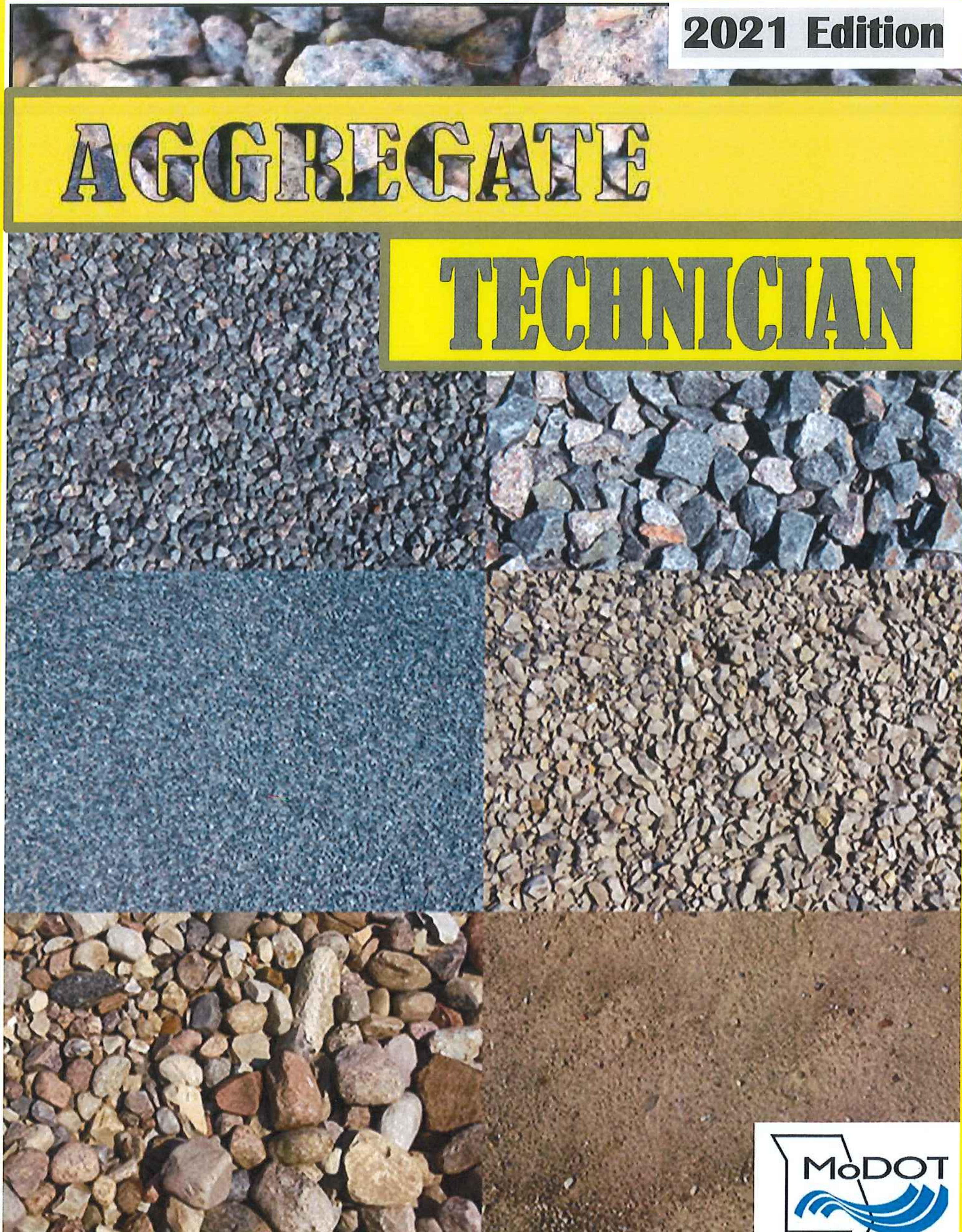
2021 Edition

AGGREGATE TECHNICIAN



Aggregate Technician

2021 – Updates

- **AASHTO T11** - Mechanical Washing: Do not wash the sample in a mechanical washer for more than 10 min.
- **Added AASHTO T85-Abs** – Absorption of coarse aggregate.

2020 – Updates

- **AUDIT NOTIFICATION SLIDE ADDED TO ALL MANUALS:** To all material testers, who work on Missouri Highways, this includes Consultants, Contractors, City, County, and MoDOT workers; you will be audited by **MoDOT IAS Inspectors** and sometimes **FHWA** personnel.
- **No Method Changes for 2020.**

COURSE CONTENT

AGGREGATE TECHNICIAN

AASHTO R 90	Sampling of Aggregate Products
AASHTO R 76 ASTM C702	Reducing Samples of Aggregate to Testing Size
AASHTO T 255 ASTM C566	Total Evaporable Moisture Content of Aggregate by Drying
AASHTO T 11 ASTM C117	Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing
AASHTO T 27 ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
MoDOT TM 71	Deleterious Content of Aggregate
ASTM D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
AASHTO T 85-ABS ASTM C136	Absorption of Coarse Aggregate

Appendix

Glossary

AASHTO R 90

Sampling Aggregate Products

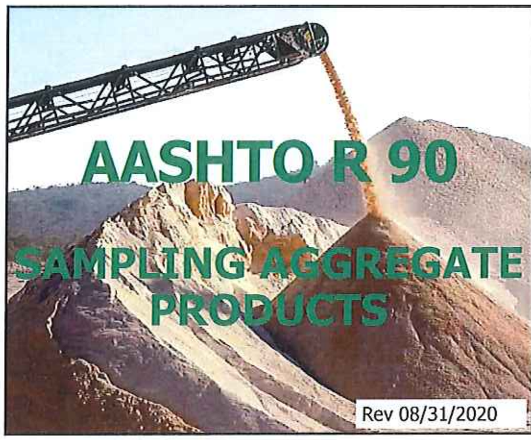
Required Audits

All testers on Federal-Aid Projects (MoDOT or Off-System) are required by the FHWA to be audited at least once per year.

Reasons:

- To ensure proper test procedures are being utilized.
- To ensure testing equipment is calibrated and operating properly.

- **Types of Audits;** procedure or comparison.
- **Be Proactive;** schedule your audit as early as possible with MoDOT Materials in district offices, do NOT wait till the end of the year.
- **Provide Proof;** when audited, present a MoDOT Certification Card, or a MoDOT Letter.



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SAFETY GEAR
Personal Protective Equipment (PPE)

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

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SCOPE

- This practice covers the procedures for obtaining representative samples of Coarse Aggregate (CA), Fine Aggregate (FA), or combinations of Coarse and Fine Aggregate (CA/FA) products to determine compliance with requirements of the specifications under which the aggregate is furnished.
- This method includes sampling from conveyor belts, transport units, roadways, and stockpiles.

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SIGNIFICANCE AND USE

- Sampling is a critical step in determining the quality of the material being evaluated. Care shall be exercised to ensure that samples are representative of the material being evaluated.
- This practice is intended to provide standard requirements and procedures for sampling coarse, fine, and combination of coarse and fine aggregate products.

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SECURING SAMPLES

(All Methods)

- *General*: Where practicable, samples to be tested for quality shall be obtained from the finished product.
- *Inspection*: The material to be sampled shall be visually inspected to determine discernible variations, corrective action shall be taken to establish *homogeneity* in the material prior to sampling.

Examples of variations: *Segregation, clay pockets, varying seams, boulders.*

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TERMINOLOGY

- **Coarse Aggregate (CA)**
  - All the material retained on the #4 (4.75mm) sieve and above.
- **Fine Aggregate (FA)**
  - All the material passing the #4 (4.75mm) sieve.
- **Special Note**
  - MoDOT – Specific sample sizes are on the following chart. **These sizes are different from AASHTO/ASTM specifications.**

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MoDOT AGGREGATE SAMPLE SIZES

Maximum size Aggregate	Minimum Weight/Mass of Sample
2″ (50 mm)	80 lb. (36kg)
1-½″ (37.5 mm)	54 lb. (25kg)
1″ (25.0 mm)	36 lb. (16kg)
¾″ (19.0 mm)	22 lb. (10kg)
½″ (12.5 mm)	14 lb. (6kg)
⅜″ (9.5 mm)	10 lb. (5kg)
Fines and Natural Sands	500g

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AGGREGATE SAMPLEING PROCEDURES:

- **Conveyor Belt**
  1. Using a sampling device (belt discharge)
  2. Using a template
- **Stockpiles**
  1. Using a loader
  2. Using a flat board
  3. Using a sampling tube (fine aggregate)
- **Transport Units**
  Not recommended, therefore not covered.
- **Roadway**
  1. In place **(preferred)**
  2. Berm or windrow **Not recommended, therefore not covered.**

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CONVEYOR BELT SAMPLING
Sampling Device Procedure
Coarse Aggregate (CA) & Combined (CA/FA)

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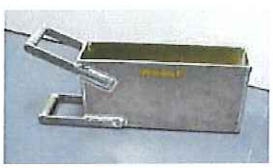
EQUIPMENT

- Safety Gear; PPE
- Sampling Device
- Proper Containers



Conveyor Belt - Sampling Device

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PROCEDURE

1. Plant is operating at the usual rate.
2. Select a random sample from a conveyor belt discharge during production.
   - If sampling for quality control or acceptance, record the sampling time, date, and location.
   - Avoid the initial or end of an aggregate run.

Conveyor Belt - Sampling Device

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3. Pass the sampling device at a constant speed through the entire cross-section of the stream flow once in each direction without overflowing the sampling device.

4. Include all material from the sampling device when empting into the container.

5. Obtain one or more equal increments as required for testing, and combine to form a field sample.

CONVEYOR BELT SAMPLING

Template Procedure

Coarse Aggregate (CA) & Combined (CA/FA)

EQUIPMENT

- Safety gear; PPE
- Template
- Scoop or trowel
- Brush or broom
- Proper containers
- Tag out items



PROCEDURE

NOTE: Record sampling time or location, or both.

1. **STOP** the conveyor belt.
   Lock and Tag Out !

2. Select a random sample area from production.
   Note: Avoid sampling at the beginning or end of an aggregate run.
3. Insert the sampling template on the belt to yield one increment.

Conveyor Belt - Template

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4. Remove all material including the fines from inside the template with a scoop and a brush into a clean dry container.
5. Obtain one or more equal increments to supply enough material for the required test(s).
6. Combine the increments to form a field sample.

Conveyor Belt - Template

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Conveyor Belt
Automatic Sampling Device

- The Automatic Sampling Device is a permanently attached device that allows a sample container to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation.
- May be used if properly maintained and inspected.

Conveyor Belt - Automatic

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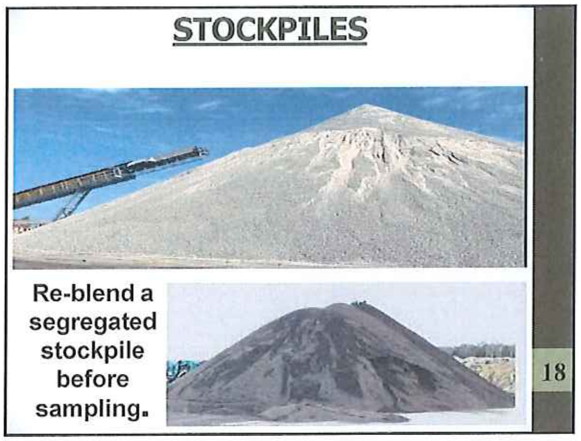
STOCKPILES
Re-blend a segregated stockpile before sampling.
18


Show Stockpile
Videohttps://youtu.be/JXXSssLHrAc
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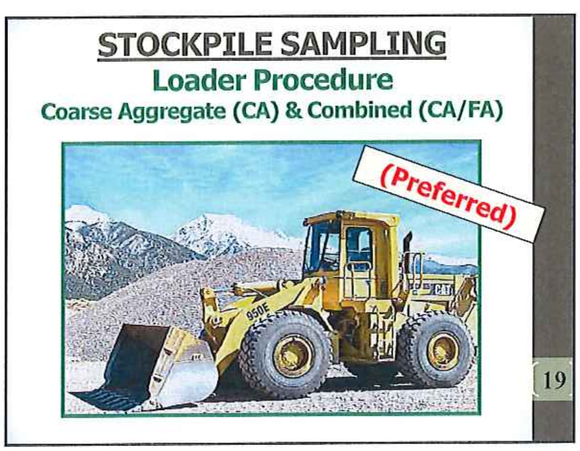
STOCKPILE SAMPLING
Loader Procedure
Coarse Aggregate (CA) & Combined (CA/FA)
(Preferred)
950E
CAT
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EQUIPMENT

Stockpile - Loader

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Stockpile – Loader Procedure
(Sampling from a flat surface created by a loader)

NOTE: Record sampling time or location, or both.

1. Re-blend segregated material with the loader.
2. Direct the loader operator to enter the stockpile with the bucket at least **1 foot** above the ground level to avoid contaminating the stockpile.
3. Discard the first bucket-full.

Stockpile - Loader

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4. Have the loader re-enter the stockpile to obtain a full loader bucket of the material.
5. Tilt the bucket just high enough to permit free flow of the material to create a small pile to the side.

(Repeat as necessary)

6. Create a flat surface by having the loader back drag the small pile.

Stockpile - Loader

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Stockpile - Loader

7. Collect a minimum of **three random** locations from the flat surface that are at least **one foot** from the sample pile edge.
8. Fully insert the shovel, exclude the underlying material, roll back the shovel, and without losing material place it in a clean dry container.
9. Combine the increments to form a field sample.

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STOCKPILE SAMPLING

Flat Board & Shovel Procedure

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

Stockpiles – Flat Board

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PROCEDURE

(Sampling from a horizontal surface on a stockpile face)

NOTE: Record sampling time or location, or both.

1. With a shovel, create a horizontal surface with a vertical face.
2. Insert a flat board against a vertical face behind sampling location to prevent sloughing.
3. Do not use sloughed material.
4. Obtain a sample from the horizontal surface near vertical face.

Stockpiles – Flat Board

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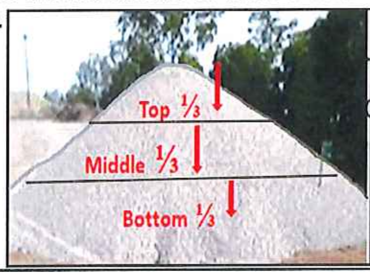
5. Obtain at least one increment of equal size from the **top** third, **middle** third, and **bottom** third of the pile.
6. Combine the increments to form a field sample.



Stockpiles – Flat Board

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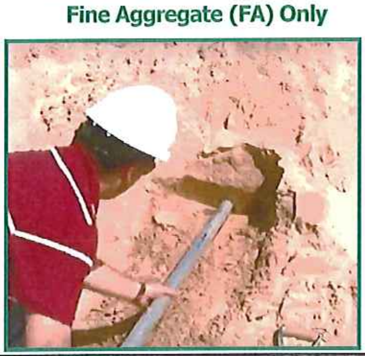
STOCKPILE SAMPLING

Sampling Tube Procedure

Fine Aggregate (FA) Only



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EQUIPMENT

- Sampling tube with the dimensions:
  - 1¼" diameter x 6 feet in length, tip cut at a 45° angle

Stockpiles – Sampling Tube

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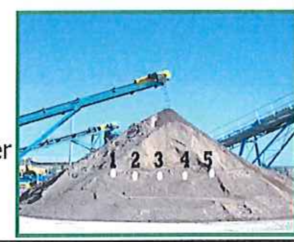
PROCEDURE

NOTE: Record sampling time or location, or both.

1. Remove the outer layer of the stockpile.
2. Using a sampling tube obtain a minimum of **5** samples from random locations on the stockpile.
3. Combine the increments in a clean dry sample container to form a field sample.



Stockpiles – Sampling Tube

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TRANSPORT UNITS

Sampling aggregate from transport units is **NOT** a recommended procedure due to safety concerns and is not covered as part of this certification.

NOT RECOMMENDED

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ROADWAY BASE IN-PLACE SAMPLING

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

Roadway Base -In-Place

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PROCEDURE

NOTE: Record sampling time or location, or both.

1. Obtain a representative sample after spreading and before compaction using a random number set for a QC/QA sample.
2. If **not** a QC/QA sample, obtain at least **1** or more random increments before compaction for a field sample.
3. Clearly mark the specific area from which materials will be removed with the template or square nosed shovel.

Roadway Base -In-Place

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Roadway Base -In-Place

4. With a shovel, remove the full depth of material from inside the marked area; exclude any underlying material.
5. Combine the increments to form a field sample.

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STOCKPILES
Roadway Base Sampling

- Sampling from a berm or windrow
  - MoDOT does not sample from berms or windrows.

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SHIPPING SAMPLES

Proper Container

- Bags made for shipping aggregates, or other suitable containers that prevent contamination or loss during shipment.
- NOTE: MoDOT prefers bags

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Proper Identification:

- Shipping containers for aggregate samples shall have suitable individual identification that is clearly marked on the outside and enclosed.
- Include ID, location, date & time, material type, and quantity of material represented by the sample, if applicable.

Shipping Samples

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Common Errors (All methods):

- Using an improper sampling device.
- Sampling in segregated areas.
- Not obtaining enough increments.
- Not labeling the bags inside and out with proper identification.
- Allowing overflowing of a stream flow device.
- Not being safe. (example; Not performing lock out/tag out on a stopped conveyer belt.)

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AASHTO R 90: Sampling of Aggregates
PROFICIENCY CHECKLIST

Applicant ______________________________

Employer ______________________________

NOTE: For all QC/QA or Acceptance sampling, record the time or location or both.

Conveyor Belt Sampling – Sampling Device – Coarse/Combined Aggregate NOTE: Automatic belt samplers may be used if properly maintained and inspected.	Trial 1	Trial 2
1. Plant was operating at the usual rate.		
2. Random samples taken from a conveyor belt discharge taken from production.		
- Avoided sampling the beginning or end of a run.		
3. Sample taken from the entire cross-section of material once in each direction without overflowing the device.		
4. Included all material from the sampling device into a clean empty container.		
5. Obtained 1 or more increments to form a field sample.		
Conveyor Belt Sampling – Template - Coarse/Combined Aggregate		
1. Conveyor belt stopped, locked and tagged out.		
2. Random samples taken from production.		
- Avoided sampling at the beginning or end of a run.		
3. Template placed on the belt to yield one increment.		
4. All material inside the template scooped into a proper container including fines.		
5. Obtained 1 or more increments to combine for a field sample.		
Stockpile Sampling – Flat Board – Coarse/Combined Aggregate		
1. Created a horizontal surface with a vertical face.		
2. Inserted board vertically against a vertical face to prevent sloughing.		
3. Discarded sloughed material.		
4. Obtained a sample from the horizontal surface close to the vertical face.		
5. Obtained at least one increment from; the top third, the middle third, and the bottom third of the stockpile.		
6. Combined to form a field sample.		
Stockpile Sampling - Sampling Tube - Fine Aggregate Only		
1. Outer layer of the stockpile removed.		
2. Obtained a minimum of 5 random tube insertions on the stockpile.		
3. Combined to form a field sample.		
Stockpile Sampling – Loader – Coarse/Combined Aggregate		
1. Segregation avoided by re-blending the pile.		
2. Loader entered the pile with bucket at least 1 foot above the ground.		
3. Discarded first bucket-full.		
4. Loader re-entered stockpile to obtain a full loader bucket of material		
5. Bucket tilted just enough to free flow material creating a small sampling pile. (Can go back for more).		
6. Back-dragged the small pile to form a sampling pad.		
7. Randomly collected a minimum of 3 increments with a shovel at least 1 foot from sample pile edge.		
8. Fully Inserted the shovel, excluding underlying material, placed in a clean dry container.		
9. Combined increments to form a field sample.		
Roadway Base Sampling – In-Place – Coarse/Combined Aggregate		
1. Obtained a representative sample after spreading and before compaction using a random number set for a QC/QA sample.		
2. If not a QC/QA sample, obtained at least 1 or more random increments before compaction for a field sample.		
3. Clearly marked the specific area with a template or square nosed shovel.		
4. Used a square nose shovel and or a metal template to mark the area.		
5. With a shovel, removed the full depth of material from inside the marked area excluding underlying material.		
6. Combined increments to form a field sample.		
	PASS FAIL	PASS FAIL

Examiner: ______________________ Date: ______________

AASHTO R 76

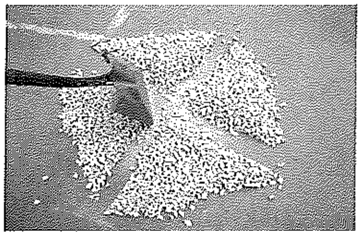
ASTM C702

Reducing Samples of Aggregate

To Testing Size

MoDOT

AASHTO R 76



REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

Rev 10/15/2020

SIGNIFICANCE AND USE

- The significance for AASHTO R 76, is to reduce a large sample obtained in the field or produced in the laboratory to the proper size for conducting a number of tests to describe the material and measure its quality. These methods are conducted in such a manner that the smaller test sample portion will be representative of the larger sample and therefore the total supply.

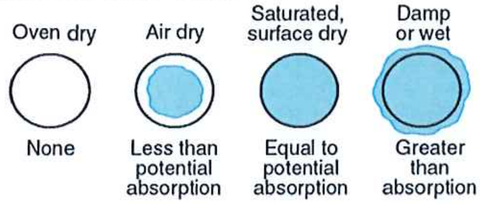
2

SAMPLING

- The samples of aggregate obtained in the field shall be taken in accordance with AASHTO R 90 (ASTM D75), or as required by individual test methods and shall be reduced by AASHTO R 76 (ASTM C702).

3

The moisture content of aggregate is defined in four states:



Total moisture

Total Moisture = Free (surface) Moisture + Absorbed Moisture

NOTE: The Damp or Wet State #4 has free moisture on the particle surface.

4

METHODS

- **Method A**: Mechanical Splitter
  - Riffle Splitter
- **Method B**: Quartering
  - Canvas
  - Hard, Clean, Level Surface
- **Method C**: Miniature Stockpile

5

Method Selection

METHOD A **Mechanical Splitter** "Air Dry"	**METHOD B** **Quartering** "Free Moisture"	**METHOD C** **Miniature Stockpile** "Free Moisture"
Fine Aggregate	Fine Aggregates	Fine Aggregates
Coarse Aggregates	Coarse Aggregates	
Combined/Mixed Aggregates	Combined/Mixed Aggregates	

6

Things to know before you begin:

- Minimize the chance of variability during handling.
- The reduction method used depends upon the maximum aggregate size, the moisture condition, and the equipment available.
- A sample collected in two or more increments shall be thoroughly mixed before reducing.
- The mechanical splitter is the preferred method for reducing coarse aggregate.

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METHOD A

MECHANICAL SPLITTER

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APPARATUS

Method A - Mechanical Splitter

- Shall have an even number of equal width chutes.
- At least **8 chutes** for coarse aggregate.
- At least **12 chutes** for fine aggregate.
- Must discharge alternately to each side of the splitter.
- Equipped with 2 receptacles to hold the two halves of the sample following splitting.

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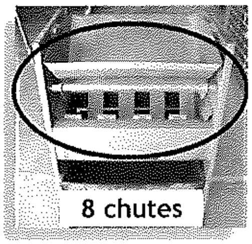
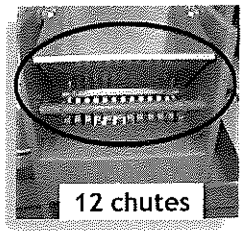


Coarse Aggregate



Fine Aggregate

Apparatus 10

- Equipped with a hopper or straightedge pan, which has a width equal to or slightly less than the overall width of the assembly of chutes.
- Designed for smooth flow without restriction or loss of material.
- For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50% larger than the largest particles in the sample to be split.

Apparatus 11

- For dry fine aggregate in which the entire sample will pass the ⅜" (9.5mm) sieve, the minimum width of the individual chutes shall be at least 50% larger than the largest particles in the sample and the maximum width shall be ¾"(19mm).
- **NOTE:** A preliminary split may be made using a mechanical splitter to reduce a fine aggregate sample that is very large. Set the chute openings to 1½ inch or more to reduce the sample to not less than 5,000g. Dry the obtained portion and reduced it to testing sample size using Method A.

Apparatus 12

SAMPLE PREPARATION

Method A - Mechanical Splitter

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

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PROCEDURE

Method A - Mechanical Splitter

1. Material is in an air-dry condition.
2. Adjust the openings for the correct chute size.
3. Load the hopper uniformly, distributing the sample from edge to edge, avoiding segregation.
4. The rate at which the sample is introduced shall allow free flowing through the chutes into the receptacles below.

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5. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test.

NOTE: The portion of the material collected in the other receptacle may be reserved for reduction in size for the other tests.

Procedure

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Procedure

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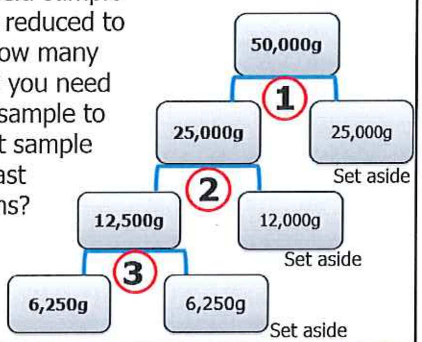
Sample Size Question…

A 50,000g field sample needs to be reduced to 10,000g. How many times would you need to split this sample to obtain a test sample size of at least 10,000 grams?



Ans: 2

METHOD B

QUARTERING

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EQUIPMENT
Method B - Quartering

- Straight-edged scoop
- Square-nosed shovel or trowel
- Broom or brush
- Canvas blanket for alternate method approximately 6′ x 8′
- Long stick

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SAMPLE PREPARATION
Method B - Quartering

- Fine, coarse, or combined aggregates must be in a moist condition.
- For fine aggregates, the sample should be wet enough to stand in a vertical face. If the sample does not have free moisture on the surfaces, the sample may be moistened to achieve this condition.

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PROCEDURE
Method B - Quartering

1. Place the sample on a clean, hard, level surface where there will be neither loss of material nor the accidental addition of foreign material.
2. Mix by turning the material over completely at least **THREE** times until thoroughly mixed.
3. Form a conical pile.

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4. Flatten evenly so the diameter is 4-8 times the thickness.
5. Divide this into 4 equal quarters with a shovel or trowel.
6. Remove two diagonally opposite quarters, including all fine material, brush the spaces clean and set the other two quarters aside for later use.

Procedure 21

7. Take the remaining 2 quarters, mix and quarter until the sample is reduced to the desired size.

NOTE: Save the unused portion until testing is completed.

Procedure 22

Method B - Quartering

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Method B - Alternate Quartering Method Using a Canvas and Broom Stick

1. Place a canvas blanket on a clean, level surface.
2. Mix by lifting opposite corners towards each other causing the material to be rolled a minimum of four times.
3. Use a stick to quarter as shown below.

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4. Take opposite quarters to test or to further reduce.

Method B – Alternate Quartering

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METHOD C

MINIATURE STOCKPILE

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EQUIPMENT

Method C - Miniature Stockpile

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

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PROCEDURE

Method C - Miniature Stockpile

1. Place the original sample of damp fine aggregate on a hard clean, level surface.
2. Mix the material thoroughly by turning the entire sample over at least three times.
3. With the last turning, shovel the entire sample into a conical pile by depositing each shovel full on top of the preceding one.

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Optional step: The conical pile may be flattened to a uniform thickness and diameter by pressing the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it.

4. Obtain a sample by selecting at least **FIVE** increments of material at random locations from the pile and combine them to attain the appropriate sample size.

Procedure

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Common Errors:

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

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AASHTO R 76: Reducing Field Samples of Aggregate to Testing Size
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
Method A – Splitting		
8 chutes for Coarse (CA), 12 chutes for Fine (FA)		
1. Material in an air-dry condition.		
2. Adjusted the openings to be 50% larger than the largest particle.		
3. Material spread uniformly on feeder from edge to edge.		
4. Rate of feed slow enough so that sample flows freely through chutes.		
5. Material in one receptacle re-split until desired weight was obtained.		

Method B - Quartering		
1. Moist sample placed on clean, hard, level surface.		
2. Mixed by turning over completely at least 3 times with shovel.		
3. Conical pile formed.		
4. Pile flattened to uniform thickness and diameter of 4-8 times thickness.		
5. Divided into 4 equal portions with shovel or trowel.		
6. Removed two diagonally opposite quarters, including all fines.		
7. Remaining quarters, mixed and quartered until reduced to desired sample size.		
NOTE: The sample may be placed upon a canvas quartering cloth and a stick or pipe may be placed under the tarp to divide the pile into quarters.		

Method C – Miniature Stockpile (Damp Fine Aggregate Only)		
1. Moist fine aggregate sample placed on clean, hard, level surface.		
2. Material thoroughly mixed by turning over completely three times.		
3. Small stockpile formed.		
4. Obtain at least 5 samples taken at random with sampling thief, small scoop, or spoon, combined to attain appropriate sample size.		

Pass Pass

Fail Fail

Examiner:______________________________Date:______________________

AASHTO T 255

ASTM C566

Total Evaporable Moisture Content

of

Aggregate by Drying

AASHTO T 255

Total Evaporable Moisture Content of Aggregate by Drying

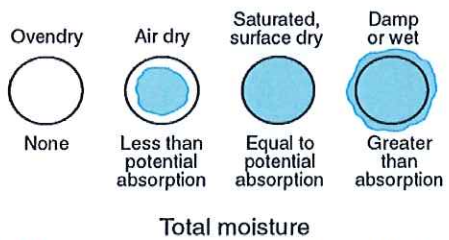
Rev. 10/15/2020

SCOPE

- This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores of the aggregate. Some aggregate may contain water that is chemically combined with the minerals in the aggregate. Such water is not evaporable and is not included in the percentage determined by this method.

2

The moisture content of aggregate is defined in four states:



Total Moisture = Free (surface) Moisture + Absorbed Moisture

NOTE: The Damp or Wet State #4 has FREE moisture on the particle surface.

3

SIGNIFICANCE AND USE

- Used for adjusting batch quantities of ingredients for concrete.
- Measures the moisture in a test sample.
- 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.
- NOTE: Larger particles will require greater time for the moisture to travel from the interior to the surface.

4

EQUIPMENT

- Scale
  - Readable to 0.1 percent of the sample mass, or better
- Source of Heat
  - Ventilated oven 230 ± 9˚F (110 ± 5°C)
  - Hot plate
  - Ventilated microwave oven
  - Electric heat lamps

5

- Sample Container
  - Air tight cans
    - Not affected by heat
    - Sufficient volume size
- Other Items
  - Gloves
  - Metal Spoon
  - Brush
  - Pans
- Shovel or Scoop
  - for sampling



Equipment

6

SAMPLING

- Obtain a sample In accordance with AASHTO R90/ASTM D75.
- Secure a sample of the aggregate representative of the moisture content in the supply being tested and having a mass not less than the amount listed in Table 1 using the *Nominal Maximum Size of Aggregate*. (See Glossary for definition)
- Protect the sample against moisture loss prior to determining the mass.

7

AASHTO Sample Size (TABLE 1)

Nominal Maximum Size of Aggregate in. (mm)	Minimum Sample Mass Lbs. (g.)
#4 (4.75)	1.1 (500)
⅜" (9.5)	3.3 (1,500)
½" (12.5)	4.4 (2,000)
¾" (19.0)	6.6 (3,000)
1" (25.0)	8.8 (4,000)
1 ½" (37.5)	13.2 (6,000)

8

Moisture Content- Video https://youtu.be/YXfpniVawc0

Performance Review

3. DETERMINE THE MASS OF THE SAMPLE TO THE NEAREST 0.1%. USE A SCALE SENSITIVE ENOUGH FOR THE SIZE OF THE SAMPLE

PROCEDURE

1. **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.
   - Protect the sample against moisture loss when transporting to a testing facility and prior to determining the mass.
2. **Weigh and record the wet sample** to the nearest 0.1% of the total mass, typically 0.1g.

(From this point on do not lose material or overheat the sample.)

10

3. **Dry the sample using one of the following; oven, hot plate, or microwave oven.**
   - Ventilated Oven: (Preferred)
     - Easily regulated at 230 ± 9˚F (110 ± 5°C).
     - Good for sensitive aggregates.
   - Hot Plate: (Fast) Exercise caution!
     - Periodically stir to avoid overheating causing aggregate to fracture.
     - If aggregate cannot be heated without fracture, use a ventilated oven.

Procedure 11

– Ventilated Microwave Oven: Use a non-metal container, stirring is optional.

(If the material explodes you can not use the microwave, go to another method of drying.)

NOTE: Material used in the microwave cannot be used for any other test method.

Procedure 12

4. **Remove the sample from the heat source** when the sample is thoroughly dried to a *constant mass*.

The sample is thoroughly dried to a constant mass when further heating causes, or would cause, less than 0.1 % additional loss in mass.

5. **Allow to cool.**

6. **Weigh and record** the mass of the dried sample to the nearest **0.1 %** of the total mass.

Procedure 13

CALCULATIONS

- Determine the total evaporable moisture content

$$p = \frac{W - D}{D} \times 100$$

- p = percent total evaporable moisture content
- W = mass of original sample, (g)
- D = mass of dried sample, (g)

14

Class Practice

Calculate the total evaporable moisture content:

- Mass of original sample = 3,523.0 g
- Mass of dried sample = 3,501.0 g
- Report your answer to the nearest 0.1%

15

Answer

$$p = \frac{W - D}{D} \times 100$$

$$\frac{3523.0 - 3501.0}{3501.0} \times 100 = \mathbf{0.6\%\ \mathit{Moisture}}$$

16

REPORTING RESULTS

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

17

Common Errors:

- Overheating
- Insufficient sample size
- Loss of material when stirring
- Loss of moisture prior to testing
- Sample not dried to a constant mass

18

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

Applicant____

Employer____

<table>
<tr><td>Trial #</td><td>1</td><td>2</td></tr>
<tr><td>1. Representative test sample secured</td><td></td><td></td></tr>
<tr><td>2. Test sample mass conforms to following from the AASHTO T 255 Table:
<table>
<tr><th>Nominal Maximum Size of Aggregate in. (mm)</th><th>Minimum Sample Mass Lbs. (g.)</th></tr>
<tr><td>#4 (4.75)</td><td>1.1 (500)</td></tr>
<tr><td>⅜” (9.5)</td><td>3.3 (1,500)</td></tr>
<tr><td>½” (12.5)</td><td>4.4 (2,000)</td></tr>
<tr><td>¾” (19.0)</td><td>6.6 (3,000)</td></tr>
<tr><td>1” (25.0)</td><td>8.8 (4,000)</td></tr>
<tr><td>1 ½” (37.5)</td><td>13.2 (6,000)</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>3. Mass determined to the nearest 0.1% of the total mass</td><td></td><td></td></tr>
<tr><td>4. Loss of moisture avoided prior to determining the mass</td><td></td><td></td></tr>
<tr><td>5. Sample dried by a suitable heat source</td><td></td><td></td></tr>
<tr><td>6. If heated by means other than a controlled temperature oven, is sample stirred to avoid localized overheating</td><td></td><td></td></tr>
<tr><td>7. Sample dried to constant mass and mass determined to nearest 0.1% of the total mass</td><td></td><td></td></tr>
<tr><td>8. Moisture content calculated by:
$\% \text{ moisture} = \frac{\text{wet sample mass} - \text{dried sample mass}}{\text{dried sample mass}} \times 100$</td><td></td><td></td></tr>
</table>

PASS PASS

FAIL FAIL

Examiner:____Date:_________________

AASHTO T 11

ASTM C117

Materials Finer Than

No. 200 Sieve in Mineral Aggregates

by Washing

AASHTO T11

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

Rev 10/14/2020

SCOPE

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

2

SIGNIFICANCE AND USE

- Material finer than the # 200 (75-ųm) sieve can be separated from larger particles much more efficiently and completely by wet sieving than through the use of dry sieving. Therefore, when accurate determinations of material finer than #200 in fine or coarse aggregate is desired, this test method should be used on the sample prior to dry sieving in accordance with AASHTO T 27.

3

EQUIPMENT

- Oven capable of 230 ± 9°F (110 ± 5°C)
- Scale, reads to 0.1% of the sample mass or better
- Sieve **#200**
  - Plus a
  - **#8** sieve or a
  - **#16** sieve
- Suitable container
- Wetting agent for "Method B"
- Water
- Spoon

4

SAMPLING

- Sample the aggregate in accordance with AASHTO R 90 (ASTM D75).
- Thoroughly mix the sample of aggregate to be tested and reduce the quantity to an amount suitable for testing using the methods described in AASHTO R 76.
- The test specimen shall be a representative sample based on **AASHTO Table 1**.

5

AASHTO Table 1 – Sample Mass Requirements

Nominal Maximum Size (NMAS), in.(mm)	Minimum Weight of Sample, grams
#4 (4.75)	300
3/8" (9.5)	1000
3/4" (19.0)	2500
1 ½" (37.5) or larger	5000

- Nominal Maximum Aggregate Size; (NMAS) is defined as the smallest sieve which 100% of sample passes.
- **Note:** If the aggregate size is an in-between size just go to the next size on the chart for the amount ex: ½" you would go to 2500 grams.

6

SAMPLE PREPARATION
Method A

- Dry the test sample to a constant mass at 230 ± 9°F (110 ± 5°C) and determine the mass to the nearest 0.1 % of the mass of the test sample.
- Check the #200 sieve for damage before testing. (if damaged replace the sieve)

NOTE: Take care not to overload the #200 sieve during washing.

7

PROCEDURE
Method A

1. Place the sample into a washing pan/vessel suitable for heating in the oven.
2. Add water to cover the aggregate.

Optional Method B:
Add a small amount of wetting agent only once per sample during agitation.

3. Agitate the sample.
(Use a spoon or similar tool to agitate the sample.)

8

4. Immediately pour the wash water through the nest of sieves avoiding the decantation of the coarser particles.

Nest of sieves: Is the use of two or more sieves stacked together. In this case the stack consist of two sieves. Use either a sieve size #8 or #16 placed on top of a #200 sieve. This will protect the delicate #200 sieve from damage while washing.

5. Add another charge of water to the sample in the pan, agitate, decant the wash water through the nest of sieves as before. Repeat several times until the wash water is clear.

Procedure

9

6. Material on sieves returned to washed sample.
   - Do not decant any water from the pan except through a # 200 sieve to avoid loss of material.
   - MECHANICAL WASHING *(Optional)*:
     If mechanical washing equipment is used, the charging of water, agitating, and decanting will be a continuous operation.

Mechanical Washers: Maximum wash time is **10 minutes**.

10 MINUTES MAX

Procedure

7. Oven dry the sample to a constant mass at a temperature of 230 ± 9°F (110 ± 5°C), weigh to the nearest 0.1 % of the original mass of the sample. **(Typically 1 gram)**
8. Calculate the loss and report the results.

Procedure 11

CALCULATIONS

- Calculate the amount of material passing a # 200 sieve by washing as follows:

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

A = Total % passing #200 (75 µm) sieve
B = Original dry mass of sample (grams)
C = Dry mass of sample after washing and drying to constant mass (grams)

12

REPORTING

Report the percentage of material finer than the #200 sieve by washing to the nearest **0.1 % if the loss is less than 10%.**

Report the result to the nearest **whole number if the loss is 10% or more.**

13

Sample Calculations

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

B = 532 grams

C = 521 grams

$$A = \frac{(532 - 521)}{532} \times 100$$

A = 2.1%

14

Classroom Exercise and Reporting Results

Determine the percent of minus #200 material and report the answer to the nearest 0.1% if less than 10%, to the nearest 1% if 10% or more:

Original dry weight (B) = 3171 g

Washed dry weight (C) = 2729 g

15

ANSWER

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

$$A = \frac{3171 - 2729}{3171} \times 100$$

Answer: A = 13.94
Reported: A = **14%**

16

Common Errors:

- Overloading #200 sieve
- Losing sample when transferring or washing
- Using a damaged #200 sieve

17

AASHTO T 11: Materials Finer Than No. 200 Sieve in Mineral Aggregates 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 allowed to cool and mass determined to 0.1%.		
3. #200 sieve checked for damage. Cover the #200 with a #8 or #16 sieve.		
4. Sample placed in a container and covered with water.		
5. Wetting agent added. (optional)		
6. Sample and contents of container vigorously agitated. Note: Mechanical washers maximum time 10min of washing.		
7. Wash water poured through the sieve nest.		
8. Wash water free of coarse particles.		
9. Operation continued until wash water is clear.		
10. Material on sieves returned to washed sample.		
11. Excess water decanted from washed sample only through the #200 sieve.		
12. Washed aggregate dried to constant mass at 230 ± 9°F (110 ± 5°C).		
13. Washed aggregate mass cooled and determined to 0.1%.		
14. Calculation: % less than #200 = $\frac{\text{Orig. dry mass} - \text{Final dry mass}}{\text{Orig. dry mass}} \times 100$		

PASS PASS

FAIL FAIL

Examiner:______________________________ Date:____________________________

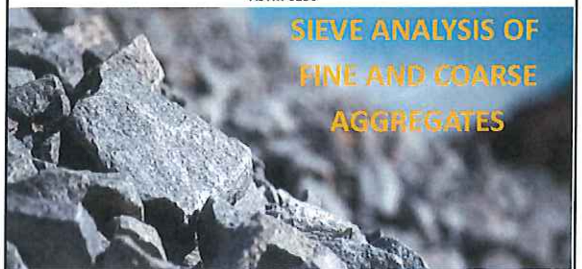
AASHTO T 27

ASTM C136

Sieve Analysis of Fine and Coarse Aggregates

AASHTO T 27

ASTM C136



Rev 10/07/2020

SCOPE

- Sieve analysis of aggregate is used to determine compliance with design, production control requirements, and verification of specifications.
- According to AASHTO, either Cumulative or Non-Cumulative methods may be used.

2

SIGNIFICANCE AND USE

- This method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregates. The results are used to determine compliance of the particle size distribution with applicable specification requirements and to provide necessary data for control of the production of various aggregate products. The data may also be useful in developing relationships concerning porosity and packing.
- Accurate determination of material finer than the #200 sieve cannot be achieved by use of this method alone. Therefore AASHTO T 11 for material finer than the #200 sieve by washing should be used.

3

EQUIPMENT

- **Scale** – readable to 0.1% of the sample mass or better
- **Sieves**
- **Brushes** – soft and stiff brushes
- **Pans**
- **Oven**– Capable of maintaining 230 ± 9°F (110 ± 5°C)
  - –A **Hot Plate** may be used

4

- **Mechanical Shaker**
  - –Check sieving thoroughness every **12 months** or **as needed** throughout the year.
    - The timer will be calibrated/verified during this process.
  - –A Record of this verification will be kept in the lab's Quality Manual System (QMS).
  - – See appendix for **AASHTO R 18** calibrating/verification process of mechanical sieve shakers.

Equipment 5

- **Brushes**
  - –Varity to clean out sieves
    - ≥ #30 sieve use a wire brush or stiff brush
    - < #30 sieve use a soft bristle brush

Equipment 6

DEFINITIONS AND LANGUAGE

- Nominal Maximum Aggregate Size (NMAS)
  - For AASHTO T 27 this is defined as the smallest sieve that the specification for the material being tested allows for 100% of the material to pass.

7

Interchangeable Words

- **Sieve Analysis** and **Gradation**
- **Weight** and **Mass**
- **Minus *(sieve #)* Material** and **Material Passing through a *(sieve #)***
  - Example: **-4 Material** = Material Passing through **#4 sieve**
- **Plus *(sieve #)* Material** and **Material Retained on a *(sieve #)***
  - Example: **+4 Material** = Material retained on a **#4 sieve**

Definitions and Language

8

THREE THINGS TO KNOW BEFORE SIEVE ANALYSIS

1. Sieve Condition
2. Check Sieving Thoroughness
3. Sieve Overloading

9

1. SIEVE CONDITION

- Check sieves for the following conditions prior to use.
  - Large Holes
  - Tears
  - Unevenly spaced wires
  - Cracks around rim
  - Bowed screens
  - Cleanliness
  - Periodically examine finer mesh sieves against a backlight or white background for damaged openings or perimeter separations; use magnified viewing if needed.

- Wash finer sieves periodically per manufacturers instructions.
- **Replace or repair any damaged sieves.**

10

2. CHECK SIEVING THOROUGHNESS

- Use a snug fitting pan and cover to prevent sample loss.
- Strike side of sieve with heel of hand at a rate of **150 times per minute**, turning about **1/6 turn** every **25 strokes.**

11

- There should not be more than **0.5 %** by mass of the total sample pass any sieve during **1 minute** of continuous hand sieving.
  - If **>0.5%** increase the time for sieving.
  - For more information see the Annex in this chapter section A2 TIME EVALUATION.

Sieving Thoroughness

12

3. SIEVE OVERLOADING

- For sieves with openings **smaller than #4**, the quantity retained on any sieve at the completion of the sieving operation shall not exceed **($4 g/in^2$)** of sieving surface area.
- For sieves with openings **#4 and greater**, the quantity retained in kg shall not exceed the product of:

  2.5 X [sieve opening, mm x (effective sieving area, m^2)]

  (This quantity is shown in AASHTO T27 Table 1)

See **Table 1** on the next slide for an example of allowable amounts on an 8"diameter sieve, and 14" square sieve.

See ANNEX A1 at the end of this chapter for more information

13

AASHTO TABLE 1

Maximum Allowable Quantity Of Material Retained*

Sieve Opening Size	8" Diameter Sieve	14" Square Sieve
2" (50 mm)	7.9 lbs (3.6 kg)	33.7 lbs (15.3 kg)
1½" (37.5 mm)	6.0 lbs (2.7 kg)	25.4 lbs (11.5 kg)
1" (25.0 mm)	4.0 lbs (1.8 kg)	17.0 lbs (7.7 kg)
3/4" (19.0 mm)	3.1 lbs (1.4 kg)	12.8 lbs (5.8 kg)
1/2" (12.5 mm)	2.0 lbs (0.89 kg)	8.4 lbs (3.8 kg)
3/8" (9.5 mm)	1.5 lbs (0.67 kg)	6.4 lbs (2.9 kg)
No. 4 (4.75 mm)	0.7 lbs (0.33 kg)	3.3 lbs (1.5 kg)

**Table 1 of the current AASHTO T 27 standard shows a complete table of different size sieves of the maximum allowable quantities of material retained on a sieve.*

Sieve Overloading 14

- To **prevent** sieve overloading on an individual sieve use one or more of the following methods:
  - Insert additional sieves.
  - Split sample into two or more portions, sieve each portion individually and combine the portions retained on the sieve before calculating the percentage of the sample on the sieve.
  - Use sieves having a larger frame size that provides a greater sieving area.

Sieve Overloading 15

SAMPLING

- Sample the aggregate in accordance with AASHTO R 90/ASTM D75.
- Thoroughly mix the sample and reduce to sample size using AASHTO R76.
- Use the Nominal Maximum Aggregate Size of the sample to determine the amount needed for testing from the MoDOT-EPG Chart on the next slide.

Note: The MoDOT-EPG Chart required amounts are different than that of AASHTO T 27.

16

MoDOT-EPG CHART

MoDOT Sample Sizes for Aggregate Gradation Test

Nominal Maximum Agg. Size in. (mm)	Minimum Mass of Test Sample lb. (g)
3/8" (9.5)	2.5 (1,000)
1/2" (12.5)	3.5 (1,500)
3/4" (19.0)	5.5 (2,500)
1" (25.0)	9 (4,000)
1 ½" (37.5)	13.5 (6,000)

Dried Fine Aggregate, Minimum **500** grams.

Found in the MoDOT EPG Section 1001 17

SAMPLE PREPARATION

- Dry the reduced sample to a constant mass in an oven at 230 ± 9°F (110 ± 5° C). A hot plate can be used – fracturing of aggregates should be avoided.

18

PROCEDURE
Sieve Analysis

19

- Weigh the dried sample and record the weight to the nearest gram. (Original Dry Mass)

Procedure – Original Dry Mass

20

PERFORM AASHTO T 11 (Optional)

NOTE: Test T 11 is an **option,** but is generally used with T 27.

- Perform **AASHTO T 11** (Washing out the minus #200 fines from the sample).
- Dry the **washed aggregate** to a constant mass at 230 ± 9°F (110 ± 5°C).
- Allow to cool.
- Weigh the **washed dried sample** and record the weight to the nearest gram.

Note: This weight will be called the "Washed Dry Mass" on your sieve analysis worksheet.

Procedure – AASHTO T 11

21

- Stack the sieves by assembling the required sieves in order of decreasing size.
- **NOTE:** Use of additional sieves may be added to prevent the required sieves from being overloaded.

- **NOTE:** For particles that are 3 inches and larger, use a Mechanical Screen-Shaker or Hand Sieve particles.

Procedure – Stacking Sieves | 22

COARSE AGGREGATE STACK

FINE AGGREGATE STACK

Procedure – Stacking Sieves | 23

- Carefully load the sieves by taking the dried, pre-weighed sample and pour it into the top of the sieve stack.
- Do not lose any material.
- Put the lid on top.

Procedure – Loading Sieves | 24

- Agitate and shake each sieve **mechanically** or **by hand** for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving.
- **Sieving Criterion**
  - Shake until ≤ **0.5%** by mass of the total sample passes during **1 minute** of continuous hand sieving.

Procedure - Agitation 25

- **Mechanical Sieving**: Place the stack of sieves in a Mechanical Shaker set at the calibrated/verified time. (Approximately 7-10 min)
- If the timer was not calibrated/verified,

Hand Sieve after agitation.

Procedure – Mechanical Agitation 26

Sieving by HAND: Shake until ≤ 0.5% by mass of the total sample passes during 1 minute of continuous hand sieving

NOTE: Do NOT force particles or manipulate them to go through the sieve openings.

Procedure – Manual Agitation 27

- **Method used to <u>check</u> mechanical shakers and hand sieving:**
  - Tap side of sieve sharply with heel of hand 150 strokes/minute, rotating 1/6 turn every 25 strokes.
  - Shake until ≤ 0.5% by mass of the total sample passes during 1 minute of continuous hand sieving.

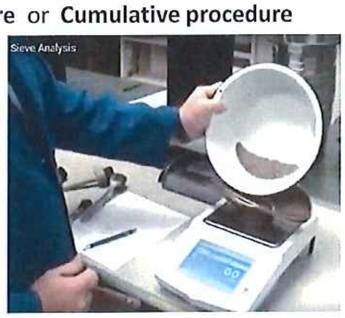
Procedure – Check for Sieving Thoroughness 28

- After agitating the sample, unload and weigh the retained material on each sieve.
- Start with the largest sieve from the top of the stack and unload the retained aggregates using the appropriate BRUSH to clean out the sieves.



Procedure – Unloading and Weighing 29

- Weigh and record the retained aggregates from each sieve using either the **Non-Cumulative procedure** or **Cumulative procedure**



Procedure – Unloading and Weighing 30

WEIGHING - Non - Cumulative Process

- Unload each sieve fraction separately into its own individual (tared) pan.
- Weigh each pan separately and write the weight next to the corresponding sieve size on the report.
- Record to nearest 0.1 % by total mass, typically 1 gram.

For The Minus #200

- Tare out a different pan and unload the minus #200 material from the pan from the sieve nest and record the weight.

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WEIGHING - Cumulative Process

- Unload the material retained on the largest sieve into a tared pan and record the weight to the nearest 0.1% of the total mass, typically 1 gram.
- ***Do not tare (zero) scale***, add material from next sieve into the same pan, record the combined weight.
- Repeat unloading and recording the combined weight until all sieves have been unloaded from the sieve stack into the same pan.

For The Minus #200

- Tare out a different pan and unload the minus #200 material from the pan from the sieve nest and record the weight.

32

CALCULATE AND REPORT

Depending upon the form, the material tested and the specification, the report shall include one of the following:

- Total percentage of material passing each sieve.
- Total percentage of material retained on each sieve.
- Percentage of material retained between consecutive sieves.

✓ All values for the percent passing are reported to the nearest whole number for all sieves including material passing the (No. #200) sieve for values ≥ 10%.

✓ Material passing the (No. # 200) sieve for values less than 10% , reported to the nearest tenth (0.1)%.

33

SIEVING ACCURACY

- MoDOT sieving accuracy: Sieving accuracy tolerance for sieve analysis is ±1 gram per sieve used. This can be found in the MoDOT EPG.

We will use MODOT sieving accuracy for this certification.

- AASHTO T 27 sieving accuracy: The total mass of the material after sieving should check closely with the total original dry mass of the sample placed on the sieves. If the two amounts differ by more than **0.3%**, based on the total original dry sample mass, the results should not be used for acceptance purposes.

34

CALCULATIONS -NON-CUMULATIVE

Equation for all sieves:

$$\%Passing = \frac{total\ weight\ passing}{original\ dry\ weight}\ x\ 100$$

Equation for the pan (Minus #200):

$$\%\ passing\ \#200 = \frac{(T11\ loss + pan\ weight)}{original\ dry\ weight}\ x\ 100$$

Equation for T11 loss:

A = Total % passing #200
B = Original dry mass of sample
C = Dry mass of sample after washing & drying to constant mass.

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

35

CALCULATIONS - CUMULATIVE

Equation for all sieves:

$$\%Passing = 1 - \left(\frac{cumulative\ weight}{original\ dry\ weight}\right) x\ 100$$

Equation for the pan (Minus #200):

$$\%\ passing\ \#200 = \frac{(T11\ loss + pan\ weight)}{original\ dry\ weight}\ x\ 100$$

Equation for T11 loss:

A = Total % passing #200
B = Original dry mass of sample
C = Dry mass of sample after washing & drying to constant mass

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

36

Calculation of the Fineness Modulus
"FOR INFORMATION ONLY"

- Calculate the fineness modulus, **when required**, by adding the total percentages of material in the sample that are coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100; Sieves: #100, #50, #30, #16, #8, #4, # ⅜, # ¾, # 1 ½, and larger, increasing the ratio of 2 to 1.
- Report the fineness modulus to the nearest 0.01%.

37

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.
- Losing material performing AASHTO T 11. (washing minus #200) prior to gradation.

38

SIEVE ANALYSIS PRACTICE PROBLEMS

***We will use Mo-DOT EPG sieving accuracy for this certification.**

NOTE: At the end of the module you will find enlarged copies of the slides and blank practice sheets.

39

Class Problem 1A		
Instruction and Practice For Cumulative and Non-cumulative Sieve Analysis	**Class Problem**	**1A**
		Weighed Amounts, g
	Dry Original Mass (g):	5226
	(T11) Dry Washed Mass (g):	5195

Sieve	Weighed Amounts, g
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
Pan	2

40

Non – Cumulative Process - Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Weight Passing (g)		Reported % Passing
25mm (1")	0	A - 0 =	5226	$\frac{5226}{5226}$ x 100 =	100
19mm (¾")	464	5226 - 464 =	4762	$\frac{4762}{5226}$ x 100 =	91
12.5mm (½")	2304	4762 - 2304 =	2458	$\frac{2458}{5226}$ x 100 =	47
9.5mm (⅜")	1162	2458 - 1162 =	1296	$\frac{1296}{5226}$ x 100 =	25
4.75mm (#4)	1182	1296 - 1182 =	114	$\frac{114}{5226}$ x 100 =	2
2.36mm (#8)	53	114 - 53 =	61	$\frac{61}{5226}$ x 100 =	1
1.18mm (#16)					
600μm (#30)					
300μm (#50)					
300μm (#50)					
150μm (#100)					
75μm (#200)	26	61 - 26 =	35		x
Pan (Minus #200)	2				x
Washing Loss (Minus #200)	31				x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$ x 100 =	0.6
Total Weight Retained :	(B) 5224				
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7			

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Non – Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Weight Passing (g)		Reported % Passing
25mm (1")	0	5226		100%
19mm (¾")	464	4762		91
12.5mm (½")	2304	2458		47
9.5mm (⅜")	1162	1296		25
4.75mm (#4)	1182	114		2
2.36mm (#8)	53	61		1
1.18mm (#16)				
600μm (#30)				
300μm (#50)				
300μm (#50)				
150μm (#100)				
75μm (#200)	26	35	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #200)	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

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Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200):	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Total Retained (g)		% Retained		Reported % Passing
25mm (1")	0		0		0		100
19mm (¾")	464	0 + 464 =	464	464/5226 x 100 =	8.9	100 - 8.9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	2768/5226 x 100 =	53.0	100 - 53.0 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	3930/5226 x 100 =	75.2	100 - 75.2 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	5112/5226 x 100 =	97.8	100 - 97.8 =	2
2.36mm (#8)	53	5112 + 53 =	5165	5165/5226 x 100 =	98.8	100 - 98.8 =	1
1.18mm (#16)							
600µm (#30)							
300µm (#50)							
300µm (#50)							
150µm (#100)							
75µm (#200)	26	5165 + 26 =	5191		x		x
Pan (Minus #200)	2						x
Washing Loss (Minus #200)	31						x
Total (Minus #200)	33	= 2 + 31		33/5226 x 100 =	→		0.6
Total Weight Retained :	(B) 5224	= 33 + 5191					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7					

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Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Total Retained (g)	% Retained	Reported % Passing
25mm (1")	0	0	0	100
19mm (¾")	464	464	8.9	91
12.5mm (½")	2304	2768	53.0	47
9.5mm (⅜")	1162	3930	75.2	25
4.75mm (#4)	1182	5112	97.8	2
2.36mm (#8)	53	5165	98.8	1
1.18mm (#16)			0.0	100
600µm (#30)			0.0	100
300µm (#50)			0.0	100
300µm (#50)			0.0	100
150µm (#100)			0.0	100
75µm (#200)	26	5191	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #20	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

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Class Problem **2B**

Work this Gradation Out **Cumulative** And Then **Non-cumulative**

Class Problem	2B
	Weighed Amounts, g
Dry Original Mass (g):	5040
(T11) Dry Washed Mass (g):	4571

37.5mm (1½")	
25mm (1")	
19mm (¾")	0
12.5mm (½")	1150
9.5mm (⅜")	
4.75mm (#4)	1700
2.36mm (# 8)	1275
1.18mm (#16)	
600µm (#30)	
300µm (#50)	
150µm (#100)	
75µm (#200)	398
Pan	44

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Non – Cumulative Class Problem 2B

2B

Dry Original Mass (g): 5040 (A)
(T11) Dry Washed Mass (g): 4571
Washing Loss (g): 469

Enlarged copy at the end of module

Sieve Size	Indiv. Sieve Wt. Retained (g)	Weight Passing (g)	Reported % Passing
37.5mm (1½")			
25mm (1")			
19mm (¾")	0	5040	100
12.5mm (½")	1150	3890	77
9.5mm (⅜")			
4.75mm (#4)	1700	2190	43
2.36mm (# 8)	1275	915	18
1.18mm (#16)			
600μm (#30)			
300μm (#50)			
150μm (#100)			
75μm (#200)	398		
Pan	44		
Washing Loss (g):	469		% Passing -200
Total Minus #200	513		10
Total Weight Retained:	5036	(B)	

Modot Accuracy Check = (A-B) = Less than 1/sieve? 5040 - 5036 = 4 4 < 5 = yes

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CUMULATIVE CLASS PROBLEM – 2B

2B

Dry Original Mass (g): 5040 (A)
(T11) Dry Washed Mass (g): 4571
Washing Loss (g): 469

Enlarged copy at the end of module

Sieve Size	Cumulative wt. Retained (g)	% Retained	Reported % Passing
37.5mm (1½")			
25mm (1")			
19mm (¾")	0	0	100
12.5mm (½")	1150	23	77
9.5mm (⅜")			
4.75mm (#4)	2850	57	43
2.36mm (# 8)	4125	82	18
1.18mm (#16)			
600μm (#30)			
300μm (#50)			
150μm (#100)			
75μm (#200)	4523		
Pan	44		
Washing Loss (g):	469		% Passing -200
=Total Minus #200	513		10
Total Weight Retained:	5036	(B)	

Modot Accuracy Check = (A-B) = Less than 1/sieve? 5040 - 5036 = 4 4 < 5 = yes

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Fine Gradation Class Problem 3A

Complete the sieve analysis on the blank worksheet provided using the weights listed here.
You may choose either Cumulative or Non-cumulative method.
When you are finished the instructor will check it.

CLASS PROBLEM:	3A
	FINE Agg
	Weighed Amounts, g
Dry Original Mass (g):	526
(T11) Dry Washed Mass (g):	520
37.5mm (1½")	
25mm (1")	
19mm (¾")	
12.5mm (½")	
9.5mm (⅜")	0
4.75mm (#4)	25
2.36mm (# 8)	60
1.18mm (#16)	209
600μm (#30)	168
300μm (#50)	40
150μm (#100)	13
75μm (#200)	2
Pan	1

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CUMULATIVE - Problem 1A

Updated 10/14/2020

Dry Original Mass (g): **5226** (A)
(T11) Dry Washed Mass (g): **5195**
Washing Loss (g): 31

Sieve Size	Cumulative wt. Retained (g)	% Retained	% Passing
37.5mm (1½")			
25mm (1")	**0**	**0**	**100**
19mm (¾")	0+**464** = **464**	(**464**/**5226**) x 100 = **9**	100-**9** = **91**
12.5mm (½")	464+**2304** = **2768**	(**2768**/**5226**) x 100=**53**	100-**53** = **47**
9.5mm (⅜")	2768+**1162** = **3930**	(**3930**/**5226**) x 100 = **75**	100-**75** =**25**
4.75mm (#4)	**5112**	**98**	100 - **98** = **2**
2.36mm (# 8)	**5165**	**99**	**1**
1.18mm (#16)			
600ɥm (#30)			
300ɥm (#50)			
150ɥm (#100)			
75ɥm (#200)	5165 + **26** = **5191**		
Pan (#200):	2		
+ Washing Loss (#200):	31		% Passing -200
=**Total Minus** (#200):	**33**		(**33**/A)*100=0.6
Total Weight Retained:	5224 (B)	Also add Total -200	**0.6**

NON-CUMULATIVE - Problem 1A

Dry Original Mass (g): **5226** (A)
(T11) Dry Washed Mass (g): **5195**
Washing Loss (g): 31

Sieve Size	Indiv. Sieve Wt. Retained (g)		% Passing
37.5mm (1½")			
25mm (1")	0	A - 0 = 5226	(5226/**5226**) x 100 =**100**
19mm (¾")	464	5226-464=**4762**	(**4762**/**5226**) x 100 = **91**
12.5mm (½")	2304	**4762**-2304 =**2458**	(**2458**/**5226**) x 100 = **47**
9.5mm (⅜")	1162	**2458**-1162= **1296**	(**1296**/**5226**) x 100 = **25**
4.75mm (#4)	1182	114	**2**
2.36mm (# 8)	53	61	**1**
1.18mm (#16)			
600ɥm (#30)			
300ɥm (#50)			
150ɥm (#100)			
75ɥm (#200)	26		
Pan (#200):	2		
+ Washing Loss (#200):	31		% Passing -200
=**Total Minus** (#200):	33		(**33**/A)*100=0.6
Total Weight Retained:	5224 (B)	Also add Total -200	**0.6**

Non – Cumulative Process - Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Weight Passing (g)			Reported % Passing
25mm (1")	0	A - 0 =	5226	5226/5226	x 100 =	100
19mm (¾")	464	5226 - 464 =	4762	4762/5226	x 100 =	91
12.5mm (½")	2304	4762 - 2304 =	2458	2458/5226	x 100 =	47
9.5mm (⅜")	1162	2458 - 1162 =	1296	1296/5226	x 100 =	25
4.75mm (#4)	1182	1296 - 1182 =	114	114/5226	x 100 =	2
2.36mm (#8)	53	114 - 53 =	61	61/5226	x 100 =	1
1.18mm (#16)						
600µm (#30)						
300µm (#50)						
300µm (#50)						
150µm (#100)						
75µm (#200)	26	61 - 26 =	35			x
Pan (Minus #200)	2					x
Washing Loss (Minus #200)	31					x
Total (Minus #200)	33	= 2 + 31		33/5226	x 100 =	0.6
Total Weight Retained :	(B) 5224					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7				

Non – Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Weight Passing (g)		Reported % Passing
25mm (1")	0	5226		100%
19mm (¾")	464	4762		91
12.5mm (½")	2304	2458		47
9.5mm (⅜")	1162	1296		25
4.75mm (#4)	1182	114		2
2.36mm (#8)	53	61		1
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
300µm (#50)				
150µm (#100)				
75µm (#200)	26	35	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #200)	33	→	→	0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Total Retained (g)		% Retained		Reported % Passing
25mm (1")	0		0		0		100
19mm (¾")	464	0 + 464 =	464	464 / 5226 x 100 =	8.9	100 - 8.9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	2768 / 5226 x 100 =	53.0	100 - 53.0 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	3930 / 5226 x 100 =	75.2	100 - 75.2 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	5112 / 5226 x 100 =	97.8	100 - 97.8 =	2
2.36mm (#8)	53	5112 + 53 =	5165	5165 / 5226 x 100 =	98.8	100 - 98.8 =	1
1.18mm (#16)							
600µm (#30)							
300µm (#50)							
300µm (#50)							
150µm (#100)							
75µm (#200)	26	5165 + 26 =	5191		x		x
Pan (Minus #200)	2						x
Washing Loss (Minus #200)	31						x
Total (Minus #200)	33	= 2 + 31		33 / 5226 x 100 =	→		0.6
Total Weight Retained :	(B) 5224	= 33 + 5191					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7					

Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Total Retained (g)	% Retained	Reported % Passing
25mm (1")	0	0	0	100
19mm (¾")	464	464	8.9	91
12.5mm (½")	2304	2768	53.0	47
9.5mm (⅜")	1162	3930	75.2	25
4.75mm (#4)	1182	5112	97.8	2
2.36mm (#8)	53	5165	98.8	1
1.18mm (#16)			0.0	100
600µm (#30)			0.0	100
300µm (#50)			0.0	100
300µm (#50)			0.0	100
150µm (#100)			0.0	100
75µm (#200)	26	5191	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #20)	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

CUMULATIVE Class Problem 2B

ANSWERS – 2B

Dry Original Mass (g): 5040 **(A)**

(T11) Dry Washed Mass (g): 4571

Washing Loss (g): 469

Sieve Size		Cumulative wt. Retained (g)	% Retained	% Passing
37.5mm	(1½")			
25mm	(1")			
19mm	(¾")	0	0	100
12.5mm	(½")	1150	23	77
9.5mm	(⅜")			
4.75mm	(#4)	2850	57	43
2.36mm	(# 8)	4125	82	18
1.18mm	(#16)			
600ųm	(#30)			
300ųm	(#50)			
150ųm	(#100)			
75ųm	(#200)	4523		
Pan		44		
Washing Loss (g)		469		
Total Minus #200		513		
Total Weight Retained:		5036	**(B)**	% Passing -200
				10

MoDOT Accuracy Check = (A-B) = Less than 1/sieve? 5040 - 5036 = 4 4 < 5 = YES

Non - CUMULATIVE Class Problem 2B

Dry Original Mass (g): 5040 **(A)**

(T11) Dry Washed Mass (g): 4571

Washing Loss (g): 469

Sieve Size		Individual Sieve wt. Retained (g)	Wt. passing	% Passing
37.5mm	(1½")			
25mm	(1")			
19mm	(¾")	0	5040	100
12.5mm	(½")	1150	3890	77
9.5mm	(⅜")			
4.75mm	(#4)	1700	2190	43
2.36mm	(# 8)	1275	915	18
1.18mm	(#16)			
600ųm	(#30)			
300ųm	(#50)			
150ųm	(#100)			
75ųm	(#200)	398		
Pan		44		
Washing Loss (g)		469		
Total Minus #200		513		
Total Weight Retained:		5036	**(B)**	% Passing -200
				10

8.2. Select sieves with suitable openings to furnish the information required by the specifications covering the material to be tested. Use additional sieves as desired or necessary to provide other information, such as fineness modulus, or to regulate the amount of material on a sieve to meet the requirements of Annex A1. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample, or portion of the sample if it is to be sieved in more than one increment, on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in Annex A2.

8.3. Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve openings a number of times during the sieving operation.

8.3.1. *Prevent an overload of material on an individual sieve as described in Table A1 by one or a combination of the following methods:*

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

8.5. Determine the mass of each size increment on a scale or balance conforming to the requirements specified in Section 6.1 to the nearest 0.1 percent of the total original dry sample mass. The total mass of the material after sieving should check closely with the total original dry mass of the sample placed on the sieves. If the two amounts differ by more than 0.3 percent, based on the total original dry sample mass, the results should not be used for acceptance purposes.

ANNEX A

(Mandatory Information)

A1. OVERLOAD DETERMINATION

A1.1. Do not exceed a mass of 7 kg/m^2 (4 g/in.^{2}) of sieving surface for sieves with openings smaller than 4.75 mm (No. 4) at the completion of the sieving operation.

A1.2. Do not exceed a mass in kilograms of the product of 2.5 × (sieve opening in mm) × (effective sieving area) for sieves with openings 4.75 mm (No. 4) and larger. This mass is shown in Table A1.1 for five sieve-frame dimensions in common use. Do not cause permanent deformation of the sieve cloth due to overloading.

Note A1—The 7 kg/m^2 (4 g/in.^{2}) amounts to 200 g for the usual 203-mm (8-in.) diameter sieve [with effective or clear sieving surface diameter of 190.5 mm (7 $^1/_2$ in.)] or 450 g for a 305-mm (12-in.) diameter sieve [with effective or clear sieving surface diameter of 292.1 mm (11 $^1/_2$ in.)]. The amount of material retained on a sieve may be regulated by: (1) the introduction of a sieve with larger openings immediately above the given sieve, (2) testing the sample in multiple increments, or (3) testing the sample over a nest of sieves with a larger sieve-frame dimension.

Table A3.1—Maximum Allowable Mass of Material Retained on a Sieve, kg

Sieve Opening Size	Nominal Dimensions of Sieve[a]				
	203.2 mm, dia[b]	254 mm, dia[b]	304.8 mm, dia[b]	350 by 350, mm	372 by 580, mm
	Sieving Area, m²				
	0.0285	0.0457	0.0670	0.1225	0.2158
125 mm (5 in.)	c	c	c	c	67.4
100 mm (4 in.)	c	c	c	30.6	53.9
90 mm (3½ in.)	c	c	15.1	27.6	48.5
75 mm (3 in.)	c	8.6	12.6	23.0	40.5
63 mm (2½ in.)	c	7.2	10.6	19.3	34.0
50 mm (2 in.)	3.6	5.7	8.4	15.3	27.0
37.5 mm (1½ in.)	2.7	4.3	6.3	11.5	20.2
25.0 mm (1 in.)	1.8	2.9	4.2	7.7	13.5
19.0 mm (¾ in.)	1.4	2.2	3.2	5.8	10.2
12.5 mm (½ in.)	0.89	1.4	2.1	3.8	6.7
9.5 mm (⅜ in.)	0.67	1.1	1.6	2.9	5.1
4.75 mm (No. 4)	0.33	0.54	0.80	1.5	2.6

a Sieve-frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

b The sieve area for round sieves is based on an effective or clear diameter of 12.7 mm (½ in.) less than the nominal frame diameter because ASTM E11 permits the sealer between the sieve cloth and the frame to extend 6.35 mm (¼ in.) over the sieve cloth. Thus, the effective or clear sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm (7½ in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm (¼ in.).

c Sieves indicated have less than five full openings and should not be used for sieve testing.

A2. TIME EVALUATION

A2.1. The minimum time requirement shall be evaluated for each shaker at least annually by the following method:

A2.1.1. Shake the sample over nested sieves for approximately 10 min.

Note A2—If the sample material may be prone to degradation, reduce the initial shaking time in Section A2.1.1 to 5 min, and begin each recheck with a new sample.

A2.1.2. Provide a snug-fitting pan and cover for each sieve and hold the items in a slightly inclined position in one hand.

A2.1.3. Hand-shake each sieve continuously for 60 s by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per min, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

A2.2. If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving, adjust the shaker time and repeat Section A2.1.

A2.3. In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

A2.4. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm (8-in.) diameter sieves to verify the adequacy of sieving.

A2.5. If the mass retained on any sieve exceeds the maximum allowable mass per Table A1.1, select a different sample and repeat Section A2.

---

[1] Similar but not identical to ASTM C136-06.

Equipment Checked: **MECHANICAL SHAKERS**

Purpose:

This method provides instructions for checking the sieving thoroughness and time required to sieve a sample.

Equipment Required:

1. Stopwatch readable to 0.1s
2. Balance, readable to 0.1g
3. Appropriate sieves, pans, lids

Tolerance:

Equipment shall meet the sieving thoroughness specified in the applicable test method(s).

Procedure:

1. Obtain a well graded sample that covers the range of sieves to be used in the mechanical shaker.
2. Starting at the lower end of the estimated sieving time, run the mechanical shaker.
3. Conduct a hand check on each sieve in the stack for sieving sufficiency as follows:
    a. Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand.
    b. Strike the side of the sieve sharply and, with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one-sixth of a revolution at intervals of about 25 strokes.
    c. In determining the sufficiency of sieving for sizes larger than the No 4. sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described motion impractical, use 8-inch diameter sieves to verify the sufficiency of sieving.
4. Determine the sieving sufficiency according the applicable test method(s).
5. Repeat the sieving and sufficiency check procedure for at least two more sieving times.
6. The first sieving time the sufficiency check meets the tolerance should be noted as the standard sieving time for your mechanic shaker.

Considerations:

1. Certain test methods note that excessive sieve time (more than 10 minutes) to adequate sieving can result in degradation of the sample.
2. Different aggregate hardness or aggregate angularity may require different sieving times with a mechanical shaker to avoid sample degradation. Additional checks may be required using the different types encountered by the laboratory. (required if complying with C1077)
3. Overloading individual sieves with too much material during the check will result in erroneous results.

Dry Original Mass (g): ______________ **(A)**

(T11) Dry Washed Mass (g): ______________

Washing Loss (g): ______________

Sieve Size		Individual Sieve Weight Retd. (g)			% Passing
37.5mm	(1½")				
25mm	(1")				
19mm	(¾")				
12.5mm	(½")				
9.5mm	(⅜")				
4.75mm	(#4)				
2.36mm	(# 8)				
1.18mm	(#16)				
600µm	(#30)				
300µm	(#50)				
150µm	(#100)				
75µm	(#200)				
Pan					
Washing Loss (g)					
Total Minus #200					
Total Weight Retained:			**(B)**		

'% Passing -200: ______

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

Dry Original Mass (g): ______________ **(A)**

(T11) Dry Washed Mass (g): ______________

Washing Loss (g): ______________

Sieve Size	Individual Sieve Weight Retd. (g)			% Passing
37.5mm (1½")				
25mm (1")				
19mm (¾")				
12.5mm (½")				
9.5mm (⅜")				
4.75mm (#4)				
2.36mm (# 8)				
1.18mm (#16)				
600ųm (#30)				
300ųm (#50)				
150ųm (#100)				
75ųm (#200)				
Pan				
Washing Loss (g)				% Passing -200
Total Minus #200				
Total Weight Retained:		**(B)**		

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

Dry Original Mass (g): ____________ **(A)**

(T11) Dry Washed Mass (g): ____________

Washing Loss (g): ____________

Sieve Size	Individual Sieve Weight Retd. (g)			% Passing
37.5mm (1½")				
25mm (1")				
19mm (¾")				
12.5mm (½")				
9.5mm (⅜")				
4.75mm (#4)				
2.36mm (# 8)				
1.18mm (#16)				
600ųm (#30)				
300ųm (#50)				
150ųm (#100)				
75ųm (#200)				
Pan				
Washing Loss (g)				**'% Passing -200**
Total Minus #200				
Total Weight Retained:		**(B)**		

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

Category: 1001 General Requirements for Material – Engineering Policy Guide

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~~ AASHTO R76. 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		
1. Reduced per AASHTO R76		
2. Minimum sample mass 500 g		
Coarse Aggregate		
1. Reduced per AASHTO R76 used sample size determined from nominal maximum aggregate size, and MoDOT' s EPG chart		
2. Sample dried to constant mass at 230 ± 9°F (110 ± 5°C), weighed to nearest 0.1% by mass (typically, 1 gram) and recorded		
- AASHTO T 11 may be performed at this point, Washing Material Finer Than No. 200 Sieve, dried to a constant mass at 230 ± 9°F (110 ± 5°C), weight recorded, and weight loss calculated to nearest whole number		
3. Stacked appropriate sieves in descending order		
4. Poured sample in the top sieve without losing material		
5. Agitated **Manually** or **Mechanically**		
- **Manual 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		
- **Mechanical Sieving** Verified annually - Timer verified/calibrated for sieving thoroughness. (Established by trial or checked by measurement on the actual test sample to meet the 0.5% criteria as in hand sieving above. (Records kept in the lab) - Set at verified/calibrated time approximately 7-10 min. - Or if timer not verified/calibrated, hand sieved afterwards for sieving accuracy		
6. Precautions taken to not overload sieves		
7. Weighed material in each sieve either by **Non-Cumulative** or **Cumulative** method		
8. Total mass of material after sieving agrees with mass before sieving to within 1 gram per sieve used (If not, do not use for acceptance testing)		
9. Percentages calculated to nearest 0.1% and reported to nearest whole number		
10. Percentage calculations based on original dry sample mass, including the passing No. 200 fraction if T 11 was used		

PASS PASS

FAIL FAIL

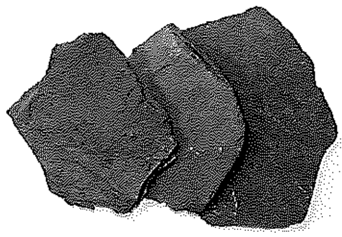
Examiner: ________________________________ Date: ____________

MoDOT TM 71

DELETERIOUS CONTENT

Of

AGGREGATE



MoDOT TM 71

MoDOT EPG

Deleterious Content of Aggregate

Rev. 12/06/2019

SCOPE

- This test method covers the determination of the percentages of various types of deleterious in a sample of aggregate by examining each piece and separating them into the various types of deleterious groups as described in the MoDOT EPG Section 106.
- **NOTE**: MoDOT TM 71 also covers the procedure for Determining the Deleterious of Fine Aggregate which is tested in accordance with AASHTO T 113 this will **NOT** be covered in this certification.

2

SIGNIFICANCE

Deleterious material can have a detrimental effect on the durability and life-span of concrete and asphalt mixtures. Most deleterious substances have tendencies to deteriorate or cause degradation in concrete or asphalt mixtures.

3

Some issues caused by deleterious:

- 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.

4

Quality:

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

5

Deleterious groups:

- Shale
- Other Foreign Material (OFM)
- Extremely Soft Rock (Deleterious)
- Soft Chert
- Hard Chert
  - Samples can vary in the types and quantity of deleterious from one to the other depending on the product type and location.

6

EQUIPMENT

- Containers –size and shape to contain the sample.
- Sieve – #4 (4.75 mm) sieve to divide the sample.
- Water – to wet sample for observation
- Scale – accurate to within 0.5 percent of the weight of the sample.
- Lamp or a good light source.

7

MoDOT EPG TM 71

Maximum Size inches (mm)	Minimum Sample Size of Plus 4 material
2" (50)	10,000 grams
1 ½" (37.5)	9,000 grams
1" (25.0)	5,000 grams
¾" (19.0)	3,000 grams
½" (12.5)	2,000 grams
⅜" (9.5)	1,000 grams

TM 71: Maximum size is defined as the smallest sieve through which 100 % of the material will pass.

8

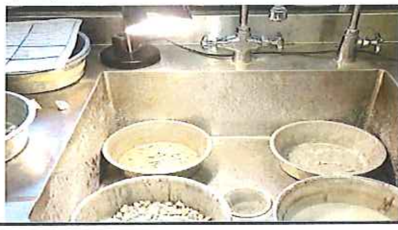
PROCEDURE

1. Material shall be tested in an "as received" condition. (May be dried in an oven at 140°F if needed)
2. Reduce the sample according to the maximum size of aggregate, with a surplus for sieving.
3. Sieve the reduced sample over a #4 sieve and discard the passing material.
4. Check the plus #4 sample weight to see if there is at least the minimum amount for testing using the MoDOT TM 71 Table.

9

5. Record the weight of the plus #4 material to the nearest whole gram. (Original Mass)
   Plus #4 material = material retained on the #4 sieve

6. Set up a work station with a good light source, plenty of pans to work with, and a pan or spray bottle of water.



Procedure 10

7. Obtain a handful of the sample and **briefly** wet the material. Do Not let the entire sample soak in water, some deleterious particles will dissolve!

8. Visually examine each piece for deleterious particles and separate into specific groups according to specifications: OFM, Hard Chert, Soft Chert, Shale, etc.

Procedure 11

9. After the sample has been completely examined, weigh each deleterious group separately to the nearest whole gram. Discard the non-deleterious.

10. Calculate the percentage of each group and record the results.

Procedure 12

CALCULATIONS

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

13

NOTES

- For 1002 Asphaltic Concrete: The Soft Chert is used in the calculation of the Deleterious Content and the Total Chert Content.
- The number of groups vary by product type.
- MoDOT TM 71 gives specific description based on product type.

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EXAMPLE PROLEM 1A

Sample: 1002 Material (Asphalt) ID NO.___ Date: ___

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	55			
Shale	7	=		% Shale
OFM	3	=		% OFM
Soft Chert	15			
Hard Chert	114			

			Percent	
Deleterious Rock + Soft Chert =		=		% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =		=		% Total Deleterious Material
Hard Chert + Soft Chert =		=		% Total Chert

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EXAMPLE PROLEM 1A

Sample: 1002 Material (Asphalt) ID NO.___ Date: ___

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	55			
Shale	7	=	0.2	% Shale
OFM	3	=	0.1	% OFM
Soft Chert	15			
Hard Chert	114			
			Percent	
Deleterious Rock + Soft Chert =	70	=	2.3	% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =	80	=	2.7	% Total Deleterious Material
Hard Chert + Soft Chert =	129	=	4.3	% Total Chert

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EXAMPLE PROLEM 1B

Sample: 1002 Material (Asphalt) ID NO.___ Date: ___

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	60			
Shale	9	=		% Shale
OFM	1	=		% OFM
Soft Chert	15			
Hard Chert	125			
			Percent	
Deleterious Rock + Soft Chert =		=		% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =		=		% Total Deleterious Material
Hard Chert + Soft Chert =		=		% Total Chert

17

EXAMPLE PROLEM 1B

Sample: 1002 Material ID NO.___ Date: ___

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	60			
Shale	9	=	0.3	% Shale
OFM	1	=	0.0	% OFM
Soft Chert	15			
Hard Chert	125			
			Percent	
Deleterious Rock + Soft Chert =	75	=	2.5	% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =	85	=	2.8	% Total Deleterious Material
Hard Chert + Soft Chert =	140	=	4.7	% Total Chert

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Summary:

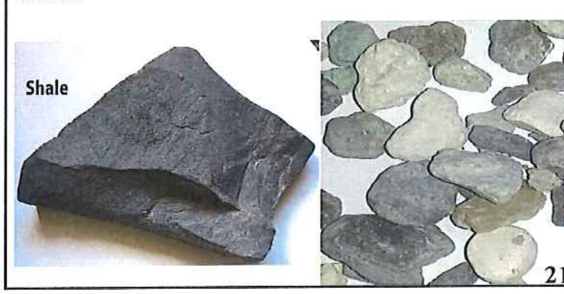
- Quality must be determined according to specification requirements for various aggregates.
- Only material retained on #4 sieve is considered for deleterious determination.
- Any particle considered soft by means of chipping or spalling with the finger or fingernail is considered deleterious.
- Any substance that will reduce the effectiveness of the product will be considered detrimental, including material considered as Other Foreign Material (OFM).

19

Descriptions of Specific Deleterious Groups and Tips on How to Determine Deleterious

20

Shale: A dull looking grayish, green, or brownish rock made of clay or mud. Shale leaves a black mark on a non-glazed ceramic bowl.



21

Other Foreign Material: Mud-balls, sticks, shell, lignite, and other miscellaneous items.

22

- **Extremely Soft and or Porous Rock (Deleterious)**: Has a dull appearance, which can be easily spalled or chipped off with the finger nail.

23

- **Soft Chert**: Will groove.

24

Hard Chert: Has sharp edges, vary in color from white to black. Chert in lime-stone must be at least 50% chert to qualify as chert. Hard chert is hard enough to mark with a metal screwdriver. Has a non cohesive property that will cause it to pop-out of concrete

Example Problem

1A

Sample: 1002 Material (Asphalt) ID NO.____ Date: ____

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	55			
Shale	7	=		% Shale
OFM	3	=		% OFM
Soft Chert	15			
Hard Chert	114			

			Percent	
Deleterious Rock + Soft Chert =		=		% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =		=		% Total Deleterious Material
Hard Chert + Soft Chert =		=		% Total Chert

Example Problem

1A

Sample: 1002 Material (Asphalt) ID NO.____ Date: ____

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	55			
Shale	7	=	0.2	% Shale
OFM	3	=	0.1	% OFM
Soft Chert	15			
Hard Chert	114			

			Percent	
Deleterious Rock + Soft Chert =	70	=	2.3	% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =	80	=	2.7	% Total Deleterious Material
Hard Chert + Soft Chert =	129	=	4.3	% Total Chert

Example Problem

1B

Sample: 1002 Material (Asphalt) ID NO.___ Date: ___

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	60			
Shale	9	=		% Shale
OFM	1	=		% OFM
Soft Chert	15			
Hard Chert	125			

			Percent	
Deleterious Rock + Soft Chert =		=		% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =		=		% Total Deleterious Material
Hard Chert + Soft Chert =		=		% Total Chert

Example Problem Answers

1B

Sample: 1002 Material ID NO.___ Date: ___

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	60			
Shale	9	=	0.3	% Shale
OFM	1	=	0.0	% OFM
Soft Chert	15			
Hard Chert	125			

			Percent	
Deleterious Rock + Soft Chert =	75	=	2.5	% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =	85	=	2.8	% Total Deleterious Material
Hard Chert + Soft Chert =	140	=	4.7	% Total Chert

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 x 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 or fingernail.

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 or fingernail.

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 or fingernail.

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.

TM71: Deleterious Content of Aggregate
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
1. Material tested in an as received condition (may be dried at 140ºF)		
2. Reduced the sample according to the Maximum Size aggregate using the TM71 table below: Note: Surplus this amount for sieving		

Maximum Size Inches (mm)	Minimum Sample Size of +4 material
2 (50)	10,000 grams
1½ (37.5)	9,000 grams
1 (25.0)	5,000 grams
¾ (19.0)	3,000 grams
½ (12.5)	2,000 grams
⅜ (9.5)	1,000 grams
Maximum size is defined as the smallest sieve through which 100% of the material will pass.	

	1	2
3. Sieved the reduced sample over a #4 sieve and discarded the passing material		
4. Reweighed the plus 4 material to see if the sample meets the minimum size needed from the table.		
5. Recorded the weight of the plus #4 material as the Original Mass		
6. Set-up a workstation with a good light, a pan or spray bottle of water and several sorting pans		
7. Obtained a handful, briefly wet a few particles and visually examined each particle **(Do not soak the particles in water)**		
8. Examined each piece and separated the deleterious particles into specific groups according to specifications: (OFM, Hard Chert, Soft chert, Shale, etc.)		
9. Recorded the weight of each group of deleterious found in the sample to the nearest whole gram		
NOTES: ❖ Groups are defined in the test method and will vary based on product type as well as the presence of any given group ❖ For 1002 material, keep soft chert separate as it will be included in both deleterious and hard chert		
10. Calculate the percentage of each group identified, report to nearest 0.1% for each category $P = \frac{C}{W} \times 100$ Where: P = Percentage of each deleterious component; C = Actual weight (mass) of deleterious for each group; 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 D4791

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

Rev. 12/06/2019

SCOPE

- This test method covers the determination of the percentages of flat particles, elongated particles, or flat and elongated particles in coarse aggregates.
- Two procedures, Method A and Method B, are presented in ASTM D4791.
- Method A uses 4 groups of F&E:

1. Flat particles,
2. Elongated particles
3. Particles that meet the criteria of both groups
4. Neither flat nor elongated.

2

- Method A is a reflection of the original procedure as developed prior to Superpave and is intended for all non-Superpave applications *and will NOT be covered in this certification. For more information on Method A, see the Appendix.*
- **Method B is a comparison of the maximum particle dimension to the minimum particle dimension and is intended for use with Superpave specifications.**

Scope

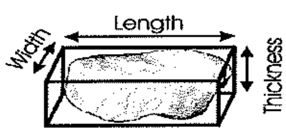
3

SIGNIFICANCE AND USE

- The particle shape of course aggregate influences the properties of some construction materials and may affect their placement and consolidation.
- This test method provides a means for checking compliance with specifications that limit such particles or to determine the relative shape characteristics of coarse aggregate.

4

Definitions



- **Flat and Elongated Particles** (F&E) - Those particles having a ratio of length to thickness greater than a specified value
- **Length** - The longest dimension
- **Thickness** - The smallest dimension
- **Width** – Intermediate dimension of the particle that is greater than or equal to the thickness

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Detrimental affects when used in mixtures:

- Interferes with placement and consolidation.
- Fractures or breaks more easily.
- When an aggregate particle breaks, it creates a face that is not coated with binder, increasing the potential of the mix to strip or ravel.
- When the coarse aggregate fractures the gradation will likely change, which may be detrimental to the mix.

6

Material Tested:

ASTM

- Material larger than ¾" (19mm) or #4 (4.75mm) as determined by specification requirements.

MoDOT

- See Engineering Policy Guide (EPG)
- 106.7.71 TM 71, Deleterious Content of Aggregate (106.7.71.6.1.6)

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MoDOT Materials Tested:

1002

- Test all sieves with more than 10% retained (on #4 sieve and above)
- Test only 5:1 comparison
- Do a weighted average calculation and report this result

SMA (Stone Mastic Aggregate)

- Test all sieves with more than 10% retained on #4 sieve and above
- Test both 3:1 and 5:1 comparison
- Do a weighted average calculation and report this result

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1005

- Test all sieves with more than 10% retained on ¾" sieve and above.
- Test only 5:1 comparison
  - Do NOT do a weighted average calculation

MoDOT Materials Tested

9

EQUIPMENT

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

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SAMPLING

- Sample the coarse aggregate in accordance with Practice AASHTO R 90 (ASTM D75).
- Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in practice AASHTO R 76. The sample for testing shall be approximately the mass desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined mass shall not be permitted.

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ASTM D4791 Sample Size

Maximum Retained Sieve Size in.(mm)	Minimum Amounts lb. (Mass in grams)
⅜" (9.5)	2 (1000)
½" (12.5)	4 (2000)
¾" (19.0)	11 (5000)
1" (25.0)	22 (10,000)
1 ½" (37.5)	33 (15,000)

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By particle count:

- Does not need to be oven dried.
- Perform AASHTO T27
- Reduce each fraction that has a minimum of 10% retained until approximately 100 particles remain
- Approximately 100 particles needed for testing

By mass/weight:

- Oven dry @ 230 ± 9°C (110 ± 5°C)
- Perform AASHTO T27
- Test all sieves with more than 10% retained on the #4 sieve and above as required by MoDOT specifications.

Sampling

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SUPERPAVE PROCEDURE; METHOD B

Acquire the amounts to be tested by count or mass.

1. Each particle in each size fraction tested and placed into one of two groups:

   Flat & Elongated OR Not Flat & Elongated

2. Proportional caliper device positioned at proper ratio? 3:1, 5:1, etc.
3. Test each particle in the caliper by setting the larger opening to the particle length.

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4. Place the particle through the opposite side of the caliper for thickness, if it slips through the smaller measure, the particle is flat and elongated.
5. Weigh the amount of F&E of each fraction and record each to the nearest whole gram on the report.

NOTE: Particle is flat and elongated if the thickness can be passed through the smaller opening.

Method B

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Evaluating Aggregates

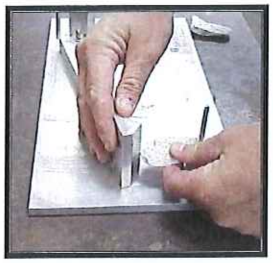

Figure 1
Checking Elongation

Figure 2
Checking Flatness

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CALCULATIONS & REPORTING

- Report each group to nearest 1%. Test all sieves with more than 10% retained on #4 sieve and above as required by MoDOT Specifications.

  NOTE: If a sieve size has less than 10% retained, see example calculation sheet item for guidance.
- Report each F&E group to nearest whole number.
- When required, the weighted average percentages based on the actual or assumed proportions of the various sieve sizes tested.

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A = Weight retained on each particular sieve

$$B = \frac{(A)}{\text{Original mass of sample}} \times 100$$ Report to nearest 0.1%

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of flat and elongated particles

$$E = \frac{D}{C} \times 100$$ Report to nearest 1%

$$F = \frac{B}{TPR}$$ Report to nearest 0.001

$$G = E \times F$$ Report to nearest 1%

Calculations & Reporting

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Common testing errors:

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

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Class Room F&E Problems

There are enlarged copies at the end of this module.

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Flat and Elongated by Mass

Problem 1A

Original Mass of Sample 6301 grams Ratio 5 to 1.

Report to:	0 g	0.0	0	0	0	0.000	0
Sieve Sizes	Mass Retained T27 (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		1973	8			
12.5mm ½"	3232		1632	44			
9.5mm ⅜"	69		0	0			
4.75mm #4	119		0	0			
Total % Retained (TPR)			(TPR)				
						Total	

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Original Mass of Sample 6301 grams Ratio 5 to 1 **Answers 1A**

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)
Report to:	0 g	0.0	0	0	0	0.000	0
37.5mm 1½"	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%

22

Flat and Elongated by Mass

Problem 2B

Original Mass of Sample 7300 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 1½"							
25.0mm 1"	0		0	0			
19.0mm ¾"	2710		1840	13			
12.5mm ½"	3252		1588	51			
9.5mm ⅜"	70		0	0			
4.75mm #4	1252		825	33			
Total % Retained			(TPR)				
						Total	

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Flat and Elongated by Mass

Problem 2B

Original Mass of Sample 7300 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 1½"							
25.0mm 1"	0		0	0			
19.0mm ¾"	2710	37.1	1840	13	1		
12.5mm ½"	3252	44.5	1588	51	3		
9.5mm ⅜"	70	1.0 <10%	0	0	4		
4.75mm #4	1252	17.2	825	33	4		
Total % Retained		99.8	(TPR)				
For column E where zero is : 3+4 =7 (7 – 2) = 3.5 = 4 Using the number above and below the zero, add, divide by 2 =4						Total	

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Flat and Elongated by Mass

Answers 2B

Original Mass of Sample __7300__ 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	37.1	1840	13	1	0.372	0
12.5mm ½"	3252	44.5	1588	51	3	0.446	1
9.5mm ⅜"	70	1.0 <10%	0	0	4	0.010	0
4.75mm #4	1252	17.2	825	33	4	0.172	1
Total % Retained		99.8	(TPR)			1.000	
For column E where zero is : 3+4 =7 (7 – 2) = 3.5 = 4 Using the number above and below the zero, add, divide by 2 =4						Total	2%

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Flat and Elongated by Count

Problem 3C

Original Mass of Sample __COUNT__ Ratio __5__ to __1__.

Report to:	0	0.0	0	0	0	0.000	0
Sieve Sizes	Mass Retained T27 (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"							
19.0mm ¾"							
12.5mm ½"		10.2	102	4			
9.5mm ⅜"		10.5	104	1			
4.75mm #4		35.8	109	3			
Total % Retained (TPR)		56.5	(TPR)				
						Total	

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Flat and Elongated by Count

Answer 3C

Original Mass of Sample __COUNT__ Ratio __5__ to __1__.

Report to:	0	0.0	0	0	0	0.000	0
Sieve Sizes	Mass Retained T27 (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"							
19.0mm ¾"							
12.5mm ½"		10.2	102	4	4	0.181	1
9.5mm ⅜"		10.5	104	1	1	0.186	0
4.75mm #4		35.8	109	3	3	0.634	2
Total % Retained (TPR)		56.5	(TPR)				
						Total	3

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FLAT AND ELONGATED PARTICLES (ASTM D 4791) **Problem 1A**

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

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

Report to:	0	0.0	0	0	0	0.000	0
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		0	0			
19.0mm ¾"	2644		1973	8			
12.5mm ½"	3232		1632	44			
9.5mm ⅜"	69		0	0			
4.75mm #4	119		0	0			
Total % Retained			**(TPR)**				
						Total	

A = Weight retained on each particular sieve

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

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of Flat and Elongated particles

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

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

$$\mathbf{G} = E \times F$$

(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)

Answer 1A

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

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

Report to:	0	0.0	0	0	0	0.000	0
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		0	0			
19.0mm ¾"	2644	42.0	1973	8	0	0.436	0
12.5mm ½"	3232	51.3	1632	44	3	0.533	2
9.5mm ⅜"	69	1.1<10%	0	0	3	0.011	0
4.75mm #4	119	1.9<10%	0	0	3	0.020	0
Total % Retained		96.3	**(TPR)**			1.000	
						Total	2%

A = Weight retained on each particular sieve

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

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 and next large sizes, if both are present.

FLAT AND ELONGATED PARTICLES (ASTM D 4791) **Problem 2B**

Project:____________**Mix Design:**____________________**Date:** 2017 .
Material/Stockpile ID ____________________ **Technician**

Original Mass of Sample 7300 **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		1840	13			
12.5mm ½"	3252		1588	51			
9.5mm ⅜"	70		0	0			
4.75mm #4	1252		825	33			
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) **Answer 2B**

Project:___________**Mix Design:**_________________**Date:** 2017 .
Material/Stockpile ID ___________________ **Technician**

Original Mass of Sample 7300 **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	37.1	1840	13	1	0.372	0
12.5mm ½"	3252	44.5	1588	51	3	0.446	1
9.5mm ⅜"	70	1.0 <10%	0	0	4	0.010	0
4.75mm #4	1252	17.2	825	33	4	0.172	1
Total % Retained		99.8	(TPR)			1.000	
For column E where zero is : 3+4 =7 (7 ÷ 2) = 3.5 = 4 Using the number above and below the zero, add, divide by 2 =4						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 and next large sizes, if both are present.

FLAT AND ELONGATED PARTICLES (ASTM D 4791) — Problem 3C

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

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

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 and next large sizes, if both are present.

FLAT AND ELONGATED PARTICLES (ASTM D 4791) **Answer 3C**

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	4	0.181	1
9.5mm ⅜"		10.5	104	1	1	0.186	0
4.75mm #4		35.8	109	3	3	0.634	2
Total % Retained		56.5	(TPR)			1.001	
						Total	3

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 and next large sizes, if both are present.

106.3.2.71.6.1.6 Flat 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 D4791: Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
PROFICIENCY CHECKLIST

Applicant: ______________________________

Employer: ______________________________

Sample Preparation Trial #	1	2
1. Sampled in accordance with AASHTO R 90		
2. Determined the Nominal Maximum size of the aggregate sample		
3. Reduced the sample using AASHTO R 76 to the testing size using the Table below		

Nominal Maximum Size in. (mm)	**Minimum Mass lb. (g,)**
⅜ (9.5)	2 (1000)
½ (12.5)	4 (2000)
¾ (19.0)	11 (5000)
1 (25.0)	22 (10,000)
1 ½ (37.5)	33 (15,000)
2 (50)	44 (20,000)

	1	2
4. Determined to test either by Count or Mass		
5. For Mass, sample oven-dried to constant mass at 230 ± 9°F (110 ± 5°C) For Count, sample is tested in an as is condition		
6. Sieve analysis completed according to AASHTO T 27, recorded the mass retained of each fraction in column A of the report		
7. Obtained the fractions needed to test per Count or Mass: **By Particle Count**: From the Sieve Analysis each fraction from the #4 or 3/4" sieve and above as required by specification, with a minimum of 10% retained will be reduced to approximately 100 particles **By Mass:** Use the material retained on the #4 or 3/4" sieve and above as required by MoDOT EPG specifications 1002, 1005, etc.		
Procedure: Method B - Flat and Elongated Particle Test		
1. Sorted each particle in each size fraction into one of two groups: (1) Flat and elongated OR (2) Not flat and elongated		
2. Proportional caliper device positioned at the proper ratio 5:1 or 3:1		
3. Tested each particle in the caliper by setting the larger opening to the particle length		
4. Placed the particle through the opposite side of the caliper for thickness, if it slips through the smaller measure, the particle is flat and elongated		
5. Weighed the amount of F&E of each fraction and recorded each to the nearest whole number on the report		
Calculations		
Percentage of flat and elongated particles calculated to nearest 1% for each sieve size as required		
	PASS FAIL	PASS FAIL

Examiner: ______________________________ Date: ______________

AASHTO T 85

Absorption
of
COARSE Aggregate

AASHTO T 85

Absorption (Abs)

of Coarse Aggregate

Rev 12/12/2019

SCOPE

- This method covers the determination of absorption of coarse aggregate.
- The bulk specific gravity (SSD) and absorption are based on aggregate after 15-19 hours of soaking in water.
  - SSD = Saturated Surface Dry
- This method is not intended to be used with lightweight aggregates.

2

SIGINIFICANCE AND USE

- Absorption values are used to calculate the change in the mass of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential.

3

EQUIPMENT

- Scale M231, Class G5
- Sieves #4 (4.75mm)or other sizes as needed
  - #8 (2.36 mm) sieve
- Towels
- Oven capable of maintaining 230 ± 9°F (110 ± 5°C)

4

SAMPLING

- Obtain a representative field sample using AASHTO R 90
- Mix and reduce the sample according to AASHTO R 76 and Chart A
- Dry sieve over a #4 sieve
  - Exceptions to using a #4 sieve:
    - Use a #8 sieve as indicated by specification.
    - Use a # 8 sieve if the coarse aggregate contains a large quantity of material finer than the #4 sieve. Keep the minus No.8 material and test per AASHTO T84 for fine aggregate.

5

Sample Size – Chart A

Nominal Maximum Size of Aggregate	Minimum Mass of Sample needed For testing
½" (12.5mm) or less	2000 grams
¾" (19.0mm)	3000 grams
1" (25.0mm)	4000 grams
1 ½" (37.5mm)	5000 grams

6

- Reject all aggregate passing the #4 sieve.
- Keep all the retained #4 aggregate, this is the plus 4 material.
  - Plus 4 aggregate = +4 aggregate
- Wash the +4 aggregate to remove dust or other coatings.

NOTE: All of these mean the same. . .
- Aggregate retained on # 4 sieve
- Plus 4 aggregate
- +4 aggregate
- Sometimes the aggregate may contain foreign material like shells and pieces of glass because of this sometimes aggregate is called +4 material.

SAMPLING

7

PROCEDURE

- Dry the +4 aggregate to a constant mass at 230 ± 9°F (110 ± 5°C).
- Cool the aggregate at room temperature for 1-3 hours.

(The sample should be comfortable to handle (~ 50° C).

8

- Place the +4 aggregate sample in a plastic container, and cover it with water for 15-19 hours.

PROCEDURE

9

PROCEDURE

- Drain excess water from the +4 aggregate sample and place it onto a large absorbent cloth.

- Dry the aggregate surfaces with an absorbent cloth until all visible surface water is gone.
- Wipe the larger particles individually.

10

PROCEDURE

NOTE: Throughout the procedure, avoid evaporation of water from the aggregate pores.

- Tare the scale.
- Weigh the sample and write the SSD mass as "**B**" in the calculations.
  - SSD = **S**aturated **S**urface **D**ry
- Determine the mass to the nearest 1gram or 0.1%.

11

PROCEDURE

- Place the sample in a pan for the oven.
- Dry to a constant mass at 230 ± 9°F (110 ± 5°C).
- Cool sample for 1-3 hours or when you can comfortably handle the aggregate (~ 50° C).
- Determine the dry mass.
  - Record to the nearest 1g.
  - This is "**A**" in the calculations.

12

CALCULATIONS

$$Absorption\ Percent = \frac{(B-A)}{A} x100$$

- Mass of Dry Sample (**A**) =________
- Mass Surface Dry Sample (**B**) =______
- Mass of Sample in Water (**C**) = _______

  - Report the Absorption to the tenth, **0.1%**

13

REPORTING

- Report the Absorption to the tenth, **0.1%**
- ***Use regular rounding.***

NOTE: If the specific gravity and absorption values were tested in an as received condition, note this in the report.

14

- **NOTE:** Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their **naturally moist condition**, the requirement for initial drying to constant mass may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the required soaking may also be eliminated.

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AASHTO T 85: Absorption of Coarse Aggregate
PROFICIENCY CHECKLIST

Rev 12/13/2019

Applicant: ______________________________

Employer: ______________________________

Procedure Trial #	1	2
1. Sample obtained by AASHTO R 90 and Reduced per AASHTO R 76.		
2. Screened on #4 sieve (4.75mm) or # 8 (2.36mm) sieve.		
When excess fine aggregate apparent; sieved out fine aggregate using a #8 sieve and saved for AASHTO T 84 testing.		
3. Kept the retained (+4 material) and attained sample mass amount by nominal maximum size aggregate as follows: (see table below)		
4. Washed to clean surfaces of aggregate.		
5. Dried to constant mass at 230 ± 9°F (110 ± 5°C) and cooled to room temperature for 1 hour or longer until comfortable to handle.		
6. Covered aggregate with water 15 to 19 hours (17 ± 2 hours).		
7. Removed sample from water, rolled in a cloth until all visible films of water were removed.		
8. Larger particles wiped individually.		
9. Evaporation avoided		
10. Weighed the SSD sample to nearest 1g, reported as (**B**) recorded all mass determinations to the nearest 1g or 0.1% of sample mass.		
11. Dried to constant mass at 230 ± 9°F (110 ± 5°C) and cooled to room temperature for 1 to 3 hours or longer until comfortable to handle.		
12. Weighed dry sample and recorded the mass to nearest 1g, Reported as (**A**)		
13. Calculate Absorption: $\frac{(B-A)}{A} \times 100 = \%Abs$		
Report: Absorption reported to nearest: **0.1%**		

Size Aggregate	Sample Amount in g.
½ in. or less	2,000
¾ in.	3,000
1 in.	4,000
1 ½ in.	5,000

PASS PASS

FAIL FAIL

Examiner: ______________________________ Date: ______________

Appendix

Aggregate Technician

FLAT AND ELONGATED PARTICLES (ASTM D4791)

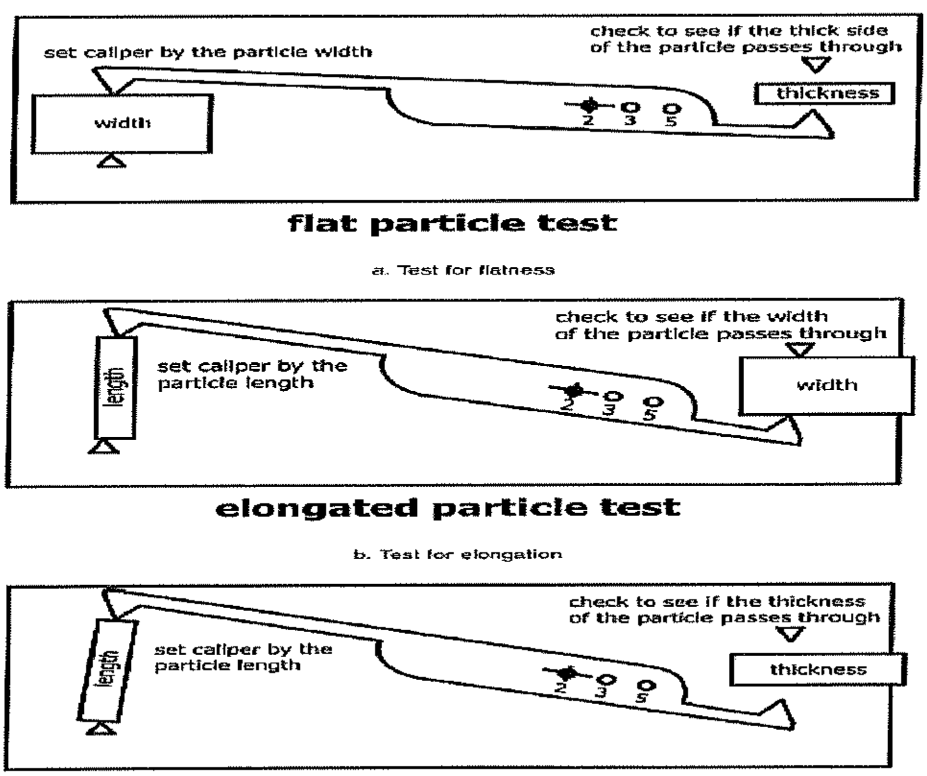
8.3 Method A

Test each of the particles in each size fraction, and place in one of four groups:
(1) Flat particles,
(2) Elongated particles,
(3) Particles that meet the criteria of both groups 1 and 2,
(4) Neither flat nor elongated particles that do not meet the criteria of either group 1 or group 2.

Each particle shall be subjected to the Flat Particle Test and Elongated Particle Test. If the particle is determined to be flat but not elongated, the particle is placed in the "flat" group. If it is determined that the particle is not flat, but is elongated, the particle is placed in the "elongated" group. In some cases it may be possible for a particle to meet the criteria of both a flat particle and an elongated particle. In this case the particle is placed in the "particles that meet the criteria of both groups 1 and 2. If the particle is not flat and is not elongated, it is placed in the "particles that do not meet the criteria of either group 1 or group2.

8.3.1 Use the proportional caliper device, positioned at the proper ratio see Figure 4 below:

D4791 – 10



flat particle test

a. Test for flatness

elongated particle test

b. Test for elongation

flat and elongated particle test

c. Test for elongation and flatness

FIG. 4 Use of Proportional Caliper

8.3.1.1 Flat Particle Test – Set the larger opening equal to the maximum particle width. The particle is flat if the maximum thickness can be placed through the smaller opening.

8.3.1.2 Elongated Particle Test – Set the larger opening equal to the maximum particle length. The particle is elongated if the maximum width can be placed through the smaller opening.

8.3.2 After each of the particles have been classified into one of the groups described in 8.3, determine the proportion of the sample in each group by either count or by mas, as required.

Glossary

Revised: 09/17/2019

Aggregate 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.

Field Sample – A quantity of the material of sufficient size to provide an acceptable estimate of the average quality of a unit.

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

Lot- A sizable isolated quantity of bulk material from a single source, assumed to have been produced by the same process (for example, a day's production or a specific mass or volume).

Maximum Aggregate Size-(*Superpave*) One size larger than the nominal maximum aggregate size.

Maximum size of Aggregate/particle – *(in specifications for aggregate*) the smallest sieve opening through which the entire amount of aggregate is required to pass.

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

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 = No Free Moisture.

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

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

Sieving to Completion – Having no more than 0.5 % 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 the 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.

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

Wet Aggregate – Aggregate containing moisture on the particle surface.

Absorption: The increase in the mass of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass. The aggregate is considered "dry" when it has been maintained at a temperature of 110 ± 5°C for sufficient time to remove all uncombined water by reaching a constant mass.

Bulk Specific Gravity (also known as Bulk Dry Specific Gravity): The ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Bulk Specific Gravity (SSD): The ratio of the mass in air of a unit volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for 15 to 19 hours (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Apparent Specific Gravity: The ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

SSD – Saturated Surface Dry: The condition in which the aggregate has been soaked in water and has absorbed water into its pore spaces. The excess, free surface moisture has been removed so that the particles are still saturated, but the surface of the particle is essentially dry.

Specific Gravity – The ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of gas-free distilled water at stated temperatures. Values are dimensionless.