Designation: D 5519 – 94

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Particle Size Analysis of Natural and Man-Made Riprap Materials[1]

This standard is issued under the fixed designation D 5519; 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 particle size and mass analysis of natural and man-made riprap and related materials, including filter stone or coarse bedding materials.

1.2 This test method is applicable for graded riprap stone, both naturally occurring and quarried. It is applicable for sizes 3 in. (75 mm) and above, with the upper size limited only by equipment available for handling and weighing of the individual particles. This test method is also applicable for evaluation, sizing, and mass determinations of man-made riprap materials, such as recycled broken concrete.

1.3 Three alternate procedures are provided. The procedure used shall be as indicated in the specification for the material being tested. If no procedure is specified, the choice should be selected and confirmed by the testing agency. The procedures and referenced sections are:

1.3.1 *Test Method A: Size-Mass Grading*—Grading of the material based on both the size and mass. See 9.2.

1.3.2 *Test Method B: Size-Range Grading*—Determination of the grading of the material based on the sizes of the individual particles. See 9.3.

1.3.3 *Test Method C: Mass-Range Grading*—Determination of the grading of the material based on the mass of the individual particles. See 9.4.

1.4 During the measurements using the methods in accordance with 1.3.1, 1.3.2, or 1.3.3, other attributes, such as the amount of slab pieces, can be determined during testing.

1.5 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units given in parentheses may be approximate.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates[2]

D 422 Method for Particle Size Analysis of Soils[3]

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

D 3740 Practice for the Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock Used in Engineering Design and Construction[3]

D 4992 Practice for Evaluation of Rock to Be Used for Erosion Control[3]

D 5240 Test Method for Testing Rock Slabs to Evaluate Soundess of Riprap by Use of Sodium Sulfate or Magnesium Sulfate[3]

D 5312 Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions[3]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[2]

3. Terminology

3.1 *Definitions:*

3.1.1 Terminology used within this test method is in accordance with Terminology D 653 with the addition of the following:

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bedding (riprap)*—a layer of gravel, crushed stone, or filter materials placed on soil and under riprap to prevent soil migration up through the riprap, and to prevent undermining of the riprap due to erosion of the soil.

3.2.2 *slab pieces*—pieces of riprap that exhibit dimensional ratios of the thickness to width or width to length, or both, in excess of a specified ratio. The specified ratios typically range from 1:4 to 1:3 or less.

4. Summary of Test Method

4.1 The following three test methods for evaluating particle size distribution are available.

4.1.1 *Test Method A: Size-Mass Grading*—A sample of the material is obtained, individual particles are measured, and the particles are grouped into size ranges desired. The total mass of particles in the desired size range is determined. Particle size

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.17 on Rock for Erosion Control.

Current edition approved March 15, 1994. Published May 1994.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

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

distribution percentages are then determined by calculation.

4.1.2 *Test Method B: Size Range Grading*—A sample of the material is obtained, individual particles are measured, counted, grouped into size ranges desired, and the distribution by size range is determined. The distribution in a size range, by mass, retained or passing, can be estimated.

4.1.3 *Test Method C: Mass-Range Grading*—A sample of the material is obtained, the mass of individual particles is measured, counted, masses are summed into mass ranges desired, and the distribution by mass ranges is determined.

5. Significance and Use

5.1 Riprap is commonly used to prevent erosion of underlying materials due to the effects of rain runoff, wind, flowing water, or wave action. The particle size distribution and mass of particles are two of the more important physical characteristics of riprap, whether quarried or from naturally occurring deposits.

5.2 The grading, particle mass, and other characteristics are important to ensure that riprap and the underlying bedding stone and filter materials will perform as designed to prevent erosion. Particle size and shape are key to having a uniform and interlocked riprap layer that will resist wind, wave, and water action. Poorly graded materials will result in either less than desired performance or the need to place additional riprap thickness.

5.3 This test method can be used to determine the particle size distribution of a sample of riprap or related materials, such as bedding, gabion, or riprap stone. It can be used during evaluation of a potential source or later as a means of product acceptance.

5.4 If a complete gradation in terms of size and mass is required, it will be necessary to perform testing in accordance with Test Method A. Mass and size can be related if the specific gravity of the rock is known and the shapes generated during production do not vary significantly. To obtain a complete gradation in terms of both mass and size, the unknown parameter may be estimated by calculation assuming that the clear square opening size is that of a particle midway between the size of sphere or cube, without significant amounts of slab-type pieces. Fig. 1 can be used to estimate either the size or mass of a rock piece.

5.5 Of the three test methods available, Test Method A is considered to provide the most quantitative description of the sample because both particle sizes and masses are determined. Test Method A employs a methodology similar to standard soil and aggregate particle size analysis tests (see Test Methods D 422 and C 136). Test Method B can be used for periodic product checks of particle sizes to ensure distribution meets specifications. Test Method C can be used if size can be inferred from a consistent source, and abnormal shapes or characteristics of the rock are not of concern.

5.6 Calculation needs for Test Methods B and C depend on the performance requirements specified for a particular project need. Requirements may be expressed in terms of percentage passing or retained for range of mass or size, or both. Test Method B determines the number of particles by size while Test Method C is by mass.

5.7 Other characteristics of interest, such as average individual particle mass, presence of bedding planes of weakness, angularity, or amount of slab material may be determined during the performance of this test method.

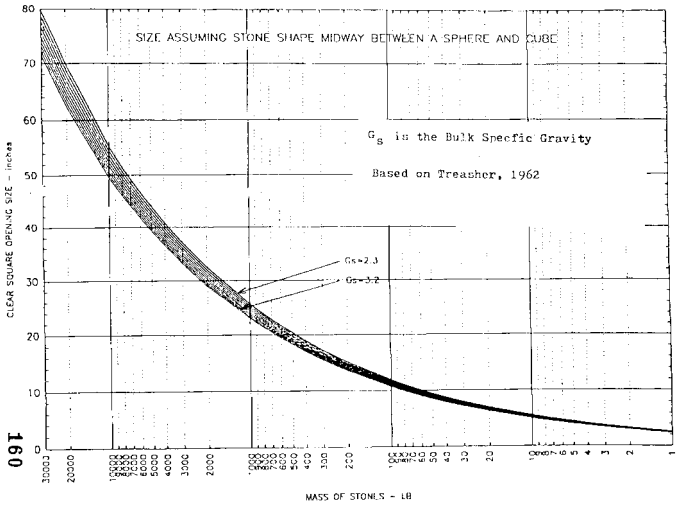


FIG. 1 Size Assuming Stone Shape Midway Between a Sphere and a Cube

5.8 The accuracy of this test method is limited by the representativeness of the sample tested. Interpretation of test results must consider the representativeness of the sample.

5.9 For large sizes of riprap, large sample sizes are required. Performance of this test method is labor and equipment intensive and therefore costly. The application of this test method should include considerations of the costs and time involved.

NOTE 1—The agency performing this test method can be evaluated in accordance with Practice D 3740. Not withstanding statements on precision and bias contained in this test method: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself ensure reliable testing. Reliable testing depends on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Scales*, of adequate capacity to determine the mass of the sorted riprap pieces either individually or in whole. The scale will be accurate to 1 % of the indicated mass. Calibrated or certified commercial truck or quarry scales of adequate capacity are typically used. For individual particle measurements using Test Method B, hoist line load cells have been used successfully.

6.2 *Sieves or Templates*, meeting the requirements of Specification E 11 for sizes up to 5 in. (125 mm). For sizes above 5 in., single-opening templates may be fabricated for the required sizes. Templates may be fabricated from steel bar or other sufficiently rigid materials in the sizes required. For templates openings from 5 in. to 16 in. (125 to 400 mm), the openings will be within ±2 % of the size, for templates greater than 16 in., the openings will be within ±0.25 in. (6.35 mm). Sieves and templates should be checked on a regular basis to verify squareness, straightness, and conformance to opening tolerances. Hand grips or handles should be considered for ease of

use. For larger sizes, it has been found useful to fabricate templates in the form of a C-shaped caliper representing the sieve opening and the diagonal of the sieve opening (see Fig. 2).

6.3 *Transport Vehicle*, capable of conveying the individual or groups of the individual sorted riprap pieces from the sampling point to the test area, and from the test area to the weighing station. If truck scales are used, the transport vehicle should be tared prior to and after determination of the masses.

6.4 *Handling Equipment*, such as forklifts, loaders, or like equipment for sampling, transporting, assisting in the sorting, loading for transport, weighing, and other tasks involved in the physical performance of the test.

6.5 *Tape Measures* for determining particle size dimensions to estimate mass or determine slab pieces.

6.6 *Test Area*, sufficiently large to allow the placement of the test sample, areas or bins to place the sorted materials, and adequate to allow trucks, loaders, and other required equipment to operate safely. The test area should have a smooth surface, preferably of concrete, to provide a suitable work surface and prevent loss of the fines.

6.7 *Proportional Calipers*, fabricated in a sufficient size or sizes for use in determining if pieces meet or exceed dimensional ratios to be considered slab pieces (see Fig. 2).

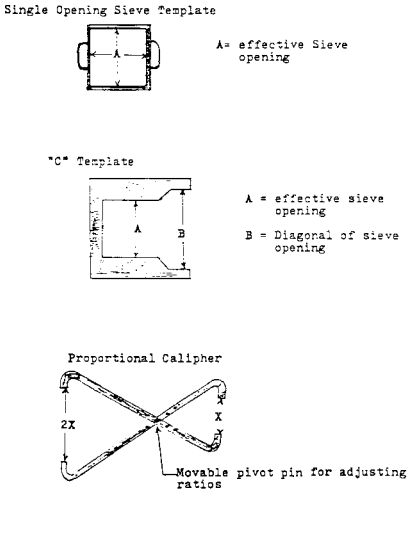
6.8 *Miscellaneous Equipment*, such as spray paints to mark pieces, rock hammers, cameras for photo documentation, sample bags, tags or signs, data-recording forms, heavy work gloves, safety goggles or glasses, respirators or dust masks, and steel-toed boots or caps, as required for the work.

7. Hazards

7.1 Performance of this test method includes the moving, lifting, measurement, and transfer of large pieces of rock. This presents the potential for personnel injury from crushing, dropped or rolling of the riprap pieces. Whenever possible, the sample should be spread to a single layer depth to reduce personnel hazard from rolling or falling pieces.

7.2 Personnel performing this test method will be in the vicinity of working heavy equipment and precautions should be taken to prevent injury from equipment.

7.3 Working with and around the pieces may subject personnel to dust, flying particles, falling pieces, and excessive noise. Personnel should be adequately equipped and trained in the use of personal protective equipment.



NOTE 1—The following figure illustrate typical apparatus that have been fabricated for use in this test method.

FIG. 2 Single-Opening Sieve Template

8. Sampling

8.1 The precision and representativeness of this test method is directly related to the sampling process. The sampling should be carefully planned and executed to achieve optimum representativeness. All parties should be involved in the planning process. The sampling plan should be documented and included as a part of the final report.

8.2 The mass of the total test specimen should be large enough to ensure a representative gradation and should be such that it provides test results to the desired level of accuracy. One analogy is to consider a test specimen size of such size that the addition or loss of the largest expected piece will not change the results by more than a specified percentage.[4] If the particle mass is not known from experience, the particle mass may be estimated using Fig. 1, with an assumed representative specific gravity, or calculated using an assumed specific gravity and volume of the largest expected piece.

NOTE 2—Example: For a test specimen size to achieve a 1 % accuracy, assume that the largest individual piece mass is expected to be 150 lb (68 kg). For this piece to represent less than 1 %, the sample mass would be 15 000-lb (6 800-kg) minimum. For this piece to represent less than 5 % accuracy, the sample size would be 3000-lb (1360-kg) minimum.

8.3 Take an adequate amount of sample to ensure that the minimum test specimen mass is available, however sampling will not be to a predetermined exact mass. Composite samples will be allowed only when included in the sample plan.

8.4 Sampling from the source material will be in accordance with the sampling plan with the emphasis on obtaining a sample representative of the whole in respect to mass, size, and shape.

8.5 Sample handling should be minimized to avoid unnecessary degradation and breakage. For materials that have been submerged, allow the sample to freely drain. Moisture content of riprap samples is considered inconsequential and the sample will be tested and reported as-found.

8.6 Other characteristics, such as soundness by Test Method D 5240, freeze-thaw resistance by Test Method D 5312 are normally determined prior to testing for size and mass. If these tests have not been performed previously, or if confirmation of the results is desirable, the sampling for these tests will be included in the sampling plan.

8.7 Photographs of the sampling process and related activities should be included in the report.

8.8 Select the selection of sieve or template sizes for size or mass range groupings, or both, in accordance with project

[4] Howard, A. K., and Horz, R. C., "Minimum Test Specimen for Gradation Analysis," *Geotechnical Testing Journal*, Vol 11, No. 3, September 1988, pp. 213–217.