Designation: D5312/D5312M – 12 (Reapproved 2013)

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

This standard is issued under the fixed designation D5312/D5312M; 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 procedures for evaluating the durability of rock for erosion control when exposed to freezing and thawing conditions on slabs of rock. This weathering test exposes the rock to freezing and thawing cycles similar to natural 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 up to 55 freezing-thawing cycles. The test is time intensive and may require up to two or more months to complete the sample preparation, testing, and analysis portions of the procedure.

1.2 The use of reclaimed concrete and other materials is beyond the scope of this test method.

1.3 *Units*—The values stated in either SI units or inch-pound units [presented in brackets] 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.

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values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.4.1 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.

1.4.2 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 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.

1.5 *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:*[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

D6026 Practice for Using Significant Digits in Geotechnical Data

E145 Specification for Gravity-Convection and Forced-Ventilation Ovens

[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.

Current edition approved Jan. 15, 2013. Published February 2013. Originally approved in 1992. Last previous edition approved in 2012 as D5312/D5312M – 12. DOI: 10.1520/D5312_D5312M-12R13.

[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.

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

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

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.

3.2.2 *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.

3.2.3 *armor stone, n*—stone generally 900 to 2,700 kg [one to three 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.

3.2.4 *breakwater stone, n*—stone generally 2,700 to 18,000 kg [three to twenty 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.

3.2.5 *riprap stone, n*—stone generally less than 1,800 kg [two tons] specially selected and graded, when properly placed prevents erosion through minor wave action, or strong currents and thereby preserves the shape of a surface, slope, or underlying structure.

3.2.6 *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.

4. Summary of Test Method

4.1 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 up to 55 freezing-thawing cycles. The trimmed slabs are initially immersed in an alcohol/water solution for a minimum of 12 h. The slabs are then frozen for a minimum of 12 h then thawed for 8 to 12 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.

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 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 freezing and thawing 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 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 freezing and thawing; therefore, 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 *Rock Saw*—A laboratory diamond saw used to cut 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 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 *Freeze-Thaw Chamber or Home Freezer*—A timer-controlled freeze-thaw chamber specifically designed for timed cycling of 16 h of freezing at -18 ± 2.5 °C [0 ± 5 °F] followed by a minimum of 8 h of thawing at 32 ± 2.5 °C [90 ± 5 °F] on a daily basis is the most desirable option. This type of apparatus is commercially available and allows for the completion of one freeze-thaw cycle every day including weekends and holidays.

6.2.1 If a freeze-thaw chamber is not available, a standard chest-type home freezer capable of reaching and maintaining the required temperature range in accordance with 6.2 may be used.

6.2.2 The limitations associated with this option are related to the fact that the freeze-thaw cycling must be accomplished manually. Typically only four cycles of freezing and thawing may be accomplished during a normal work week.

6.3 *Thawing Oven* (if option 6.2.1 is used)—Thermostatically controlled oven meeting the requirements of Specification E145 and capable of maintaining a constant temperature of 32 ± 2.5 °C [90 ± 5 °F]. Preferably the oven should be vented outside the building.

6.4 *Drying Oven*—Thermostatically controlled oven meeting the requirements of Specification E145 and 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. Preferably the oven should be vented outside the building.

6.4.1 A single oven may be used in lieu of the thawing and drying ovens if it meets the requirements of both 6.3 and 6.4.

6.5 *Containers*—Of sufficient size to hold the specimens partially immersed in an alcohol/water solution. It is advised that these containers be non-reactive, resistant to breakage and resistant to deformation and degradation when exposed to temperatures encountered in this test method.

6.6 *Absorptive Pads*—6-mm [¼ in.] thick felt pads, blotters, synthetic fiber carpeting or similar absorptive material for placing between specimens and the container bottom.

6.7 *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.

6.8 *Camera*—A digital or film camera capable of producing good quality, color photographs for "before" and "after" photographs.

6.9 *Stereomicroscope*—A microscope or other suitable magnifying device, capable of at least 20× magnification for examination of the specimen prior to and after testing. Ideally, a camera body could be mounted to the stereomicroscope, allowing the user to document the small-scale bedding or potential planes of weakness within the test specimen.

6.10 *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. 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.

7. Special Solutions

7.1 The special solution required for this test method consists of a 0.5 % isopropyl alcohol/water solution. This solution may be mixed and stored ahead of time. It will be used to replenish the solution as the test proceeds. Commercially available isopropyl alcohol as opposed to reagent grade is suitable.

NOTE 2—The 0.5 % isopropyl alcohol contained in the special solution is to lower the viscosity of water, allowing for more thorough penetration of the water into the test specimen's micro-pores prior to freezing.

8. Sampling, Test Specimens, and Test Units

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

8.2 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.

8.2.1 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.

8.2.2 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.

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

8.3 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.

8.4 Each rock sample shall be of sufficient size to provide the finished size specimens described in Section 9.

8.5 In all cases, the rock pieces selected for the sample 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 will significantly affect the test results and subsequent proposed use of the rock.

8.6 Each piece will be of a size such that testing may proceed without further mechanical crushing; however, the chosen pieces shall be as large as the laboratory can handle but in no case shall the sample be less than 125 mm (5 in.) on a side.

9. Preparation of Test Specimens

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

9.2 Saw each sample, as obtained in accordance with 8.2.1 and 8.2.2, in accordance with Practice D5121. Cut each specimen to 65 ± 5 mm [2.5 ± 0.25 in.] thick and cut normal to bedding or any potential planes of weakness which 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 3—Test specimens may also be prepared by cutting a 65 ± 5 mm [2.5 ± 0.25 in.] thick slab from a 150-mm [6-in.] diameter diamond drill core such that any apparent zones of weakness are included.

NOTE 4—The best estimates of rock durability are those estimates that are based on the results 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.

10. Procedure

10.1 Examine each slab both macroscopically and microscopically using a minimum of 20× magnification. Note the presence of bedding planes, microfractures, and other planes of weakness and their condition. Describe each slab in accordance with Practice D5121.

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

10.3 Dry each trimmed slab in an oven to a constant mass (±0.1 % of total mass) at 110 ± 5 °C [230 ± 9 °F] and record the mass. When determining constant mass, rock that contains gypsum, (calcium sulfate dihydrate), shall be dried at the 60 °C [140 °F] temperature recommended in Test Method D2216.

10.4 Place each test specimen, sawed surface down, in a container on an absorptive pad. Add enough of the alcohol/

water solution to the container such that the solution covers the test specimen and let stand for a minimum of 12 h.

10.5 Decant enough liquid such that the absorptive pad is just immersed.

10.6 Begin the freezing sequence by placing the container and test specimen in the freeze-thaw chamber or freezer and subject the specimen to a freezing temperature of -18 ± 2.5 °C [0 ± 5 °F] for a minimum of 12 h (there is no upper limit for storage during freezing). Upon completing the required time for freezing, subject the container and specimen to complete thawing at a temperature of 32 ± 2.5 °C [90 ± 5 °F] for 8 to 12 h. The required thawing sequence may be accomplished either in the freeze-thaw chamber or in an oven; however, the test specimen must be left in its container during the entire thawing process. Replenish the alcohol/water solution to maintain coverage of the absorptive pad.

10.7 The completion of the freezing and thawing sequences constitutes one freezing-thawing cycle.

10.8 Repeat the process of freezing and thawing for a total number of cycles equivalent to the index number rounded to the nearest five cycles of the geographic area of intended use as determined by Fig. 1.[3]

10.9 Preferably, the test shall be performed continuously until the specified number of cycles is obtained. However, if the test must be interrupted, leave the specimens in the freezer until the testing can be resumed.

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

10.11 Upon completion of the specified number of cycles, dry the largest remaining piece of each slab in an oven to a constant mass and record the mass as in accordance with 10.3.

NOTE 5—Fig. 1 is an index map based on National Oceanic and Atmospheric Agency (NOAA) climatic data and was developed to determine the geographic distribution of the severity of freeze-thaw cycles. The figure not only takes into account the annual number of freeze-thaw cycles, but also the amount of moisture associated with each cycle and the temperature extremes of the freeze-thaw cycle. The index number, therefore, is not a prediction of the annual number of freeze-thaw cycles, but rather, is an indicator of the severity of the freeze-thaw process by geographic area. Since the freeze-thaw severity varies from one geographic location to another, it is not possible to provide a reliable indication of the serviceability of rock for erosion control for a given locality unless the test procedure is customized for that locality. The freeze-thaw severity index allows for this type of customization.

[3] Lienhart, D. A., "The Geographic Distribution of Intensity and Frequency of Freeze-Thaw Cycles," *Bulletin of the Association of Engineering Geologists*, Vol XXV, No. 4, 1988, pp. 465–471.

11. Calculation

11.1 *Quantitative Examination*—For each slab perform the following calculation:

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

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.

11.2 Calculate the percent loss determined to the nearest 0.1 percent for each specimen.

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

12. Qualitative Examination

12.1 Visually examine the slabs every five cycles, and at the completion of testing for any changes that have taken place over the duration of the test and describe the changes. Identify the type of deterioration (spalling, splitting, disintegration, and other types of deterioration). Observe and record any changes to previously noted planes of weakness.

12.2 Take color photographs of each slab every five cycles and at the completion of testing. Provide close-ups of any unusual features. Include a scale in all photographs.

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

13.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s), as given below, is covered in 1.3.

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

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

13.3 Record as a minimum the following test specimen data:

13.3.1 The name and initials of testing personnel.

13.3.2 The initial oven-dried specimen mass.

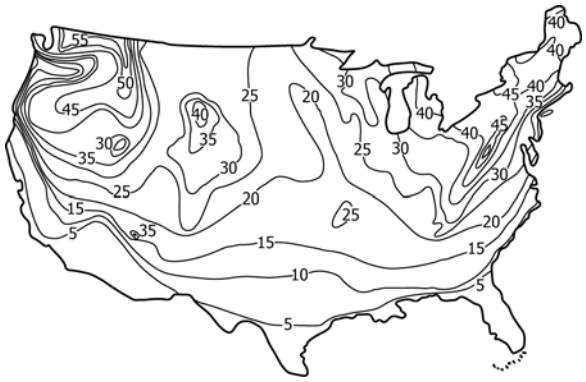

FIG. 1 Isoline Map of the Freeze-Thaw Severity Index

13.3.3 The start and finish time and date for each freezing-thawing cycle.

13.3.4 The initial qualitative examination observations and those made every fifth freezing-thawing cycle.

13.3.5 "Before," "during," and "after" color photographs.

13.3.6 The final oven-dried specimen mass.

13.4 Report as a minimum the following information:

13.4.1 Sample identification number.

13.4.2 Sample source location.

13.4.3 Location of intended use.

13.4.4 Rock type.

13.4.5 The mean percent loss of the quantitative examination required in 11.3 to the nearest 0.1 %,

13.4.6 A written description of the qualitative examination for each specimen in accordance with 12.1, and the findings of this examination.

13.4.7 "Before" and "After" color photographs.

13.5 The following items are optional for the report:

13.5.1 Geological formation name.

13.5.2 Geological setting of the source with pertinent information on planes of weakness noted in the field.

14. Precision and Bias

14.1 *Precision*—Due to the nature of the rock materials tested by this test method, it is, at this time, either not feasible or too costly to produce multiple test specimens that have uniform physical properties. Since test specimens that would yield the same test results cannot be tested, Subcommittee D18.17 cannot determine the variation between tests since any variation observed is just as likely to be due to test specimen variation as to operator or laboratory testing variation. Subcommittee D18.17 welcomes proposals to resolve this problem that would allow for the development of a valid precision statement.

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

15. Keywords

15.1 armor stone; breakwater stone; climatic setting; erosion control; freeze-thaw; gabion-fill; laboratory testing; riprap; rock; rock material properties

APPENDIX

(Nonmandatory Information)

X1. DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS WORKSHEET

ASTM D 5312 Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions						
Project:				Lab Number:		
Test Start Date:		Test End Date:		Tested By:		
(A) Initial Specimen Mass, g:				(B) Final Specimen Mass, g:		
Initial Qualitative Description:						
Cycle 1	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 2	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 3	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 4	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 5	Freeze Start Date/Time	Thaw Start Date/Time		Qualitative Description:		
By						
Cycle 6	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 7	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 8	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 9	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 10	Freeze Start Date/Time	Thaw Start Date/Time		Qualitative Description:		
By						
Cycle 41	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 42	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 43	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 44	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 45	Freeze Start Date/Time	Thaw Start Date/Time		Qualitative Description:		
By						
Cycle 46	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 47	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 48	Freeze Start Date/Time	Thaw Start Date/Time		Cycle 49	Freeze Start Date/Time	Thaw Start Date/Time
By				By		
Cycle 50	Freeze Start Date/Time	Thaw Start Date/Time				
By						
Final Qualitative Description:						
Calculations		% Loss = (A – B) / A × 100				
By						

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D5312 – 04) that may impact the use of this standard. (Approved July 1, 2012.)

(1) The Scope (Section 1) was expanded to indicate the test method's intent and limitations. Clarification and reference to Practice D6026 was expanded and a statement was added indicating that the values stated in either SI units or inch-pound units [presented in brackets] are to be regarded separately as standard.
(2) Reference Documents (Section 2) was expanded to include the reference to Specification E145 Specification for Gravity-Convection and Forced-Ventilation Ovens.
(3) The Terminology (Section 3) was expanded to include terms specific to the standard.
(4) A Summary of Test Method (Section 4) was added to present a clear and concise summary of the test method.
(5) The Significance and Use (Section 5) was updated to improve readability.
(6) The Apparatus (Section 6) was clarified to reflect the wording in Practice D5121, to eliminate superlative wording and expanded to better define required and optional apparatus.
(7) Note 2 was added to clarify the use of the special solution described in Section 7.
(8) The Sampling, Test Specimens, and Test Units (Section 8) was expanded and broken down into simple sections for clarification and to improve readability.
(9) The Preparation of Test Specimens (Section 9) was updated to improve readability.
(10) The Procedure (Section 10) was updated to clarify the sequencing of, and to remove ambiguity from, the test.
(11) Rationalized SI and inch-pound units were added throughout the standard.
(12) The Calculation (Section 11) was updated to indicate that the percent loss is to be determined to the nearest 0.1 percent and the mean of the loss of the specimen set is to be determined.
(13) The Qualitative Examination (Section 12) was updated to improve readability.
(14) The Report: Test Data Sheet(s)/Form(s) (Section 13) was expanded to specify the manner in which the data is recorded and reported.
(15) Appendix X1 was added to provide the user with a worksheet for data recording. This worksheet is strictly an example that the user may vary to suit their particular requirements.