Technician Certification

Aggregate

MoDOT

COURSE CONTENT

Aggregate Technician

AASHTO	T 2	Sampling of Aggregates
AASHTO	T 248	Reducing Samples of Aggregate to Testing Size
AASHTO	T 11	Materials Finer than No. 200 by Washing
AASHTO	T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO	T 255	Total Moisture Content of Aggregates by Drying
MoDOT	TM 71	Deleterious Content of Aggregates
ASTM	D4791	Flat & Elongated particles in Coarse Aggregate
GLOSSARY		Glossary of Terms
MTRAC		MTRAC (Informational Only)

AASHTO T 2

Sampling of Aggregates

AASHTO T 2

SAMPLING OF AGGREGATES

Sampling of Aggregates

- Safety
- Secure a representative sample
- Random
  - By either using random number set or multiple increments at different locations.
- Avoid short-term variations
  (clay pockets, boulders or varying seams)
- At least three increments

Aggregate Sampling Procedures

- Flowing Aggregate Stream (Bins or Belt Discharge)
- Conveyor Belt
- Stockpiles or Transportation Units
- Roadway (Bases and Subgrade)

Reasons for Sampling

- Initial Approval – Ledge sample for determination of possible use.
- Source Approval – Final product sample for quality determination.
- QC/QA Sampling – Taken at the mixing plant or roadway.
- Acceptance – Making sure final product meets specification.

Segregated Stockpile

Show Stockpile Video

Aggregate Sample Size

MoDOT Specified Values

Maximum Size of Particle	Minimum Weight [Mass] of Sample lb. (kg)
2" [50 mm]	80 (36)
1-½" [37.5 mm]	54 (25)
1" [25.0 mm]	36 (16)
¾" [19.0 mm]	22 (10)
½" [12.5 mm]	14 (6)
⅜" [9.5 mm]	10 (5)

Aggregate Sample Size

- Maximum size particle is defined as the smallest size through which 100% of the material will pass.
- AASHTO specifies sample sizes of an alternate amount than MoDOT.
- These amounts can be found in the test method.

Note: For the proper sample size for shipping to the Central Laboratory, refer to the Engineering Policy Guide (EPG) section 1001.2.1

Shipping Samples

- Proper container
  - Generally bags made for shipping aggregates, or other suitable containers that prevent contamination or loss during shipment.
- Proper identification
  - It is a good idea to place identification information both inside and outside of the shipping container.

Safety Equipment

- Hardhat
- Safety Vest
- Steel-toe Boots
- Goggles or Safety Glasses
- Ear Plugs or Ear Muffs
- Dust Mask

Flowing Aggregate Stream Sample

Flowing Aggregate Stream Sampling Equipment

- Safety equipment
- Sampling device

Flowing Aggregate Stream Procedure

- Rapidly pass the sampling device through the entire cross-section of the stream flow.
- Plant operating at usual rate
- Catch entire flow
- 3 or more equal increments
- Obtain necessary sample size

Conveyor Belt Sampling Equipment

- Safety equipment
- Template
- Scoop or trowel
- Brush or broom
- Proper containers

Conveyor Belt Sampling Procedure

- Stop belt and insert template
- Remove aggregate inside template with scoop or hand
- Brush fines into container
- 3 or more equal increments
- Obtain necessary sample size

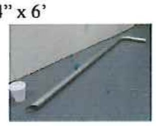
Belt Sample Template

Belt Sampling

- Stop belt and insert template
- Remove aggregate inside template with scoop or hand
- Brush fines into container
- 3 or more equal increments

Stockpile Sampling Equipment

- Safety equipment
- Sampling tube, (aka sample thief)
  - Fine aggregate only, approximately 1 1/4" x 6'
- Square-nosed shovel
- Flat board
- Sample containers, tags, etc.
- Front-end loader (if available)



Loader Stockpile

Stockpile Sampling Procedure

- If a front-end loader is available, create a small, representative stockpile
- Combine several increments to compose the field sample

Stockpile Sampling from Original Stockpile

- If **NO** front-end loader is available
- ***Coarse Aggregates*** - Use shovel & board to collect sample
  - Insert board vertically above sampling point to reduce segregation

Stockpile Sampling from Original Stockpile

- Sample from top third, midpoint, and bottom third of the stockpile for coarse aggregate (At least 3 increments)

Stockpile Sampling from Original Stockpile

- ***Fine Aggregates*** - After removing the outer layer, sample with tube, a minimum of 5 locations for fine aggregate

Transportation Unit Sampling

This method is not a recommended procedure for sampling due to safety concerns. The process to complete this sampling is outlined in the MTRAC attachment for your information.

Roadway Base Sampling Equipment

- Safety equipment
- Square-nosed shovel
- Square or rectangular template
- Sample containers, tags, etc.

Roadway Base Sampling Template

Roadway Base Sampling Procedure

- Locations selected at random per ASTM D3665
- For QC/QA sampling, take one increment behind the spreader before compaction.
- When sampling for other purposes, (i.e. Not using random numbers to select location) a minimum of three approximately equally increments should be taken.

Roadway Base Sampling Procedure

•Clearly mark the specific area from which material is to be removed.

•Take sample for full depth of material.

•Take care to exclude any underlying material.

•A metal template will aid in securing sample.

Common Errors
(All Methods)

- Using improper sampling device.
- Sampling in segregated areas.
- Not obtaining enough increments.
- Improper sampling method for aggregate types (sand, fine aggregate, coarse aggregate).
- Allowing overflowing in a stream flow device.

1001.3 Sampling Procedures

Sampling procedures shall be in accordance with AASHTO T2. Portions shall be combined and reduced in accordance with AASHTO T248.

When sampling a stockpile, it is recommended that separate samples be taken from different parts of the pile, care being taken to avoid any segregated areas and bearing in mind that the material near the base of the pile is likely to be segregated and coarser than the average of the material in the stockpile.

Table 1001.3 Size of Original Field Samples

Maximum Size of Particle[1]	Minimum Weight (Mass) of Sample, lb. (kg)[2]
2" (50 mm)	80 (36)
1-1/2" (37.5 mm)	54 (25)
1" (25.0 mm)	36 (16)
3/4" (19.0 mm)	22 (10)
1/2" (12.5 mm)	14 (6)
3/8" (9.5 mm)	10 (5)
[1] Maximum size of particle is defined as the smallest sieve through which 100 percent of the material will pass.	
[2] The samples prepared for testing shall be obtained from the field sample in accordance with AASHTO T248	

1001.4 Types of Samples

1001.4.1 Initial Evaluation

Sampling for initial evaluation shall be done by, or under the supervision of the District Geologist.

1001.4.1.1 Mines and Quarries

Producers should be reminded that all quarries will be sampled initially on a "ledge" basis regardless of intended use. The initial sample will be obtained for Central Laboratory testing from each ledge of stone that varies from the adjacent material. Sampling shall be in compliance with all federal, state and local safety requirements. It is suggested that the sample be obtained from the pile after each ledge has been excavated.

AASHTO T2: Sampling of Aggregates
PROFICIENCY CHECKLIST

Applicant________________________________

Employer________________________________

Trial #	1	2
Sampling Stream with a Sample Catcher		
1. Pass sample device through entire cross-section of stream		
2. Pass device through stream rapidly enough to prevent any overflow of material during the sampling process		
3. Minimum of 3 passes		
Conveyor Belt Check List		
1. Insert template into aggregate on stopped conveyor belt		
2. Remove all the aggregate from the belt		
3. Obtain at least 3 increments for each field sample		
Sampling Coarse Aggregate Stockpiles With Loader		
1. Create small stockpile from various levels and locations from main pile		
2. Combine several increments to compose field sample		
Sampling Coarse Aggregate Stockpiles Without Loader		
1. Insert board vertically above sampling point		
2. Minimum of 3 increments should be sampled		
3. Places must include areas of top, middle, and bottom areas		
Sampling Fine Aggregate Stockpile with a Sample Tube		
1. Stockpile must be sampled a minimum of 5 places		
Sampling from a Roadway Base Location		
1. Obtain at least 1 increment, using random number set. (Alternately 3 increments if not using random numbers to determine location)		
2. Use a square nose shovel to aide in defining sample area		
3. Get full depth without accessing underlying material		

Pass Pass

Fail Fail

Examiner:________________________________ Date:________________

AASHTO T 248

Reducing Samples of Aggregate

To Testing Size

AASHTO T 248

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

Terms

- Nominal Maximum Size
- Saturated Surface Dry (SSD)
- Air Dry
- Fine Aggregate
- Coarse Aggregate
- Combined Aggregate

AASHTO T 248 2

Reducing Samples of Aggregate to Testing Size

Reducing Methods

- Mechanical Splitter
- Quartering
- Miniature Stockpile

AASHTO T 248 3

Summary of Sample Reduction

- Minimize the chance of variability during handling
- Reduction method depends on maximum aggregate size (as defined in AASHTO T 2), moisture content and available equipment
- A sample collected in two or more increments shall be thoroughly mixed before reducing.

AASHTO T 248 4

Appropriate Reduction Methods

Mechanical Splitter	Quartering	Miniature Stockpile
Fine Aggregates – Air Dry	Fine Aggregates – Free Moisture on the Particle Surface	Fine Aggregate – Free Moisture on the Particle Surface
Coarse Aggregates	Coarse Aggregates	Not Appropriate for Coarse Aggregates
Combined Aggregates	Combined Aggregates with free moisture on the Particle Surface	Not Appropriate for Combined Aggregates

AASHTO T 248 5

Mechanical Splitter Equipment

- Mechanical splitter –
  - even number of openings
  - minimum chute size (50% larger than Nominal Maximum Size)
    - (i.e. ¾"agg. = 1 ½" Opening, ½" increments)
  - at least 8 openings for coarse aggregate
  - at least 12 openings for fine aggregate
- Clean Catch pans
- The hopper or pan used to introduce the material into the splitter shall have a width equal to or slightly less than the overall width of the assembly of chutes.

AASHTO T 248 6

Mechanical Splitter

AASHTO T 248 7

Mechanical Splitter Sample Preparation

- Sample should be air-dry
- Clean chutes between splits
- Large samples should be representative of the material. Blending may be necessary.

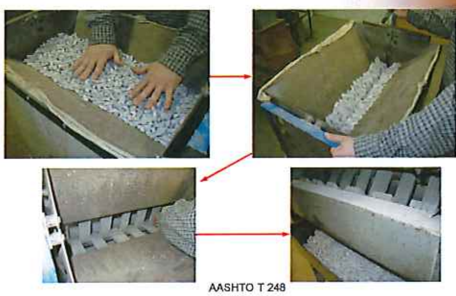
AASHTO T 248 8

Mechanical Splitter Sample Procedure

- Uniformly distribute sample through chutes
- Aggregate should flow freely through the openings
- Do not overfill catch pans
- Split as necessary to obtain desired sample size

AASHTO T 248 9

Mechanical Splitter Sample Procedure



AASHTO T 248 10

Quartering Method Equipment

- Straight-edged scoop
- Square-nosed shovel or trowel
- Broom or brush
- Canvas blanket for alternate method

AASHTO T 248 11

Quartering Method Preparation for Aggregates

- Fine or combined aggregates must be in moist condition
- When reducing fine aggregates, the sample should be wet enough to stand in a vertical face
- The preferred method of splitting coarse aggregates is the Mechanical Method

AASHTO T 248 12

Quartering Method Procedure
for Aggregates

- Mix thoroughly (at least 3 times)
- Make a conical pile
- Flatten evenly so diameter is 4-8 times the thickness


AASHTO T 248 13

Quartering Method Procedure
for Aggregates

- Divide pile into 4 equal parts
- Remove the opposite quarters, including fines


AASHTO T 248 14

Quartering Method Procedure
for Aggregates

- Mix and quarter the remaining material until desired sample size is reached
- Save the unused portion until testing is completed

AASHTO T 248 15

Quartering Method Procedure
for Aggregates

AASHTO T 248 16

Alternate Method B for Quartering

- Use blanket in place of hard, clean, level surface
- Mixing may be accomplished by rolling the blanket

AASHTO T 248 17

Miniature Stockpile Method Equipment

- Shovel or trowel (for mixing the aggregate)
- Straight-edged scoop
- Small sampling thief, small scoop, or spoon.

AASHTO T 248 18

Miniature Stockpile Method Preparation

- Method only used for reducing fine aggregate
- Sample must be in moist condition

AASHTO T 248 19

Miniature Stockpile Method Procedure

- Mix sample by turning at least 3 times with a shovel on clean, level, hard surface
- Shovel into a conical pile by placing each scoop onto the preceding one

AASHTO T 248 20

Miniature Stockpile Method Procedure

- Obtain at least 5 increments of material from random locations in the pile

AASHTO T 248 21

Common Errors

- Improper method for reduction based on moisture content
- Using wrong size chute openings
- Failure to introduce sample to chutes evenly
- Failure to use proper flow rate while splitting

AASHTO T 248 22

AASHTO T 248: Reducing Field Samples of Aggregate to Testing Size
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
Insure method of reducing matches type, size and moisture conditions of sample.		
Method A - Splitting		
1. Material spread uniformly on feeder, avoiding segregation.		
2. Rate of feed slow enough so that sample flows freely through chutes.		
3. Material in one pan re-split until desired weight is obtained.		
Method B - Quartering		
1. Sample placed on clean, hard, level surface. (See Note below)		
2. Mixed by turning over 3 times with shovel or by raising canvas and pulling over pile.		
3. Conical pile formed.		
4. Pile flattened to uniform thickness and diameter.		
5. Diameter about 4 to 8 times thickness.		
6. Divided into 4 equal portions with shovel or trowel. (See Note below)		
7. Two diagonally opposite quarters, including all fine material, removed.		
8. Cleared space between quarters brushed clean.		
9. Process continued until desired sample size obtained **NOTE:** The sample may be placed upon a canvas quartering cloth and a stick or pipe may be placed under the cloth to divide the pile into quarters		

Method C – Miniature Stockpile (Fine Aggregate Only)		
1. Sample placed on clean, hard, level surface.		
2. Material thoroughly mixed by turning over three times.		
3. Small stockpile formed.		
4. At least 5 grab samples taken at random with sampling thief, small scoop or spoon.		

Pass Pass

Fail Fail

Examiner:__________________________________ Date:________________________

AASHTO T 11

Materials Finer Than

No. 200 By Washing

AASHTO T 11

MATERIALS FINER THAN #200 (75 µm) SIEVE IN MINERAL AGGREGATES BY WASHING

Scope

- This test washes the fine particles through the #200 (75 µm) sieve to give an accurate determination of minus #200 portion in the sample.

AASHTO T 11 2

Equipment

- Balance
- Sieves (#200, and a #8 or #16 to prevent damage of the #200)
- Big pan
- Oven or Hotplate
- Wetting agent as needed
- Water

AASHTO T 11 3

Sample Preparation

Table 1 – Sample Mass Requirements

Nominal Maximum Size, in.(mm)	Minimum Weight of Sample, grams
#4 (4.75)	500
3/8" (9.5)	1000
3/4" (19.0)	2500
>= 1 ½" (37.5)	5000

Nominal Maximum is defined as the smallest sieve which 100% of sample passes.

Procedure

- Check #200 sieve for damage
- Dry sample
- Allow to cool
- Weigh and record
- Place sample in pan

AASHTO T 11 5

Procedure

- Add water and agitate
- Add wetting agent as necessary (Optional)
  - Should generate a small amount of suds when agitated
  - Only once per sample
- Pour excess water over nested sieves.

AASHTO T 11 6

Procedure

- Continue washing until water is clear.
- Combine, material retained on sieves with washed sample, in pan suitable for oven drying.
- Oven dry at 230 ± 9 °F (110 ± 5°C) to a constant mass
  - May use hot plate, stirring frequently to avoid overheating
- Allow to cool and record weight to nearest 0.1 % of the mass of the test sample. **(Typically 1 gram)**

AASHTO T 11 7

Calculations

$$A = \frac{(B - C)}{B} * 100$$

A = Total % passing #200 (75 μm) sieve

B = Original dry mass of sample

C = Dry mass of sample after washing and drying to constant mass

AASHTO T 11 8

Calculations

- Report the percentage of material finer than the #200 (75 μm) sieve to the nearest 0.1 %, except if the result is 10 % or more, then report the percentage to the nearest whole number

AASHTO T 11 9

Sample Calculations

$$A = \frac{(B-C)}{B} * 100$$

$$B = 532.3 grams$$

$$C = 521.6 grams$$

$$A = \frac{(532.3 - 521.6)}{532.3} * 100$$

$$A = 2.0\%$$

AASHTO T 11 10

Classroom Exercise

Determine the percent of minus #200 material given:
Original weight (B) = 5359 gms
Washed weight (C) = 5262 gms

AASHTO T 11 11

Common Errors

- Overloading wash sieve
- Losing sample when transferring or washing
- Using a damaged #200 (75 μm) sieve

AASHTO T 11 12

AASHTO T11: Materials Finer Than No. 200 By Washing
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
1. Test sample dried to constant mass at 230±9°F (110±5°C).		
2. Test sample mass determined to 0.1%.		
3. #200 sieve checked for damage. Cover with #8 or #16 sieve.		
4. Sample placed in container and covered with water.		
5. Wetting agent added. (optional)		
6. Sample and contents of container vigorously agitated.		
7. Complete separation of coarse and fine particles.		
8. Wash water poured through sieve nest.		
9. Wash water free of coarse particles.		
10. Operation continued until wash water is clear.		
11. Material on sieves returned to washed sample.		
12. Excess water decanted from washed sample only through the #200 sieve.		
13. Washed aggregate dried to constant mass at 230±9°F (110±5°C).		
14. Washed aggregate mass determined to 0.1%.		
15. Calculation: $\% \text{ less than \#200} = \frac{\text{Orig. dry mass} - \text{Final dry mass}}{\text{Orig. dry mass}} \times 100$		

Pass Pass

Fail Fail

Examiner:______________________________ Date:____________________

AASHTO T 27

Sieve Analysis of Fine and

Coarse Aggregates

AASHTO T 27

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

Scope

- Sieve analysis of aggregate is used to determine compliance with design, production control requirements, and verification of specifications
- Generally used with AASHTO T 11
- According to AASHTO, either cumulative or non-cumulative methods may be used

Test Equipment

- Balance
- Sieves
- Brush
- Mechanical shaker, if available
- Oven or Hotplate
- Pans for material weighing

Sieve Problems

- Check condition of sieves for indications of the following problems prior to use.
  - Holes
  - Tears
  - Unevenly spaced wires
  - Cracks around rim
  - Bowed screens

AASHTO T 27 4

Checking Sieve Thoroughness

- Periodically check thoroughness
  - Strike side of sieve with heel of hand at a rate of 150 times per minute, turning about 1/6 turn every 25 strokes.
  - Use pan and lid to prevent loss.
  - If the mass passing is > 0.5 % of total sample weight, in 1 minute of shaking, additional shaking is needed.

AASHTO T 27 5

Sieving Accuracy

Final total mass, is within 1 gram per sieve used, of the original mass.

NOTE: This procedure is specified in the Engineering Policy Guide. It is a variation from the stated procedure in AASHTO.

AASHTO T 27 6

Sieve Overloading

- Avoid overloading sieves
  - (mass retained in excess of 2.5x the sieve opening)
- Table in next slide indicates acceptable loading

AASHTO T 27 7

Table 1 from AASHTO T 27

From Table X1.1 Maximum Allowable Quantity of Material Retained on a Sieve

Sieve Designation, mm (in.)	Nominal Dimensions of Sieves, mm (in.)		
	203.2 (8 in.)	254 (10 in.)	304.8 (12 in.)
	Sieving Area, square meters		
	0.028502	0.04573	0.067012
37.5 (1 1/2 in.)	2.67 kg	4.29 kg	6.28 kg
25 (1 in.)	1.78 kg	2.86 kg	4.19 kg
19 (3/4 in.)	1.35 kg	2.17 kg	3.18 kg
12.5 (1/2 in.)	0.89 kg	1.43 kg	2.09 kg
9.5 (3/8 in.)	0.67 kg	1.09 kg	1.59 kg
4.75 (#4)	0.33 kg	0.54 kg	0.80 kg

AASHTO Definition

- The Nominal Maximum Aggregate Size definition for T 27 is the smallest sieve that the specification for the material being tested allows for 100% of the material to pass.

AASHTO T 27 9

MoDOT Sample Sizes for Aggregate Gradation
(MoDOT EPG Section 1001.4.1.2)

Maximum Size Agg. in. (mm)	Minimum Mass of Test Sample lb. (kg)
3/8" (9.5)	2.5 (1)
1/2" (12.5)	3.5 (1.5)
3/4" (19.0)	5.5 (2.5)
1" (25.0)	9 (4)
1 ½" (37.5)	13.5 (6)

Fine Aggregate after drying shall be min. 500 grams

AASHTO Sample Size

- AASHTO T-27 defines alternate sample weights that can be used for the completion of the this test method.

AASHTO T 27 11

Sample Preparation

- Determine Nominal Maximum Aggregate Size.
- Obtain and reduce to test size.
- Dry @ 230 ± 9°F (110 ± 5° C) to constant mass or use material from AASHTO T 11.
- Allow to cool
- Weigh the dried sample

AASHTO T 27 12

Sieve Analysis Procedure

- Assemble the required sieves

AASHTO T 27 13

Sieve Analysis Procedure

- Agitate and shake until graded

AASHTO T 27 14

Sieve Analysis Procedure

- If a mechanical shaker is used, be sure to hand shake each sieve after removing from shaker.
- Hand-sieve only on particles larger than 3" (75 mm)
  - (No mechanical allowed)

AASHTO T 27 15

Sieve Un-Loading and Cleaning

- Gently clean out openings
  - $\geq$ #30 use wire brush
  - < #30 use soft bristle brush
    - May lightly brush with fingers.

AASHTO T 27 16

Procedure for Cumulative Process

- Tare out a pan
- Place material retained on largest sieve in tarred pan and record the weight to the nearest 0.1% of the total mass, typically 1 gram
- ***Do not zero scale.*** Add material from next sieve to pan.
- Record weight

AASHTO T 27 17

Procedure for Cumulative Process

- Continue with each successive sieve until all but pan weight (Minus #200) is added and recorded.
- Tare out a pan
- Weigh the material in the pan (Minus #200) and record

AASHTO T 27 18

Calculations for Cumulative Process

- Percent passing =

[1 - (cumulative wt. / original dry wt.)] *100

- Repeat process for all sieves, except the pan.
- For pan (Minus #200)…[(Loss(From T 11) + pan wt.) / original dry wt.] X 100 = percent passing #200

AASHTO T 27 19

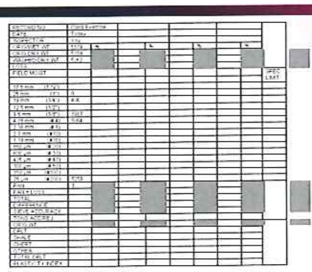
Sieve Size	Cumulative Weight	Calculation	Reported Value
1"	0	100.0	100
3/4"	429	91.8	92
3/8"	3885	26.0	26
No. 4	5161	1.7	2
No. 200	5234		
Minus 200	15	0.3	0.3

Pan	1
T 11 Loss	14
Total - 200	15

Original Weight	5248
Weight Weighed	5249
Difference	1
Allowed	5
Acceptable Error	Yes

Cumulative Calculation Example

Classroom Exercise Cumulative



AASHTO T 27 21

Cumulative Calculation Example

Lab. No.:	Cumulative Calculation Example		
Material:		Grad. No:	
Co. & Proj.#:			
Producer:	1" Concrete		
Contractor:			
Sampled By:		Date:	
Sample Loc.:			

Original Dry Mass:	(A) 5082
Dry Mass Washed:	5015
Washing Loss:	67

Sieve Size	Indiv. Sieve Weight Retd.	Total Retained	% Retained	% Passing
37.5mm(1½")				
25mm (1")	0	0	0	100
19mm (¾")	918	918	18	82
12.5mm (½")	3168	4086	80	20
9.5mm (⅜")	603	4689	92	8
4.75mm (#4)	257	4946	97	3
2.36mm (#8)	33	4979	98	2
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
150µm (#100)				
75µm (#200)	32	5011		
Wash	67			
Pan	3			
Total Minus #200	70			1.4
Total Weight Retained, Pan and Wash	(B) 5081			

Accuracy Check = (A-B) = Less than 1/sieve?

= (5082 - 5081) = 1

Procedure for Non-Cumulative Process

- Tare out a pan
- Weigh material retained on each sieve and record to nearest 0.1 % by total mass, typically 1 gram
- Weigh the material in the pan (Minus #200) and record

AASHTO T 27 22

Calculations for Non-Cumulative Process

- Percent passing =
  (weight passing / original dry wt.) x 100
- Repeat process for all sieves, except the pan.
- For pan (Minus #200)…
  (Loss(From T 11) + pan wt.) / original dry wt. *100 = percent passing #200

AASHTO T 27 23

Sieve Size	Retained Weight	Total Weight Passing	Calculation	Reported Value
1"	0	5248	100.0	100
3/4"	429	4819	91.8	92
3/8"	3456	1363	26.0	26
No. 4	1276	87	1.7	2
No. 200	73			
Minus 200	15	15	0.3	0.3

Pan	1
T 11 Loss	14
Total - 200	15

Original Weight	5248
Weight Weighed	5249
Difference	1
Allowed	5
Acceptable Error	Yes

Non-Cumulative Process Example

Non-Cumulative Process Example

Lab. No.:	Non-Cumulative Calculation Example		
Material:		Grad. No:	
Co. & Proj.#:			
Producer:	1" Concrete		
Contractor:			
Sampled By:		Date:	
Sample Loc.:			

Original Dry Mass:	(A) 5082
Dry Mass Washed:	5015
Washing Loss:	67

Sieve Size	Indiv. Sieve Weight Retd.	Weight Passing		% Passing
37.5mm(1½")				
25mm (1")	0	5082		100
19mm (¾")	918	4164		82
12.5mm (½")	3168	996		20
9.5mm (⅜")	603	393		8
4.75mm (#4)	257	136		3
2.36mm (#8)	33	103		2
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
150µm (#100)				
75µm (#200)	32	71		
Wash	67			
Pan	3			
Total Minus #200	70			1.4
Total Weight Retained, Pan and Wash(B)	5081			

Accuracy Check = (A-B) = Less than 1/sieve?

= (5082 - 5081) = 1

Classroom Exercise Non-Cumulative

Original

Weight (C) ________ [illegible]g

Washed Wt. = ________ [illegible]g

Weight Loss = ________ g

% Passing = ________ %

No. 200 Sieve

(Sieve Analysis of Fine and Coarse Aggregates)

		Calculations	
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING
1	0	5359	
¾	406		
½			
3/8	3581		
No. 4	1077		
No. 8			
No. 16			
No. 200	134	(A)	
Minus No. 200 Material			
PAN	3 g		
T11 Loss	g	% Passing No. 200	
Total - #200	g (B)		

Accuracy Check = (A - B) = Less than 1%sieve?
= (______ - ______) = ______

AASHTO T 27 25

Reporting

- All values for the percent passing are reported to the nearest whole number (1) for all sieves except for the #200 (75μm).
- The #200 is reported to the nearest whole number (1) for values ≥ 10%.
- The #200 is reported to the nearest tenth (0.1) for values below 10%

AASHTO T 27 26

Common Errors

- Insufficient sample size
- Overloading sieves
- Loss of material when transferring from sieve to weighing pan
- Insufficient cleaning of sieves
- Using worn or cracked sieves
- Sieving not thorough

AASHTO T 27 27

Lab. No.:	Cumulative Calculation Example	
Material:		Grad. No: Classroom Exercise
Co. & Proj.#:		
Producer:	1" Concrete	
Contractor:		
Sampled By:		Date:
Sample Loc.:		

Original Dry Mass:	(A) 5226
Dry Mass Washed:	5195
Washing Loss:	

Sieve Size	Indiv. Sieve Weight Retd.			% Passing
37.5mm(1½")				
25mm (1")	0			
19mm (¾")	464			
12.5mm (½")	2304			
9.5mm (⅜")	1162			
4.75mm (#4)	1182			
2.36mm (#8)	53			
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
150µm (#100)				
75µm (#200)	26			
Wash				
Pan	2			
Total Minus #200				
Total Weight Retained, Pan and Wash	(B)			

Accuracy Check = (A-B) = Less than 1/sieve?

= (__________ - __________) = __________

Lab. No.:	Non-Cumulative Calculation Example	
Material:		Grad. No: Classroom Exercise
Co. & Proj.#:		
Producer:	1" Concrete	
Contractor:		
Sampled By:		Date:
Sample Loc.:		

Original Dry Mass:	(A) 5226
Dry Mass Washed:	5195
Washing Loss:	

Sieve Size	Indiv. Sieve Weight Retd.			% Passing
37.5mm(1½")				
25mm (1")	0			
19mm (¾")	464			
12.5mm (½")	2304			
9.5mm (⅜")	1162			
4.75mm (#4)	1182			
2.36mm (#8)	53			
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
150µm (#100)				
75µm (#200)	26			
Wash				
Pan	2			
Total Minus #200				
Total Weight Retained, Pan and Wash	(B)			

Accuracy Check = (A-B) = Less than 1/sieve?

= (__________ - __________) = _________

1001.5 Field Testing Procedures

1001.5.1 Sieve Analysis

The frequency of aggregate Quality Assurance tests shall be in accordance with the specifications. This includes retained samples from quality control tests and independent samples. Sieve analysis of mineral filler shall be in accordance with AASHTO T37. Sieve analysis for the determination of particle size distribution of coarse and fine aggregate shall be performed in accordance with AASHTO T27 and T11, with the following exceptions.

1001.5.1.1 Apparatus

Sample being split

(a) Stove - Electric, natural gas, propane, or other suitable burner capable of maintaining a controlled temperature, may be used in lieu of an oven.

(b) Pans - Pans of sufficient size and quantity for washing and drying samples and for holding separated fractions of material.

(c) Brass sieve brush.

(d) Large spoon or trowel.

(e) Sample splitter.

1001.5.1.2 Sample Preparation

Samples of aggregate for sieve analysis shall be taken in accordance with EPG 1001.3 Sampling Procedures and reduced to the proper size for testing in accordance with AASHTO T248. The sample for testing shall be approximately the size shown below and shall be the end result of the sampling method. The selection of samples of an exact predetermined weight (mass) shall not be attempted.

Table 1001.5.1.2 Size of Testing

Coarse Aggregate	
Maximum Size of Particle[1]	**Minimum Weight (Mass) of Sample lb. (kg)**
2" (50 mm)	20 (9)
1-1/2" (37.5 mm)	13.5 (6)
1" (25.0 mm)	9 (4)
3/4" (19.0 mm)	5.5 (2.5)
1/2" (12.5 mm)	3.5 (1.5)
3/8" (9.5 mm)	2.5 (1)
[1] Maximum size of particle is defined as the smallest sieve through which 100 percent of material will pass.	
Fine Aggregate	
Manufactured Fines and Natural Sand	500 grams

1001.5.1.3 Procedure

The sieve analysis shall be performed in accordance AASHTO T27. When determination of the minus 200 material is required, this shall be performed in accordance with AASHTO T11. A dry gradation may be run on any material where the accuracy of the sieve analysis does not require washing. The district Construction and Materials Engineer should be consulted when there is a question as to whether a dry or washed gradation should be run.

1001.5.1.4 Worksheet Form T-630R and Calculations, Passing Basis

One method for calculating gradation on a passing basis is as follows: The material that has been separated by the sieving operation shall be weighed starting with the largest size retained. This weight (mass) shall be recorded in the plant inspector's workbook on the line corresponding to the sieve on which the material is retained. Examples are given in Fig 1001.10.2 Form T-630R Example 1, page 1 and page 2. The second largest sized material is then added to the largest size in the weigh pan and the accumulated total is recorded on the line corresponding to the sieve on which the material is retained.

This operation is continued with the accumulated total being recorded on the line corresponding to the sieve on which the material is retained down to the smallest sieve, in this example, the No. 200 (75 μm) size sieve. The final quantity of material remaining in the pan (in this instance, minus No. 200 (75 μm) material) should be recorded on the line designated as "PAN." The "PAN + LOSS" is the sum of the "LOSS" from washing over a No. 200 (75 μm) sieve plus the amount retained in the "PAN". The quantity retained on the smallest sieve is then added to the quantity in the "PAN + LOSS" and is to be recorded on the line designated as "TOTAL". The "TOTAL" should equal the original dry weight (mass) within a tolerance of one gram for each sieve that the material passed through. The difference between the "TOTAL" and the "ORIGINAL DRY WEIGHT (MASS) is recorded on the line designated "DIFFERENCE". Tolerance for the sieving is plus or minus 1 gram per sieve. In the examples above, the tolerance should be equal to or less than plus or minus 5 grams (five sieves were used, beginning with the smallest sieve through which 100 percent passed). This tolerance is to be recorded on the line designated as "SIEVE ACCURACY".

The total amount of material finer than the smallest sieve shall be determined by adding the weight (mass) of material passing the smallest sieve obtained by dry sieving to that lost by washing. In the example, the amount lost by washing as recorded on the "LOSS" line was found to be 442 grams. The 7 on the "PAN" line shows that 7 additional grams were obtained in the dry sieving operation. This total quantity, 449 grams, is recorded on the "PAN + LOSS" line.

Except for the smallest sieve used, the percent passing is determined by dividing the quantity shown for each sieve by the original dry weight (mass) and subtracting the percentage from 100. The percentage passing the smallest sieve is found by dividing the quantity shown on the "PAN + LOSS" line by the original dry weight (mass). The percentage for the smallest sieve is shown on the line for that sieve.

Enter the SM Sample ID in the column next to “RECORD NO,” then enter information from Form T-630R in SM.

The following shows Form T-630R being used to record the gradation of a material produced to meet Section 1003 specifications.

FORM T-630R

PLANT INSPECTION AGGREGATE WORKSHEET

MATERIAL ______________________________ PRODUCT OR SPEC. NO ______________________________

FACILITY CODE ______________________________ PRODUCER ______________________________

PURCHASE ORDER NO. ______________________________ PLANT LOCATION ______________________________

CONSIGNED TO ______________________________ LEDGE ______________________________

DESGINATION ______________________________

MECHANICAL SIEVE ANALYSIS

RECORD NO.											
DATE											
INSPECTOR											
ORIG/WET WT.		%		%		%		%		%	
ORIG.DRY WT.											
WASHED DRY WT.											
LOSS											
FIELD MOIST.											SPEC LIMIT
37.5 mm (1 ½")											
25 mm (1")											
19 mm (3/4")											
12.5 mm (1/2")											
9.5 mm (3/8")											
4.75 mm (# 4)											
2.36 mm (# 8)											
2.0 mm (#10)											
1.18 mm (#16)											
850 µm (# 20)											
600 µm (# 30)											
425 µm (# 40)											
300 µm (# 50)											
150 µm (#100)											
75 µm (#200)											
PAN											
PAN + LOSS											
TOTAL											
DIFFERENCE											
SIEVE ACCURACY											
TONS ACC/REJ.											

QUALITY DETERMINATION

ORIG.WT.										
DELT										
SHALE										
CHERT										
OTHER										
TOTAL DELT										
PLASTICITY INDEX										
IN COMPUTER		☐		☐		☐		☐		☐

REPORT DATA AND REMARKS

____

____

____

____

AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregate
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial#	1	2
Fine Aggregate		
Coarse Aggregate		
1. Sample dried to constant mass at 230±9° F (110±5° C)		
2. Mass determined to nearest 0.1% **Note:** If specimen consists of material leftover after T 11, then Step 2 does not apply because it is assumed that total specimen mass was determined as part of that test		
3. Sieving continued until not more than 0.5% by mass of the total sample passes a given sieve during 1 minute of continuous hand sieving		
4. Sieves not overloaded: a. Mass of residue on each sieve [finer that # 4 (4.75mm) sieves] does not exceed 7kg/m^2 of sieving surface (200g for 8" diameter sieve) b. Mass of residue on each sieve [for # 4 (4.75mm) sieves and larger] does not exceed 2.5 x (sieve opening, mm) x (effective sieving area, m^5)		
5. Total mass of material after sieving agrees with mass before sieving to within 1 gram per sieve (If not, do not use for acceptance testing)		
6. Percentages calculated to the nearest 0.1% and reported to the nearest whole number		
7. Percentage calculations based on original dry sample mass, including passing # 200 fraction (if T 11 was used)		

Pass Pass

Fail Fail

Examiner:________________________________ Date:____________________

AASHTO T 255

Total Moisture Content of Aggregate by Drying

AASHTO T 255

Total Moisture Content of Aggregate by Drying

BACKGROUND AND OVERVIEW

- Used to help determine batch scale weights for concrete mixes
- Calculates the free moisture of aggregates to adjust for water-cement ratio
- Affects the concrete plant report calculations
- Affects the asphalt plant production rate and asphalt-cement content

AASHTO T 255 2

EQUIPMENT AND APPARATUS

- Balance or scales
- Heat sources
  - hot plate
  - microwave
  - oven / stove 230 ± 9°F (110 ± 5°C) ventilated
- Sample container
  - air tight
  - sufficient volume size

AASHTO T 255 3

EQUIPMENT AND APPARATUS

- Cooking utensils
  - gloves
  - spoon
  - brush
  - small mirror or reflective surface
  - tared pans (pre-weighed)
  - cooking pans
- Shovel or scoop (for sampling)

AASHTO T 255 4

PROCEDURE

- Obtain representative sample in an air tight container.
  - It is advised to retrieve sample from interior of aggregate stockpile.
  - Cover immediately to prevent any moisture loss.

AASHTO T 255 5

Sample Size

Nominal Maximum Size in. (mm)	Minimum Sample Mass Lbs. (kg.)
#4 (4.75)	1.1 (0.5)
⅜" (9.5)	3.3 (1.5)
½" (12.5)	4.4 (2)
¾" (19.0)	6.6 (3)
1" (25.0)	8.8 (4)
1 ½" (37.5)	13.2 (6)

PROCEDURE

- Weigh and record the wet sample to the nearest 0.1% of the total mass or typically 0.1 gram
- Dry the sample
  - There are various methods to dry material.

AASHTO T 255 7

Hot Plate Drying

- Fast (Use when time is short)
- Sample must be periodically stirred to avoid localized overheating causing aggregate fractures.
  - If aggregate can't be heated without fracture, use an oven.
  - Reflective surface often used to determine when drying is complete.
  - Alcohol can be used to expedite drying process.

AASHTO T 255 8

Hot Plate Drying

AASHTO T 255 9

Oven Drying

- Most common
- Easily regulated
  - Temperature set at 230 ± 9°F (110 ± 5°C)
- Not as fast as a hotplate, but doesn't require constant attention while drying.
- Sensitive aggregates are less likely to be affected by oven drying.

AASHTO T 255 10

Microwave

- Quicker than a hotplate, except microwave will often fracture and pop aggregate particles.
- Some experimentation will be necessary to ensure the best settings for your material, to avoid fracture and pop.

AASHTO T 255 11

PROCEDURE

- Weigh and record the dry sample to the nearest 0.1% of the total mass
  - Allow to cool so as not to damage the balance.
  - Take care to avoid losing any material.
  - The sample is thoroughly dry when further heating causes less than 0.1% additional loss in mass.

AASHTO T 255 12

CALCULATIONS

- Determine the moisture content

$$T = \frac{A-B}{B} x100$$

- T= percent moisture content
- A= wet sample weight
- B= dry sample weight

AASHTO T 255 13

Classroom Exercise

RECORD NO.	Class Exercise	
DATE	Today	
INSPECTOR	You	
ORIG WET WT.	5379	%
ORIG DRY WT.	5359	
WASHED DRY WT.	5262	
LOSS		
FIELD MOIST.		
37.5 mm (1 1/2")		
25 mm (1")	0	
19 mm (3/4")	436	
12.5 mm (1/2")		
9.5 mm (3/8")	3387	
4.75 mm (# 4)	5064	
2.36 mm (# 8)		
2.0 mm (#10)		
1.18 mm (#16)		
850 µm (# 20)		
600 µm (# 30)		
425 µm (# 40)		
300 µm (# 50)		
150 µm (#100)		
75 µm (#200)	5358	
PAN	3	
PAN + LOSS		
TOTAL		
DIFFERENCE		
SIEVE ACCURACY		
TONS ACC'R.EJ.		
ORIG WT		
DELT		
SHALE		
CHERT		
OTHER		
TOTAL DELT		
PLASTICITY INDEX		

SPEC LIMIT

AASHTO T 255 14

DOCUMENTATION

- Record results in the bound field book to the nearest 0.1 % total moisture
- Notify plant operator of results

AASHTO T 255 15

Common Testing Errors

- Overheating
- Insufficient sample size
- Loss of material when stirring
- Pre-drying of sample

AASHTO T 255 16

AASHTO T 255: Total Moisture Content of Aggregate by Drying
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
1. Representative test sample obtained		
2. Test sample mass conforms to following: #4 - .5kg; ⅜" – 1.5kg; ½" – 2kg; ¾" – 3kg; 1" – 4kg; 1 ½" – 6kg; 2" – 8kg; 2 ½" – 10 kg		
3. Mass determined to the nearest 0.1%		
4. Loss of moisture avoided prior to determining the mass		
5. Sample dried by a suitable heat source		
6. If heated by means other than a controlled temperature oven, is sample stirred to avoid localized overheating		
7. Sample dried to constant mass and mass determined to nearest 0.1%		
8. Moisture content calculated by: $\% \text{ moisture} = \frac{\text{wet sample mass - dried sample mass}}{\text{dried sample mass}} \times 100$		

Pass Pass

Fail Fail

Examiner:________________________________ Date:____________________

MoDOT TM 71

Deleterious Content

of Aggregate

MoDOT TM 71

Deleterious Content of Aggregate

Why is Deleterious Harmful?

- Deleterious material can have a detrimental effect on the durability and life-span of concrete and bituminous mixtures. Consequently care must be taken that a quality product is incorporated into these mixes.
- Most deleterious substances have tendencies to deteriorate or cause degradation in concrete or asphalt mixes.

MoDOT TM 71 2

Why is Deleterious Harmful?

- Clay, mud balls and other foreign material will breakdown quickly and cause pitting and excessive air void pockets.
- Hard chert has non-cohesive properties that will cause it to "pop out" of concrete.
- Excessive minus #200 can be detrimental to the strength and durability of the final product.

MoDOT TM 71 3

Why is Deleterious Harmful?

- It is always a good idea to check the history of aggregates in specific areas and locations. As an example, if a quarry has a history of shale problems this would be a good place to start looking for deleterious material.
- The Columnar Section will have this information.

MoDOT TM 71 4

How is Quality Determined?

- The quality of an aggregate depends on the application of it's intended use and can be found in the following MoDOT specifications:
  - 1002, Asphaltic Concrete
  - 1003, Seal Coats
  - 1004, Bituminous Surface
  - 1005, Concrete
  - 1006, Surfacing
  - 1007, Bases

MoDOT TM 71 5

Definitions

- Descriptions of specific deleterious material can be found in Test Method MoDOT TM 71.

MoDOT TM 71 6

Equipment Needed

- Containers – of such a size and shape to contain the sample.
- Sieve – one #4 (4.75 mm) sieve to divide the sample.
- Water – to wet sample for observation
- Balance – accurate to within 0.5 percent of the weight of the sample.
- Lamp (optional)

MoDOT TM 71 7

Test Procedure

- Split sample according to gradation of material being tested.
- Sieve sample over #4 sieve and discard the passing material. Material shall be in an "as received" condition, not oven dried.
- Reduce plus #4 to appropriate size.
- Record weight of plus #4 material.

MoDOT TM 71 8

Test Sample Size – plus No. 4 material

Maximum Size in. (mm)	Sample Size grams
2 (50)	10,000
1 ½"(37.5)	9,000
1" (25.0)	5,000
¾" (19.0)	3,000
½" (12.5)	2,000
⅜" (9.5)	1,000

Maximum size is defined as the smallest sieve through which 100 % of the material will pass.

Test Procedure

- Obtain a handful of the sample and ***briefly*** wet the material.
- Visually examine each piece for deleterious particles.

MoDOT TM 71 10

Test Procedure

- Place the particles into separate piles as defined in the following slide. Continue this process until all particles are examined.

Note: Do not let the entire sample soak in water! This is because some Deleterious Material will dissolve.

MoDOT TM 71 11

Test Procedure

- Separate deleterious particles into required groups:
- Example-

1. Deleterious Rock 2. Shale
3. Other Foreign Material 4.Chert

- The number of groups varies by product type.

NOTE: TM 71 gives specific description based on product type.

MoDOT TM 71 12

Test Procedure

•Record the weight of each of the groups of particles.

NOTE

Soft Chert is used in the calculation of the Deleterious Content <u>and</u> the Total Chert Content for 1002 material only (TM 71)

MoDOT TM 71 13

Calculation

- % Deleterious Substances = $\dfrac{C}{W} \times 100$
- C = Actual weight (mass) of deleterious substance.
- W = Weight (Mass) of test sample for the portion retained on the #4 sieve.
- Record % Deleterious to the nearest tenth (0.1)

MoDOT TM 71 14

Example Problem:1002

Sample	ID NO.	Date: INSP:
	Mass, grams	Percent
Original Mass +4	3000	
Deleterious Rock	55	
Deleterious Rock + Soft Chert	70	2.3
Shale	7	0.2
OFM	3	0.1
Total Deleterious Material	80	2.6
Hard Chert	114	
Soft Chert	15	
Total Chert: Hard and Soft	129	4.3

See next page for full size copy.

Deleterious Material

Sample	ID NO.	Date: INSP:
[redacted]	Mass, grams	Percent
Original Mass +4	3000	[redacted]
Deleterious Rock	55	
Deleterious Rock + Soft Chert	70	2.3
Shale	7	0.2
OFM	3	0.1
Total Deleterious Material	80	2.6 (2.7)
Hard Chert	114	[redacted]
Soft Chert	15	
Total Chert: Hard and Soft	129	4.3

Classroom Exercise:1002 Material

Deleterious Material

Sample	ID NO.	Date: INSP:
	Mass, grams	Percent
Original Mass +4	3000	
Deleterious Rock	60	
Deleterious Rock + Soft Chert		
Shale	9	
OFM	1	
Total Deleterious Material		
Hard Chert	125	
Soft Chert	15	
Total Chert: Hard and Soft		

Summary

- Quality must be determined according to specification requirements for various aggregates.
- Only material retained on #4 sieve is considered for deleterious determination.
- Any particle considered soft by means of chipping or spalling with a finger nail is deleterious.

MoDOT TM 71 17

Summary

- Any substance that will reduce the effectiveness of the product will be considered detrimental. These will include material considered as Other Foreign Material.
- In some aggregate products, the minus #200 material can also be considered deleterious.

MoDOT TM 71 18

Deleterious Material

Sample	ID NO.	Date: INSP:
	Mass, grams	Percent
Original Mass +4	3000	
Deleterious Rock	60	
Deleterious Rock + Soft Chert		
Shale	9	
OFM	1	
Total Deleterious Material		
Hard Chert	125	
Soft Chert	15	
Total Chert: Hard and Soft		

Deleterious Material

Sample	ID NO.	Date: INSP:
	Mass, grams	Percent
Original Mass +4		
Deleterious Rock		
Deleterious Rock + Soft Chert		
Shale		
OFM		
Total Deleterious Material		
Hard Chert		
Soft Chert		
Total Chert: Hard and Soft		

106.3.2.71 TM-71, Deleterious Content of Aggregate

This test method determines the deleterious content of fine and coarse aggregates.

106.3.2.71.1 Apparatus

1) Containers of such a size and shape to contain the sample.

2) Sieves - No. 4 (4.75 mm) and No. 16 (1.18 mm).

3) Water to wet particles for observation.

4) Balance sensitive to within 0.5 percent of the weight (mass) of sample to be weighed.

106.3.2.71.2 Procedure for Coarse Aggregate Deleterious

106.3.2.71.2.1 Preparation

The sample shall be tested in an "as obtained" condition. The obtained sample shall be sieved over a No. 4 (4.75 mm) sieve, discarding the material passing the sieve. The material retained shall be the test sample used to determine the deleterious content.

106.3.2.71.2.2 Sample Size

Recommended minimum test sample sizes of plus No. 4 (4.75 mm) material are as follows:

Maximum Size[1], in. (mm)	Sample Size, g
2 (50)	10,000
1 ½ (37.5)	9,000
1 (25.0)	5,000
3/4 (19.0)	3,000
1/2 (12.5)	2,000
3/8 (9.5)	1,000
[1] Maximum size is defined as the smallest sieve through which 100 percent of the material will pass.	

106.3.2.71.2.3 Test

Each individual particle comprising the sample shall be examined piece-by-piece and separated into the various constituents as required by the specifications and in accordance with the descriptions shown in

EPG 106.3.2.71.6, Deleterious Definitions. The sample may be rinsed at the time of examination but shall not be soaked in water. Material not considered deleterious may be discarded except as needed for review. Each deleterious constituent shall be weighed, and the weight recorded. In some instances when required by the specification, the constituents are to be combined prior to weighing.

106.3.2.71.3 Procedure for Fine Aggregate Deleterious

106.3.2.71.3.1 Lightweight (Low Mass Density) Particle Content including Coal and Lignite

The test shall be in accordance with AASHTO T 113, however lightweight (low mass density) sand particles are not considered deleterious lightweight (low mass density) particles.

106.3.2.71.3.2 Percent Other Deleterious Substances, Clay Lumps and Shale in Fine Aggregate

106.3.2.71.3.2.1 Preparation

Recommended test sample size is approximately 200 grams, before sample is sieved over the No. 16 sieve.

106.3.2.71.3.2.2 Sample Size

The sample shall be tested in a dry condition (dried to a constant weight). Sample shall be sieved over a No. 16 sieve, discarding material passing the sieve. The material retained shall be the test sample used to determine the clay lumps and shale.

106.3.2.71.3.2.3 Procedure

The test sample shall be visually examined for shale, clay lumps and other deleterious substances. Particles may be lightly rinsed at the time of examination, but shall not be soaked in water. The deleterious substances shall be separated out into the constituents required by specification.

Shale is determined by using a non-glazed ceramic bowl (Plastic Index bowl). If particles leave a black mark on the bowl when pressure is applied to the material while moving it across the bottom of the bowl, this material is considered shale.

106.3.2.71.4 Calculations for Deleterious Content

The percentage of a deleterious substance shall be calculated as follows:

$P = 100 \times C / W$

Where:

P = Percentage of each deleterious substance component.

C = Actual weight (mass) of deleterious substance for that component.

Quick Test for Per Cent of Deleterious Material

Report, 2009

See also: Innovation Library

W = Weight (mass) of test sample for the portion retained on the No. 4 sieve

106.3.2.71.5 Reports

Report the percent deleterious obtained for each constituent required by specification, to the nearest tenth (0.1).

106.3.2.71.6 Definitions of Deleterious Materials

The definition of deleterious material varies with the intended use and the anticipated affect on the final product.

106.3.2.71.6.1 Coarse Aggregate for Portland Cement Concrete

For coarse aggregate for portland cement concrete (Sec 1005), the following definitions apply:

106.3.2.71.6.1.1 Deleterious Rock

Deleterious rock includes the following material:

(1) Shaly rock. A rock that is generally contaminated with shale to a high degree. Color may vary but the rock usually has a dull gray appearance and is reasonably uniform in appearance. Also may occur in the form of numerous shale lines or seams closely spaced throughout the particle, thus giving a laminated or streaked appearance.

(2) Cap plus 20 percent. A rock particle with a line of demarcation of a layer or "cap" of shale or shaly rock which usually occurs on one face, but may be found on two faces; in either case, the summation of the percent of "caps" exceeds 20 percent of the volume of the rock particle.

(3) Extremely soft and/or porous rock. A rock which can be readily broken with the fingers. In some cases, due to the size or shape of the rock it cannot be broken, however, small areas can be spalled or chipped off with the fingers. Porosity or high absorption may be detected by rapid disappearance of surface water or by breaking rock in half and observing the depth of penetration of moisture.

106.3.2.71.6.1.2 Shale

A fine-grained rock formed by the consolidation of clay, mud, or silt; generally having a finely stratified or laminated structure.

106.3.2.71.6.1.3 Chert in Limestone

A fine-grained rock consisting of silica minerals, sharp-edged and may be highly absorptive. May occur in the form of nodules, lenses, or layers in limestone formations; and may vary in color from white to black. Quartz-type material is excluded. Any particle that contains more than 50% chert will be entirely classified as chert.

106.3.2.71.6.1.4 Other Foreign Material

Clay lumps, mud balls, lignite, coal, roots, sticks and other foreign material not related to the inherent material being inspected.

106.3.2.71.6.1.5 Material Passing No. 200 [75 µm] Sieve

The portion of material passing a No. 200 (75 µm) sieve as determined by a washed analysis.

106.3.2.71.6.1.6 Thin or Elongated Pieces

Rock particles that have a length greater than five times the maximum thickness. In case two sizes of coarse material are required to be combined into coarse aggregate, the limitation on "thin or elongated pieces" shall apply only to the coarser size so combined and shall only apply to particles retained on the 3/4 in. (19.0 mm) sieve. In the case of coarse aggregate produced without combining two sizes, the limitation on "thin or elongated pieces" shall apply only to particles retained on a 3/4 in. (19.0 mm) sieve.

106.3.2.71.6.2 Coarse Aggregate for Asphaltic Concrete, Plant Mix Bituminous Pavement, Plant Mix Bituminous and Seal Coats

For coarse aggregate for asphaltic concrete, plant mix bituminous pavement, plant mix bituminous leveling and seal coats (Sec 1002 and Sec 1003), the following definitions apply

106.3.2.71.6.2.1 Deleterious Rock

Deleterious rock includes the following materials:

(1) Shaly rock. A rock that is generally contaminated with shale to a high degree. Color may vary but the rock usually has a dull gray appearance and is reasonably uniform in appearance. Also may occur in the form of numerous shale lines or seams closely spaced throughout the particle, thus giving a laminated or streaked appearance.

(2) Cap plus 20 percent. A rock particle with a line of demarcation of a layer or "cap" of shale or shaly rock which usually occurs on one face, but may be found on two faces; in either case the summation of percent of "caps" exceeds 20 percent of the volume of the rock particle.

(3) Extremely soft rock. A rock that can be readily broken with the fingers. In some cases, due to size or shape of the rock it cannot be broken, however, small areas can be spalled or chipped off with the fingers.

(4) Chert. Chert which is soft and highly absorptive is considered deleterious.

106.3.2.71.6.2.2 Shale

A fine-grained rock formed by the consolidation of clay, mud, or silt; generally having a finely stratified or laminated structure.

106.3.2.71.6.2.3 Other Foreign Material

Clay lumps, mud balls, lignite, coal, roots, sticks, and other foreign material not related to the inherent material being inspected.

106.3.2.71.6.3 Coarse Aggregate for Bituminous Surface and Plant Mix Bituminous Base

For coarse aggregate for bituminous surface and plant mix bituminous base (Sec 1004), the following definitions apply:

106.3.2.71.6.3.1 Deleterious Rock

Deleterious rock includes the following materials:

(1) Shaly rock. A rock that is generally contaminated with shale to a high degree. Color may vary, but the rock usually has a dull gray appearance and is reasonably uniform in appearance. Pieces of rock having shaly seams, skin shale, and pieces of rock, which are not predominantly shaly, are not to be considered as deleterious.

(2) Extremely soft rock. A rock that can be readily broken with fingers, or from which small areas can be spalled or chipped off readily with the fingers.

106.3.2.71.6.3.2 Shale

A fine-grained rock formed by the consolidation of clay, mud or silt; generally having a finely stratified or laminated structure.

106.3.2.71.6.3.3 Mud balls

Balls of mud.

106.3.2.71.6.3.4 Clay

A clay material that is more or less uniformly dispersed throughout the produced product.

106.3.2.71.6.3.5 Other Foreign Material

Any material not related to the inherent material being inspected.

106.3.2.71.6.4 Coarse Aggregate for Surfacing

For coarse aggregate for surfacing (Sec 1006), the following definitions apply:

106.3.2.71.6.4.1 Deleterious Rock

Deleterious rock includes extremely soft rock; a rock that can be readily broken or spalled with the fingers.

106.3.2.71.6.4.2 Shale

A fine-grained rock formed by the consolidation of clay, mud, or silt; generally having a finely stratified or laminated structure.

106.3.2.71.6.4.3 Mud Balls

Balls of mud.

106.3.2.71.6.4.4 Other Foreign Material

Any material not related to the inherent material being inspected.

106.3.2.71.6.5 Coarse Aggregate for Base

For coarse aggregate for base (Sec 1007), the following definitions apply:

106.3.2.71.6.5.1 Deleterious Rock

Deleterious rock includes extremely soft rock; a rock that can be readily broken or spalled with the fingers.

106.3.2.71.6.5.2 Shale

A fine-grained rock formed by the consolidated of clay, mud or silt; generally having a finely stratified or laminated structure.

106.3.2.71.6.5.3 Mud Balls

Balls of mud.

QLIS Initial 2.imr
Revised 20031117*

Missouri Department of Transportation
Quarry Ledge Information Summary - Initial

Date: 12/29/2004

Buffton Quarry - Missouri Valley **636-390-7534**

0.8 Mi W/O Bluffton on Rt 94 **Union, MO** **Montgomery County** **63084**

longitude/latitude: **091 37 55 038 42 26** **3168400113**

Ledge / Approval	Thickness	Formation/Member / Lab I.D. #	Date	Description / L.A.	SPG	ABS	MoDOT T 14	AASHTO T 104
	0-5'	*Overburden*						
		G300-00083	*20020808*					
	45-50'	*Jefferson City*						
		G300-00084	*20020808*					
		Bench						
		G300-00085	*20020808*					
3	12.5'	**Jefferson City** Brown to gray, thin to medium bedded, fine grained, arenaceous dolomite with skin shale on partings. Approval based on specifications July 1, 2004.						
1006CAAS		**G396-02975**	**19960318**	**37**	**2.45**	**4.6**		
2	18.0'	**Jefferson City** Brownish gray to greenish gray, medium bedded, fine grained, arenaceous dolomite with skin shale on partings. Approval based on specifications July 1, 2004						
1006CAAS		**G396-02974**	**19960318**	**39**	**2.40**	**5.5**		
	0.1'	*Olive Green Shale Seam*						
		G300-00086	*20020808*					

Signed (Seal)

____

Missouri Department of Transportation
Quarry Ledge Information Summary - Initial

Date: 12/29/2004

Buffton Quarry - Missouri Valley 636-390-7534

0.8 Mi W/O Bluffton on Rt 94 **Union, MO** **Montgomery County** **63084**

longitude/latitude: **091 37 55 038 42 26** **3168400113**

Ledge / Approval	Thickness	Formation/Member / Lab I.D. #	Date	L.A.	SPG	ABS	MoDOT T 14	AASHTO T 104
1	14.5'	**Jefferson City** — **Brownish gray to gray, thin to medium bedded, fine grained, arenaceous dolomite with olive green skin shale on partings. Shale seam near middle of this ledge.**						
1002CAAC		**G396-02973**	**19960318**	**43**	**2.50**	**2.8**		
		Bench						
		G300-00087	*20020808*					
A	7.0'	**Jefferson City** — **Gray to brown fine to coarse grained dolomite, medium bedded, with some calcopyrite and a shale seam at the bottom.**						
1002CAAC		**03DGL115**	**20000615**	**34**	**2.50**	**3.9**	**3.7**	**0**
B	8.6'	**Jefferson City** — **Gray to brown fine grained arenaceous dolomite, medium to thick bedded with a shale seam at the bottom.**						
1002CAAC		**03DGL116**	**20000615**	**30**	**2.51**	**3.4**	**1.5**	**15**
C	7.7'	**Jefferson City** — **Gray with brown mottling, fine to medium grained dolomite, thick bedded, arenaceous with chert nodules and worm burrows throughout. Green skin shale on partings.**						
1005CACM		**03DGL117**	**20000615**	**36**	**2.52**	**2.9**	**1.2**	**8**
D	7.0'	**Jefferson City** — **Gray to brown, medium grained dolomite, medium to thick bedded, arenaceous with chert nodules, calcopyrite and green skin shale on partings.**						
1002CAAC		**03DGL118**	**20000615**	**30**	**2.49**	**3.8**	**4.0**	**0**

Signed (Seal)

____

MoDOT TM 71: Deleterious Content of Aggregate
PROFICIENCY CHECKLIST

Applicant_______________________________________

Employer_______________________________________

Trial #	1	2
1. Sieve sample over # 4 sieve and discard minus #4 material		
2. Reduce plus #4 material to appropriate testing size		
3. Record original weight of plus #4 material		
4. Visually examine each particle by wetting with water, but not soaking		
5. Separate deleterious particles into specific groups: **Groups are defined in the test method and will vary based on product type as well as the presence of any given group.** NOTE: For 1002 material, keep soft chert separate as it will be included in both deleterious and hard chert.		
6. Record weight of each of the groups of particles		
7. Calculate % of original + #4 material for each group identified. P = C/Wx100 Where: P = Percentage of each deleterious substance component C = Actual weight (mass) of deleterious substance for that component W = Weight (mass) of test sample for the portion retained on the #4 sieve		

Pass Pass

Fail Fail

Examiner:_______________________________Date:_________________________

ASTM D 4791

Flat Particles, Elongated Particles, Or Flat and Elongated Particles In Coarse Aggregate

ASTM D 4791

Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

Definitions

- **Flat and Elongated Particles** - Those particles having a ratio of length to thickness greater than a specified value
- **Length** - The longest dimension
- **Thickness** - The smallest dimension
- **Width** - The other dimension

ASTM D 4791 2

Detrimental Affects When used in Mixtures

- Fracture more easily
- Interferes with consolidation
- Mixture difficult to place

ASTM D 4791 3

Material Tested

- Material larger than ¾" (9.5mm) or #4 (4.75mm) as determined by specification requirements.
  - For MoDOT :
    - 1002 requires plus #4 (4.75mm)
    - 1005 requires plus ¾" (19.0mm)
      - See Engineering Policy Guide (EPG) 106.7.71 TM 71, Deleterious Content of Aggregate (106.7.71.6.1.6)

ASTM D 4791 4

Equipment

- Proportional Caliper Device
- Balance, accurate to 0.5% of the sample mass
- Oven or hot plate

ASTM D 4791 5

Test Procedure

- If using particle count, drying is not necessary.
- Perform AASHTO T27.
- Reduce each fraction that has minimum of 10% retained until approximately 100 particles remain.
- Approximately 100 Particles needed for testing

ASTM D 4791 6

Test Procedure

- Mass may be used instead of particle count.
- When using mass instead of particle count, oven dry @ 230 ± 9°F (110 ± 5°C) to a constant mass.
- Sieve sample in accordance with AASHTO T27.
- Using the material retained on the ¾" (9.5mm) or #4 (4.75mm), as required by MoDOT specification.

ASTM D 4791 7

Sample Size

Maximum Retained Sieve Size in.(mm)	Mass grams
⅜ (9.5)	1000
½ (12.5)	2000
¾ (19.0)	5000
1 (25.0)	10,000
1 ½ (37.5)	15,000

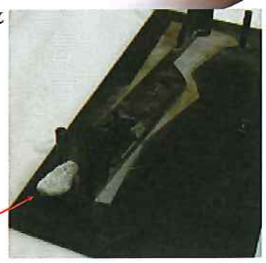
Test Procedure

- Evaluate each piece individually.
- Set caliper at desired ratio as per specifications.
- Set the larger opening equal to the "length" of the particle.

ASTM D 4791 9

Test Procedure

- The particle is flat & elongated if, when oriented to measure its "thickness", can pass through the smaller end of the caliper.



This particle is not F&E

ASTM D 4791 10

Test Procedure

- Separate into two groups: (1) flat & elongated or (2) not flat and elongated.
- Determine the proportion of each group by either count or mass as required.

ASTM D 4791 11

Calculations

- Report each group to nearest 1% for each sieve size greater than ¾" (9.5mm) or #4 (4.75mm), as required by MoDOT Spec..
  - If a sieve size has less than 10% retained, see example calculation sheet item (9.2) for guidance.
- Report each group to nearest whole number.

ASTM D 4791 12

FLAT AND ELONGATED PARTICLES (ASTM D 4791)

Project: J5P0433 Mix Design: SP250 05-43 Date: 7/25/05
Material Stockpile ID: 1" Buckskin Technician: Paul Stegemann

Original Mass of Sample 6301 Ratio 3 to 1

Sieve Sizes	Mass Retained (A)	Percent Retained (B)	Number or Mass Tested (C)	Number or Mass F & E (D)	Percent F & E (E)	Sieve Fraction Retained Factor (F)	Percent F&E Weighted Ave. (G)
37.5mm 1 ½"	0						
25.0mm 1"	0						
19.0mm ¾"	2644	42.0	1973	8	0	.436	0
12.5mm ½"	3232	51.3	1632	44	3	.333	2
9.5mm ⅜"	69	1.1<10%	0	0	3	0.011	0
4.75mm #4	119	1.9<10%	0	0	3	.020	0
Total % Retained		95.3	(TPR)			1.000	
						Total	2%

A = Weight retained on each particular sieve

B = $\frac{(A)}{\text{original mass of sample}}$ X 100

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of Flat and Elongated particles

E = $\frac{D}{C}$ X 100

F = $\frac{B}{TPR}$

G = E x F

(9.1) (E & G) Calculated to nearest 1%

(9.2) When a weighted average for a sample is required, assume that the sieve sizes not tested (those representing less than 10% of the sample) have the same percentage of F&E particles as the next smaller or next larger size, or use the average for the next smaller or next large sizes, if both are present.

Classroom Exercise Using Mass

Original Mass of Sample 6355 Ratio 5 to 1.

Sieve Sizes	Mass Retained (A)	Percent Retained (B)	Number or Mass Tested (C)	Number or Mass F & E (D)	Percent F & E (E)	Sieve Fraction Retained Factor (F)	Percent F&E Weighted Ave. (G)
37.5mm 1 ½"							
25.0mm 1"	0		0	0			
19.0mm ¾"	2710	42.6	1842	15	1	.437	0
12.5mm ½"	3252	51.2	1595	54	3	.526	2
9.5mm ⅜"	70	1.1 <10%	0	0	3	0.011	0
4.75mm #4	157	2.5 <10%	0	0	3	0.026	0
Total % Retained		97.4	(TPR)				
						Total	2%

ASTM D 4791 14

Classroom Exercise Using Particle Count

Original Mass of Sample Count Ratio 5 to 1.

Sieve Sizes	Mass Retained (A)	Percent Retained (B)	Number or Mass Tested (C)	Number or Mass F & E (D)	Percent F & E (E)	Sieve Fraction Retained Factor (F)	Percent F&E Weighted Ave. (G)
37.5mm 1 ½"							
25.0mm 1"			0	0			
19.0mm ¾"			0	0			
12.5mm ½"	NA	10.2	102	4	4	.180	1
9.5mm ⅜"	NA	10.5	104	1	1	.186	0
4.75mm #4	NA	35.8	109	3	3	.634	2
Total % Retained		56.5	(TPR)				
						Total	3

ASTM D 4791 15

Common Testing Errors

- Not obtaining a representative sample
- Not reducing the sample properly
- Not sieving to completion
- Improper positioning in the machine

ASTM D 4791 16

FLAT AND ELONGATED PARTICLES (ASTM D 4791)

Project: J8P0633 **Mix Design:** SP250 05-43 **Date:** 7/25/05
Material/Stockpile ID: 1" fraction **Technician:** Charlie Wate

Original Mass of Sample 6301 **Ratio** 5 **to** 1

Sieve Sizes	Mass Retained (A)	Percent Retained (B)	Number or Mass Tested (C)	Number or Mass F & E (D)	Percent F & E (E)	Sieve Fraction Retained Factor (F)	Percent F&E Weighted Ave. (G)
37.5mm 1 ½"	0						
25.0mm 1"	0						
19.0mm ¾"	2644	42.0	1973	8	0	.436	0
12.5mm ½"	3232	51.3	1632	44	3	.533	2
9.5mm ⅜"	69	1.1<10%	0	0	3	0.011	0
4.75mm #4	119	1.9<10%	0	0	3	.020	0
Total % Retained		96.3	(TPR)			1.000	
						Total	2%

A = Weight retained on each particular sieve

$$B = \frac{(A)}{\text{original mass of sample}} \times 100$$

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of Flat and Elongated particles

$$E = \frac{D}{C} \times 100$$

$$F = \frac{B}{TPR}$$

$$G = E \times F$$

(9.1) (E&G) Calculated to nearest 1%

(9.2) When a weighted average for a sample is required, assume that the sieve sizes not tested (those representing less than 10% of the sample) have the same percentage of F&E particles as the next smaller or next larger size, or use the average for the next smaller or next large sizes, if both are present.

FLAT AND ELONGATED PARTICLES (ASTM D 4791)

Project: J8P0633 **Mix Design:** SP250 05-43 **Date:** 7/25/08 .
Material/Stockpile ID 1" Fraction **Technician: Bob Poteet**

Original Mass of Sample 6355 **Ratio** 5 **to** 1 .

Sieve Sizes	Mass Retained (A)	Percent Retained (B)	Number or Mass Tested (C)	Number or Mass F & E (D)	Percent F & E (E)	Sieve Fraction Retained Factor (F)	Percent F&E Weighted Ave. (G)
37.5mm 1 ½"							
25.0mm 1"	0		0	0			
19.0mm ¾"	2710		1842	15			
12.5mm ½"	3252		1595	54			
9.5mm ⅜"	70		0	0			
4.75mm #4	157		0	0			
Total % Retained			(TPR)				
						Total	

A = Weight retained on each particular sieve

$$B = \frac{(A)}{\text{original mass of sample}} \text{ X } 100$$

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of Flat and Elongated particles

$$E = \frac{D}{C} \text{ X } 100$$

$$F = \frac{B}{TPR}$$

$$G = E \times F$$

(9.1) (E&G) Calculated to nearest 1%

(9.2) When a weighted average for a sample is required, assume that the sieve sizes not tested (those representing less than 10% of the sample) have the same percentage of F&E particles as the next smaller or next larger size, or use the average for the next smaller and next large sizes, if both are present.

FLAT AND ELONGATED PARTICLES (ASTM D 4791)

Project: J8P0633 Mix Design: SP250 05-43 Date: 7/25/08 .
Material/Stockpile ID ¾" Fraction Technician: Bob Poteet

Original Mass of Sample Count Ratio 5 to 1 .

Sieve Sizes	Mass Retained (A)	Percent Retained (B)	Number or Mass Tested (C)	Number or Mass F & E (D)	Percent F & E (E)	Sieve Fraction Retained Factor (F)	Percent F&E Weighted Ave. (G)
37.5mm 1 ½"							
25.0mm 1"			0	0			
19.0mm ¾"			0	0			
12.5mm ½"		10.2	102	4			
9.5mm ⅜"		10.5	104	1			
4.75mm #4		35.8	109	3			
Total % Retained		56.5	(TPR)				
						Total	

A = Weight retained on each particular sieve

$$B = \frac{(A)}{\text{original mass of sample}} \text{ X } 100$$

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of Flat and Elongated particles

$$E = \frac{D}{C} \text{ X } 100$$

$$F = \frac{B}{TPR}$$

G = E x F

(9.1) (E&G) Calculated to nearest 1%

(9.2) When a weighted average for a sample is required, assume that the sieve sizes not tested (those representing less than 10% of the sample) have the same percentage of F&E particles as the next smaller or next larger size, or use the average for the next smaller and next large sizes, if both are present.

106.3.2.71.6.1.6 Thin or Elongated Pieces

Rock particles that have a length greater than five times the maximum thickness. In case two sizes of coarse material are required to be combined into coarse aggregate, the limitation on "thin or elongated pieces" shall apply only to the coarser size so combined and shall only apply to particles retained on the 3/4 in. (19.0 mm) sieve. In the case of coarse aggregate produced without combining two sizes, the limitation on "thin or elongated pieces" shall apply only to particles retained on a 3/4 in. (19.0 mm) sieve.

ASTM D 4791: Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
PROFICIENCY CHECKLIST

Applicant:____

Employer:____

Trial #	1	2
Sample Preparation		
1. Test sample mass when dry conforms to following table		
2. Mass may be used instead of particle count		
Procedure		
1. If determination by mass, sample oven-dried to constant mass at 230 ± 9°F (110 ± 5°C)		
2. Sample sieved according to AASHTO T27		
3. Using material retained on 3/4" (19.0 mm) or No. 4 (4.75 mm) as required by the specification being used, reduce each sieve fraction present in the amount of 10% or more of the original sample in accordance with T 248 until approximately 100 particles are obtained for each sieve fraction required		
Flat and Elongated Particle Test		
1. Each particle in each size fraction tested and placed into one of two groups (1) flat and elongated or (2) not flat and elongated		
2. Proportional caliper device positioned at proper ratio		
3. Larger opening set equal to particle length		
4. Particle is flat and elongated if the thickness can be placed in the smaller opening		
5. Proportion of sample in each group determined by count or mass as required		

Nominal Maximum Size, in. (mm)	Minimum Mass lb. (Kg,)
⅜ (9.5)	2 (1)
½ (12.5)	4 (2)
¾ (19.0)	11 (5)
1 (25.0)	22 (10)
1 ½ (37.5)	33 (15)
2 (50)	44 (20)

ASTM D 4791: Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate PROFICIENCY CHECKLIST (cont.)

Calculation		
1. Percentage of flat and elongated particles calculated to nearest 1% for each sieve size greater than 3/4" (19.0 mm) or No. 4 (4.75 mm) as required		

Pass Pass

Fail Fail

Examiner:____________________________________Date:________________________

Glossary of Terms

Absorption – The increase in mass (weight) due to water contained in the pores of the material.

Air Dry Aggregate – Aggregate that is dry at the particle surface but containing some internal moisture.

Coarse Aggregate – Aggregate which is predominately larger than the #4 (4.75mm) sieve.

Combined Aggregate – Aggregate that is a blend of both coarse and fine particles.

Fine Aggregate – Aggregate which has a nominal maximum size of the 4.75mm (No. 4) sieve or smaller.

Nominal Maximum Size – The largest sieve size listed in the applicable specification, upon which any material may be retained.

Oven Dry Aggregate – Aggregate that has no internal or external moisture.

Saturated Surface Dry – An ideal condition in which the aggregate can neither absorb nor contribute water. In this condition, the interior has absorbed all the moisture it can hold, but the surface is dry.

Sieve Analysis – Determination of particle size distribution (gradation) using a series of progressively finer sieves.

Sieving to Completion – Having no more than 0.5 percent of aggregate particles retained on any sieve after shaking which should have passed through that sieve. Percent is calculated by mass of material retained divided by original mass.

Tare – The mass (weight) of a pan or container. Normally the balance is adjusted to a "zero" reading by moving the scale counterbalance, or in the case of electronic scales, by tapping the tare button after the pan is placed on the scale to get a zero reading.

Wet Aggregate – Aggregate containing moisture on the particle surface.

SAMPLING OF AGGREGATES

AASHTO T 2

Developed by
Multi-Regional Aggregate Training & Certification Group
Revised 2006

NOTE

AASHTO T2 is identical to ASTM D75.
All references to ASTM C702 contained in ASTM D75 shall be replaced with AASHTO T248.

Successful completion of the following training materials, including examination and performance evaluation are prerequisites for this training package.

- ASTM D3665, Practice for Random Sampling ofConstruction Materials

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SAMPLING OF AGGREGATES

Aggregates are the main ingredient in most highway construction. They are used in all phases from base construction, structural and pavement mixes, granular shoulders, granular surfacing, and erosion control. For aggregates to perform as intended, they must meet certain requirements such as proper gradation, durability to resist the effects of weathering and resistant to abrasion loss.

The most important phase of an aggregate inspector's duties is securing a representative sample. At this point, all the money and time which will be expended on the remaining activities of testing and evaluation may be lost or rendered useless by an improper sampling technique. In other words, if the samples taken are not representative of the total material, it is impossible to end up with meaningful test results. At the completion of this instruction, the technician must know how to obtain a proper sample. Without this knowledge, it is useless to proceed further into the areas of the test procedures.

Test samples should represent the total amount of the material being produced or used. This is normally accomplished by random sampling. All material should have an equal chance of being tested. Random samples are taken when the plant or operation is continuing at the usual rate. During production at the source, care must be taken to ensure the virgin material being processed is normal to the overall consistency of the available material. Clay pockets, boulders or varying seams in a gravel pit, mine, or quarry may create short-term variations in the consistency of the product.

It must be pointed out that not all samples are random samples. At times the inspector must choose the time of sampling, especially during the production phase. Control samples may be needed during start-up, equipment changes or changes in the virgin material. These circumstances will directly affect the gradation of the material and must be checked to keep the material within proper limits. During a normal day's operation, all samples taken may be random samples if all operations are running consistently. Some days may have no random samples taken, such as the first days run to establish crusher settings, etc. Some days will have a combination of random and control check samples. When random sampling the inspector should not determine when or what to sample by judging if the materials looks good, bad, or average, because that represents a judgment sample and not a random sample.

Keep in mind that during normal, steady operations the samples should be selected in a random method such as described in ASTM D 3665.

The discussion of securing samples would not be complete without mentioning safety. The production and placement of aggregates during use requires the use of heavy equipment and large bins. The conditions are frequently dusty and noisy. The aggregate technician must use extreme caution and ensure themselves that sampling locations are safe.

When securing processed aggregate samples, at least three increments of coarse aggregate shall be taken by an appropriate method as described in this instruction. There should be five increments of fine aggregate sampled using the sampling tube. More increments may, and when practicable, should be taken to build the field sample. Taking more increments is getting a better cross-section of the total material.

SUMMARY OF AGGREGATE SAMPLING

There are four methods approved by AASHTO for securing aggregate samples. The method the technician uses depends on the type of aggregate they are sampling, the location of the sample, and the equipment available at the sampling location. The four methods include:

- Flowing Aggregate Stream (Bins or Belt Discharge)
- Conveyor Belt
- Stockpiles or Transportation Units
- Roadway (Bases and Subbases)

The most accurate way to ensure that aggregate, as produced, meets the requirements would be to test the entire stockpile. This would not only be impractical, but virtually impossible. Accurate, representative samples must be secured for testing to ensure the required characteristics are met.

Aggregate samples may be obtained at different stages of production or construction:

- Preliminary source investigation to determine potential end product. These samples are normally obtained by the party responsible for development of the source.
- During aggregate production at the source, samples of materials for control of the production at the source are obtained by the manufacturer, contractor or other parties responsible for the work such as private consultants.
- Control of the operations at the job site is also the responsibility of the producer, contractor or other qualified parties.
- Samples to determine acceptance or rejection by the purchaser are obtained by the purchaser or an authorized representative.

Samples secured for the purpose of quality testing such as soundness, clay content, resistance to abrasion, etc., should be obtained from the finished product when possible. Samples from the finished product to be tested for resistance to abrasion shall not be subject to further crushing or manual reduction in particle size unless the size of the finished product is such that it requires further reduction for testing purposes.

COMMON SAMPLING ERRORS

- Using improper sampling device.
- Sampling in segregated areas.
- Not obtaining enough increments.
- Improper sampling method for aggregate types (sand, fine aggregate, coarse aggregate).
- Allowing overflowing in a stream flow device.

NUMBER AND MASS OF FIELD SAMPLES

The number of field samples required depends on how variable the material is and how critical the test is. Identify each unit from which a field sample is to be obtained prior to sampling. The number of field samples during production must be sufficient to give the desired confidence in the test results. The amount of material to be represented by a single field sample should neither be so large as to mask the effects of significant variability within the unit nor so small as to be effected by the inherent variability between small portions of any bulk material.

Field sample masses (weights) must be based on the type and number of tests to be run on the aggregate. Standard acceptance and control tests are covered by AASHTO/ASTM standards and specify the portion of the field sample required for each specific test. Generally speaking, the masses shown in the following table will provide sufficient material for routine grading and quality analysis. Extract test portions from the field sample according to AASHTO Designation T 248.

Nominal Maximum Size of Aggregates*	Appropriate Minimum Mass of Field Samples, kg (lb.)**
Fine Aggregates	
2.36 mm (No. 8)	10 (25)
4.75 mm (No. 4)	10 (25)
Coarse Aggregates	
9.5 mm (3/8 in.)	10 (25)
12.5 mm (½ in.)	15 (35)
19.0 mm (¾ in.)	25 (55)
25.0 mm (1 in.)	50 (110)
37.5 mm (1½ in.)	75 (165)
63 mm (2 in.)	100(220)
50 mm (2½ in.)	125 (275)
75 mm (3 in.)	150 (330)
90 mm (3½ in.)	175 (385)

** For processed aggregate the nominal maximum size of particles is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.*

*** For combined coarse and fine aggregates, minimum mass shall be equal to the coarse aggregate minimum plus 10 kg (25 lb.).*

SHIPPING SAMPLES

Transport aggregate samples in bags made for that purpose or other suitable containers which will prevent loss or contamination of the sample, or damage to the contents from handling during shipping.

The sample containers shall have suitable individual identification attached and enclosed so the field reporting, laboratory logging, and test reporting may be facilitated.

SAMPLING METHODOLOGY - AGGREGATE STREAMFLOW

Before taking a sample, you must first assemble all the equipment you will need to obtain the sample. To obtain a sample using the aggregate streamflow, you will need the following:

- A sampling device designed for use at each particular plant. This device consists of a pan of sufficient size to intercept the entire cross section of the discharge stream and retain the required quantity of material without overflowing. In some situations, a set of rails may be necessary to support the pan as it is passed through the streamflow.
- Safety equipment such as hard hat, glasses, etc.
- Sample containers, tags, etc.

Sampling Procedure

Pass the sampling device through the streamflow, being sure to cut through the entire cross section of the material as it is being discharged. Care must be taken to pass the device through the stream rapidly enough to prevent any overflow of material during the sampling procedure. Obtain a minimum of three increments for each sample. Obtain the appropriate mass to accommodate all tests to be performed on the sample. Allow an amount of time to elapse between passes to better get a representative sample of the material. When sampling aggregate from a loaded bin, increments should not be obtained when the belt first starts or when the bin is nearly empty to avoid the natural segregation that may occur as the material exits the bin.

Streamflow Sampling

SAMPLING METHODOLOGY - CONVEYOR BELT

The equipment to sample from a conveyor belt is somewhat different than that used for sampling from a streamflow. The following equipment is needed to secure a proper sample from a stopped conveyor belt:

- A template constructed to conform to the shape of the loaded belt. An adjustable spacer between the two ends of the template is helpful to allow for adjustment of the device to the amount of aggregate on the belt.
- A scoop or trowel to aid in removing the aggregate from the stopped belt.
- A brush or broom to aid in removing the fine particles of the increment from the belt surface.
- Sample containers, tags, etc.
- Safety equipment such as hard hat, gloves, glasses, etc.
- Lock out switch on the conveyor belt

Sampling Procedure

Insert the template into the aggregate on the <u>stopped</u> conveyor belt being sure the template passes through the aggregate and rests on the surface of the belt. Do not sample the portions of material first discharged on the belt or material discharged as the bin empties. These areas are normally segregated and the sample will not be representative. Using the small scoop or hand, remove as much of the aggregate from the belt as possible. Brush the remaining fines into the sample container. A dustpan may be useful in some applications to collect the fines. Obtain at least three increments for each field sample being sure to collect the minimum mass needed to perform all applicable tests. Allow the belt to run awhile between each increment. This will aid in obtaining a sample more representative of the lot of material being tested.

Conveyor Belt Sampling

SAMPLING METHODOLOGY - STOCKPILES OR TRANSPORTATION UNITS

The equipment necessary to obtain a sample from a stockpile or transportation unit is listed below:

- Sampling tube (approximately 30 mm (1¼ in.) minimum in diameter by 2 m (6 ft.) in length.
- Square-nosed shovel.
- Flat board
- Sample containers, tags, etc.
- Safety equipment, such as hard hat, gloves, glasses, etc.
- Front-end loader (if available)

Sampling Procedure

Avoid sampling coarse or combined aggregate from stockpiles and transportation units whenever possible, especially when the sample taken is intended to determine characteristics dependent upon the grading of the sample. It is very difficult to ensure unbiased samples, due to the segregation which often occurs when material is stockpiled, with the coarser particles rolling to the outside base of the pile.

If circumstances dictate the need to obtain stockpile samples of coarse or combined aggregate, develop a sampling plan for the specific case under consideration. This approach will allow the sampling agency to use a sampling plan that will give a confidence in results obtained that is agreed upon by all parties concerned to be acceptable for the particular situation. This plan shall define the number of samples necessary to represent the lots and sublots of specific sizes. General principles for sampling from stockpiles apply to sampling from transportation units such as trucks, rail cars, and barges.

When available, have the power equipment create a small stockpile for sampling by drawing material from various levels and locations from the main pile. Several increments should then be sampled from this pile using the square-nosed shovel. Create as near a vertical face as practicable at several locations around the pile. A flat board shoved vertically into the pile just above the sampling point aids in preventing further segregation by holding the material above the location in place.

When power equipment is not available, the same method may be used at various levels and locations around the main pile. A minimum of three increments must be obtained, one from the top third, one from the midpoint, and one from the bottom third of the pile.
If necessary to determine the degree of variability existing within the pile, separate samples should be drawn from separate areas of the pile.

When sampling from transportation units, power equipment should be used whenever available, to expose the aggregate at various levels and random locations. A common procedure when power equipment is not available requires trenching at three or more locations across the unit in areas that visually appear to represent the characteristics of the load. The trench bottom should be approximately level, at least 0.3 m (1 ft.) in width and in depth below the surface. A minimum of three increments from approximately equally spaced points along each trench should be taken by pushing the shovel downward into the material.

Sampling of fine aggregates from stockpiles or transportation units should be accomplished with the sampling tube. The technician must be careful to avoid segregated areas such as around the base of the stockpile or unit to be sampled. Use a square-nosed shovel or other means to dig into the pile a little ways before insertion of the sampling tube. Insert the tube into the pile at several locations to extract a minimum of five increments of material to compile the field sample. This method should not be used for coarse or combined aggregates.

The technician may choose to sample the fine aggregate by creating a vertical face in the selected sample areas with a square-nosed shovel and then carefully slide the nose of the shovel in an upward motion from the base of the prepared sample area. The shovel should be held at an approximate ninety degree angle to the vertical face and inserted into the fine aggregate approximately 50 mm (2 in.). The aggregate should be in a damp condition to use this method.

When sampling a unit of fine aggregate, select at least three areas to obtain the individual increments, that when combined, will make up the field sample. The mass of the field sample must be large enough to provide enough material for each test to be performed on the aggregate.

Stockpile Sampling With a Probe

Stockpile Sampling With a Square-nosed Shove

SAMPLING METHODOLOGY - ROADWAY (BASES AND SUBBASES)

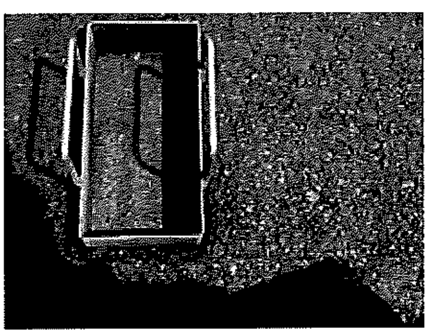
The equipment to sample aggregate from the roadway includes the following:

- Square-nosed shovel.
- Square or rectangular template
- Sample containers, tags, etc.
- Safety equipment, such as hard hat, gloves, glasses, etc.

Sampling Procedure

Selecting representative samples of aggregate in place creates a special challenge. A method of random sampling, such as found in ASTM D 3665, must be used to help in obtaining unbiased samples.

Obtain at least three increments from the unit being sampled, and combine to form a field sample with a mass that meets or exceeds the minimum amount required for the type of material being sampled. Increments taken from the roadway must be to the full depth of the material. Care must be used to avoid contaminating the sample with underlying material. A square or rectangular template placed over the area to be sampled is a definite aid in securing approximately equal amounts of material in each increment. A square-nosed shovel may also be used to aid in defining the sample area.



Template Placed in Subbase

NOTE

Always remember when sampling in a construction zone to be aware of the activities around you.

GLOSSARY

Field Sample - a quantity of the material to be tested that is of sufficient size to provide an acceptable estimate of the average quality of a unit.

Lot - a sizeable isolated quantity of bulk material from a single source, assumed to have been produced by the same process.

Test Portion - a quantity of the material that is of sufficient size, extracted from the field sample by a procedure designed to ensure accurate representation of the field sample, and thus of the unit sampled.

Unit - a batch or finite subdivision of a lot of bulk material (for example, a truck load, a specific area covered, or a certain amount of tons produced).

Fine Aggregate - Fine Aggregate - An aggregate sample with predominately material which will pass the 4.75 mm (#4) sieve.

Coarse Aggregate - Normally an aggregate consisting of particles predominately larger than a 4.75 mm (#4) sieve. For the purposes of this test method, coarse aggregate is defined as any aggregate sample containing 50 percent or more particles retained on the 4.75 mm (#4) sieve.

Combined Aggregate - An aggregate containing both coarse and fine particles in a relatively even amount.

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

AASHTO T 248

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NOTE

Successful completion of the following training materials, including examination and performance evaluation are prerequisites for this training package.

- AASHTO D3665, Practice for Random Sampling Construction Materials
- AASHTO T2, Sampling of Aggregates

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REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

Aggregates are the main ingredient in highway construction. They are used in all phases from base construction, pavement and structural mix, granular shoulders, and granular surfacing, as well as, erosion control. In order to ensure the aggregate performs as intended for the specified use, a variety of tests must be performed on the aggregate. These samples must be representative of the aggregate selected for use and should be obtained by appropriate methods as described in AASHTO T 2.

The field samples of aggregate must generally be reduced to an appropriate size for testing to determine physical characteristics, such as, sieve analysis, soundness, hardness, etc. The methods described in this text are intended to minimize variations in the aggregate characteristics between the smaller test samples and the larger field samples.

Several methods of sample reduction will be described. The technician must be sure to use the appropriate technique dependent on such factors as aggregate size and moisture content.

The reduction methods include:

- Method A - Mechanical Splitter
- Method B - Quartering
- Method C - Miniature Stockpile

In some circumstances, reducing the field sample prior to testing is not recommended. Substantial differences may unavoidably occur during sample reduction, i.e., in the case of an aggregate having relatively few large size particles in the sample. These few particles may be unequally distributed among the reduced size test samples. If the test sample is being examined for certain contaminants occurring as a few discreet particles in a small percentage, the reduced test sample may not be truly representative of the total aggregate as produced. In these cases, the entire original field sample should be tested.

Failure to carefully follow the procedures in these methods of sample reduction may result in providing a nonrepresentative sample for subsequent testing, resulting in inaccurate test results, and ultimately, failure of the aggregate to perform as intended.

SUMMARY OF SAMPLE REDUCTION

Aggregate and other materials sampled in the field need to be reduced to appropriate sizes for testing. It is, therefore, necessary to reduce field samples while minimizing the chance of variability during handling. In some instances a few particles on a given sieve might affect a gradation significantly enough to alter an interpretation of the field sample and subsequently the entire lot's compliance with specifications.

The appropriate field sample reduction method is dependent chiefly on the nominal maximum size of the aggregate, the amount of free moisture in the sample, and the equipment available.

The glossary at the back of this section should be read thoroughly before proceeding with sample reduction

The following chart should be used in selecting the appropriate reduction method for the aggregate to be tested.

Mechanical Splitter	Quartering	Miniature Stockpile
Fine Aggregates - Air Dry	Fine Aggregates - Free Moisture on the Particle Surface	Fine Aggregate - Free Moisture on the Particle Surface
Coarse Aggregates	Coarse Aggregates	Not Appropriate for Coarse Aggregate
Combined Aggregates	Combined Aggregates with Free Moisture on the Particle Surface	Not Appropriate for Combined Aggregate

COMMON SAMPLE REDUCTION ERRORS

- Failure to obtain a field sample using the methods and guidelines given in AASHTO T 2.
- Failure to select proper method for sample reduction based on aggregate moisture content.
- Failure to uniformly distribute the field sample from edge to edge while placing it in the hopper or pan prior to pouring it through the chutes when using a mechanical splitter.
- Failure to, when using a mechanical splitter, control the rate at which the materials are poured through the chutes such that the material is free flowing into the receptacle pans below. This includes using a hopper or straight-edged pan that, per AASHTO T 248, has a width equal to or slightly less than the overall width of the assembly of chutes.
- Failure to use or set mechanical splitters to meet the applicable requirements for number of chute openings and chute width.
- When using the quartering method or miniature stockpile method, failure to mix the sample thoroughly by turning the entire sample over three times.
- When using the quartering method, failure to brush the cleared spaces clean of fines after removing the two diagonally opposite quarters from the flattened field sample.
- When using the miniature stockpile method, failure to obtain the five (minimum) increments of material from random locations in the miniature stockpile. Do not take all five samples from the same location.

SAMPLE REDUCTION - METHOD A (MECHANICAL SPLITTER)

Before beginning any procedure, you must first assemble all the equipment needed to perform the test.

Apparatus (Mechanical Sample Splitter)

- The mechanical sample splitter must have an even number of equal width chutes, not less than eight for coarse or combined aggregate, or twelve for fine aggregate.
- The chutes must discharge alternately to each side of the splitter.
- For coarse and combined aggregates the minimum width of the individual chutes shall be approximately fifty percent larger than the largest size particle in the sample to be reduced.
- For dry fine aggregate in which the entire sample will pass the 9.5 mm (⅜ in.) sieve, the minimum width of the chutes shall be at least fifty percent larger than the largest particles in the sample with a maximum width of 19 mm (¾ in.).
- The splitter must be equipped with at least two receptacles(catch pans) to hold the two halves of the sample during splitting.
- It shall also be equipped with a hopper or straight-edge pan with a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate into the chutes.
- The splitter and accessories shall be designed to allow the sample to flow smoothly without restriction or loss of material.

NOTE:
Mechanical splitters are commonly available in sizes adequate for aggregate having the largest particle size not over 37.5 mm (1½ in.).

Sample Preparation

Using the mechanical splitter to reduce a fine aggregate sample, the aggregate should be in an air dry condition. The entire sample may be dried to at least a saturated surface dry condition using temperatures that do not exceed those specified for any of the tests intended to be performed on the material.

If the damp, fine aggregate sample is too large to efficiently dry in this manner, a preliminary split may be performed using a mechanical splitter with chute openings no smaller than 37.5 mm (1½ in.). Reduce the sample to not less than 5000 g and dry this sample. Reduce the dried sample using a mechanical splitter with individual chute openings not to exceed 19 mm (¾ in.) to the required test sample size(s).

When reducing a coarse aggregate by mechanical splitting, the sample may be reduced in a damp condition taking care that any fine particles adhering to the chutes are brushed into the catch pans. Samples containing excess water should be allowed to drain before reduction is attempted.

Combined aggregates may also be reduced in a damp condition, as long as the aggregate flows freely through the chute openings without plugging and any small particles adhering to the chutes are brushed into the catch pans.

When practicable, allow all samples to attain an air dry condition before using a mechanical splitter.

Note:
If the field sample was originally collected in two or more increments (separate sacks containing material from different parts of the same stockpile), then the separate increments must be thoroughly mixed together to form one homogenous field sample. Mixing can be done using an adequate sample splitter or by mixing the sample with a shovel as detailed later in the section describing the quartering method procedure.

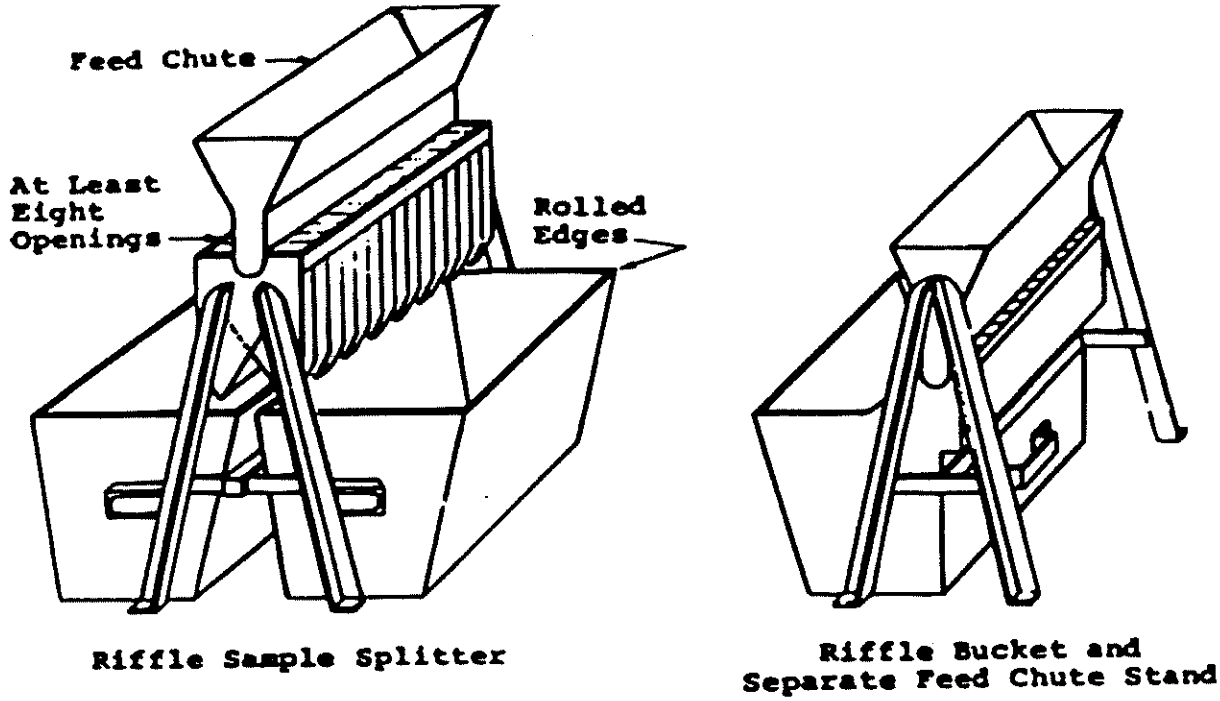
Reduction Procedure

Place the original sample, or portion thereof, in the hopper or pan and uniformly distribute it from edge to edge being sure the sample appears homogenous (well-blended). Carefully introduce the sample into the chutes in a manner to allow the aggregate to flow freely through the openings and into the catch pans. Continue this procedure until the entire large sample has been halved, being careful that catch pans do not overflow.

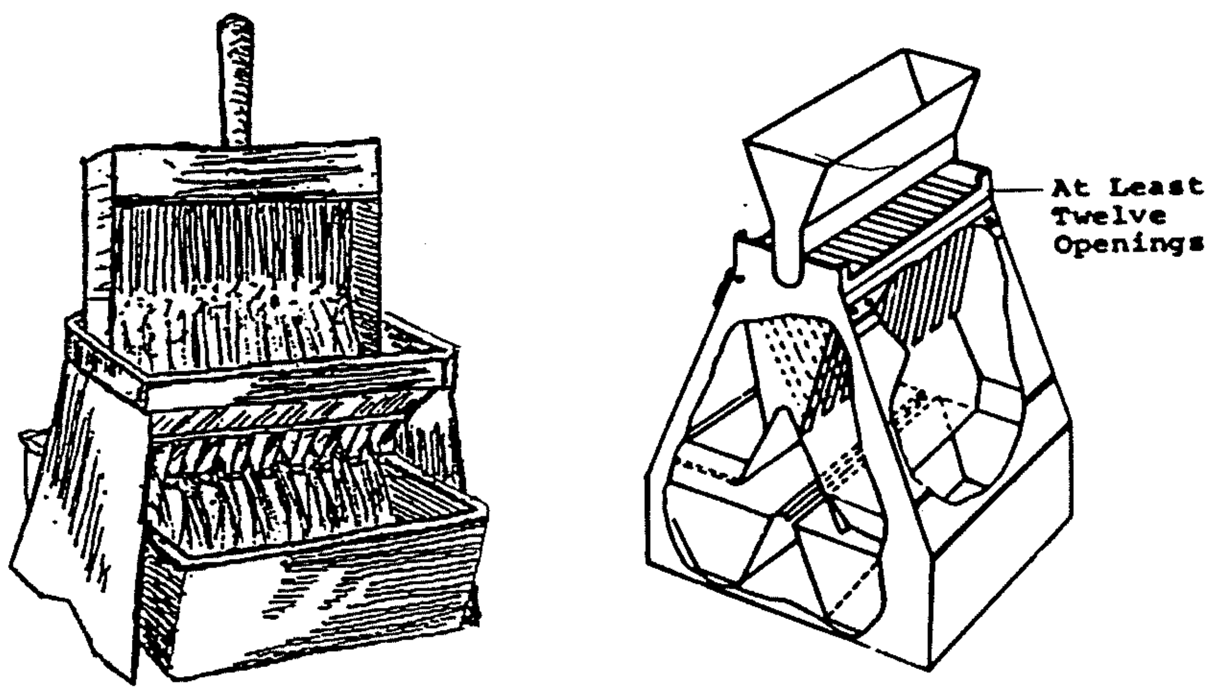
Remove the catch pans and set aside. Continue splitting the other half into quarters. Follow this procedure, being sure to split entire increments, until the desired test sample size is obtained. Retain the unused material until all desired tests are performed in case a retest is needed.

The mechanical splitter method is the preferred method of sample reduction and should be used when practicable. Mechanical splitters are commonly available in sizes adequate for aggregates with particle sizes up to 37.5 mm (1½ in.).

Note:
Sometimes a significant amount of fines may be lost in the splitting process if the sample is extremely dry and the action of pouring the sample through the splitter chutes creates a large dust cloud, suspending the fines in the air above the splitter. If this is a serious concern, then add a small amount of water to the original sample and mix thoroughly before splitting the sample. The extra moisture will prevent many of the fines from becoming suspended in the air and drifting off. Remember to not add so much water that the moisture content ends up being at or greater than the SSD condition, in which case the mechanical splitting method would no longer be valid. In any case, be sure to perform the splitting procedure in a well-ventilated area while wearing a suitable dust mask (one which is designed to protect against silica dust) or injury to the lungs, over time, may result.



(a) Large Riffle Samplers for Coarse Aggregate.



NOTE—May be constructed as either closed or open type. Closed type is preferred. (*b*) Small Riffle Sampler for Fine Aggregate.

FIGURE 1 Sample Splitters

MECHANICAL SAMPLE SPLITTER

Mechanical Splitter

Sample in Splitter

Sample Being Split

SAMPLE REDUCTION - METHOD B (QUARTERING)

Apparatus

The following are the apparatus needed to perform Method B.

- Straight-edged scoop.
- Flat-edged shovel or trowel.
- Broom or brush.
- Alternate method only - canvas blanket measuring approximately 2 m by 2.5 m (6 ft. X 8 ft.).

Sample Preparation

Fine aggregate must be in a moist condition to use Method B - quartering, to reduce the sample. The material should be damp enough to allow it to stand in an almost vertical face.

Coarse aggregate may be either damp or dry when using Method B. (*Method A is the preferred sample reduction method for coarse aggregates).*

Combined aggregates must be in a moist condition to reduce the sample by Method B, again able to stand in an almost vertical face.

Reduction Procedure

Place the original sample on a hard, clean, level surface. Mix the material thoroughly by turning the entire sample over with the shovel three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with the shovel so that each quarter section of the resulting pile will contain the material originally in it. The pile diameter should be approximately four to eight times the thickness.

Divide the flattened pile into four equal quarters with the shovel or trowel. Remove two diagonally opposite quarters, including all fine material. Brush the cleared spaces clean. Successively mix and quarter the remaining material in the same fashion as the original sample. Continue this process until the desired quantity is obtained.

Save the unused portion of the original field sample until all testing is completed in case a retest is needed.

METHOD B - ALTERNATIVE

As an alternative to Method B, when the floor surface is uneven, the field sample may be placed on a canvas blanket and mixed with a shovel, or by alternatively lifting each corner of the blanket and pulling it over the sample toward the diagonally opposite corner causing the material to be rolled. Flatten and divide the pile as described in Method B, or if the surface beneath the blanket is too uneven, insert a stick or pipe dividing the pile into two equal parts. Remove the stick leaving a fold in the canvas between the sample halves. Slide the stick under the canvas blanket again at a right angle to the first division and dissecting the two halves of the sample through their centers. Lift the stick evenly from both ends dividing the sample into equal quarters. Remove two diagonal parts including the fine material and clean the area. Successively mix and quarter the remaining material until the desired sample size is obtained.

Note:

The quartering method is fairly time intensive and thus is generally used in situations where an adequate mechanical splitter is unavailable. Diligence and care is required to ensure that the samples obtained by quartering remain representative of the entire field sample.

METHOD B

Mix by Forming New Cone

Flatten Cone

Divide Sample Into Quarters

Method B (alternative)

Stick Placed Under Flattened Sample

Sample Divided in Half

Sample Divided Into Quarters

SAMPLE REDUCTION - METHOD C (MINIATURE STOCKPILE)

APPARATUS

The equipment needed to reduce an aggregate sample using Method C include the following items.

- Straight-edged scoop.
- Shovel or trowel (for mixing the aggregate).
- Small sampling thief, small scoop, or spoon.

Sample Preparation

The miniature stockpile method must only be used when reducing a sample of fine aggregate.
The sample must be in a moist condition before performing this method.

Reduction Procedure

This method is for damp, fine aggregate only.

Place the field sample on a hard, clean, level surface where there will be no loss of material or contamination. Mix the sample by turning the entire sample over three times with a shovel. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. If desired, the conical pile may be flattened to a uniform thickness and diameter by pressing on the apex of the conical pile with the shovel.

Obtain a sample for each test to be performed by selecting at least five increments of material at random locations from the miniature stockpile using a sample thief, small scoop, or spoon.

Miniature Stockpile

Taking One of At Least Five Increments

GLOSSARY

Nominal Maximum Size - The largest sieve size listed in the applicable specification, upon which any material may be retained.

Note:
Occasionally the largest particles in a material as produced may be smaller than the nominal maximum size as defined and still be in specification compliance. Sample size and reduction method may be revised to reflect the material to be tested.

INSTRUCTOR'S NOTE
Refer to state specification for definition of nominal maximum size by material type.

Saturated Surface Dry (SSD) - An aggregate is considered to be in a saturated surface dry condition when there is no free moisture present but the aggregate is in a nonabsorbent state. In other words, the aggregate has all the moisture it can absorb and surface of the aggregate is dry.

Air Dry - When the aggregate appears to be dry but still has some absorbed moisture in its pore structure.

Fine Aggregate - Aggregate which has a nominal maximum size of the 4.75 mm (No. 4) sieve or smaller.

Coarse Aggregate - Aggregate which is predominately larger than the 4.75 mm (No. 4) sieve.

Combined Aggregate - Aggregate which has a blend of both coarse and fine particles.

MATERIALS FINER THAN 75 µm (No. 200 SIEVE) IN MINERAL AGGREGATES BY WASHING

AASHTO T 11

FHWA SPONSORED

Developed by
Multi-Regional Aggregate Training and Certification Group
Revised 2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation are prerequisites to this training package.

- AASHTO T 2, Sampling
- ASTM D 3665, Practice for Random Sampling of Construction Materials
- AASHTO T 248, Reducing Samples of Aggregate to Testing Size

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Material Finer Than 75 µm (No. 200 Sieve) In Mineral Aggregates By Washing

Aggregates are the main ingredient in highway construction. They are used in all phases - base construction, pavement mixes, granular surfacing and erosion control. In order to ensure the aggregate performs as intended for the specific use, a variety of tests must be performed on the aggregate. One such test determines materials finer than the 75µm (#200) sieve in mineral aggregate by washing. Fine materials such as clay particles or water-soluble particles can cling to larger particles and do not dislodge readily. This test washes the fine particles through the 75 µm (#200) sieve to give an accurate determination (when combined with dry sieving) of the minus 75 µm (#200) portion in the sample.

The determination of minus 75 µm (#200) material is used to compare material performance with gradation specifications, and, indirectly, to gauge such properties as plasticity, permeability and soils classifications. Such knowledge helps in determining whether a material is frost susceptible or not, whether permeability (measurement of material capacity to allow water to flow through it) will be affected.

Common Testing Errors

- Plugging the wash sieve
- Loss of material during test, water flow/pressure too high
- Using a damaged wash sieve (e.g., holes in screen, cracked, etc.)
- Not drying sample to a constant weight before and after test procedure
- Using a balance not accurate enough for the sample to be tested

Summary of Procedure

A sample, representative of the aggregate to be tested, is washed using water or water containing a wetting agent. The water, containing suspended and dissolved material, is poured off the sample through a 75 μm (#200) sieve. The loss in mass (weight) after this process is calculated as the amount of material finer than the 75 μm (#200) sieve by washing, based on the original dry mass (weight) of the test sample.

The **total** fraction of material finer than the 75 μm (#200) sieve is calculated by adding the washing loss to the amount that passed the 75 μm (#200) sieve after dry sieving and dividing that total by the original dry weight of the test sample (Method T 27).

Fines suspended in the water are washed over a 2.36mm(#8) and a 0.075mm(#200) sieve.

Wash sample in a large washing bowl. Sample should be stirred or agitated in order to suspend the fines in the water.

Material retained on the 0.075mm(#200) sieve after one rinse.

The washed sample should be relatively clear. If you can see the sample beneath the water, then the sample is probably adequately washed.

Wash the material retained on the sieve to one side in order to more easily move it to a drying pan.

A water bottle is used to wash the material from the 0.075mm sieve to the drying pan.

TEST METHODOLOGY

APPARATUS

- Balance (scale) – conforming to the requirements of AASHTO M 231, accurate to within 0.1 percent of the mass (weight) of the sample to be tested.
- Sieves – conforming to the requirements of AASHTO M 92; one 75µm #200) wash sieve and one 2.36 mm (#8) or 1.18 mm (#16) sieve to place over the wash sieve to protect the wash sieve from damage.
- Container (pan for washing) – large enough to hold the sample covered with water and to allow agitation without losing any water or portion of the sample.
- Oven (or drying stove/hot plate) – oven capable of maintaining a uniform temperature of 110° ± 5°C (230° ± 9°F). A drying stove or hot plate may be used as long as the temperature is controlled to prevent popping and splattering of the sample, and the temperature does not cause fracturing or chemical breakdown of the aggregate.
- Wetting Agent – any dispersing agent, such as liquid dish soap, which will help the separation of the fine materials.

Note
The use of a mechanical apparatus to do the washing operation is allowed as long as the results are consistent with the hand method. Some softer aggregates may tend to break down (degrade) when using a mechanical washer.

Sampling

Sample the aggregate by the appropriate method as described in AASHTO T 2.

Sample Preparation

The field sample of aggregate is reduced to the size needed for testing by using the appropriate method for sample reduction as described in AASHTO T 248. The test sample must be the end result of the reduction. Reduction to an exact predetermined mass (weight) is not allowed.

If a complete sieve analysis is to be run on this sample (AASHTO T 27), the mass (weight) of the test sample must comply with the required sample sizes listed in AASHTO T 27.

When the sample is to be tested only for the amount finer than the 75 µm (#200), use the following table to determine sample size. The following masses (weights) are **minimum** dry masses (weights).

NOMINAL MAXIMUM SIZE	MINIMUM SAMPLE MASS (WEIGHT), g
4.75 mm (#4)*or smaller*	300
9.5 mm (_ in.)	1000
19.0 mm (¾ in.)	2500
37.5 mm (1½ in.) or larger	5000

Note

Normally, when a complete sieve analysis and the amount finer than the 75 µm (#200) sieve is to be determined, the entire test sample is used when the maximum aggregate size is 12.5 mm (½ in.) or less. When the aggregate size is larger, a second sample may be reduced from the original field sample for the wash test (using the above chart to determine size).

Also, when testing aggregates with large nominal maximum sizes, i.e. 50 mm (2 in.) or larger, the specifications for material finer than the 75 µm (#200) sieve may be on the portion of material passing the 25.0 mm (1 in.) or smaller sieve, since it is impractical to attempt washing samples of the size required. In this case the test sample to be washed is first screened over the designated sieve and the portion passing this sieve, minus 25.0 mm (1 in.), is tested.

TEST PROCEDURE

The test sample must be dried to a constant mass (weight). When the sample has cooled to a point safe to handle, weigh the sample to the nearest 0.1 percent of the mass (weight) of the test sample and record the mass (weight) as the original dry mass (weight).

Place the sample in a wash container large enough to prevent any loss of material during the washing process and add enough water to cover the aggregate. Any loss of material during the washing process will give an inaccurate test result. Agitate the sample with a rotary motion of the pan hard enough to cause the fine particles to suspend or dissolve in the water. This usually takes about 5 to 10 seconds. The use of a large spoon or other similar tool to stir the sample has been found to work also, but care must be used to avoid breaking down aggregate particles.

After the sample has been stirred, carefully pour the water with the suspended material through the nest of two sieves with the coarser sieve on top of the 75 µm (#200) sieve (for protection against damage to the finer mesh). Continue this process until the wash water is reasonably clear.

Note

When mechanical washing equipment is used, the addition of water, agitation, and decanting of water may be a continuous operation.

Some aggregates, especially combined aggregate samples, may tend to plug the mesh of the 75μm (#200) sieve during the washing process. A spray nozzle, piece of tubing on the faucet, or a rinsing bottle may be used to help keep the mesh unclogged so that the water and suspended material will pass the 75μm (#200) sieve. The water pressure must be controlled to prevent any material splashing over the sides of the sieve.

After the last washing cycle, any material retained on the 75μm (#200) sieve must be flushed back into the test sample. Rinse the retained material into a corner of the 75μm (#200) wash sieve using the rinse bottle, sprayer, etc.. Then, using as little water as possible, rinse the material back into the sample. After this process, to avoid any loss of material, no water is to be poured from the container except through the 75μm (#200) sieve. Excess water from flushing should be evaporated from the sample in the drying process.

Note

A wetting agent **should not be used unless** specified or when directed by the agency for which the work is being done.

When a wetting agent (liquid detergent) is used, place only a drop or two in the pan containing the sample covered with water before the first washing cycle. The quantity of detergent needed may vary depending on water hardness and type of detergent. **Excessive suds may overflow the sieves and carry some material with them. Detergent should only be added during the first wash cycle.**

Dry the washed sample to a constant dry mass (weight). During the drying process the sample must be stirred occasionally to help speed the drying. Also, when using a stove or hot plate, the heat setting must not be too high. The wet aggregate will tend to pop and sputter if too much heat is applied, causing loss of material or particle breakdown.

Calculations

When the sample has dried to a constant mass (weight) and cooled, weigh the sample and record this mass (weight) as the mass (weight) of the washed dry sample. Subtract this mass (weight) from the original dry mass (weight) to determine washing loss. To determine percent of washing loss, divide the mass (weight) of the washing loss by the original dry mass (weight) of the sample (x 100).

Note

If the sample is not going to have a complete sieve analysis run, use the following to determine the total amount of material passing the 75μm (#200) sieve. Screen the washed and dried sample over a 2.36 mm (#8) sieve. Place the material passing the 2.36 mm (#8) sieve on a nest of sieves with the 75μm (#200) sieve and pan on the bottom of the stack. The nest of sieves above the 75μm (#200) sieve is to protect the mesh of the 75μm (#200) sieve from excessive material. A 1.18 mm (#16) and 300 μm (#50) sieve is usually adequate.

Shake this nest in a mechanical sieve shaker, or by hand, until sieving to completion is attained. Normally, about 5 minutes is long enough in a mechanical shaker.

Weigh the material in the pan after sieving. Add this amount to the mass (weight) of washing loss and divide this total by the mass (weight) of the original dry sample (x 100).

When the washed sample is to have a complete sieve analysis run on it, follow AASHTO T 27 for sieve analysis of aggregates.

The **total** percent of material passing the 75μm (#200) sieve is then determined by adding the mass (weight) of washing loss to the amount passing the 75μm (#200) sieve after dry sieving and dividing that sum by the **original dry mass (weight) of the sample (x 100)**.

Note

Excessive amounts (10 to 15 grams) of material in the pan after dry sieving may be an indication that washing time needs to be increased. It also may indicate the aggregate is breaking down during dry sieving.

Report

Report the percent of material finer than the 75μm (#200) sieve by washing to the nearest 0.1 percent. If the amount is more than 10 percent, report to the nearest whole percent. A statement as to which procedure was used must be included.

Glossary

Coarse Aggregate – Aggregate particles retained on and above the 4.75mm (#4) sieve.

Fine Aggregate – Aggregate predominately passing the 4.75mm (#4) sieve.

Wetting Agent – A dispersing agent, such as liquid dish soap.

Sieve Analysis – The separation of an aggregate sample based on particle size.

Constant Dry Mass (weight) – Aggregate condition with no internal or external moisture.

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

AASHTO T 27

Developed by
Multi-Regional Training and Certification Group
Revised 2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation are prerequisites for this training package.

- AASHTO T 2, Sampling
- ASTM D 3665, Practice for Random Sampling of Construction Materials
- AASHTO T 248, Reducing Samples of Aggregate to Testing Size

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SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

SIEVE ANALYSIS OF AGGREGATES

Aggregates are the main ingredient in highway construction. They are used in all phases - base construction, pavement mixes, granular shoulders, granular surfacing, and erosion control. In order to ensure the aggregate performs as intended for the specific use, a variety of tests must be performed. One such test is the sieve analysis (gradation). Sieve analysis determines the distribution of aggregate particles (or gradation), by size, within a given sample. The gradation data is used to determine compliance with design requirements, production control requirements and verification specifications. The data may also be useful in calculating relationships between various aggregate blends (i.e. asphalt or Portland cement concrete mix designs), to check compliance with such blends, and to predict trends in gradations by plotting gradation curves graphically. Used along with other tests, the sieve analysis is a powerful quality control tool.

Aggregate gradation requirements are dependent on the intended use. Coarse, fine or a blend of both coarse and fine (combined) aggregate may be specified. The basic sieve analysis test procedures are the same for all types. Some test variations are needed to avoid overloading of sieves during the sieving operations. Also, this test method alone is not recommended when an accurate determination of the amount of material smaller than the 75μm (#200) sieve is specified. A combination of this test method and AASHTO T 11, Materials Finer Than 75μm (#200) Sieve in Mineral Aggregates by Washing, must be used in that case.

Sieve sizes commonly used to test a coarse aggregate are:

> 37.5mm (1½ in.); 25.0mm (1 in.); 19.0mm (¾ in.); 12.5mm (½ in.);
> 9.5mm (⅜ in.); 4.75 mm (#4); and 2.36mm (#8).

Sieve sizes commonly used to test a fine aggregate are:

> 4.75mm (#4); 2.36mm (#8); 1.18mm (#16); 600μm (#30); 300μm (#50);
> 150μm (#100); and 75μm (#200).

Note: This test method alone is not sufficient to determine the <u>total</u> percent passing the 75μm (#200) sieve. AASHTO T 11, Materials Finer then 75μm (#200) Sieve in Mineral Aggregates by Washing, must be also used when the amount passing the 75μm (#200) sieve is specified.

COMMON TESTING ERRORS

- Improper sample size
- Overloading of sieves
- Loss of material while performing test procedures
- Insufficient sieve cleaning
- Using damaged sieves (e.g. holes in screen, cracked, etc.)
- Not sieving to completion
- Using a balance not accurate enough for the sample to be tested
- Not drying sample to a constant weight before test procedure

Summary of Procedure

A known amount of material (sample size), which is determined by the nominal maximum size of the aggregate, is placed in a nest of sieves starting with the largest required sieve and continuing with consecutively smaller sieves through the specified smallest screen. The sieve(s) are then placed in a mechanical sieve shaker or hand sieved for a period of time that will assure sieving to completion has been accomplished.

The material is cleaned from each sieve and weighed in individual increments. Each retained mass (weight) is recorded.

Specification requirements are given in terms of either percent retained or percent passing.

The percent **retained** on each sieve is then calculated by dividing each increment's mass (weight) by the mass (weight) of the original dry sample and multiplying by 100. The percent **passing** may then be determined be consecutive subtraction of the percent retained.

TEST METHODOLOGY

Apparatus

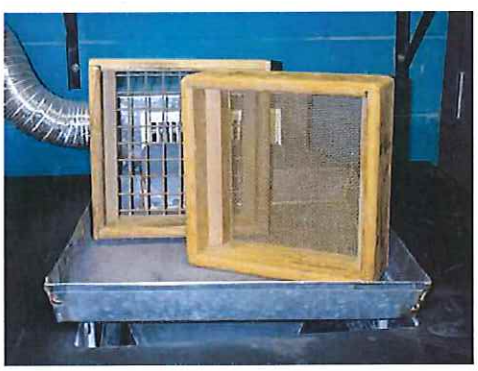
Balance – Accurate to 0.1 percent of the sample to be tested; conforming with the requirements of AASHTO M 231.

Sieves – Mounted on substantial frames and constructed to prevent loss of material during sieving. The sieves must meet the requirements of AASHTO M 92. Sieves with openings larger than 125mm (5 in.) may vary ± 2 percent in average openings and have a nominal wire diameter of 8.0mm (5/16 in.) or larger.

Oven (or drying stove/hot plate) – An oven of appropriate size capable of maintaining a uniform temperature of 110°± 5°C (230°± 9°F). A drying stove or hot plate may be used as long as the temperature is controlled to prevent popping and splattering of the sample, and the temperature does not cause fracturing or chemical breakdown of the aggregate.

Mechanical Sieve Shaker – A mechanical sieve shaker, if used shall impart a vertical, or lateral and vertical, motion to the sieve(s). This motion causes the aggregate particles to bounce and turn during sieving. The action should allow sieving to completion, as described in the test procedures, within a reasonable amount of time.

Fiber-bristle Sieve Cleaning Brush – To aid in cleaning the finer-meshed sieves.



Sample Preparation

A field sample of the aggregate to be tested must be obtained by an appropriate method as described in AASHTO T 2.

Reduce the field sample to the required sample size for sieve analysis by following an approved method from AASHTO T 248. Recommended sample sizes are in the following table. Some agencies may have modified guidelines to fit individual needs, and the technician needs to be aware of any modifications.

Sample Sizes for Sieve Analysis
Coarse Aggregate

Nominal Maximum Size Square Openings mm (in.)		Minimum Mass of Test Sample kg (lb.)	
9.5	(⅜)	1	(2)
12.5	(½)	2	(4)
19.0	(¾)	5	(11)
25.0	(1)	10	(22)
37.5	(1½)	15	(33)
50.0	(2)	20	(44)
63.0	(2½)	35	(77)
75.0	(3)	60	(130)
90.0	(3½)	100	(220)
100.0	(4)	150	(330)
112.0	(4½)	200	(440)
125.0	(5)	300	(660)
150.0	(6)	500	(1100)

Sample Sizes for Sieve Analysis
Fine Aggregate

Aggregate samples with at least 95% passing the 2.36mm (#8) sieve need a **minimum** dry sample mass (weight) of 100 grams.

Aggregate samples with at least 85% passing the 4.75mm (#4) sieve need a **minimum** dry sample mass (weight) of 500 grams.

For combined aggregates (aggregates with a blend of both coarse and fine particles) use the sample size chart for coarse aggregates based on the nominal maximum size of the coarse particles in the aggregate to be tested.

Note

Occasionally the largest particles in a material as produced may be smaller than the nominal maximum size as defined and still be in specification compliance. Sample size may be revised to reflect the material to be tested.

For example: A specification that uses a nominal maximum size of 25.0mm (1 in.) may have a requirement of 95 to 100 percent passing the 25.0mm (1 in.) (by definition, this is the nominal maximum size of the aggregate). If 100 percent passes this screen, the actual maximum size of the aggregate is 19.0mm (¾ in.), but it still meets the 25.0mm (1 in.) specification.

Test sample sizes for aggregate with a nominal maximum size of 50mm (2 in.) or larger require larger mechanical sieve shakers than may be practical for some lab situations. The sample sizes may be reduced as long as the criteria for acceptance or rejection of the material is based on the average of several samples. In this case the sample size used multiplied by the number of samples must equal or exceed the minimum mass (weight) shown in the sample size chart.

Test Procedure

Note

When a determination is to be made on the amount of material finer than 75µm (#200), the sample will need to be tested by AASHTO T 11 first. When determining this amount on a coarse aggregate sample with particles larger than 12.5mm (½ in.), a separate test sample may be used. This test sample may be reduced from the original field sample by using AASHTO T 248.

Dry the sample to a constant mass (weight) in the oven at a temperature of 110°± 5°C (230°± 9°F). This is not necessary if AASHTO T 11 has already been performed. A drying stove or hot plate may be used as long as the temperature is controlled to prevent popping and splattering of the sample, and the temperature does not cause fracturing or chemical breakdown of the aggregate. If aggregate fracturing happens during the drying process, throw out the sample and start a new one.

When the sieve analysis is to be performed on coarse aggregate with a nominal maximum size of 12.5mm (½ in.) or larger, drying to a constant mass (weight) may not be needed if the material contains only a minimal amount of material passing the 4.75mm (#4) sieve and does not have highly absorptive particles (such as lightweight aggregates). The sample should be in an "air-dry" condition before testing (no visible moisture).

When the sample is cool to a point safe to handle, weigh the sample to the nearest 0.1 percent based on the original dry mass (i.e. a 500 gram minimum sample mass must be weighed to the nearest 0.5 gram: 1000 to the nearest 1.0 gram, etc. – refer to the sample size charts in sample preparation section).

The sample is now ready to be screened. Use the number of sieves needed to determine specification compliance. Additional sieves may be desirable to provide other information such as Fineness Modulus, or to aid in preventing the overload of consecutively smaller sieves.

The amount of material on any given sieve must be limited to allow all particles the opportunity to pass through the sieve openings a number of times during the operation. The mass (weight) retained on sieves with openings smaller than 4.75mm (#4) must not exceed 6kg/m^2 (4 g/in.^{2}) of sieving surface. This amounts to 194 grams on a 203mm (8 in.) diameter sieve and approximately 450 gram on a 305mm (12 in.) diameter sieve.
For sieves with openings 4.75mm (#4) and larger, the mass (weight) in kg/m^2 of sieving surface shall not exceed the product of 2.5 x (the sieve opening in mm). The mass (weight) of the sample must never be so large as to cause any deformation of the sieve cloth.

To prevent overloading a sieve, place a sieve with larger openings above the given sieve when practical, or sieve the sample in smaller increments.

When using a mechanical sieve shaker nest the sieves, one on top of the next. The screen with the largest openings goes on top with decreasing opening sizes to the smallest, followed by the pan. Place the test sample, or portion of the sample if it is to be sieved in more than one increment, on the top sieve. Start the mechanical shaker, being sure the nest of sieves is properly secured in the shaker. The length of sieving time must be sufficient to allow for sieving to completion.

Wire brush on plus 0.60mm

Fiber-bristle on minus 0.60mm

When hand-sieving a sample, a nest of sieves may be used, or it may be easier to sieve the sample one screen at a time. When using a nest of sieves, care must be taken to prevent material loss.

After sieving, aggregate trapped in the sieve mesh should be removed. Coarse aggregate sieves are cleaned by gently working the entrapped aggregates from the mesh by hand. Excessive banging and dropping may damage the sieve. A wire brush may be used on finer mesh sieves through the 0.60mm (#30) sieve. A fiber –bristle brush and gentle tapping of the sieve should be used to clean sieves smaller than the 0.60mm (#30) sieve.

Whether hand-sieving or using a mechanical shaker, each sample increment must be sieved to completion.

For round sieves with openings 4.75mm (#4) and smaller, a check for sieving to completion by hand is to be performed as follows: Hold the individual round sieve, with a cover and snug fitting catch pan, in one hand and slightly tilted. Strike the sieve sharply with an upward motion against the heel of the other hand at an approximate speed of 150 times per minute. Turn the sieve about one-sixth revolution every 25 strokes.

For sizes larger than 4.75 (#4), check for sieving to completion with a single layer of material on the sieve surface.

Weigh any material passing the sieve in question and divide that mass (weight) by the original dry mass (weight) of the sample (x100) to determine the percent. If this percentage is greater than 0.5, longer sieving times or smaller increments may be needed on future samples.

Experience and multiple testing of the material will help the technician in determining the amount of material and length of sieving time needed to achieve sieving to completion. Excessive sieving times, especially when testing more abrasive aggregates, may cause the breakdown of some particles, altering the true gradation of the material. This must be avoided.

Each sample increment is weighed to at least the required accuracy and the mass (weight) is recorded as mass (weight) retained on the individual sieve. Each increment should be saved individually until the entire test procedure is completed.

The amount of material placed into the sieves must be the same as the total of the material retained in the sieves and the pan after sieving, within a tolerance of 0.3 percent. To check this, add the retained masses (weights) together, including the mass (weight) of the pan. Do not include the amount of washing loss of the sample if it has been tested by using AASHTO T 11 before sieving. Divide this total by the dry mass (weight) of the sample before sieving (after washing if applicable) x 100. This result must be within 0.3 percent. If this result is over 0.3, the technician should check the sieves for any excessive retained material. Reweigh each increment after assuring the pan tare is correct. If the error cannot be found, the test result must not be used to accept or reject the material being tested and the test must be repeated with a new sample.

NOTE:

When the cumulative method is used, saving individual increments is not possible. If the total mass (weight) retained in the sieves and pan after sieving is not within the 0.3 percent tolerance, a new sample must be tested.

Test Procedure for Combined Aggregates

When performing a sieve analysis on a sample containing a mixture of both coarse and fine particles (combined aggregate), sieve overload of the screens smaller than 4.75mm (#4) should be anticipated, especially when using 203mm (8 in.) round sieves. When this is the case, the minus 4.75mm (#4) material may be sieved in more than one increment, and the increments from each sieve size recombined for weighing.

An alternate method is also acceptable and is detailed as follows:

Sieve the prepared sample through the required coarse screens including the 4.75mm (#4).

Weigh the material passing the 4.75mm (#4) sieve and record as (W1). Reduce it with a mechanical sample splitter per AASHTO T 248. The reduced sample size should be no less than 500 grams each. Weigh the reduced minus 4.75 (#4) material and record as (W2).

Divide W1 by W2 and record as the conversion factor. Carry this result 4 places to the right of the decimal point.

Place the reduced sample in the required nest of sieves and shake in the mechanical sieve shaker until sieving to completion is achieved (usually about 7 to 10 minutes).

Clean the material from each sieve and the pan, weighing each increment. Record each mass (weight) as (B). Save each increment individually until the test procedure has been completed.

Add these masses (weights) retained, including the pan, but not the washing loss. This total should equal, within 0.3 percent of the mass (weight) of the reduced minus 4.75mm (#4) material (in other words, the mass (weight) of the total material after sieving should be the same as the mass (weight) of the material that was introduced into the sieves).
Multiply each recorded increment mass (weight) (B) by the conversion factor obtained by dividing W1 by W2 and record as mass (weight) retained final for each sieve.

$$A = W1 \div W2 \times B$$

Where:

A = mass (weight) of each increment based on the total minus 4.75mm (#4) material before reduction.

W1 = mass (weight) of the total minus 4.75mm (#4) material

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

B = mass (weight) of each increment of the reduced sample, after sieving

Add this mass (weight) retained column, including the sieve masses (weights) of the screens larger than 4.75mm (#4) not including the washing loss. This total must also be within 0.3 percent of the washed dry mass (weight) of the sample.

Calculations

The percent of material retained on each sieve is calculated by dividing the mass (weight) retained on each sieve by the mass (weight) of the original dry sample, (before washing if applicable). This result is then multiplied by 100 to convert to percent and recorded to the nearest 0.1 percent.

Note:
When the total percent of material finer than the 75µm (#200) sieve is required (when the sample has been tested by AASHTO T 11), combine the washing loss mass (weight) and mass (weight) retained in the pan after dry sieving on the 75µm (#200) sieve and divide by the original dry sample mass (weight) to determine the total percent passing.

This column should, when added, equal 100 percent. Often, due to rounding, this column will not equal 100 percent exactly. The difference should be prorated to the sieves containing the larger amounts of material. If the total is not within 0.3 percent, an error in calculations may have been made and should be checked and corrected.

The percentage passing each sieve may now be determined by consecutively subtracting the percent retained, starting with the first sieve used which has no material retained (100 percent passing).

The percent passing the last sieve tested must equal the last result calculated in the percent retained column or subtraction error has occurred. This would be the 75µm (#200) sieve if the sample were tested by using AASHTO T 11.

The Fineness Modulus, when required, may now be calculated by adding the percent retained on each of the following sieves larger than the 75µm (#200) sieve and dividing that sum by 100: 150µm (#100); 300µm (#50); 600µm (#30); 1.18mm (#16); 2.36mm (#8); 4.75mm (#4); 9.5mm (⅜in.); 19.0mm (¾ in.); 37.5mm (1½ in.); and larger, (i.e. doubling the previous sieve size).

Reporting

Depending upon specification requirements the sieve analysis test results are reported as (1) percent passing each sieve, (2) percent retained on each sieve, (3) percent retained between consecutive sieves.

The percentages are to be reported to the nearest whole number, except when the percent passing the 75µm (#200) sieve is less than 10.0. This result is reported to the nearest 0.1 percent. The fineness modulus is reported to the nearest 0.01 percent.

GLOSSARY

Sieve Analysis – Determination of particle size distribution (gradation) using a series of progressively finer sieves.

Coarse Aggregate – Aggregate which is predominately larger than the 4.75 mm (#4) sieve.

Fine Aggregate – Aggregate which has a nominal maximum size of 4.75 mm (#4) or smaller.

Combined Aggregate – Aggregate that is a blend of both coarse and fine particles.

Nominal Maximum Size – The largest sieve size listed in the applicable specification, upon which any material may be retained. (*Note: Occasionally the largest particles in a material as produced may be smaller than the nominal maximum size as defined and still be in specification compliance. Sample size and reduction method may be revised to reflect the material to be tested).*

Saturated Surface-Dry (SSD) – An aggregate is considered to be in a saturated surface-dry condition when there is no free moisture present but the aggregate is in a nonabsorbent state. In other words, the aggregate has all the moisture it can absorb and the surface of the aggregate is dry.

Sieving to Completion – Having no more than 0.5 percent, of aggregate particles retained on any sieve after shaking which should have passed through that sieve. Percent is calculated by mass of material retained divided by original mass.

Fineness Modulus – An index which reflects the relative coarseness or fineness of a fine aggregate.

Tare – The mass (weight) of the pan or container. Normally, the balance is adjusted to a "zero" reading by moving the scale counterbalance, or in the case of electronic scales, by tapping the tare button after the pan is placed on the scale to get a zero reading (or tare).

TOTAL MOISTURE CONTENT OF AGGREGATE BY DRYING

AASHTO T255

Developed by
Multi-Regional Aggregate Training and Certification Group
Revised 2006

NOTE

Successful completion of the following training materials, including examination and performance evaluation are prerequisites for this training package.

- AASHTO T2, Sampling
- ASTM D3665, Practice for Random Sampling of Construction Materials

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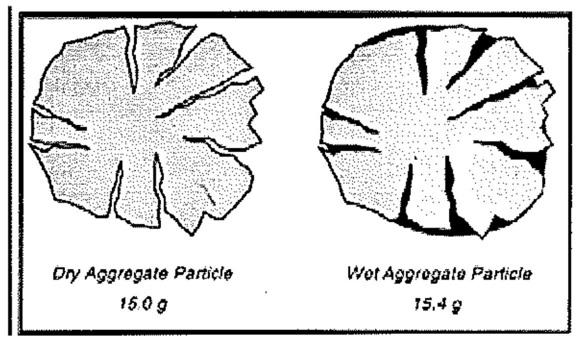
TOTAL MOISTURE CONTENT OF AGGREGATE BY DRYING

Scope

Aggregates are the main ingredient in highway construction. They are used in all phases from base construction, pavement mix, granular shoulders, and granular surfacing, as well as, erosion control. In order to ensure the aggregate performs as intended for the specific use, a variety of tests must be performed on the aggregate. One such test is the moisture content of an aggregate. The moisture content in aggregate needs to be determined to identify aggregate absorption, a base to determine maximum allowable water concern for Portland cement concrete, moisture restrictions for hot mix asphalt, and determination of density.

Basically, a known amount of material is taken, heated to drive off the moisture and the percentage moisture determined. Several methods of heating can be used, including:

- Hot plate
- Oven
- Microwave oven



Moisture Content Diagram

COMMON ERRORS

- Overheating
- Insufficient sample size
- Loss of material when stirring
- Predrying the sample
- Use of a volatile
- Performing the calculation

Apparatus

- Balance, general purpose, meeting the requirements of AASHTO M231
- Source of heat for Aggregate: a ventilated oven capable of maintaining a temperature of 110±5°C(230±9°F), or a hot plate (Figure 1), electric heat lamps, microwave oven.
- Sample container for Aggregate: Should be suitable for method selected, not affected by heat and nonmetallic if using a microwave.
- Stirrer to mix sample while drying to assist in water evaporation

Procedure

1. Select the proper sample size based on the following chart (Table 1).

Aggregate Moisture Content Sample Sizes	
Nominal Maximum size mm (in.)	Minimum Sample Mass
4.75 (#4) or smaller	0.5 kg (1.1lbs.)
9.5 (3/8)	1.5 kg (3.3 lbs.)
12.5 (1/2)	2 kg (4.4 lbs.)
19 (3/4)	3 kg (6.6 lbs.)
25 (1)	4 kg (8.8 lbs)
37.5 (1 1/2)	6 kg (13.2 lbs.)
50 (2)	8 kg (17.6 lbs.)

2. Obtain the sample, according to AASHTO T 2, and protect it from moisture loss during transport to the testing facility. An airtight container or plastic bag is best for this purpose.

3. Weigh the sample to the nearest 0.1% (figure 1), and record this mass as the original mass, W, of the sample.

4. Dry the sample in a suitable container on a selected source of heat until the sample shows less than 0.1% change in mass over subsequent weighing. In the event that you encounter material with a nominal size aggregate over 37.5 mm (1 1/2"), be aware that larger aggregate particles require longer drying times. Record the mass of the dried aggregate (after it has cooled sufficiently so as not to damage the scale) to the nearest 0.1% as the dry mass, D.

Weighing the Sample

Drying in the oven

> **NOTE**
> Avoid heating the aggregate sample so fast that steam causes the aggregate to break or spatter.

Heat Sources for Aggregates

There are several alternatives to chose from when drying aggregates.

Hot Plate: An excellent choice when you're in a hurry. Be careful to avoid excessive localized overheating and fracturing of aggregates. When you use a hot plate, be sure to stir the sample repeatedly while observing the state of the aggregate. Some types of aggregate will not tolerate the high localized heat and may fracture despite the best of care, in which case an oven is recommended. **If the sample fractures, do to heat, or a loss of material is observed discontinue the test and obtain a new sample.**

Oven: The most common is probably an oven regulated at 110±5°C (230±9°F). An oven is a good choice when time is not of the essence. Samples dried in the oven, depending on the type of container you use and the moisture content of the sample, can take anywhere from one to several hours to dry to a constant mass. The benefit of using an oven is that it's very unlikely that sensitive aggregate will overheat and fracture. If you are working with sensitive aggregates, then, an oven is probably your best choice. If you are working with a material that contains soils or highly absorbent items (such as clay), they may be affected by excessive moisture within the oven as other items are drying. Check the oven's evaporation rate in accordance with AASHTO T104 to optimize drying time.

Microwave: This is a quicker solution than a hot plate, except that microwave drying will often fracture and pop the aggregate particles. Some experimentation will be necessary to ensure the best settings for your material to avoid this situation.

SAFETY CAUTION – The microwave should NOT be used where there is metal or metal oxides present in the aggregate.

Calculation

The calculation for moisture content (P) is as follows: Multiply the difference of the original mass (W) and dry mass (D) times 100 and divide that result by the dry mass (D). Round to the nearest tenth in most asphalt testing applications.

$$P = 100(W - D)/D$$

where: P = moisture content of sample, %
W = original (wet) mass of sample, g
D = dry mass of sample, g

Example

W = 546.2, D = 541.2
p = [100 (546.2 – 541.2)] / 541.2
p = [100 (5)] /541.2
p = 500 / 541.2
p = 0.9%

Note:
Surface moisture is determined by subtracting the percent of absorption from the total percent of evaporable moisture. The percent of absorption is determined by AASHTO T84 or T85.

GLOSSARY

Oven Dry Aggregate – Aggregate that has no internal or external moisture.

Air Dry Aggregate – Aggregate that is dry at the particle surface but containing some internal moisture.

Saturated Surface Dry – An ideal condition in which the aggregate can neither absorb nor contribute water. In this condition, the interior has absorbed all the moisture it can hold, but the surface is dry.

Wet Aggregate – Aggregate containing moisture on the particle surface.

Absorption – The increase in mass (weight) due to water contained in the pores of the material.

FLAT PARTICLES, ELONGATED PARTICLES, OR FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE

ASTM D 4791

Multi-Regional Training and Certification

M-TRAC

FHWA SPONSORED

Developed by

Multi-Regional Aggregate Training and Certification Group

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NOTE

Successful completion of the following training materials, including examination and performance evaluation are prerequisites for this training package.

- AASHTO D 75, Practice for Sampling Aggregates.
- ASTM D 3665, Practice for Random Sampling of Construction Materials
- AASHTO T 248, Reducing Sample of Aggregate to Testing Size.
- AASHTO T 27, Sieve Analysis of Aggregates.

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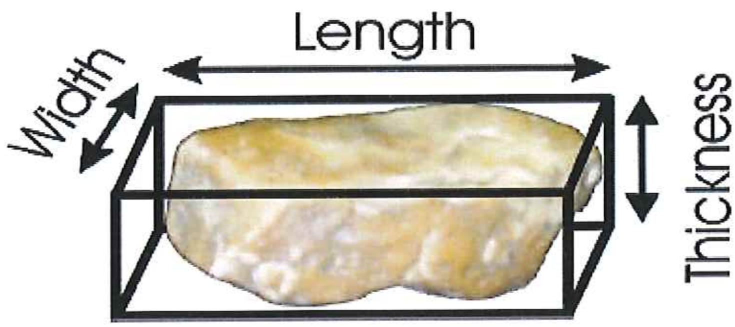
GLOSSARY

Flat and Elongated Particles of Aggregate - Those particles having a ratio of length to thickness greater than a specified value.

Length - the longest dimension.

Thickness - the smallest dimension.

Width - the other dimension.



FLAT PARTICLES, ELONGATED PARTICLES, OR FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE

This test method covers tests for flat particles, elongated particles, or flat and elongated particles in coarse aggregate. In this text only flat and elongated particles will be covered because at this time the only national specification that references this test is the Superpave Specification, which refers to Flat and Elongated Particles in Coarse Aggregate.

Flat and elongated particles of coarse aggregates have a tendency to fracture more easily than other aggregate particles. When the coarse aggregate does fracture, the gradation will likely change which may be detrimental to the mix. Additionally, flat and elongated particles of aggregate, for some construction uses, may interfere with consolidation and may result in harsh, difficult to place mixtures.

SUMMARY OF TESTING

Individual aggregates of specific sieve sizes are tested for ratios of width to thickness, length to width, or length to thickness. The test is performed on a sample of coarse aggregate reduced from a representative field sample. The sample is sieved to separate each size larger than the 9.5 mm (3/ 8 in.) Sieve. Each size is then tested in a proportional caliper device by setting the caliper to the longer dimension and attempting to fit the smaller dimension of the particle through the other caliper gap, which is a prescribed ration smaller then the larger dimension (i.e., usually a 5:1 ration). Particles are counted or weighed to determine a percentage of flat, elongated, or flat and elongated particle in a sample. Superpave specifications require asphalt mixtures to have less than 10% flat and elongated particles using a 5:1 ratio.

Common Testing Errors

- Not obtaining a representative sample.
- Not reducing the sample properly.
- Not sieving to completion.
- Improper positioning in the machine.

TESTING METHODOLOGY

Apparatus

The following apparatus is needed to perform the test for flat and elongated particles:

- Proportional Caliper Device.
- Balance - Accurate to 0.5% of the mass of the sample.
- Oven or hot plate (if determination is made by mass).

Note: If the proportional caliper is not used, the degree of error could increase dramatically.

Sampling

Sample the coarse aggregate in accordance with AASHTO T 2. Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in AASHTO T 248.

Sample Size

Set up the test sample according to the following table:

If Maximum Size of the Material is: (retained on)	Then Split Out:
9.5 mm (3/8 in.)	1 kg (2 lb.)
12.5 mm (½ in.)	2 kg (4 lb.)
19.0 mm (3/4 in)	5 kg (11 lb.)
25.0 mm (1 in.)	10 kg (22 lb.)
37.5 mm (1 ½ in.)	15 kg (33 lb.)

Note: This is the entire sample (+4 and -4). Put it in the appropriate size pan (or bag) as needed. It will then be sieved out by size. Mark the work sheet as "Flat and Elongated Particles". (Only test the sizes that are present in the amount of 10% or more of the original sample, in other words the gradation needs to be completed first.)

Test Procedure

1. If determination by mass is required, oven dry the sample to a constant mass at a temperature of 110° ± 5° C. If determination is by particle count, drying is not necessary.

2. Sieve the sample of coarse aggregate to be tested in accordance with test method AASHTO T 27. Reduce each size fraction larger than the 4.75mm (#4) or 9.5 (⅜ in.) sieve that is present in the amount of 10% or more of the original sample in accordance with method AASHTO T 248 until approximately 100 particles are obtained.

3. Use the proportional caliper device positioned at the 5:1 ratio.

4. Set the larger opening equal to the particles longest dimension. The particle is considered flat and/or elongated if the particles thinnest dimension passed through the smaller opening.

5. Test each of the particles in each size fraction and place in one of two groups: (1) Particles with longest to thinnest ratios over 5:1 and (2) Particles with longest to thinnest ratios less than 5:1.

Checking Elongation

Checking Flatness

6. After particles have been classified into the two groups, determine the proportion of the sample in each group by either count or by mass as required.

Calculation

Calculate the percentage of flat and elongated particles to the nearest 1% for each sieve size greater the 9.5mm(⅜ in.).

Note: Follow the rounding rules specified by your state.

Example Calculation

19.0mm (3/ 4 in) Stone

Sieve	25.0mm	19.0mm	12.5mm	9.5mm
% Passing	100	99.4	75.7	46.4
% Retained	0	0.6	23.7	29.3

No test is performed on the 19.0mm size aggregate because it is less than 10 percent of the total sample. It will be assumed that the 19.0mm particles have the same percentage of flat and elongated as the next sieve (12.5mm).

The 12.5mm size material totaled 715.3 grams after reducing to approximately 100 particles. 6.9 grams were classified as flat and elongated, therefore, the percent flat and elongated on the 12.5mm sieve is:

$$\frac{6.9}{715.3} \text{ X } 100 = 1.0\%$$

Likewise, the 9.5mm size totaled 239.7 grams after reduction and 12.2 grams were classified as flat and elongated. The percent flat and elongated on the 9.5mm sieve is:

$$\frac{12.2}{239.7} \text{ X } 100 = 5.1\%$$

The percentage of flat and elongated particles on each sieve is reported to the nearest whole percent.

To calculate the weighted average percent flat and elongated particles for the sample, the percentage calculated for each individual sieve needs to be multiplied by the ratio of the percent retained for that sieve to the total percent retained above the 9.5mm sieve and the results totaled for all sieves.

The total percent retained for the example is 53.6%. The percent flat and elongated on the 19.0 mm sieve is assumed to be 1.0% (same as the 12.5mm size). The percent retained on the 19.0 sieve is 0.6%, therefore, to calculate the weighted average percent:

$$(1.0)\ \frac{0.6}{53.6} = 0.0\%$$

For the 12.5mm sieve the weighted average percent is:

$$(1.0)\ \frac{23.7}{53.6} = 0.4\%$$

And for the 9.5mm sieve the weighted average percent is:

$$(5.1)\ \frac{29.3}{53.6} = 2.8\%$$

Finally, the weighted average percent flat and elongated particles in the coarse aggregate is determined by adding the weighted average percent for each sieve:

$$0.0 + 0.4 + 2.8 = 3.2\%$$

For reporting, round the result to the nearest whole percent.

FLAT AND ELONGATED PARTICLES (ASTM D 4791) WORKSHEET

Project ~~Example~~ Mix Design ID ________ Date ________

Material/Stockpile ID ________ Technician ________

Sieve Sizes	Original Percent Retained **A**	Mass Tested grams **B**	Mass Failing 5:1 ratio (g) **C**	%Flat &Elong. Individual sieve **D**	%Flat & Elong. Weighted Ave. **E**
37.5mm (1 ½ in.)					
25.0mm (1 in.)					
19.0mm (3/4 in.)	0.6	NA	NA	1.0	0.0
12.5mm (½ in.)	23.7	715.3	6.9	1.0	0.4
9.5mm (3/8 in.)	29.3	239.7	12.2	5.1	2.8
Total % Retained	53.6			Total	3.2

Remarks: Example

Weighted average percent Flat & Elongated particles = 3%

FLAT AND ELONGATED PARTICLES (ASTM D 4791) WORKSHEET

Project____________________ Mix Design ID ________________ Date __________

Material/Stockpile ID ________________________ Technician __________________

Sieve Sizes	Original Percent Retained	Mass Tested grams	Mass Failing 5:1 ratio (g)	%Flat &Elong. Individual sieve	%Flat & Elong. Weighted Ave.
	A	**B**	**C**	**D**	**E**
37.5mm (1 ½ in.)	______	______	______	______	______
25.0mm (1 in.)	______	______	______	______	______
19.0mm (3/4 in.)	______	______	______	______	______
12.5mm (½ in.)	______	______	______	______	______
9.5mm (3/8 in.)	______	______	______	______	______
Total % Retained	______			Total	______

Remark ____

____

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