Designation: D 4221 – 99

Standard Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer[1]

This standard is issued under the fixed designation D 4221; 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, when used in conjunction with a test performed by Test Method D 422 on a duplicate soil sample, provides an indication of the natural dispersive characteristics of clay soils **(1).**[2]

1.2 This test method is applicable only to soils with a plasticity index greater than 4 as determined in accordance with Test Method D 4318 and more than 12 % of the soil fraction finer than 5-µm as determined in accordance with Test Method D 422 **(2).**

1.3 This test method is similar to Test Method D 422, except that this method covers the determination of percent of soil particles smaller than 5-µm in diameter in a soil-water suspension without mechanical agitation and to which no dispersing agent has been added.

1.4 The amount of particles smaller than 5-µm determined by this method compared with the total amount of particles smaller than 5-µm determined by Test Method D 422 is a measure of the dispersive characteristics of the soil.

1.5 This test method may not identify all dispersive clay soils. Pinholes (Test Method D 4647 and crumb tests, or both, (**3-5)**or the analysis of pore water extract (4-7) may be performed to help verify dispersion.

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 422 Test Method for Particle-Size Analysis of Soils[3]

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

D 1193 Specification for Reagent Water[4]

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

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[3]

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

D 4647 Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test[3]

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

E 1 Specification for ASTM Thermometers[5]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[6]

E 100 Specification for ASTM Hydrometers[5]

E 145 Specification for Gravity-Convection and Forced-Ventilation Ovens[7]

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 Such soils usually have a high proportion of their adsorptive capacity saturated with sodium cation although adsorbed lithium and magnesium may also play a role **(6)**. 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 other definitions relating to this standard, refer to Terminology D 653.

4. Summary of Test Method

4.1 The percent passing the 5-µm size is determined using test procedures in Test Method D 422.

4.2 The percent passing the 5-µm size is determined using the test procedures in this test method. This test method differs from Test Method D 422 primarily in that no mechanical agitation nor chemical dispersants are used.

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.06 on Physico-Chemical Properties of Soils and Rocks.

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

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

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 14.03.

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

[7] *Annual Book of ASTM Standards*, Vol 14.04.

4.3 The percent dispersion is calculated by dividing the percent passing the 5-µm size using this test method by the percent passing the 5-µm size obtained using Test Method D 422 and by multiplying the result by 100.

5. Significance and Use

5.1 Dispersive clays are those which normally deflocculate when exposed to water of low-salt concentration, the opposite of aggregated clays that would remain flocculated in the same soil-water system **(3, 4, 7).** Generally, dispersive clays are highly erosive, possibly subject to high shrink-swell potential, may have lower shear strength, and have lower permeability rates than aggregated clays.

5.2 Available data **(1)** indicates that the test method has about 85 % reliance in predicting dispersive performance (85 % of dispersive clays show more than 35 % dispersion).

5.3 Since this test method may not identify all dispersive clays, design decisions based solely on this test method may not be conservative. It is often run in conjunction with the crumb test **(4, 7)**, the pinhole test given in Test Method D 4647, or the analysis of pore water extract **(4, 7)**, or combination thereof, to identify possible dispersive clay behavior.

NOTE 1—Notwithstanding the statement on precision and bias contained in this test method; the precision of this test method is dependent on the competence of the personal 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 this test method 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. Apparatus

6.1 *Sieve*—A 2.00-mm (No. 10) sieve conforming to the requirements of Specification E 11. The physical condition of sieves should be checked at least every 12 months.

6.2 *Containers*—Airtight, for storing moist sample.

6.3 *Balance*, meeting the requirements of Class GP2 in Specification D 4753. Measurements should be verified every 12 months.

6.4 *Filtering Flask*—A 500-mL filtering flask with a rubber stopper and a side tube capable of withstanding a vacuum.

6.5 *Vacuum Pump*, for evacuating entrapped air from the samples, and capable of pulling at least 20 to 25 in. Hg. Check pressure every 12 months.

6.6 *Sedimentation Cylinder*—A glass cylinder approximately 460 mm (18 in.) in height and 63.5 mm (2.5 in.) in diameter and marked 360 ± 20 mm from the bottom of the inside for a volume of 1000 mL.

6.7 *Hydrometer*—An ASTM hydrometer conforming to the requirements for Hydrometers 151H or 152H of Specification E 100. Zero point should be checked every 12 months.

6.8 *Thermometer*, accurate to 0.5°C and conforming to Specification E 1. Zero point should be checked every 12 months.

6.9 *Timing Device*—A watch or clock capable of being read to the nearest second.

6.10 *Distilled Water*, with a pH 5.5–7.

NOTE 2—Trace minerals may be present in some Type IV water. However, since this is a qualitative test, such minerals should not affect the test results.

6.11 *Drying Oven*, conforming to the requirements of Specification E 145. The oven should be thermostatically controlled, preferably of the forced-draft type, and capable of maintaining a uniform temperature of 110 ± 5°C throughout the drying chamber. The temperature should be verified every four months.

7. Sample Preparation

7.1 Sieve approximately 200 g of soil through a 2.00-mm (No. 10) sieve. If materials are quite moist, this may require hand rubbing or use of a rubber-tipped pestle to force material through the sieve. It is recommended that this test be performed at natural water content. When samples are very moist, they should be dried to about the plastic limit before proceeding with the test.

7.2 Collect a representative sample of about 100 g of material passing the No. 10 sieve for water content determination and retain the remainder of the minus No. 10 material in an airtight container.

7.3 Determine the water content of the minus No. 10 material in accordance with Test Method D 2216.

8. Procedure

8.1 Obtain 50 g of oven-dried soil in accordance with 7.3. Determine the percent passing 5 µm in accordance with Test Method D 422.

8.2 Place approximately 125 mL of distilled water in the filtering flask.

8.3 Obtain from the container of minus No. 10 moist soil, a representative sample equivalent to 25.0 g of oven-dry soil, by splitting or other appropriate means, and place into the filtering flask with the distilled water.

8.3.1 Determine the mass of moist soil equivalent to 25.0 g of dry soil as follows:

$$W_m = W_d \times \left(1.0 + \frac{w}{100}\right) \quad (1)$$

where:

W_m = mass moist soil, g,
W_d = mass oven-dried soil, g, and
w = water content of sample, %.

8.4 Place a rubber stopper into the mouth of the filtering flask and connect the flask to the vacuum pump. If the soil is dry, it should be soaked for a minimum of 2 h before the filtering flask is connected to the vacuum pump. Under most conditions, 20 to 23 in. Hg is sufficient to de-air the sample.

8.5 Start vacuum pump and apply full vacuum. If bubbles do not appear, the vacuum is insufficient.

8.6 At 3 min, 5 min, and 8 min after application of vacuum, swirl the flask several times in a rotating manner to assist in removing entrapped air.

8.7 Disconnect the flask from the vacuum after a total evacuation time of 10 min.

8.8 Wash the soil-water suspension from the flask into the sedimentation cylinder and add Type IV water until the total volume is 1000 mL.

8.9 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), shake the

cylinder end over end for a period of 1 min (see Note 3). At the end of 1 min, set the cylinder in a convenient location and record the time. This is the start of the sedimentation period. The time interval between step 8.5 and step 8.9 should not exceed 1 h.

NOTE 3—The number of turns during the minute should be approximately 60, counting the turn upside down and back as two turns. Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by shaking the cylinder while it is in the inverted position.

8.10 Take hydrometer and temperature readings necessary to determine the percent of material finer than 5-µm in suspension using procedures and calculations described in Test Method D 422.

NOTE 4—It should be recognized that the hydrometer composite correction described in Test Method D 422 must be made using Type IV water instead of a solution of dispersing agent.

9. Calculation

9.1 Calculate percent dispersion from:

$$\% \text{ Dispersion} = \frac{\% \text{ passing } 5-\mu\text{m in this test}}{\% \text{ passing } 5-\mu\text{m in Test Method D 422}} \times 100 \quad (2)$$

10. Report

10.1 Report results as percent dispersion of the 5-µm (5 micron) fraction.

NOTE 5—When the percent dispersion equals 100, it indicates a completely dispersive clay-sized fraction. When the percent dispersion equals 0, it indicates completely nondispersive.

11. Precision and Bias

11.1 *Precision*:

11.1.1 *Single-Operator Precision*—The single-operator coefficient of variation has been found to be 3.9 %. Therefore, results of two properly conducted tests by the same operator with the same equipment should not be considered suspect unless they differ by more than 11.1 % of their mean.

11.1.2 *Multilaboratory Precision*—An interlaboratory test program is being conducted to determine a multilaboratory precision statement. As soon as this data has been collected and analyzed, this test method will be revised to include a precision statement for multilaboratory precision.

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

12. Keywords

12.1 clays; deflocculation; dispersion; dispersive clay; erosion; gradation; hydrometer analysis; jugging; particle size; piping

REFERENCES

(**1**) Decker, R. S., and Dunnigan, L. P.," Development and Use of the Soil Conservation Service Dispersion Test," *Dispersive Clays, Related Piping, and Erosion in Geotechnical Projects, ASTM STP 623*, 1977, pp. 94–109.

(**2**) Ryker, N. L., "Encountering Dispersive Clays on Soil Conservation Service Projects in Oklahoma," *Dispersive Clays, Related Piping, and Erosion in Geotechnical Projects, ASTM STP 623* , 1977, pp. 370–389.

(**3**) Volk, G. M., "Method of Determination of Degree of Dispersion of the Clay Fraction of Soils," *Proceedings*, Soil Science Society of America, Vol II, 1937, p. 561.

(**4**) Sherard, J. L., Decker, R. S., and Ryker, N. L., "Piping in Earth Dams of Dispersive Clay," *Proceedings of the Speciality Conference on Performance of Earth Supported Structures*, American Society of Civil Engineers, 1972.

(**5**) Holmgram, G.C.S., and Flanagan, C.P., "Factors Affecting Spontaneous Dispersion of Soil Materials as Evidenced by the Crumb Test," *Symposium on Dispersive Clays, Related Piping, and Erosion in Geotechnical Projects, ASTM STP 623*, ASTM, 1977, p. 218-239.

(**6**) Bell, J.G., and Maude, R.R., "Dispersive Soils: A Review from the South Africa Perspective," *Quarterly Journal of Engineering Geology*, Vol 27, 1994, pp. 195-210.

(**7**) Sherard, J. L., Dunnigan, L. P., and Decker, R. S., "Some Engineering Problems with Dispersive Clay," *Dispersive Clays, Related Piping, and Erosion in Geotechnical Projects, ASTM STP 623*, 1977, pp. 3–12.