Designation: D 4751 – 99a

Standard Test Method for Determining Apparent Opening Size of a Geotextile[1]

This standard is issued under the fixed designation D 4751; 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 determination the apparent opening size (AOS) of a geotextile by sieving glass beads through a geotextile.

1.2 This test method shows the values in both SI units and inch-pound units. SI units is the technically correct name for the system of metric units known as the International System of Units. Inch-pound units is the technically correct name for the customary units used in the United States. The values in inch-pound units are provided for information only.

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:*

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

D 123 Terminology Relating to Textiles[3]

D 1776 Practice for Conditioning Textiles for Testing[3]

D 4238 Test Method for Electrostatic Propensity of Textiles[3]

D 4354 Practice for Sampling of Geosynthetics for Testing[4]

D 4439 Terminology for Geotextiles[4]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *apparent opening size* (AOS), O_{95}, *n—for a geotextile*, a property that indicates the approximate largest particle that would effectively pass through the geotextile.

3.1.2 *atmosphere for testing geosynthetics*, *n*—air maintained at a relative humidity between 50 to 70 % and a temperature of 21 ± 2°C (70 ± 4°F).

3.1.3 *Discussion*—The laboratory conditions are very important to the AOS test. For example, excessive humidity (above 70 %) can cause beads to stick together; while too low a relative humidity (below 50 %) can result in an increase in static electricity.

3.1.4 *geotechnics*, *n*—the application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the earth's crust to the solution of engineering problems.

3.1.5 *Discussion*—Geotechnics embraces the fields of soil mechanics, rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.

3.1.6 *geotextile*, *n*—any permeable textile material used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of a man-made project, structure, or system.

3.1.7 For the definitions of the other terms relating to geotextiles, refer to Terminology D 4439.

3.2 For the definitions of the other terms relating to textiles, refer to Terminology D 123.

4. Summary of Test Method

4.1 A geotextile specimen is placed in a sieve frame, and sized glass beads are placed on the geotextile surface. The geotextile and frame are shaken laterally so that the jarring motion will induce the beads to pass through the test specimen. The procedure is repeated on the same specimen with various size glass beads until its apparent opening size has been determined.

5. Significance and Use

5.1 Using a geotextile as a medium to retain soil particles necessitates compatibility between it and the adjacent soil. This test method is used to indicate the apparent opening size in a geotextile, which reflects the approximate largest opening dimension available for soil to pass through.

5.2 Test Method D 4751 for the determination of opening size of geotextiles is acceptable for testing of commercial shipments of geotextiles. Current estimates of precision, between laboratories, are being established.

5.2.1 In case of a dispute arising from differences in reported test results when using Test Method D 4751 for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if

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[1] This test method is under the jurisdiction of ASTM Committee D-35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

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

[3] *Annual Book of ASTM Standards*, Vol 07.01.

[4] *Annual Book of ASTM Standards*, Vol 04.09.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are homogeneous as possible and that are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Students *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results in the light of the known bias.

6. Apparatus

6.1 *Mechanical Sieve Shaker*—A mechanical sieve shaker, which imparts 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, should be used. The sieve shaker should be a constant frequency device utilizing a tapping *arm* to impart the proper motion to the glass beads.[6]

NOTE 1—Care should be given to the cork or rubber contact point on shakers when the vertical motion comes from an arm striking the cork or rubber. Excessive wear on the cork or rubber could affect the motion imparted to the glass beads and, therefore, the test result.

6.2 *Pan, Cover, and 200-mm (8-in.) Diameter Sieves*.

6.3 *Spherical Glass Beads*,[7] in size fractions in accordance with Table 1. It is only necessary to have on hand the bead size fractions necessary for the range of geotextiles for which testing is anticipated. The sizing of all beads shall be verified prior to each use by sieving on the pairs of sieves shown in Table 1. Prepare at least 50 g of each size fraction to be used prior to beginning the test. Bead sizes to be used in this test method are shown in Table 1.

6.4 *Balance*, having a capacity adequate for the mass of samples anticipated and accurate to ±0.05 g.

6.5 *Static Elimination*, to prevent the accumulation of static electricity when the beads are shaken on the surface of geotextile.[8] Commercially available devices or anti-static sprays are acceptable.

6.6 *Pan*, for collecting sieved beads.

7. Sampling

7.1 *Lot Sample*—For routine quality control testing, divide the product into lots and take the lot sample as directed in Practice D 4354, Section 7 Procedure B Sampling for Quality Assurance Testing. For Specification Conformance testing, sample as directed in Practice D 4354, Section 6 Procedure A—Sampling for Specification Conformance.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take a full width swatch 1-m (1-yd) long from the end of each roll of fabric in the lot sample, after first discarding a minimum of 1 m (1 yd) of fabric from the very outside of the roll.

7.3 *Test Specimens*—Cut five specimens from each swatch in the laboratory sample with each specimen being cut to fit the appropriate sieve pan. Cut the specimens from a single swatch spaced along a diagonal line on the swatch.

8. Specimen Preparation

8.1 Weigh the specimens and then submerge them in distilled water for 1 h at the standard atmosphere for testing. Bring the specimens to moisture equilibrium in the atmosphere for testing geosynthetics. Equilibrium is considered to have been reached when the change in the mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1 g.

NOTE 2—It is recognized that in practice, geosynthetic materials are frequently not weighed to determine when moisture equilibrium has been reached. While such a method cannot be accepted in cases of dispute, it may be sufficient in routine testing to expose the material to the standard atmosphere for testing geosynthetics for a reasonable period of time before the specimens are tested. A time of at least 24 h has been found acceptable in most cases. However, certain fibers may contain more moisture upon receipt than after conditioning. When this is known, a preconditioning cycle, as described in Practice D 1776, may be agreed upon by the contractual parties.

9. Procedure

9.1 Run the test at the atmosphere for testing geotextiles in such a manner that static electricity is prevented from affecting test results. If standard atmosphere cannot be maintained and static electricity is noticed, two methods are available that will prevent static electricity:

9.1.1 Install static eliminating devices equally spaced about the circumference of sieve and one on center of cover, or

TABLE 1 Glass Bead Sizes

Bead Size Range				Bead Size Designation[A]	
Passing		Retained			
mm	Sieve Number[B]	mm	Sieve Number[B]	mm	Sieve Number
2.0	10	1.70	12	1.7	12
1.4	14	1.18	16	1.18	16
1.00	18	0.850	20	0.850	20
0.710	25	0.600	30	0.600	30
0.500	35	0.425	40	0.425	40
0.355	45	0.300	50	0.300	50
0.250	60	0.212	70	0.212	70
0.180	80	0.150	100	0.150	100
0.125	120	0.106	140	0.106	140
0.090	170	0.075	200	0.075	200

[A] The designated bead size is the "retained on" size of the sieve pair used to size the beads. For example, beads designated No. 40 are beads that pass the No. 35 sieve and are retained on the No. 40 sieve. These beads are typically sold as 35-40 beads.

[B] See Specification E 11.

[6] A sieve shaker of this type is available from W. S. Tyler, Inc., 8200 Tyler Blvd., Mentor, OH 44060.

[7] Glass beads available from Cataphote Division, Ferro Corporation, P.O. Box 2369, Jackson, MS 39205, or Potters Industries, Inc., 377-T, Route 17, Hasbrouck Heights, NJ 07604, or beads of equal quality have been found satisfactory for this purpose.

[8] Static Eliminators available from Staticmaster Ionizing Units, Model #2U500, Nuclear Products Co., P.O. Box 5178, El Monte, CA 91733, or Western Static Eliminators Co., 215-219 S. Western Avenue, Chicago, IL 60612, have been found satisfactory for this purpose. For other availability addresses, see Footnote 7 of Test Method D 4238.

9.1.2 Apply commercially available anti-static spray uniformly to the geotextile.

9.2 Secure the geotextile in such a way that it is taut, without wrinkles or bulges. The geotextile must not be stretched or deformed such that it changes or distorts the openings in the fabric. Two systems may be used to secure the geotextiles sample:

9.2.1 Wedge between two sieve frames.

9.2.2 Secure with hoop inside the sieve frame.

9.3 Prior to use, sieve the glass beads in the laboratory to verify size of beads.

NOTE 3—All size glass beads are sieved through a single specimen of geotextile unless the geotextile has an average thickness equal to or greater than 2.3 mm (0.091 in.). A geotextile of this thickness or greater (especially nonwovens) may trap beads within the layers of the fabric, which may pass through the specimen when testing with a different bead size, thus creating an error in the test results. In the case of the thicker geotextiles, a different specimen may be used for each bead size; however, it should be noted in the report that different specimens were used.

9.4 Start with the smallest diameter glass beads that will be tested. Place 50 g of one size glass beads on the center of the geotextile.

9.5 Place cover and pan on sieve frame and place in shaker. Shake sieves for 10 min.

9.6 Place the glass beads still on the surface of the specimen in a pan and weigh. Include beads that fall off as a result of turning the specimen over and tapping the rims of the sieves.

NOTE 4—This step provides information concerning the amount of glass beads trapped within the geotextile and the amount of any beads lost during testing.

9.7 Weigh the glass beads that pass through the specimen, and record data. (See Fig. 1 for a sample worksheet which can be used to record the desired data).

9.8 Repeat 9.3 through 9.7 using the next larger bead size fraction. Repeat the trial using succeedingly larger bead size fractions until the weight of beads passing through the specimen is 5 % or less. Perform the trials such that the percent passing decreases from a value greater than 5 % to a value less than or equal to 5 %.

9.9 Repeat 9.2 to 9.8 for all five specimens.

10. Calculation

10.1 For each size of beads tested with each specimen,

DETERMINATION OF APPARENT OPENING SIZE OF GEOTEXTILE

DATE: _____
TEST BY: _____
COMP BY: _____
CHECK BY: _____

Range (mm) US Std Mesh	Minimum Dia. (mm)	Wt. F+G * W/ Beads	Wt. F+G	Wt. Beads	% Retained	Wt. Pan W/ Beads	Wt. Pan	Wt. Beads	% Passing	Wt. F+G Before	Wt. F+G After	Wt. Retained In Geotextile	% Retained In Geotextile
2.0 – 1.70	1.70												
1.4 – 1.18	1.18												
1.0 – .850	.850												
.710 – .60	.600												
.50 – .425	.425												
.355 – .30	.300												
.25 – .212	.212												
.18 – .15	.150												
.125 – .106	.106												
.09 – .075	.075												

GEOTEXTILE DESCRIPTION: _____

* F=FRAME
G=GEOTEXTILE

FIG. 1 Sample Worksheet

compute to the nearest percent the beads passing through the specimen using Eq 1:

$$B = 100\,P/T \quad (1)$$

where:
B = beads passing through specimen, %,
P = mass of glass beads in the pan, g, and
T = total mass of glass beads used, g.

10.2 Record calculations and percent beads passing (see Fig. 1).

10.3 Assign the AOS for each specimen as the size designation in millimetres (see 6.3) of the beads of which 5 % or less pass.

10.4 Determine the AOS for the test by averaging the AOS values of the five specimens.

11. Plotting

11.1 It is often desirable to determine the AOS value by plotting the percentage of beads passing the specimen versus the bead size for each of the bead sizes used for each specimen. When plotting is desirable, proceed as follows:

11.1.1 For each specimen, plot the values of Percent Passing (Ordinate) versus Bead Size, mm (Abscissa) on semi-log graph (see Fig. 2). Draw a straight line connecting the two data points representing the bead sizes that are immediately on either side of the 5 % passing ordinate. The particle size in mm (abscissa) at the intersection of the straight line plotted and the 5 % passing ordinate is the AOS of the specimen in mm, that is, the theoretical bead size that would result in exactly 5 % passing the specimen.

11.1.2 Determine the sample AOS, in mm, by averaging the five AOS values obtained by the graphic interpolation in 11.1.1.

11.1.3 Determine the sample AOS, expressed in terms of sieve number, as the number of the U.S. Sieve (see the sieve number column under Bead Size Designation of Table 1) having nominal opening, in millimetres, equal to or next larger than the AOS, in millimetres, obtained in 11.1.1.

12. Report

12.1 Report that the specimens were tested as directed in Test Method D 4751. Describe the material or product sampled and the method of sampling used.

12.2 Report the following information:

12.2.1 Results in written form indicating the bead size

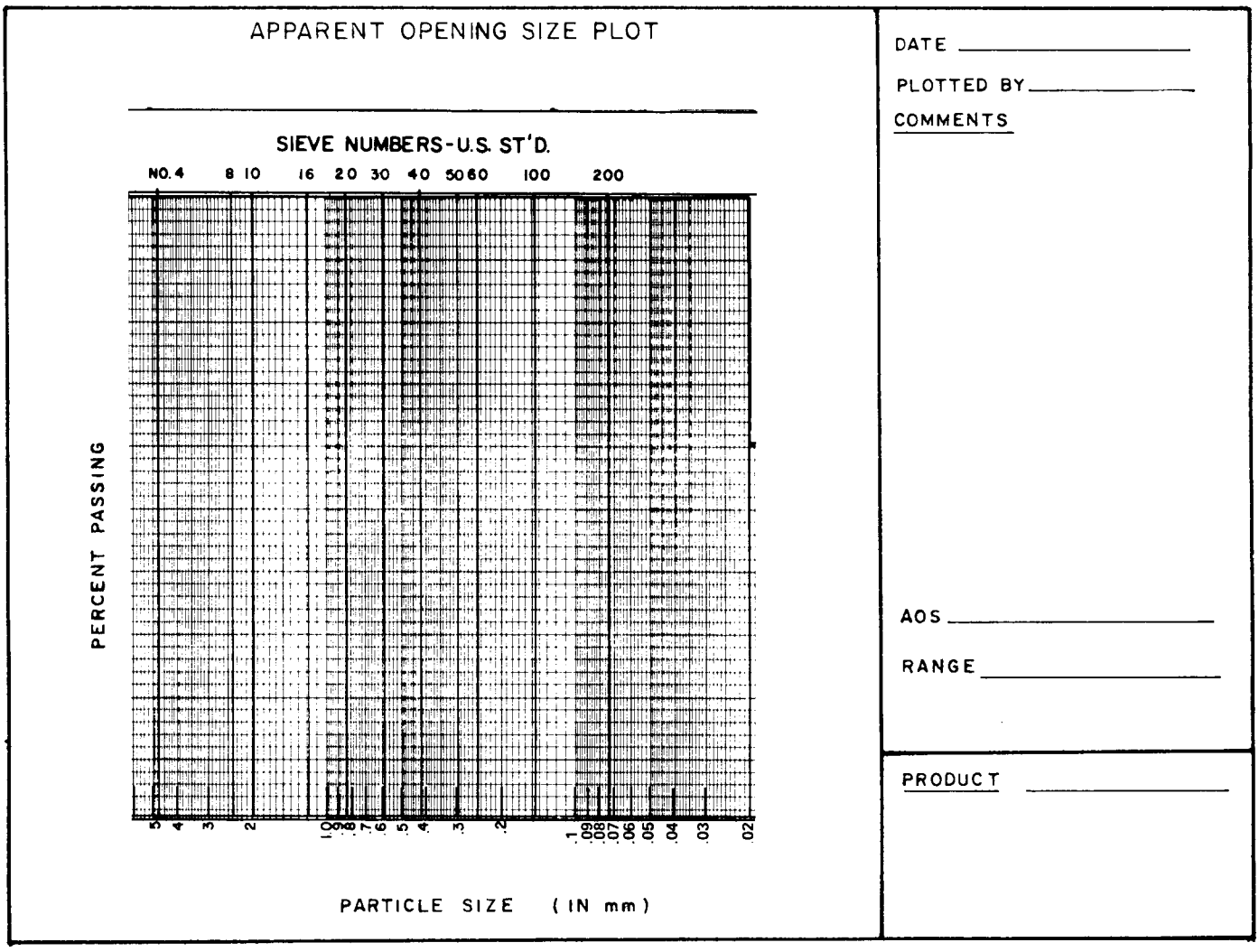

FIG. 2 Semilog Plot

ranges used in millimetres.

12.2.2 If requested, plots of bead size versus percentage beads passing for each specimen will be provided (as described in Section 11).

12.2.3 The average determined from five specimens as the apparent opening size (AOS = O_{95}) in millimetres.

12.2.4 Weight of each sample.

12.2.5 Type of sieve shaker used.

12.2.6 When requested, express the AOS in terms of sieve number. The AOS expressed this way shall be the number of the U.S. Standard Sieve (see Specification E 11) having nominal openings, in millimetres, next larger than or equal to the AOS, in millimetres.

12.2.7 Any deviation from the described test method.

13. Precision and Bias

13.1 *Precision*:

13.1.1 *Interlaboratory Test Program*—An interlaboratory study of this test method was performed in 1999. Three sets (five test specimen each) which were randomly drawn from each of four materials, two woven and two nonwoven, were tested for apparent opening size in each of five laboratories. The design of the experiment, similar to that of Practice E 691, and a within-between analysis of the data are given in an ASTM Research Report[9].

13.1.2 *Test Result*—The precision information is given in Table 2. The precision values are for the apparent opeing size test results and are in terms of coefficients of variation, CV%.

13.2 *Bias*—The procedure in Test Method D 4751 for measuring the apparent opening size of geotextiles has no bias because the value of the apparent opening size can be defined only in terms of test method.

14. Keywords

14.1 apparent opening size; geotextile; glass beads; sieve

[9] An ASTM Research Report is available from ASTM Headquarters. Request RR:D35–1006..

TABLE 2 Precision

Statistic	Slit Film, Woven	Mono-filament, Woven	Needle-Punched, Nonwoven	Heat-Bonded, Nonwoven
Average AOS, mm	0.179	0.142	0.182	0.137
Within Laboratory Repeatability Limit, CV%Sr	8.3	3.4	4.0	5.9
Between Laboratory Reproducibility Limit, CV%SR	13.9	8.6	22.7	10.8
95 % Confidence Limit Within Laboratory Repeatability, CV%r	23.4	9.4	11.7	16.5
95 % Confidence Limit Between Laboratory Reproducibility, CV%R	39.1	24.2	63.4	30.2