SIEVE ANALYSIS OF AGGREGATES

SCOPE

This method of test covers the procedure for determination of the particle size distribution of aggregates.

PROCEDURE

A. Apparatus

1. Balance accurate to within 0.1 percent of weight (mass) of the sample to be tested. For most aggregates, a 6,000 gram capacity balance readable to a 0.1 gram will be appropriate. **NOTE:** The balance shall be reset to zero before each weighing.

2. Sieves with square openings mounted on substantial frames are constructed in such a manner to prevent loss of material during sieving. Use suitable sieve sizes to furnish the information required by the specifications covering the material to be tested. The woven wire cloth shall conform to AASHTO M-92. This will normally consist of a set of each of the following:

   Box Sieves for testing coarse aggregates consisting of the following sizes:

37.5 mm (1 1/2-in.)	19 mm (3/4-in.)	4.75 mm (#4)
25 mm (1-in.)	12.5 mm (1/2-in.)	2.36 mm (#8)
	9.5 mm (3/8-in.)	

203 mm (8 in.) Diameter Sieves for testing fine aggregates consisting of the following sizes:

4.75 mm (#4)	1.18 mm (#16)	150 µm (#100)
2.36 mm (#8)	600 µm (#30)	75 µm (#200)
	300 µm (#50)	Pan

A set of **305 mm (12 in.) Diameter Sieves** may be used for testing fine aggregate or aggregate containing both coarse and fine material.

3. Mechanical and hand-powered sieve shakers

4. Drying oven or stove

5. Fiber bristle sieve cleaning brush (similar to stencil brush or cropped paintbrush)

B. Test Sample

1. Test samples for sieve analysis shall conform to the sample size for the applicable material as indicated by Materials IM 301.

2. Obtain the sample for sieve analysis (test sample) from the material to be tested (field sample) by the appropriate method as outlined in Materials IM 336. The test sample shall be approximately of the weight (mass) desired when dry and must be the end result of the reduction. Reduction to an exact predetermined weight (mass) shall not be permitted.

C. Preparation of Sample

1. When a determination of the amount of material passing the #200 (75 µm) sieve is required, the test sample must first be subjected to Materials IM 306, Determining the Amount of Material Finer Than the #200 (75 µm) Sieve. Coarse aggregates may have a *separate* "wash" sample of the appropriate size (per IM 306) *reduced* from the remaining portion of the field sample, per IM 336.

2. Coarse aggregates, which have changes in moisture for different particle sizes, must be dried to a constant weight (mass). When the absorbed moisture stays essentially the same for different particle sizes the sample may be sieved at a surface-dry condition (no free water present).

   NOTE: Material from crushed composite (HMA/PC) pavements shall be sieved at a surface-dry condition using no artificial heat. No gradation determination will be made for material finer than the #8 (2.36 mm) sieve. For material made from crushed PC pavement, determination of the percent passing the #200 sieve may be required. In some instances, larger particles may be coated to the extent that dry sieving will not accurately reflect the true gradation of the material. In these instances, the air-dried sample must be washed over the #8 (2.36 mm) sieve and allowed to come to a surface-dry condition by air-drying. The total percent passing this sieve is the sum of the washing loss and pan after dry sieving divided by the original (air) dry/weight (mass). Coated particles may also be a problem with some virgin aggregate material (e.g., Class D crushed stone, etc.). When this condition exists, the material shall be dried to a constant weight (mass), washed over the smallest sieve for which there is a specification requirement, and dried again. The total percentage passing this sieve is a combination of the washing loss and the amount passing the sieve obtained by dry sieving the washed sample divided by the original dry weight (mass).

D. Test Procedure

1. Weigh and record the weight (mass) of the test sample as the Original Dry Mass.

2. Sieve the sample over the required sieves. The sieving operation must be accomplished by using a lateral and vertical motion of the sieve(s), accompanied by a jarring action, which keeps the sample moving continuously over the surface of the sieve. Do not attempt to turn or manipulate the aggregate particle through the sieve openings by hand.

   When using a mechanical sieve shaker, excessive sieving times may result in degradation of the sample.

   The sieving operation may be considered complete when not more than 0.5 percent by weight (mass) of the original sample passes any sieve during an additional one minute of hand-sieving.

   a. On the #4 (4.75 mm) and larger sieves, limit the amount of material carried on the sieve to a single layer when determining sieving to completion.

b. Overloading of the 8 in. (203 mm) and 12 in. (305 mm diameter sieves, #4 (4.75 mm) and smaller, must be avoided to allow for sieving to completion. The weights retained should not exceed the following:

8 in. (203 mm) diameter sieves	12 in. (305mm) diameter sieves
#4 (4.75 mm) and smaller 200 grams	#4 (4.75 mm) 850 grams #8 (2.36mm) and smaller 450 grams

If sieving to completion (as described above) is not readily accomplished, reduce the amount of material carried on the sieve.

c. When the aggregate being tested has a mixture of coarse and fine material, the portion of the sample finer than the #4 (4.75 mm) sieve may be distributed among two or more sets of sieves to prevent overloading of individual sieves. Alternately, the portion passing the #4 (4.75 mm) sieve may be reduced to a minimum of 500 grams using a mechanical splitter according to IM 336. If this procedure is followed, compute the weight (mass) of each size increment of the original sample as follows:

$$A = \frac{W1}{W2} \times B$$

Where:

A = calculated weight (mass) of the material retained on each sieve based on the total sample weight (mass).

W1 = weight (mass) of the total amount of material passing the #4 (4.75 mm) sieve.

W2 = weight (mass) of the reduced, minus #4 (4.75 mm) sieve material.

B = weight (mass) of the reduced sample material retained on each sieve.

NOTE: This method is recommended when using 8 in. (203 mm) diameter sieves to test the fine aggregate portion of a sample when overload is anticipated. If using 12 in. (305 mm) sieves and the original test sample is reasonably close to the required weight (mass), overload should not occur. When sieve overload is anticipated on the #8 (2.36 mm) sieve only, sieve the original sample through the #8 (2.36 mm) box sieve before placing the fine portion in the nest of 8 in. (203 mm) round sieves.

3. Clean the retained material from each sieve for weighing. Remove as much material as practical without damaging the wire cloth. Particles may be removed most readily from a sieve by inverting the sieve over a pan and tapping the sieve by hand and/or pushing (without force) the particles out of the mesh into the pan. Care must be taken while cleaning the sieves, so no damage occurs to the wire mesh by bending or breaking the wires. A fiber-bristle brush should be used for cleaning the #16 (1.18 mm), #30 (600 µm), and #50 (300 µm) sieves. Do not use a brush or any external force on the wire cloth to attempt cleaning the #100 (150 µm), or #200 (75 µm) sieves. If clogging of the mesh occurs on these finer sieves, they should be sent to the District Materials Laboratory for cleaning.

4. Weight the fraction of material retained on each sieve and in the pan, to at least the nearest 0.5 gram and record. Total the weight (mass) of the material retained on the sieves and in the pan.

5. An accuracy check must be made comparing the weight (mass) of the material before sieving to the total weight (mass) after sieving. The total of the weights retained on the sieves and in the pan must be within 0.5 percent of the Original Dry Mass by washing.

   When the percent finer than the #200 (75µm) sieve is <u>not</u> determined:

$$\frac{\text{Total}}{\text{Original Dry Mass}} \times 100 = \text{Tolerance (99.5 to 100.5)}$$

   When the percent finer than the #200 (75 µm) sieve is determined by washing (IM 306):

$$\frac{\text{Total - Washing Loss}}{\text{Dry Mass Washed}} \times 100 = \text{Tolerance (99.5 to 100.5)}$$

   If the difference exceeds the 0.5 percent tolerance, check all the calculations, the sieves for retained material and the balance for proper care. If needed, weigh each increment of material retained again. If the error cannot be found, the test is void and a new sample shall be tested.

E. Calculations

1. Divide the weight (mass) of the material retained on each sieve, and in the pan, by the Original Dry Weight (mass) of the sample. When computing the percent retained of a **washed** sample the sum of the washing loss and pan weight (mass) shall be divided by the Original Dry Weight (mass). Computation shall be carried out to the nearest 0.1 percent when determining percent retained and the consequent percent passing.

2. The percent-retained column should equal 100 percent when totaled. Because the weight (mass) of material retained on the sieves may not equal the Original Dry Weight (mass), the total of the percentages retained may not equal 100 percent. If this occurs, the percentages retained should be altered by prorating on the larger quantities, so they do equal 100 percent.

3. The percent passing is then determined by subsequent subtraction starting with the sieve which had no material retained (100 percent passing).

4. Sieve analysis results are to be reported in terms of percent passing and recorded to two significant figures, i.e., to the nearest whole percent for percentages above 10.0 and to the nearest tenth of a percent for lower results.

Examples:	Test Result	Report
	10.5	11
	11.5	12
	11.4	11
	9.8	9.8
	0.5	0.5

5. The fineness Modulus, when required, may now be calculated by cumulative addition of the percent retained on each of the following sieves coarser than the 75 µm (#200) sieve and dividing that sum by 100: 150 µm (#100); 300 µm (#50); 600 µm (#30); 1.18 mm (#16); 2.36 mm (#8); 4.75 mm (#4); 9.5 mm (3/9 in.); 19.0 mm (3/4 in.); 37.5 mm (1 ½ in.), and larger, (i.e. doubling the previous sieve size).

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EXAMPLE #1, COARSE AGGREGATE

Lab. No.:		
Material:		Grad. No.:
Co. & Proj.#:		
Producer:		
Contractor:		
Sampled By:	Date:	
Sample Loc.:		

Original Dry Mass:	5793.0	Total Minus 4.75 mm (W1):	
Dry Mass Washed:		Reduced Minus 4.75mm(W2)	
Washing Loss:		Conversion Factor: W1/W2	
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus4.75mm	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
37.5mm(1½")		0.0	0.0	100.0	
25mm (1")		577.0	10.0	90.0	
19mm (¾)		1068.0	18.4	71.6	
12.5mm (½")		1448.0	25.0	48.6	
9.5mm (⅜")		1383.0	23.9	22.7	
4.75mm (4)		1082.0	18.7	4.0	
2.36mm (8)	(B)	141.0 (A)	1.8	1.8	
1.18mm (16)	(B)	(A)			
600µm (30)	(B)	(A)			
300µm (50)	(B)	(A)			
150µm (100)	(B)	(A)			
75µm (200)	(B)	(A)			
Wash					
Pan	(B)	1.5 (A)	1.8		
Total		5790.0	100.0		
Tolerance		99.9			

Wash Sample		
Original Dry Mass:		2571.0
Dry Mass Washed:		2555.0
Washing Loss:		16.0

Sieve Size	Mass Retd.	% Retd.	% Passing	Specs.
75 µm (200)			0.8	
Wash	16.0			
Pan	4.0	0.8		

Date Reported:	Cert No.:
Tested By:	

NOTE: No more than 200 grams should be retained on the 203mm (8"ø) sieves. No more than 850 grams should be retained on the 306mm (12"ø) 4.75mm (#4) sieve, and a maximum of 450 grams on the 2.36mm (#8) and smaller sieves.

Comments: _____

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EXAMPLE # 2, FINE AGGREGATE

Lab. No.:		
Material:		Grad. No.:
Co. & Proj.#:		
Producer:		
Contractor:		
Sampled By:	Date:	
Sample Loc.:		

Original Dry Mass:	594.0	Total Minus 4.75 mm (W1):	
Dry Mass Washed:	591.5	Reduced Minus 4.75mm(W2)	
Washing Loss:	2.5	Conversion Factor: W1/W2	
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus4.75mm	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
37.5mm(1½")					
25mm (1")					
19mm (¾)					
12.5mm (½")					
9.5mm (⅜")		0.0	0.0	100.0	
4.75mm (4)		29.0	4.9	95.1	
2.36mm (8)	(B)	64.5 (A)	10.9	84.2	
1.18mm (16)	(B)	102.0 (A)	17.2	67.0	
600µm (30)	(B)	181.5 (A)	30.6**(30.7)**	36.3	
300µm (50)	(B)	154.5 (A)	26.0**(26.1)**	10.2	
150µm (100)	(B)	51.0 (A)	8.6	1.6	
75µm (200)	(B)	6.0 (A)	1.0	0.6	
Wash		2.5			
Pan	(B)	1.0 (A)	0.6		
Total		592.0	99.8**(100.0)**		
Tolerance		99.7			

Wash Sample				
	Original Dry Mass:			
	Dry Mass Washed:			
	Washing Loss:			
Sieve Size	Mass Retd.	% Retd.	% Passing	Specs.
75 µm (200)				
Wash				
Pan				

Date Reported:	Cert No.:
Tested By:	

NOTE: No more than 200 grams should be retained on the 203mm (8"ø) sieves. No more than 850 grams should be retained on the 306mm (12"ø) 4.75mm (#4) sieve, and a maximum of 450 grams on the 2.36mm (#8) and smaller sieves.

Comments: _____

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EXAMPLE #3, COMBINED AGGREGATE,
8" AND BOX SIEVES

Lab. No.:		
Material:		Grad. No.:
Co. & Proj.#:		
Producer:		
Contractor:		
Sampled By:	Date:	
Sample Loc.:		

Original Dry Mass:	2457.2	Total Minus 4.75 mm (W1):	2115.7
Dry Mass Washed:	2410.5	Reduced Minus 4.75mm(W2)	537.2
Washing Loss:	46.7	Conversion Factor: W1/W2	3.9384
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus4.75mm	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
37.5mm(1½")					
25mm (1")		0.0	0.0	100.0	
19mm (¾)		14.6	0.6	99.4	
12.5mm (½")		45.9	1.9	97.5	
9.5mm (⅜")		81.0	3.3	94.2	
4.75mm (4)		154.0	6.3	87.9	
2.36mm (8)	57.6 (B)	226.9 (A)	9.2	78.7	
1.18mm (16)	93.0 (B)	366.3 (A)	14.9	63.8	
600µm (30)	178.3 (B)	694.3 (A)	28.3**(28.4)**	35.4	
300µm (50)	172.5 (B)	679.4 (A)	27.6	7.8	
150µm (100)	32.7 (B)	128.8 (A)	5.2	2.6	
75µm (200)	3.9 (B)	15.4 (A)	0.6	2.0	
Wash		46.7			
Pan	0.8 (B)	3.2 (A)	2.0		
Total	536.8	2456.5	99.9**(100.0)**		
Tolerance	99.9	100.0			

Wash Sample

Original Dry Mass:	
Dry Mass Washed:	
Washing Loss:	

Sieve Size	Mass Retd.	% Retd.	% Passing	Specs.
75 µm (200)				
Wash				
Pan				

Date Reported:	Cert No.:
Tested By:	

NOTE: No more than 200 grams should be retained on the 203mm (8"ø) sieves. No more than 850 grams should be retained on the 306mm (12"ø) 4.75mm (#4) sieve, and a maximum of 450 grams on the 2.36mm (#8) and smaller sieves.

Comments: _____

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EXAMPLE #4, COMBINED AGGREGATE, 12" SIEVES

Lab. No.:		
Material:		Grad. No.:
Co. & Proj.#:		
Producer:		
Contractor:		
Sampled By:	Date:	
Sample Loc.:		

Original Dry Mass:	2051.2	Total Minus 4.75 mm (W1):	
Dry Mass Washed:	2011.4	Reduced Minus 4.75mm(W2)	
Washing Loss:	39.8	Conversion Factor: W1/W2	
		Calculated Weight (A)=Conversion Factor x (B)	

Sieve Size	Reduced Minus4.75mm	Total or Calc. Weight Retd.	% Retained	% Passing	Specs.
37.5mm(1½")					
25mm (1")		0.0	0.0	100.0	
19mm (¾)		26.8	1.3	98.7	
12.5mm (½")		80.7	3.9	94.8	
9.5mm (⅜")		55.1	2.7	92.1	
4.75mm (4)		182.7	8.9	83.2	
2.36mm (8)	(B)	229.7 (A)	11.2	72.0	
1.18mm (16)	(B)	362.8 (A)	17.7	54.3	
600µm (30)	(B)	**610.5*** (A)	29.8	24.5	
300µm (50)	(B)	377.1 (A)	18.4	6.1	
150µm (100)	(B)	72.2 (A)	3.5	2.6	
75µm (200)	(B)	10.2 (A)	0.5	2.1	
Wash		39.8			
Pan	(B)	3.4 (A)	2.1		
Total		2051.0	100.0		
Tolerance		100.0			

Wash Sample				
	Original Dry Mass:			
	Dry Mass Washed:			
	Washing Loss:			
Sieve Size	Mass Retd.	% Retd.	% Passing	Specs.
75 µm (200)				
Wash				
Pan				

Date Reported:	Cert No.:
Tested By:	

NOTE: No more than 200 grams should be retained on the 203mm (8"ø) sieves. No more than 850 grams should be retained on the 306mm (12"ø) 4.75mm (#4) sieve, and a maximum of 450 grams on the 2.36mm (#8) and smaller sieves.

Comments: ***The #30 sieve was overloaded. Sieving to completion was verified by hand sieving .**

Fineness Modulus Calculation
For Concrete Sand (Grad. #1 – Spec. 4110)
AASHTO T27

The Fineness Modulus is simply a calculation based on the 'cumulative' percent retained from the sieve analysis sample.

Starting with the largest sieve retaining any material, add the cumulative percents retained on each sieve through the #100 sieve and divide this total by 100. The result is reported to the nearest 0.01%.

Note: The percent retained on the #200 sieve is not calculated in determining the Fineness Modulus.

Example:

Sieve	Percent Retained	Cumulative Percent Retained
3/8"	0	0
#4	3.6	3.6
#8	16.9	20.5
#16	19.6	40.1
#30	23.4	63.5
#50	26.1	89.6
#100	9.5	99.1

Total Cumulative Percent Retained = 316.4

316.4 ÷ 100 = 3.16 Fineness Modulus