remolded soil approximately 15 mm ( $\frac{5}{8}$  in.) 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 white porcelain dish containing 250 mL of distilled water.

4.2 Temperature of the water is recorded and visual determinations of dispersion grade are made and recorded at 2 min, 1 h, and 6 h. 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 (Nondispersive),

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 11.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 14.03.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 14.02.

Grade 2 (Intermediate), Grade 3 (Dispersive), and Grade 4 (Highly Dispersive).

## 5. Significance and Use

5.1 The crumb test method provides a simple, quick method for field or laboratory identification of a dispersive clay 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 method, 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 D 4221) and pinhole test (Test Method D 4647) 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 these test methods 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 D 3740 are generally considered capable of competent and objective testing. Users of these test methods are cautioned that compliance with Practice D 3740 does not in itself ensure reliable testing. Reliable testing depends on several factors; Practice D 3740 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 Using other than Type IV water in accordance with Specification D 1193, can interfere with dispersion of the colloidal clay particles.

6.3 Carefully place the cube or crumb 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 porcelain dish 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 natural, irregular-shaped soil crumbs may result in a specimen that is not representative of the total sample. Therefore, several crumb test specimens should be selected to ensure 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.

6.6 These test methods are not applicable to soils with less than 12 % fraction finer than 0.005 mm and with a plasticity index less than or equal to 8.

## 7. Apparatus

7.1 *Specimen Container*—Dish, porcelain, evaporating, 300-mL capacity.

NOTE 3—Plastic bowls or cups can also be used but they should be white or clear to help in distinguishing the colloidal cloud. The container should be at least 85 mm (3 in.) across the bottom if flat-bottomed.

7.2 *Thermometer*—0 to 50°C range, 0.1°C divisions, conforming to the requirements of Specification E 1.

7.3 *Sieve*, 4.75-mm (No. 4) and 2-mm (No. 10) sieve, in accordance with Specification E 11.

## 8. Reagents and Materials

8.1 *Purity of Water*—Type IV of Specification D 1193 with a pH between 5.5 and 7.0 shall be used for conducting the test method and preparing remolded specimens. Distilled water is preferred.

## 9. Sampling, Test Specimens, and Test Units

9.1 *Sampling*—Obtain a representative soil sample of –4.75-mm (No. 4) soil. Depending on the percentage of coarse sand in the material, approximately 25 to 75 g of material is needed to perform a crumb test method and approximately 400 to 500 g of material is needed to perform the crumb, pinhole, and double-hydrometer tests.

NOTE 4—Do not use oven-dried material for the crumb test method because irreversible changes may occur to the soil pore-water physicochemical properties responsible for dispersion. Soil at natural moisture or at specified compaction moisture is preferred.

### 9.2 Test Specimens:

9.2.1 Test specimens may be from natural, irregularly shaped soil crumbs (Test Method A) or may be remolded from material passing a 2-mm (No. 10) sieve (Test Method B). Material for the crumb test method should be selected as soon as possible after obtaining the soil sample.

#### 9.2.2 Test Method A—Natural Soil Crumbs:

9.2.2.1 A natural, irregularly shaped soil crumb is selected that has been preserved at natural moisture or only allowed to air-dry. This soil crumb should be approximately the same volume as a cube 15 mm ( $\frac{5}{8}$  in.) on each side (about the size of a single die of a pair of dice). Smaller soil crumbs down to a volume equivalent to a cube 7 mm ( $\frac{1}{4}$  in.) on each side may be used if larger ones are unavailable.

9.2.2.2 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 ensure the total sample is represented. The number chosen is dependent on the homogeneity of the total sample.

#### 9.2.3 Test Method B—Remolded Specimens:

9.2.3.1 A cube, approximately 15 mm ( $\frac{5}{8}$  in.) on each side, is prepared from moist soil which has passed a 2-mm (No. 10) sieve.

9.2.3.2 If the crumb test method is being done in conjunction with the pinhole test method (Test Method D 4647), the cube can be prepared from material cured to the moisture content desired for compacting the pinhole specimen. Alternatively, air-dried soil or soil at natural moisture can be passed through a 2-mm (No. 10) sieve and formed into the cube. If additional moisture is needed to form the cube, Type IV water

in accordance with Specification D 1193 can be added until the cube can be formed.

NOTE 5—Results of the crumb test methods can be altered by mixing portions of a sample that have dispersive properties with a portion of the sample with nondispersive properties. If remolded crumbs are used for testing, minimize the mixing of visually nonhomogeneous soil to obtain the material for the remolded crumb to avoid mixing dispersive and nondispersive segments of the sample.

10. Conditioning

10.1 Preserve crumb test specimens at natural moisture, if possible, or allow specimens to air-dry. Do not oven-dry crumb test specimens.

11. Procedure

11.1 Record all data on a “Crumb Test Method” form. An example of an acceptable form is shown in Fig. 1.

11.2 Place a 300-mL porcelain evaporating dish on a horizontal working surface, which will be relatively free of vibration for the next 6 h.

NOTE 6—Placing the dish on the top edge of the crumb test form facilitates easy identification of a number of specimens and reduces the potential for misidentification.

11.3 Pour approximately 250 mL of Type IV water in accordance with Specification D 1193 into the porcelain dish and allow the water temperature to stabilize.

11.4 Record the applicable test specimen information on the crumb test form as shown in Fig. 1.

11.5 Prepare a crumb test specimen using one of two test methods.

11.5.1 Test Method A: Natural Soil Crumbs:

11.5.1.1 A natural soil crumb equivalent in volume to a cube

approximately 15 mm (5/8 in.) on each side is selected from a homogeneous soil sample with an abundance of aggregated soil lumps suitable for crumb test specimens. If no one crumb is equivalent to a cube approximately 15 mm on each side, a series of smaller cubes can be used. Crumb volume should not be less than equivalent to a cube 7 mm (1/4 in.) on each side.

NOTE 7—When using natural crumb specimens, it is better to use a series of crumbs to ensure results representative of the entire sample.

11.5.2 Test Method B: Remolded Soil Crumbs:

11.5.2.1 Prepare a crumb test specimen by lightly compressing a moist soil sample into a cube approximately 15 mm (5/8 in.) on each side. Use the thumbs and index finger to gently form the cube.

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

11.7 Note and record the time of specimen placement on the crumb test form and start the stopwatch.

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

NOTE 8—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.”

11.9 At 2 min, 1 h, and 6 h, determine and record the soil dispersion grade in accordance with to the following criteria:

11.9.1 Grade 1, (Nondispersive)—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.

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

11.9.3 Grade 3, (Dispersive)—Moderate reaction; an easily visible cloud of suspended clay colloids is seen around all of the outside soil crumb surface. The cloud may extend up to 10 mm (3/4 in.) away from the soil crumb mass along the bottom of the dish.

11.9.4 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.

11.10 After determining the dispersion grade, determine and record the water temperature at 2-min, 1 h, and 6 h after beginning the test. Be careful to submerge the thermometer bulb without touching or disturbing the test specimen. The water temperature should be 21 + 6°C (70 + 10°F).

11.11 If a permanent record is desired, photograph the crumb test specimen after the 6-h reading.

**CRUMB TEST FOR DISPERSIBILITY OF CLAYEY SOILS**

Sample no. 56C-24 Feature Example Location Borrow area 3

Drill hole no. Test pit 1 Depth 0.9-1.8  m  ft  Disturbed  Undisturbed

Color Red Natural moisture content (as received) 23.4 %

Specimen type:  Natural irregularly shaped crumb  Remolded crumb cube.

Moisture content:  Natural moisture  Air-dried  Distilled water added to remold specimen

Curing time 0 min Water used:  Distilled  Distilled and demineralized

Initial water temperature 21 °C Time at beginning of test 9:00  am  pm

Tested by: Betsy Kunzer Date tested: 12-22-97

Specimen Number	Dish Number	2 minutes		1 hour		6 24 hours	
		Grade	°C	Grade	°C	Grade	°C
56C-24 #1	235	2	21	4	22	4	22
56C-24 #2	CL-135	2	21	4	22	4	22
56C-24 #3	96-35	3	21	3	22	4	22

FIG 1. Example of data sheet for crumb test

FIG. 1 Example of Data Sheet for Crumb Test for Dispersibility of Clayey Soils

## 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.

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-h 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 and 6-h readings, use the 6-h reading.

## 13. Report

13.1 Report the following information for the crumb test for dispersive clayey soils:

13.1.1 Name and location of project.

13.1.2 Drill hole number, depth, color, and purpose of sample tested, such as, Test Hole No. 1, depth 0.9 to 1.8 m, (3 to 6 ft), red clay, embankment borrow area.

13.1.3 Type of water used for testing: distilled or distilled and demineralized.

13.1.4 Type of crumb tested: natural or remolded.

13.1.5 Water content of the sample prior to specimen preparation: natural, air-dried, or water content determined in accordance with Test Method D 2216.

13.1.6 Curing time, if applicable.

13.1.7 Name of operator performing the test method and date test started.

13.1.8 Dispersive classification of the test method as: non-dispersive, intermediate, dispersive, or highly dispersive.

13.1.9 If desired, take a visual record of the specimen 6 h from start of test method.

NOTE 9—For reasons of economy, black and white photographs are used in this test method. Color, black and white, or digital records are acceptable in the report.

## 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.

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 erodability; crumb test method; dispersibility; dispersion; dispersive clays; erosion

## REFERENCES

- (1) Kinney, James L., "Laboratory Procedures for Determining the Dispersibility of Clayey Soils," Bureau of Reclamation Report No. REC-EERC 70-10, 1979, 20 pp.
- (2) Holgren, G.C.S., and Flanagan, C. P., "Factors Affecting Spontaneous Dispersion of Soil Materials As Evidenced by the Crumb Test," *ASTM Proceeding son Symposium on Dispersive Clays, STP 623*, Chicago, IL, 1976, pp. 218-239.
- (3) Acciardi, Raymond, "Pinhole Test Equipment Design and Test Result Evaluation," Bureau of Reclamation, *Report No. REC-ERC-85-3*, 1985, 76 pp.
- (4) Bell, F.G., and Maud, R. R., "Dispersive Soils: A review from a South Africa Perspective," *Quarterly Journal of Engineering Geology*, Vol 27, 1994, pp. 195-210.
- (5) Sherard, J.L., et al, "Identification and Nature of Dispersive Soils," *Journal of Geotech. Eng. Div., ASCE*, Vol 102, No. GT-4, 1976, pp. 287-301.
- (6) Emerson, W.W., "A Classification of Soil Aggregates Based on Their Coherence in Water," *Australian Journal of Soil Research*, Vol 2, 1964, pp. 211-217.

*The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).*