METHODS OF SAMPLING AND TESTING
MT 202-11
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
(*Modified AASHTO T 11 AND T 27*)

1 Scope

1.1 This method covers the determination of the particle size distribution of fine and coarse aggregates by sieving.

1.2 Material passing the 4.75 mm (no. 4) sieve will be washed. Clay particles and other aggregate particles that are dispersed by the wash water, as well as water-soluble materials, will be removed from the aggregate during testing.

2 Referenced Documents

AASHTO

M 231 Weighing Devices Used in the Testing of Materials
R 18 Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
T 11 Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
T 27 Sieve Analysis of Fine and Coarse Aggregates

MT Materials Manual

MT 201 Sampling Roadway Materials
MT 607 Reducing Field Samples of Aggregate to Testing Size

3 Definitions

3.1 *Constant Mass* – Constant mass has been reached when there is less than a 0.1 percent change in mass over a monitored drying time. For an oven (110 ± 5° C (230 ± 9° F)), an additional 30 minutes of drying. For an uncontrolled heating source such as hot plates, an additional 20 minutes of drying, or microwaves, an additional 10 minutes of drying.

4 Apparatus

4.1 *Balance* – The scale or balance for the coarse 4.75 mm (plus 4 mesh) material shall have a sensitivity of 0.01 pounds or 0.01 kilograms. The scale or balance for the fine 4.75 mm (minus 4 mesh) material shall have a sensitivity of 0.1 gram.

4.2 *Sieves* – The sieve cloth shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The sieves shall conform to the requirements of AASHTO R 18.

4.2.*1* *Sieves* – A nest of two sieves, the lower being a 75-µm (No. 200) sieve and the upper being a sieve with openings in the range of 2.36 mm (No. 8) to 1.18 mm (No. 16), both conforming to the requirements of AASHTO R 18.

4.3 *Container* – A container sufficient in size to contain the sample covered with water and to permit vigorous agitation without inadvertent loss of any part of the sample or water.

4.4 *Heat Source* – A heat source capable of drying samples in accordance with Section 5.

4.5 *Mechanical Sieve Shaker* – A mechanical sieving device shall create motion of the sieves to cause the particles to bounce, tumble, or otherwise turn so as to present different orientations to the sieving surface. The sieving action shall be such that the requirement for sieving thoroughness as described in Section 7.3 is met within a reasonable amount of time.

5 Preparation of Samples

5.1 Samples for sieve analysis shall be prepared in accordance with MT 607, Reducing Field Samples of Aggregates to Testing Size. The samples shall be the mass desired when dry. The selection of samples of an exact predetermined mass shall not be permitted.

5.2 Dry the sample to a constant mass. For control purposes, particularly where rapid results are desired, it is generally not necessary to dry coarse aggregate to a constant mass for the sieve analysis test. The results are insignificantly affected by the moisture content unless the nominal maximum size is smaller than 12.5 mm (½ in.), or the coarse aggregate contains appreciable material finer than 4.75 mm (No. 4); or the coarse aggregate is highly absorptive (a lightweight aggregate, for example). Samples may be dried at higher temperatures associated with the use of hot plates or other uncontrolled heat sources without affecting results, provided steam escapes without generating pressures sufficient to fracture the particles, and temperatures are not so great as to cause chemical breakdown of the aggregate.

Note 1 – Samples taken for Liquid Limit, Plastic Limit, and Plasticity Index shall be air dried or dried at a temperature no greater than 140°F or 60°C.

Note 2 – Air drying is an acceptable method.

5.3 Representative samples will be graded to determine the percentage of fine material adhering to the coarser fractions.

5.4 *Fine Aggregate* – The test sample of fine aggregate shall weigh, after drying, approximately the following amount:

Aggregate with at least 95% passing a 2.36 mm (No. 8) sieve . . . 100g
Aggregate with at least 85% passing a 4.75 mm (No. 4) sieve
and more than 5% retained on a 2.36 mm (No. 8) sieve 500g

5.5 *Coarse Aggregate* – The mass of the test sample of coarse aggregate shall conform with the following:

Specified 100% Passing Sieve Size		Min. Field Test Sample Size*	
mm	(in)	Kg	(lb)
*9.5	(3/8)	6.8	(15)
*12.5	(1/2)	6.8	(15)
*19.0	(3/4)	9.1	(20)
*25.0	(1)	11.3	(25)
*37.5	(1½)	15	(33)
50	(2)	20	(44)
63	(2½)	35	(77)

Note 3 – For cover material, concrete aggregate, and samples that require a wear, cleanliness value test, the sample size sent to Helena must be doubled.

5.6 *Coarse and Fine Aggregate Mixtures* – The mass of the test sample of coarse and fine aggregate mixtures shall be the same as for coarse aggregate.

6 Procedure for Calculating Clinging Fines

6.1 Follow the procedure in Section 5 for the original test. Save the plus 4.75 mm (4 mesh) material.

6.2 Wash the plus 4.75 mm (4 mesh) material over a protected 75 µm (200 mesh) screen. In most cases it is not necessary to rewash the minus 4.75 mm (4 mesh) material. Dry and re-screen over the original sized screens. Use the original mass of sample taken for the calculation of the plus 4.75 mm (4 mesh) percentages.

6.3 Obtain the difference between the original plus 4.75 mm (4 mesh) material and the washed plus 4.75 mm (4) material. Record for use in calculations of the minus 4.75 mm (4 mesh) material. To convert from the pounds of minus 4 mesh material to grams, multiply by 453.6.

Example: (0.39 pounds) X (453.6) = 176.9 grams.

Use the percentage difference passing the 4.75 mm (4 mesh) divided by the before wash weight to get the reciprocal for multiplication.

Example: (1.55%)/176.9 g) = 0.00876

6.4 The total percent clinging fines is the difference in percent of the plus 4.75 mm (4 mesh) screen sizes.

Example: 55.61%(dry) - 54.06%(washed) = 1.55% (report as 1.6%)

7 Procedure for Aggregate without Clinging Fines

7.1 The total sample as prepared in Section 5 shall be separated into a series of sizes. To determine compliance with the specifications for the material under test, avoid overloading the screens.

7.2 Coarse Aggregate: Plus 4.75 mm (4 Mesh) Material – The individual mass of the plus 4.75 mm (4 mesh) portion of the sample, retained on each screen, shall be determined and recorded to the nearest 0.01 of a pound or 0.01 kilogram.

7.2.1 The individual portions shall be saved until the entire plus 4.75 mm (4 mesh) portion of the sample has been screened, weighed and the weights recorded, before any of the material is discarded.

7.2.2 The total amount of material finer than the plus 4.75 mm (4 mesh) sieve may be determined by subtracting the total mass of material retained on the plus 4.75 mm (4 mesh) sieve from the total mass of the initial dry sample being tested.

7.3 Fine Aggregate: Minus 4.75 mm (4 Mesh) Material – At the completion of the sieving as described in Section 7.2, the entire minus 4.75 mm (4 mesh) portions shall be thoroughly mixed and reduced to a minimum of 500 grams.

7.3.1 After drying the sample to a constant mass and weighing, place the test sample in the container and add sufficient water to cover it. 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 (Note 4). Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the 75 µm (No. 200) sieve from the coarser particles, and to bring the fine material into suspension. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, arranged with the coarser sieve on top. Take care to avoid, as much as feasible, the decantation of coarser particles of the sample.

Note 4 – There should be enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity will depend on the hardness of the water and the quality of the detergent. Excessive suds may overflow the sieves and carry some material with them.

7.3.2 Add a second change of water (without wetting agent) to the sample in the container, agitate, and decant as before. Repeat the operation until the wash water is clear.

Note 5 – If mechanical washing equipment is used, the charging of water, agitating, and decanting may be a continuous operation.

Note 6 – A spray nozzle or a piece of rubber tubing attached to a water faucet may be used to rinse any of the material that may have fallen into the sieves. The velocity of the water, which may be increased by pinching the tubing, should not be sufficient to cause any splashing of the sample over the sides of the sieves.

7.3.3 Return all material retained on the nested sieves by flushing to the washed sample. Dry the washed aggregate to a constant mass.

7.3.4 Following the washing of the sample and flushing any materials retained on the 75 µm (No. 200) sieve back into the container, no water should be decanted from the container except through the 75 µm sieve, to avoid loss of material. Excess water from flushing should be evaporated from the sample in the drying process.

7.3.5 The individual weights of each size of the minus 4.75 mm (4 mesh) portion retained on each sieve shall be determined and recorded to the nearest 0.1 gram.

7.3.6 The individual portions shall be saved until the entire minus 4.75 mm (4 mesh) portion of the sample that was washed has been screened, weighed, and the weights recorded, before any of the material is discarded.

8 Sieving Procedure

8.1 Nest the sieves in order of decreasing size of opening from top to bottom and place the sample, or portion of the sample if it is to be sieved in more than one increment, on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in Section 8.3.

8.2 Limit the quantity of material on a given sieve so that all particles have an opportunity to reach sieve openings a number of times during the sieving operation. Table 1 shows the maximum allowable quantity of material that can be retained on each individual sieve at the completion of the sieving operation. In no case shall the quantity retained be so great as to cause permanent deformation of the sieve cloth.

8.2.1 Prevent an overload of material on an individual sieve by splitting the sample into two or more portions, sieving each portion individually. Combine the masses of the several portions retained on a specific sieve before calculating the percentage of the sample on the sieve.

8.3 Continue sieving for a sufficient period and in such manner that, after completion, not more than 0.5 percent by mass of the total sample passes any sieve during one minute of continuous hand sieving. Perform as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the 4.75 mm (No. 4) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203 mm (8 in.) diameter sieves to verify the sufficiency of sieving.

8.4 Unless a mechanical shaker is used, hand sieve particles obtained on the 75 mm (3 in) by determining the smallest sieve opening through which each particle will pass by rotating the particles, if necessary, in order to determine whether they will pass through the particular opening, however, do not force the particles to pass through an opening.

8.5 The efficiency of the mechanical shaker shall be checked periodically by comparing results with the hand method. This practice will help determine the length of time required for the mechanical bshaker to adequately separate material sizes.

Table 1 – Maximum Allowable Quantity of Material Retained on a Sieve, Kg (lb)

Sieve Opening Size	Nominal Dimensions of Sieve 8 in dia	10 in dia	12 in dia	14 x 14 in dia	16 x 24 in dia
125 mm (5 in)	a	a	a	a	67.4 (148.6)
100 mm (4 in)	a	a	a	30.6 (67.5)	53.9 (118.8)
90 mm (31/2 in)	a	a	15.1 (33.3)	27.6 (60.8)	48.5 (106.9
75 mm (3 in)	a	8.6 (19.0)	12.6 (27.8)	23.0 (50.7)	40.5 (89.3)
63 mm (21/2 in)	a	7.2 (15.9)	10.6 (23.4)	19.3 (42.6)	34.0 (75.0)
50 mm (2 in)	3.6 (7.9)	5.7 (12.6	8.4 (18.5)	15.3 (33.7)	27.0 (59.5)
37.5 mm (11/2 in)	2.7 (6.0)	4.3 (9.5)	6.3 (13.9)	11.5 (25.4)	20.2 (44.5)
25.0 mm (1 in)	1.8 (4.0)	2.9 (6.4)	4.2 (9.5)	7.7 (17.0)	13.5 (29.8)
19.0 mm (3/4 in)	1.4 (3.1)	2.2 (4.9)	3.2 (7.1)	5.8 (12.8)	10.2 (22.5)
12.5 mm (1/2 in)	0.89 (2.0)	1.4 (3.1)	2.1 (4.6)	3.8 (8.4)	6.7 (14.8)
9.5 mm (3/8 in)	0.67 (1.5)	1.1 (2.4)	1.6 (3.5)	2.9 (6.4)	5.1 (11.2)
4.75 mm (No 4)	0.33 (0.7)	0.54 (1.2)	0.80 (1.8)	1.5 (3.3)	2.6 (5.7)

a = Sieves as indicated have less than 5 full openings and should not be used for sieve testing.

9 Calculations

9.1 Calculate the cumulative weight passing and the percentages to the nearest 0.01 percent on the basis of the total mass of the initial dry sample.

9.2 *Coarse Aggregate: Plus 4.75 mm (4 Mesh) Material* – For each of the various sieves, the individual cumulative weights must be converted to total weight passing. The total weight passing is divided by the total weight of the initial dry sample multiplied by 100, which will result in the percent passing. (See the example on the following worksheets).

9.3 *Fine Aggregate: Minus 4.75 mm (4 Mesh) Material* - Calculating the percentages of the minus 4.75 mm (4 mesh) portion of the sample is simplified by using a reciprocal. The reciprocal is determined by dividing the percent of material passing the minus 4.75 mm (4 mesh) sieve by the weight of the minus 4.75 mm (4 mesh) sample before washing. This reciprocal, when multiplied by the various total weights passing, results in the percent passing, in relation to the total sample. (See the example on the following worksheets).

10 Report

10.1 Unless otherwise required, the results of the sieve analysis shall be reported as the total percentages passing each sieve size and reported to the nearest whole number for all material coarser than the 75 μm (200 mesh) and reported to one tenth of one percent for the 75 μm (200 mesh). Percentages shall be calculated on the basis of the total mass of the initial dry sample, including any material finer than the 75 μm (200 mesh) sieve.

11 Hot Plant Mix Aggregates

11.1 Plant mix aggregates shall be governed by the provisions of MT 202, except that sampling will be in accordance with MT 201, which provides that the samples be obtained by means of an approved sampling device.

Form No. 123-E
(Rev. 11/8/11)

Montana Department of Transportation

Materials Lab. No. _____ UPN _____ Contract No. _____
Dist. Lab. No. _____ Sample _____ Hole/IA# _____ Contract Item # _____
Project No. _____
Project Name _____
Date Sampled _____ Date Rec. Helena _____ Kind of Deposit _____
Sampled By _____ Witnessed by _____ Address _____
Submitted By _____ Title _____ Date _____
Quantity _____ Area by Stationing _____
Area is in _____ Sec. _____ T- _____ R- _____
Lab. No. _____ County _____
Supplier _____ Address _____
Sta. and/or Tons Production Sample _____ Lift No. _____
Examined for _____

Constant Mass (500 gram sample): Initial Wt. 524.3 grams Check Wt. 518.6 grams Second Check Wt. 518.6 grams

Wt. of Sample Taken	40.83	lbs.	100.00	%
Wt. Retained 4-Mesh	26.92	lbs.	65.93	%
Wt. Passing 4-Mesh.	13.91	lbs.	34.07	%

Before Wash	518.6	After	425.3	LBW	93.3

LL	PL	PI
Wear %	Fld.Agg.Chart No.	
Fracture %	Sp.Gr. (F)	(C)
Max. Dens.	Soil Class	
Opt. Moist	Wt./Ft.	
Dust Ratio	Sand Equiv.	

Wt. Ret.	"	Wt Pass	Pct	Spec
	3"			
	2½"			
	2"			
	1½"		100	
3.63	1"	37.2	91	
9.42	3/4"	31.41	77	
16.18	1/2"	24.65	60	
20.04	3/8"	20.79	51	
26.92	4M	13.91	34	
146.5	8M/10M	372.1	24	
279.6	40M	239.0	16	
375.2	80M	143.4	9	
423.9	200M	94.7	6.2	
425.1	Pan Wt.			
0.0657	Reciprocal	0.04% is less than 0.3%		

Volume Swell

Age	Treat	%Swell	Spec.	Specimen Condition

"R-Value"

Extrude Pressure	
Expansion Pressure	
Equilibrium	

Micro-Deval / Sodium Sulfate

Micro-Deval Loss	%	Sodium Sulfate Loss	%

Adhesion

% Adhesion	Bitumen	Adhesive Agent

Checked & Approved	Date	Name

Distribution List

☐	District Administrator
☐	District Lab Supervisor
☐	Area Lab Supervisor
☐	Engr Project Manager
☐	Maintenance Superintendent
☐	Construction
☐	Preconstruction
☐	County File
☐	Surfacing Design
☐	Helena
☐	Master Lab File
☐	

Independent Assurance Comparison

Sieve	Field	Dist	Helena

REMARKS: See the following page for a written explanation of calculations used for this form (F123-E).

Calculations used on form F123-E

PLUS 4.75 mm (+4 MESH) MATERIAL - The total weight passing each sieve divided by the total weight of the initial sample taken (40.83 lbs.), multiplied by 100, results in the percent passing. EXAMPLE: 13.91 ÷ 40.83 = 0.34 X 100 = 34% The value is rounded and recorded to the nearest whole number.

MINUS 4.75 mm (-4 MESH) MATERIAL – (By Reciprocal Method). This sample is dried to a constant mass before and after washing. A reciprocal is determined by dividing the percent of material passing the 4 mesh (34.07%) by the mass of the minus 4 mesh sample (518.6 grams). This reciprocal (0.0657) is multiplied by the cumulative weight passing for each sieve size.

EXAMPLE: 518.6 - 146.5= 372.1; 372.1 x 0.0657 = 24.45% and is rounded down to and is recorded as 24%. The rounding is either up or down to the nearest whole number with the exception of the 200 mesh which is carried to one tenth of a percentage (6.2%). The result represents the percent passing in relation to the total sample.

The adjusted cumulative mass retained in the pan plus the Loss By Wash (LBW) mass should be within 0.3% of original dry mass of the total sample. EXAMPLE: 425.1+93.3=518.4, 518.6-518.4=0.2, (0.2/518.6)x100=0.04%

MONTANA DEPARTMENT OF TRANSPORTATION

Field Aggregate Chart - *Sample for Clinging Fines*

Project No.:_____ Contract No.:_____ Project Name: _____ Mat'ls. Suprv.: _____

Contract Item # _____ UPN : _____ Material # : _____

County: _____ Laboratory Pit No.: _____ Test For: _____

Pit Location: _____ Section: _____ Township: _____ Range: _____

Test No. _____ Lot No. _____ Date _____ Sampled By _____ Tested By _____

Stationing _____ Lift _____ Lane _____

Constant Mass Wt. 1 ____ Wt. 2 ____ Wt. 3 ____

Wt. of Sample Taken 25.23 Lbs. 100%

Wt. Retained 4-Mesh 11.59 Lbs. 45.94%

Wt. Passing 4-Mesh 13.64 Lbs. 54.06%

Before Wash 520.5 After Wash 448.0 LBW 72.5

Constant Mass Wt. 1 ____ Wt. 2 ____ Wt. 3 ____

Wt. of Orig. Sample Taken 25.23 Lbs.

Difference in Weight Passing 4 - Mesh 0.39 Lbs 1.55%

Before Wash 176.9 After Wash _____ LBW _____

Cum. Wt. Ret.	Size	Tot. Wt. Pass	Percent	Spec.
	4½"			
	4"			
	3½"			
	3"			
	2½"			
	2"			
	1½"			
	1¼"			
	1"			
0	⅝ ¾"	25.23	100	
1.29 lbs	½"	23.94	94.89	
4.69 lbs	⅜"	20.54	81.41	
* 11.59 lbs	4 M	13.64	54.06	
219.7 g	8/10 M	300.8	31.25	
375.8 g	40 M	144.7	15.03	
420.5 g	80 M	100.0	10.39	
447.9 g	200 M	72.6	7.54	
	Pan/Total			
	Reciprocal	0.1039		

* ±4 Mesh Sample Split and Sieved

Dust Ratio _____%
Moisture _____%
Fracture _____%
Liquid Limit _____
Plasticity Index _____

Cum. Wt. Ret.	Size	Tot. Wt. Pass	Percent	Spec.
	4½"			
	4"			
	3½"			
	3"			
	2½"			
	2"			
	1½"			
	1¼"			
	1"			
0	⅝ ¾"	25.23	100	
1.22 lbs	½"	24.01	95.16	
4.43 lbs	⅜"	20.80	82.44	
* 11.20 lbs	4 M	14.03	55.61	
19.9 g	8/10 M	157.0	1.38	
48.4 g	40 M	128.5	1.13	
90.0 g	80 M	86.9	0.76	
174.9 g	200 M	2.0	0.02	
	Pan/Total			
	Reciprocal	0.0088		

Dust Ratio _____%
Moisture _____%
Fracture _____%
Liquid Limit _____
Plasticity Index _____

Actual Grading % Passing	Size	% Clinging Fines
	4½"	
	4"	
	3½"	
	3"	
	2½"	
	2"	
	1½"	
	1¼"	
	1"	
100	⅝ ¾"	0
95.16	½"	0.27
82.44	⅜"	1.03
55.61	4 M	1.55
32.63	8/10 M	
16.16	40 M	
11.15	80 M	
7.56	200 M	
	Pan/Total	
	Reciprocal	

NOTE: Report the % Clinging Fines to the tenth, 1.6%

Dust Ratio _____%
Moisture _____%
Fracture _____%
Liquid Limit _____
Plasticity Index _____

Checked by _____ Date _____ Entered by _____ Date _____

REMARKS: **See the following page for a written explanation of calculations used for this form (F104C-E).**

Calculations used on form F104C-E

PLUS 4.75 mm (+4 MESH) MATERIAL - The total weight passing each sieve divided by the total weight of the initial sample taken (25.23 lbs.), multiplied by 100, results in the percent passing. EXAMPLE: 13.64 ÷ 25.23 = 0.5406 X 100 = 54.06%

MINUS 4.75 mm (-4 MESH) MATERIAL – (By Reciprocal Method). This sample is dried to a constant mass before and after washing. A reciprocal is determined by dividing the percent of material passing the 4 mesh (54.06%) by the mass of the minus 4 mesh sample (520.5 grams). This reciprocal (0.1039) is multiplied by the cumulative weight passing for each sieve size. EXAMPLE: 520.5 – 219.7= 300.8; 300.8 x 0.1039 = 31.25% and is rounded down to and is recorded as 31%. The rounding is either up or down to the nearest whole number with the exception of the 200 mesh which is carried to one tenth of a percentage (7.5%). The result represents the percent passing in relation to the total sample.

For the Actual Grading % Passing of the +4 MESH, use the second gradation.

To calculate the % of Clinging Fines on each sieve (change in percentage), take the percent from the +4 MESH of the second gradation and subtract the percent from the +4 MESH of the first gradation. EXAMPLE 95.16 – 94.89 = 0.27%

In order to calculate the Actual Grading % Passing the MINUS 4.75 mm (-4 MESH), the percent passing in the second gradation is added to the percent passing the first gradation. EXAMPLE: 31.25 + 1.38 = 32.63

The reciprocal for the second sieve analysis is calculated by taking the % of clinging fines on the +4 MESH and dividing it by the before wash weight of the second gradation. EXAMPLE: 1.55 ÷ 176.9 = 0.0088

The adjusted cumulative mass retained in the pan plus the Loss By Wash (LBW) mass should be within 0.3% of original dry mass of the total sample.
EXAMPLE: 447.9+72.5=520.4, 520.5-520.4=0.1, (0.1/520.5)x100=0.02%