

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES FOP FOR AASHTO T 27 (11)

MATERIALS FINER THAN 75 μm (No. 200) SIEVE IN MINERAL AGGREGATE BY WASHING FOP FOR AASHTO T 11 (11)

Scope

Sieve analysis determines the gradation or distribution of aggregate particle sizes within a given sample.

Accurate determination of material smaller than 75 μm (No. 200) cannot be made with AASHTO T 27 alone. If quantifying this material is required, it is recommended that AASHTO T 27 be used in conjunction with AASHTO T 11.

This FOP covers sieve analysis in accordance with AASHTO T 27 and materials finer than 75 μm (No. 200) in accordance with AASHTO T 11 performed in conjunction with AASHTO T 27. The procedure includes three method choices: A, B, and C.

Apparatus

- Balance or scale: Capacity sufficient for the masses shown in Table 1, accurate to 0.1 percent of the sample mass or readable to 0.1 g, and meeting the requirements of AASHTO M 231
- Sieves: Meeting the requirements of AASHTO M 92
- Mechanical sieve shaker: Meeting the requirements of AASHTO T 27
- Suitable drying equipment (see FOP for AASHTO T 255)
- Containers and utensils: A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water
- Optional mechanical washing device

Sample Sieving

- In all procedures, it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification.
- The sieves are nested in order of decreasing size from the top to the bottom and the sample, or a portion of the sample, is placed on the top sieve.

- Sieves are shaken in a mechanical shaker for approximately 10 minutes, or the minimum time determined to provide complete separation for the sieve shaker being used. As established by the Time Evaluation.

Time Evaluation

The sieving time for each mechanical sieve shaker shall be checked at least annually to determine the time required for complete separation of the sample by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.
2. Provide a snug-fitting pan and cover for each sieve, and hold in a slightly inclined position in one hand.
3. Hand-shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample prior to sieving passes any sieve after one minute of continuous hand sieving adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

Overload Determination

- For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m^2 (4 g/in^2) of sieving surface.
- For sieves with openings 4.75 mm (No. 4) and larger, the mass, in grams shall not exceed the product of $2.5 \times (\text{sieve opening in mm}) \times (\text{effective sieving area})$. See Table 1.

Additional sieves may be necessary to keep from overloading sieves or to provide other information, such as fineness modulus. The sample may also be sieved in increments to prevent overload.

TABLE 1
Maximum Allowable Mass of Material Retained on a Sieve, g
Nominal Sieve Size, mm (in.)
Exact size is smaller (see AASHTO T 27)

Sieve Size mm (in.)	203 dia (8)	305 dia (12)	305 by 305 (12 × 12)	350 by 350 (14 × 14)	372 by 580 (16 × 24)
	Sieving Area m ²				
	0.0285	0.0670	0.0929	0.1225	0.2158
90 (3 1/2)	*	15,100	20,900	27,600	48,500
75 (3)	*	12,600	17,400	23,000	40,500
63 (2 1/2)	*	10,600	14,600	19,300	34,000
50 (2)	3600	8400	11,600	15,300	27,000
37.5 (1 1/2)	2700	6300	8700	11,500	20,200
25.0 (1)	1800	4200	5800	7700	13,500
19.0 (3/4)	1400	3200	4400	5800	10,200
16.0 (5/8)	1100	2700	3700	4900	8600
12.5 (1/2)	890	2100	2900	3800	6700
9.5 (3/8)	670	1600	2200	2900	5100
6.3 (1/4)	440	1100	1500	1900	3400
4.75 (No. 4)	330	800	1100	1500	2600
-4.75 (-No. 4)	200	470	650	860	1510

Sample Preparation

Obtain samples in accordance with the FOP for AASHTO T 2 and reduce to the size shown in Table 2 in accordance with the FOP for AASHTO T 248. These sample sizes are standard for aggregate testing but, due to equipment restraints, samples may need to be partitioned into several “subsamples.” For example, a gradation that requires 100 kg (220 lbs) of material would not fit into a large tray shaker in one batch.

Some agencies permit reduced sample sizes if it is proven that doing so is not detrimental to the test results. Some agencies require larger sample sizes. Check agency guidelines for required or permitted test sample sizes.

TABLE 2
Sample Sizes for Aggregate Gradation Test

Nominal Maximum Size* mm (in.)	Minimum Dry Mass g (lb)
4.75 (No. 4)	500 (1)
6.3 (1/4)	1000 (2)
9.5 (3/8)	1000 (2)
12.5 (1/2)	2000 (4)
19.0 (3/4)	5000 (11)
25.0 (1)	10,000 (22)
37.5 (1 1/2)	15,000 (33)
50 (2)	20,000 (44)
63 (2 1/2)	35,000 (77)
75 (3)	60,000 (130)
90 (3 1/2)	100,000 (220)
100 (4)	150,000 (330)
125 (5)	300,000 (660)

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps between specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Selection of Procedure

Agencies may specify what method will be performed. If a method is not specified method A will be performed.

Overview

Method A

- Determine dry mass of original sample
- Wash through a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve material

Method B

- Determine dry mass of original sample
- Wash through a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve coarse material
- Determine dry mass of fine material
- Reduce fine portion
- Determine mass of reduced portion
- Sieve fine portion

Method C

- Determine dry mass of original sample
- Sieve coarse material
- Determine mass of fine material
- Reduce fine portion
- Determine mass of reduced portion
- Wash through a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve reduced fine portion

Procedure Method A

1. Dry the sample to a constant mass in accordance with the FOP for AASHTO T 255, and record to the nearest 0.1 percent of the total sample mass or 0.1 g.
2. When the specification requires that the amount of material finer than 75 μ m (No. 200) be determined, perform Step 3 through Step 9; otherwise, skip to Step 10.
3. Nest a sieve, such as a 2.0 mm (No. 10), above the 75 μ m (No. 200) sieve.
4. Place the test sample in a container and add sufficient water to cover it.
Note 1: A detergent, dispersing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the 75 μ m (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.
5. Agitate vigorously to ensure complete separation of the material finer than 75 μ m (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. When using a mechanical washing device, exercise caution to avoid degradation of the sample.
6. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, being careful not to pour out the coarser particles.
7. Add a second change of water to the sample remaining in the container, agitate, and repeat Step 6. Repeat the operation until the wash water is reasonably clear. If a detergent or dispersing agent is used, continue washing until the agent is removed.
8. Remove the upper sieve, return material retained to the washed sample.
9. Rinse the material retained on the 75 μ m (No.200) sieve until water passing through the sieve is reasonably clear.
10. Return all material retained on the 75 μ m (No.200) sieve to the container by flushing into the washed sample.

Note 2: Excess water may be carefully removed with a bulb syringe as long as the removed water is discharged back over the No. 200 sieve to preclude loss of fines.

11. Dry the washed aggregate to constant mass in accordance with the FOP for AASHTO T 255, and then cool prior to sieving. Record the “dry mass after washing”.
12. Select sieves to furnish the information required by the specifications. Nest the sieves in order of decreasing size from top to bottom and place the sample, or a portion of the sample, on the top sieve.
13. Place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.
14. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g. Ensure that all material trapped in full openings of the sieve are cleaned out and included in the mass retained.

Note 4: For sieves #4 and larger, material trapped in less than a full opening shall be checked by sieving over a full opening. Use coarse wire brushes to clean the 600 μm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.
15. In the case of coarse / fine aggregate mixtures, the minus 4.75 mm (No. 4) may be distributed among two or more sets of sieves to prevent overloading of individual sieves.

Calculations

The total mass of the material after sieving, for both coarse and fine portions should check closely with the original mass of sample placed on the sieves. If performing T 11 with T 27, this would be the dry mass after wash. If performing just T 27 this would be the original dry mass. When the masses before and after sieving differ by more than 0.3 percent, do not use the results for acceptance purposes.

Calculate the total percentages passing, individual or cumulative percentages retained, or percentages in various size fractions to the nearest 0.1 percent by dividing the masses for Method A, or adjusted masses for methods B and C, on the individual sieve masses or cumulative sieve masses by the total mass of the initial dry sample. If the same test sample was first tested by T 11, use the total dry sample mass prior to washing in T 11 as the basis for calculating all percentages. Report percent passing as indicated in the “Report” section at the end of this FOP.

Percent Retained:

Where:

IPR= Individual Percent Retained

CPR= Cumulative Percent Retained

M= Total Dry Sample mass before washing

IMR= Individual Mass Retained OR Adjusted Individual mass from Methods B or C

CMR= Cumulative Mass Retained OR Adjusted Cumulative Mass from
Methods B or C

$$IPR \frac{IMR}{M} \times 100 \quad \text{or} \quad CPR = \frac{CMR}{M} \times 100$$

Percent Passing (Calculated):

Where:

PP= Percent Passing

PPP= Previous Percent Passing

$$PP = PPP - IPR \quad \text{or} \quad PP = 100 - CPR$$

Method A Sample Calculation

Calculate percent retained on and passing each sieve on the basis of the total mass of the initial dry sample. This will include any material finer than 75 µm (No. 200) that was washed out.

Example:

Dry mass of total sample, before washing: 5168.7 g

Dry mass of sample, after washing out the 75µm (No. 200) minus: 4911.3 g

Amount of 75µm (No. 200) minus washed out: 5168.7 g – 4911.3 g = 257.4 g

Gradation on All Sieves

Sieve Size mm (in.)	Individual Mass Retained, g (IMR)	Individual Percent Retained (IPR)	Cumulative Mass Retained, g (CMR)	Cumulative Percent Retained (CPR)	Calc'd Percent Passing (CPP)	Reported Percent Passing* (RPP)
19.0 (3/4)	0	0	0	0.0	100.0	100
12.5 (1/2)	724.7	14.0	724.7	14.0	86.0	86
9.5 (3/8)	619.2	12.0	1343.9	26.0	74.0	74
4.75 (No. 4)	1189.8	23.0	2533.7	49.0	51.0	51
2.36 (No. 8)	877.6	17.0	3411.3	66.0	34.0	34
1.18 (No. 16)	574.8	11.1	3986.1	77.1	22.9	23
0.600 (No. 30)	329.8	6.4	4315.9	83.5	16.5	16
0.300 (No. 50)	228.5	4.4	4544.4	87.9	12.1	12
0.150 (No. 100)	205.7	4.0	4750.1	91.9	8.1	8
0.075 (No. 200)	135.4	2.6	4885.5	94.5	5.5	5.5
Pan	20.4		4905.9			

*Report 75 µm (No. 200) sieve to 0.1 percent. Report all others to 1 percent.

Check sum: $[(4911.3 - 4905.9) / 4911.3] \times 100 = 0.11\%$ is within the 0.3 percent requirement.

Percent Retained:

9.5 mm (3/8) sieve:

$$\frac{619.2}{5168.7} \times 100 = 12.0\% \quad \text{or} \quad \frac{1343.9}{5168.7} \times 100 = 26.0\%$$

Percent Passing (Calculated):

9.5 mm (3/8) sieve:

$$86.0 - 12.0 = 74.0\% \quad \text{or} \quad 100 - 26.0 = 74.0\%$$

Procedure Method B

1. Perform steps 1 through 11 from the “Procedure – Method A”, then continue as follows:
2. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the 4.75 mm (No. 4) with a pan at the bottom to retain the minus 4.75 mm (No. 4).

3. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker, or place the sieves in the mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

4. Determine the individual or cumulative mass retained on each sieve to the nearest 0.1 percent or 0.1 g. Ensure that all particles trapped in full openings of the sieve are cleaned out and included in the mass retained.

Note 4: For sieves #4 and larger, material trapped in less than a full opening shall be checked by sieving over a full opening. Use coarse wire brushes to clean the 600 μm (No. 30) and larger sieves, and soft hair bristle for smaller sieves.

5. Determine the mass of the material in the pan [minus 4.75 mm (No. 4)] (M_1).
6. Reduce the minus 4.75 mm (No. 4) using a mechanical splitter in accordance with the FOP for AASHTO T 248 to produce a sample with a mass of 500 g minimum. Determine and record the mass of the minus 4.75 mm (No. 4) split (M_2).
7. Select fine sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the 75 μm (No. 200) with a pan at the bottom to retain the minus 75 μm (No. 200).
8. Repeat steps 3 and 4, Method B, with the minus 4.75 mm (No. 4) including determining the mass of the material in the pan.
- 9a. Compute the “Adjusted Individual Mass Retained” of the size increment of the original sample as follows when determining “Individual Mass Retained”.

$$IMR = \frac{M_1}{M_2} \times B$$

where:

IMR = adjusted individual mass retained of the size increment on a total sample basis

M_1 = mass of minus 4.75mm (No. 4) sieve in total sample

M_2 = mass of minus 4.75mm (No. 4) sieve actually sieved

B = individual mass of the size increment in the reduced portion sieved

9b. Compute the “Adjusted Cumulative Mass Retained” of the size increment of the original sample as follows when determining “Cumulative Mass Retained”:

$$CMR = \left(\frac{M_1}{M_2} \times B \right) + D$$

where:

CMR = Total cumulative mass retained of the size increment based on a total sample

M₁ = mass of minus 4.75mm (No. 4) sieve in total sample

M₂ = mass of minus 4.75mm (No. 4) sieve actually sieved

B = cumulative mass of the size increment in the reduced portion sieved

D = cumulative mass of plus 4.75mm (No. 4) portion of sample

Method B Sample Calculation

Sample calculation for percent retained and percent passing each sieve in accordance with Method B when the previously washed 4.75mm (No. 4) minus material is split:

Example:

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample, after washing out the 75 μm (No. 200) minus: 3085.1 g

Amount of 75 μm (No. 200) minus washed out: 3214.0 g – 3085.1 g = 128.9 g

Gradation on Coarse Sieves

Sieve Size mm (in.)	Individual Mass Retained, g (IMR)	Individual Percent Retained (IPR)	Cumulative Mass Retained, g (CMR)	Cumulative Percent Retained (CPR)	Calculated Percent Passing (CPP)
16.0 (5/8)	0	0	0	0	100
12.5 (1/2)	161.1	5.0	161.1	5.0	95.0
9.50 (3/8)	481.4	15.0	642.5	20.0	80.0
4.75 (No. 4)	475.8	14.8	1118.3	34.8	65.2
Pan	1966.7 (M ₁)		3085.0		

Coarse check sum: [(3085.1 - 3085.0) / 3085.1] × 100 = 0.00 % is within the 0.3 percent requirement.

Note 5: The pan mass determined in the laboratory (M₁) and the calculated mass (3085.1 – 1118.3 = 1966.7) should be the same if no material was lost.

The pan (1966.7 g) was reduced in accordance with the FOP for AASHTO T 248, so that at least 500 g are available. In this case, the mass determined was **512.8 g**. This is M₂.

In order to account for the fact that only a portion of the minus 4.75mm (No. 4) material was sieved, the mass of material retained on the smaller sieves is adjusted by a factor equal to

M_1/M_2 . The factor determined from M_1/M_2 must be carried to three decimal places. Both the individual mass retained and cumulative mass retained formulas are shown.

Individual Mass Retained:

M_1 = total mass of the minus 4.75mm (No. 4) before reducing.

M_2 = mass before sieving from the reduced portion of the minus 4.75 mm (No. 4).

$$\frac{M_1}{M_2} = \frac{1,966 \text{ g}}{512.8 \text{ g}} = 3.835$$

Each “individual mass retained” on the fine sieves must be multiplied by this adjustment factor.

For example, the overall mass retained on the 2.00mm (No. 10) sieve is:

$3.835 \times 207.1 \text{ g} = 794.2 \text{ g}$, as shown in the following table:

**Final Gradation on All Sieves
Calculation by Individual Mass**

Sieve Size mm (in.)	Individual Mass Retained, g (IMR)	Adjusted Individual Mass Retained (AIMR)	Individual Percent Retained (IPR)	Calc'd Percent Passing (CPP)	Reported Percent Passing* (RPP)
16.0 (5/8)	0	0	0.0	100.0	100
12.5 (1/2)	161.1	161.1	5.0	95.0	95
9.5 (3/8)	481.4	481.4	15.0	80.0	80
4.75 (No. 4)	475.8	475.8	14.8	65.2	65
2.0 (No. 10)	207.1 × 3.835	794.2	24.7	40.5	40
0.425 (No. 40)	187.9 × 3.835	720.6	22.4	18.1	18
0.210 (No. 80)	59.9 × 3.835	229.7	7.1	11.0	11
0.075 (No. 200)	49.1 × 3.835	188.3	5.9	5.1	5.1
Pan	7.8 × 3.835	29.9			
Dry mass of total sample, before washing: 3214.0 g					

*Report 75 μm (No. 200) sieve to 0.1 percent. Report all others to 1 percent.

Fine check sum: $[(512.8-511.8) / 512.8] \times 100 = 0.2\%$ is within the 0.3 percent requirement.

For Percent Passing (Calculated) see “Calculation” under Method A.

Cumulative Mass Retained:

M_1 = mass of the minus 4.75 mm (No. 4) before split

M_2 = mass before sieving of the split of the minus 4.75 mm (No. 4)

$$\frac{M_1}{M_2} = \frac{1,966 \text{ g}}{512.8 \text{ g}} = 3.835$$

Each “cumulative mass retained” on the fine sieves must be multiplied by this adjustment factor then the cumulative mass of plus 4.75 mm (No. 4) portion of sample is added to equal the adjusted cumulative mass retained .

For example, the adjusted cumulative mass retained on the 0.425 mm (No. 40) sieve is:

$$3.835 \times 395.0 \text{ g} = 1514.8 \text{ g}$$

1514.8 + 1118.3 g = 2633.1: “Total Cumulative Mass Retained” as shown in the following table:

**Final Gradation on All Sieves
Calculation by Cumulative Mass**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Adjusted Cumulative Mass Retained, g (ACMR)	Total Cumulative Mass Retnd., g (TCMR)	Cumulative Percent Retnd. (CPR)	Calc'd Percent Passing (CPP)	Reported Percent Passing* (RPP)
16.0 (5/8)	0		0	0.0	100.0	100
12.5 (1/2)	161.1		161.1	5.0	95.0	95
9.5 (3/8)	642.5		642.5	20.0	80.0	80
4.75 (No. 4)	1118.3		1118.3	34.8	65.2	65
2.0 (No. 10)	207.1×3.835	$794.2 + 1118.3$	1912.5	59.5	40.5	40
0.425 (No. 40)	395.0×3.835	$1514.8 + 1118.3$	2633.1	81.9	18.1	18
0.210 (No. 80)	454.9×3.835	$1744.5 + 1118.3$	2862.8	89.1	10.9	11
0.075 (No. 200)	504.0×3.835	$1932.8 + 1118.3$	3051.1	94.9	5.1	5.1
Pan	511.8×3.835	$1962.8 + 1118.3$	3081.1			

*Report 75 µm (No. 200) sieve to 0.1 percent. Report all others to 1 percent.

Fine check sum: $[(512.8-511.8) / 512.8] \times 100 = 0.2\%$ is within the 0.3 percent requirement.

For Percent Passing (Calculated) see “Calculation” under Method A.

Procedure Method C

1. Dry sample in accordance with the FOP for AASHTO T 255. Determine and record the total dry mass of the sample to the nearest 0.1 percent.

Note 6: AASHTO T 27 allows for coarse aggregate to be run in a moist condition unless the nominal maximum size of the aggregate is smaller than 12.5 mm (1/2 in.), the coarse aggregate (CA) contains appreciable material finer than 4.75 mm (No. 4), or the coarse aggregate is highly absorptive.

2. Break up any aggregations or lumps of clay, silt or adhering fines to pass the 4.75 mm (No. 4) sieve. If substantial coatings remain on the coarse particles in amounts that would affect the percent passing any of the specification sieves, the sample should be tested with either Method A or Method B.
3. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the 4.75 mm (No.4) with a pan at the bottom to retain the minus 4.75 mm (No. 4).
4. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker or place the sieves in the mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

5. Determine the cumulative mass retained on each sieve to the nearest 0.1 percent or 0.1 g. Ensure that all material trapped in full openings of the sieve are cleaned out and included in the mass retained.

Note 4: For sieves #4 and larger, material trapped in less than a full opening shall be checked by sieving over a full opening. Use coarse wire brushes to clean the 600 μ m (No. 30) and larger sieves, and soft bristle brush for smaller sieves.

6. Determine the mass of material in the pan [minus 4.75 mm (No. 4)] (M_1).
7. Reduce the minus 4.75mm (No. 4), using a mechanical splitter in accordance with the FOP for AASHTO T 248, to produce a sample with a mass of 500 g minimum.
8. Determine and record the mass of the minus 4.75mm (No. 4) split ($M_{\#4}$).
9. Perform steps 3 through 11 of Method A (Wash) on the minus 4.75mm (No. 4) split.
10. Select fine sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the 75 μ m (No. 200) with a pan at the bottom to retain the minus 75 μ m (No. 200).
11. Repeat steps 4 and 5, Method C, with the minus 4.75mm (No. 4) including determining the mass of the material in the pan.

12. Compute the “Cumulative Percent Retained” and “Cumulative Percent Passing” as follows:

$$CPR = \frac{CMR}{M} \times 100 \quad CPP = 100 - CPR$$

where:

- CMR = Cumulative Mass Retained
- CPR= Cumulative Percent Retained
- M= Total Dry Sample mass before washing
- CPP= Cumulative Percent Passing

Method C Sample Calculation

Sample calculation for percent retained and percent passing each sieve in accordance with Method C when the minus 4.75mm (No. 4) material is reduced and then washed:

Dry Mass of total sample: 3304.5 g

Dry Mass of minus 4.75mm (No. 4) reduced portion before wash, $M_{\#4}$: 527.6

Dry Mass of minus 4.75mm (No. 4) reduced portion after wash: 495.3

Gradation on Coarse Sieves

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Calc'd Percent Retained (CPR)	Calc'd Percent Passing (CPP)	Reported Percent Passing* (RPP)
16.0 (5/8)	0	0.0	100.0	100
12.5 (1/2)	125.9	3.8	96.2	96
9.50 (3/8)	604.1	18.3	81.7	82
4.75 (No. 4)	1295.6	39.2	60.8	61
Pan	2008.9			
Total Dry Sample = 3304.5				

Coarse check sum: $[(3304.5 - 3304.5) / 3304.5] \times 100 = 0.0 \%$ is within the 0.3 percent requirement

The pan (2008.9 g) was reduced in accordance with the FOP for AASHTO T 248, so that at least 500 g are available. In this case, the mass determined was $M_{\#4} = 527.6 \text{ g}$.

The Cumulative Mass Retained-_{#4} was determined.

$$CPR_{-#4} = \frac{CMR_{-#4}}{M_{-#4}} \times 100 \quad CPP_{-#4} = 100 - CPR_{-#4} \quad CPP = \frac{(CPP_{-#4} \times CPP_{#4})}{100}$$

Where:

CMR_{#4} = Cumulative mass retained for the sieve size based on a -#4 split sample

CPR_{#4} = Calculated cumulative percent retained based on the -#4 split

CPP_{#4} = Calculated percent passing based on the -#4 split

M_{#4} = Total mass of the -#4 split before washing

CPP_{#4} = Calculated percent passing the #4 sieve

**Final Gradation on All Sieves
Calculation by Cumulative Mass**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR _{#4})	Cumulative Percent Retained _{#4} (CPR _{#4})	Calc'd Percent Passing _{#4} (CPP _{#4})	Calc'd Percent Passing (CPP)	Reported Percent Passing* (RPP)
16.0 (5/8)	0	0.0		100.0	100
12.5 (1/2)	125.9	3.8		96.2	96
9.5 (3/8)	604.1	18.3		81.7	82
4.75 (No. 4)	1295.6	39.2		60.8	61
2.0 (No. 10)	194.3	36.8	63.2	38.4	38
0.425 (No. 40)	365.6	69.3	30.7	18.7	19
0.210 (No. 80)	430.8	81.7	18.3	11.1	11
0.075 (No. 200)	484.4	91.8	8.2	5.0	5.0
Pan	495.1				
Dry mass (M) of minus 4.75 mm (No. 4) sample, before washing: 527.6 g					
Dry mass of minus 4.75 mm (No. 4) sample, after washing: 495.3 g					

*Report 75 µm (No. 200) sieve to 0.1 percent. Report all others to 1 percent

Fine check sum: [(495.3 – 495.1) / 495.3] × 100= 0.04% is within the 0.3 percent requirement.

Also note that for Minus #4 material using this method that:

$$CPP = \frac{CPP_{#4} \times (M - CMR_{#4})}{M}$$

Fineness Modulus

Fineness Modulus (FM) is used in determining the degree of uniformity of the aggregate gradation in PCC mix designs. It is an empirical number relating to the fineness of the aggregate. The higher the FM, the coarser the aggregate. Values of 2.40 to 3.00 are common for FA in PCC.

The sum of the cumulative percentages retained on specified sieves in the following table divided by 100 gives the FM.

Sample Calculation

	Example A				Example B		
	Percent				Percent		
		Retained				Retained	
Sieve Size mm (in)	Passing		On Spec'd Sieves*		Passing		On Spec'd Sieves*
75*(3)	100	0	0		100	0	0
37.5*(11/2)	100	0	0		100	0	0
19*(3/4)	15	85	85		100	0	0
9.5*(3/8)	0	100	100		100	0	0
4.75*(No.4)	0	100	100		100	0	0
2.36*(No.8)	0	100	100		87	13	13
1.18*(No.16)	0	100	100		69	31	31
0.60*(No.30)	0	100	100		44	56	56
0.30*(No.50)	0	100	100		18	82	82
0.15*(100)	0	100	100		4	96	96
			$\Sigma = 785$				$\Sigma = 278$
			FM = 7.85				FM = 2.78

In decreasing size order, each * sieve is one-half the size of the preceding * sieve.

Report

Results shall be reported on standard forms approved for use by the agency. Depending on the agency, this may include:

- Mass retained on each sieve
- Percent retained on each sieve
- Cumulative mass retained on each sieve
- Cumulative percent retained on each sieve

- Percent passing each sieve to the nearest 1 percent except for the percent passing the 75 μm (No. 200) sieve, which shall be reported to the nearest 0.1 percent
- FM to the nearest 0.01

PERFORMANCE EXAM CHECKLIST

**METHOD A
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27
MATERIALS FINER THAN 75 µm (No. 200) SIEVE IN MINERAL AGGREGATE
BY WASHING
FOP FOR AASHTO T 11**

Participant Name _____ Exam Date _____

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Minimum sample mass meets requirement of Table 2?	_____	_____
2. Test sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
3. Test sample cooled and mass determined to nearest 0.1 percent or 0.1 g?	_____	_____
4. Sample placed in container and covered with water? (If specification requires that the amount of material finer than the 75 µm (No. 200) sieve is to be determined.)	_____	_____
5. Contents of the container vigorously agitated?	_____	_____
6. Complete separation of coarse and fine particles achieved?	_____	_____
7. Wash water poured through nested sieves such as 2 mm (No. 10) and 75 µm (No. 200)?	_____	_____
8. Operation continued until wash water is clear?	_____	_____
9. Material retained on sieves returned to washed sample?	_____	_____
10. Washed aggregate dried to a constant mass by FOP for AASHTO T 255?	_____	_____
11. Washed aggregate cooled and mass determined to nearest 0.1 percent or 0.1 g?	_____	_____
12. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)	_____	_____
13. Material sieved in verified mechanical shaker for proper time?	_____	_____
14. Mass of residue on each sieve and pan determined to 0.1 g?	_____	_____
15. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?	_____	_____

OVER

Procedure Element

Trial 1 Trial 2

16. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except 75 μm (No.200) - reported to the nearest 0.1 percent?

17. Percentage calculations based on original dry sample mass?

18. Calculations performed properly?

Comments: First attempt: Pass _____ Fail _____ Second attempt: Pass _____ Fail _____

Examiner Signature _____

WAQTC #: _____

PERFORMANCE EXAM CHECKLIST

**METHOD B
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27
MATERIALS FINER THAN 75 µm (No. 200) SIEVE IN MINERAL AGGREGATE
BY WASHING
FOP FOR AASHTO T 11**

Participant Name _____ Exam Date _____

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Minimum sample mass meets requirement of Table 2?	_____	_____
2. Test sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
3. Test sample cooled and mass determined to nearest 0.1 percent or 0.1 g?	_____	_____
4. Sample placed in container and covered with water? (If specification requires that the amount of material finer than the 75 µm (No. 200) sieve is to be determined.)	_____	_____
5. Contents of the container vigorously agitated?	_____	_____
6. Complete separation of coarse and fine particles achieved?	_____	_____
7. Wash water poured through nested sieves such as 2 mm (No. 10) and 75 µm (No. 200)?	_____	_____
8. Operation continued until wash water is clear?	_____	_____
9. Material retained on sieves returned to washed sample?	_____	_____
10. Washed aggregate dried to a constant mass by FOP for AASHTO T 255?	_____	_____
11. Washed aggregate cooled and mass determined to nearest 0.1 percent or 0.1 g?	_____	_____
12. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)	_____	_____
13. Material sieved in verified mechanical shaker for proper time?	_____	_____
14. Mass of residue on each sieve and pan determined to the nearest 0.1 percent or 0.1 g?	_____	_____
15. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?	_____	_____

OVER

Procedure Element

Trial 1 Trial 2

- 16. Material in pan reduced in accordance with FOP for AASHTO T 248 to a minimum sample size of 500 g and weighed to the nearest 0.1 g? _____
- 17. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.) _____
- 18. Material sieved in verified mechanical shaker for proper time? _____
- 19. Mass of residue on each sieve and pan determined to the nearest percent or 0.1 g? _____
- 20. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent? _____
- 21. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except 75 µm (No.200) - reported to the nearest 0.1 percent? _____
- 22. Percentage calculations based on original dry sample mass? _____
- 23. Calculations performed properly? _____

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass_____Fail_____

Examiner Signature _____

WAQTC #:_____

PERFORMANCE EXAM CHECKLIST

**METHOD C
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27
MATERIALS FINER THAN 75 µm (No. 200) SIEVE IN MINERAL AGGREGATE BY
WASHING
FOP FOR AASHTO T 11**

Participant Name _____ Exam Date _____

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Minimum sample mass meets requirement of Table 2?	_____	_____
2. Test sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
3. Test sample cooled and mass determined to the nearest 0.1 percent or 0.1 g?	_____	_____
4. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)	_____	_____
5. Material sieved in verified mechanical shaker for proper time?	_____	_____
6. Mass of residue on each sieve and in pan determined to the nearest 0.1 percent or 0.1 g?	_____	_____
7. Complete separation of coarse and fine particles achieved?	_____	_____
8. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?	_____	_____
9. Material in pan reduced to test size for washing in accordance with FOP for AASHTO T 248?	_____	_____
10. Mass of the fine aggregate wash sample determined to nearest 0.1 g?	_____	_____
11. Sample placed in container and covered with water?	_____	_____
12. Contents of the container vigorously agitated?	_____	_____
13. Complete separation of coarse and fine particles achieved?	_____	_____
14. Wash water poured through a set of nested sieves, such as a No. 10 over the No. 200?	_____	_____
15. Operation continued until wash water is clear?	_____	_____
16. Material retained on sieves returned to washed sample?	_____	_____

OVER

