

METHODS OF SAMPLING AND TESTING
MT 202-09
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:

2.1 AASHTO:

M231 Weighing Devices Used in the Testing of Materials
T11 Materials Finer Than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing
T27 Sieve Analysis of Fine and Coarse Aggregates

MT Manual:

MT-201 Sampling Roadway Materials
MT-405 Wire Cloth Sieves for Testing Purposes
MT-417 Reducing Field Samples to Testing Size

3 Apparatus:

- 3.1 *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.
- 3.2 *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 MT-405, Wire Cloth Sieves for Testing Purposes.
- 3.2.1 *Sieves*--A nest of two sieves, the lower being a 75- μ m (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 requirement of MT 405.
- 3.3 *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.
- 3.4 *Oven* - An oven of sufficient size, capable of maintaining a uniform temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) is required.
- 3.5 *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.

4 Preparation of Samples:

- 4.1 Samples for sieve analysis shall be prepared in accordance with MT-417, Reducing Field Samples 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.

4 Preparation of Samples: (continued)

4.2 Dry the sample at a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) to a constant mass. For control purposes, particularly where rapid results are desired, it is generally not necessary to dry coarse aggregate 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 ($\frac{1}{2}$ 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 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.

4.3 Samples are considered dry when complete separation of the coarse aggregate from the minus 4.75 mm (4 mesh) material is observed, and the material is dryer than SSD (Saturated Surface Dry). **NOTE: Two moisture checks per shift will be required.**

4.4 Representative samples will be graded to determine the percentage of fine material adhering to the coarser fractions. At least one sample shall be taken by field personnel at the start of production of aggregate. When material is being removed from the stockpile before production of aggregate has concluded, it is suggested that more samples be taken to insure uniform production. The Materials Bureau will require one sample from the material submitted for mix design.

4.5 *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

4.6 *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	(1 1/2)	15	(33)
50	(2)	20	(44)
63	(2 1/2)	35	(77)

Note 2 - For cover material, concrete aggregate, and samples that require a wear, cleanliness value test, the sample size sent to Helena must be doubled.

4.7 *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.

5 Procedure for Clinging Fines:

- 5.1 Follow the procedure in Section 4 for the original test. Save the plus 4.75 mm (4 mesh) material.
- 5.2 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.
- 5.3 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

- 5.4 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%)

6 Procedure for Aggregate without Clinging Fines:

- 6.1 The total sample as prepared in Section 4 shall be separated into a series of sizes. To determine compliance with the specifications for the material under test, avoid overloading the screens.
- 6.2 *Coarse Aggregate: Plus 4.75 mm (4 Mesh) Material* - The individual mass of the air dried 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..
- 6.2.1 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.
- 6.2.2 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.
- 6.3 *Fine Aggregate: Minus 4.75 mm (4 Mesh) Material* - At the completion of the sieving as described in Section 6.2, the entire minus 4.75 mm (4 mesh) portions shall be thoroughly mixed and reduced to a minimum of 500 grams.
- 6.3.1 After drying 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 3). 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.

6 Procedure for Aggregate without Clinging Fines: (continued)

Note 3 – 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.

6.3.2 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 4 – If mechanical washing equipment is used, the charging of water, agitating, and decanting may be a continuous operation.

Note 5 – 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.

6.3.3 Return all material retained on the nested sieves by flushing to the washed sample. Dry the washed aggregate to a constant mass. Constant mass has been reached when there is less than a 0.1 percent change after an additional 30 minutes of drying for ovens or when close control of temperature is not required, such as hot plates, an additional 20 minutes drying.

6.3.4 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.

Note 6 - A minimum drying time will be established and posted in the test trailer and checked periodically.

6.3.5 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.

6.3.6 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.

7 Sieving Procedure:

7.1 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 7.3.

7.2 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.

7.2.1 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.,

7.3 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

7 Sieving Procedure: (continued)

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.

- 7.4** 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.
- 7.5** 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 shaker 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 (3 1/2 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 (2 1/2 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 (1 1/2 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.

8 Calculations:

- 8.1** 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.
- 8.2** *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).
- 8.3** *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).

9 Report:

- 9.1** 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.

10 Hot Plant Mix Aggregates:

- 10.1** 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.

ARCHIVE

MBA Form No. 123
3255-1300
(Rev. 3-92)

Montana Department of Transportation
Materials Bureau
2701 Prospect Ave.
Helena, MT 59620-9726

District Lab. No. _____
Lab. No. _____ Sample _____ Hole _____ Project _____
Termini _____
Date Sampled _____ Date Received _____ Kind of Deposit _____
Sampled by _____ Title _____ Address _____
Submitted by _____ Title _____ Date _____
Quantity _____ Area by Stationing _____
Area is in _____ Sec. _____ T- _____ R- _____
Lab. No. _____ County _____
Owner _____ Address _____
Sta. and/or Tons Production Sample _____ Lift No. _____
Examined for 3/4" CTS A Gr. 2

Wt. of Sample Taken 11.84 Kg. 100.00 % LL _____ PL _____ PI _____
Wt. Retained 4-Mesh 6.40 Kg. 54.05 % Wear _____ % Fld. Agg. Chart No. _____
Wt. Passing 4-Mesh 5.44 Kg. 45.95 % Fracture _____ % Sp. Gr. (F) _____ (C) _____
Before Wash 478.7 After 450.7 LBW 28.0 Max. Dens. _____ Soil Class _____
Opt. Moist _____ Wt./Ft.³ _____
Dust Ratio _____ Sand Equiv. _____

Cum.wt.	Size	Wt.Pass.	Pct.	Spec.	VOLUME SWELL			Specimen
					Age	Treat.	% Swell	Spec.Condition
_____	114 mm	_____	_____	_____	_____	_____	_____	_____
_____	100 mm	_____	_____	_____	_____	_____	_____	_____
_____	90 mm	_____	_____	_____	_____	_____	_____	_____
_____	75 mm	_____	_____	_____	_____	_____	_____	_____
_____	63 mm	_____	_____	_____	_____	_____	_____	_____
_____	50 mm	_____	_____	_____	_____	_____	_____	_____
_____	37.5mm	_____	_____	_____	_____	_____	_____	_____
_____	31.5mm	_____	_____	_____	_____	_____	_____	_____
_____	25 mm	<u>11.84</u>	<u>100</u>	_____	_____	_____	_____	_____
<u>1.22</u>	16,19mm	<u>10.62</u>	<u>90</u>	_____	_____	_____	_____	_____
<u>3.55</u>	12.5 mm	<u>8.29</u>	<u>70</u>	_____	_____	_____	_____	_____
<u>5.05</u>	9.5 mm	<u>6.79</u>	<u>57</u>	_____	_____	_____	_____	_____
<u>6.40</u>	4.75mm	<u>5.44</u>	<u>46</u>	_____	_____	_____	_____	_____
<u>149.5</u>	2.36/2.0mm	<u>329.2</u>	<u>32</u>	_____	_____	_____	_____	_____
<u>319.1</u>	.425 mm	<u>159.6</u>	<u>15</u>	_____	_____	_____	_____	_____
<u>417.1</u>	.180 mm	<u>61.6</u>	<u>6</u>	_____	_____	_____	_____	_____
<u>450.7</u>	.075 mm	<u>28.0</u>	<u>2.7</u>	_____	_____	_____	_____	_____

CHECKED AND APPROVED Name _____ Date _____

REMARKS: PLUS 4.75 mm (4 MESH) MATERIAL - The total weight passing each sieve divided by the total weight of the sample (11.84 Kg.), multiplied by 100, results in percent passing.
EXAMPLE: $5.44 \div 11.84 = 0.46 \times 100 = 46\%$

MINUS 4.75 mm (4 MESH) MATERIAL - (By reciprocal method) A reciprocal is determined by dividing the percent of material passing the 4 mesh (45.95) by the weight of the minus 4 mesh sample before washing (478.7 grams). This reciprocal (0.09599) multiplied by the various total weights passing, results in the percent passing in relation to the total sample.

Form 104 (Rev. 11/87)
3255-1150
MT270

DEPARTMENT OF TRANSPORTATION
FIELD AGGREGATE CHART

Project No. **(Sample for Clinging Fines)** Designation _____ Mat'ls. Supvr. _____
 County _____ Laboratory Pit No. _____ Test For _____
 Pit Location _____ Section _____ Township _____ Range _____
 Test No. _____ Lot No. _____ Test No. _____ Lot No. _____ Test No. _____ Lot No. _____
 Date _____ Date _____ Date _____
 Sampled By _____ Sampled By _____ Sampled By _____
 Tested By _____ Tested By _____ Tested By _____
 Stationing _____ Stationing _____ Stationing _____
 Lift _____ Lane _____ Lift _____ Lane _____ Lift _____ Lane _____

Wt.of Sample Taken 25.23 lbs. 100 %
 Wt.Retained 4-Mesh 11.59 lbs. 45.9 %
 Wt.Passing 4-Mesh 13.64 lbs. 54.1 %
 Bef.Wash 520.5 Aft.Wash 448.0 LBW 72.5

Wt.of Orig. Sample Taken 25.23 lbs.
 Difference in Weight _____
 Passing 4-Mesh 0.39 lbs. 1.55 %
 Bef.Wash 176.9 Aft.Wash _____ LBW _____

Wt.of Sample Taken _____ lbs. 100 %
 Wt.Retained 4-Mesh _____ lbs. _____ %
 Wt. Passing 4-Mesh _____ lbs. _____ %
 Bef.Wash _____ Aft.Wash _____ LBW _____

Cum.Wt.	Size	Tot.Wt. Pass.	%	Cum.Wt.	Size	Tot.Wt. Pass.	%	Act.Grading % Passing	Size	% Clinging Fines
_____	4 1/2"	_____	_____	_____	4 1/2"	_____	_____	_____	4 1/2"	_____
_____	4"	_____	_____	_____	4"	_____	_____	_____	4"	_____
_____	3 1/2"	_____	_____	_____	3 1/2"	_____	_____	_____	3 1/2"	_____
_____	3"	_____	_____	_____	3"	_____	_____	_____	3"	_____
_____	2 1/2"	_____	_____	_____	2 1/2"	_____	_____	_____	2 1/2"	_____
_____	2"	_____	_____	_____	2"	_____	_____	_____	2"	_____
_____	1 1/2"	_____	_____	_____	1 1/2"	_____	_____	_____	1 1/2"	_____
_____	1 1/4"	_____	_____	_____	1 1/4"	_____	_____	_____	1 1/4"	_____
_____	1"	_____	_____	_____	1"	_____	_____	_____	1"	_____
0	3/4"	25.23	100	0	3/4"	25.23	100	100	3/4"	0
1.29 lbs.	1/2"	23.94	94.89	1.22 lbs.	1/2"	24.01	95.16	95.16	1/2"	.27
4.69 lbs.	3/8"	20.54	81.41	4.43 lbs.	3/8"	20.80	82.44	82.44	3/8"	1.03
11.59 lbs.	4 M	13.64	54.06	11.20 lbs.	4 M	14.03	55.61	55.61	4 M	1.55
* 219.7 g	8/10 M	300.8	31.24	19.9 g	8/10 M	157.0	1.38	32.62	8/10 M	_____
375.8 g	40 M	144.7	15.03	48.4 g	40 M	128.5	1.13	16.16	40 M	_____
420.5 g	80 M	100.0	10.39	90.0 g	80 M	86.9	0.76	11.15	80 M	_____
447.9 g	200 M	72.6	7.54	174.9 g	200 M	2.0	0.02	7.56	200 M	_____
_____	Total	_____	_____	_____	Total	_____	_____	_____	Total	_____

*-4 Mesh Sample Split and Sieved

-4+10 _____ %	-4+10 _____ %
Dust Ratio _____ %	Dust Ratio _____ %
Moisture _____ %	Moisture _____ %
Fracture _____ %	Fracture _____ %
Liquid Limit _____	Liquid Limit _____
Plasticity Index _____	Plasticity Index _____
Checked By _____	Date _____ Entered By _____

Note: Report the Percent Clinging Fines as 1.6%

-4+10 _____ %
Dust Ratio _____ %
Moisture _____ %
Fracture _____ %
Liquid Limit _____
Plasticity Index _____
Date _____