

WSDOT Errata to FOP for AASHTO T 27_T 11

Sieve Analysis of Fine and Coarse Aggregates

WAQTC FOP for AASHTO T 27_T 11 has been adopted by WSDOT with the following changes:

Procedure Method C – *Method not recognized by WSDOT.*

Sample Preparation

Table 1 Test Sample Sizes for Aggregate Gradation Test – *Shall conform to the following table and nominal maximum size definition.*

Nominal Maximum Size*in (mm)		Minimum Dry Mass lb (kg)	
US No. 4	(4.75)	1	(0.5)
¼	(6.3)	2	(1)
⅜	(9.5)	2	(1)
½	(12.5)	5	(2)
⅝	(16.0)	5	(2)
¾	(19.0)	7	(3)
1	(25.0)	13	(6)
1¼	(31.5)	17	(7.5)
1½	(37.5)	20	(9)
2	(50)	22	(10)
2½	(63)	27	(12)
3	(75)	33	(15)
3½	(90)	44	(20)

*For Aggregate, the nominal maximum size sieve is the largest standard sieve opening listed in the applicable specification upon which more than 1-percent of the material by weight is permitted to be retained. For concrete aggregate, the nominal maximum size sieve is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

**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**

Scope

A sieve analysis, or ‘gradation,’ measures distribution of aggregate particle sizes within a given sample.

Accurate determination of the amount of material smaller than 75 μm (No. 200) cannot be made using just AASHTO T 27. If quantifying this material is required, use AASHTO T 11 in conjunction with AASHTO T 27.

This FOP covers sieve analysis in accordance with AASHTO T 27-14 and materials finer than 75 μm (No. 200) in accordance with AASHTO T 11-05 performed in conjunction with AASHTO T 27. The procedure includes three methods: 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 ASTM E11
- Mechanical sieve shaker: Meeting the requirements of AASHTO T 27
- Suitable drying equipment (refer to FOP for AASHTO T 255)
- Containers and utensils: A pan or vessel of sufficient size to contain the sample covered with water and permit vigorous agitation without loss of material or water
- Optional
 - Mechanical washing device
 - Mallet: With a rubber or rawhide head having a mass of 0.57 ± 0.23 kg (1.25 ± 0.5 lb)

Sample Sieving

- In all procedures, the sample is shaken in nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the sample, or a portion of the sample, is placed on the top sieve.
- The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A; *Time Evaluation*.

- Care must be taken so that sieves are not overloaded, refer to Annex B; *Overload Determination*. The sample may be sieved in increments and the mass retained for each sieve added together from each sample increment to avoid overloading sieves.

Sample Preparation

Obtain samples according to the FOP for AASHTO R 90 and reduce to sample size, shown in Table 1, according to the FOP for AASHTO R 76.

TABLE 1
Sample Sizes for Aggregate Gradation Test

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

*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.

Sample sizes in Table 1 are standard for aggregate sieve analysis, due to equipment restraints samples may need to be divided into several “subsamples.” For example, a gradation that requires 100 kg (220 lbs.) of material would not fit into a large tray shaker all at once.

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 sample sizes.

Selection of Procedure

Agencies may specify which method to perform. If a method is not specified, perform Method A.

Overview**Method A**

- Determine original dry mass of the sample
- Wash over a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve washed sample
- Calculate and report percent retained and passing each sieve

Method B

- Determine original dry mass of the sample
- Wash over a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve sample through coarse sieves, 4.75 mm (No. 4) sieves and larger
- Determine mass of fine material, minus 4.75 mm (No. 4)
- Reduce fine material
- Determine mass of reduced portion
- Sieve reduced portion
- Calculate and report percent retained and passing each sieve

Method C

- Determine original dry mass of the sample
- Sieve sample through coarse sieves, 4.75 mm (No. 4) sieves and larger
- Determine mass of fine material, minus 4.75 mm (No. 4)
- Reduce fine material
- Determine mass of reduced portion
- Wash reduced portion over a 75 μ m (No. 200) sieve
- Determine dry mass of washed reduced portion
- Sieve washed reduced portion
- Calculate and report percent retained and passing each sieve

Procedure Method A

1. Dry the sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the original dry mass of the sample to the nearest 0.1 percent or 0.1 g. Designate this mass as *M*.

When the specification does not require the amount of material finer than 75 μm (No. 200) be determined by washing, skip to Step 11.

2. Nest a sieve, such as a 2.0 mm (No. 10), above the 75 μm (No. 200) sieve.
3. Place the sample in a container and cover with water.

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 μm (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.

4. Agitate vigorously to ensure complete separation of the material finer than 75 μm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device.
5. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μm (No. 200) sieve.
6. Add water to cover material remaining in the container, agitate, and repeat Step 5. Continue until the wash water is reasonably clear.
7. Remove the upper sieve and return material retained to the washed sample.
8. Rinse the material retained on the 75 μm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.
9. Return all material retained on the 75 μm (No. 200) sieve to the container by rinsing into the washed sample.

Note 2: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 μm (No. 200) sieve to prevent loss of fines.

10. Dry the washed sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the dry mass of the sample.
11. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 μm (No. 200).
12. Place the washed sample, or a portion of the washed sample, on the top sieve. Sieves may already be in the mechanical shaker, if not 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, the time determined by Annex A).

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

13. Determine and record the individual or cumulative mass retained for each sieve and in the pan. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening 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.

Note 5: In the case of coarse / fine aggregate mixtures, distribute the minus 4.75 mm (No. 4) among two or more sets of sieves to prevent overloading of individual sieves.

14. Perform the *Check Sum* calculation – Verify the *total mass after sieving* agrees with the *dry mass before sieving* to within 0.3 percent. The *dry mass before sieving* is the dry mass after wash or the original dry mass (M) if performing the sieve analysis without washing. Do not use test results for acceptance if the *Check Sum* result is greater than 0.3 percent.
15. Calculate the total percentages passing, and the individual or cumulative percentages retained to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the original dry mass (M) of the sample.
16. Report total percent passing to 1 percent except report the 75 μm (No. 200) sieve to 0.1 percent.

Method A Calculations

Check Sum

$$\text{Check Sum} = \frac{\text{dry mass before sieving} - \text{total mass after sieving}}{\text{dry mass before sieving}} \times 100$$

Percent Retained

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

Where:

IPR	=	Individual Percent Retained
CPR	=	Cumulative Percent Retained
M	=	Original dry mass of the sample
IMR	=	Individual Mass Retained
CMR	=	Cumulative Mass Retained

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Percent Passing (PP)

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

Where:

PP = Percent Passing

PPP = Previous Percent Passing

Method A Example Individual Mass RetainedOriginal dry mass of the sample (*M*): 5168.7 g

Dry mass of the sample after washing: 4911.3 g

Total mass after sieving equals

Sum of Individual Masses Retained (IMR),
including minus 75 μm (No. 200) in the pan: 4905.9 g

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

Check Sum

$$\text{Check Sum} = \frac{4911.3 \text{ g} - 4905.9 \text{ g}}{4911.3 \text{ g}} \times 100 = 0.1\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Individual Percent Retained (IPR) for 9.5 mm (3/8 in.) sieve:

$$IPR = \frac{619.2 \text{ g}}{5168.7 \text{ g}} \times 100 = 12.0\%$$

Percent Passing (PP) 9.5 mm (3/8 in.) sieve:

$$PP = 86.0\% - 12.0\% = 74.0\%$$

Reported Percent Passing = 74%

**Method A Individual
Gradation on All Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR Divide IMR by <i>M</i> and multiply by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from Previous PP	Percent Passing (PP)	Reported Percent Passing*
19.0 (3/4)	0		0		100.0	100
12.5 (1/2)	724.7	$\frac{724.7}{5168.7} \times 100 =$	14.0	$100.0 - 14.0 =$	86.0	86
9.5 (3/8)	619.2	$\frac{619.2}{5168.7} \times 100 =$	12.0	$86.0 - 12.0 =$	74.0	74
4.75 (No. 4)	1189.8	$\frac{1189.8}{5168.7} \times 100 =$	23.0	$74.0 - 23.0 =$	51.0	51
2.36 (No. 8)	877.6	$\frac{877.6}{5168.7} \times 100 =$	17.0	$51.0 - 17.0 =$	34.0	34
1.18 (No. 16)	574.8	$\frac{574.8}{5168.7} \times 100 =$	11.1	$34.0 - 11.1 =$	22.9	23
0.600 (No. 30)	329.8	$\frac{329.8}{5168.7} \times 100 =$	6.4	$22.9 - 6.4 =$	16.5	17
0.300 (No. 50)	228.5	$\frac{228.5}{5168.7} \times 100 =$	4.4	$16.5 - 4.4 =$	12.1	12
0.150 (No. 100)	205.7	$\frac{205.7}{5168.7} \times 100 =$	4.0	$12.1 - 4.0 =$	8.1	8
0.075 (No. 200)	135.4	$\frac{135.7}{5168.7} \times 100 =$	2.6	$8.1 - 2.6 =$	5.5	5.5
minus 0.075 (No. 200) in the pan	20.4					
Total mass after sieving = sum of sieves + mass in the pan = 4905.9 g						
Original dry mass of the sample (<i>M</i>): 5168.7g						

* Report total percent passing to 1 percent except report the 75 μ m (No. 200) sieve to 0.1 percent.

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Method A Example Cumulative Mass Retained

Original dry mass of the sample (M):	5168.7 g
Dry mass of the sample after washing:	4911.3 g
Total mass after sieving equals Final Cumulative Mass Retained (FCMR) (includes minus 75 μm (No. 200) from the pan):	4905.9 g
Amount of 75 μm (No. 200) minus washed out (5168.7 g – 4911.3 g):	257.4 g

Check Sum

$$\text{Check Sum} = \frac{4911.3 \text{ g} - 4905.9 \text{ g}}{4911.3 \text{ g}} \times 100 = 0.1\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR) for 9.5 mm (3/8 in.) sieve:

$$\text{CPR} = \frac{1343.9 \text{ g}}{5168.7 \text{ g}} \times 100 = 26.0\%$$

Percent Passing (PP) 9.5 mm (3/8 in.) sieve:

$$\text{PP} = 100.0\% - 26.0\% = 74.0\%$$

Reported Percent Passing = 74%

**Method A Cumulative
Gradation on All Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR Divide CMR by M and multiply by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Reported Percent Passing*
19.0 (3/4)	0		0.0		100.0	100
12.5 (1/2)	724.7	$\frac{724.7}{5168.7} \times 100 =$	14.0	$100.0 - 14.0 =$	86.0	86
9.5 (3/8)	1343.9	$\frac{1343.9}{5168.7} \times 100 =$	26.0	$100.0 - 26.0 =$	74.0	74
4.75 (No. 4)	2533.7	$\frac{2533.7}{5168.7} \times 100 =$	49.0	$100.0 - 49.0 =$	51.0	51
2.36 (No. 8)	3411.3	$\frac{3411.3}{5168.7} \times 100 =$	66.0	$100.0 - 66.0 =$	34.0	34
1.18 (No. 16)	3986.1	$\frac{3986.1}{5168.7} \times 100 =$	77.1	$100.0 - 77.1 =$	22.9	23
0.600 (No. 30)	4315.9	$\frac{4315.9}{5168.7} \times 100 =$	83.5	$100.0 - 83.5 =$	16.5	17
0.300 (No. 50)	4544.4	$\frac{4544.4}{5168.7} \times 100 =$	87.9	$100.0 - 87.9 =$	12.1	12
0.150 (No. 100)	4750.1	$\frac{4750.1}{5168.7} \times 100 =$	91.9	$100.0 - 91.9 =$	8.1	8
0.075 (No. 200)	4885.5	$\frac{4885.5}{5168.7} \times 100 =$	94.5	$100.0 - 94.5 =$	5.5	5.5
FCMR	4905.9					
Total mass after sieving: 4905.9 g						
Original dry mass of the sample (M): 5168.7 g						

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Procedure Method B

1. Dry the sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the original dry mass of the sample to the nearest 0.1 percent or 0.1 g. Designate this mass as *M*.

When the specification does not require the amount of material finer than 75 μm (No. 200) be determined by washing, skip to Step 11.

2. Nest a protective sieve, such as a 2.0 mm (No. 10), above the 75 μm (No. 200) sieve.
3. Place the sample in a container and cover with water.

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 μm (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.

4. Agitate vigorously to ensure complete separation of the material finer than 75 μm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device.
5. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μm (No. 200) sieve.
6. Add water to cover material remaining in the container, agitate, and repeat Step 5. Continue until the wash water is reasonably clear.
7. Remove the upper sieve and return material retained to the washed sample.
8. Rinse the material retained on the 75 μm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.
9. Return all material retained on the 75 μm (No. 200) sieve to the container by rinsing into the washed sample.

Note 2: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 μm (No. 200) sieve to prevent loss of fines.

10. Dry the washed sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the dry mass after wash.
11. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 4.75 mm (No. 4).
12. Place the washed sample, or a portion of the washed sample, on the top sieve. Sieves may already be in the mechanical shaker, if not 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, the time determined by Annex A).

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

13. Determine and record the individual or cumulative mass retained for each sieve. Ensure that all particles trapped in full openings of the sieve are removed and included in the mass retained.
- Note 4:** For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening 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.
14. Determine and record the mass of the minus 4.75 mm (No. 4) material in the pan. Designate this mass as M_1 .
15. Perform the *Coarse Check Sum* calculation – Verify the *total mass after coarse sieving* agrees with the *dry mass before sieving* to within 0.3 percent. The *dry mass before sieving* is the dry mass after wash or the original dry mass (M) if performing the sieve analysis without washing. Do not use test results for acceptance if the *Check Sum* result is greater than 0.3 percent.
16. Reduce the minus 4.75 mm (No. 4) according to the FOP for AASHTO R 76 to produce a sample with a minimum mass of 500 g. Determine and record the mass of the minus 4.75 mm (No. 4) split, designate this mass as M_2 .
17. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 μm (No. 200) up to, but not including, the 4.75 mm (No. 4) sieve.
18. Place the sample portion on the top sieve and place the sieves in the mechanical shaker. Shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).
19. Determine and record the individual or cumulative mass retained for each sieve and in the pan. Ensure that all particles trapped in full openings of the sieve are removed and included in the mass retained.
- Note 4:** For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening 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.
20. Perform the *Fine Check Sum* calculation – Verify the *total mass after sieving* agrees with the *dry mass before sieving* (M_2) to within 0.3 percent. Do not use test results for acceptance if the *Check Sum* result is greater than 0.3 percent.
21. Calculate to the nearest 0.1 percent, the Individual Mass Retained (IMR) or Cumulative Mass Retained (CMR) of the size increment of the reduced sample and the original sample.
22. Calculate the total percent passing.
23. Report total percent passing to 1 percent except report the 75 μm (No. 200) sieve to 0.1 percent.

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Method B Calculations**Check Sum**

$$\text{Coarse Check Sum} = \frac{\text{dry mass before sieving} - \text{total mass after coarse sieving}}{\text{dry mass before sieving}} \times 100$$

$$\text{Fine Check Sum} = \frac{M_2 - \text{total mass after fine sieving}}{M_2} \times 100$$

Percent Retained for 4.75 mm (No. 4) and larger

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

Where:

IPR	=	Individual Percent Retained
CPR	=	Cumulative Percent Retained
M	=	Original dry mass of the sample
IMR	=	Individual Mass Retained
CMR	=	Cumulative Mass Retained

Percent Passing (PP) for 4.75 mm (No. 4) and larger

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

Where:

PP	=	Percent Passing
PPP	=	Previous Percent Passing

Minus 4.75mm (No. 4) adjustment factor (R)

The mass of material retained for each sieve is multiplied by the adjustment factor, the total mass of the minus 4.75 mm (No. 4) from the pan, M_1 , divided by the mass of the reduced split of minus 4.75 mm (No. 4), M_2 . For consistency, this adjustment factor is carried to three decimal places.

$$R = \frac{M_1}{M_2}$$

where:

- R = minus 4.75 mm (No. 4) adjustment factor
- M_1 = total mass of minus 4.75 mm (No. 4) before reducing
- M_2 = mass of the reduced split of minus 4.75 mm (No. 4)

Adjusted Individual Mass Retained (AIMR):

$$AIMR = R \times B$$

where:

- AIMR = Adjusted Individual Mass Retained
- R = minus 4.75 mm (No. 4) adjustment factor
- B = individual mass of the size increment in the reduced portion sieved

Adjusted Cumulative Mass Retained (ACMR)

$$ACMR = (R \times B) + D$$

where:

- ACMR = Adjusted Cumulative Mass Retained
- R = minus 4.75 mm (No. 4) adjustment factor
- B = cumulative mass of the size increment in the reduced portion sieved
- D = cumulative mass of plus 4.75mm (No. 4) portion of sample

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Method B Example Individual Mass Retained

Dry mass of total sample, before washing:	3214.0 g
Dry mass of sample after washing:	3085.1 g
Total mass after sieving	
Sum of Individual Masses Retained (IMR) plus the minus 4.75 mm (No. 4) from the pan:	3085.0 g
Amount of 75 µm (No. 200) minus washed out (3214.0 g – 3085.1 g):	128.9 g

Coarse Check Sum

$$\text{Coarse Check Sum} = \frac{3085.1 \text{ g} - 3085.0 \text{ g}}{3085.1 \text{ g}} \times 100 = 0.0\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Individual Percent Retained (IPR) for 9.5 mm (3/8 in.) sieve

$$\text{IPR} = \frac{481.4 \text{ g}}{3214.0 \text{ g}} \times 100 = 15.0\%$$

Percent Passing (PP) for 9.5 mm (3/8 in.) sieve:

$$\text{PP} = 95.0\% - 15.0\% = 80.0\%$$

Reported Percent Passing = 80%

**Method B Individual
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR Divide IMR by M and multiply by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from Previous PP	Percent Passing (PP)
16.0 (5/8)	0		0		100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0
9.50 (3/8)	481.4	$\frac{481.4}{3214.0} \times 100 =$	15.0	$95.0 - 15.0 =$	80.0
4.75 (No. 4)	475.8	$\frac{475.8}{3214.0} \times 100 =$	14.8	$80.0 - 14.8 =$	65.2
Minus 4.75 (No. 4) in the pan	1966.7 (M_1)				
Total mass after sieving = sum of sieves + mass in the pan = 3085.0 g					
Original dry mass of the sample (M): 3214.0 g					

Fine Sample

The minus 4.75 mm (No. 4) from the pan, M_1 (1966.7 g), was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **512.8 g**. This is M_2 .

The reduced mass was sieved.

Total mass after sieving equals

Sum of Individual Masses Retained (IMR) including
minus 75 μ m (No. 200) in the pan 511.8 g

Fine Check Sum

$$\text{Fine Check Sum} = \frac{512.8 \text{ g} - 511.8 \text{ g}}{512.8 \text{ g}} \times 100 = 0.2\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Adjustment Factor (R) for Adjusted Individual Mass Retained (AIMR) on minus 4.75 (No. 4) sieves

The mass of material retained for each sieve is multiplied by the adjustment factor (*R*) carried to three decimal places.

$$R = \frac{M_1}{M_2} = \frac{1,966.7 \text{ g}}{512.8 \text{ g}} = 3.835$$

where:

- R = minus 4.75 mm (No. 4) adjustment factor
- M₁ = total mass of minus 4.75 mm (No. 4) from the pan
- M₂ = mass of the reduced split of minus 4.75 mm (No. 4)

Each “individual mass retained” on the fine sieves must be multiplied by *R* to obtain the *Adjusted Individual Mass Retained*.

Adjusted Individual Mass Retained (AIMR) for 2.00 mm (No. 10) sieve

$$AIMR = 3.835 \times 207.1 \text{ g} = 794.2 \text{ g}$$

Individual Percent Retained (IPR) for 2.00 mm (No. 10) sieve:

$$IPR = \frac{794.2 \text{ g}}{3214.0 \text{ g}} \times 100 = 24.7\%$$

Percent Passing (PP) 2 mm (No. 10) sieve:

$$PP = 65.2\% - 24.7\% = 40.5\%$$

Reported Percent Passing = 41%

**Method B Individual
Gradation on Fine Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine TIMR Multiply IMR by $R \left(\frac{M_1}{M_2} \right)$	Total Individual Mass Retained (TIMR)
2.00 (No. 10)	207.1	$207.1 \times 3.835 =$	794.2
0.425 (No. 40)	187.9	$187.9 \times 3.835 =$	720.6
0.210 (No. 80)	59.9	$59.9 \times 3.835 =$	229.7
0.075 (No. 200)	49.1	$49.1 \times 3.835 =$	188.3
minus 0.075 (No. 200) in the pan	7.8		
Total mass after sieving = sum of fine sieves + the mass in the pan = 511.8 g			

**Method B Individual
Final Gradation on All Sieves**

Sieve Size mm (in.)	Total Individual Mass Retained g (TIMR)	Determine IPR Divide TIMR by M and multiply by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from Previous PP	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0		0		100	100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0	95
9.50 (3/8)	481.4	$\frac{481.4}{3214.0} \times 100 =$	15.0	$95.0 - 15.0 =$	80.0	80
4.75 (No. 4)	475.8	$\frac{475.8}{3214.0} \times 100 =$	14.8	$80.0 - 14.8 =$	65.2	65
2.00 (No. 10)	794.2	$\frac{794.2}{3214.0} \times 100 =$	24.7	$65.2 - 24.7 =$	40.5	41
0.425 (No. 40)	720.6	$\frac{720.6}{3214.0} \times 100 =$	22.4	$40.5 - 22.4 =$	18.1	18
0.210 (No. 80)	229.7	$\frac{229.7}{3214.0} \times 100 =$	7.1	$18.1 - 7.1 =$	11.0	11
0.075 (No. 200)	188.3	$\frac{188.3}{3214.0} \times 100 =$	5.9	$11.0 - 5.9 =$	5.1	5.1
minus 0.075 (No. 200) in the pan	29.9					
Original dry mass of the sample (M): 3214.0 g						

* Report total percent passing to 1 percent except report the 75 μ m (No. 200) sieve to 0.1 percent.

Method B Example Cumulative Mass Retained

Original dry mass of the sample (<i>M</i>):	3214.0 g
Dry mass of sample after washing:	3085.1 g
Total mass after sieving equals	
Cumulative Mass Retained (CMR) on the 4.75 (No. 4) plus the minus 4.75 mm (No. 4) in the pan:	3085.0 g
Amount of 75 μm (No. 200) minus washed out (3214.0 g – 3085.1 g):	128.9 g

Coarse Check Sum

$$\text{Coarse Check Sum} = \frac{3085.1 \text{ g} - 3085.0 \text{ g}}{3085.1 \text{ g}} \times 100 = 0.0\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR) for 9.5 mm (3/8 in.) sieve

$$CPR = \frac{642.5 \text{ g}}{3214.0 \text{ g}} \times 100 = 20.0\%$$

Percent Passing (PP) for 9.5 mm (3/8 in.) sieve

$$PP = 100.0\% - 20.0\% = 80.0\%$$

Reported Percent Passing = 80%

**Method B Cumulative
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR Divide CMR by M and multiply by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)
16.0 (5/8)	0		0		100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0
9.50 (3/8)	642.5	$\frac{642.5}{3214.0} \times 100 =$	20.0	$100.0 - 20.0 =$	80.0
4.75 (No. 4)	1118.3 (D)	$\frac{1118.3}{3214.0} \times 100 =$	34.8	$100.0 - 34.8 =$	65.2
Minus 4.75 (No. 4) in the pan	1966.7 (M ₁)				
CMR: 1118.3 + 1966.7 = 3085.0					
Original dry mass of the sample (M): 3214.0 g					

Fine Sample

The mass of minus 4.75 mm (No. 4) material in the pan, M_1 (1966.7 g), was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **512.8 g**. This is M_2 .

The reduced mass was sieved.

Total mass after fine sieving equals

Final Cumulative Mass Retained (FCMR) (includes minus 75 μ m (No. 200) from the pan): 511.8 g

Fine Check Sum

$$\text{Fine Check Sum} = \frac{512.8 \text{ g} - 511.8 \text{ g}}{512.8 \text{ g}} \times 100 = 0.2\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

The cumulative mass of material retained for each sieve is multiplied by the adjustment factor (R) carried to three decimal places and added to the cumulative mass retained on the 4.75 mm (No. 4) sieve, D , to obtain the *Adjusted Cumulative Mass Retained (ACMR)*.

Adjustment factor (R) for Cumulative Mass Retained (CMR) in minus 4.75 (No. 4) sieves

$$R = \frac{M_1}{M_2} = \frac{1,966.7 \text{ g}}{512.8 \text{ g}} = 3.835$$

where:

- R = minus 4.75 mm (No. 4) adjustment factor
- M_1 = total mass of minus 4.75 mm (No. 4) from the pan
- M_2 = mass of the reduced split of minus 4.75 mm (No. 4)

Adjusted Cumulative Mass Retained (ACMR) for the 2.00 mm (No. 10) sieve

$$ACMR = 3.835 \times 207.1 \text{ g} = 794.2 \text{ g}$$

Total Cumulative Mass Retained (TCMR) for the 2.00 mm (No. 10) sieve

$$TCMR = 794.2 \text{ g} + 1118.3 \text{ g} = 1912.5 \text{ g}$$

Cumulative Percent Retained (CPR) for 2.00 mm (No. 10) sieve:

$$CPR = \frac{1912.5 \text{ g}}{3214.0 \text{ g}} \times 100 = 59.5\%$$

Percent Passing (PP) 2.00 mm (No. 10) sieve:

$$PP = 100.0\% - 59.5\% = 40.5\%$$

Reported Percent Passing = 41%

**Method B Cumulative
Gradation on Fine Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Determine AIMR Multiply IMR by $R \left(\frac{M_1}{M_2} \right)$ and adding D	Total Cumulative Mass Retained (TCMR)
2.00 (No. 10)	207.1	$207.1 \times 3.835 + 1118.3 =$	1912.5
0.425 (No. 40)	395.0	$395.0 \times 3.835 + 1118.3 =$	2633.1
0.210 (No. 80)	454.9	$454.9 \times 3.835 + 1118.3 =$	2862.8
0.075 (No. 200)	504.0	$504.0 \times 3.835 + 1118.3 =$	3051.1
FCMR	511.8		
Total sum of masses on fine sieves + minus 75 μm (No. 200) in the pan = 511.8			

**Method B Cumulative
Final Gradation on All Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR Divide CMR by M and multiply by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0		0		100.0	100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0	95
9.5 (3/8)	642.5	$\frac{642.5}{3214.0} \times 100 =$	20.0	$100.0 - 20.0 =$	80.0	80
4.75 (No. 4)	1118.3 (D)	$\frac{1118.3}{3214.0} \times 100 =$	34.8	$100.0 - 34.8 =$	65.2	65
2.00 (No. 10)	1912.5	$\frac{1912.5}{3214.0} \times 100 =$	59.5	$100.0 - 59.5 =$	40.5	41
0.425 (No. 40)	2633.1	$\frac{2633.1}{3214.0} \times 100 =$	81.9	$100.0 - 81.9 =$	18.1	18
0.210 (No. 80)	2862.8	$\frac{2862.8}{3214.0} \times 100 =$	89.1	$100.0 - 89.1 =$	10.9	11
0.075 (No. 200)	3051.1	$\frac{3051.1}{3214.0} \times 100 =$	94.9	$100.0 - 94.9 =$	5.1	5.1
FCMR	3081.1					
Original dry mass of the sample (M): 3214.0 g						

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Procedure Method C

1. Dry the sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the original dry mass of the sample to the nearest 0.1 percent or 0.1 g. Designate this mass as M .
2. Break up any aggregations or lumps of clay, silt or adhering fines to pass the 4.75 mm (No. 4) sieve.
3. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 4.75 mm (No. 4) sieve.
4. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker, if not 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, the time determined by Annex A).

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

5. Determine and record the cumulative mass retained for each sieve. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening sieving over a full opening. Use coarse wire brushes to clean the 600 μm (No. 30) and larger sieves, and soft bristle brush for smaller sieves.

6. Determine and record the mass of the minus 4.75 mm (No. 4) material in the pan. Designate this mass as M_1 .
7. Perform the *Coarse Check Sum* calculation –Verify the *total mass after coarse sieving* agrees with the *original dry mass (M)* within 0.3 percent.
8. Reduce the minus 4.75 mm (No. 4) according to the FOP for AASHTO R 76, to produce a sample with a minimum mass of 500 g.
9. Determine and record the mass of the minus 4.75 mm (No. 4) split, designate this mass as M_3 .
10. Nest a protective sieve, such as a 2.0 mm (No. 10), above the 75 μm (No. 200) sieve.
11. Place the sample in a container and cover with water.

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 μm (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.

12. Agitate vigorously to ensure complete separation of the material finer than 75 μm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device.
13. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μm (No. 200) sieve.

14. Add water to cover material remaining in the container, agitate, and repeat Step 12. Repeat until the wash water is reasonably clear.
15. Remove the upper sieve and return material retained to the washed sample.
16. Rinse the material retained on the 75 μm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.
17. Return all material retained on the 75 μm (No. 200) sieve to the container by flushing into the washed sample.

Note 2: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 μm (No. 200) sieve to prevent loss of fines.

18. Dry the washed sample portion to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the dry mass, designate this mass as *dry mass before sieving*.
19. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 μm (No. 200) sieve up to, but not including, the 4.75 mm (No. 4) sieve.
20. Place the washed sample portion on the top sieve. 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, the time determined by Annex A).

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

21. Determine and record the cumulative mass retained for each sieve. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening 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.

22. Perform the *Fine Check Sum* calculation – Verify the *total mass after fine sieving* agrees with the *dry mass before sieving* within 0.3 percent. Do not use test results for acceptance if the *Check Sum* is greater than 0.3 percent.
23. Calculate the Cumulative Percent Retained (CPR) and Percent Passing (PP) for the 4.75 mm (No. 4) and larger.
24. Calculate the Cumulative Percent Retained (CPR_{#4}) and the Percent Passing (PP_{#4}) for minus 4.75 mm (No. 4) split and Percent Passing (PP) for the minus 4.75 mm (No. 4).
25. Report total percent passing to 1 percent except report the 75 μm (No. 200) sieve to 0.1 percent.

Method C Calculations**Check Sum**

$$\text{Coarse check sum} = \frac{M - \text{total mass after coarse sieving}}{M} \times 100$$

$$\text{Fine check sum} = \frac{\text{dry mass before sieving} - \text{total mass after fine sieving}}{\text{dry mass before sieving}} \times 100$$

where:

M = Original dry mass of the sample

Cumulative Percent Retained (CPR) for 4.75 mm (No. 4) sieve and larger

$$CPR = \frac{CMR}{M} \times 100$$

where:

CPR = Cumulative Percent Retained of the size increment for the total sample

CMR = Cumulative Mass Retained of the size increment for the total sample

M = Total dry sample mass before washing

Percent Passing (PP) 4.75 mm (No. 4) sieve and larger

$$PP = 100 - CPR$$

where:

PP = Percent Passing of the size increment for the total sample

CPR = Cumulative Percent Retained of the size increment for the total sample

Or, calculate PP for sieves larger than 4.75 mm (No. 4) sieve without calculating CPR

$$\frac{M - CMR}{M} \times 100$$

Cumulative Percent Retained (CPR_{#4}) for minus 4.75 mm (No. 4) split

$$CPR_{\#4} = \frac{CMR_{\#4}}{M_3} \times 100$$

where:

- CPR_{#4} = Cumulative Percent Retained for the sieve sizes of M₃
- CMR_{#4} = Cumulative Mass Retained for the sieve sizes of M₃
- M₃ = Total mass of the minus 4.75 mm (No. 4) split before washing

Percent Passing (PP_{#4}) for minus 4.75 mm (No. 4) split

$$PP_{\#4} = 100 - CPR_{\#4}$$

where:

- PP_{#4} = Percent Passing for the sieve sizes of M₃
- CPR_{#4} = Cumulative Percent Retained for the sieve sizes of M₃

Percent Passing (PP) for sieves smaller than 4.75 mm (No. 4) sieve

$$PP = \frac{(PP_{\#4} \times \#4 PP)}{100}$$

where:

- PP = Total Percent Passing
- PP_{#4} = Percent Passing for the sieve sizes of M₃
- #4 PP = Total Percent Passing the 4.75 mm (No. 4) sieve

Or, calculate PP for sieves smaller than 4.75 mm (No. 4) sieve without calculating CPR_{#4} and PP_{#4}

$$PP = \frac{\#4 PP}{M_3} \times (M_3 - CMR_{\#4})$$

where:

- PP = Total Percent Passing
 #4 PP = Total Percent Passing the 4.75 mm (No. 4) sieve
 M₃ = Total mass of the minus 4.75 mm (No. 4) split before washing
 CMR_{#4} = Cumulative Mass Retained for the sieve sizes of M₃

Method C Example

Original dry mass of the sample (M): 3304.5 g

Total mass after sieving equals

Cumulative Mass Retained (CMR) on the 4.75 (No. 4) plus the minus 4.75 mm (No. 4) from the pan: 3085.0 g

Coarse Check Sum

$$\text{Coarse Check Sum} = \frac{3304.5 \text{ g} - 3304.5 \text{ g}}{3304.5 \text{ g}} \times 100 = 0.0\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR) for the 9.5 mm (3/8 in.) sieve:

$$CPR = \frac{604.1 \text{ g}}{3304.5 \text{ g}} \times 100 = 18.3\%$$

Percent Passing (PP) for the 9.5 mm (3/8 in.) sieve:

$$PP = 100.0\% - 18.3\% = 81.7\%$$

Reported Percent Passing = 82%

Example for Alternate Percent Passing (PP) formula for the 9.5 mm (3/8 in.) sieve:

$$PP = \frac{3304.5 - 604.1}{3304.5} \times 100 = 81.7\%$$

Reported Percent Passing = 82%

**Method C Cumulative
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Determine CPR Divide CMR by M and multiply by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0		0.0		100.0	100
12.5 (1/2)	125.9	$\frac{125.9}{3304.5} \times 100 =$	3.8	$100.0 - 3.8 =$	96.2	96
9.50 (3/8)	604.1	$\frac{604.1}{3304.5} \times 100 =$	18.3	$100.0 - 18.3 =$	81.7	82
4.75 (No. 4)	1295.6	$\frac{1295.6}{3304.5} \times 100 =$	39.2	$100.0 - 39.2 =$	60.8 (#4 PP)	61
Mass in pan	2008.9					
CMR: 1295.6 + 2008.9 = 3304.5						
Original dry mass of the sample (M) = 3304.5						

AGGREGATE

WAQTC

FOP AASTHO T 27 / T 11 (19)

Fine Sample

The pan (2008.9 g) was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **527.6 g**. This is M_3 .

Dry mass of minus 4.75mm (No. 4) reduced portion before wash (M_3): 527.6 g

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

Total mass after fine sieving equals

Final Cumulative Mass Retained (FCMR)
(includes minus 75 μm (No. 200) from the pan): 495.1 g

Fine Check Sum

$$\text{Fine Check Sum} = \frac{495.3 \text{ g} - 495.1 \text{ g}}{495.3 \text{ g}} \times 100 = 0.04\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR_{#4}) for minus 4.75 mm (No. 4) for the 2.0 mm (No. 10) sieve:

$$\text{CPR}_{\#4} = \frac{194.3 \text{ g}}{527.6 \text{ g}} \times 100 = 36.8\%$$

Percent Passing (PP_{#4}) for minus 4.75 mm (No. 4) for the 2.0 mm (No. 10) sieve:

$$\text{PP}_{\#4} = 100.0\% - 36.8\% = 63.2\%$$

**Method C Cumulative
Gradation on Fine Sieves**

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Sieve Size mm (in.)	Cumulative Mass Retained g (CMR-#4)	Determine CPR-#4 Divide CMR by M ₃ and multiply by 100	Cumulative Percent Retained-#4 (CPR-#4)	Determine PP-#4 by subtracting CPR-#4 from 100.0	Percent Passing-#4 (PP-#4)
2.0 (No. 10)	194.3	$\frac{194.3}{527.6} \times 100 =$	36.8	$100.0 - 36.8 =$	63.2
0.425 (No. 40)	365.6	$\frac{365.6}{527.6} \times 100 =$	69.3	$100.0 - 69.3 =$	30.7
0.210 (No. 80)	430.8	$\frac{430.8}{527.6} \times 100 =$	81.7	$100.0 - 81.7 =$	18.3
0.075 (No. 200)	484.4	$\frac{484.4}{527.6} \times 100 =$	91.8	$100.0 - 91.8 =$	8.2
FCMR	495.1				
Dry mass of minus 4.75mm (No. 4) reduced portion before wash (M ₃): 527.6 g					
Dry mass after washing: 495.3 g					

Percent Passing (PP) for the 2.0 mm (No. 10) sieve for the entire sample:

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#4 PP (Total Percent Passing the 4.75 mm (No. 4) sieve) = 60.8%

$$PP = \frac{63.2\% \times 60.8\%}{100} = 38.4\%$$

Reported Percent Passing = 38%

**Method C Cumulative
Final Gradation on All Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Cumulative Percent Retained (CPR)	Percent Passing (PP -#4)	Determine PP multiply PP-#4 by #4 PP and divide by 100	Percent Passing (PP)	Reported Percent Passing*
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 (#4 PP)	61
2.0 (No. 10)	194.3	36.8	63.2	$\frac{63.2 \times 60.8}{100} =$	38.4	38
0.425 (No. 40)	365.6	69.3	30.7	$\frac{30.7 \times 60.8}{100} =$	18.7	19
0.210 (No. 80)	430.8	81.7	18.3	$\frac{18.3 \times 60.8}{100} =$	11.1	11
0.075 (No. 200)	484.4	91.8	8.2	$\frac{8.2 \times 60.8}{100} =$	5.0	5.0
FCMR	495.1					

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Example for Alternate Percent Passing (PP) for the 4.75 mm (No. 4) sieve for the entire sample:

#4 PP (Total Percent Passing the 4.75 mm (No. 4) sieve) = 60.8%

$$PP = \frac{60.8\%}{527.6} \times (527.6 - 194.3) = 38.4\%$$

Reported Percent Passing = 38%

**Alternate Method C Cumulative
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Determine PP subtract CMR from M, divide result by M multiply by 100	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0.0		100.0	100
12.5 (1/2)	125.9	$\frac{3304.5 - 125.9}{3304.5} \times 100 =$	96.2	96
9.5 (3/8)	604.1	$\frac{3304.5 - 604.1}{3304.5} \times 100 =$	81.7	82
4.75 (No. 4)	1295.6	$\frac{3304.5 - 1295.6}{3304.5} \times 100 =$	60.8 (#4 PP)	61
Mass in Pan	2008.9			
Cumulative sieved mass: 1295.6 + 2008.9 = 3304.5				
Original dry mass of the sample (M) = 3304.5				

**Alternate Method C Cumulative
Gradation on Fine Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR _{#4})	Determine PP _{#4} subtract CMR _{#4} from M ₃ , divide result by M ₃ multiply by 100	Percent Passing _{#4} (PP _{#4})
2.0 (No. 10)	194.3	$\frac{527.6 - 194.3}{527.6} \times 100 =$	63.2
0.425 (No. 40)	365.6	$\frac{527.6 - 365.6}{527.6} \times 100 =$	30.7
0.210 (No. 80)	430.8	$\frac{527.6 - 430.8}{527.6} \times 100 =$	18.3
0.075 (No. 200)	484.4	$\frac{527.6 - 484.4}{527.6} \times 100 =$	8.2
FCMR	495.1		
Dry mass of minus 4.75mm (No. 4) reduced portion before wash (M ₃): 527.6 g			
Dry mass after washing: 495.3 g			

**Alternate Method C Cumulative
Final Gradation on All Sieves**

Sieve Size mm (in.)	Percent Passing _{#4} (PP _{#4})	Determine PP multiply PP _{#4} by #4 PP and divide by 100	Determined Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)			100.0	100
12.5 (1/2)			96.2	96
9.5 (3/8)			81.7	82
4.75 (No. 4)			60.8 (#4 PP)	61
2.0 (No. 10)	63.2	$\frac{63.2 \times 60.8}{100} =$	38.4	38
0.425 (No. 40)	30.7	$\frac{30.7 \times 60.8}{100} =$	18.7	19
0.210 (No. 80)	18.3	$\frac{18.3 \times 60.8}{100} =$	11.1	11
0.075 (No. 200)	8.2	$\frac{8.2 \times 60.8}{100} =$	5.0	5.0

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

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 fine aggregate 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 on forms approved by the agency
- Sample ID
- Percent passing for each sieve
- Individual mass retained for each sieve
- Individual percent retained for each sieve
or
- Cumulative mass retained for each sieve
- Cumulative percent retained for each sieve
- FM to the nearest 0.01

Report percentages 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.

ANNEX A**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.

Note A1: A mallet may be used instead of the heel of the hand if comparable force is used.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand shaking 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.

ANNEX B**Overload Determination**

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 overloading.

- For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m² (4 g/in²) 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 × (sieve opening in mm) × (effective sieving area). See Table B1.

TABLE B1

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	203 dia	305 dia	305 by 305	350 by 350	372 by 580
mm (in.)	(8)	(12)	(12 × 12)	(14 × 14)	(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

AGGREGATE

WAQTC

FOP AASTHO T 27 / T 11 (19)

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 1?	_____	_____
2. Sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
3. Sample cooled, and original dry mass of the sample recorded to the nearest 0.1 percent or 0.1 g?	_____	_____
4. Sample placed in container and covered with water?	_____	_____
5. Contents of the container vigorously agitated?	_____	_____
6. Suspension of minus 75 µm (No. 200) 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 reasonably clear?	_____	_____
9. Material retained on sieves returned to washed sample?	_____	_____
10. Washed sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
11. Washed sample cooled, and dry mass recorded to the 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 material on each sieve and pan recorded to 0.1 g?	_____	_____
15. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent (check sum)?	_____	_____

OVER

AGGREGATE

WAQTC

FOP AASHTO T 27/T 11 (17)

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) which is reported to the nearest 0.1 percent?

17. Percentage calculations based on original dry mass of the sample?

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 1?	_____	_____
2. Sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
3. Sample cooled, and original dry mass recorded to nearest 0.1 percent or 0.1 g?	_____	_____
4. Sample placed in container and covered with water?	_____	_____
5. Contents of the container vigorously agitated?	_____	_____
6. Suspension of minus 75 µm (No. 200) 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 reasonably clear?	_____	_____
9. Material retained on sieves returned to washed sample?	_____	_____
10. Washed sample dried to a constant mass by FOP for AASHTO T 255?	_____	_____
11. Washed sample cooled, and dry mass recorded 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 material 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 (coarse check sum)?	_____	_____

OVER

AGGREGATE

WAQTC

FOP AASHTO T 27/T 11 (17)

Procedure Element

Trial 1 Trial 2

16. Material in pan reduced in accordance with FOP for AASHTO R 76 to at least 500 g?

17. Mass of minus 4.75 mm (No. 4) split recorded to the nearest 0.1 g?

18. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)

19. Material sieved in verified mechanical shaker for proper time?

20. Mass of material on each sieve and pan recorded to the nearest percent or 0.1 g?

21. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent (fine check sum)?

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

23. Percentage calculations based on original dry mass of the sample?

24. Calculations performed properly?

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

Examiner Signature _____ **WAQTC #:** _____