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Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions[1]

This standard is issued under the fixed designation D5313/D5313M; 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 procedures for evaluating the durability of rock for erosion control when exposed to wetting and drying conditions on slabs of rock using both qualitative and quantitative methods. This durability test exposes the rock samples to a cycle of wetting and drying such as those experienced due to fluctuating water levels and weather conditions, with tests done at room temperature as the baseline. The rock slabs, prepared per procedures in Practice D5121, are intended to be representative of the proposed source of erosion control rock and its weaknesses.

1.2 The test is appropriate for breakwater stone, armor stone, riprap, and gabion sized rock materials.

1.3 ~~This test method covers procedures for evaluating the durability of rock for erosion control when exposed to wetting and drying conditions on slabs of rock. This weathering test exposes the rock to wetting and drying cycles similar to fluctuating water levels and weather conditions. The rock slabs, prepared in accordance with procedures in Practice D5121, are intended to be representative of erosion control rock and its weaknesses. The test is appropriate for breakwater stone, armor stone, riprap and gabion sized rock materials.~~

The limitations of the test are twofold. ~~First, the size of the cut rock slab specimens may eliminate some of the internal defects present in the rock 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. Secondly, the test requires the rock slabs to be exposed to 80 wetting-drying cycles. The test is time intensive and will require approximately three months to complete the sample preparation, testing, and analysis portions of the procedure.~~

1.3.1 First, the size of the cut rock slab specimens may eliminate some of the internal defects present in the rock 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 is essential in minimizing this limitation.

1.3.2 Secondly, the test requires the rock slabs to be exposed to 80 cycles of wetting and drying. The test is time-intensive and would require a minimum of three months and up to six months to complete the sample preparation, testing, and analysis portions of the procedure.

1.4 The use of reclaimed concrete and other ~~materials~~ such materials as rip rap is beyond the scope of this test method.

1.5 *Units*—The values stated in either SI units or inch-pound units [presented in brackets] are to be regarded separately as

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

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.

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 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and of 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.

1.5.3 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, the 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.

1.7 *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.*

1.8 *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
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
D5121 Practice for Preparation of Rock Slabs for Durability Testing
D5240/D5240M Test Method for Evaluation of the Durability of Rock for Erosion Control Using Sodium Sulfate or Magnesium Sulfate
D5312/D5312M Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions
D6026 Practice for Using Significant Digits in Geotechnical Data

[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. Terminology

~~3.1 *Definitions*—See Terminology D653 for general definitions.~~

3.1 ~~*Definitions of Terms Specific to This Standard:*~~*Definitions:*

~~3.2.1 *rock saw, n*—a saw capable of cutting rock. The term "rock saw" shall include the blade which saws the rock, any components that control or power the sawing process or both, and framework on which the blade and any other associated components are mounted.~~

3.1.1 See Terminology D653 for general definitions.

~~3.2.2 *slab, n*—a section of rock having two smooth, approximately parallel faces, produced by two saw cuts. The thickness of the slab is generally less than the other dimensions of the rock. The slab will be the specimen of a rock which will subsequently undergo durability tests. The words "slab" and "specimen" are interchangeable throughout the test method.~~

3.1.2 *armor stone, n*—stone generally 900 to ~~2700~~2,700 kg [1 to 3 tons] resulting from blasting, cutting, or by other methods placed along shorelines or in jetties to protect the shoreline from erosion due to the action of large waves. **D5240/D5240M, D5312/D5312M**

3.1.3 *breakwater stone, n*—stone generally ~~2700~~2,700 to ~~18 000~~ 18,000 kg [3 to 20 tons] resulting from blasting, cutting, or by other methods placed along shorelines or in jetties to protect the shoreline from erosion due to the action of large waves. **D5240/D5240M, D5312/D5312M**

3.1.4 *gabion-fill stone, n*—stone generally less than 22 kg [50 lb] and placed in baskets of wire or other suitable material. These baskets are then tied together to form an integral structure designed to resist erosion along stream banks and around bridge piers. **D5240/D5240M, D5312/D5312M**

3.1.5 *riprap stone, n*—stone generally less than ~~1800~~1,800 kg [2 tons] specially selected and graded, when properly placed prevents erosion through minor wave ~~action,~~action or strong currents, and thereby preserves the shape of a surface, slope, or underlying structure. **D5240/D5240M, D5312/D5312M**

3.1.6 ~~*gabion-fill stone,*~~*rock saw, n*—~~stone generally less than 22 kg [50 lb] and placed in baskets of wire or other suitable material. These baskets are then tied together to form an integral structure designed to resist erosion along stream banks and around bridge piers.~~a saw capable of cutting rock.

3.1.6.1 *Discussion*—

The term "rock saw" shall include the blade which saws the rock, any components that control or power the sawing process or both, and the framework on which the blade and any other associated components are mounted. **D5240/D5240M, D5312/D5312M**

3.1.7 *slab, n*—a section of rock having two smooth, approximately parallel faces, produced by two saw cuts, which will subsequently undergo durability tests. The words "slab" and "specimen" are interchangeable throughout the test method.

3.1.7.1 *Discussion*—

The words "slab" and "specimen" are interchangeable throughout the test method. **D5240/D5240M, D5312/D5312M**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *room temperature, n*—colloquially, the range of air temperatures that most people prefer for indoor settings, which feel comfortable when wearing typical indoor clothing.

3.2.1.1 *Discussion*—

Human comfort can extend beyond this range depending on humidity, air circulation, and other factors. In specific fields, like science and engineering, and within a specific context, room temperature can mean different agreed-on ranges. In contrast, ambient temperature is the air's actual temperature (or other medium and surroundings) in any particular place, as measured by a thermometer. It may be very different from the usual room temperature, for example, an unheated room in winter.

4. Summary of Test Method

4.1 Erosion control rock samples are selected, and the pieces within each sample type are trimmed into saw-cut slab specimens. Each slab is structurally examined macroscopically and under 20× magnification.

4.2 ~~Erosion control rock samples are trimmed into saw-cut slab specimens. Each slab is structurally examined macroscopically and under 20× magnification.~~ The specimens are exposed to 80 wetting-drying cycles. Each cycle consists of full immersion in potable water for a minimum of 12 h, then drying under infrared heat lamps or in an oven for a minimum of 6 h. ~~At the completion of the test the percent loss by mass for each specimen set is determined.~~ A visual examination of the slabs is performed throughout and at the end of testing. ~~The type of deterioration and changes to previously noted planes of weakness are recorded.~~

4.3 At the completion of the test, the percent loss by mass for each specimen slab and sample type is determined. The type of deterioration and changes to previously noted planes of weakness are recorded.

5. Significance and Use

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

5.2 This test method is designed to determine the effects of wetting and drying action on the individual pieces of rock for erosion control and the resistance of the rock to deterioration. This test method ~~was developed to be~~ is used in conjunction with additional test methods listed in Practice D4992. This test method does not provide an absolute value but rather an indication of the resistance to wetting and ~~drying; therefore,~~drying. Therefore, the results of this test method are not to be used as the sole basis for the determination of rock durability. The data is summarized, and any interpretations of the data are made by the end-user or client.

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

NOTE 2—The apparatus system and procedures that follow are geared toward a manual operation. However, many laboratories have set up a partial or automated system that complies with the intent and directions within this standard to make the testing more efficient. The use of any such automation that follows this procedure is not regarded as nonconformance with this standard.

6.1 *Rock Saw*—A laboratory diamond saw used ~~to cut~~for cutting geological and concrete specimens, or a diamond saw used for lapidary purposes, shall be acceptable. A minimum blade diameter of 36 cm [14 in.] ~~will be~~ is needed to obtain the required slab sizes (a larger one is preferable). The blade shall be a circular diamond blade.

6.1.1 The rock saw apparatus shall have a fixed or removable vise to hold the samples during the cutting process. An automatic feed (either gravity, hydraulic, or screwfeed operated) that controls the cutting action is preferred; however, a manual feed is also acceptable. The saw shall have a platform to prevent the cut slab from falling and shattering.

6.2 *Containers*—Of sufficient size to hold the specimens ~~fully immersed in potable water. It is advised that these containers~~ and set up to fully immerse the specimen in potable water and fully unwater the container either manually or automatically. The containers should be non-reactive, resistant to breakage, and resistant to deformation and degradation when exposed to temperatures ~~encountered~~ and immersion fluids involved and required movement of the samples in this test method.

6.3 *Drying Oven*—Thermostatically controlled oven, capable of maintaining a uniform temperature of 110 ± 5°C [230 ± 9°F] throughout the drying ~~chamber.~~ chamber for each of the specified temperatures in this standard. These requirements typically require the use of a forced-draft type oven. Preferably the oven should be vented outside the building.

6.4 *Drying Apparatus*—Infrared heat lamps (150 ~~W) or a thermostatically controlled oven capable of maintaining a uniform temperature of 65 ± 5°C [150 ± 9°F] throughout the drying chamber.~~W).

NOTE 3—The U.S. Army Corps of Engineers used a bank of infrared heat lamps spaced about 1-foot apart. The objective was to uniformly or evenly heat the specimen even if only on one side of the specimen.

6.5 *Stereomicroscope*—A microscope or other suitable magnifying device capable of at least 20× magnification for an examination

of the specimen prior to and after testing. Ideally, with a film or digital camera mounted to the stereomicroscope, allowing the user to document the small-scale bedding or potential planes of weakness within the test specimen.

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

6.7 *Camera*—A digital or film ~~camera~~device capable of ~~producing~~providing good quality, color images, or photographs for documenting "before" and "after" ~~photographs.~~testing specimen conditions and as required in 12.3.5.

6.8 *Photographic Scale*—A scale of appropriate dimension and division when compared to the field of view and the detail being studied. When selecting a scale, always choose the scale that will provide at least as precise a measurement as the system that will be measuring the photographic information. For example, if the system has a precision to one millimeter, make sure the scale used is accurate and precise to at least one millimeter across the entire scale.

6.9 *Drying Pans*—Metal pans of sufficient size and strength capable of holding the specimen, the safe movement, and resistant to degradation when exposed to the temperatures and immersion fluids involved in this test method.

6.10 *Plus No. 8 size insoluble sand* is recommended as bedding to support the specimens above the bottom of the pan and allow for the immersion fluid to flow underneath the specimen. However, a metal rack or grate underneath the specimens that accomplishes the same purpose and prevents any rock fragments from each specimen from being lost is allowed too.

7. ~~Sampling, Test Specimens,~~ Sampling and Test ~~Units~~Specimens

7.1 A source of rock to be sampled shall be guided by the principles in Practice D4992.

7.2 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.

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

7.4 ~~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.~~*Sample Size:*

7.4.1 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.~~sample type.

7.4.2 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.~~sample type.

~~7.2.3 Sample the rock types in their approximate proportion to the types that occur at the source.~~

7.5 Planes of weakness will be included in each sample such that a determination may be made as to the durability of the various planes of weakness and their effect on the overall durability of a rock mass that would contain these planes of weakness.

7.6 Each rock ~~sample~~ piece in a sample type shall be of sufficient size to provide the finished size specimens described in Section 8.

7.7 In all cases, the rock pieces selected for the sample type shall be chosen to be representative of the majority of the rock at the source. Rock pieces, as determined by their macroscopic properties, which comprise less than 5 percent of the source material, may be ignored unless their presence in a ~~sample~~ sample, types will significantly affect the test results and subsequent proposed use of the rock.

7.8 Each piece will be of a size such that preparation of specimens for testing may proceed without further mechanical ~~crushing;~~

or other methods of rock fragmentation; however, the chosen pieces shall be as large as the laboratory can handle, but in no case shall the sample pieces be less than 125 mm [5 in.] on ~~a~~any side.

8. Preparation of Test Specimens

8.1 Prepare a separate slab test specimen for each orientation of the various planes of weakness unless all such planes can be intersected with one orientation.

8.2 ~~Saw each sample, as obtained in accordance with~~ Prepare a test specimen by sawing each rock piece within the sample type, as obtained per ~~7.2.1~~7.4.1 and ~~7.2.2~~7.4.2, in accordance with Practice D5121. Each finished specimen will be ~~cut to~~ 65 ± 5 mm [2.5 ± 0.25 in.] thick and cut normal to bedding or any potential planes of weakness that may be observed in the samples. In no case will the size of the slab be less than 125 mm [5 in.] on a side, excluding the thickness.

NOTE 4—Test specimens may also be prepared by cutting a 65 mm [2.5 in.] thick slab from a 150-mm [6-in.] diameter diamond drill core such that any apparent zones of weakness are included.

NOTE 5—The best estimates of rock durability are the result of tests performed on the largest possible slabs of rock. The maximum slab size shall be limited only by the capacity of the laboratory and its equipment.

9. Procedure

9.1 Examine each slab macroscopically and under a minimum of 20× magnification. Note the presence of bedding planes, microfractures, and other planes of weakness and their condition. Describe each slab as indicated in Practice D5121.

9.2 Label each specimen with a suitable waterproof or indelible marker.

9.3 ~~Label each specimen with a suitable waterproof marker.~~ Photograph each test specimen ~~digitally or using color film in such a way that the~~ so that the image of the slab fills most of the ~~photograph.~~ captured view. Wet or partially wet specimens usually show more detail than dry specimens. Include a scale in all photographs.

9.4 ~~Dry each trimmed slab in an oven~~ Transfer the trimmed slab to a drying pan and then place in a preheated oven and dry to a constant mass (±0.1 % change of the total mass) at 110 ± 5°C [230 ± 9°F] and record the ~~mass.~~ mass to the nearest gram [0.002 lb]. Rock that contains gypsum (calcium sulfate ~~dihydrate),~~ dihydrate) or anhydrite (calcium sulfate) shall be dried at the 60°C [140°F] temperature recommended in Test Method D2216.

9.5 Begin the wetting sequence by placing each specimen, sawed surface down, in a container on a thin layer, 6 mm [¼ in.], of plus No. 8 size ~~sand.~~ sand or a suitable support rack. Add enough potable water to the container such that the specimen is fully immersed and let stand at room temperature for a minimum of 12 h.

9.6 Begin the drying sequence by decanting or siphoning the water and placing the container in an oven at a temperature of 65 ± 5°C [150 ± 9°F]. As an alternative, the sample may be dried under ~~an~~ infrared heat ~~lamp~~lamps such that the rock surface is 40 to 50 cm [16 to 20 in.] from the lamp. Thoroughly dry the specimen for a minimum of 6 h.

9.7 The completion of the wetting and drying ~~sequences~~sequence constitutes one wetting-drying cycle.

9.8 At the completion of the drying sequence allow the samples to cool to ambient room temperature.

9.9 Repeat the process of wetting and drying ~~in accordance with~~ per ~~9.4~~9.5 and ~~9.5~~9.6 for a total of 80 ~~cycles.~~cycles with a qualitative examination after every fourth cycle, as required in Section 11.

9.10 Preferably, the test shall be performed continuously until the specified number of cycles is obtained. However, if the test must be interrupted, leave the samples at the ambient room temperature ~~attained~~existing in ~~9.7~~9.8 until the testing can be resumed.

~~9.10 Photograph and perform a qualitative examination on each slab as specified in Section 11.~~

9.11 Upon completion of the 80 cycles, ~~dry~~transfer the largest remaining ~~piece~~ piece, from each slab specimen to a drying pan and place them in an oven to obtain a constant mass and record the mass for each piece as per 9.4 and as shown in the example data sheets in Appendix X1 and Appendix X2~~of each slab in~~ . If present, place up to three of the next largest pieces from the slab specimens that are at least greater than 10 % of the original slab specimen mass, in a drying pan and place them in an oven to obtain a constant mass and record the mass ~~as in accordance with~~ for each piece as per ~~9.3~~9.4.

10. Quantitative Examination

10.1 For each ~~slab~~ specimen slab, perform the following calculation:

$$\% \text{ loss} = (A - B)/A \times 100 \quad (1)$$

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where:

A = oven dried mass of the specimen prior to testing, and
~~B = oven dried mass of the largest remaining piece of each slab after testing.~~

A = oven dried mass of the specimen slab prior to testing, and
B = oven dried mass of the largest remaining pieces of each specimen slab after testing.

NOTE 6—By reporting the single largest remaining piece, the second largest piece, etc., and residual fragments, the user can evaluate how the rock performed. The "single largest piece" is still the percent retained, and all other pieces are defined as a loss; however, a user given this additional data may decide that a particular source that is close to the project site will perform satisfactorily. For example, if 20 % of the pieces typically split into two approximately equal pieces, that is, 1,800 lb riprap is specified with 10 % max loss specified. So testing indicates that 4 out of 5 pieces lose less than 1 %, but 1 out of 5 breaks into 20 % and 80 % pieces, a 360 lb piece and a 1,440 lb piece and the engineer might decide that material will do the job.

10.1.1 Record the percent loss determined to the nearest 0.1 percent for each specimen slab.

10.2 Calculate the mean of the percent loss for the sample type.

10.3 ~~Calculate the percent loss determined to the nearest 0.1 percent for each specimen.~~For any smaller pieces for each slab, perform the following calculation on each piece:

$$\% \text{ loss}_{x=c,\, d,\, or\, e} = X/A \times 100 \quad (2)$$

where:

A = oven-dried mass of the specimen prior to testing, and
X = oven-dried mass of the largest remaining pieces (c, d, or e) of each slab after testing.

10.3.1 Report the percent loss determined to the nearest 0.1 percent for each specimen slab.

10.4 (Optional) Calculate the mean of the percent loss for the ~~specimen set.~~smaller pieces.

10.5 For each slab specimen, perform the following calculation for the residual (fragment) mass and percent loss:

$$\text{Residual (fragment) mass} = A - B + C + D + E \quad (3)$$

$$\% \text{ loss} = (C,\, D,\, \text{or } E)/A \times 100 \quad (4)$$

10.5.1 Record the calculated residual mass to the nearest gram [0.002 lb] and the percent loss determined to the nearest 0.1 percent for each specimen slab.

11. Qualitative Examination

11.1 Visually examine the slabs ~~every four cycles, and at the completion of testing for~~samples daily, but data should only be recorded/photographed at the onset of any deterioration and thereafter on an as-needed basis. This may be dependent on how rapidly deterioration proceeds after initial onset. At the completion of testing, describe any changes that have taken place ~~over the~~