Designation: D5444 – 15

Standard Test Method for Mechanical Size Analysis of Extracted Aggregate[1]

This standard is issued under the fixed designation D5444; 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 a procedure for determination of the particle size distribution of fine and coarse aggregates extracted from bituminous mixtures using sieves with square openings.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D2172 Test Methods for Quantitative Extraction of Bitumen From Bituminous Paving Mixtures

D6307 Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *AASHTO Standard:*[3]

AASHTO Test Method T 30 Mechanical Analysis of Extracted Aggregate

3. Significance and Use

3.1 This test method is used to determine the grading of aggregates extracted from bituminous mixtures. The results are used to determine compliance of the particle size distribution with applicable specifications requirements, and to provide necessary data for control of the production of various aggregates to be used in bituminous mixtures.

4. Apparatus

4.1 *Balances,* or scales, readable to 0.1 g and accurate to 0.1 g or 0.1 % of the test load, whichever is greater, at any point within the range of use.

4.2 *Sieves,* with square openings, mounted on substantial frames constructed in a manner that will prevent the loss of materials during sieving. Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The woven wire cloth sieves shall conform to the requirements of Specification E11.

4.3 *Mechanical Sieve Shaker*—If used, it shall impart a vertical, or lateral and vertical, motion to the sieve, causing the particles thereon to bounce and turn so as to present different orientations to the sieving surface. The sieving action shall be such that the criterion for adequacy of sieving described in 6.8 is met in a reasonable time period.

4.4 *Oven,* of appropriate size, capable of maintaining a uniform temperature of 110 ± 5°C.

4.5 *Container*—A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any of the sample or water.

5. Sample

5.1 The sample shall consist of the entire sample of aggregate from Test Method D2172 or Test Method D6307.

5.1.1 Aggregate extracted by the ignition method in Test Method D6307 shall not be used for gradation analysis if the correction factor obtained in Test Method D6307 is greater than 1.0 (see Note 1).

5.2 The size of the test sample shall be governed by the nominal maximum aggregate size and shall conform to the mass requirements shown in Table 1.

NOTE 1—The temperatures used during the ignition method of asphalt content determination can cause temperature-related deterioration, such as

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[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] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

TABLE 1 Size of Sample

Nominal Maximum Aggregate Size	Minimum Mass of Sample, kg
4.75 mm (No. 4)	0.5
9.5 mm	1
12.5 mm	1.5
19.0 mm	2
25.0 mm	3
37.5 mm	4

calcination of some carbonate minerals, and quartz phase transitions.[4] These reactions can result in particle breakdown, which will yield gradation results that are finer than the actual material that was used in the mixture.

6. Procedure

6.1 Dry the sample at 110 ± 5°C to constant weight. Determine the weight to the nearest 0.1 % of the sample weight. The total weight of aggregate in the bituminous mixture being tested is the sum of the weights of the dried aggregates and the mineral matter contained in the extracted bitumen. When using Test Method D2172, the latter is to be taken as the sum of the weight of ash in the extract and the increase in weight of the filter element as determined in the test method.

6.2 After drying and weighing the test sample, place it in a container and cover it with water. Add a sufficient amount of wetting agent to ensure a thorough separation of the material finer than the 75-µm sieve from the coarser particles (see Note 2). The contents of the container shall be agitated vigorously and the washwater poured immediately over a nest of two sieves consisting of a 2.00 or 1.18-mm sieve superimposed on a 75-µm sieve. The use of a large spoon to stir and agitate the aggregate in the washwater has been found satisfactory.

NOTE 2—Wetting agents may include any dispersing agent such as a liquid detergent, or a soap, that will promote the separation of fine material. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity of wetting agent will depend on the hardness of the water and quality of the agent. Excessive suds may overflow the sieves and carry some material with them.

6.3 The agitation shall be sufficiently vigorous to result in complete separation from the coarse particles of all particles finer than the 75-µm sieve and to bring them into suspension so that they may be removed by decantation of the washwater. Take care to avoid decantation of the coarse particles of the sample as much as possible. Repeat the operation until any wetting agent used is removed and the washwater is clear.

6.4 Return all material retained on the nested sieves to the container. Dry the washed aggregate in the container to constant weight at a temperature not to exceed the mixture laboratory compaction temperature +5°C and not less than 105°C, and weigh to the nearest 0.1 % of the original dry weight of the sample.

6.5 Then sieve the aggregate over sieves of the various sizes required by the specification covering the mixture, including the 75-µm sieve. Record the weight of material passing each sieve and retained on the next and the amount passing the 75-µm sieve. The summation of these various weights must check the dried weight after washing within 0.2 % of the total weight. Add the weight of dry material passing the 75-µm sieve by dry sieving to the weight of mineral matter in the bitumen and the weight removed by washing in order to obtain the total passing the 75-µm sieve. If it is desired to check the weight of material washed through the 75-µm sieve, the washwater may be evaporated to dryness or filtered through a tared filter paper that is dried and weighed subsequently. Convert the weights of fractions retained on the various sieves and the total passing the 75-µm sieve to percentages by dividing each by the total weight of aggregate in the bituminous mixture from 6.1.

6.6 Nest the sieves in order of decreasing size of opening from top to bottom, and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in 6.7.

6.7 Limit the quantity of material on a given sieve so that all particles have the opportunity to reach sieve openings a number of times during the sieving operation. For sieves with openings smaller than 4.75-mm (No. 4), the weight retained on any sieve at the completion of the sieving operation shall not exceed 6 kg/m^2 of sieving surface. For sieves with openings 4.75 mm (No. 4) and larger, the weight in kg/m^2 of sieving surface shall not exceed the product of 2.5 × (sieve opening in mm). In no case shall the weight be so great as to cause permanent deformation of the sieve cloth.

6.8 Continue sieving for a sufficient period and in such manner that, after completion, not more than 0.5 % by weight of the total sample passes any sieve during 1 min of continuous hand sieving performed as follows: hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at a rate of approximately 150 times per minute, turning the sieve approximately one-sixth of a revolution at intervals of approximately 25 strokes. In determining the sufficiency of sieving for sizes larger than the 4.75-mm (No. 4) sieve, limit the materials on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm diameter sieves to verify the sufficiency of sieving.

7. Calculation

7.1 Calculate the results of the sieve analysis as follows: (*1*) total percentages passing each sieve, (*2*) total percentages retained on each sieve, or (*3*) percentages retained between consecutive sieves, depending on the form of the specifications for use of the material under test. Calculate percentages to the nearest 0.1 %.

8. Report

8.1 Depending on the form of the specification for use of the material under test, report the following information:

[4] Information presented by Chris Rogers at the Annual Symposium of the "International Center for Aggregate Research," April, 2004, Denver, CO.

TABLE 2 Precision

	Total Percent of Material Passing		Standard Deviation (1s), %[A]	Acceptable Range of Two Results (d2s),[A] %
Extracted Aggregate:[B]				
Single-operator precision	<100	≥95	0.5	1.4
	<95	≥35	1.0	2.9
	<35	≥25	0.7	2.0
	<25	≥10	0.4	1.2
	<10	≥5	0.3	0.9
	<5	≥2	0.2	0.6
	<2	>0	0.2	0.5
Multilaboratory precision	<100	≥95	0.5	1.5
	<95	≥35	1.2	3.5
	<35	≥25	0.9	2.7
	<25	≥10	0.8	2.2
	<10	≥5	0.6	1.6
	<5	≥2	0.4	1.1
	<2	>0	0.3	0.9

[A] These numbers represent, respectively, the (1s) and (d2s) limits described in Practice C670.
[B] The precision estimates are based on aggregates with nominal maximum sizes of 19.0 to 9.5 mm.

8.1.1 Total percentage of material passing each sieve, or

8.1.2 Total percentage of material retained on each sieve, or

8.1.3 Percentage of material retained between consecutive sieves.

8.2 Report percentages to the nearest whole number except for the percentage passing the 75-µm (No. 200) sieve, which shall be reported to the nearest 0.1 %.

9. Precision and Bias

9.1 *Precision*—The estimates of precision for this test method are listed in Table 2. The estimates are based on the results from the AASHTO Materials Reference Laboratory Proficiency Sample Program, with testing conducted by AASHTO Test Method T 30. The data are based on analyses of the test results from 47 to 133 laboratories who tested 14 pairs of proficiency test samples (Samples No. 1 through 28). The values in the table are given for different ranges of total percent of aggregate passing a sieve.

9.2 *Bias*—This test method has no bias since the values determined can be defined only in terms of this test method.

10. Keywords

10.1 aggregate; extraction; gradation