Designation: D8281/D8281M – 21

Standard Test Method for Determining the Presence of Expanding Clays in Rock for Erosion Control Using Ethylene Glycol[1]

This standard is issued under the fixed designation D8281/D8281M; 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 covers the testing for and quantitative determination of the presence of swelling clays of the smectite group in rock for erosion control. The test particles are intended to be representative of erosion control rock and its durability. The test is appropriate for breakwater stone, armor stone, riprap and gabion sized rock materials.

1.2 Ethylene glycol is one of the materials that react with swelling clays to form an organoclay complex having a larger basal spacing than that of the clay mineral itself. Rock containing swelling clay of the smectite group will be expected to undergo expansive breakdown upon soaking in ethylene glycol. If the amount, distribution, state of expansion, and ability to take up glycol is such as to cause such breakdown to occur, it may be expected that similar breakdown may occur of similar rock samples exposed, for longer times, to wetting and drying or freezing and thawing in a water-soaked condition in service.

1.3 The prepared size of the rock specimens may eliminate some of the internal features present in the gross structure. The test specimens may not be representative of the quality of the larger rock samples used in construction. Careful examination of the rock source and proper sampling are essential in minimizing this limitation.

1.3.1 The test is time intensive and requires over two weeks to complete the sample preparation, testing and analysis portions of the procedure.

1.4 The use of reclaimed concrete and materials other than natural rock is beyond the scope of this test method.

1.5 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.5.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The slug unit is not given unless dynamic (F=ma) calculations are involved.

1.5.2 The SI units presented for apparatus are substitutions of the inch-pound units, other similar SI units should be acceptable providing they meet the technical requirements established by the inch-pound apparatus.

1.5.3 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and force (lbf). This practice implicitly combines two separate systems of units: the absolute and the gravitational systems. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording density in lbm/ft^3 shall not be regarded as nonconformance with this standard.

1.5.4 Calculations are done using only one set of units; either SI or gravitational inch pound. Other units are permissible provided appropriate conversion factors are used to maintain consistency of units throughout the calculations, and similar significant digits or resolution, or both are maintained.

1.6 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.6.1 For purposes of comparing measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal or significant digits in the specified limits.

1.6.2 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

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.17 on Rock for Erosion Control.

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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.

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

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:*[2]

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

D2693 Specification for Ethylene Glycol (Withdrawn 2021)[3]

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

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

D4992 Practice for Evaluation of Rock to be Used for Erosion Control

D6026 Practice for Using Significant Digits in Geotechnical Data

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *USACE Standards:*

CRD-C 148-69 Method of Testing Stone for Expansive Breakdown on Soaking in Ethylene Glycol[4]

3. Terminology

3.1 *Definitions:*

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

4. Summary of Test Method

4.1 Erosion control rock samples are prepared by sieving, crushing, or breaking pieces to pass a minus 75.0 mm [3 in.] size sieve. The specimens are then washed and built to a specific grading. The test specimens are exposed to ethylene glycol for a period of 15 days. At the completion of the test, the percent loss by mass for each grading is determined. A visual examination of the specimen particles is performed throughout and at the end of testing. The type of deterioration is recorded.

5. Significance and Use

5.1 Rock for erosion control consists of individual pieces of natural quarried stone or large boulders and cobbles. The ability of these individual pieces of stone to resist deterioration due to weathering action affects the stability of the integral placement of rock for erosion control and hence, the stability of construction projects, structures, shorelines, and stream banks.

5.2 Deterioration of stone in this test is one indicator that similar samples exposed to wet/dry and freeze/thaw cycles may break down in a water-soaked environment condition in service.

5.3 This test method was developed to be used in conjunction with additional test methods listed in Practice D4992. This test method provides a quantitative value indicating potential resistance to weathering; however, the results of this test method are not to be used as the sole basis for the determination of rock durability.

NOTE 1—The quality of the result produced by this standard is dependent upon 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 depend on many factors; Practice D3740 provides a means of evaluation some of those factors.

6. Apparatus

6.1 *Immersion Containers*—Containers with tight-fitting lids, of sufficient size to hold the specimens fully immersed to a depth of not less than 12.5 mm [½ in.] in ethylene glycol. It is advised that these containers be non-reactive, resistant to breakage and resistant to deformation and degradation when exposed to ethylene glycol.

6.2 *Drying Containers* shall conform with ASTM D2216, subsection 6.3.

6.3 *Drying Oven*—A thermostatically controlled oven, capable of maintaining a uniform temperature of 110 ± 5°C [230 ± 9°F] throughout the drying chamber. These requirements typically require the use of a forced-draft type oven. The oven shall be vented outside the building.

6.4 *Balance*—A balance capable of determining the mass of the specimen to the nearest 0.1 % of the total mass meeting the requirements of Specification D4753.

6.5 *Sieves,* 75 mm [3 in.], 63 mm, [2 ½ in.], 50 mm [2 in.], 37.5 mm [1 ½ in.], 25.0 mm [1 in.] and 19.0 mm [¾ in.] conforming to the requirements of Specification E11.

6.6 *Camera*—A video or still camera capable of producing good quality, color images for "before testing" and "after testing" photographs.

7. Reagents and Materials

7.1 *Ethylene Glycol*—The reagent used in this method shall be ethylene glycol meeting requirements of ASTM D2693.

[2] 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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] For referenced USACE Standards, visit the USACE website, http://www.wbdg.org/ffc/army-coe/standards

8. Hazards

8.1 Ethylene glycol is hazardous in case of ingestion, slightly hazardous in case of skin contact (irritant, permeator), eye contact (irritant), or inhalation. Review the current appropriate Safety Data Sheets (SDS) for detailed information concerning toxicity, first aid procedures, and safety precautions. Refer to 1.7.

NOTE 2—Disposal of residual amounts of ethylene glycol can be accomplished safely by submittal to recycling and automotive service facilities.

9. Sampling and Preparation of Test Specimens

9.1 *Sampling of Rock Source*—A source of rock to be sampled shall be guided by the principles in Practice D4992.

9.2 Rock sources may be from mine, quarry, outcrop, or field boulders. Visual observation of color, texture, mineralogy, or some other feature, will be the key to proper representative sampling.

9.2.1 A rock source that is macroscopically uniform shall be represented by a minimum of five pieces of the material obtained from separate locations within the source area. This group is considered as a specimen set.

9.2.2 A rock source that is macroscopically non-uniform shall be represented by a minimum of eight pieces of the material obtained from separate locations within the source area. This group is considered as a specimen set.

9.2.3 Sample the rock types in their approximate proportion to the types that occur at the source.

9.3 Observed planes of weakness or other potential deleterious macro-features shall be included in each sample such that a determination may be made as to the durability of such features and their effect on the overall durability of a rock mass.

9.4 *Preparation of Test Specimens*—Crush or cut and then grade specimens to provide a sample set meeting the requirements given in Table 1.

9.4.1 After the particles have been separated into the various sieve sizes, thoroughly wash each size fraction with a water spray to remove adherent dust and fine particles then dry the sample to a constant mass at 110 ± 5°C [230 ± 9°F]. Constant mass will be considered to have been achieved when weight mass loss is less than 0.1 % of specimen mass in four hours of drying. The specimen shall be of such a size that it shall yield the amounts indicated in Table 1 by sieving to refusal. Weigh out quantities of the different fractional sizes within the tolerances of Table 1 and record the initial masses.

TABLE 1 Grading Requirements

Sieve Size				Mass, g
Passing		Retained on		
75.0 mm	(3 in.)	63.0 mm	[2½ in.]	7000 ± 1000
63.0 mm	[2½ in.]	50.0 mm	[2 in.]	3000 ± 300
50.0 mm	[2 in.]	37.5 mm	[1½ in.]	2000 ± 200
37.5 mm	[1½ in.]	25.0 mm	[1 in.]	1000 ± 50
25.0 mm	[1 in.]	19.0 mm	[¾ in.]	500 ± 30
Total				13,500 ± 1000

9.4.2 When only qualitative observation of the effects of the ethylene glycol treatment is desired, the weighing of the specimen may be omitted. When a greater degree of quantitative evaluation is desired, the specimen, after having been prepared as described in 9.4, shall be sieved using the 75.0 mm [3 in.], 63.0 mm [2½ in.], 50.0 mm [2 in.], 37.5 mm [1½ in.], 25.0 mm [1 in.] and 19.0 mm [¾ in.] sieves and the individual sieve fractions tested separately.

10. Procedure

10.1 Photograph "before test" images and document shape, color, and any unusual or unique properties of the material to be tested and include in the report.

10.2 Immerse the specimens in the ethylene glycol solution so that the specimens are fully immersed to a depth of not less than 12.5 mm [½ in.]. Store the immersed specimens at ambient room temperature.

10.3 At intervals not exceeding three days, the specimens shall be removed from the container, examined, changes noted, and if significant changes have taken place, photographed. The normal duration of the test shall be 15 days (Note 3).

NOTE 3—Further valuable information may be obtained in certain cases by continuing the testing beyond 15 days. In other cases expansive breakdown may have been so extensive at earlier periods during testing that no information of value will be obtained by continuing the testing for the full 15 days.

10.4 When the exposure to ethylene glycol has been terminated the specimen shall be thoroughly washed over a 19.0 mm (¾ in.) or finer sieve to remove the reagent from the surface of the particles. All rinse water containing residual amounts of ethylene glycol should be collected and recycled or disposed of in an approved manner. After the reagent has been removed, dry each fraction of the specimen to constant mass as described in 9.4.1.

10.5 Photograph "after test" images to document the changes that may have occurred during the particles' exposure to ethylene glycol, and include in the report. Identify the type of deterioration (spalling, splitting, disintegration, and other types of deterioration).

10.6 Sieve the individual fraction over the same sieve on which it was retained before the test. Sieving shall be by hand, with agitation sufficient only to assure that all undersize material passes the sieve. No extra manipulation shall be employed to break up particles or cause them to pass the sieves. Determine the mass of the material retained on each sieve and record each amount. The difference between each of these amounts and the initial mass of the fraction of the specimen tested is the loss in the test and is to be expressed as a percentage of the initial mass.

11. Calculations

11.1 *Quantitative Determination*—For each size fraction perform the following calculation:

$$\text{Percent Loss Individual Size Fraction} = ((A - B) / A) \times 100 \quad (1)$$

where:

A = original oven-dried mass of the individual size fraction specimen, and

B = final oven-dried mass of the individual size fraction specimen.

11.1.1 Calculate the percent loss determined to the nearest 0.1 percent for each size fraction specimen.

11.1.2 Calculate the mean of the percent loss determined to the nearest 0.1 percent for the specimen set.

11.2 *Qualitative Determination*—For each size fraction perform the following calculation:

11.2.1 Make a qualitative examination of test specimens coarser than 19.0 mm [¾ in.] as follows (Note 4).

11.2.2 Separate the particles into groups according to the action produced by the test (Note 4).

11.2.3 Record the number of particles showing each type of distress.

11.2.4 Take color photographs of particles at completion of testing.

NOTE 4—Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flacking, etc. While only particles larger than ¾ in. in size are required to be examined qualitatively, it is recommended that examination of the smaller sizes be made in order to determine whether there is any evidence of excessive splitting.

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

12.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s), as given below, is covered in 1.6.

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

12.2.1 Sample/specimen identifying information, such as Project No., Sample No., Sample source location, Depth, etc.

12.3 Record as a minimum the following test specimen data:

12.3.1 The name and initials of testing personnel.

12.3.2 The initial oven-dry specimen mass.

12.3.3 The start and finish time and date for each soak cycle.

12.3.4 The initial qualitative description from 10.1 and those made during the course of the duration of the soak period in accordance with 10.3.

12.3.5 "Before," "during," and "after" testing color photographs.

12.3.6 The final oven-dry mass.

12.4 Report as a minimum the following information:

12.4.1 Specimen identification number.

12.4.2 Specimen source location.

12.4.3 Location of intended use.

12.4.4 Rock type (lithology).

12.4.5 The percent loss of the individual size fractions and mean percent loss from the quantitative determination in accordance with 11.1 to the nearest 0.1 percent.

12.4.6 A written description of the qualitative examination for each specimen in accordance with 11.2.

12.5 The following items are optional for the report:

12.5.1 Geological formation name.

12.5.2 Geological setting of the source with pertinent examination on planes of weaknesses noted in the field.

13. Precision and Bias

13.1 It is not possible to specify the precision of the procedure in Test Method D8281 because it is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

13.2 No information can be presented on the bias of the procedure in Test Method D8281 for measuring loss due to exposure to ethylene glycol because no material having an accepted reference value is available.

14. Keywords

14.1 armor stone; breakwater stone; climatic setting; erosion control; ethylene glycol; expanding clays; freeze-thaw; gabion-fill; jetty stone; laboratory testing; riprap; rock; rock material properties; Smectite; wet dry

APPENDIX

(Nonmandatory Information)

X1. DETERMINING THE PRESENCE OF EXPANDING CLAYS IN ROCK FOR EROSION CONTROL USING ETHYLENE GLYCOL WORKSHEET

X1.1 See Fig. X1.1.