2026 Edition

AGGREGATE TECHNICIAN

PART ONE

MoDOT

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Notes if Needed

Aggregate Technician

2026 – Updates

- No major changes in the methods.
- All new powerpoints

2025 – Updates

- AASHTO T11 – Added: Do not overflow or overload the #200 sieve.
    - Wash any material sticking to the spoon back into the washed sample.
    - Added dry to a constant mass (see AASHTO T55)
- AASHTO T27 – No major changes in the methods.

2024 – Updates

- **New: Aggregate is now divided into two parts, see the COURSE CONTENT PAGE for the division.**
    - **NOTE: Must have both parts to receive certification in Aggregate Technician.**
- No major changes in the methods.

2023 – Updates

- **AASHTO T11**:
    - **T11 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
        - NOTE 1: Thermometer types to use include:
            - ASTM E1 Mercury Thermometer
            - ASTM 2877 digital metal stem thermometer
            - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
            - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
            - Dial gauge metal stem (bi-metal) thermometer

    - **T255 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
        - NOTE 1: Thermometer types to use include:

        - ASTM E1 Mercury Thermometer
        - ASTM 2877 digital metal stem thermometer
        - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
        - 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
        - Dial gauge metal stem (Bi-metal) thermometer

- **<u>AASHTO T27</u>:**
    - **T27 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 3),
        - NOTE 3: Thermometer types to use include:
            - ASTM E1 Mercury Thermometer
            - ASTM 2877 digital metal stem thermometer
            - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
            - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
            - Dial gauge metal stem (Bi-metal) thermometer

2022 – Updates

- **No updates**

2021 – Updates

- **AASHTO T11** - Mechanical Washing: Do not wash the sample in a mechanical washer for more than 10 min.

COURSE CONTENT

AGGREGATE TECHNICIAN

PART ONE

AASHTO R 90 Sampling of Aggregate Products

AASHTO R 76 Reducing Samples of Aggregate to Testing Size
ASTM C702

AASHTO T 255 Total Evaporable Moisture Content of Aggregate by Drying
ASTM C566

AASHTO T 11 Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing
ASTM C117

AASHTO T 27 Sieve Analysis of Fine and Coarse Aggregates
ASTM C136

Appendix

Glossary

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Notes if Needed

Aggregate Technician

PART ONE

AASHTO R 90

Sampling Aggregate Products

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Notes if Needed


AASHTO R 90

SAMPLING AGGREGATE PRODUCTS

1

SCOPE

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

Significance & 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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SAFETY GEAR
Personal Protective Equipment (PPE)

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

Safety Gear

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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.*

Securing Samples

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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.**

Terminology

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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 SAMPLING PROCEDURES:

Aggregate Sampling 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 for aggregates; If approved by MoDOT, use a safety rail, sample with a shovel.**
- **Roadway**
  1. In place
  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)

Conveyor Belt - Sampling Device

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EQUIPMENT

- Safety Gear; PPE
- Sampling Device
- Proper Containers




Conveyor Belt - Equipment

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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 - Procedure

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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 – Procedure

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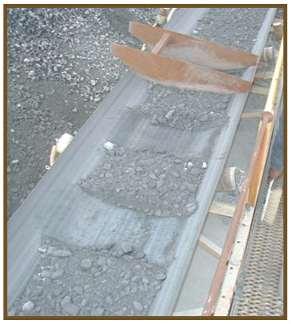
CONVEYOR BELT SAMPLING

Template Procedure

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



Conveyor Belt - Template

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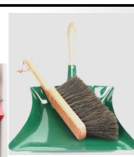
EQUIPMENT

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



Conveyor Belt Template Equipment

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PROCEDURE

NOTE: Record sampling time or location, or both.

1. **STOP** the conveyor belt.
   Lock and Tag Out !
   Communication with plant is key for this method.
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 Procedure

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Conveyor Belt Template Procedure

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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.

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Conveyor Belt - Automatic

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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.

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StockPiles

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STOCKPILES

Re-blend a segregated stockpile before sampling.

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Show Stockpile Videohttps://youtu.be/JXXSssLHrAc

Stockpile Video

19

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STOCKPILE SAMPLING

Loader Procedure

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

Stockpile - Loader

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EQUIPMENT

Stockpile – Loader Equipment

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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 Procedure 22

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Stockpile – Loader Procedure

(Sampling from a flat surface created by a loader)

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 Procedure 23

23

Stockpile – Loader Procedure

(Sampling from a flat surface created by a 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.

Stockpile Loader Procedure 24

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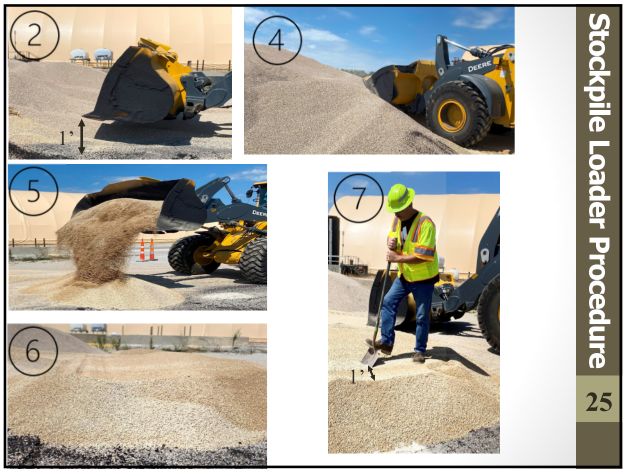
Stockpile Loader Procedure
25
2
4
5
6
7
1'
1'

25


STOCKPILE SAMPLING
Flat Board & Shovel Procedure
Coarse Aggregate (CA) & Combined (CA/FA)
Stockpiles – Flat Board
26

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EQUIPMENT
Stockpiles Flat Board Equipment
27

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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 Procedure

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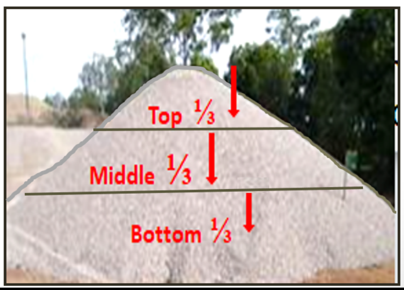
5. Obtain at least one increment of equal size from the **top** third, **middle** third, and **bottom** third of the pile.
6. Combine the increments to form a field sample.



Stockpiles Flat Board Procedure

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STOCKPILE SAMPLING

Sampling Tube Procedure

Fine Aggregate (FA) Only

Stockpiles – Sampling Tube

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EQUIPMENT

- Sampling tube with the dimensions:
  - 1¼″ diameter, tip cut at a 45° angle



Stockpiles Sampling Tube Equipment

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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 Procedure

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Transport Units

NOT RECOMMENDED for aggregate sampling,

This can be pre-approved by the MoDOT Engineer.

Procedure:

- Use a platform with safety railing; Use a shovel.
- Visually divide an area into 4 quadrants.
- Remove 1 foot from the top surface.
- Obtain an increment from a quadrant and another increment from the opposite quadrant, repeat if needed, combine for a sample.

Transport Units

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ROADWAY BASE IN-PLACE SAMPLING

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

Roadway Base - In-Place

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EQUIPMENT

Roadway Base - In-Place Equipment

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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 Procedure

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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.

Roadway Base -In-Place Procedure

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Roadway

Base Sampling

Sampling from a berm or windrow

Stockpile - Loader

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SHIPPING SAMPLES

Proper Container

- Bags made for shipping aggregates, or other suitable containers that prevent contamination or loss during shipment.

Shipping Samples

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Proper Identification:

- Shipping containers (select proper container for test being ran on material) for aggregate samples shall have suitable individual identification that is clearly marked on the outside and enclosed.
  - Identification Label Information:
    - Date & Time Sample was Obtained
    - Sampling Location
    - Quantity of Material Represented by sample (if Applicable)
    - Material Type
    - Supplier

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 or proper PPE)

Common Errors

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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 until the end of the year.
- **Provide Proof;** when audited, present a MoDOT Certification Card (Printed Copy of Card or Photo)

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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: ______________

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AASHTO R 76

ASTM C702

Reducing Samples of Aggregate

To Testing Size

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Notes if Needed

AASHTO R76

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

1

SCOPE

- These Methods cover the reduction of large samples of aggregate to the appropriate size for testing, these techniques are intended to minimize variations in measured characteristics between the test samples selected and the large sample.

- SI units are to be the standard

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SIGNIFICANCE & USE

- 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.

- Failure to carefully follow these procedures in these methods could result in a nonrepresentative sample to be used in subsequent testing

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SAMPLING

- The samples of aggregate obtained in the field shall be taken in accordance with AASHTO R90 (ASTM D75), or as required by individual test methods and reduced by AASHTO R76 (ASTM C702)

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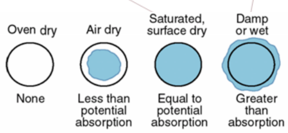
FOUR STATES OF MOISTURE CONTENT IN AGGREGATES



Total moisture

Total Moisture = Free (surface) Moisture + Absorbed Moisture

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

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NEED TO KNOW

- 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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SELECTION OF METHOD

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

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METHODS

Method A
- Mechanical Splitter
- Riffle Splitter

Method B
- Quartering
  - Canvas
  - Hard, Clean, Level Surface

Method C
- Miniature Stockpile

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METHOD A: MECHANICAL SPLITTER

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METHOD A: MECHANICAL SPLITTER

Coarse Aggregate

Fine Aggregate

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METHOD A: MECHANICAL SPLITTER

APPARATUS

- 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.
- 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.

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METHOD A: MECHANICAL SPLITTER
APPARATUS

- 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.
- 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).

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METHOD A: MECHANICAL SPLITTER
APPARATUS

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.

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METHOD A: MECHANICAL SPLITTER
SAMPLE PREPARATION

- 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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METHOD A: MECHANICAL SPLITTER PROCEDURE

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

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METHOD A: MECHANICAL SPLITTER PROCEDURE

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

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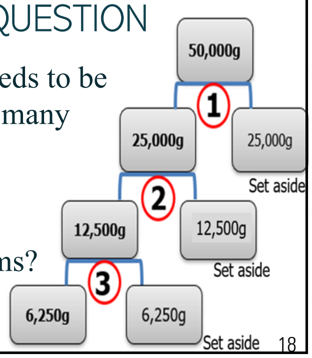
SAMPLE SIZE QUESTION

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

18

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METHOD B: QUARTERING

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METHOD B: QUARTERING

APPARATUS

- Straight-edged scoop
- Square-nosed shovel or trowel
- Broom or brush
- Canvas (make sure not to lose fines) or Tarp for alternate method approximately 6’ x 8’
- Long stick or pipe

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METHOD B: QUARTERING

SAMPLE PREPARATION

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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METHOD B: QUARTERING

PROCEDURE

- Place the sample on a clean, hard, level surface where there will be neither loss of material nor the accidental addition of foreign material.
- Mix by turning the material over completely at least **THREE** times until thoroughly mixed. To form a conical pile.
- Flatten evenly so the diameter is 4-8 times the thickness. Divide this into 4 equal quarters with a shovel or trowel.
- Remove two diagonally opposite quarters, including all fine material, brush the spaces clean and set the other two quarters aside for later use
- Take the remaining 2 quarters, mix and quarter until the sample is reduced to the desired size.

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METHOD B: QUARTERING

PROCEDURE

Save the unused portion until testing is completed.

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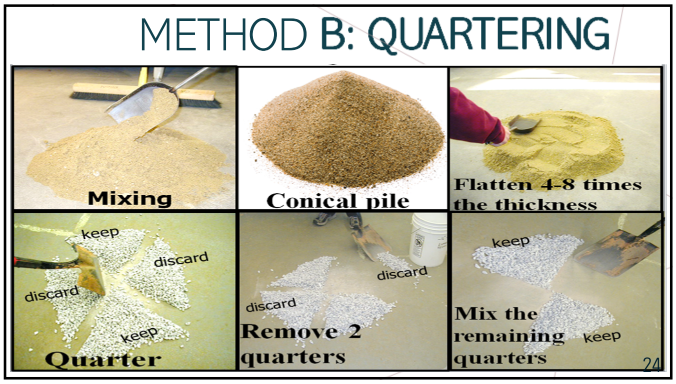
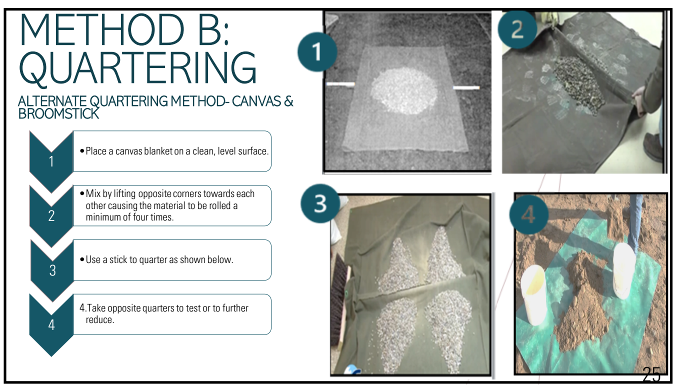

METHOD B: QUARTERING
Mixing
Conical pile
Flatten 4-8 times the thickness
keep
discard
discard
keep
Quarter
discard
discard
Remove 2 quarters
keep
Mix the remaining quarters
keep
24

25


METHOD B: QUARTERING
ALTERNATE QUARTERING METHOD- CANVAS & BROOMSTICK
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.
4
4.Take opposite quarters to test or to further reduce.
1
2
3
4
25

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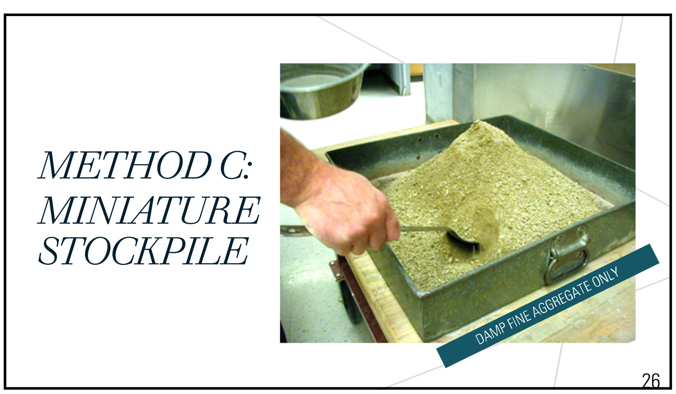
METHOD C: MINIATURE STOCKPILE
DAMP FINE AGGREGATE ONLY
26

27

METHOD C: MINIATURE STOCKPILE

APPARATUS

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

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METHOD C: MINIATURE STOCKPILE

PROCEDURE

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.
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.

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

28

29

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.

29

30

AASHTO R76: Reducing Field Samples of Aggregate to Testing Size
PROFICIENCY CHECKLIST

Revised on 10/14/2020

Applicant: ____

Trial #	1	2
Method A – Splitting		
(8 chutes for Coarse CA, 12 chutes for Fine FA)		
1. Material in an air-dried 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 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 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: ______________________

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AASHTO T 255

ASTM C566

Total Evaporable Moisture Content

of

Aggregate by Drying

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AASHTO T255

TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING

1

SCOPE

- 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.
- SI units are regarded standard.

2

SIGNIFICANCE & 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.

3

EQUIPMENT

Other Items
- Gloves
- Brush
- Pans
- Shovel

Thermometer
- Temperature range of @ least 90-130 ±1.25° C (194-226 ±2.25° F)

Scale
- Readable to 0.1% of the sample mass, or better
- Conform to the requirements of M 231

Stirrer
- Spatula
- Spoon

Source of Heat
- Oven for Heating and drying- Temperature between 100-120 ±5°C (212-248 ±9°F)
- Other Suitable Heat Sources- electric/gas hot plate, electric heat lamps, ventilated microwave oven

Sample Container
- Airtight
- Sufficient volume to contain the sample- no spilling
- Not affected by heat

4

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.

5

SAMPLING

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)

6

PROCEDURE

1) Obtain Sample
- Airtight container- ensure no moisture loss getting sample or transport

2) Weigh Wet Sample
- Weigh the total mass to the nearest 0.1% (typically 0.1gram)
- Do not lose material or overheat the sample

3) Dry the Sample
- Ventilated Oven (Preferred)
  - Regulated @ 110 ±5° C
  - Good for sensitive aggregates
- Hot Plate (Fast)
  - Periodically stir to avoid overheating
  - sing aggregate to fracture (if fracture is happening use oven)
- Ventilated Microwave Oven
  - Use a non-metal container, stirring is optional (if fracture is happening use oven)

7

PROCEDURE CONT.

4) Sample is Dry- Remove from heat
- The sample is dried thoroughly to a constant mass
- The sample is thoroughly dried to a constant mass when further heating causes, or would cause, less then 0.1% additional loss in mass

5) Allow to cool- do not damage scale

6) Weigh & Record
- Mass of the dried sample to the nearest 0.1% of the total mass

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

8

CALCULATIONS: CONSTANT MASS

$$\% \text{ Change} = \frac{A-B}{A} \times 100$$

- A = Previous Mass Determination (0.1g)
- B=Newest Mass Determination (0.1g)

Report to the nearest 0.1%

*** Constant Mass: When the change in mass is less than or equal to 0.1%*

9

CALCULATIONS

* Calculate 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)

10

CLASS PRACTICE PROBLEM

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%

11

CLASS PRACTICE PROBLEM
ANSWER

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

$$\frac{3{,}523.0 - 3{,}501.0}{3{,}501.0} \times 100 = 0.6\%\ Moisture$$

12

REPORTING RESULTS

- RECORD RESULTS IN THE BOUND FIELD BOOK TO THE NEAREST **0.1 %** TOTAL MOISTURE.
- NOTIFY PLANT OPERATOR OF RESULTS.
- FOR STEP #4 USE THE FOLLOWING EQUATION
  - $\% \, change = \frac{M_p - M_n}{M_p} \times 100$
  - $M_p = Previous\ mass\ measurement$
  - $M_n = new\ mass\ measurement$

13

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

14

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

Applicant____

Employer____

Trial #	1	2
1. Representative test sample secured		
2. Test sample mass conforms to following from the AASHTO T 255 Table:		
3. Mass determined to the nearest 0.1% of the total mass		
4. Loss of moisture avoided prior to determining the mass		
5. Sample dried by a suitable heat source		
6. If heated by means other than a controlled temperature oven, is sample stirred to avoid localized overheating		
7. Sample dried to constant mass and mass determined to nearest 0.1% of the total mass		
8. Moisture content calculated by: % moisture = $\frac{\text{wet sample mass - dried sample mass}}{\text{dried sample mass}}$ x 100		

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)

PASS PASS

FAIL FAIL

Examiner:____Date:_________________

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AASHTO T 11

ASTM C117

Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing

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AASHTO T11

MATERIALS FINER THAN NO. 200 (75 MM) SIEVE IN MINERAL AGGREGATES BY WASHING

1

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.
- SI units are regarded as standard
- This standard is dependent on the capability, calibration and maintenance of equipment being used by a competence personnel performing the test

2

2

SIGNIFICANCE & USE

- Material finer than the # 200 (75-ɥm) sieve can be separated from larger particles much more efficiently and completely by wet sieving than through 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.
- Plain water is adequate to separate the finer than the #200 from the coarser material in most aggregates. In some cases, such as clay or extracted material a wetting agent may need to be used in the water.

3

3

EQUIPMENT

Balance
- Readable to 0.1g
- Conform to M 231

Sieves
- Nest of 2 sieves
- #200 and upper being #8 or # 16
- Conforming to ASTM E11

Mixing Utensil
- Spoon
- Agitating the sample during the washing

Container
- Pan or vessel to contain sample covered with water
- Vigorous agitation without loss of any part of sample or water

Oven
- 230 ± 9°F (110 ± 5°C)
- Thermometer for measuring temp with range of 90-130 ± 1.25° C

Wetting Agent
- Procedure B ONLY
- Any detergent used shall not leave residue on sample

Mechanical Washing Apparatus (optional)

4

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

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

6

PROCEDURE- PREPARATION

Dry the test sample to a constant mass according to T 255 (nearest 0.1 gram 230 ± 9°F (110 ± 5°C))

- Check the #200 sieve for damage before testing (if damaged replace)
- Make sure not to overload #200 Sieve
- **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.

7

7

PROCEDURE-METHOD A

1) Place the sample into a sample container (suitable for oven) add water to cover it.

→ 2) Agitate the sample with a large spoon or similar device

→ 3) Immediately pour the wash water through the nest of sieves – make sure to avoid decantation of the courser materials

→ 4) Add another charge of water to the sample in the pan and repeat steps 2 & 3 serval times until the wash water is clear

→ 5) Material on the sieves is returned to the washed sample

Do not decant any water from the pan except through the #200 sieve

Wash any material sticking to the spoon back into the washed sample →

8

8

PROCEDURE-METHOD A CONT.

6) Oven dry the sample to constant mass (same as sample preparation)

→ 7) Calculate the loss and report results

9

9

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)

10

10

REPORTING THE ANSWER

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.**

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

11

11

CLASSROOM EXERCISE

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

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

12

12

CLASSROOM EXERCISE- ANSWER

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

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

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

13

13

COMMON ERRORS

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

14

14

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

Revised on 10/14/2020

Applicant: ______________________________________

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 is 10 min 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 = $\frac{\text{Orig. dry mass} - \text{Final dry mass}}{\text{Orig. dry mass}}$ x 100		

	PASS	PASS
	FAIL	FAIL

Examiner: ______________________________ Date: __________________________

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AASHTO T 27

ASTM C136

Sieve Analysis of Fine
and
Coarse Aggregates

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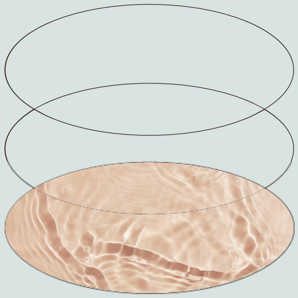
AASHTO T27

ASTM C136

Sieve Analysis of
Fine & Coarse
Aggregates



1

Scope

- This method determines the particle size distribution of fine and coarse aggregates by sieving
- Sample of dry aggregate of known mass is separated through a series of sieves of progressively smaller opening for determining the particle size distribution
- Analysis of aggregate extracted from asphalt mixtures is conducted in accordance with AASHTO T30 (Mechanical Analysis of Extracted Aggregate).

2

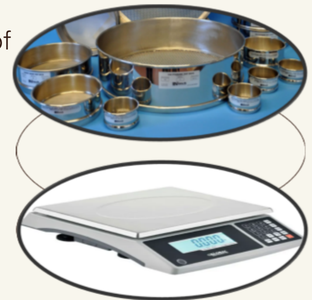
Significance & Use

- This method is used primarily to determine the grading of materials being used in concrete, asphalt, aggerate bases. 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
- ❖Pans
- ❖Oven- Capable of maintaining uniform temperature of 230 ± 9°F (110 ± 5°C)
  - Hot plates may be used



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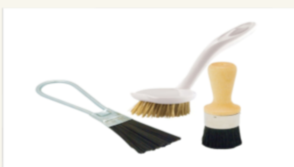
Equipment cont.



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

5

Equipment

- ❖ Mechanical Shaker
  - Check Sieving thoroughness ever 12 months or as needed through the year
  - Record this verification will be kept in the QMS
  - See AASHTO R18 for calibrating/verification process

6

Definitions & 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.

Fine Aggregate

Fine aggregates are typically composed of natural sand or finely crushed stone. The size of the test sample of aggregate after drying is 300g minimum.

Coarse Aggregate

Coarse Aggregate is typically composed of gravel or crushed stone and serves as an inert filler, contributing to the structural strength. The mass of the test sample of coarse aggregate shall follow the table on next slide.

7

Nominal Maximum Size Square Openings, mm (in.)	Minimum Mass of Test Sample, kg (lb)
9.5 (3/8)	1 (2)
12.5 (1/2)	2 (4)
19.0 (3/4)	5 (11)
25.0 (1)	10 (22)
37.5 (1 1/2)	15 (33)
50 (2)	20 (44)
63 (2 1/2)	35 (77)
75 (3)	60 (130)
90 (3 1/2)	100 (220)
100 (4)	150 (330)
125 (5)	300 (660)

Test sample size on Coarse Aggregates

8

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

9

Three Things to Know & Review Before Sieve Analysis

Sieve Condition

Sieving Thoroughness

Sieve Overloading

10

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.

11

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.
- ❖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.

12

Sieve Overloading

- For sieves with openings smaller then #4, the quantity retained on any sieve t the completion of the sieving operation shall not exceed ($4g/in^2$) of sieving surface area.

- For sieves with openings #4 and greater, the quantity retained in kg shall not exceed the product of: 2.5x(sieve opening(effective sieving area, m^2))
  - This quantity is shown in AASHTO T27 table 1

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

13

Sieve Overloading

AASHTO TABLE 1

Maximum Allowable Quantity Of Material Retained*

Sieve Opening Size	8" Diameter Sieve	12" Diameter Sieve
2" (50 mm)	7.9 lbs (3.6 kg)	18.5 lbs. (8.4 kg)
1½" (37.5 mm)	6.0 lbs (2.7 kg)	13.75 lbs. (6.3 kg)
1" (25.0 mm)	4.0 lbs (1.8 kg)	9.25 lbs. (4.2 kg)
3/4" (19.0 mm)	3.1 lbs (1.4 kg)	7.5 lbs. (3.2 kg)
1/2" (12.5 mm)	2.0 lbs (0.89 kg)	4.7 lbs. (2.1 kg)
3/8" (9.5 mm)	1.5 lbs (0.67 kg)	3.5 lbs. (1.6 kg)
No. 4 (4.75 mm)	0.7 lbs (0.33 kg)	1.75 lbs. (0.8 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.*

14

Sieve Overloading

- 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.

15

5. MoDOT-EPG CHART Table 1001.5.1.2

MoDOT Sample Sizes for Aggregate Gradation Test

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 13

16

Procedure

Sieve Analysis

17

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.

18

Procedure

1 Sieve Analysis- Stacking Sieves

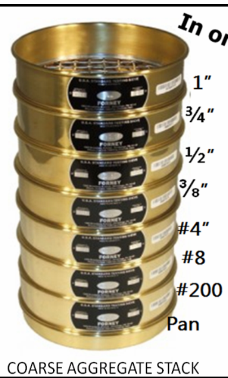
• Stack the sieves by assembling the required sieves in order of decreasing size.

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.

19

1



20

Procedure

2 Sieve Analysis- Loading Sieves

• 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.

Note: Always include the #200 sieve, even if T11 was performed.

21

Procedure

3 Sieve Analysis- Agitation

- 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.

22

Procedure

3 Sieve Analysis- Mechanical Agitation

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.

23

Procedure

3 Sieve Analysis- Hand Agitation

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

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

24

Procedure
4 Sieve Analysis- Sieving Thoroughness

Method used to check 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.

25

Procedure
5 Sieve Analysis- Unloading & Weighing

- ❖ 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.

26

Procedure
5 Sieve Analysis- Unloading & Weighing

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

27

Sieve 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.

28

Calculations & Reporting

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)%.

29

Calculations

T-11 Loss Review

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

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)

30

Calculations

Non-Cumulative

Equation for all sieves:

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

Equation for the pan (Minus #200):

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

31

Calculations

Cumulative

Equation for all sieves:

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

Equation for the pan (Minus #200):

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

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Calculations

Fineness Modulus
*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%.

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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.

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Sieve Analysis

Practice Problem 1A

Instruction and Practice

For Cumulative & Non-Cumulative

Class Problem	1A
	Weighed Amounts, g
Dry Original Mass (g):	5226
(T11) Dry Washed Mass (g):	5195
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

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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 (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 =	9	100 – 9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	2768/5226	x 100 =	53	100 – 53 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	3930/5226	x 100 =	75	100 – 75 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	5112/5226	x 100 =	98	100 – 98 =	2
2.36mm (#8)	53	5112 + 53 =	5165	5165/5226	x 100 =	99	100 – 99 =	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	9	91
12.5mm (½")	2304	2768	53	47
9.5mm (⅜")	1162	3930	75	25
4.75mm (#4)	1182	5112	98	2
2.36mm (#8)	53	5165	99	1
1.18mm (#16)			0	100
600µm (#30)			0	100
300µm (#50)			0	100
300µm (#50)			0	100
150µm (#100)			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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Sieve Analysis

Practice Problem 2B

Work this Gradation

For Cumulative
&
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**

Enlarged copy at the end of module

Dry Original Mass (g):	5040	(A)	
(T11) Dry Washed Mass (g):	4571		
Washing Loss (g):	469		
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		[redacted]
Pan	44		
Washing Loss (g):	469		% Passing -200
Total Minus #200	513		10
Total Weight Retained:	5036	(B)	

MoDOT Accuracy Check = (A-B)= < 1/ sieve?
5040 grams – 5036 grams =4

✓ 4 < 5 yes

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CUMULATIVE CLASS PROBLEM – 2B — **2B**

Enlarged copy at the end of module

Dry Original Mass (g):	5040	(A)	
(T11) Dry Washed Mass (g):	4571		
Washing Loss (g):	469		
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		[redacted]
Pan	44		
Washing Loss (g):	469		% Passing -200
=Total Minus #200	513		10
Total Weight Retained:	5036	(B)	

MoDOT Accuracy Check = (A-B)= < 1/ sieve?
5040 grams – 5036 grams =4

✓ 4 < 5 yes

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Sieve Analysis

Practice 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
600ųm (#30)	168
300ųm (#50)	40
150ųm (#100)	13
75ųm (#200)	2
Pan	1

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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.

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Intentionally Left Blank-
Notes if Needed

AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregate

PROFICIENCY CHECKLIST

Revised on 12/06/2019

Applicant: ____

Trial#	1	2
Fine Aggregate		
1. Reduce per AASHTO R76		
2. Minimum sample mass 500 g		
Coarse Aggregate		
1. Reduce 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% and recorded		
- AASHTO T11 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: ___________

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)			
600ųm	(#30)			
300ųm	(#50)			
150ųm	(#100)			
75ųm	(#200)	5165 + **26** = **5191**		[redacted]
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)			
600ųm	(#30)			
300ųm	(#50)			
150ųm	(#100)			
75ųm	(#200)	26		[redacted]
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 =	9	100 – 9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	2768/5226	x 100 =	53	100 – 53 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	3930/5226	x 100 =	75	100 – 75 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	5112/5226	x 100 =	98	100 – 98 =	2
2.36mm (#8)	53	5112 + 53 =	5165	5165/5226	x 100 =	99	100 – 99 =	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	9	91
12.5mm (½")	2304	2768	53	47
9.5mm (⅜")	1162	3930	75	25
4.75mm (#4)	1182	5112	98	2
2.36mm (#8)	53	5165	99	1
1.18mm (#16)			0	100
600µm (#30)			0	100
300µm (#50)			0	100
300µm (#50)			0	100
150µm (#100)			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, m^2				
	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 (3$^1/_2$ in.)	[c]	[c]	15.1	27.6	48.5
75 mm (3 in.)	[c]	8.6	12.6	23.0	40.5
63 mm (2$^1/_2$ 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 (1$^1/_2$ 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 ($^3/_4$ in.)	1.4	2.2	3.2	5.8	10.2
12.5 mm ($^1/_2$ in.)	0.89	1.4	2.1	3.8	6.7
9.5 mm ($^3/_8$ 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 ($^1/_2$ 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 ($^1/_4$ 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 (7$^1/_2$ in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm ($^1/_4$ 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)				
600ɥm (#30)				
300ɥm (#50)				
150ɥm (#100)				
75ɥm (#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? ________

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? ________

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

____

____

____

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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

(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 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.

Sample being split

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 AWP Sample ID in the column next to "RECORD NO," then enter information from Form T-630R in AWP.

Fig 1001.10.3 Form T-630R, Example 2 shows Form T-630R being used to record the gradation of a material produced to meet Section 1003 specifications.

Appendix

Aggregate Technician

AT - Appendix

2023 – Thermometer List for Aggregate Technician Methods

- **AASHTO T11:**
  - **T11 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
      - Dial gauge metal stem (bi-metal) thermometer

      - IEC 60584: thermocouple thermometer, Type T, Class 1

- **AASHTO T27:**
  - **T27 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 3),
    - NOTE 3: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
      - Dial gauge metal stem (Bi-metal) thermometer

2023 – AT - Thermometer list continued . . .

- **T255 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
        - ASTM E1 Mercury Thermometer
        - ASTM 2877 digital metal stem thermometer
        - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
        - 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
        - Dial gauge metal stem (Bi-metal) thermometer

Glossary

Aggregate Glossary of Terms

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 ± 5ºC for sufficient time to remove all uncombined water by reaching a constant mass.

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 water distilled at a stated temperature.

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

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.

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.

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.

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.

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

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.

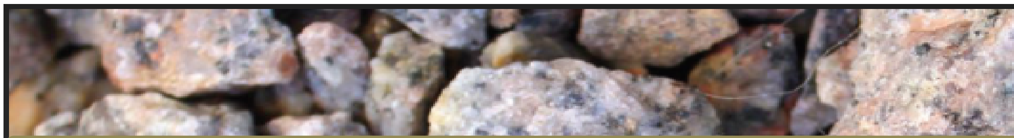
Test Portion - A quantity of the material to be tested of sufficient size extracted from the larger field sample by a procedure designed to ensure accurate representation of the field sample, and thus of the unit sampled.

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.

2026 Edition



AGGREGATE TECHNICIAN

PART TWO

Aggregate Technician - Part 2

2026 – Updates

- No updates on test methods
- Updated all slides

2025 – Updates

- No updates on test methods
- Updated all slides

2025 – Updates

- No updates

2024 – Updates

- **New: Aggregate is now divided into two parts, see the COURSE CONTENT PAGE for the division.**
  - **NOTE: Must have both parts to receive certification in Aggregate Technician.**
- No major changes in the methods.

2023 – Updates

- **<u>AASHTO T85</u>:**
  - **T85 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type T, Class 1
      - Dial gauge metal stem (Bi-metal) thermometer

- **T85 Water Bath**: The thermometer for measuring the temperature of the water bath shall meet the requirements of M339M/M339 with a temperature range of at least 16 to 27°C (60 to 80°F) and an accuracy of ±0.5°C (±0.9°F) (see note 2),
  - NOTE 2: Thermometer types to use include:
    - ASTM E1 Mercury Thermometer
    - ASTM E2877 digital metal stem thermometer
    - ASTM E230/E230M thermocouple thermometer, Type T, Special
    - IEC 60584: thermocouple thermometer, Type T, Class 1

- **AASHTO T84**:
  - **T84 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
      - IEC 60584 thermocouple thermometer, Type j or K, Class1, Type T any Class
      - Dial gauge metal stem (Bi-metal) thermometer

  - **T84 Water Bath**: The thermometer for measuring the temperature of the water bath shall meet the requirements of M339M/M339 with a temperature range of at least 16 to 27°C (60 to 80°F) and an accuracy of ±0.5°C (±0.9°F) (see note 2),
    - NOTE 2: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM E2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type T, Special
      - IEC 60584: thermocouple thermometer, Type T, Class 1
      - Dial gauge metal stem (Bi-metal) thermometer

2022 – Updates

- **Removed** Absorption T85
- **Added** Aggregate Specific Gravity T84, T85, and Core-Lok information.
- **AASHTO T85** – Added AASHTO T255 and 122°F for cooling sample.

COURSE CONTENT

AGGREGATE TECHNICIAN

PART TWO

MoDOT TM 71	Deleterious Content of Aggregate
ASTM D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
AASHTO T 84 ASTM C128	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85 ASTM C127	Specific Gravity and Absorption of Coarse Aggregate
MoDOT TM81	Specific Gravity & Absorption of Aggregate Using Automatic Vacuum Sealing Method. **(Information Only)**
Appendix	
Glossary	

PART TWO

MoDOT TM 71

DELETERIOUS CONTENT

Of

AGGREGATE

MoDOT TM 71

MoDOT EPG 106.3.2.71

Deleterious Content of Aggregate

1

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

2

SIGNIFICANCE:

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

3

3

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

4

4

Quality Issues Caused By Deleterious Material

- 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.

5

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

6

MoDOT Spec:

Deleterious Maximums

	Asphalt	Concrete
Deleterious Material	**1002 - max**	**1005 - max**
Deleterious	8.0 %	6.0 %
Shale	1.0 %	1.0 %
Chert		4.0 %
OFM	0.5 %	0.5 %

7

7

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

8

8

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.

9

9

PROCEDURE:

1. Material shall be tested in an "as received" condition.
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.

10

10

PROCEDURE:

5. Record the weight of the plus #4 material to the nearest whole gram. (Original Mass)

   -For Fine Aggregate use the #16 sieve

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

11

11

PROCEDURE:

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

12

12

CALCULATIONS:

$$\% \text{ Deleterious Substances} = \frac{C}{W} \times 100$$

- **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

13

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

14

14

Deleterious Rock:

Deleterious rock includes the following:

1) Shaly Rock: rock contaminated with shale to a high degree

2) Cap plus 20%: the percent of "caps" exceeds 20% of the volume of the rock particle

3) Extremely soft and/or porous rock: rock that is readily broken with fingers

15

15


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.
Shale
16

16

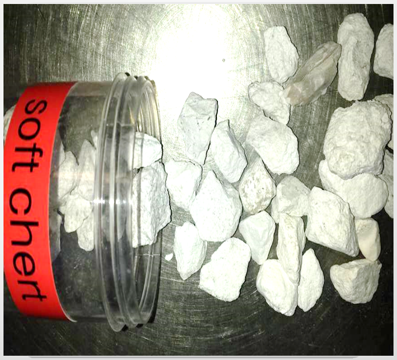

OFM
Other Foreign Material: Mud-balls, sticks, shell, lignite, and other miscellaneous items.

17


Extremely Soft and or Porous Rock (Deleterious): Has a dull appearance, which can be easily spalled or chipped off with the fingernail.
18

18

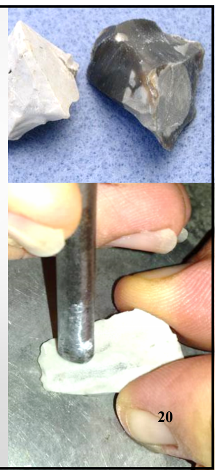
Soft Chert: Will groove.



19

19

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



20

20

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).

21

21

CLASSROOM — 1A

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

Enlarged

	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

22

22

CLASSROOM — 1A

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

Enlarged

This Sample passes.

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	55			
Shale	7	=	0.2	% Shale (Max 1.0%)
OFM	3	=	0.1	% OFM (Max 0.5%)
Soft Chert	15			
Hard Chert	114			
			Percent	(Max 8.0%)
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

23

23

CLASSROOM — 1B

Sample: 1005 Material (Concrete) ID NO.___ Date: ___

Enlarged

	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

24

24

CLASSROOM 1B

Sample: 1005 Material (Concrete) ID NO.___ Date: ___ Enlarged

This sample **Failed**
% Total Chert

	Mass, grams		Percent	
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	60			
Shale	9	=	0.3	% Shale (Max 1.0)
OFM	1	=	0.0	% OFM (Max 0.5)
Soft Chert	15			
Hard Chert	125			
			Percent	(Max 6.0)
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 (Max 4.0)

25

25

On Your Own

Question, Do these samples pass MoDOT Spec?

Asphalt- 1002	Concrete- 1005
Test Results for BR549:	Test Results for Rk409
Sample Size: ¾" agg. 3,250 g	Sample Size: 1" agg. 5,125 g
Deleterious Rock: 36 g	Deleterious Rock: 25 g
Shale: 3 g	Shale: 2 g
OFM: 18 g	OFM: 5 g
Soft Chert: 11 g	Soft Chert: 9 g
Hard Chert: 33 g	Hard Chert: 15 g

Blank worksheets in the book.
For answers, see instructor

26

26

Sample ID : ________

Sample: ____________ ID NO.___ Date: ___ Enlarged

Pass/Fail? ________

	Mass, grams		Percent	
Original Mass +4				
Deleterious Rock (Very soft rock)				
Shale		=		% Shale
OFM		=		% OFM
Soft Chert				
Hard Chert				
			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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27

On Your Own: Key

Asphalt

1. Shale: 0.1%
2. OFM: 0.6 % -Fail
3. Total Deleterious Rock: 1.4 %
4. Total Chert: 1.4%
   - Fail!

Concrete

1. Shale: 0.0%
2. OFM: 0.1 %
3. Total Deleterious Rock: 0.7 %
4. Total Chert: 0.5%
   - Pass!

28

28

1A

Enlarged

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

16

1A

Enlarged key

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

This Sample passes.

	Mass, grams		Percent		
Original Mass +4	3000				
Deleterious Rock (Very soft rock)	55				
Shale	7	=	0.2	% Shale	(Max 1.0%)
OFM	3	=	0.1	% OFM	(Max 0.5%)
Soft Chert	15				
Hard Chert	114				

			Percent	
				(Max 8.0%)
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

1B

Enlarged

Sample: 1005 Material (Concrete) ID NO.____ Date: ____

	Mass, grams			
Original Mass +4	3000			
Deleterious Rock (Very soft rock)	60		Percent	
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

18

1B

Enlarged key

Sample: 1005 Material (Concrete) ID NO.____ Date: ____

This sample **Failed** % Total Chert

	Mass, grams				
Original Mass +4	3000				
Deleterious Rock (Very soft rock)	60		Percent		
Shale	9	=	0.3	% Shale	(Max 1.0)
OFM	1	=	0.0	% OFM	(Max 0.5)
Soft Chert	15				
Hard Chert	125				
			Percent		
Deleterious Rock + Soft Chert =	75	=	2.5	% Total Deleterious Rock	(Max 6.0)
Deleterious Rock + Soft Chert + Shale + OFM =	85	=	2.8	% Total Deleterious Material	
Hard Chert + Soft Chert =	140	=	4.7	% Total Chert	(Max 4.0)

19

Sample ID : ________

Sample: ____________________ ID NO.___ Date: ___

Enlarged

	Mass, grams			
Original Mass +4			Pass/Fail? ________	
Deleterious Rock (Very soft rock)			Percent	
Shale		=		% Shale
OFM		=		% OFM
Soft Chert				
Hard Chert				
			Percent	
Deleterious Rock + Soft Chert =		=		% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =		=		% Total Deleterious Material
Hard Chert + Soft Chert =		=		% Total Chert

Sample ID : ________

Sample: ____________________ ID NO.___ Date: ___

Enlarged

	Mass, grams			
Original Mass +4			Pass/Fail? ________	
Deleterious Rock (Very soft rock)			Percent	
Shale		=		% Shale
OFM		=		% OFM
Soft Chert				
Hard Chert				
			Percent	
Deleterious Rock + Soft Chert =		=		% Total Deleterious Rock
Deleterious Rock + Soft Chert + Shale + OFM =		=		% Total Deleterious Material
Hard Chert + Soft Chert =		=		% Total Chert

TM71: Deleterious Content of Aggregate
PROFICIENCY CHECKLIST

Applicant____

Employer____

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

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.	

PASS PASS

FAIL FAIL

Examiner: ______________________________ Date: ________________

106.3.2.71 TM-71, Deleterious Content of Aggregate

Contents

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- 106.3.2.71.2.2 Sample Size
- 106.3.2.71.2.3 Test

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
- 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
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106.3.2.71.6 Definitions of Deleterious Materials

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- 106.3.2.71.6.2 Coarse Aggregate for Asphaltic Concrete, Plant Mix Bituminous Pavement, Plant Mix Bituminous and Seal Coats
  - 106.3.2.71.6.2.1 Deleterious Rock
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  - 106.3.2.71.6.2.3 Other Foreign Material
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  - 106.3.2.71.6.3.4 Clay
  - 106.3.2.71.6.3.5 Other Foreign Material
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106.3.2.71.6.4.1 Deleterious Rock
106.3.2.71.6.4.2 Shale
106.3.2.71.6.4.3 Mud Balls
106.3.2.71.6.4.4 Other Foreign Material
106.3.2.71.6.5 Coarse Aggregate for Base
106.3.2.71.6.5.1 Deleterious Rock
106.3.2.71.6.5.2 Shale
106.3.2.71.6.5.3 Mud Balls

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.

The "rock cap", in place for a new highway, is the top 2 ft. of material laid before asphalt or concrete is placed on the new road. The rock cap is graded to the final elevation of the road, provides a stable base for the surface and allows water to drain from under the road without compromising the pavement or ground around the highway.

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.

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

Quick Test for Per Cent of Deleterious Material

Report, 2009 (https://spexternal.modot.mo.gov/sites/cm/CORDT/or10010.pdf)

See also: Research Publications (https://www.modot.org/research-publications)

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 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=14)), 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 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=14) and Sec 1003 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=14)), 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 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=14)), the following definitions apply:

106.3.2.71.6.3.1 Deleterious Rock

Deleterious rock includes the following materials:

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

considered as deleterious.

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

106.3.2.71.6.3.2 Shale

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

106.3.2.71.6.3.3 Mud balls

Balls of mud.

106.3.2.71.6.3.4 Clay

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

106.3.2.71.6.3.5 Other Foreign Material

Any material not related to the inherent material being inspected.

106.3.2.71.6.4 Coarse Aggregate for Surfacing

For coarse aggregate for surfacing (Sec 1006 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=14)), the following definitions apply:

106.3.2.71.6.4.1 Deleterious Rock

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

106.3.2.71.6.4.2 Shale

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

106.3.2.71.6.4.3 Mud Balls

Balls of mud.

106.3.2.71.6.4.4 Other Foreign Material

Any material not related to the inherent material being inspected.

106.3.2.71.6.5 Coarse Aggregate for Base

For coarse aggregate for base (Sec 1007 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=14)), the following definitions apply:

106.3.2.71.6.5.1 Deleterious Rock

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

106.3.2.71.6.5.2 Shale

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

106.3.2.71.6.5.3 Mud Balls

Balls of mud.

106.3.2 Material Inspection Test Methods

ASTM D 4791

Flat and Elongated Particles

In Coarse & Fine Aggregate

ASTM D4791

Flat & Elongated Particles in Coarse & Fine Aggregate

1

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.

2

Method A

Method A uses 4 Group of F & E

1. Flat Particles
2. Elongated Particles
3. Particles that meet the criterial of both groups
4. Neither Flat or Elongated

3

Method B

- Comparison of the maximum particle dimension to the minimum particle dimension and is intended for use with Superpave specifications.

4

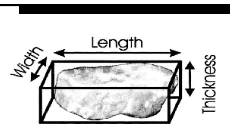
Significance & Use

- 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.

5

Definitions

- Flat & Elongated Particles (F & E)
  - Those particles have 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



6

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.

7

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)

8

Different Size of Aggregate

9

MoDot Material Tested

1002

Test all; sieves with more than 10% retained.

- on #4 sieve and above

SMA (Stone Mastic Aggregate)

Test all Sieves with more than 10% retained.

- On #4 sieve and above

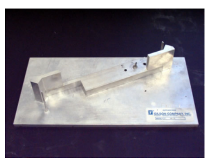
Test both 3:1 and 5:1 comparison.

Do a weighted average calculation and report the results.

10

Equipment

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



11

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 result of the reduction. Reduction to an exact predetermined mass shall not be permitted.

12

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)

13

Particle Count & By Mass/Weight

By Particle Count

- Does not need to be oven dried.
- Perform AASHTO T27 (Gradation)
- 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°F (110 ± 5°C)
- Perform AASHTO T27 (Gradation)
- Test all sieves with more than 10% retained on the #4 sieve and above as required by MoDOT specifications.

14

Superpave Procedure: Method B

- Acquired the amounts to be tested by count or mass.

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

    Flat & Elongated or Not Flat & Elongated

  Proportional caliper device positioned at ratio?

    3:1, 5:1, etc....

  Test each particle in the caliper by setting the larger opening to the particle length.

15

Superpave Procedure: Method B Cont.

- Acquired the amounts to be tested by count or mass.

  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.

  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.

16

Evaluating Aggregates

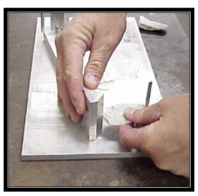


Figure 1
Checking Elongation

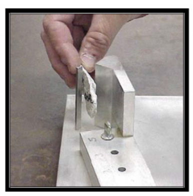


Figure 2
Checking Flatness

17

Calculations & Reporting

- Report each group to the nearest 1%. Test all sieves with more that 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.

18

Calculations & Reporting Cont.

A = Weight retained on each sieve

B = (A) / Original mass of sample x 100 (Report to the nearest 0.1%)

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of flat and elongated particles

E = D / C x 100 Report to nearest 1%

F = B / TPR Report to nearest 0.001

G = E x F Report to nearest 1%

19

Common Testing Errors

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

20

Classroom F & E Problems

These are enlarged copies at the end of this Module

21

Flat & 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	

22

Problem 1A: Answer

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

Report to:	0 g	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						
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	.020	0
Total % Retained		96.3	(TPR)			1.000	
						Total	2%

23

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 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	

24

Flat and Elongated by Mass: Problem 2B Answer

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		
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	

25

Flat and Elongated by Mass: Answer 2B Cont.

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%

26

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	

27

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

28

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

Project: J8P0633 Mix Design: SP250 05-43 Date: 7/25/24 .
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

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

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

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) **Answer 1A**

Project: J8P0633 Mix Design: SP250 05-43 Date: 7/25/24 .
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

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

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 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:___2024_______.
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

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

C = Weight of mass tested (Approximately 100 pieces)

D = Weight of Flat and Elongated particles

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

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

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) — Answer 2B

Project:____________**Mix Design:**__________________**Date:** 2024 .
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

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

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) — Problem 3C

Project: J8P0633 Mix Design: SP250 05-43 Date: 7/25/24 .
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 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) Answer 3C

Project: J8P0633 **Mix Design:** SP250 05-43 **Date:** 7/25/24 .
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

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

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 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.

MoDOT EPG

106.3.2.71.6.1.6 Thin or Elongated Pieces

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

ASTM 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		
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, drying is not necessary.		
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

Table for item 3:

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)

Examiner: ______________________________________Date:________________

AASHTO T84

ASTM C128

Specific Gravity and

Absorption

of

Fine Aggregate

1

Scope

This methods covers the determination of bulk & apparent specific gravity at 73.4/73.4˚F and the absorption of fine aggregate.

SI units are to be regarded as the standard.

2

Significance & Use

Specific Gravity

- Is the ratio of mass of an aggregate to the mass of a volume of water equal to the volume of the aggregate
- It is also the ratio of density of the aggregate particles to the density of water
- Distinction is made between the density and the bulk density (T19M)

Bulk Specific Gravity

- Is the characteristic used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including hydraulic cement concrete or other mixtures
- SSD determined on the oven-dry basis is used for computation when aggregate is dry or assumed to be dry
- Use if the aggregate is in a wet condition; if its absorption has been satisfied

3

Significance & Use

4

Apparent Specific Gravity

- Pertains to the relative density of a solid material making up the constituent particles not including the pore space that are accessible to water
- Not widely used in construction aggregate

Absorption

- Value used to calculate in the mass of an aggregate due to water absorbed in the pore spaces 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
- The laboratory standard for absorption is that obtained after soaking dry aggregate in water.

4

5

Absorption:
The amount of water that an aggregate retains in voids and pores. These values used to calculate the change in the mass of an aggregate due to the water absorbed in the pore spaces within the particle

Pycnometer:
This instrument is a precision laboratory device, used to accurately measure the density or volume of liquids, powders, and solids

5

6

Saturated Surface Dry:
This is when the aggregate is saturated on the inside, but the surface is dry

Specific Gravity:
This is a ratio of the aggregate's density to the density of water

6

Air Dried:
When the aggregate is dried at temperature ≤ 140° F (60°C)

Oven Dried:
When the aggregate is dried to a constant mass when temperature is 230 ± 9° F (110 ± 5° C)

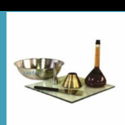
7

7

Equipment

8

- Balance
- Thermometer
- Tamper
- Oven
  - Capable of 230±9°F
- 500 ml Pycnometer
- #4 Sieve



- Mold
  - To form a frustum of a cone
  - Thickness of 0.8mm
  - 40±3mm inside diameter @ top
  - 90±3mm inside diameter @ bottom
  - 75±3mm in height

8

SAMPLE PREPARATION

9

1. • Obtain 1 kg of fine aggregate from sample following R76
2. • Dry the sample to constant mass at temperature of 110±5°C
   •Allow it to cool to handling temp.
   •Cover with water let stand for 15-19 hours
   *see alternative
3. • Remove the excess water with care- making sure not to lose fine
   Place on nonabsorbent surface exposed to gently moving warm air
4. • Getting the aggregates to SSD condition you will need to stir
   • Conduct cone test (see additional slides) to check for surface moisture

9

What You Need to Know!

Things to know before starting the cone test:

- If the sample falls flat, on the first cone test, or before the SSD state, it has been dried past the SSD condition.

What to do. . .

- Mix in a few milliliters of water
- Cover
- Let stand for 30 minutes.
- Return to nonabsorbent surface, stirring and continuing with cone testing till SSD is reached.

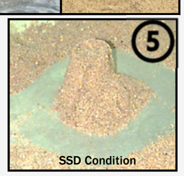
10

CONE TEST PROCEDURE

1) Place the mold on a flat, nonabsorbent surface, with the large diameter down.
2) Fill the mold to overflowing.
3) Tamp 25 times with **5mm** drops (0.2 in).
4) Allow the tamper to fall freely.
5) Remove the material from around the base of the mold, then lift cone vertically.
6) Continue drying and doing cone tests until the sample slumps slightly = SSD condition.

11

Pictures of the Steps of a Cone Test



12

CONE TEST NOTES

- It should take two or more trials to reach SSD.

- The closer testing gets to the SSD state, increase the number of cone tests.

- If the material do not readily slump use one of the following test methods: Provisional Cone test, Provisional Surface Test, SSD on Single-Size Material, Colorimetric Procedures

13

Cone Test Summary

14

Procedure Once SSD Condition is Reached

1. Immediately weigh 500 ± 10 grams of SSD material and add it to the pycnometer.
2. Record the SSD weight to the nearest 0.1g, this is "S" in the equation.
3. Fill Pycnometer with additional water to approximately 90% capacity. *Usually, 90% is just into or slightly below the neck of the flask.
4. Roll, invert, and agitate the pycnometer to remove all the air bubbles. *Should take around 15-20 minutes
5. After removing air from the sample, adjust the water level in the pycnometer to its calibrated capacity.

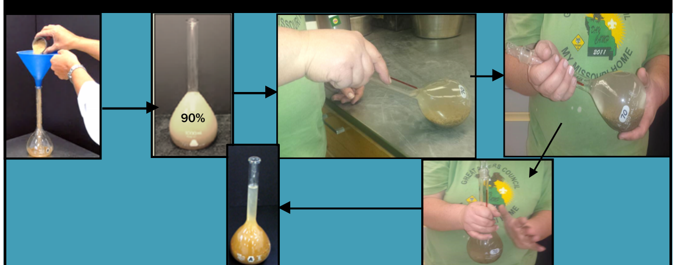
15

Procedure Once SSD Condition is Reached

6. Place the pycnometer in a bath 73.4 ± 3°F (23.0 ± 1.7°C). After 30-45 minutes check the water inside the pycnometer with a thermometer to verify that the temperature is at 73.4 ± 3°F (23.0 ± 1.7°C).
7. Determine total mass of the pycnometer, sample, and water. Weigh to 0.1 gram = "**C**" in the equation.
8. Remove the sample from pycnometer into a small pre-weighed pan.
9. Oven dry sample to constant weight at 230 ± 9° (110 ± 5°C).
10. Cool sample in air at room temperature for 1.0 ± 0.5 hour(s), weigh the dry sample to the nearest 0.1g. Report as "**A**" (dry wt.) in the equation.

16

Photos for Procedure



17

Calculations: Bulk Specific Gravity (Dry)

$$Bulk\ Specific\ Gravity = \frac{A}{(B + S - C)}$$

A = mass of oven-dry sample in air (g)
B = mass of pycnometer filled with water (g)
S = mass of saturated surface-dry sample (g)
C = mass of pycnometer with sample and water (g) (to calibration mark)
* 23±1.7°C

18

Calculations: Bulk Specific Gravity (SSD)

19

$$SSD = \frac{S}{(B + S - C)}$$

S = mass of the saturated surface-dry sample (g)
B = mass of pycnometer filled with water (g)
C = mass of pycnometer with sample and water (g)
(to calibration mark)

* 23±1.7°C

19

Calculations: Apparent Specific Gravity

20

$$App\ Sp.\ Gr. = \frac{A}{(B + A - C)}$$

A = mass of oven dry sample in air
B = mass of pycnometer filled with water
C = mass of pycnometer with sample and water
(to the calibration mark)

* 23±1.7°C

20

Calculations: Absorption

21

$$Abs.\% = \left[\frac{(S - A)}{A}\right] x100$$

A = mass of oven dry sample in air
B = mass of pycnometer filled with water
S = mass of the saturated surface dry sample
C = mass of pycnometer with sample and water
(to the calibration mark)

21

Reporting Answers

- Specific Gravity
  - M6 & 1005 (Concrete): 0.01
  - 1002 (Asphalt): 0.001
- Absorption
  - To the tenth: 0.1%
- Alternative
  - Naturally, moist condition report the source of the sample, and the processed used to prevent drying prior to testing

22

T84 for Aggregate Maintained in A Naturally Moist Condition

As an alternative, where the absorption and specific gravity values are to be used in their naturally moist condition, the requirement for initial drying to constant mass may be eliminated and, if the surfaces of the particles have been kept wet, the required soaking may also be eliminated.

Notes

23

Fine Aggregate – Classroom #1

24

Calculate the 3 specific gravities and the absorption from the test results below:

Report answers for Asphalt (1002) and Concrete (1005):

Wt. of Dry Sample	499.9 g	A
Wt. of Pyc + Water	683.9 g	B
Wt. of SSD Sample	503.3 g	S
Wt. of Pyc +Water + Sample	990.1 g	C

24

1. Bulk Specific Gravity

$$\frac{A}{(B+S-C)} \quad \frac{499.9}{(683.7+503.3-990.1)} = \frac{499.9}{196.9} = 2.5388$$

Concrete, Report to 2.54 Asphalt, Report to 2.539

ANSWER

2. Bulk Specific Gravity (SSD)

$$SSD = \frac{S}{(B+S-C)} \quad \frac{503.3}{(683.7+503.3-990.1)} = \frac{503.3}{196.9} = 2.5561$$

Concrete, Report to 2.56 Asphalt, Report to 2.556

25

3. Apparent Specific Gravity

$$\frac{A}{(B+A-C)} \quad \frac{499.9}{(683.7+499.9-990.1)} = \frac{499.9}{193.5} = 2.5834$$

Concrete, Report to 2.58 Asphalt, Report to 2.583

ANSWER

4. Percent Absorption

$$Abs.\% = \left[\frac{(S-A)}{A}\right] x100 \quad \frac{(503.3-499.9)}{499.9} \text{ X } 100 = \frac{3.4}{499.9} \text{ X } 100 = 0.680$$

Concrete & Asphalt, Report to 0.7%

26

Fine Aggregate – On your own #2

Calculate the 3 specific gravities and the absorption from the test results below:

Report answers for Asphalt (1002) and Concrete (1005):

Wt. of Dry Sample	495.8 g	A
Wt. of Pyc + Water	1233.0 g	B
Wt. of SSD Sample	502.1 g	S
Wt. of Pyc +Water + Sample	1541.1 g	C

27

Fine Aggregate – On your own #2

28

1. Bulk Spg.: Asphalt = 2.556, Concrete 2.56
2. SSD: Asphalt = 2.588, Concrete 2.59
3. Apparent Spg: Asphalt = 2.641, Concrete 2.64
4. Percent Abs: Asphalt and Concrete, 1.3%

28

Fine Aggregate – On your own #3

29

Calculate the 3 specific gravities and the absorption from the test results below:

Report answers for Asphalt (1002) and Concrete (1005):

Wt. of Dry Sample	492.3 g	A
Wt. of Pyc + Water	1128.4 g	B
Wt. of SSD Sample	500.9 g	S
Wt. of Pyc +Water + Sample	1438.1 g	C

29

Fine Aggregate – On your own #3

30

1. Bulk Spg.: Asphalt = 2.575, Concrete 2.58
2. SSD: Asphalt 2.620, Concrete 2.62
3. Apparent Spg: Asphalt = 2.696, Concrete 2.70
4. Percent Abs: Asphalt and Concrete, 1.7%

30

Calculate the 3 specific gravities and the absorption for the FINE aggregate sample below. Report results for Asphalt (1002) and Concrete (1005).

Sample ID		
Weight of dried sample (g)		A
Weight of pyc filled with water (g)		B
Weighty of SSD sample (g)		S
Weight of pyc + water + sample (g)		C

1. Bulk Specific Gravity:

$$\frac{A}{(B + S - C)}$$

2. Bulk Specific Gravity (SSD):

$$SSD = \frac{S}{(B + S - C)}$$

3. Apparent Specific Gravity:

$$\frac{A}{(B + A - C)}$$

4. Percent Absorption:

$$Abs.\% = \left[\frac{(S - A)}{A}\right] x100$$

AASHTO T 84: Specific Gravity for Fine Aggregate
PROFICIENCY CHECKLIST
(rev 9/18/25)

Applicant: ____

Employer: ____

. Trial #	1	2
Sample Preparation		
1. Obtain a representative sample. (AASHTO R90)		
2 Mix and Reduce. (AASHTO R76)		
3. Sieved over #4 sieve, keep minus 4 material (approximately 1,000 g)		
4. Dried to constant mass at 230 ± 9°F (110 ± 5°C) **Note:** Oven drying not necessary if naturally moist condition is desired **Note:** See Provisional Tests 1-4 for materials that do not readily slump found in appendix		
5. Sample is covered with water, allowed to stand 15-19 hours		
6. Pycnometer calibrated at 73.4 ± 3ºF record this weight to nearest 0.1g (This is "**B**" in the equation)		
7. After 15-19hrs, decant the excess water off the sample without loss of fines		
8. Calibrated pycnometer partially filled with water, set by the scale		
STEPS 9-15 is the CONE TEST		
9. Sample spread on a flat nonabsorbent surface		
10. Sample uniformly dried by a current of warm air		
11. Mold placed on flat nonabsorbent surface and filled to overflowing		
12. Tamped 25 times with 5 mm drop, and allowed to fall freely		
13. Sample removed from around base, and mold lifted vertically		
14. Sample should retain the shape of the cone on first trial. If slumps on the first trial, water added, sample covered and allowed to stand for 30min….then back to cone testing.		
15. Drying continued, and slump test repeated at frequent intervals until sample slumps slightly = SSD Condition		
16. Immediately weighed 500±10g of the SSD sample to the partially filled pycnometer. (Report the mass to nearest 0.1 this is "**S**" in the equation)		
17. Pycnometer filled to 90% of total capacity and agitated to eliminate air bubbles. **Note:** Paper towel or isopropyl alcohol may be used to disperse foam on the water surface		
18. Pycnometer filled with water to the calibrated capacity line.		
19. When temperature of contents reach 73.4 ± 3°F (23.0 ± 1.7°C), towel dried the outside of the pycnometer and determined the total mass of the pycnometer, sample, and water to the nearest 0.1g (Report this as "**C**" in the equation)		
20. Sample removed from the pycnometer, placed in a pre-weighed pan and dried to constant mass at 230 ± 9°F (110 ± 5°C)		
21. Sample cooled in air at room temperature for 1.0 ± 0.5 hr. and dry mass determined to the nearest 0.1g, this is "**A**" in the equation.		
22. Calculations completed as needed: **Report:** Specific Gravity for Asphalt (1002) to the nearest: **0.001** Specific Gravity for Concrete (1005) and M6 to the nearest: **0.01** And Absorptions Report to the nearest: **0.1%**		

PASS PASS

FAIL FAIL

Examiner: ____ Date: __________________

AASHTO T85

(ASTM C127)

Specific Gravity and

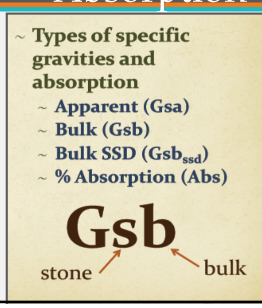
Absorption
of
COARSE Aggregate

AASHTO T85

Specific Gravity & Absorption
Coarse Aggregate

1

Types of Specific Gravities & Absorption



2

Scope

- This method covers the determination of specific gravity and absorption of coarse aggregate.
- The specific gravity may be expressed as bulk specific gravity, bulk specific gravity (saturated surface-dry (SSD)), or apparent specific gravity.
- The bulk specific gravity (SSD) and absorption are based on aggregate after 15-19 hours of soaking in water.

3

Significance & Use

- **General procedures-** This test method are suitable for determining the absorption of aggregates that have had conditioning other than the required soak. The values given for absorption by other methods will be different than the values from the required soak as well as the SSD.
- **Lightweight Aggregates-** This test method is not intended for these aggregates. This is due to the aggregates' absorption potential could take many days.

4

4

Significance & Use

- **Specific Gravity**- The ratio of mass of an aggregate to the mass of a volume of water equal to the volume of the aggregate. Use T19M for the distinction between the density of aggregate particles and the bulk density of aggregates.
- **Bulk specific gravity-** The characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate, including Portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis.

5

5

Significance & Use

- **Absorption** – Used to calculate the change in 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.
- **Apparent Specific Gravity-** The relative density of the solid material making up the constituent particles, not including the pore space within the particles that are accessible to water.

6

6

Equipment

- Scale M231, Class G5
- Sieves #4 or #8
- Basket mesh- [No.6 or (No.10 or smaller)]
- Towels
- Oven capable of maintaining 230 ± 9°F (110 ± 5°C)
- Water Tank - Watertight with an overflow outlet for maintaining a constant water level
- Suspended Apparatus - A wire of smallest practical size
- Thermometer- measuring @ least 16-27º C (60-80ºF)

7

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.

8

Sampling

- 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.

9

Sample Size- Table 1

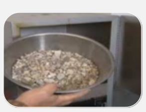
Nominal Maximum Size	Minimum Mass of Sample Needed for Testing
½″ (12.5mm) or less	2,000 grams
¾″ (19.0mm)	3,000 grams
1″ (25.0mm)	4,000 grams
1 ½″ (37.5mm)	5,000 grams

10

10

Procedure

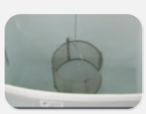
11



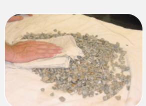
Dry the +4 aggregate to a constant mass at 230 ± 9°F (110 ± 5°C), according to AASHTO T255

- Cool the aggregate at room temperature for 1-3 hours
- The sample should be comfortable to handle ~ 122°F (50°C)

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



Prepare the water bath: Overflow the water outlet. Adjust the temperature to **73.4 ± °F (23.0 ± 1.7°C)**



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. (SSD = **S**aturated **S**urface **D**ry)
- Wipe the larger particles individually

12

12

Tare the scale

- Weigh the sample and write the SSD mass as "**B**" in the calculations
- Determine the mass to the nearest 1gram or 0.1%

Immediately place sample in the wire basket

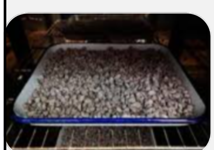
- Shake the basket while immersed to remove entrapped air

Weigh the sample in water to the nearest **1g**

- (This weight is "**C**" in the calculations)

13

13



Place the sample in a pan for the oven.

Remove all particles from the basket

Dry to a constant weight at 230 ± 9°F (110 ± 5°C)

- Cool sample for 1-3 hours or when comfortably handle 122°F (~ 50° C)

Determine the dry mass

- Record to the nearest 1g
- use this as "**A**" in the calculations.

14

14

Calculations

$$Bulk\ Specific\ Gravity = \frac{A}{(B-C)}$$

A = Mass of Dry Sample
B = Mass Surface Dry Sample
C = Mass of Sample in Water

15

15

Calculations

$$SSD\ Specific\ Gravity = \frac{B}{(B - C)}$$

B = Mass Surface Dry Sample
C = Mass of Sample in Water

16

16

Calculations

$$Apparent\ Specific\ Gravity = \frac{A}{(A - C)}$$

A = Mass of Dry Sample
C = Mass of Sample in Water

17

17

Calculations

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

A = Mass of Dry Sample
B = Mass Surface Dry Sample

18

18

Reporting Answers

Report the Specific Gravities to
- **0.01:** 1005 Concrete
- **0.01:** M80 Cement Concrete
- **0.001:** 1002 Asphalt

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.

19

Coarse Aggregate Classroom #1

Calculate the 3 specific gravities and the absorption from the test results below:

Report answers for Asphalt (1002) and Concrete (1005):

Dry Weight: 2058.3 g	A
SSD Weight: 2102.5 g	B
Submerged Weight: 1288.4 g	C

20

20

1. Bulk Specific Gravity

$$\frac{A}{(B-C)} \qquad \frac{2058.3}{(2102.5-1288.4)} = \frac{2058.3}{814.1} = 2.5283$$

Concrete, Report to 2.53 Asphalt, Report to 2.528

2. Bulk Specific Gravity (SSD)

$$\frac{B}{(B-C)} \qquad \frac{2102.5}{(2102.5-1288.4)} = \frac{2102.5}{814.1} = 2.5826$$

Concrete, Report to 2.58 Asphalt, Report to 2.583

21

21

3. Apparent Specific Gravity

$$\frac{2058.3}{(2058.3 - 1288.4)} = \frac{2058.3}{769.9} = 2.6734$$

$$\frac{A}{(A-C)}$$

Concrete, Report to 2.67 Asphalt, Report to 2.673

4. Percent Absorption

$$\frac{(B-A)}{A}x100$$

$$\frac{(2102.5 - 2058.3)}{2058.3} \text{ X } 100 = \frac{44.2}{2058.3} \text{ X } 100 = 2.147$$

Concrete & Asphalt, Report to 2.1%

22

22

Coarse Aggregate #2

On your own calculate the 3 specific gravities and the absorption from the test results below:

Report answers for Asphalt (1002) and Concrete (1005):

Dry Weight: 3040.5 g	A
SSD Weight: 3075.2 g	B
Submerged Weight: 1903.2 g	C

23

23

Coarse Aggregate #3

On your own calculate the 3 specific gravities and the absorption from the test results below:

Report answers for Asphalt (1002) and Concrete (1005):

Dry Weight: 2,110.0 g	A
SSD Weight: 2,127.2 g	B
Submerged Weight: 1,335.3 g	C

24

24

Answers Aggregate #2

1. Bulk Spg.: Asphalt = 2.594
   Concrete= 2.59
2. SSD: Asphalt = 2.624
   Concrete= 2.62
3. Apparent Spg.: Asphalt = 2.673
   Concrete= 2.67
4. Percent Abs: Asphalt and
   Concrete= 1.1%

25

Answers Aggregate #3

1. Bulk Spg..: Asphalt = 2.664,
   Concrete= 2.66
2. SSD: Asphalt = 2.686
   Concrete= 2.69
3. Apparent Spg.: Asphalt = 2.724
   Concrete= 2.72
4. Percent Abs: Asphalt and
   Concrete= 0.8%

26

AASHTO T 85: Specific Gravity and Absorption Of Coarse Aggregate

PROFICIENCY CHECKLIST

Revised on: 09/21/2021

Applicant: ____

Employer: ____

Trial#	1	2
Procedure		
1. Sample obtained by ASHTO R90, and Reduced per AASHTO R76		
2. Screened on No. 4 sieve (4.75mm) or No. 8 (2.36mm) sieve		
3. Sample mass as follows: ½ in. or less – 2 kg; ¾ in. – 3 kg; 1 in. – 4 kg; 1 ½ in. – 5kg		
4. Washed to clean surfaces of particles		
5. Dried to constant mass at 230 ± 9°F (110 ± 5°C) and cooled to room temperature for 1 to 3 hours (for up to 1 ½ in. nominal maximum size, longer for larger sizes) According to AASHTO T255.		
6. Covered with water for 15 to 19 hours		
7. Prepared bath, overflowed the water for level, and adjusted temperature to 73.4 ± 3°F (23.0 ± 1.7°C)		
8. Rolled in cloth to remove visible films of water		
9. Larger particles wiped individually		
10. Evaporation avoided		
11. Weigh the SSD sample and Record all masses determined to the nearest 1g or 0.1% of sample mass.		
12. Sample immediately placed in the wire basket		
13. Entrapped air removed before weighing by shaking the wire basket while immersed.		
14. Mass determined in water at 73.4 ± 3°F (23.0 ± 1.7°C)		
15. Dried to constant mass at 230 ± 9°F (110 ± 5°C) and cooled to room temperature for 1 to 3 hours [or until aggregate has cooled to comfortable handling temperature, approximately 122°F (50°C)]		
16. Weigh the dry sample and record the mass		
17. Calculated the Bulk Specific Gravity and Absorption. **Report:** Specific Gravity for Asphalt (1002) to the nearest: **0.001** Concrete (1005) and M80 to the nearest: **0.01** And Absorption to the nearest: **0.1%**		

PASS PASS

FAIL FAIL

Examiner: ___________________________ Date: ________________

Calculate the 3 specific gravities and the absorption for the COARSE aggregate sample below. Report results for Asphalt (1002) and Concrete (1005).

Sample ID:		
Dry Weight (g):		A
SSD Weight (g):		B
Submerged Weight (g):		C

1. Bulk Specific Gravity:

$$\frac{A}{(B-C)}$$

2. Bulk Specific Gravity (SSD):

$$\frac{B}{(B-C)}$$

3. Apparent Specific Gravity:

$$\frac{A}{(A-C)}$$

4. Percent Absorption:

$$\frac{(B-A)}{A}x100$$

MoDOT TM-81

"Core-Lok"

Informational Only

MoDOT TM – 81 CORELOK

Specific Gravity and Absorption of Aggregate

Using Automatic Vacuum Sealing Method

1

Summary of Method

- The known volume of the vessel with water only, mass of dry aggregate and mass of sample in vessel with water, are used to calculate the **bulk** specific gravity oven dry "OD".
- The dry mass and submerged mass are used to calculate **apparent** specific gravity.
- Dry aggregate to a constant mass.
- The sample is weighed in water in a vessel of known volume

2

Summary of Method

- This test can be used for rapid determination of aggregate properties in construction testing laboratories.
- The results from the two (bulk and apparent) are then used to calculate absorption and bulk specific gravity saturated surface and dry (SSD).
- For each test
  - Two representative samples of the same material tested (Bulk Specific Gravity).
  - One sample is vacuum saturated and weighed under water (Apparent Specific Gravity).

3

Summary of Method

- The results from the two (bulk and apparent) are then used to calculate absorption and bulk specific gravity saturated surface dry (SSD)
- This test can be used for rapid determination of aggregate properties in construction testing laboratories

4

Equipment


Water Bath – 24 x 18 x 18in. Min., capable of maintaining water temperature of 25±1°C (77±2° F)


Balance – readable to 0.1%


Pycnometer – two sizes, the smaller equipped with fixture to hold the lid in place during test


Sample holder – for water displacement


Vacuum Chamber – for placing aggregate in vacuum and sealing in a bag in one operation

5

Equipment


Accessories – timer, knife or scissors, spray bottle of isopropyl alcohol, bucket, syringe, small paint brush, rubber sheets

A Vacuum Measurement Gauge – independent of the vacuum sealing device, capable of reading down to 3mm Hg ± 1 mm Hg


Plastic bags - two sizes are required with minimums specified for dimensions, opening and thickness

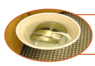
6

Verification & Calibration

- Verify the vacuum system annually, when relocated or after major repairs
- Calibrate pycnometer daily – calibration is achieved by repeating the procedure until three masses are within
  - 0.5 gram for fine aggregates (small pyc)
  - 1 gram for coarse aggregates (large pyc)

7

Verification & Calibration


Condition the pycnometer by submerging in water maintained at 25 ± 1°C


Remove from water, empty and place lid on top


Fill pycnometer with water


Weigh in the same manner as you will with a sample


Small pycnometer is weighed using the clamping device

8

Sampling

Sample in accordance with AASTO R90

Fine Aggregate	For fine aggregate, thoroughly mix sample and reduce it to one sample, 1000 ± 10 grams for the apparent SpGr, and two samples, 500 ± 3 grams for the bulk SpGr. Use AASHTO T 248 to reduce material.
Coarse Aggregate	Thoroughly mix sample and reduce it to one sample, 2000 ± 10 grams for the apparent SpGr, and two samples, 1000 ± 10 grams for the bulk SpGr. Use AASHTO T 248 to reduce material When coarse aggregates of large size are encountered, it may be easier to perform the test using two or more sub-samples.

9

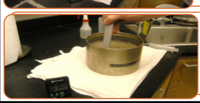
Bulk Specific Gravity Test Procedure

10

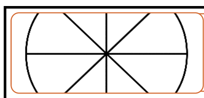

Dry samples to a constant mass
Allow to cool to room temperature
Weigh a 1000 ± 10 grams sample and record

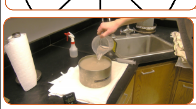

Fill the conditioned pycnometer half full of water at test temperature (25 ± 1°C)

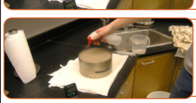

The following steps shall be completed in less than 2 min.
Slowly and evenly pour the sample into the pycnometer, ensuring that no material is lost in the process

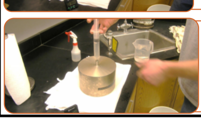

The following steps shall be completed in less than 2 min.
Insert a metal spatula along the inside of the pycnometer until it reaches the bottom.

11


Slowly drag the spatula to the center
Repeat 7 more times moving 45° along the wall


The following steps shall be completed in less than 2 min.
Top off water level to just below (10mm) the lip
If water spills during lid placement, test is void and must be repeated

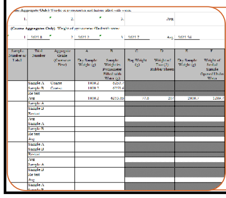

The following steps shall be completed in less than 2 min.
Use spray bottle with alcohol to eliminate bubbles
Place lid on pycnometer


The following steps shall be completed in less than 2 min.
Use syringe to finish filling the pycnometer
Fill pycnometer until water just comes out of hole on the surface of the lid

12

Dry water from around hole on surface

"Times up! - Place pycnometer on scale & Record mass



Repeat procedure for a second sample.

Record average

13

Apparent Specific Gravity

Test Procedure

14

Set vacuum device according to manufactures recommendation

1

Before using, check condition of plastic bags, discard if flaw is discovered

2

Weigh both bags and record

3

Weigh rubber sheets and record

4

Weigh 2000 ± 10 grams of aggregate and record

5

Place sample in small bag-- Use caution to prevent damaging the bag

6

Place large bag into vacuum chamber

7

Place first rubber sheet into large bag-- Push all the way to the back of the large bag

8

Place the small bag containing the sample into the large bag--Center it on top of the rubber sheet

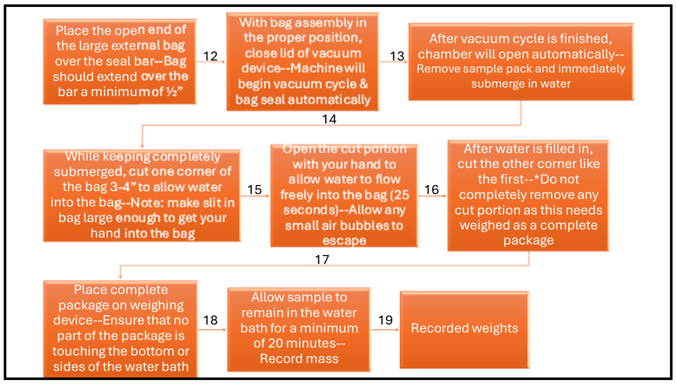
9

Manually spread the sample inside the small bag--Lightly spray mist samples that contain high amounts of minus No. 200 material

10

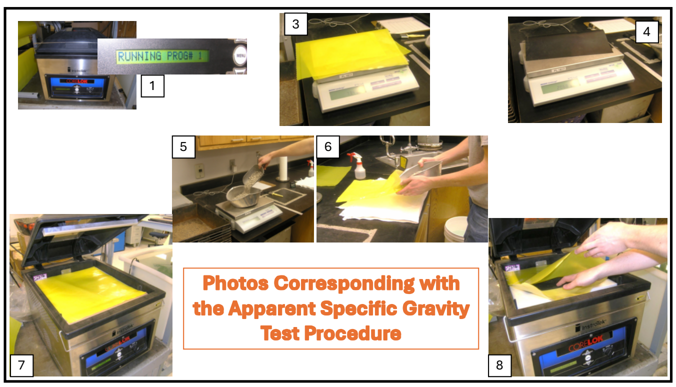
Place the second rubber sheet on top of the small bag

15



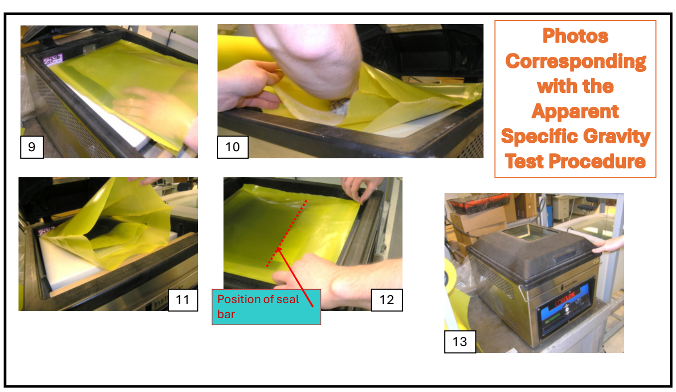
Place the open end of the large external bag over the seal bar--Bag should extend over the bar a minimum of ½"
12
With bag assembly in the proper position, close lid of vacuum device--Machine will begin vacuum cycle & bag seal automatically
13
After vacuum cycle is finished, chamber will open automatically--Remove sample pack and immediately submerge in water
14
While keeping completely submerged, cut one corner of the bag 3-4" to allow water into the bag--Note: make slit in bag large enough to get your hand into the bag
15
Open the cut portion with your hand to allow water to flow freely into the bag (25 seconds)--Allow any small air bubbles to escape
16
After water is filled in, cut the other corner like the first--*Do not completely remove any cut portion as this needs weighed as a complete package
17
Place complete package on weighing device--Ensure that no part of the package is touching the bottom or sides of the water bath
18
Allow sample to remain in the water bath for a minimum of 20 minutes--Record mass
19
Recorded weights

16



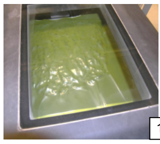
RUNNING PROG# 1
1
3
4
5
6
7
8
Photos Corresponding with the Apparent Specific Gravity Test Procedure

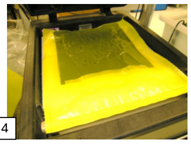
17

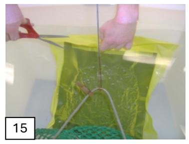


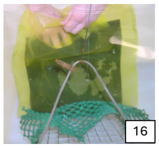
9
10
Photos Corresponding with the Apparent Specific Gravity Test Procedure
11
12
Position of seal bar
13

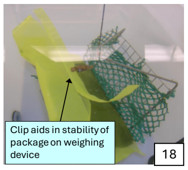
18











Photos Corresponding with the Apparent Specific Gravity Test Procedure

19

Calculations

Results may be obtained using software developed by the equipment manufacturer, Alternatively, users can develop their own software and correlations for calculation of the results with the equations given in section 10.0 of the test method

20

Standard Method of Test for

Specific Gravity and Absorption of Aggregate Using Automatic Vacuum Sealing Method

AASHTO Format MoDOT TM-81

1. SCOPE

1.1 This standard covers the determination of specific gravity and absorption of fine aggregates by Method A and coarse and blended aggregates by Method B.

1.2 The values are stated in SI units and are regarded as the standard units.

1.3 A multi-laboratory precision and bias statement for coarse and combined aggregate tests in this standard has not been developed at this time. Therefore, this standard should not be used for acceptance or rejection of coarse and combined aggregate materials for purchasing purposes.

1.4 *This standard may involve hazardous materials, operations and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards:*

- M43, Sizes of Aggregate for Road and Bridge Construction
- M 29, Wire-Cloth Sieves for Testing Purposes
- M 132, Terms Relating to Density and Specific Gravity of Solids, Liquids and Gases
- M 231, Weighing Devices Used in the Testing of Materials
- T 2, Standard Practice for Sampling of aggregates
- T 19, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
- T 27, Test Method for Sieve Analysis of Fine and Coarse Aggregates
- T 85, Standard Test method for Specific Gravity and Absorption of Coarse Aggregate
- T 84, Standard Test Method for Specific Gravity and Absorption of Fine Aggregate
- T 248, Standard Practice for Reducing Samples of Aggregate to Testing Size

2.2 *ASTM Standards:*

- D4753, Standard Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Testing Soil, Rock and Related Construction Materials
- C 670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

- C 691, Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
- C29/ C29 M, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
- C 127, Standard Test method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
- C128, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
- C 125, Terminology Relating to Concrete and Concrete Aggregates
- C 702, Standard Practice for Reducing Samples of Aggregate to Testing Size
- D 75, Standard Practice for Sampling of Aggregates
- D 136, Test Method for Sieve Analysis of Fine and Coarse Aggregates

2.3 *Other Standards:*

- CoreLok Operational Instructions (InstroTek, Inc.)

3. TERMINOLOGY

3.1 *Definitions*:

3.1.1 *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 ± 5ºC for sufficient time to remove all uncombined water.

3.1.2 *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 water at stated temperatures. Values are dimensionless.

3.1.2.1 *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.

3.1.2.2 *bulk 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.

3.1.2.3 *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 vacuum saturating (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.

4. SUMMARY OF METHOD

4.1 Sufficient aggregate sample is dried to constant mass. For each test, two representative dry aggregate samples of the same material are selected for testing. One sample is evacuated in a vacuum chamber inside a plastic bag and opened under water for rapid saturation of the aggregate. The dry mass and submerged mass of the sample is used for calculation of apparent specific gravity. The second sample of the same aggregate is tested in a known volume metal pycnometer. The known mass of the pycnometer with water, mass of the dry aggregate, and mass of the aggregate and pycnometer filled with water is used for calculation of bulk specific gravity oven dry (OD.) The results from the two samples tested are then used to calculate absorption, and bulk specific gravity saturated-surface-dry (SSD.)

4.2 This test can be completed in less than 30 minutes and can be used for rapid determination of aggregate properties in construction testing laboratories.

4.3 This test can be performed on fine, coarse and blended (combined) aggregates by using appropriate plastic bag and pycnometer sizes.

5. SIGNIFICANCE AND USE

5.1 Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate, including Portland cement concrete, hot mix asphalt, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in test T 19. Bulk specific gravity SSD is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk specific gravity OD is used for computations when the aggregate is dry or assumed to be dry.

5.2 Apparent specific gravity pertains to the solid material making up the constituent particles not including the pore space within the particles which is accessible to water.

5.3 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. The laboratory standard for absorption is that obtained after submerging dry aggregate for a prescribed period of time.

6. APPARATUS

6.1 *Balance*—A balance that conforms to M 231. The balance shall be sensitive, readable and accurate to 0.1% of the test sample mass. The balance shall be equipped with suitable apparatus for suspending the sample in water.

6.2 *Water Bath*—A container with minimum dimensions (Length × Width × Depth) of 610 × 460 × 460 mm (24 × 18 × 18 in.) or a large cylindrical container with a minimum diameter of 460 mm and depth of 460 mm (18 × 18 in), for completely submerging the sample in water while suspended, equipped with an overflow outlet for maintaining a constant water level. Temperature controls may be used to maintain the water temperature at 25 ± 1° C (77 ± 2 °F).

Note 1—It is preferable to keep the water temperature constant by using a temperature controlled heater. Also, to reduce the chance for the bag to touch the sides of the water tank, it is preferable to elevate the water tank to a level at which the sample can be placed on the weighing mechanism while the operator is standing up (waist height), and the placement of the sample and the bag in the water tank can easily be inspected.

6.3 Sample *holder* for water displacement of the sample, having no sharp edges.

6.4 *Vacuum Chamber*—with a pump capable of evacuating a sealed and enclosed chamber to a pressure of 6 mm Hg, when at sea level. The device shall automatically seal the plastic bag and exhaust air back into the chamber in a controlled manner to ensure proper conformance of the plastic to the specimen. The air exhaust and vacuum operation time shall be set at the factory so that the chamber is brought to atmospheric pressure in 80 to 125 seconds, after the completion of the vacuum operations.

6.5 *A Vacuum Measurement Gauge*, independent of the vacuum sealing device, that could be placed directly inside the chamber to verify vacuum performance and the chamber door sealing condition of the unit. The gauge shall be capable of reading down to 3 mm Hg and readable to ± 1 mm Hg.

6.6 *Plastic Bags*, used with the vacuum device, shall be one of the two following sizes: The smaller bags shall have a minimum opening of 235 mm (9.25 in.) and maximum opening of 260 mm (10.25 in.) and the larger bags shall have a minimum opening of 375 mm (14.75 in.) and a maximum opening of 394 mm (15.5 in.). The bags shall be of plastic material, shall be puncture resistant, and shall be impermeable to water. The bags shall have a minimum thickness of 0.127mm (0.005 in.). The manufacturer shall provide the apparent specific gravity for the bags.

6.7 Small metal pycnometer with 137 ± 0.13 mm (5.375 ± 0.005 in.) inside diameter (ID) and 89 ± 0.41 mm (3.5 ± 0.016 in.) height, for testing fine aggregates. The pycnometer shall be machined to be smooth on all surfaces. The inside of the lid shall be machined at a 5° angle to create an inverted conical surface. The pycnometer shall be equipped with a temperature strip to allow the user to monitor temperature during testing.

6.8 Large metal pycnometer with 198 ± 0.13 mm (7.776 ± 0.005 in.) ID and 114 ± 0.8 mm (4.5 ± 0.03 in.) height, for testing coarse and blended aggregate. The pycnometer shall be machined to be smooth on all surfaces. The inside of the lid shall be machined at a 5° angle to create an inverted conical surface. The pycnometer shall be equipped with a temperature strip to allow the user to monitor temperature during testing.

6.9 Fine aggregate fixture to hold and secure the lid on the small metal pycnometer from lifting during fine aggregate tests. The fixture shall be provided with a level indicator.

6.10 *Accessories*— A bag cutting knife or scissors, spray bottle filled with isopropyl alcohol, a bucket large enough to allow the pycnometer to be fully submerged in water, water containers to dispense water into pycnometer during testing, syringe with a needle no larger in diameter than 3 mm (0.125 in.), small paint brush and 25 mm (1 in.) wide aluminum spatula.

6.11 Rubber sheets, for protecting the plastic bags against punctures caused by sharp edges on coarse and blended aggregate samples. The manufacturer shall provide the apparent specific gravity for the rubber sheets.

7. VERIFICATION

7.1 *System Verification:*

7.1.1 The vacuum settings of the vacuum chamber shall be verified once every 12 months and after major repairs and after each shipment or relocation.

7.1.2 Place the gauge inside the vacuum chamber and record the setting, while the vacuum unit is operating. The gauge should indicate a pressure of 6 mm Hg (6 TORR) or less. The unit shall not be used if the gauge reading is above 6 mm Hg (6 TORR).

7.1.3 Vacuum gauge used for verification shall be verified for accuracy once every three years.

Note 2— In line vacuum gauges, while capable of indicating vacuum performance of the pump, are not suitable for use in enclosed vacuum chambers and cannot accurately measure vacuum levels.

7.2 *Calibration of the Small Pycnometer:*

7.2.1 Prior to testing, condition the pycnometer to 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F). Place the fine aggregate fixture on a level surface. Use a level indicator or the provided level to level the fixture.

7.2.2 Remove the pycnometer from the water bucket and dry it with a towel. Place the pycnometer in the fixture and push it back until it makes contact with the stops.

7.2.3 Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) from the top. Using the alcohol spray bottle, spray the surface of the water to remove bubbles.

7.2.4 Gently place the lid on the pycnometer and close the clamps on the fixture.

7.2.5 Using a syringe filled with 25 ± 1°C (77 ± 2°F) water, slowly fill the pycnometer through the large fill hole on the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step prevents formation of air bubbles inside the pycnometer.

7.2.6 Fill the pycnometer until water comes out the 3 mm (1/8-in.) hole on the surface of the lid.

7.2.7 Wipe any remaining water from the top of the lid with a towel.

7.2.8 Place the entire fixture with the pycnometer on the scale and record the mass. Record the mass in the top portion of the Aggregate Worksheet. (See Appendix X.1)

7.2.9 Clean the pycnometer and repeat steps 7.2.1 to 7.2.8 two more times and average the calibration masses obtained in 7.2.8.

7.2.10 If the range for the 3 calibration masses is larger than 0.5 grams, then the test is not being run correctly. Check to see if the fixture is level. Make certain the water injection with the syringe is done below the pycnometer water surface and is applied gently. Check the water temperature. Check the pycnometer temperature. Repeat the above procedure until you have three masses that are within ± 0.5 gram.

7.2.11 Re-calibrate the pycnometer daily.

7.3 *Calibration of the Large Pycnometer:*

7.3.1 Prior to testing, condition the pycnometer to 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F).

7.3.2 Remove the pycnometer from the water bucket and dry it with a towel. Set the pycnometer on a level surface.

7.3.3 Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) from the top. Using the alcohol spray bottle, spray the surface of the water to remove any air bubbles.

7.3.4 Gently place the lid on the pycnometer. Using a syringe filled with 25 ± 1°C (77 ± 2°F) water, slowly fill the pycnometer through the large fill hole on the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step prevents formation of air bubbles inside the pycnometer. Fill the pycnometer until water comes out the 3 mm (1/8-in.) hole on the surface of the lid.

7.3.5 Wipe any remaining water from the top of the lid and sides with a towel. Place the pycnometer on the scale and record the mass. Record the mass in the top portion of the Aggregate Worksheet.

7.3.6 Clean the pycnometer and repeat steps 7.3.2 to 7.3.5 two more times and average the calibration masses obtained in 7.3.5.

7.3.7 If the range for the 3 calibration masses is larger than 1 gram, then the test is not being run correctly. Check to see if the fixture is level. Make certain the water injection with the syringe is done below the pycnometer water surface and is applied gently. Check the water temperature. Check the pycnometer temperature. Repeat the above procedure until you have three masses that are within 1 gram range.

7.3.8 Re-calibrate the pycnometer daily.

8. SAMPLING

8.1 *Fine aggregate samples (Method A):*

8.1.1 Sampling shall be done in accordance with T 2. For fine aggregate testing thoroughly mix the sample and reduce it to obtain one 1000 ± 10 gram sample for apparent specific gravity and two 500 ± 3 gram samples for bulk specific gravity determination. For aggregate reduction use the appropriate procedures described in T 248.

8.2 *Coarse aggregate samples (Method B):*

8.2.1 Sample the aggregate in accordance with T 2.

8.2.2 Dry the aggregate to constant mass and thoroughly mix the sample of aggregate and reduce it to one 2000 ± 10 gram sample for determination of apparent specific gravity and two 1000 ± 10 gram samples for determination of bulk specific gravity. For reduction of the aggregate samples, use the appropriate procedures in T 248.

8.2.3 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with test T 27, including the sieves used for separating the size fractions for the determinations in this method.

Note 3— When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more sub samples, and the values obtained combined for the computations.

9. PROCEDURES

9.1 *Method A, Fine Aggregate Test:*

9.1.1 Make certain water temperature used for this test remains at 25 ± 1°C (77 ± 2°F).

9.1.2 Prior to testing, condition the pycnometer to 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F).

9.1.3 *Determine Bulk Specific Gravity:*

9.1.3.1 Make certain the samples are dried to constant mass.

9.1.3.2 For a single test select and separate two 500 ± 3 gram samples (samples A and B) for the test in the pycnometer and one 1000 ± 10 gram sample for vacuum saturation test.

9.1.3.3 Allow the sample to cool to room temperature.

9.1.3.4 Place the empty pycnometer in the fixture and push it back until it makes contact with the stops.

9.1.3.5 Weigh a 500 ± 3 gram dry sample that is at 25 ± 1°C (77 ± 2°F) and record in column A of the worksheet.

9.1.3.6 Steps 9.1.3.8 to 9.1.3.15 shall be completed in less than 2 minutes.

9.1.3.7 Place approximately 500 ml (halfway full) of 25 ± 1°C (77 ± 2°F) water in the pycnometer.

9.1.3.8 Slowly and evenly pour the sample into the pycnometer. Make certain aggregate is not lost in the process of filling the pycnometer. Use a brush if necessary to sweep any remaining fines into the pycnometer. If any aggregate is lost during the process of filling the pycnometer, start the test over.

9.1.3.9 Use a metal spatula and push it to the bottom of the pycnometer against the inside circumference. Slowly and gently drag the spatula to the center of the pycnometer, removing the spatula after reaching the center. Repeat this procedure 7 more times so that the entire circumference is covered in 8 equal angles, i.e. every 45 degrees until the starting point is reached. If necessary, use a squeeze water bottle to rinse any sample residue off the spatula into the pycnometer.

9.1.3.10 Fill the pycnometer with 25 ± 1°C (77 ± 2 °F) water to approximately 10 mm (0.375 in.) of the pycnometer rim. It is important that the water level is kept at or below the 10 mm line to avoid spills during lid placement.

9.1.3.11 Use the spray bottle filled with isopropyl alcohol and spray the top of the water to remove air bubbles.

9.1.3.12 Gently place the lid on the pycnometer and lock the clamps. Using the syringe, slowly fill the pycnometer through the center hole on top of the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step will prevent formation of air bubbles inside the pycnometer.

9.1.3.13 Fill the pycnometer until water just comes out the 3 mm (1/8-in.) hole on the surface of the lid.

9.1.3.14 Wipe any remaining water from around the 3 mm (1/8-in.) hole with a towel.

9.1.3.15 Weigh the sample, pycnometer and the fixture. Record this mass in column B of the worksheet.

9.1.3.16 Repeat steps 9.1.3.6 to 9.1.4.15 for the second 500 ± 3 gram sample, Sample B.

9.1.3.17 Average the mass in each column of the worksheet for sample A and sample B.

9.1.3.18 Record the average weight of the pycnometer from section 7.2.9 in column C.

9.1.4 *Determine Apparent Specific Gravity:*

9.1.4.1 Set the vacuum device according to manufacturer's recommendation.

9.1.4.2 Use a small plastic bag and inspect the bag to make sure there are no holes, stress points or side seal discontinuities in the bag. If any of the above conditions are noticed, use another bag.

9.1.4.3 Weigh the bag and record in column D of the worksheet.

Note 4—Always handle the bag with care to avoid creating weak points and punctures.

9.1.4.4 Weigh 1000 ± 10 grams of oven dry aggregate and record the mass in column F.

9.1.4.5 Place the sample in the bag. Support the bottom of the bag on a smooth tabletop when pouring the aggregate to protect against punctures and impact points.

9.1.4.6 Place the bag containing the sample inside the vacuum chamber.

9.1.4.7 Grab the two sides of the bag and spread the sample flat by gently shaking the bag side to side. Do not press down or spread the sample from outside the bag. Pressing down on the sample from outside the bag will cause the bag to puncture and will negatively impact the results. Lightly spray mist aggregates with high minus 75-µm (No. 200) sieve material to hold down dust prior to sealing.

9.1.4.8 Place the open end of the bag over the seal bar and close the chamber door. The unit will draw a vacuum and seal the bag, before the chamber door opens.

9.1.4.9 Gently remove the sample from the chamber and immediately submerge the sample in a large water tank equipped with a balance for water displacement analysis. It is extremely important that the bag be removed from the vacuum chamber and immediately placed in the water bath. Leaving the bag in the vacuum chamber or on a bench top after sealing can cause air to slowly enter the bag and can result in low apparent specific gravity results.

9.1.4.10 Cut one corner of the bag, approximately 25 to 50 mm (1 to 2 in.) from the side while the top of the bag is at least 2-inch below the surface of the water. Make sure the bag is completely submerged before cutting. Introducing air into the bag will produce inaccurate results.

9.1.4.11 Open the cut portion of the bag and hold open for 45 seconds. Allow the water to freely flow into the bag. Allow any small residual air bubbles to escape. Do not shake or squeeze the sample, as these actions will cause the fines to escape from the bag.

9.1.4.12 After water has filled in, cut the other corner of the bag approximately 25 to 50 mm (1 to 2 in.). Squeeze any residual air bubbles on top portion of the bag through the cut corners by running your fingers across the top of the bag. Do not completely remove corners from bag nor allow any portion of the bag to reach the surface of the water.

9.1.4.13 Place the bag containing the aggregate on the weighing basket in the water to obtain the under water mass. The bag may be folded before placing it on the basket. However, once on the basket under water, unfold the bag and allow water to freely flow into the bag. Keep the sample and bag under water at all times. Make certain the bag or the sample are not touching the bottom, the sides, or floating out of the water tank. If the bag contacts the tank it will negatively impact the results of this test.

9.1.4.14 Allow the sample to stay in the water bath for a minimum of fifteen (15) minutes.

9.1.4.15 Record the submerged mass in column G of the worksheet.

9.1.4.16 Results may be obtained using software developed by the equipment manufacturer. Alternatively, users can develop their own software and correlations for calculation of the results with equations given in section 10.0.

9.2 *Method B, Coarse and Combined Aggregate Test:*

9.2.1 Make certain water temperature used for this test remains at 25 ± 1°C (77 ± 2°F)

9.2.2 Prior to testing, condition the pycnometer to 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F).

9.2.3 *Determine Bulk Specific Gravity:*

9.2.3.1 Make certain the samples are dried to constant mass.

9.2.3.2 Allow the sample to cool to room temperature.

9.2.3.3 For a single test select and separate two 1000 ± 10 gram samples (samples A and B) for the test in the pycnometer and one 2000 ± 10 gram sample for vacuum saturation test.

9.2.3.4 Make certain the pycnometer is set on a level surface.

9.2.3.5 Weigh a 1000 ± 10 gram dry sample (sample A) that is at 25 ± 1°C (77 ± 2°F) and record in column A of the worksheet.

9.2.3.6 Steps 9.2.3.8 to 9.2.3.15 shall be completed in less than 2 minutes.

9.2.3.7 Place approximately 1000 ml (halfway full) of 25 ± 1°C (77 ± 2°F) water in the pycnometer.

9.2.3.8 Slowly and evenly pour the sample into the pycnometer. Make certain aggregate is not lost in the process of filling the pycnometer. Use appropriate pouring techniques to help in transferring the aggregate into the pycnometer. If any aggregate is lost during the process of filling the pycnometer, start the test over.

9.2.3.9 Use a metal spatula and push it to the bottom of the pycnometer against the inside circumference. Slowly and gently drag the spatula to the center of the pycnometer, removing the spatula after reaching the center. Repeat this procedure 7 more times so that the entire circumference is covered in 8 equal angles, i.e. every 45 degrees until the starting point is reached. If necessary, use a squeeze water bottle to rinse any sample residue off the spatula into the pycnometer.

9.2.3.10 Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) of the pycnometer rim. It is important that the water level is kept at or below the 10 mm line in order to avoid spills during lid placement

9.2.3.11 Use the spray bottle filled with isopropyl alcohol and spray the top of the water to remove air bubbles.

9.2.3.12 Gently place the lid on the pycnometer. Using the syringe, slowly fill the pycnometer through the center hole on top of the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step will prevent formation of air bubbles inside the pycnometer.

9.2.3.13 Fill the pycnometer until you see water coming out the 3 mm (1/8-in.) hole on the surface of the lid.

9.2.3.14 Wipe any remaining water from around the 3 mm (1/8-in.) hole with a towel.

9.2.3.15 Weigh the pycnometer and the fixture. Record this mass in column B of the worksheet.

9.2.3.16 Repeat steps 9.2.3.6 to 9.2.3.15 for the second 1000 ± 10 gram sample, Sample B.

9.2.3.17 Average the mass in each column of the worksheet, for Sample A and Sample B.

9.2.3.18 Record the average weight of the pycnometer from section 7.3.6 in column C.

9.2.4 *Determine Apparent Specific Gravity:*

9.2.4.1 Set the vacuum device according to manufacturers recommendation.

9.2.4.2 Use one small and one large plastic bag. Inspect both bags to make sure there are no holes, stress points or side seal discontinuities in the bag. If any of the above conditions are noticed, use another bag.

9.2.4.3 Weigh both bags and record the mass in column D of the worksheet.

Note 5—Always handle the bag with care to avoid creating weak points and punctures.

9.2.4.4 Weigh the two rubber sheets and record the mass in column E.

9.2.4.5 Weigh 2000 ± 10 grams of aggregate and record the mass in column F.

9.2.4.6 Place the sample in the small bag. When filling, support the bottom of the bag on a smooth tabletop to protect against puncture and impact points.

9.2.4.7 Place the large bag into the vacuum chamber, then place one of the rubber sheets inside the large bag. The rubber sheet should be flat, centered, and pushed all the way to the back of the large bag.

9.2.4.8 Place the small bag containing the sample into the large bag centered on top of the rubber sheet. Manually spread the sample inside the small bag. Be sure the area taken up by the sample inside the small bag remains completely contained within the area of the rubber sheets. Lightly spray mist aggregates with high minus 75-µm (No. 200) sieve material to hold down dust prior to sealing.

9.2.4.9 Place the other rubber sheet on top of the small bag, inside the large bag. The small bag should be between the two rubber sheets.

9.2.4.10 Place the open end of the large external bag over the seal bar and close the chamber door. Make certain the rubber sheets are not over the seal bar.

9.2.4.11 After the chamber door opens, gently remove the sample from the chamber. Immediately place the sample in the water, for water displacement analysis.

9.2.4.12 Cut one corner of the bag, approximately 70 to 100 mm (3 to 4 in.) from the side. Make sure the bag is completely submerged before cutting. Introducing air into the bag will produce inaccurate results.

9.2.4.13 Open the cut portion of the large bag and the small bag with your fingers and hold open for 25 seconds. Allow water to freely flow into the bags. Allow any small residual air bubbles to escape from the bags.

9.2.4.14 After water has filled in, cut the other corner of the bag approximately 70 to 100 mm (3 to 4 in.). Squeeze any residual air bubbles out of the cut corners by running your fingers across the top of the bag. Do not completely remove corners from bag nor allow any portion of the bag to reach the surface of the water.

9.2.4.15 Place the bags containing the rubber sheets and the aggregate on the provided weighing basket under water. You may fold the bag to place it on the basket. However, once on the basket under water, unfold the bag and allow water to freely flow into the bag.

9.2.4.16 Make certain the bag or the sample are not touching the bottom, the sides, or floating out of the water tank. If the bag contacts the tank during mass measurement, it will negatively impact the results of this test. Allow the sample to stay in the water bath for a minimum of twenty (20) minutes.

9.2.4.17 Record the submerged mass in column G of the worksheet.

9.2.4.18 Results may be obtained using software developed by the equipment manufacturer. Alternatively, users can develop their own software and correlations for calculation of the results with equations given in section 10.0.

10. CALCULATIONS

10.1 *Initial Specific Gravity:*

10.1.1 *Initial Bulk Specific Gravity*—Calculate the bulk specific gravity, 25°C (77°F) as follows:

$$\text{Cor G}_{\text{sb}} = \frac{A}{C-(B-A)} \qquad (1)$$

where:

A = Mass of oven-dry sample 1 in air, g
B = Mass of pycnometer and oven-dry sample in water, g
C = Mass of plastic bag(s), g
D = Mass of 2 rubber sheets, g
E = Mass of oven-dry sample 2 in air, g
F = Mass of saturated sample 2 in water, g
ρ_{bag} = Density of plastic bag(s)
ρ_{rbr} = Density of rubber sheets

10.1.2 *Initial Apparent Specific Gravity*—Calculate the bulk specific gravity, 25°C (77°F) as follows:

$$\text{Cor G}_{\text{sa}} = \frac{F}{(D+E+F-G)-(D/\rho_{bag}-E/\rho_{rbr})} \qquad (2)$$

10.1.3 *Initial Absorption*—Calculate the absorption, percent, as follows:

$$\text{Cor Abs} = \frac{CorG_{sa}-CorG_{sb}}{CorG_{sa}\times CorG_{sb}}\times 100 \qquad (3)$$

10.1.4 *Initial Bulk Specific Gravity (Saturated-Surface-Dry)*—Calculate the bulk specific gravity, 25°C (77°F) on the basis of saturated-surface-dry aggregate as follows:

$$\text{Cor G}_{\text{sb}}\text{(SSD)} = (1+CorAbs/100)\times CorGsb \qquad (4)$$

10.2 Predicted properties account for the effects of absorption during the measurement of the dry aggregate volume by correlating the results to those obtained by T 85 using absorption. When an aggregate does not contain a coarse fraction, e.g. natural sand, T 84 absorption may be used. The result of equations 1 and 2 are used to calculate the following:

Note 6—Development of regression equations for correlation of properties may be found in Missouri Department of Transportation Report OR06.016. These equations may be substituted for correlation to local aggregates.

10.2.1 *Predicted Bulk Specific Gravity*—

$$G_{sb} = 0.342355 + 0.8751137 CorG_{sb} - 0.051843 Abs_{T85} \quad (5)$$

where:

Abs_{T85} = Absorption from T 85

10.2.2 *Predicted Apparent Specific Gravity*—

$$G_{sa} = 0.24680896 + 0.90993947 CorG_{sa} - 0.02031058 Abs_{T85} \quad (6)$$

10.2.3 *Predicted Absorption*—

$$\text{Abs} = \frac{G_{sa} - G_{sb}}{G_{sa} \times G_{sb}} \times 100 \quad (7)$$

10.2.4 *Predicted Bulk Specific Gravity (Saturated-Surface-Dry)*—

$$G_{sb}\,(\text{SSD}) = (1 + Abs/100) \times G_{sb} \quad (8)$$

10.3 *Average Specific Gravity Values*—When the sample is tested in separate size fractions, the average value for bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity can be computed as the weighted average of the values as computed in accordance with Section 9.1 using the following equation:

$$G = \frac{1}{\frac{P_1}{100\,G_1} + \frac{P_2}{100\,G_2} + \cdots \frac{P_n}{100\,G_n}} \quad (9)$$

where:

G = average specific gravity (All forms of expression of specific gravity can be averaged in this manner.);

$G_1, G_2 \ldots G_n$ = appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged; and

$P_1, P_2 \ldots P_n$ = mass percentages of each size fraction present in the original sample.

Note 7—Some users of this method may wish to express the results in terms of density. Density may be determined by multiplying the bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity by the density of water (997.5 kg/m^3 or 0.9975 Mg/m^3 or 62.27 lb/ft^3 at 23ºC). Some authorities recommend using the density of water at 4ºC (1000 kg/m^3 or 1.000 Mg/m^3 or 62.43 lb/ft^3) as being sufficiently accurate. Results should be expressed to three significant figures. The density terminology corresponding to bulk specific gravity, bulk specific gravity (SSD), and apparent specific gravity has not been standardized.

10.4 *Average Absorption*—Calculate the percentage of absorption, as follows:

$$\text{Absorption, percent} = [(B - A)/A] \times 100 \quad (10)$$

10.5 *Average Absorption Value*—When the sample is tested in separate size fractions, the average absorption value is the average of the values as computed in Section 9.3, weighted in proportion to the mass percentages of the size fractions in the original sample as follows:

$$A = (P_1 A_1 / 100) + (P_2 A_2 / 100) + \cdots (P_n A_n / 100) \quad (11)$$

where:

A = average absorption, percent;

$A_1, A_2 \ldots A_n$ = absorption percentages for each size fraction; and

$P_1, P_2 \ldots P_n$ = mass percentages of each size fraction present in the original sample.

11. REPORT

11.1 Report predicted specific gravity results to the nearest 0.001, and indicate the type of specific gravity, whether bulk, bulk (SSD), or apparent.

11.2 Report the predicted absorption result to the nearest 0.1 percent.

X1. WORKSHEET

(Fine Aggregate Only) Mass of pycnometer and fixture filled with water.

1._________ 2. __________ 3. ___________ Avg. __________

(Coarse Aggregates Only) Mass of pycnometer filled with water.

1. _________ 2. __________ 3. ___________ Avg. __________

Sample Number or Label	Trial Number	Aggregate Grade (Coarse or Fine)	A Dry Sample Mass (g)	B Sample Mass in Pycnometer Filled with Water (g)	C Mass of Pycnometer Filled with Water-Avg. (g)	D Bag Mass (g)	E Mass of Two (2) Rubber Sheets (g)	F Dry Sample Mass (g)	G Mass of Sealed Sample Opened Under Water
	Sample A								
	Sample B								
	Re-test								
	Avg								
	Sample A								
	Sample B								
	Re-test								
	Avg								
	Sample A								
	Sample B								
	Re-test								
	Avg								
	Sample A								
	Sample B								
	Re-test								
	Avg								

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:

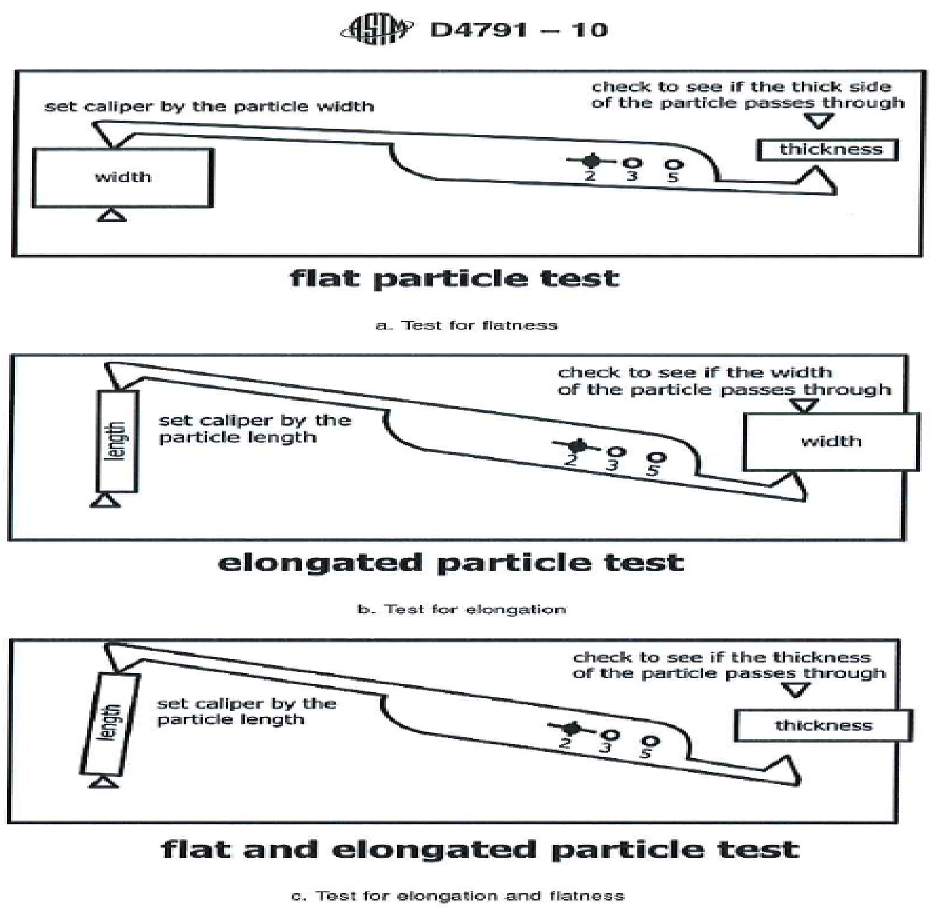


FIG. 4 Use of Proportional Caliper

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.

2023 – THERMOMETERS

- **AASHTO T85**:
  - **T85 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type T, Class 1
      - Dial gauge metal stem (Bi-metal) thermometer

  - **T85 Water Bath**: The thermometer for measuring the temperature of the water bath shall meet the requirements of M339M/M339 with a temperature range of at least 16 to 27°C (60 to 80°F) and an accuracy of ±0.5°C (±0.9°F) (see note 2),
    - NOTE 2: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM E2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type T, Special
      - IEC 60584: thermocouple thermometer, Type T, Class 1

2023 – THERMOMETERS CONTINUED . . .

- **AASHTO T84:**
  - **T84 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
      - IEC 60584 thermocouple thermometer, Type j or K, Class1, Type T any Class
      - Dial gauge metal stem (Bi-metal) thermometer
  - **T84 Water Bath**: The thermometer for measuring the temperature of the water bath shall meet the requirements of M339M/M339 with a temperature range of at least 16 to 27°C (60 to 80°F) and an accuracy of ±0.5°C (±0.9°F) (see note 2),
    - NOTE 2: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM E2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type T, Special
      - IEC 60584: thermocouple thermometer, Type T, Class 1
      - Dial gauge metal stem (Bi-metal) thermometer

2023 – THERMOMETERS CONTINUED . . .

- **AASHTO T84**:
  - **T84 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
    - NOTE 1: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
      - IEC 60584 thermocouple thermometer, Type j or K, Class1, Type T any Class
      - Dial gauge metal stem (Bi-metal) thermometer

  - **T84 Water Bath**: The thermometer for measuring the temperature of the water bath shall meet the requirements of M339M/M339 with a temperature range of at least 16 to 27°C (60 to 80°F) and an accuracy of ±0.5°C (±0.9°F) (see note 2),
    - NOTE 2: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM E2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type T, Special
      - IEC 60584: thermocouple thermometer, Type T, Class 1
      - Dial gauge metal stem (Bi-metal) thermometer

The following have been used on materials that do not readily slump:

1. Provisional Cone Test - Fill the cone mold as described in the presentation for T84, except only use 10 drops of the tamper. Add more fine aggregate and use 10 drops of the tamper again. Then add material two more times using three and two drops of the tamper, respectively. Level off the material even with the top of the mold, remove loose material from the base, and lift the mold vertically.

2. **Provisional Surface Test** – If airborne fines are noted when the fine aggregate is such that it will not slump when it is at a moisture condition, add more moisture to the sand, and at the onset of the surface-dry condition, with the hand lightly pat approximately 100g of the material on a flat, dry, clean, dark, or dull nonabsorbent surface such as a sheet of rubber, a worn oxidized, galvanized, or steel surface, or a black-painted metal surface. After 1 to 3 seconds, remove the fine aggregate. If noticeable moisture shows on the test surface for more than 1 to 2 seconds, then surface moisture is considered to be present on the fine aggregate.

3. Colorimetric procedures described by Kandhal and Lee, Highway Research Record No. 307, page 44.

4. For reaching the SSD condition on a **single-size material** that slumps when wet, hard-finish paper towels can be used to surface-dry the material until the point is just reached where the paper towel does not appear to be picking up moisture from the surfaces of the fine aggregate particles.

Glossary

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 ± 5ºC 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.