Designation: ~~D4221 – 11~~ D4221 – 17

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

This standard is issued under the fixed designation D4221; 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~~method provides an indication of the natural dispersive characteristics of clay soils ~~D422 on a duplicate soil sample, provides an indication of the natural dispersive characteristics of clay soils~~ by comparing the amount of particles finer than 2-μm as determined by this method compared to the amount of particles finer than 2-μm as determined by Test Method D7928(**1**).[2] In order to do this comparison, two similar specimens must be obtained from the sample.

1.2 This test method follows the procedure given in Test Method D7928 with the exception that the soil slurry is not mechanically dispersed and no dispersing agent is added.

1.3 This test method is applicable only to soils ~~with a plasticity index greater than 4 as determined in~~where the position of the plasticity index versus liquid limit plots (Test Methods D4318~~accordance with Test Method~~) falls on or ~~D4318~~above the "A" line (Practice D2487) and more than 12 % of the soil fraction is finer than ~~5-μm~~2-μm as determined in accordance with Test Method ~~D422~~D7928(**2**).

~~1.3 This test method is similar to Test Method D422, 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 D422 is a measure of the dispersive characteristics of the soil.~~

1.4 ~~This~~ Since this test method may not identify all dispersive clay ~~soils. Pinholes (Test Method~~soils, other tests such as, pinhole dispersion (Test Methods ~~D4647~~D4647/D4647M ~~and crumb tests, or~~), crumb (Test Methods D6572~~both,~~) (**3-5**)~~or~~ and the analysis of pore water ~~extract~~ extraction (Test Methods D4542) (**4-67**) may be performed individually or used together to help verify dispersion.

1.5 *Units*—The values stated in SI units are to be regarded as the standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this test method.

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

1.6.1 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 analysis methods for engineering design.

~~1.7 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~~ safety, health and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

---

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

Current edition approved ~~March 1, 2011~~July 1, 2017. Published ~~March 2011~~July 2017. Originally approved in 1983. Last previous edition approved in ~~2005~~2011 as ~~D4221–99(2005).~~D4221–11. DOI: ~~10.1520/D4221-11.~~10.1520/D4221-17.

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

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

1.8 *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]

~~D422 Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)~~[4]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

~~D2251~~D2487 ~~Test Method for Metal Corrosion by Halogenated Organic Solvents and Their Admixtures~~Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4220/D4220M Practices for Preserving and Transporting Soil Samples

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~~D4647/D4647M Test ~~Method~~Methods for Identification and Classification of Dispersive Clay Soils by the Pinhole Test

~~D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing~~

D6026 Practice for Using Significant Digits in Geotechnical Data

~~E1~~D6572 ~~Specification for ASTM Liquid-in-Glass Thermometers~~Test Methods for Determining Dispersive Characteristics of Clayey Soils by the Crumb Test

~~E11~~D6913 ~~Specification for Woven Wire Test Sieve Cloth and Test Sieves~~Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

~~E100~~D7928 ~~Specification for ASTM Hydrometers~~Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

~~E145 Specification for Gravity-Convection and Forced-Ventilation Ovens~~

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 (7). Such soils also generally have a high shrink-swell potential, have low resistance to erosion, and have low permeability in an intact state.~~

3.1 ~~For other definitions relating to this standard, refer to Terminology D653.~~*Definitions:*

3.1.1 For definitions of common technical terms used 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 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.

4. Summary of Test Method

~~4.1 The percent passing the 5-μm size is determined first using test procedures in Test Method D422.~~

4.1 ~~Then the percent passing the 5-μm size is determined using the test procedures in this test method. This test method differs from~~ This test method is used to determine the percent dispersion of a soil. In order to calculate the percent dispersion, two similar specimens are obtained from a representative sample and then a sedimentation (hydrometer) analysis is performed on each specimen to determine the amount of particles finer than 2-μm. The sedimentation analysis is performed following Test Method

[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.

D422D7928 primarily in that no mechanical agitation nor chemical dispersants are used.for both specimens, except that one of the specimens is de-aired and is not mechanically or chemically dispersed.

4.2 The percent dispersion is calculated by dividing the percent passing the 5-µm size using this test method 2-µm size from the de-aired, not dispersed specimen by the percent passing the 5-µm size obtained using Test Method2-µm size from the specimen that D422was dispersed 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, 67**). 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 When the percent dispersion equals 100, it indicates a completely dispersive clay-size fraction. When the percent dispersion equals 0, it indicates completely nondispersive clay-size fraction.

5.3 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).

5.4 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 (D6572) (**4, 67**) ,), the pinhole test given in Test Method (D4647D4647/D4647M,), or the analysis of the pore water extract (D4542) (**4, 67**), 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 The quality of the result produced by this standard 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 D3740 are generally considered capable of competent and objective testing.testing/sampling/inspection/etc. Users of this test method standard are cautioned that compliance with Practice D3740 does not in itself ensureassure reliable testing.results. Reliable testingresults depends on severalmany factors; Practice D3740 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 Section 6 of Test Method E11D7928. The physical condition of sieves should be checked at least every 12 months. describes the equipment and tools needed for performing the sedimentation (hydrometer) analysis portion of this standard.

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

6.2 *Balance, Container*—meeting the requirements of Class GP2 in SpecificationAn airtight, glass or equivalent inert container with D4753. Measurements should be verified every 12 months.enough capacity to hold the minus No. 10 (2.0-mm) specimen(s).

6.3 *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 E100. Zero point should be checked every 12 months.

6.8 *Thermometer,* accurate to 0.5°C and conforming to Specification E1. In addition, thermometric devices such as Resistance Temperature Detectors (RTDs), thermistors, thermocouples, and liquid-in-glass thermometers conforming to Test Method D2251, may be used. 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.

6.4 *Drying Oven, Vacuum System*— conforming to the requirements of Specification A vacuum pump or water aspirator E145. 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.capable of producing a vacuum between 508 and 635 mm of Hg on the vacuum gauge.

7. Reagents

7.1 Section 7 of Test Method D7928 describes the reagents needed for performing the mechanically and chemically dispersed sedimentation (hydrometer) analysis portion of this standard.

7.2 *Distilled Water*—Distilled or demineralized water with a pH between 5.5 and 7 is the only permissible test fluid for use in the sedimentation portion of the test. The use of tap water is not permitted.

8. Sampling

8.1 *General*—This test method does not address, in any detail, procurement of the sample. It is assumed the sample is obtained using appropriate methods and is representative of the material under evaluation. The testing agency must preserve all samples in accordance with Practice D4220/D4220M, Group B, except if the as-received sample does not meet those requirements. In which case, the water content of the sample does not have to be maintained. Section 9 of Test Method D6913 gives additional information regarding sampling from different sources.

8.2 Follow the steps given in 8.4 of Test Method D7928, including the mass requirements given in Table 1 of that standard, to obtain the reduced sample from which the test specimens are to be obtained.

9. ~~Sample Preparation~~ Preparation of the Test Specimens

9.1 *Specimen Procurement*—This standard presents two preparation methods to obtain the sedimentation specimens: moist and air-dried. Moist and air-dried refers to the condition of the sample as it is being reduced to an appropriate particle size and mass. The test shall not be performed on oven-dried soil. The air-dried method shall only be used on samples received in the air-dried state (Note 2). Since some fine-grained air-dried soils aggregate, a mortar and rubber covered pestle is used to break up aggregations. Care must be taken to avoid disintegration or reduction of individual particles. Use only enough force as necessary to break up the aggregations without destroying the individual particles. Additional guidance for splitting materials to obtain a representative specimen is given in Test Method D6913, Annex A2.

9.2 See 9.2 and 9.3 of Test Method D7928 for the moist and air-dried preparation methods, respectively.

9.3 ~~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~~ If the reduced sample contains particles larger than the No. 10 (2.0-mm) sieve, the soil must be separated using a No. 10 (2.0-mm) sieve. Process the entire reduced sample over the No. 10 (2.0-mm) sieve using a rubber scraper and, if needed, distilled water to aid in working the soil 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.~~Check that the soil retained on the sieve does not contain aggregations of finer particles. Any aggregations should be broken and passed through the sieve. It is not necessary that the separation be totally complete, but the soil passing the sieve must be representative. The amount of soil passing the No. 10 (2.0-mm) sieve must be sufficient to obtain two specimens for sedimentation analysis and one water content determination.

~~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.~~

9.4 ~~Determine~~ If there is sufficient minus No. 10 (2.0-mm) soil, split or quarter this soil into at least three portions: one for the water content ~~of the~~ determination and two for the sedimentation analyses. The water content specimen must contain 50 ± 10 g of soil. If there is insufficient minus No. 10 (2.0-mm) soil, do not obtain a water content specimen. Obtain the dry mass of the minus No. 10 ~~material in accordance with~~(2.0-mm) soil at the end of the test as discussed in 11.12 of Test Method ~~D2216~~D7928. See Note 11 in Test Method D7928.

9.5 If sufficient soil is available, immediately use one of the three specimens for determination of the water content in accordance with Test Methods D2216 and record the water content, w_c to the nearest 0.1 %. Immediately place the other two specimens into separate airtight containers. If the water content is to be determined at the end of the test, immediately place the two specimens in air tight containers to prevent moisture change.

NOTE 2—Air drying causes irreversible changes to the clay particles that cause permanent flocculations and decreases the fine fraction. (**8**)

10. Procedure

10.1 *Mechanically and Chemically Dispersed*—~~Obtain 50 g of oven-dried soil in accordance with~~Use one of the specimens stored in one of ~~7.3. Determine the percent passing 5 µm~~ the containers to determine the amount of particles finer than 2-µm in accordance with Test Method ~~D422~~D7928. The stirring apparatus shall be used to disperse the specimen.

~~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:~~

$$w_m = w_d x\left(1.0+\frac{w}{100}\right) \quad (1)$$