AGGREGATE TESTING 101

Ohio Aggregates & Industrial Minerals Association

LARRY SHIVELY
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QUALITY CONTOL

AGGREGATE TESTING 101

In all aspects of aggregate production some type of testing has to be done depending on the use and the customer's demands.

The purpose of this presentation is to show the various common tests that can be performed.

It is not intended to show all the detailed procedures involved in aggregate testing.

AGGREGATE TESTING 101

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- Stationary Stacker Conveyor

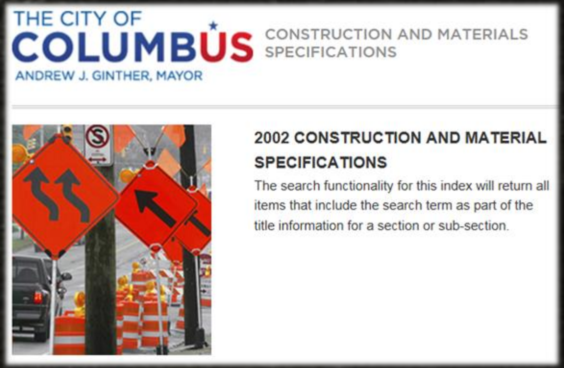
- Radial Stacker Conveyor

- Telescoping Radial Stacker

- Truck

AGGREGATE TESTING 101

Almost all specs have some type of aggregate testing requirements.



Franklin County Engineer's Office

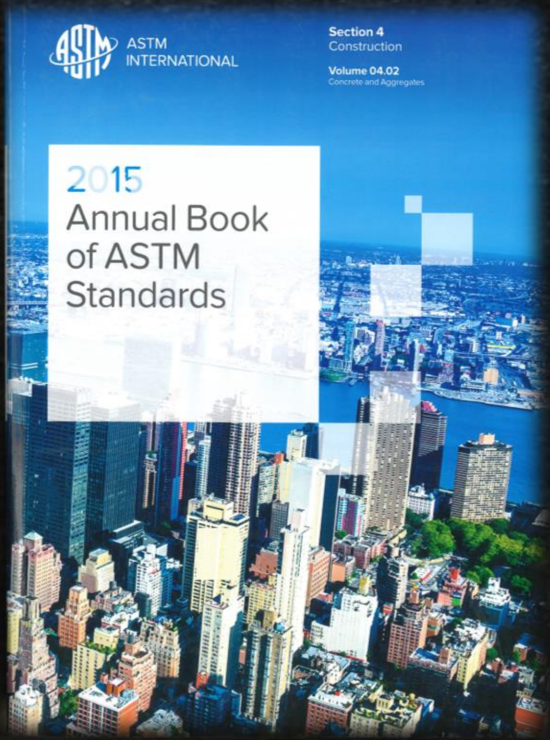
Dean C. Ringle, P.E., P.S.

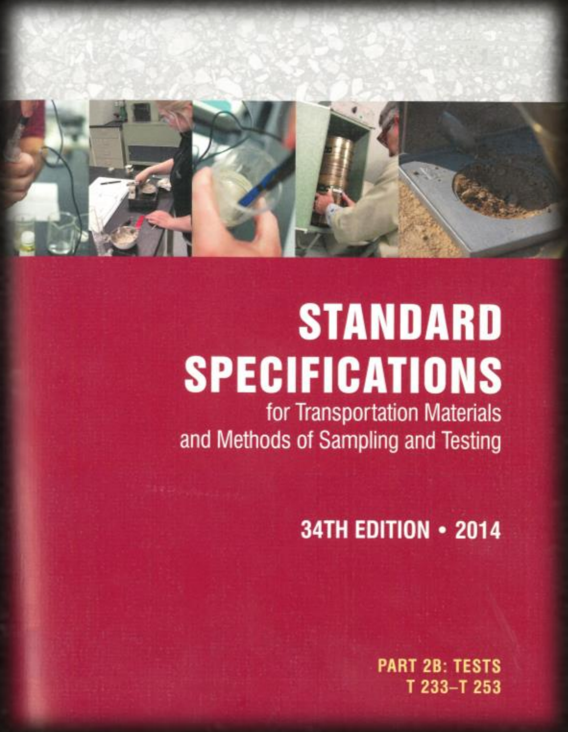
"A tradition of excellence"

PART 5 – FLEXIBLE SURFACE COURSES (MS Word)	ITEM P-401 HOT MIX ASPHALT (HMA) PAVEMENTS
	ITEM P-403 HOT MIX ASPHALT (HMA) PAVEMENTS (Base, Leveling or Surface Course)

AGGREGATE TESTING 101

Most aggregate test procedures are covered in AASHTO or ASTM standards. There can be some slight differences in the two.





Aggregate Specifications-section 703

ODOT COVERS MOST OF THE AGGREGATE TESTING AND SPECIFICATIONS AND MANY CUSTOMERS REFERENCE ODOT.

703.01

C. Size. Provide aggregate according to the size specified in the material specification, the construction item, or as shown in AASHTO M 43.

D. Method of Test. Provide aggregate tested by the following methods:

Amount finer than No. 200 (75 µm) sieve	S1004
Clay lumps	S1017
Coal and lignite	AASHTO T 113
Crushed pieces	ASTM D 5821
Deleterious materials	S1029
Effect of organic impurities on strength of mortar	AASHTO T 71
Liquid limit	AASHTO T 89
Percent of wear, Los Angeles abrasion test	AASHTO T 96 or ASTM C 535
Plasticity index	AASHTO T 90
Sieve analysis	S1004, S1005
Sieve analysis of mineral filler	AASHTO T 37
Sodium sulfate soundness test, 5 cycle	AASHTO T 104
Specific Gravity and percent absorption for fine and coarse aggregate	S1031
Unit weight	AASHTO T 19
Lightweight chert in aggregates	AASHTO T 113
Sand equivalent	AASHTO T 176
Uncompacted void content	AASHTO T 304
Flat and elongated	ASTM D 4791
Rapid freezing and thawing	ASTM C 666, Procedure B
Insoluble residue of carbonate aggregates	ASTM D 3042
Compaction testing of Unbound Materials	S1015
In place gradation sampling	S1090
Sulfur leachate test	S1027
Soundness of aggregate by freezing and thawing	AASHTO T 103
Micro-Deval	AASHTO T 327
Silicon Dioxide	ASTM C 146
Sodium sulfate soundness test, Rock slabs	ASTM D 5240

ODOT Supplement

- Have additional information specific to ODOT specs
- May reference AASHTO or ASTM

SUPPLEMENT 1004
METHOD OF TEST FOR SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (AASHTO METHOD T 27 MODIFIED)

July 15, 2011

1004.01 Scope. This method of test covers the requirements in addition to or superseding the requirements of AASHTO T 11 AND T 27 for the determination of the particle size distribution of fine and coarse aggregates. This method of test does not apply to the sieve analysis of aggregates recovered from bituminous mixtures nor to the sieve analysis of mineral fillers.

Document Type : Supplement (122)

1001	1/15/2016	Approval and Testing of Air Entraining Agents and Chemical Admixtures for Concrete	1001_01152016_for_2016	None
1002	10/20/2006	Archiving of Shop Drawings	1002_10202006_for_2016	None
1003	7/17/2015	High Voltage Direct Current Test Procedure	1003_07172015_for_2016	None
1004	7/15/2011	Method of Test for Sieve Analysis of Fine and Coarse Aggregates (AASHTO Method T 27 Modified)	1004_07152011_for_2016	None
1005	12/31/2012	Sieve Analysis for all Materials in 304, 411, 611 Type 1 & 2 , and 617	1005_12312012_for_2016	None
1006	4/15/2005	Plastic Limit Determination of Soil- Aggregate Materials for Use in Items 304, 310, 411, and 617	1006_04152005_for_2016	None
1007	4/19/2002	Testing of Agricultural Liming Materials	1007_04192002_for_2016	None
1008	7/21/2017	Method of Test For Glass Beads	1008_07212017_for_2016	None
1009	4/15/2005	Method of Test Weight of Coating on Zinc- Coated (Galvanized) or Aluminum-Coated Iron or Steel Articles	1009_04152005_for_2016	None
1010	10/20/2006	Micro-Deval Quality Acceptance of Aggregate	1010_10202006_for_2016	None
1011	7/15/2016	ODOT Revision to AASHTO/AWS Bridge Welding Code D1.5	1011_07152016_for_2016	None
1013	10/21/2016	Methods of Testing Asphalt Emulsions	1013_10212016_for_2016	None
1014	1/15/2016	Methods Of Testing Cut-Back Asphalt Emulsions	1014_01152016_for_2016	None
1015	4/21/2017	Compaction of Unbound Materials	1015_04212017_for_2016	None
1016	1/20/2017	Carbonate Micro-Fines Certification	1016_01202017_for_2016	None
1017	4/17/2009	Method Of Test For Clay Lumps In Aggregate	1017_04172009_for_2016	None

EACH SECTION IN SECTION 703 LISTS THE TESTS REQUIRED AND THE TEST LIMITS.

- **703.02 CONCRETE AGGREGATE**

703.02 Aggregate for Portland Cement Concrete.

A. Fine Aggregate.

1. Provide fine aggregate consisting of natural sand or sand manufactured from stone.

2. Sieve analysis.

Sieve Size	Total Percent Passing
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	70 to 100
No. 16 (1.18 mm)	38 to 80
No. 30 (600 µm)	18 to 60
No. 50 (300 µm)	5 to 30
No. 100 (150 µm)	0 to 10
No. 200 (75 µm)	0 to 5

Should the fineness modulus of a job control sample of sand from any source vary by more than 0.20 percent from that of the representative sample from that source, the sand may be rejected.

3. Physical properties.

	Maximum
Loss, sodium sulfate soundness test	
Item 305	12 %
Items 255, 256, 451, 452, 511, 515, 519, 526, 602, 611, 604, 608, 609, 610, 622, and 625	10 %
Aggregations of soil, silt, etc. by weight	0.5 %

When tested for the effect of organic impurities on strength of mortar, ensure that the compressive strength at 3 and 7 days of mortar made with untreated sand is not less than 95 percent of the compressive strength of mortar made with treated sand.

Provide fine aggregate for Items 255, 256, 451, 452, 526, and 511 deck slabs with at least 25 percent siliceous particles as determined by the acid insoluble residue test [ASTM D3042]. Ensure material has been tested and results are on file at the Laboratory. For sources not tested and on file at the laboratory, submit certified test data from an AMRL accredited independent laboratory verifying the minimum 25 percent.

B. Coarse Aggregate.

- **703.05 ASPHALT AGGREGATE**

703.05 Aggregate for Asphalt Concrete (Intermediate and Surface Courses), Prime Coat (408), **Chip Seal** (422), **and Microsurfacing** (421).

A. Fine Aggregate.

1. Provide fine aggregate consisting of natural sand or sand manufactured from stone, gravel, ACBFS or, for intermediate courses only, steel slag (OH, EAF or BOF) conforming to 703.01.E and 401.03.

2. Sieve analysis.

Standard 703.05 Gradation

Sieve Size	Total Percent Passing
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	90 to 100
No. 8 (2.36 mm)	65 to 100
No. 16 (1.18 mm)	40 to 85
No. 30 (600 µm)	20 to 60
No. 50 (300 µm)	7 to 40
No. 100 (150 µm)	0 to 20
No. 200 (75 µm)	0 to 10

Screenings

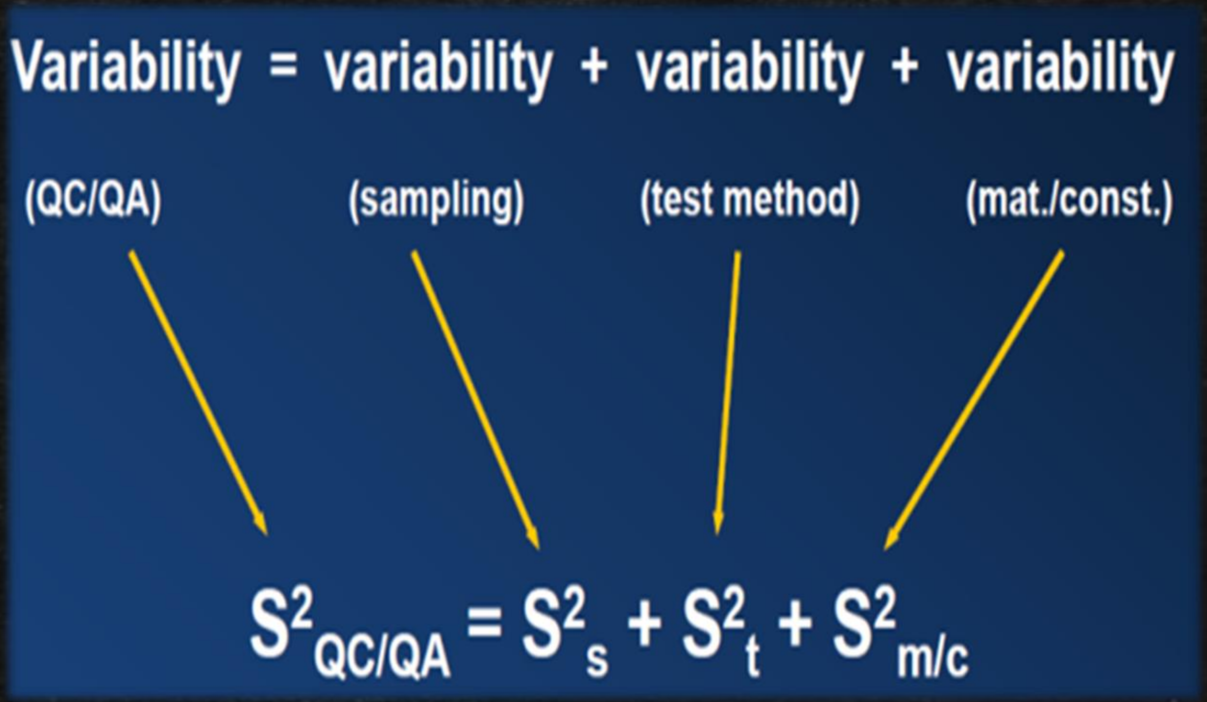
Sieve Size	Total Percent Passing
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	85 to 100
No. 100 (150 µm)	10 to 30

3. Physical properties.

	Maximum
Loss, sodium sulfate soundness test	15 %
Aggregations of soil, silt, etc., by weight	0.5 %

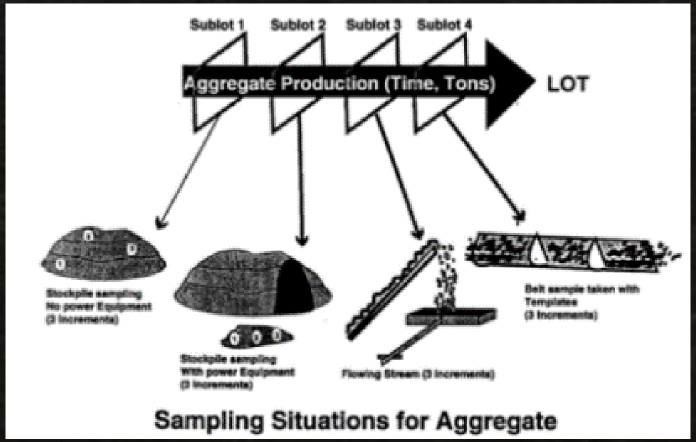
AGGREGATE TESTING 101-before you test you have to sample the product!

- Proper sampling is the first step of testing any product
  - **Quality of the Sample => Quality of the Test Result!**
- Other variability components often overshadow the result
  - Sampling and Testing variability is ~50% in most cases
- Objective: Eliminate the unnecessary variability



Possible Sampling Locations

- **Aggregate Plant**
  - Conveyor Belt
    - Manual/Automatic
    - Flow of Material from Belt
  - Bin
    - Flow of Material from Bin
  - Stockpile
- **Roadway**
  - After placement (e.g., road base)
- **Truck**
- **Railcar**
- **Barge**



Stockpile Sampling-detailed procedure

- Different methods of sampling stockpiles
- Best to sample stockpiles as they are being built or as material is being removed
- Preferred stockpile sampling procedure
  - Use loader to dig as far inside the pile as possible at multiple sites
  - Blend dug out material into miniature stockpile
  - Take multiple increments from the miniature stockpile to comprise field sample

The Shelly Company

Oldcastle Materials

Aggregate Testing 101

Aggregate Testing

- Physical Testing (size, weight, shape, cleanliness)
  - Specific Gravity and Absorption
  - Angularity (Fractured face and fine aggregate angularity)
  - Particle Shape (Flat and Elongated)
  - Sand Equivalent
  - Methylene Blue
  - Deleterious Materials (Clay Lumps and Friable Particles)
  - Grading-Unit Wt
- Mechanical Testing (strength, stiffness, resistance to deformation)
  - Hardness (Los Angeles Abrasion)
  - Micro Deval Abrasion
  - Soundness (Sodium or Magnesium Sulfate)
  - Polishing

Physical Testing

Specific Gravity and Absorption

Specific Gravity & Absorption

- **One of the most important properties**
- Bridge between mass and volume
- Specific gravity (G_s) is the ratio of aggregate weight to the weight of an equal volume of water
  - Dimensionless number (no units attached)
- ASTM C127, AASHTO T85 (coarse) / ASTM C128, AASHTO T84 (fine)

Specific Gravity & Absorption- Coarse

- Prepare sample by screening out #4 material
- Wash the material
- Dry

Specific Gravity & Absorption-Coarse Agg

- Specific gravity test is basically testing a given amount of agg in air, water, and at SSD (surface saturated dry).
- Sample prep is important
- Soak time of 15-19 hours

Specific Gravity & Absorption

- SSD condition can be done by the towel method.
- Aggregate should have a dull look
- Not dry
- Only surface moisture removed

"SSD" moisture condition is when all surface permeable voids are filled with no excess surface free moisture

Specific Gravity & Absorption

- A quicker way to achieve SSD is the use of high speed centrifuge (ODOT method)
- The spinning action removes surface moisture
- Can help with turn around time and consistency

Specific Gravity & Absorption

- As soon as SSD is reached weigh the sample
- Then the weight in water is done by suspending the sample in a wire basket in a water bath using an under the bench weighing scale
- Then the sample must be dried again
- Weight in air

Specific Gravity & Absorption

Sequence of test:

- Screen out the minus #4 material (some materials may require the #8)
- Wash the sample
- Dry
- Cover with water 15-19 hours (shoot for 17)
- Towel or Centrifuge to SSD condition
- Weight at SSD
- Submerge and weigh
- Dry and determine dry weight in air

Specific Gravity & Absorption

- Oven dried sample weight is noted as **A**
- SSD weight is noted as **B**
- Under water weight is noted as **C**
- From these 3 weights we can determine:

  Bulk

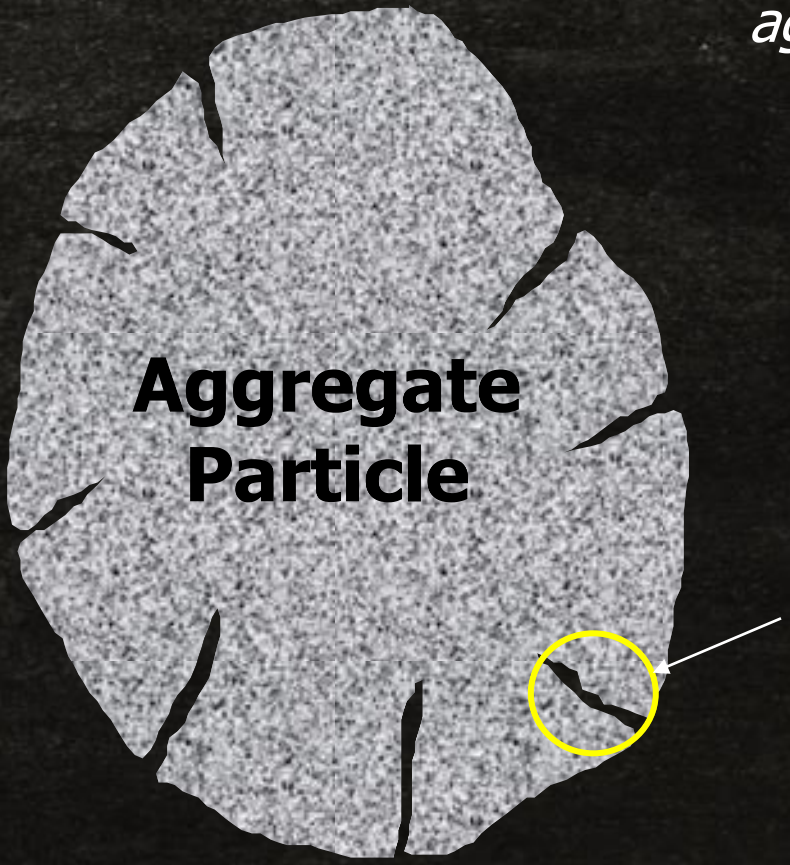
  Bulk SSD

  Apparent

  Absorption

Aggregate Apparent Specific Gravity

Apparent Volume = volume of solid aggregate particle only



not included

A/(A-C)

Oven dried wt **A**

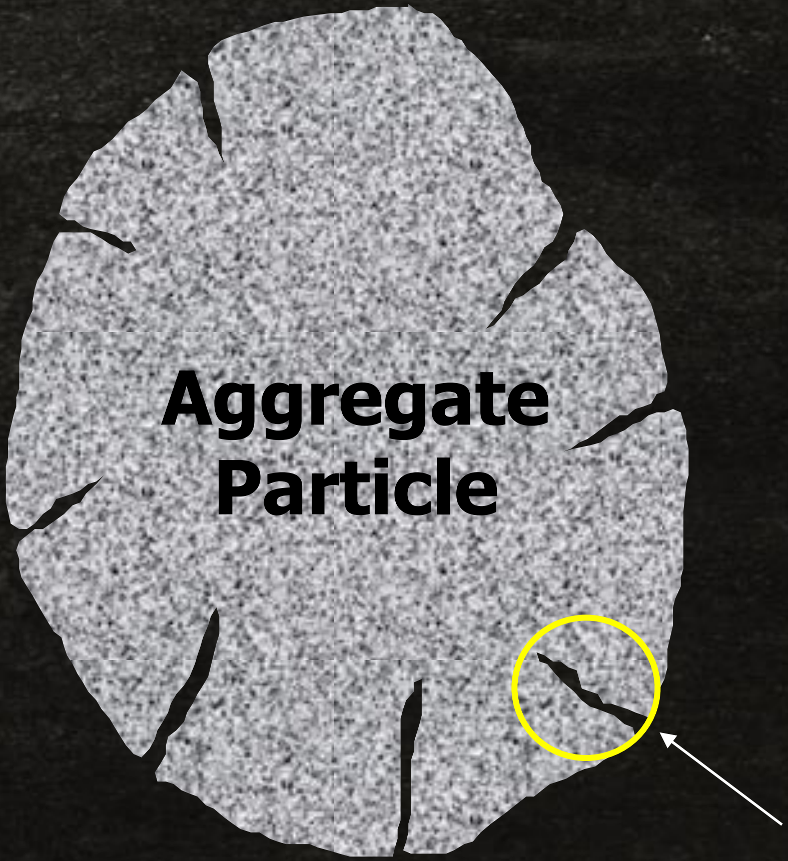
SSD weight **B**

Under water weight **C**

Aggregate Bulk Specific Gravity

$$G_{sb} = \frac{\text{Dry Mass}}{\text{Bulk Vol}}$$

Bulk volume = solid aggregate particle volume + the total water permeable surface void volume



A/(B-C)

Oven dried weight **A**

SSD weight **B**

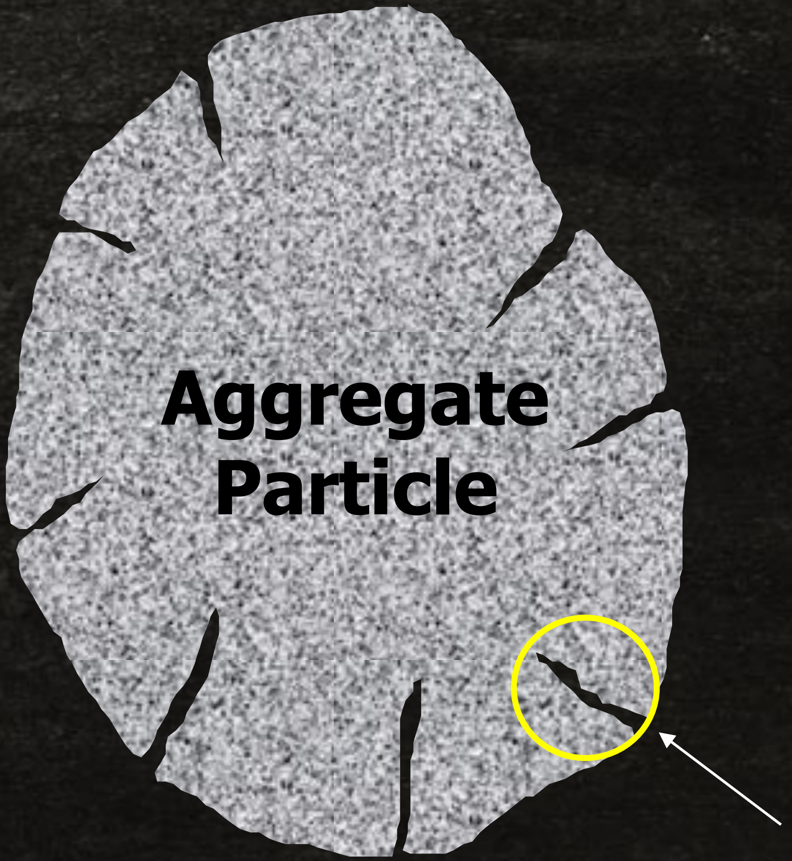
Under water weight **C**

Water permeable surface void included

Aggregate Bulk (SSD) Specific Gravity

$$G_{sb} = \frac{\textbf{SSD Mass}}{\textbf{Bulk Vol}}$$

Bulk volume = solid aggregate particle volume + the total water permeable surface void volume



B/(B-C)

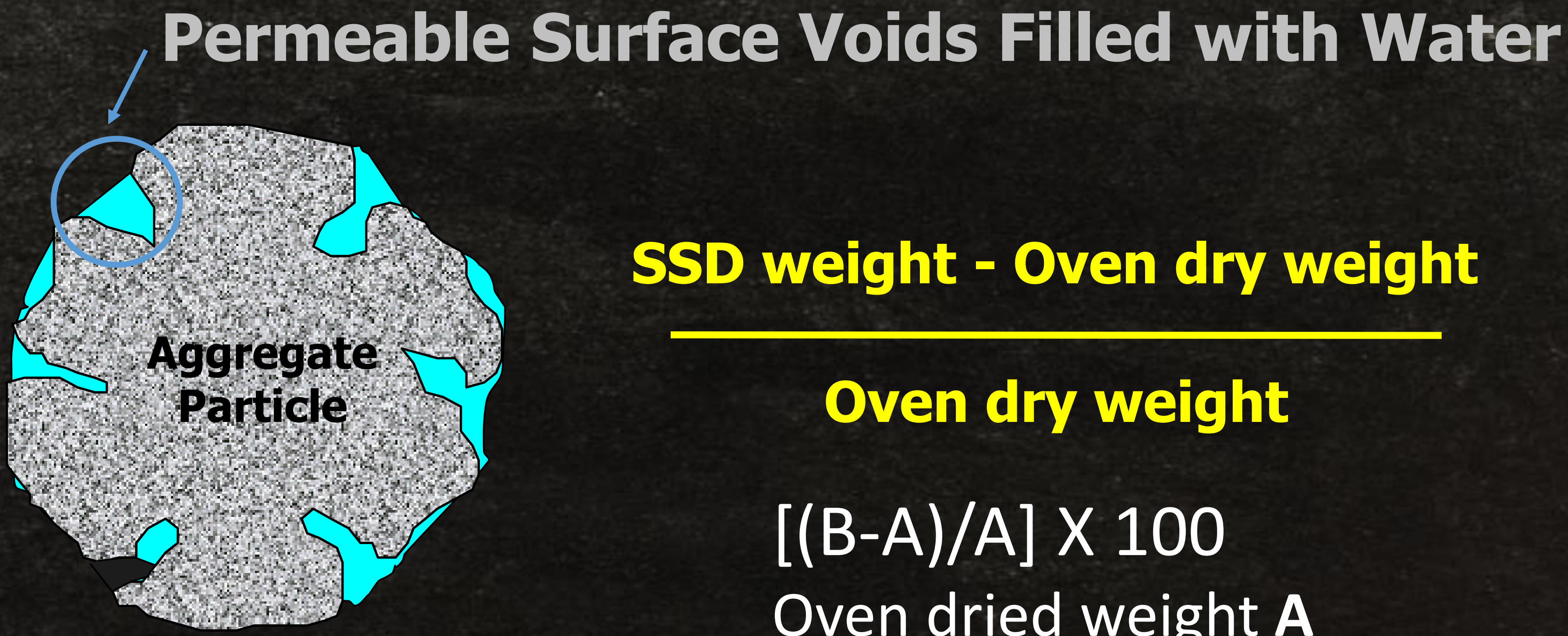
Oven dried weight **A**

SSD weight **B**

Under water weight **C**

Water permeable surface void included

Water Absorption



$$\frac{\textbf{SSD weight - Oven dry weight}}{\textbf{Oven dry weight}}$$

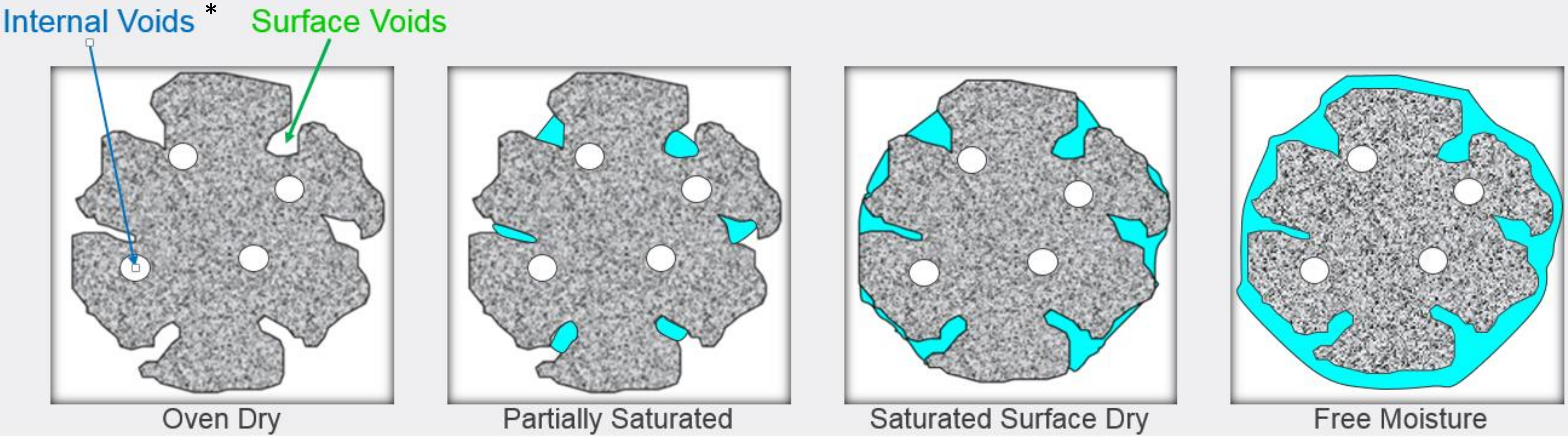
[(B-A)/A] X 100

Oven dried weight **A**

SSD weight **B**

Under water weight **C**

Specific Gravity



***NORMALLY INTERNAL VOIDS ARE NOT CONSIDERED IN AGGREGATES**

Water Absorption

- Absorption is the amount of water absorbed in the permeable surface void space of aggregate particles.
- Absorption is important to asphalt because of the potential to absorb liquid binder.
- Also, it is an indicator of the potential of an aggregate to retain moisture.
- Water absorption and asphalt binder may not occur at the same levels but still is a good indicator.

Coarse Aggregate Specific Gravity Issues

- SSD Determination
  - “The visual method of determining when aggregates reach a SSD condition is subjective and therefore is not consistent from operator to operator. Some operators determine the SSD state based on the shine of the water film while others judge based on a slight color change in the aggregate (3).
- Submerged Mass
  - The submerged mass may not be determined accurately if the sample is not washed correctly. If adherent fines are not removed prior to testing, they can be removed when the SSD sample is shaken while immersed to remove all entrapped air, resulting in an error in the submerged mass.

Fine Aggregate Specific Gravity

- AASHTO T-84 /ASTM C-128
- Same concept as the coarse aggregate specific gravity except for flask used for weight in water, SSD determined by cone and tamp.
- Sample may be washed over the #200.
- Dry
- Soak

DRIED SAMPLE PRIOR TO SOAKING


SAMPLE COVERED WHILE SOAKING

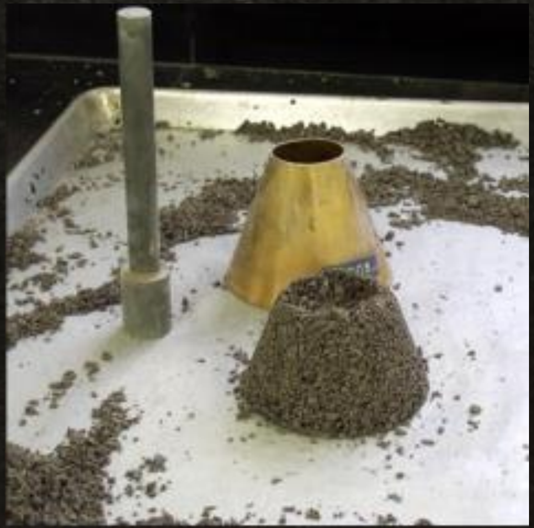

SAMPLE AFTER SOAKING

Fine Aggregate Specific Gravity

- After the soak period decant the water without loss of fines
- SSD will be determined by cone and tamp
- Sample on flat non absorbent surface
- Mold filled to overflowing
- Tamp 25 times, with 5mm drop (free falling)
- SSD is when cone slumps “slightly”-repeat as necessary

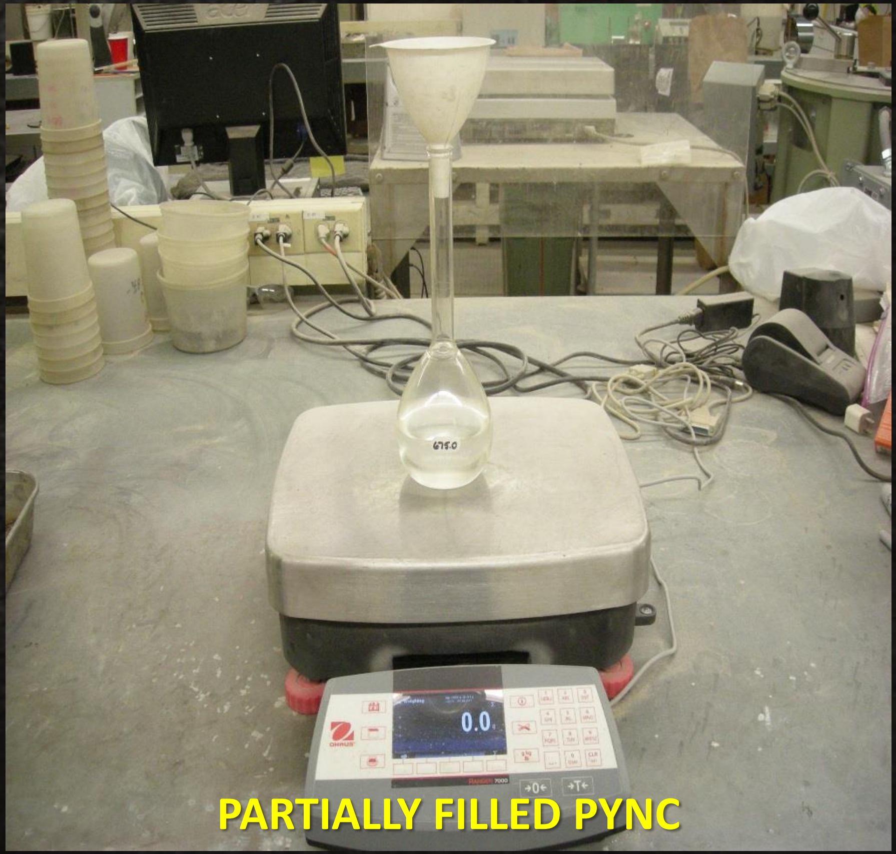
Fine Aggregate Specific Gravity

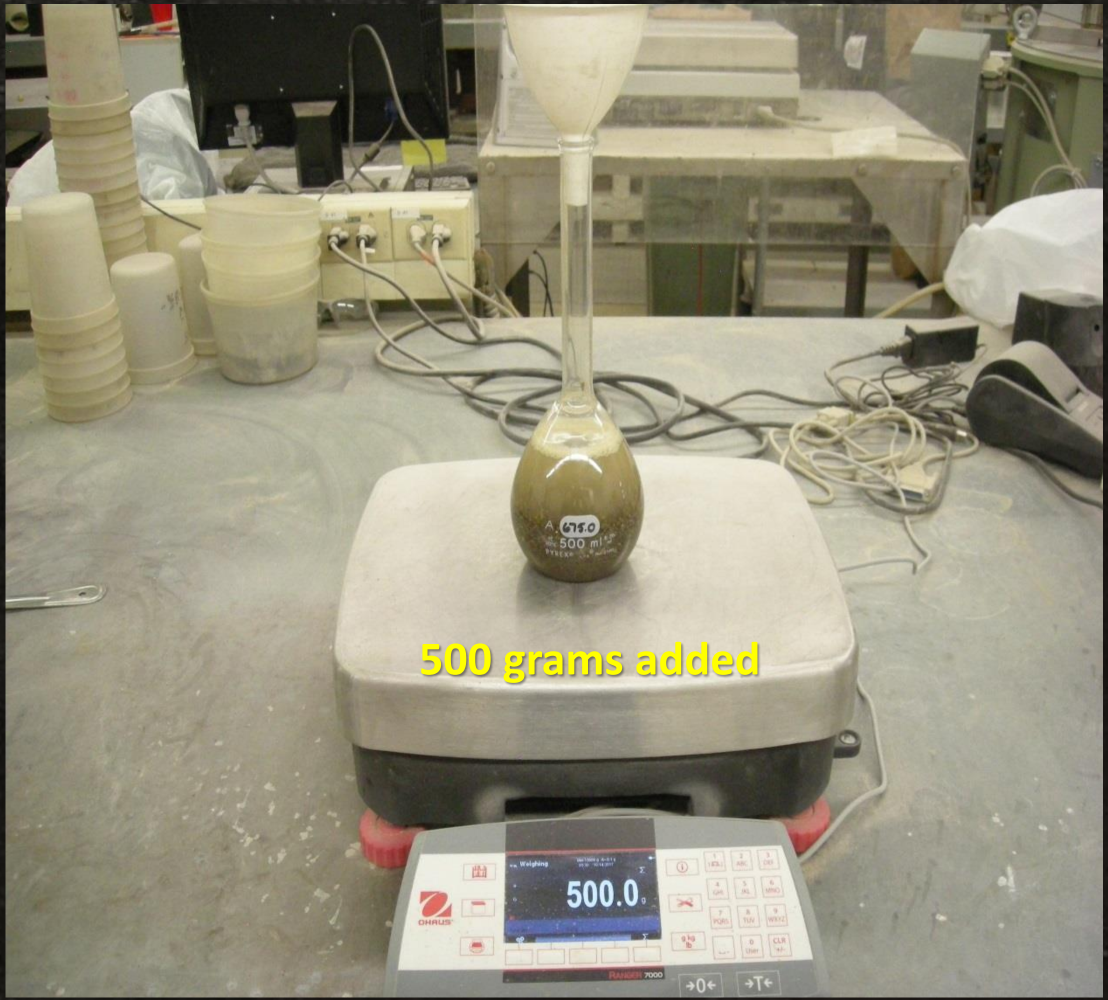
- With some aggregates, the accurate determination of SSD with the cone test is **difficult**
- Angularity and high fines content may make the fine aggregate appear wetter than actual
- Result is the sample being dried past the true SSD condition
- ODOT now allows to wash the fine aggregate over the No. 200 sieve prior to testing



Fine Aggregate Specific Gravity

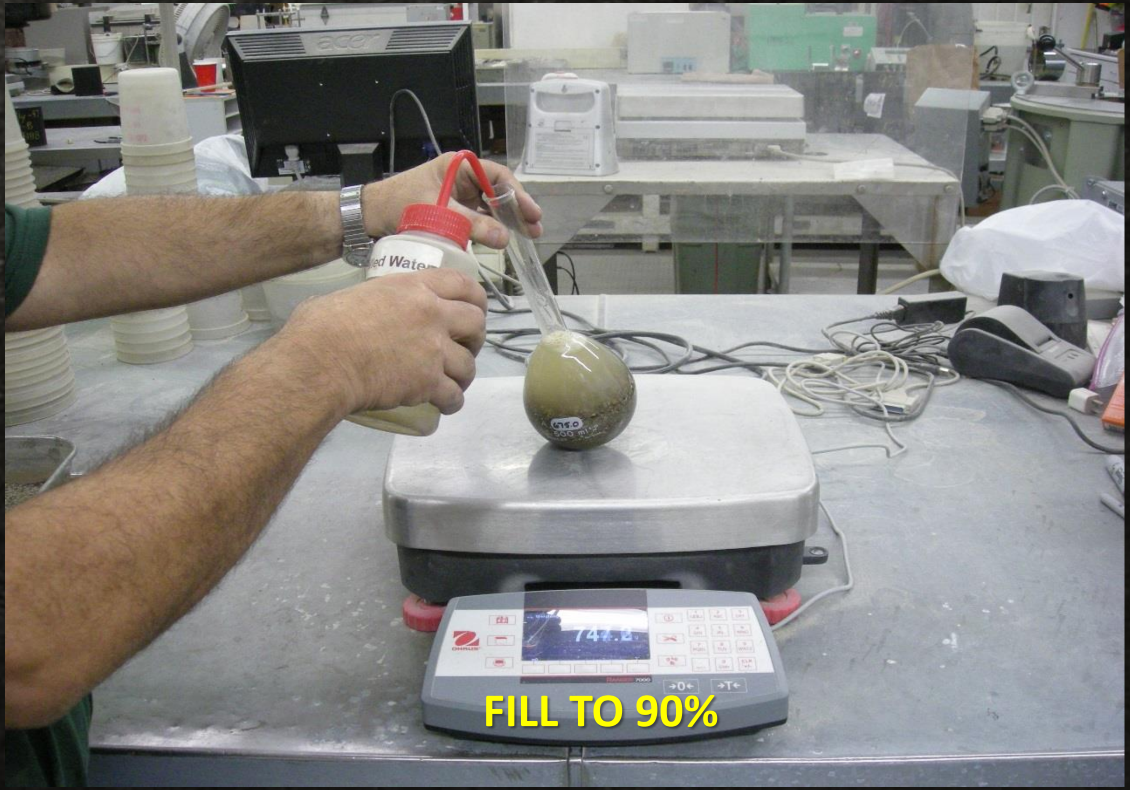
- Pycnometer partially filled with water
- Add 500+-10 grams sample (SSD)





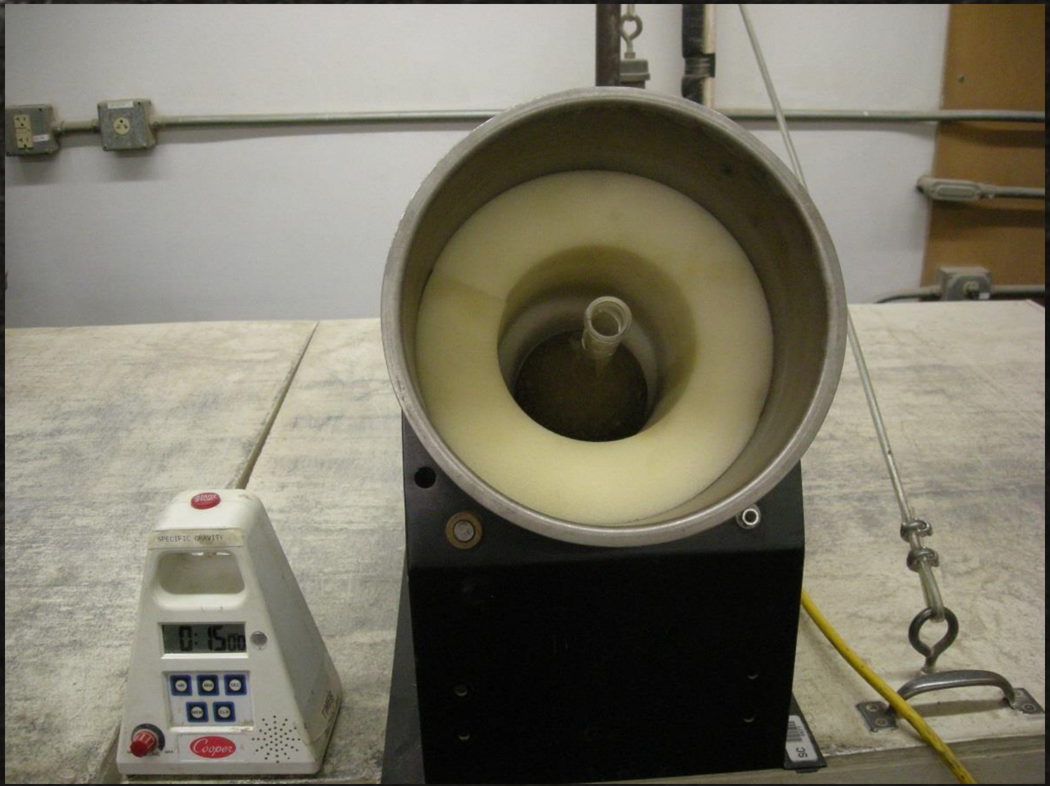
Fine Aggregate Specific Gravity

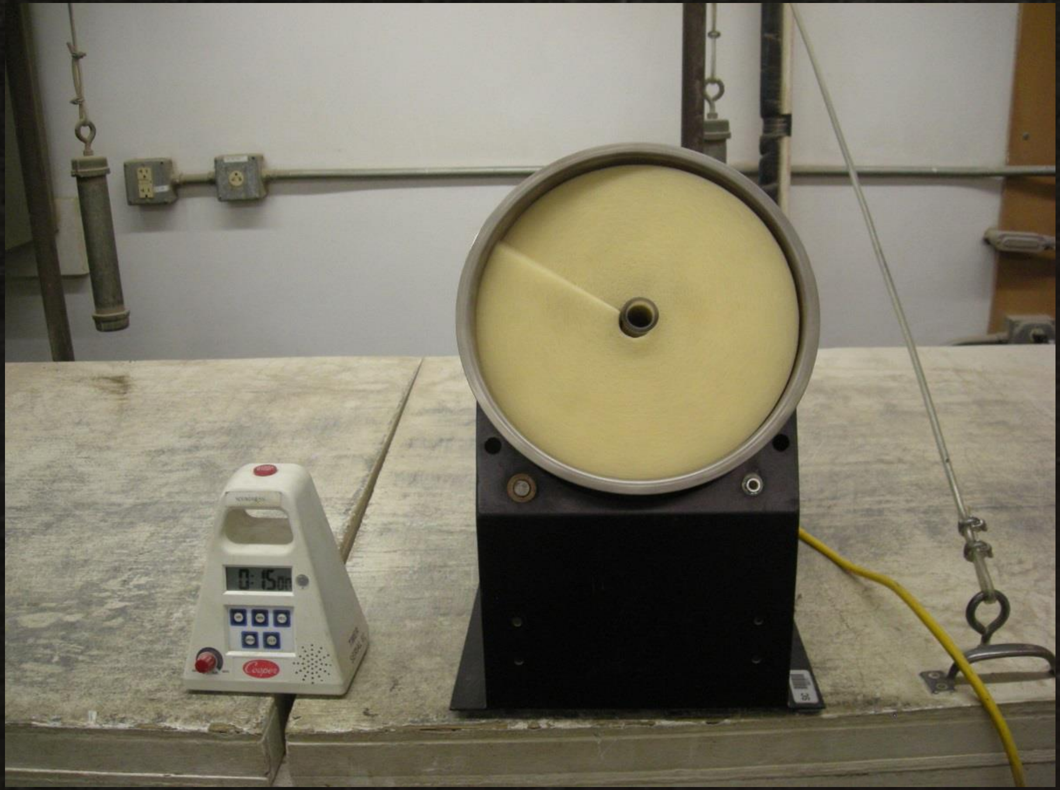
- Pycnometer filled to 90%
- Agitated to eliminate air bubbles



Fine Aggregate Specific Gravity

- Mechanically de-airing is acceptable by using a mechanical aggregate washer with foam inserts.





Fine Aggregate Specific Gravity

- After de-airing add water to the calibration mark of the pycnometer
- Due to possible foaming isopropyl alcohol can be added to disperse the foam so the water can be accurately filled to the mark

Fine Aggregate Specific Gravity

- Fill to calibration mark and weigh
- This pycnometer must be calibrated when empty
- All water must be at 73.4+/-3^{o}F

Fine Aggregate Specific Gravity

- With the known weights of the sample:
  - SSD-**S**
  - Weight in air-**A**
  - Weight of pycnometer water only-**B**
  - Weight of pycnometer water and sample-**C**
- Bulk specific gravity: A/(B+S-C)
- Bulk specific gravity SSD: S/(B+S-C)
- Apparent specific gravity: A/(B+A-C)
- Absorption: [(S-A)/A] x 100

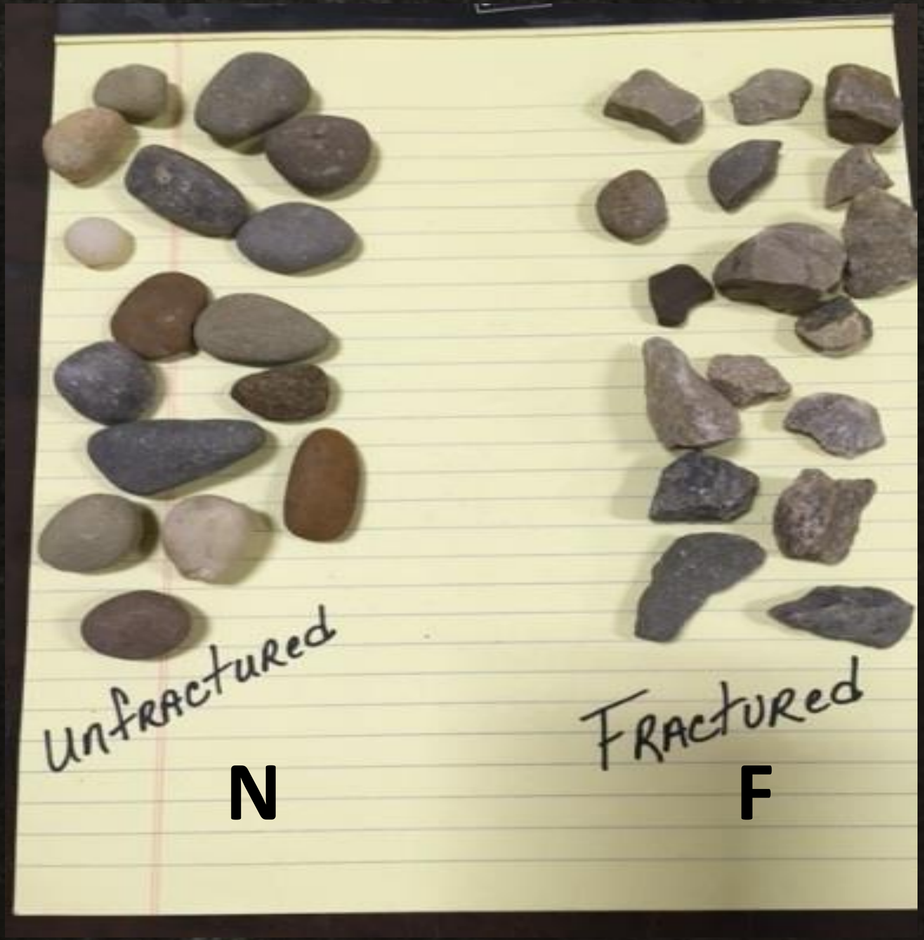
Coarse Aggregate Angularity-Fracture count

- Fractured face (FF) test for coarse aggregate (ASTM D5821/AASHTO T335)
- Minimum sample sizes listed in procedure
- Each particle visually examined
- Each particle separated into group specified by the specification criteria
- Examples: 2 face fracture, 1 face fracture

Fractured Face (Gravels)

Coarse Angularity-% Fractured

- Each particle is examined and must have at least ¼ of the maximum cross-section area of the particle
- Must have sharp & well defined edges
- F=weight or count of fracture pieces
- N=weight or count of pieces not meeting
- Percent of fracture= [F/(F+N)] x 100



Fine Aggregate Angularity-FAA

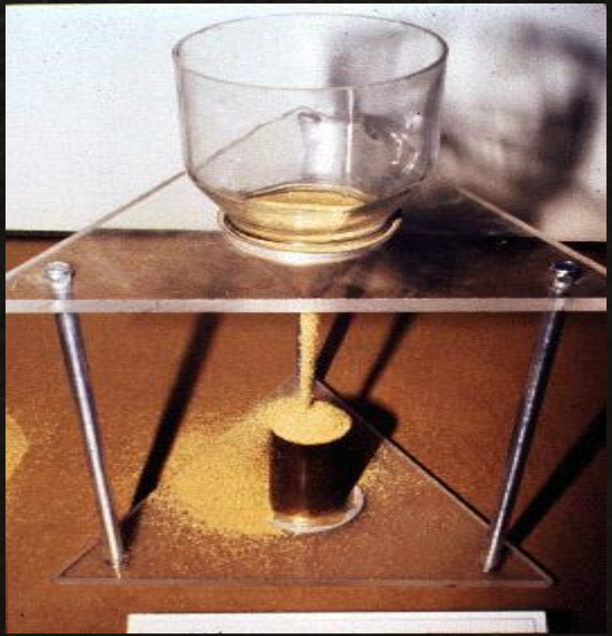
- Fractured face (FF) test for coarse aggregate (ASTM D5821/AASHTO T335) and uncompacted voids (UV), (ASTM C1252/AASHTO T304) for fine aggregate
- Crushed, angular materials typically result in HMA with a higher shear strength and ultimately less rutting
- 44% minimum UV found in Superpave specs

TABLE 442.02-1 GYRATION LEVEL AND MATERIAL REQUIREMENTS

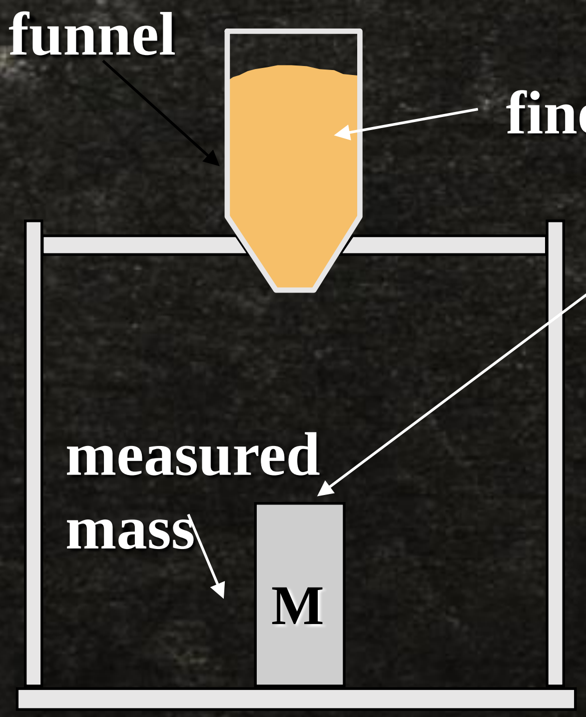
Lane ADTT	Nini	Ndes	Nmax	Coarse Aggregate Angularity	Fine Aggregate Angularity	Flat and Elongated Particles	Sand Equivalent
<4000	7	65	105	95 [1] /90 [2]	44	10	45
>4000	7	65	105	100 [1] /100 [2]	44	10	50

[1] Percent fractured (one or more faces) according to ASTM D5821
[2] Percent fractured (two or more faces) according to ASTM D5821

Uncompacted **Voids or Fine Aggregate** Angularity

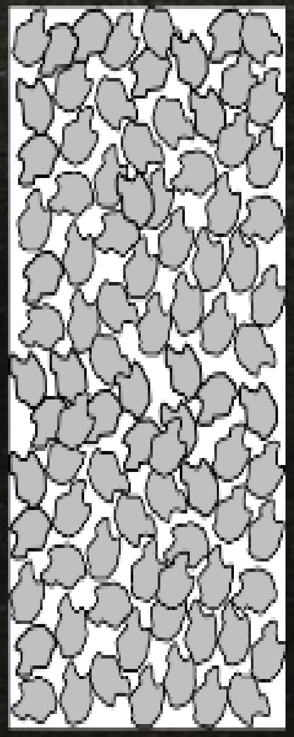


Fine Aggregate Angularity

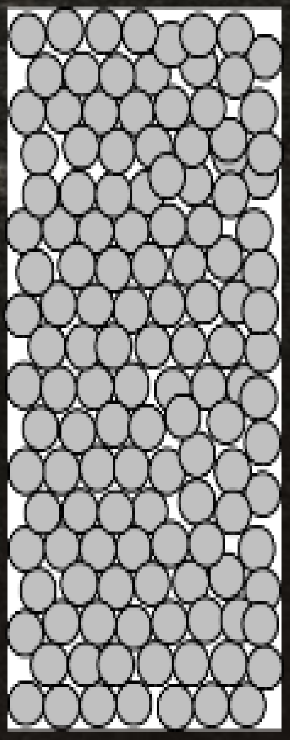


uncompacted voids =

$$\frac{V - M / G_{sb}}{V} \times 100\%$$



~49%



~39%

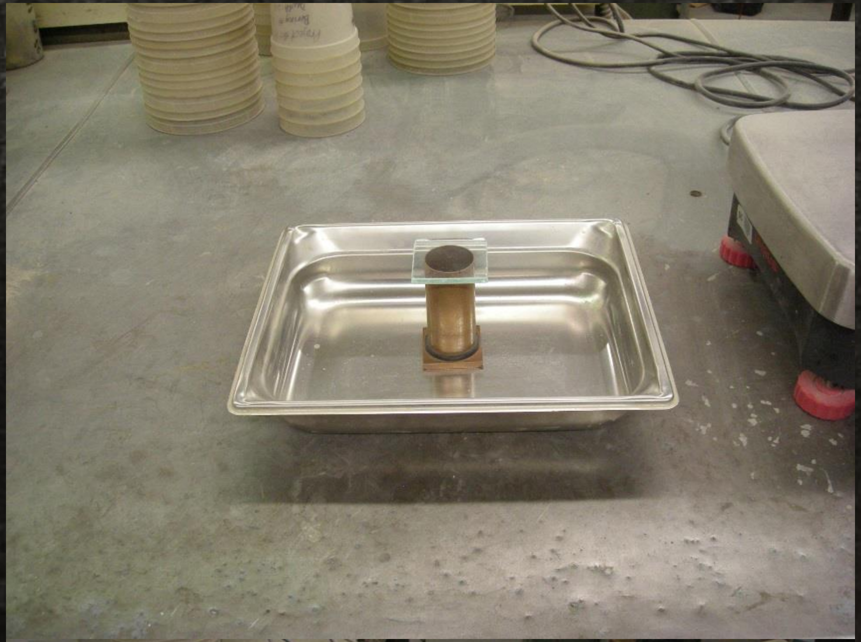
HIGHER VOID CONTENTS TYPICALLY MEAN MORE FRACTURED FACES

Fine Aggregate Angularity

- Prepare sample as required
- Three methods of sample prep
- Method A: standard graded
- Method B: Individual size fractions
- Method C: As received grading
- The specific gravity of the fine aggregate must be known as per T-84

Fine Aggregate Angularity

- Must first calibrate the cylindrical measure
- Apply light coating of grease to top edge of the cylinder
- Fill with water and determine the temperature
- Cover with glass and be sure no air bubbles trapped
- Weigh
- Density of water at given temperatures can be found in table T 19M/T
- Determine net weight of cylinder



Fine Aggregate Angularity

- Center the cylinder under the funnel
- Put finger under the funnel
- Fill the funnel

Fine Aggregate Angularity

- Allow the material to flow freely

Fine Aggregate Angularity

- In a rapid motion strike off the over filled cylinder
- Use the spatula in a single motion
- Avoid any vibration during this operation

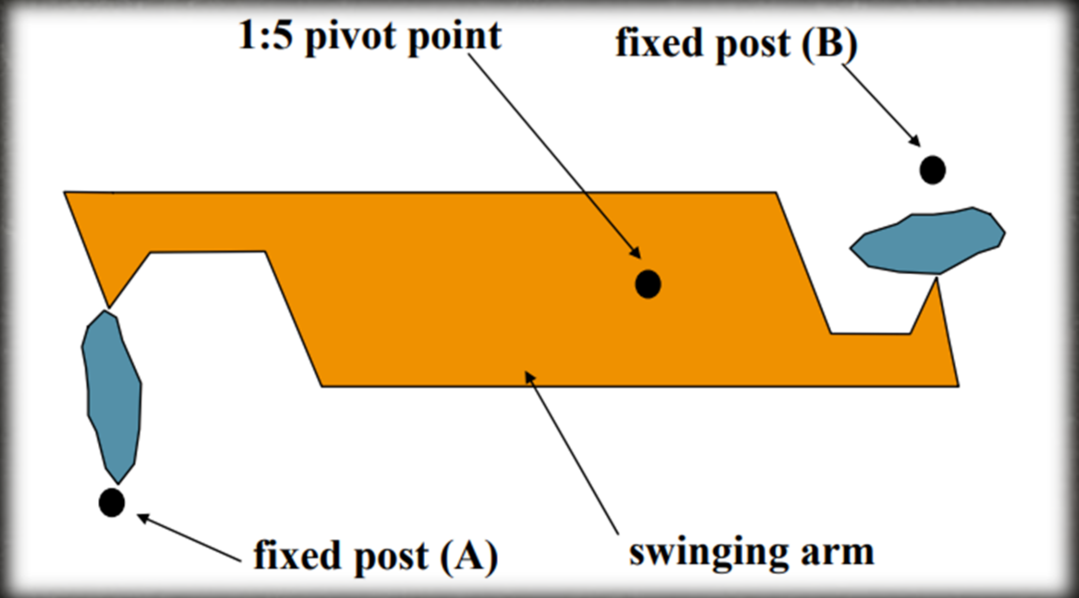
Fine Aggregate Angularity

- After the strike off tap the cylinder lightly so to make it easier to move to the scale.
- Record weight
- The formula is [V-(F/G)]/V*100
- V-volume of cylinder
- F-net mass of fine agg
- G-bulk specific gravity of fine agg

Different equipment type

Flat and Elongated

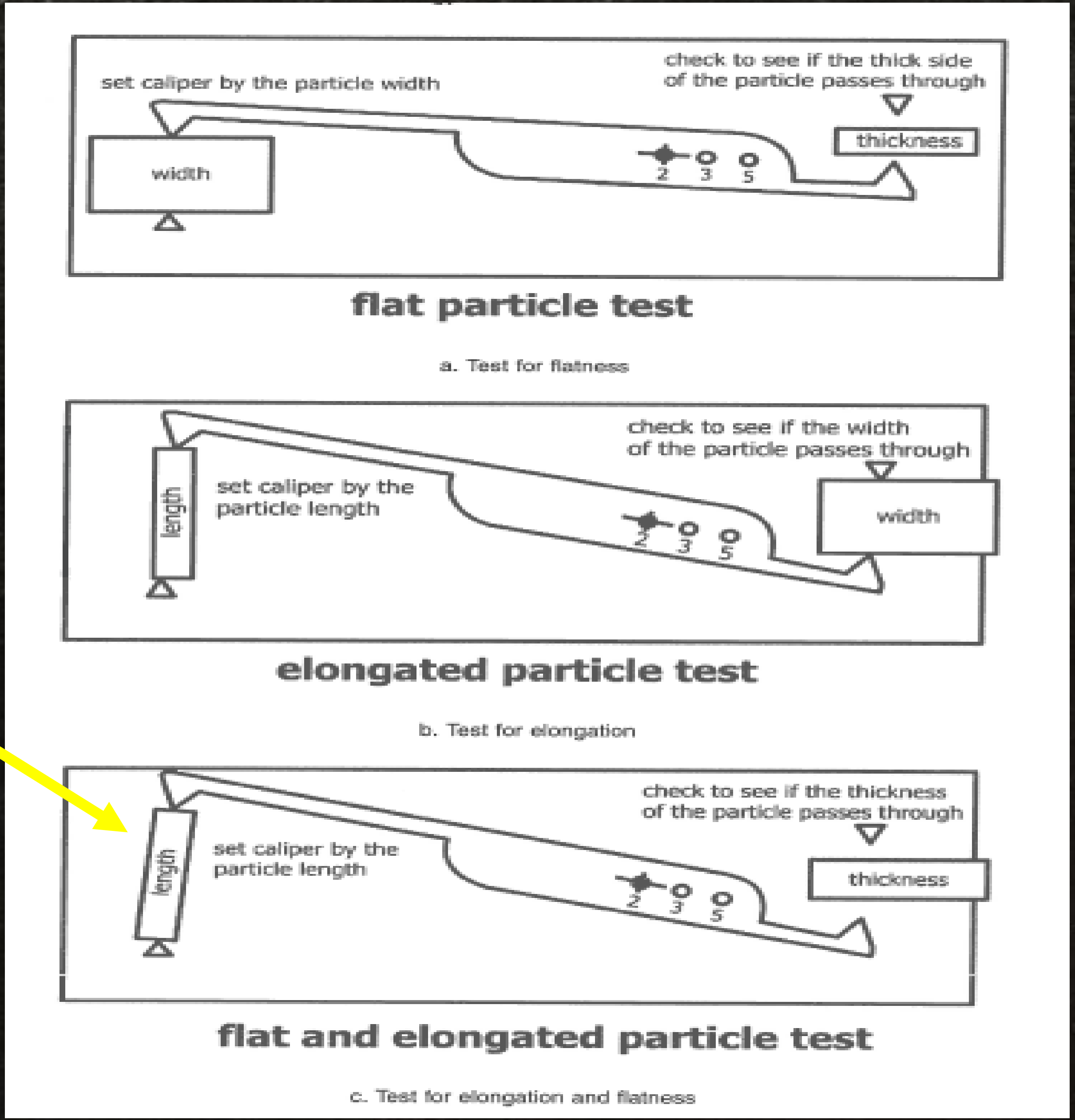
- Particles that are flat and elongated may break down during production and laydown. This may result in possible gradation changes and uncoated particles
- Typical specification allow 10% max 5:1
- ASTM D4791/AASHTO T248



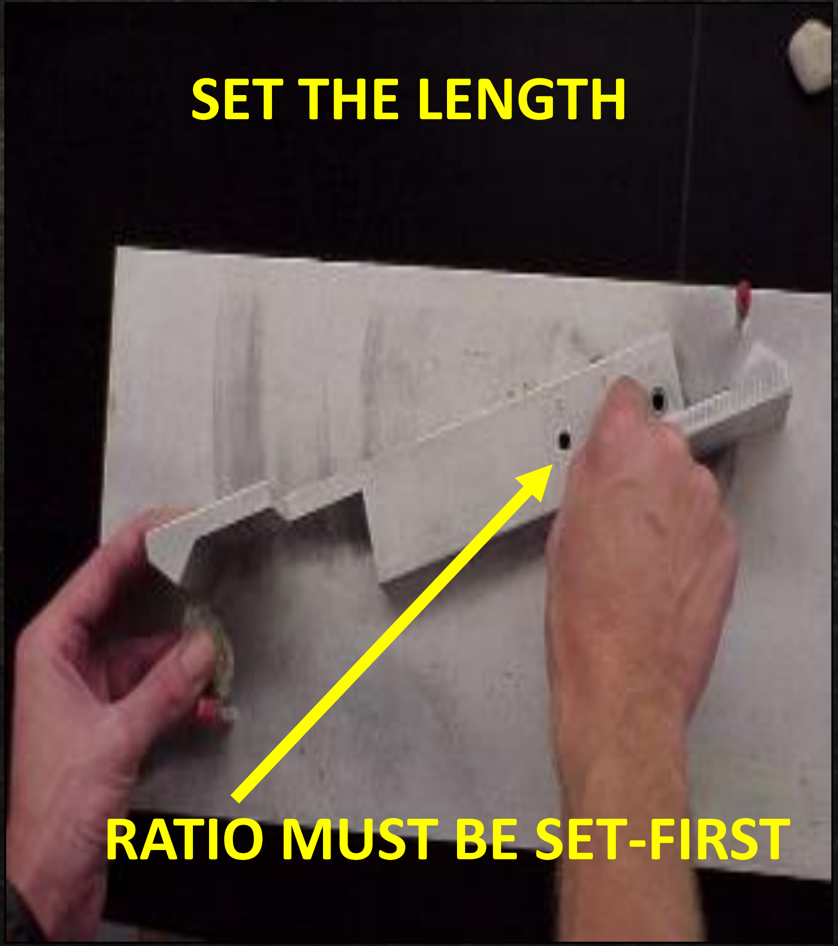
Flat and Elongated

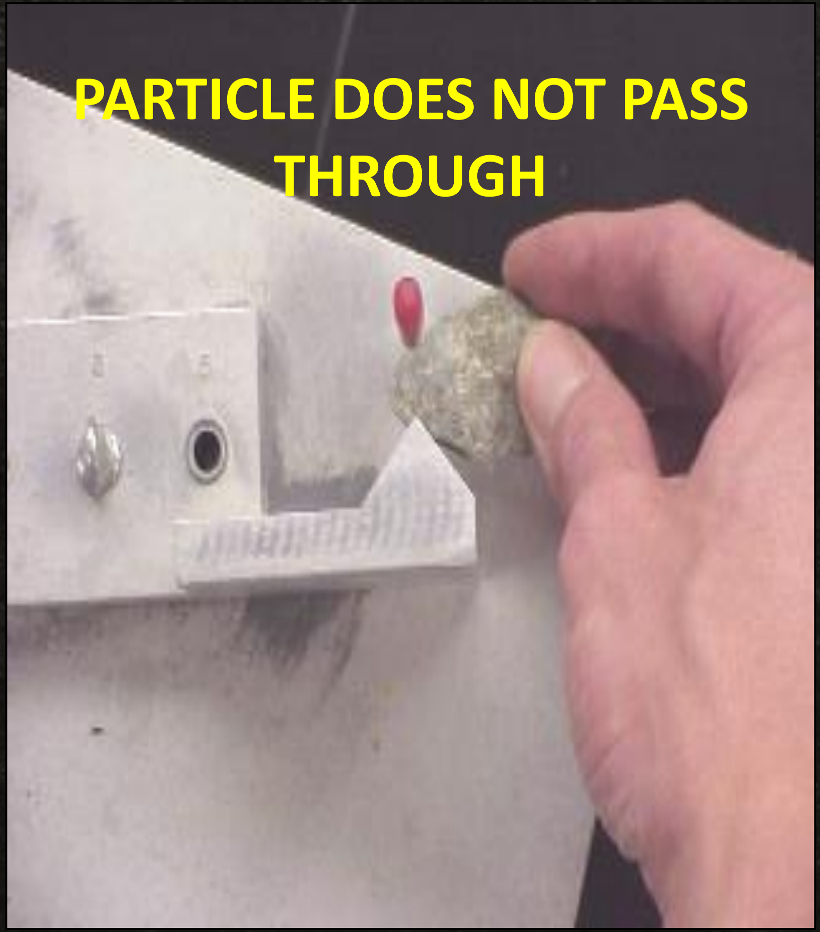
Flat and Elongated

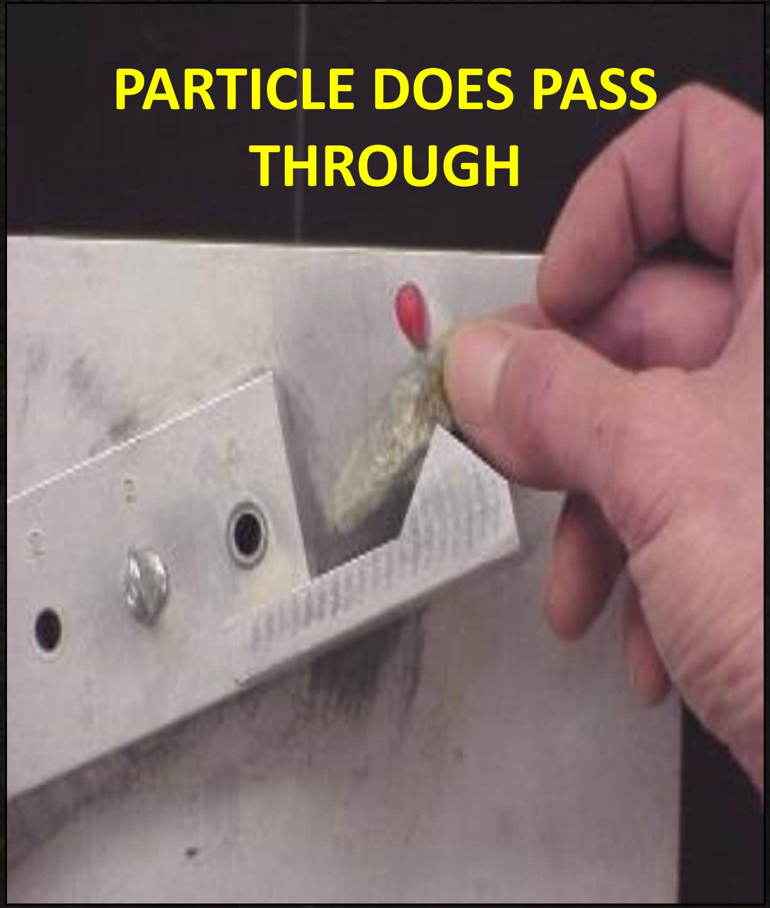
- You can test for flat, elongated or both.
- Most specs refer to flat and elongated



FLAT AND ELONGATED







FLAT AND ELONGATED

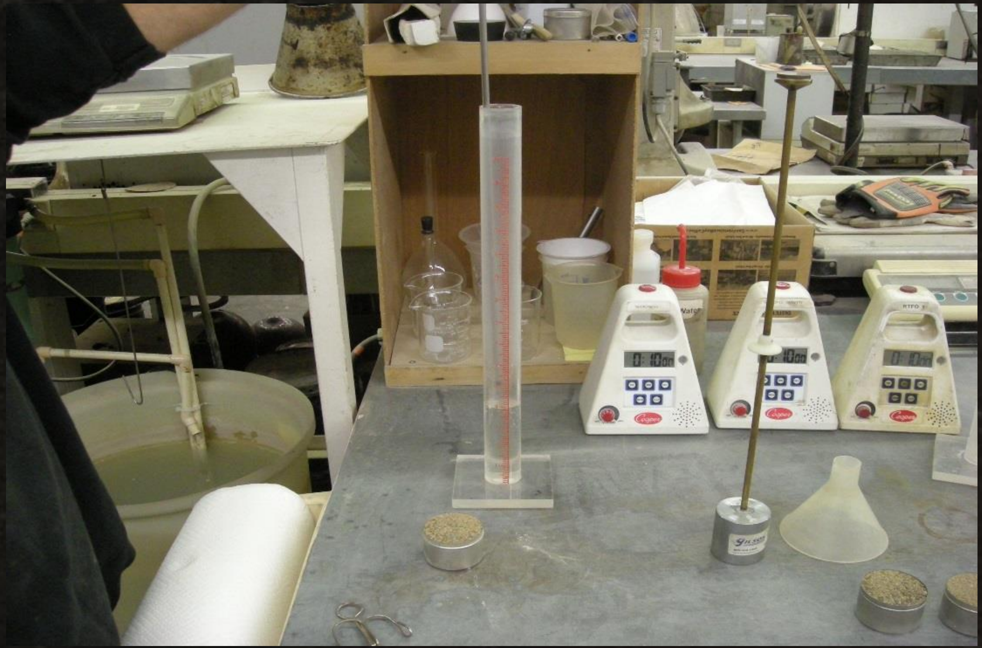
Sand Equivalent

SE = Sand/Clay *100

- Goal is to determine the amount of clay like materials present in the aggregate blend
  - Clay coating may degrade the bond between binder and aggregate
  - Typical specification is 50% minimum
  - ASTM D2419/AASHTO T176
  - It **does not** tell you the amount of clay, only the relative amount of "clay like" fines relative to the "sand" fraction
  - The "clay like" fines may **OR** may not be clay
    - Minus No. 200 particle size distribution is critical
      - Hydrometer (ASTM D422/AASHTO T88) could be used to evaluate (Clay size < 2μm)

Sand Equivalent

- A working solution of calcium chloride is needed T-176/D2419 provides the solution details
- A plastic graduated cylinder is partly filled with solution by siphoning into the cylinder



SE = Sand/Clay *100

Sand Equivalent

- Sample is poured into the cylinder using a funnel
- The bottom of the cylinder is tapped sharply to release air bubbles
- Wetted sample allowed to stand undisturbed for 10+/-1 minutes.

Sand Equivalent

- Stopper placed in end of cylinder
- 3 methods of shaking
  - Manual
  - Mechanical
  - Hand

Sand Equivalent

- Each shaking method has specific times and procedures
- Following the shaking the cylinder is set upright
- An irrigator tube is inserted in the cylinder and material is rinsed from the walls
- The tube is pushed (stabbing) and twisted into the material

Sand Equivalent

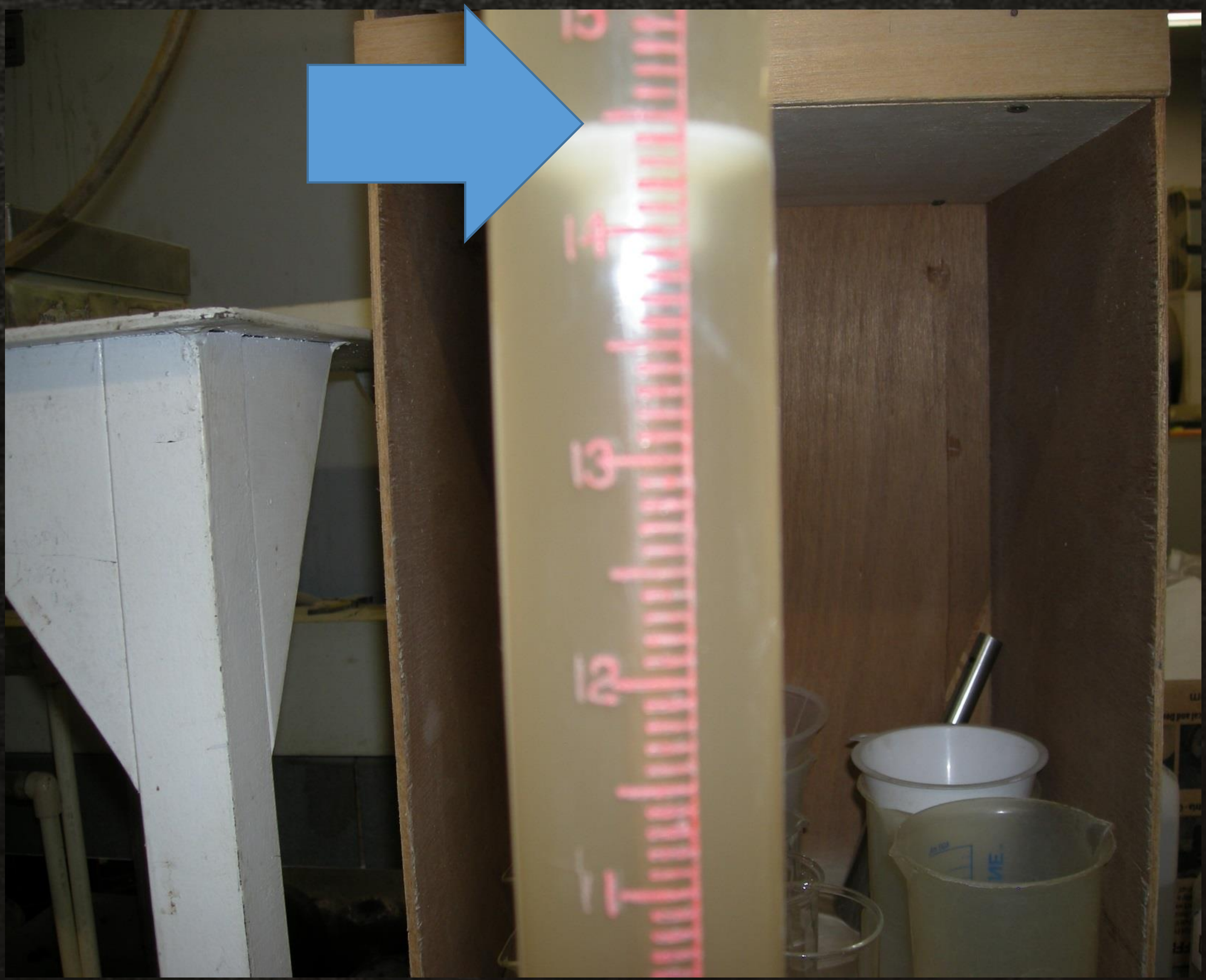
- Solution level is adjusted to 15 inches
- Cylinder and contents stand undisturbed for 20 minutes +/- 15 seconds (start time as soon as irrigator removed)

Sand Equivalent

- After sedimentation level at the top of the clay reading can be obtained.
- If no clear line of demarcation sample can stand for additional time

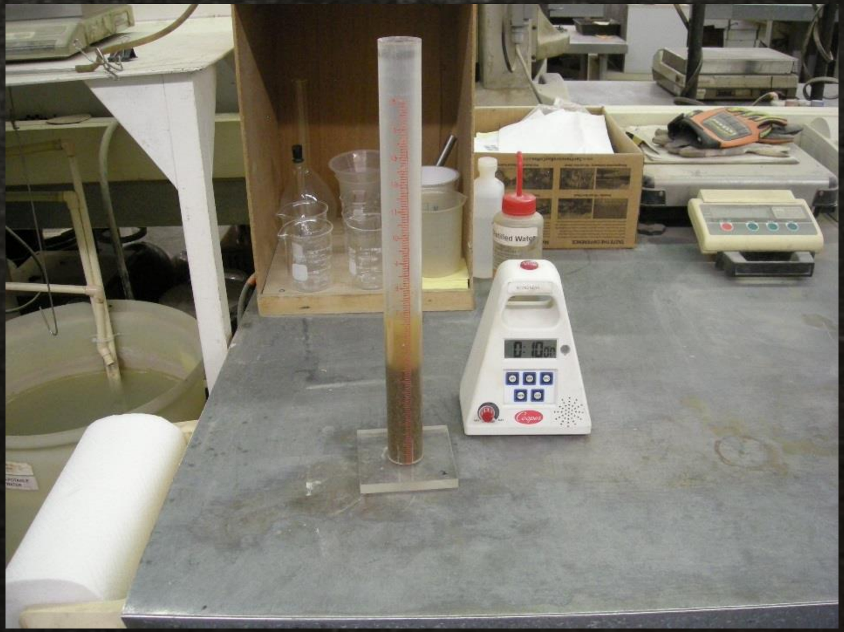
Sand Equivalent

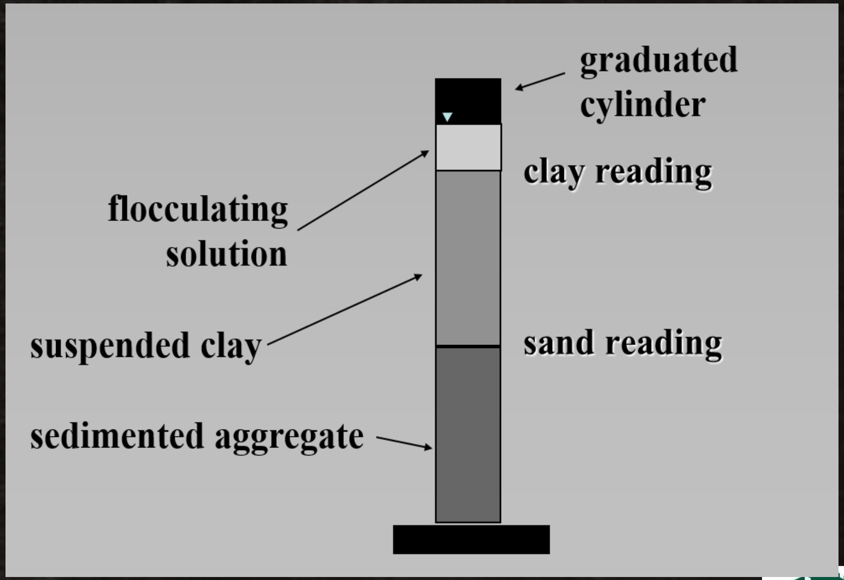
- Weighted foot assembly is gently lowered into the cylinder without hitting the mouth of the cylinder
- When the foot rests on the sand it is tipped forward towards the graduations until it touches the sides
- The length is subtracted from level reading and this value is the sand reading



Comment on Sand Equivalent

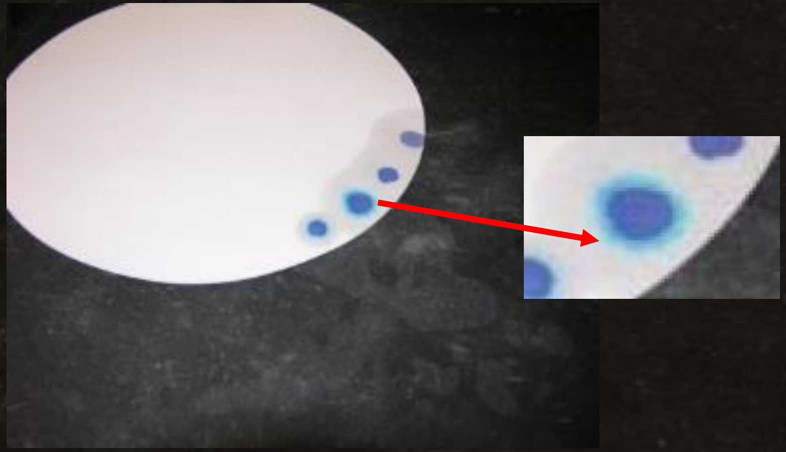
- The formula is: SE = Sand/Clay *100
- Reported as whole number





Methylene Blue Test

- A much better test for deleterious clay evaluation is the methylene blue (MB) test
    - Evaluates absorption capacity of the clay
    - Greater the amount of MB solution absorbed, the greater the clay reactivity
    - Blue halo appears around the drop when the clay has reached capacity
    - AASHTO T330/ASTM C1777 (Rapid Test)

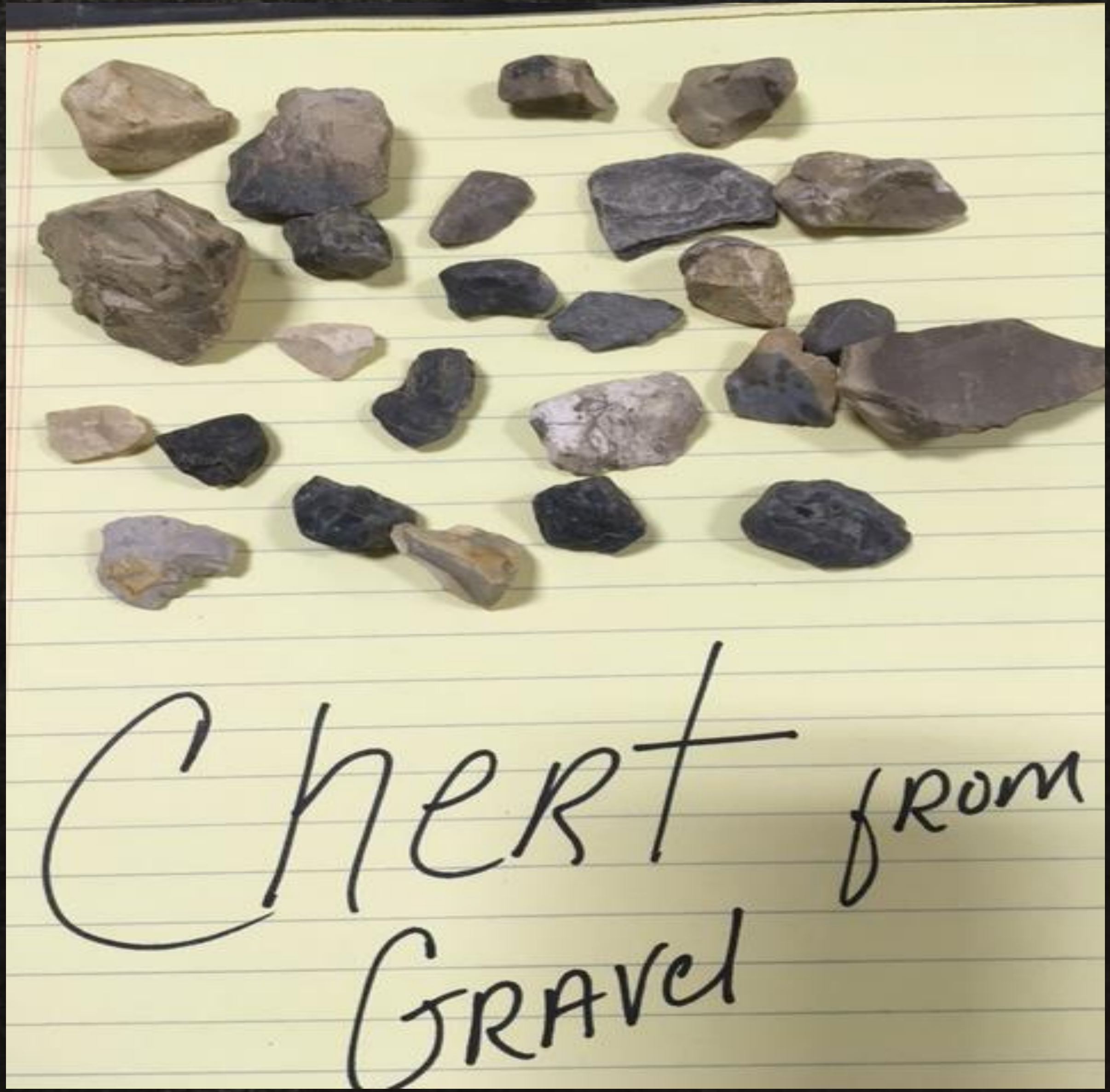


Deleterious Materials (Clay Lumps / Friable Particles, Lightweight Pieces)

- Materials which can be harmful to the desired properties of aggregate-binder systems
  - Soft particles
  - Clay or clay coatings
  - Lightweight particles
- Test methods:
  - ASTM C142 / AASHTO T112 (Clay Lumps / Friable Particles)
  - ASTM C123 / AASHTO T113 (Lightweight Pieces)
    - Float in 2.0 or 2.4 Specific Gravity Solution
      - Coal / lignite identified with 2.0 solution
      - Chert / shale identified with 2.4 solution

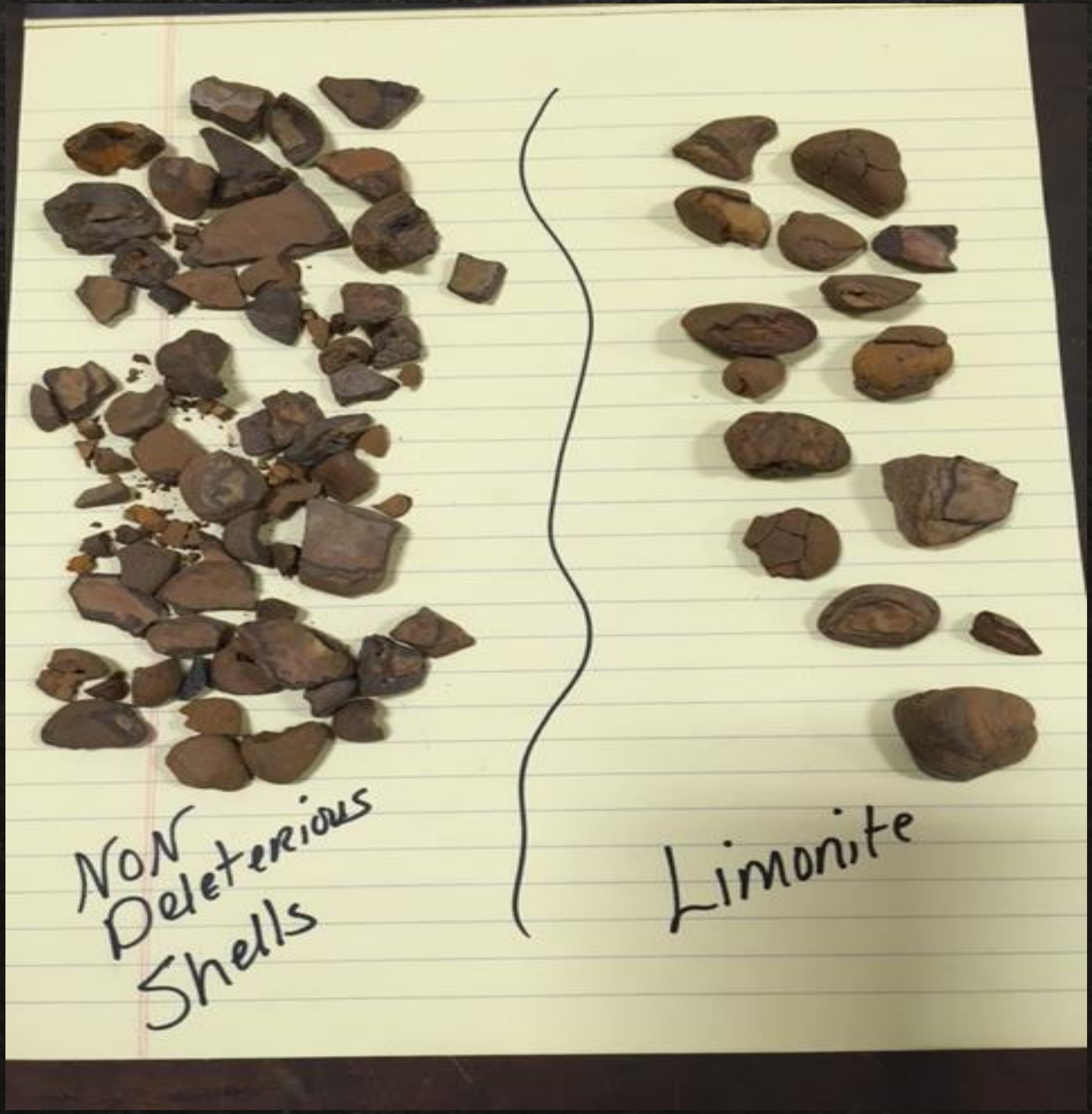
Chert

- Visual, hand picked
- Chert is a very hard and resistant microcrystalline variety of quartz
- It is extremely resistant to weathering
- Can easily shatter
- Not all chert is bad



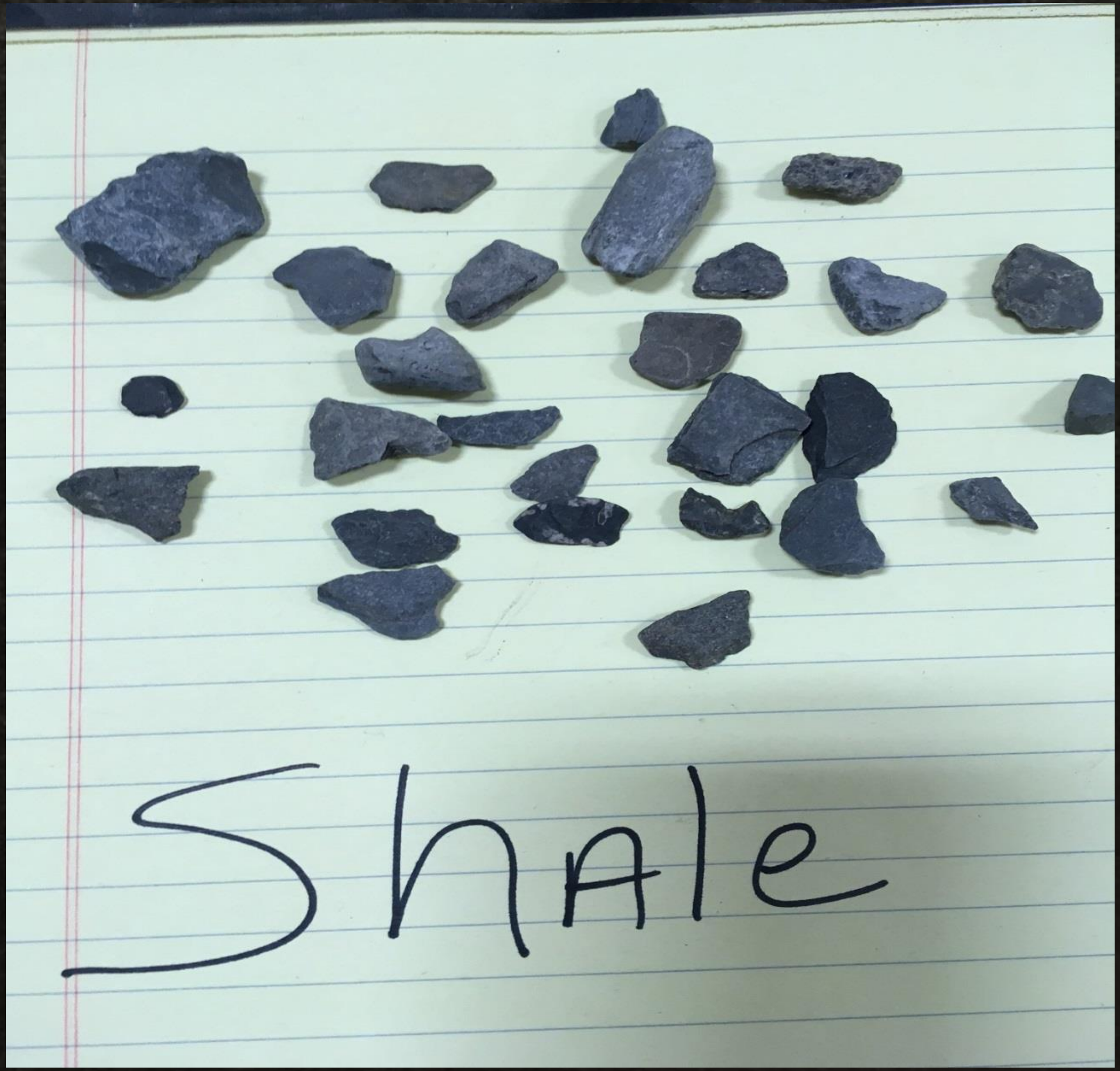
Limonite

- Visual, hand picked
- Limonite is an iron ore formed from the alteration of iron materials
- Has a distinctive streak of yellow or brown



Shale

- Visual, hand picked
- Is composed of very small to silt-sized particles of clay
- Shale results from the compaction of fine graded material (mud)
- It is easily eroded and can be found in rock formations as thin layers



Nominal Maximum and Maximum Aggregate Size

- ***Maximum* Aggregate Size**
  - one size larger than nominal maximum size
- ***Nominal Maximum* Aggregate Size (NMS)**
  - one size larger than the first sieve to retain more than 10%

IMPORTANT TO KNOW DUE TO MANY OF THE TEST PROCEDURES USE NMS

Percent Passing

3/4" : 100%

1/2" : 95%

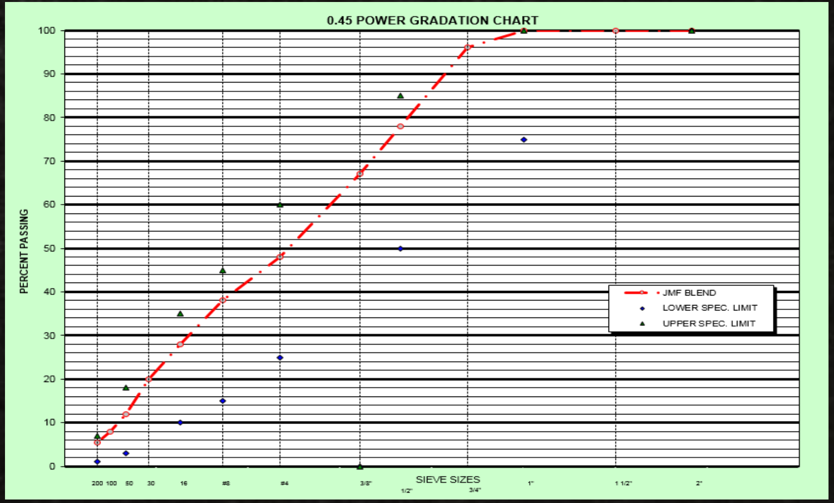
3/8" : 89% **11% Retained**

#4 : 63%

#8 : 39%

Gradation

- One of our most common tests.
- Provides a snap shot of the particle distribution of the material.
- Easy to run.
- But should not be taken for granted.
- .45 graph great tool!!



Gradation-Coarse

- AASHTO T-27
- AASHTO M-43 LIST COMMON COARSE AGGREGATE SIZES AND LIMITS.

Table 703.01 (AASHTO M43) Standard Sizes of Processed Aggregate

Size No.	Nominal size [1] square openings		Amounts finer than each laboratory sieve (square openings), percent by weight														
	inch	mm	4 in. 100 mm	3 1/2 in. 90 mm	3 in. 75 mm	2 1/2 in. 63 mm	2 in. 50 mm	1 1/2 in. 37.5 mm	1 in. 25 mm	3/4 in. 19 mm	1/2 in. 12.5 mm	3/8 in. 9.5 mm	No. 4 4.75 mm	No. 8 2.36 mm	No. 16 1.18 mm	No. 50 300 µm	No. 100 150 µm
1	3 1/2 to 1 1/2	90 to 37.5	100	90 to 100		25 to 60		0 to 15		0 to 5							
2	2 1/2 to 1 1/2	63 to 37.5			100	90 to 100	35 to 70	0 to 15		0 to 5							
24	3 1/2 to 3/4	63 to 19			100	90 to 100		25 to 60		0 to 10	0 to 5						
3	2 to 1	50 to 25				100	90 to 100	35 to 70	0 to 15		0 to 5						
357	2 to No. 4	50 to 4.75				100	95 to 100		35 to 70		10 to 30		0 to 5				
4	1 1/2 to 3/4	37.5 to 19					100	90 to 100	20 to 55	0 to 15		0 to 5					
467	1 1/2 to No. 4	37.5 to 4.75					100	95 to 100		35 to 70		10 to 30	0 to 5				
5	1 to 1/2	25 to 12.5						100	90 to 100	20 to 55	0 to 10	0 to 5					
56	1 to 3/8	25 to 9.5						100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5				
57	1 to No. 4	25 to 4.75						100	95 to 100		25 to 60		0 to 10	0 to 5			
6	3/4 to 3/8	19 to 9.5							100	90 to 100	20 to 55	0 to 15	0 to 5				
67	3/4 to No. 4	19 to 4.75							100	90 to 100		20 to 55	0 to 10	0 to 5			
68	3/4 to No. 8	19 to 2.36							100	90 to 100		30 to 65	5 to 25	0 to 10	0 to 5		
7	1/2 to No. 4	12.5 to 4.75								100	90 to 100	40 to 70	0 to 15	0 to 5			
78	1/2 to No. 8	12.5 to 2.36								100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5		
8	3/8 to No. 8	9.5 to 2.36									100	85 to 100	10 to 30	0 to 10	0 to 5		
89	3/8 to No. 16	9.5 to 1.18									100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	
9	No. 4 to 16	4.75 to 1.18										100	85 to 100	10 to 40	0 to 10	0 to 5	
10	No. 4 to 0 [2]	4.75 to 0 [2]										100	85 to 100				10 to 30

[1] Numbered sieves are those of the United States Standard Sieve Series.

[2] Screenings.

Where standard size of coarse aggregate designated by two or three digit numbers are specified, obtain the specified gradation by combining the appropriate single digit standard size aggregates by a suitable proportioning device which has a separate compartment for each coarse aggregate combined. Perform the blending as directed by the Laboratory.

Gradation-Coarse

- Reduction of Sample in Accordance with AASHTO T 248 / ASTM C 702

Gradation-Coarse

- Large screen shakers most common for coarse size gradations.
- Detailed minimum sample sizes based on **NMS**
- Sieve until no more than 0.5% by mass of the total sample passes a given sieve during one minute of hand sieving

Gradation-Fine aggregate

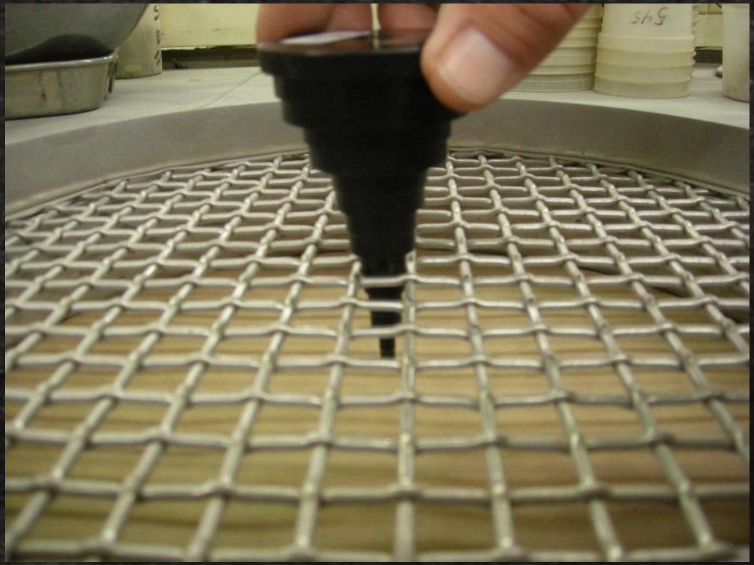
- AASHTO T-27
- Important to classify the fine aggregate
- Various Types Of “Shakers”

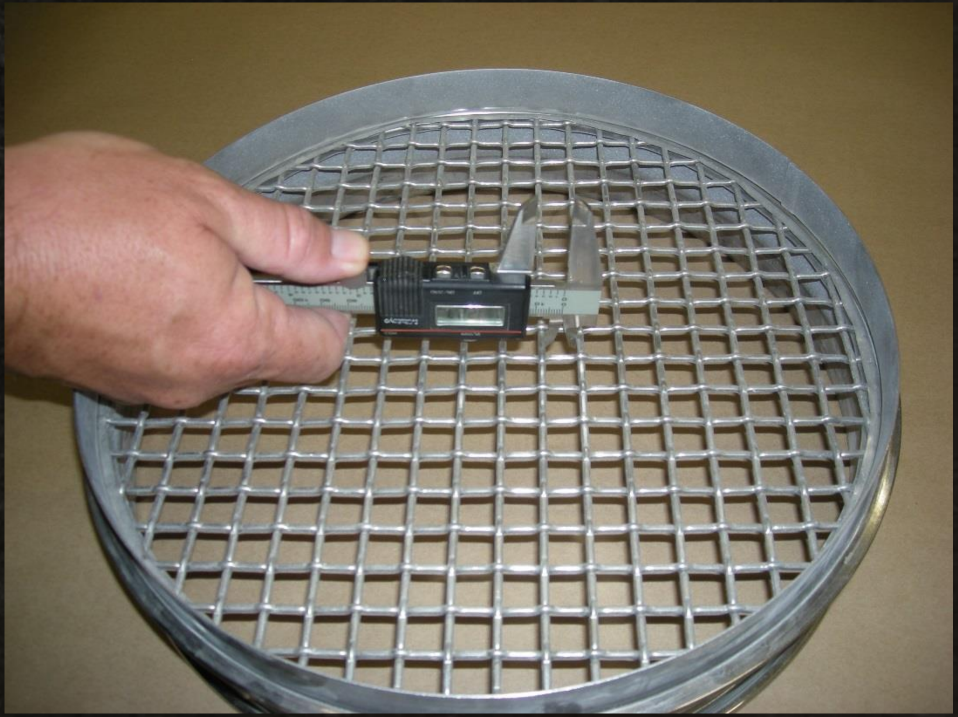
Gradation-Fine aggregate

- Procedure details how much can each sieve be loaded.
- Proper cleaning technique.
- Sieves need to be inspected.

Gradation

- Sieves need to be inspected.
- ASTM E-11 has detailed procedure for verification of sieve openings and wire size.





Gradation-minus #200 wash

- AASHTO T-11
- Can Be Hand Washed Or Mechanically Aided Washed.
- Expect Slightly Higher Results With The Mechanical Washers.
- Process Continues Until Decant Wash Water Is Clear.
- Method B Available To Use A Wetting Agent.

Gradation-Mechanical Washer

- Same process as hand washing but continuous.
- AASHTO T-11 does state: ***"The use of a mechanical apparatus to perform the washing operation is not precluded, provide the results are consistent with those obtained using manual operations"***.
- Mechanical washers do save time and provide a consistent method.

Unit Weight

- Measure's volume must be determined annually
- Tare container
- Fill with water
- Cover with plate glass to eliminate air bubbles
- Determine mass of container, water, and measure
- Determine water temperature
- Determine volume by using density of water table 3 in T19

Unit Weight-DRY RODDED

- AASHTO T19 ASTM C29
- Provides for "loose or compacted" unit weight.
- Calculated voids between particles in fine, coarse, or mixed aggregates.
- Can not be used for aggregates greater than 5 inch nominal maximum size (AASHTO 6 inches limit).
- Fill volumetric container in 3 equal lifts and rod each lift 25 times.

Unit Weight

ROD 25 TIMES PER LAYER

LEVEL EACH LAYER WITH FINGERS

OVERFILL AND ROD LAST LAYER

Unit Weight

- Dry rodded unit weight-common
- Jigging method
- Shovel method
- Has various uses
- Volumetric container size is determined by size of the aggregate, sizes vary from 1/10 cf to 3.5 cf
- Calculation is the net weight of aggregate divided by the volume of the container (or you can establish a calibration factor)

Mechanical Testing

L.A. Abrasion

- Determine the aggregate’s ability to resist degradation during processing, mixing, compaction, etc.
- Place sample and steel charges into LA Machine
- Rotate 500 revolutions (30-33 rpm)
- AASHTO T96, ASTM C535 (Large Stone), ASTM C131 (Small Stone)

L.A. Abrasion

- Determine the Grading based on most nearly corresponding range of sizes in the aggregate.
- Example #57 uses Grading B
- Total sample 5000+-10 grams

SIEVE SIZE	GRADING A	GRADING B	GRADING C	GRADING D
1 to 1 ½ in	1250 ± 25 g			
3/4 to 1 in	1250 ± 25 g			
½ to 3/4 in	1250 ± 10 g	2500 ± 10 g		
3/8 to ½ in	1250 ± 10 g	2500 ± 10 g		
1/4 to 3/8 in			2500 ± 10 g	
No. 4 to 1/4 in			2500 ± 10 g	
No. 8 to No. 4				5000 ± 10 g
Total Mass	5000 ± 10 g	5000 ± 10 g	5000 ± 10 g	5000 ± 10 g

L.A. Abrasion

- Number and weight of steel charges in LA Machine based on grading of the aggregate (46mm-48mm/390-445 grams)

SIEVE SIZE	GRADING A	GRADING B	GRADING C	GRADING D
1 to 1 ½ in	1250 ± 25 g			
3/4 to 1 in	1250 ± 25 g			
½to 3/4 in	1250 ± 10 g	2500 ± 10 g		
3/8 to ½in	1250 ± 10 g	2500 ± 10 g		
1/4 to 3/8 in			2500 ± 10 g	
No. 4 to 1/4 in			2500 ± 10 g	
No. 8 to No. 4				5000 ± 10 g
Total Mass	5000 ± 10 g	5000 ± 10 g	5000 ± 10 g	5000 ± 10 g
# OF CHARGES:	**12**	**11**	**8**	**6**

L.A. Abrasion

- Place sample and steel charges into LA Machine
- Rotate 500 revolutions (30-33 rpm)
- Remove steel charges and sieve over #12
- Wash retained and dry
- Determine loss

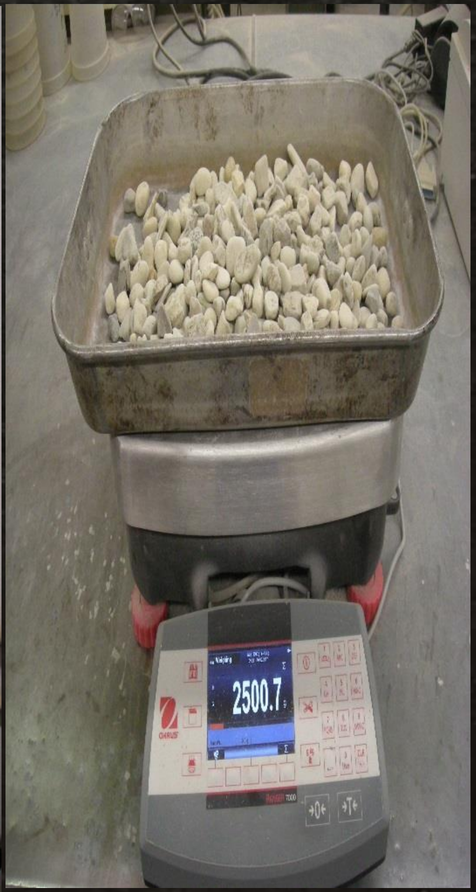
L.A. Abrasion

NO. 12
SIEVE

Minus
NO. 12

Plus NO.
12

Wash Plus
NO. 12



Dried Plus
NO. 12

L.A. Abrasion

$$Loss = \frac{W_{initial} - W_{final}}{W_{initial}} \times 100$$

THE shelly COMPANY

Oldcastle® Materials

Micro-Deval

- Micro-Deval looks like a small LA Abrasion
- Seems to be a good indicator of polish resistance and weathering resistance
- Test Procedure
  - Fine agg-500g of aggregate, .75 liters of water, and 11 pounds (1250 grams) of 3/8” diameter steel balls
  - Coarse agg-1500g of aggregate, 2.0 liters of water, and 5,000 grams steel balls
  - Run through a jar mill at 100 +-5rpm for two hours*
  - The sample is then washed and dried to determine the amount of material passing the No.16 sieve
- AASHTO T327 / ASTM D6928 (Coarse), ASTM D7428 (Fine)
- *some devices have counters so the number of revolutions are counted

Micro-Deval

- Water, charges, canister
- Sample prep

Micro-Deval

Micro-Deval


REMOVE STEEL BALLS


DATE
SAMPLED BY
DATE TESTED
% MOISTURE
WT. BEFORE
PAN WT.
WT. AFTER
№ 81811
MAT TYPE
FROM
№ 81808
DRY SAMPLE

Micro-Deval

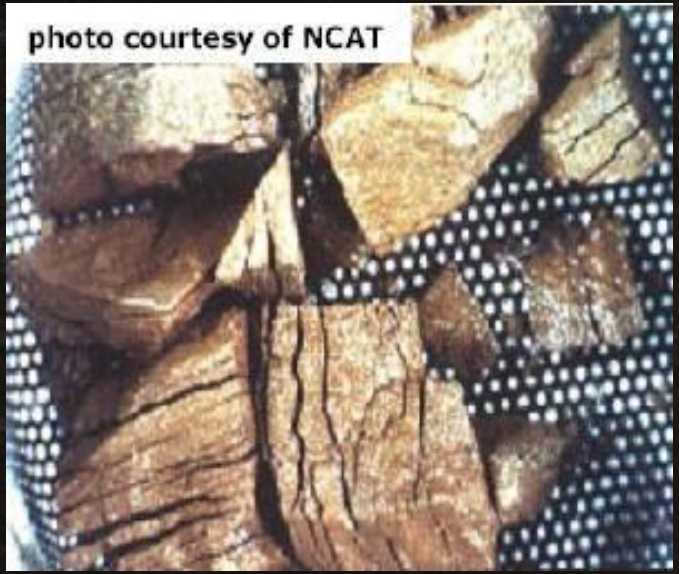

Weighing
1304.8
OHAUS
MASS OF COMPLETED SAMPLE


COMPLETED SAMPLE

Soundness

- Aggregates must be able to withstand freezing and thawing conditions.
- Unsound material will result in breakdown and potential pavement failure
- Sulfate solution simulates salt solution
- Material is soaked / dried for 5 to 10 cycles and loss measured
- ASTM C88/AASHTO T104

Before



After

Soundness

SAMPLE PREPARATION

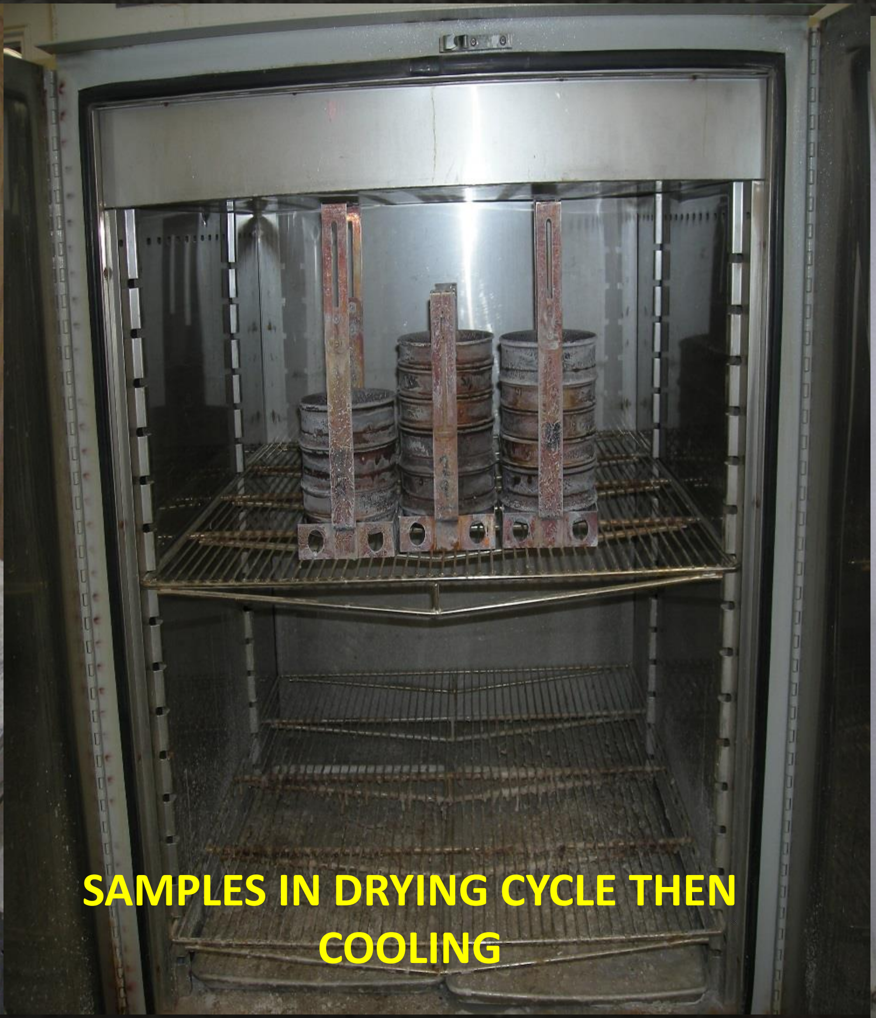
NEST OF SIEVES

CHECK SOLUTION AND TEMPERATURE

SAMPLES IN SOLUTION

Soundness


SAMPLES AFTER CYCLE OF SOAKING


SAMPLES IN DRYING CYCLE THEN COOLING


RINSE CYCLE

Soundness-5 CYCLES

SAMPLES SPLIT

SAMPLES AFTER TEST

Soundness


WASH CYCLE WATER BATH
TEMPERATURE


110 DEGREE F WATER BATH


BARIUM CHLORIDE TO CHECK
COMPLETENESS OF WASHING
(NO SALT)

Soundness


AFTER TESTING PRIOR TO HAND SIEVING


AFTER TESTING PRIOR TO HAND SIEVING

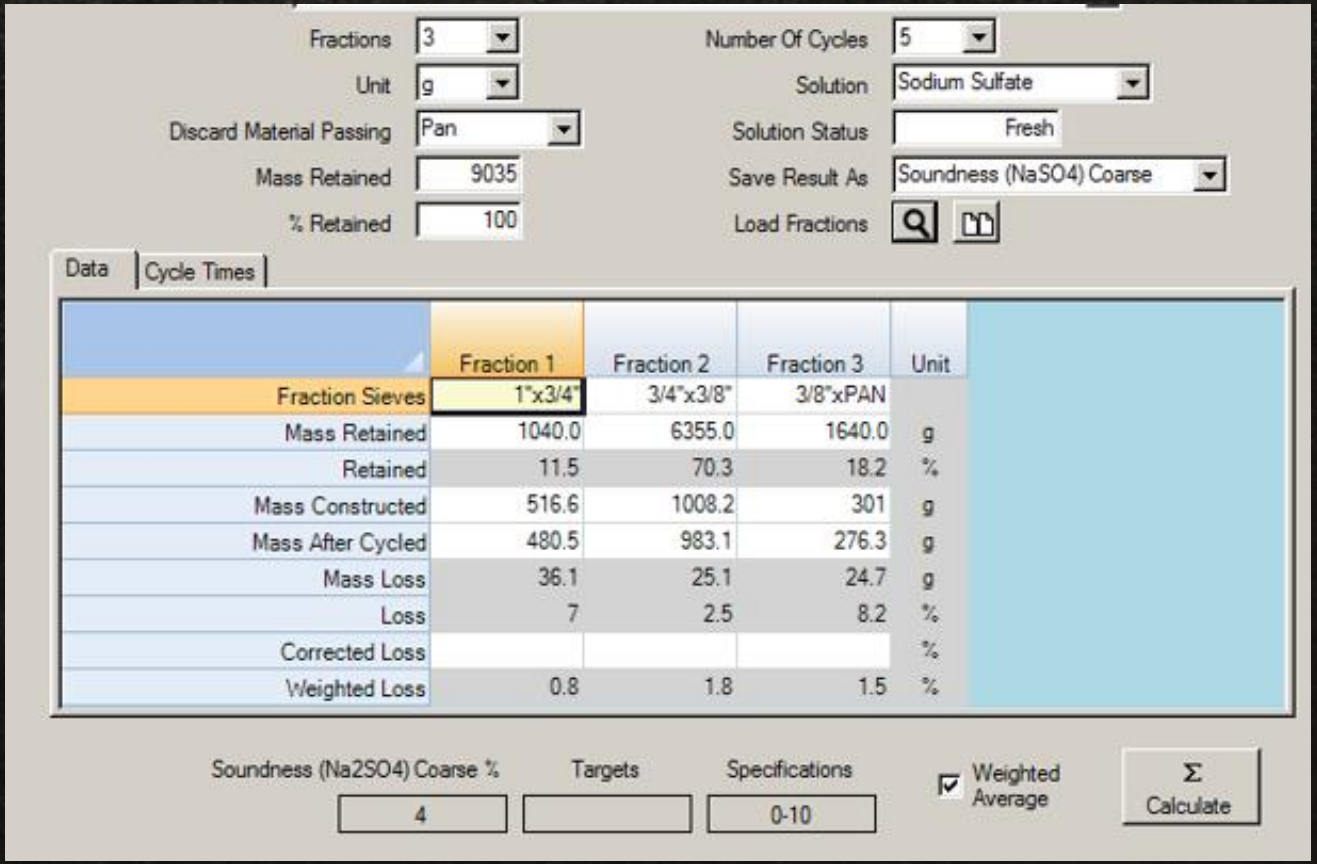

HAND SIEVING OVER DESIGNATED SIEVE

Soundness


AFTER HAND SIEVING LOSS FOR EACH INDIVIDUAL SIEVE FRACTION

Soundness-calculations

- Calculation takes in account the gradation
- Uses the loss per fraction size and applies to the gradation
- Ignores any fraction that is less than 5% retained
- Recommendation: USE A SPREADSHEET OR SOFTWARE PROGRAM



	Fraction 1	Fraction 2	Fraction 3	Unit
Fraction Sieves	1"x3/4"	3/4"x3/8"	3/8"xPAN	
Mass Retained	1040.0	6355.0	1640.0	g
Retained	11.5	70.3	18.2	%
Mass Constructed	516.6	1008.2	301	g
Mass After Cycled	480.5	983.1	276.3	g
Mass Loss	36.1	25.1	24.7	g
Loss	7	2.5	8.2	%
Corrected Loss				%
Weighted Loss	0.8	1.8	1.5	%

Friction (Polish) Resistance

- Resistance to being “polished” by traffic
- Polishing results in reduced skid resistance of the pavement surface
- Influenced mainly by the types of minerals in the aggregate
    - Silicate minerals more resistant to polishing than carbonate minerals
- Test methods: ASTM D3319/E303, AASHTO T278/T279

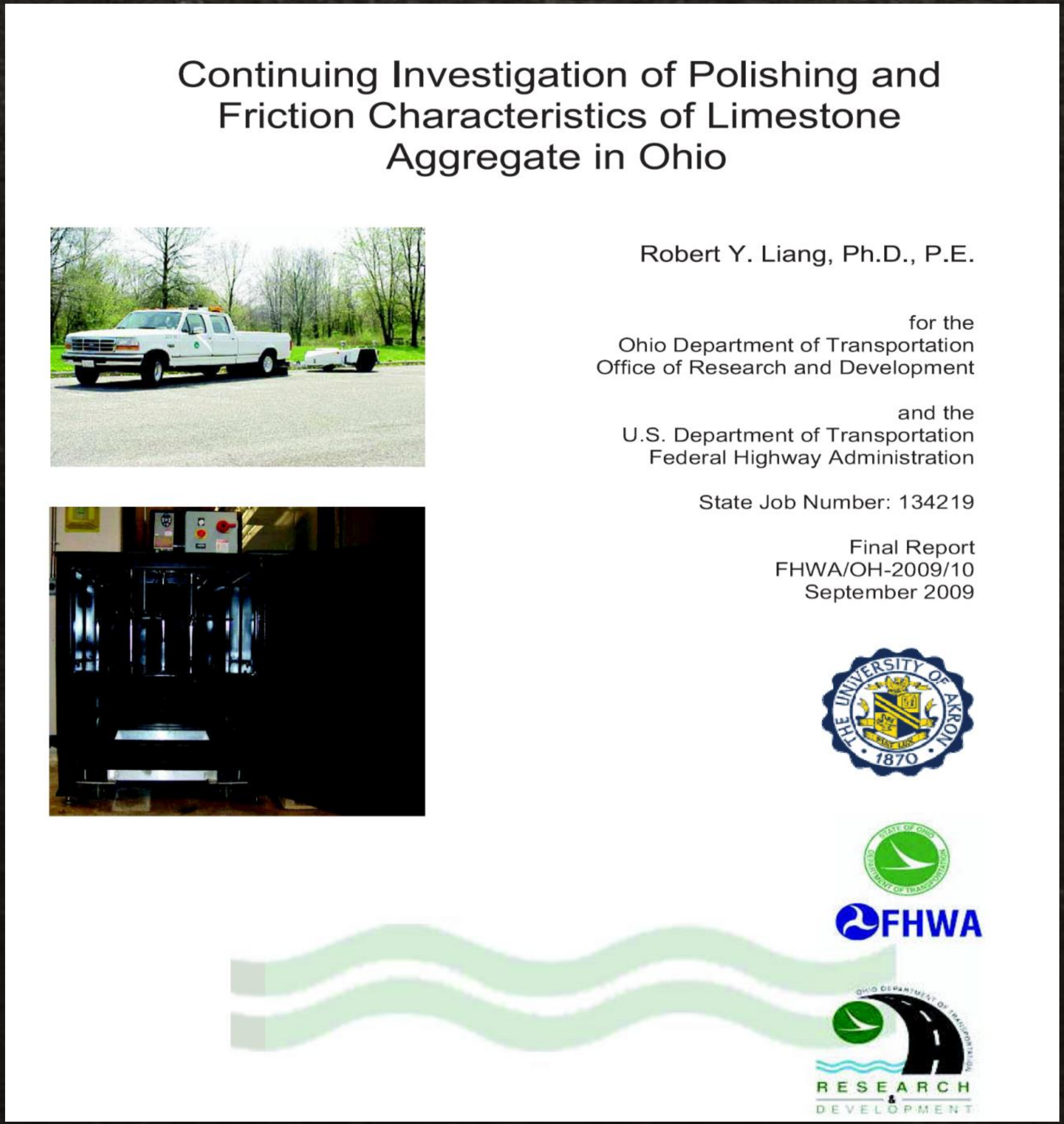
Coupon

Polish Wheel

Skid Tester

Friction (Polish) Resistance

- University of Akron, ODOT and FHWA research into friction and a way to perform laboratory test.



Continuing Investigation of Polishing and Friction Characteristics of Limestone Aggregate in Ohio

Robert Y. Liang, Ph.D., P.E.

for the
Ohio Department of Transportation
Office of Research and Development

and the
U.S. Department of Transportation
Federal Highway Administration

State Job Number: 134219

Final Report
FHWA/OH-2009/10
September 2009

FHWA

RESEARCH & DEVELOPMENT

Friction (Polish) Resistance

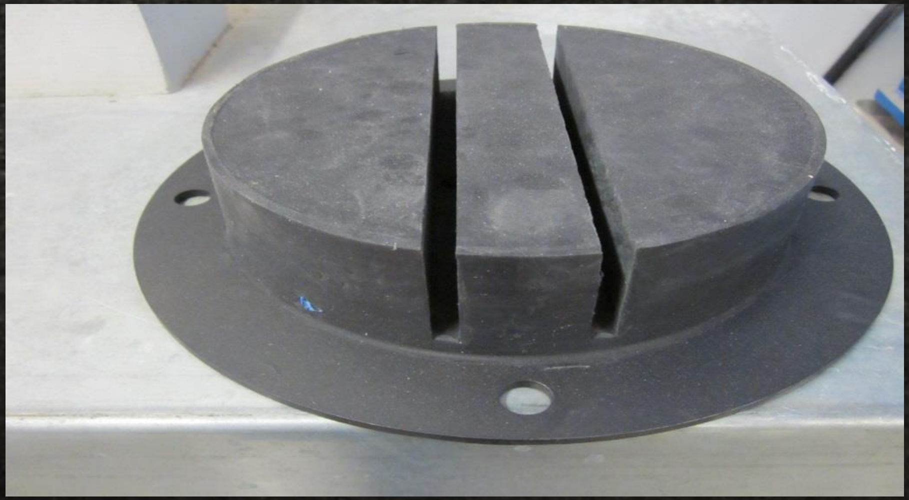
- ODOT developed a Supplement to establish the testing.
- Plan to include in several projects.
- The device developed called "The Polisher"

Coupon

Polish Wheel

Friction (Polish) Resistance

- The 6 inch specimens are exposed to a hard rubber disk.
- The disk rotates over the specimen for 8 hours.



Coupon

Polish Wheel

Friction (Polish) Resistance

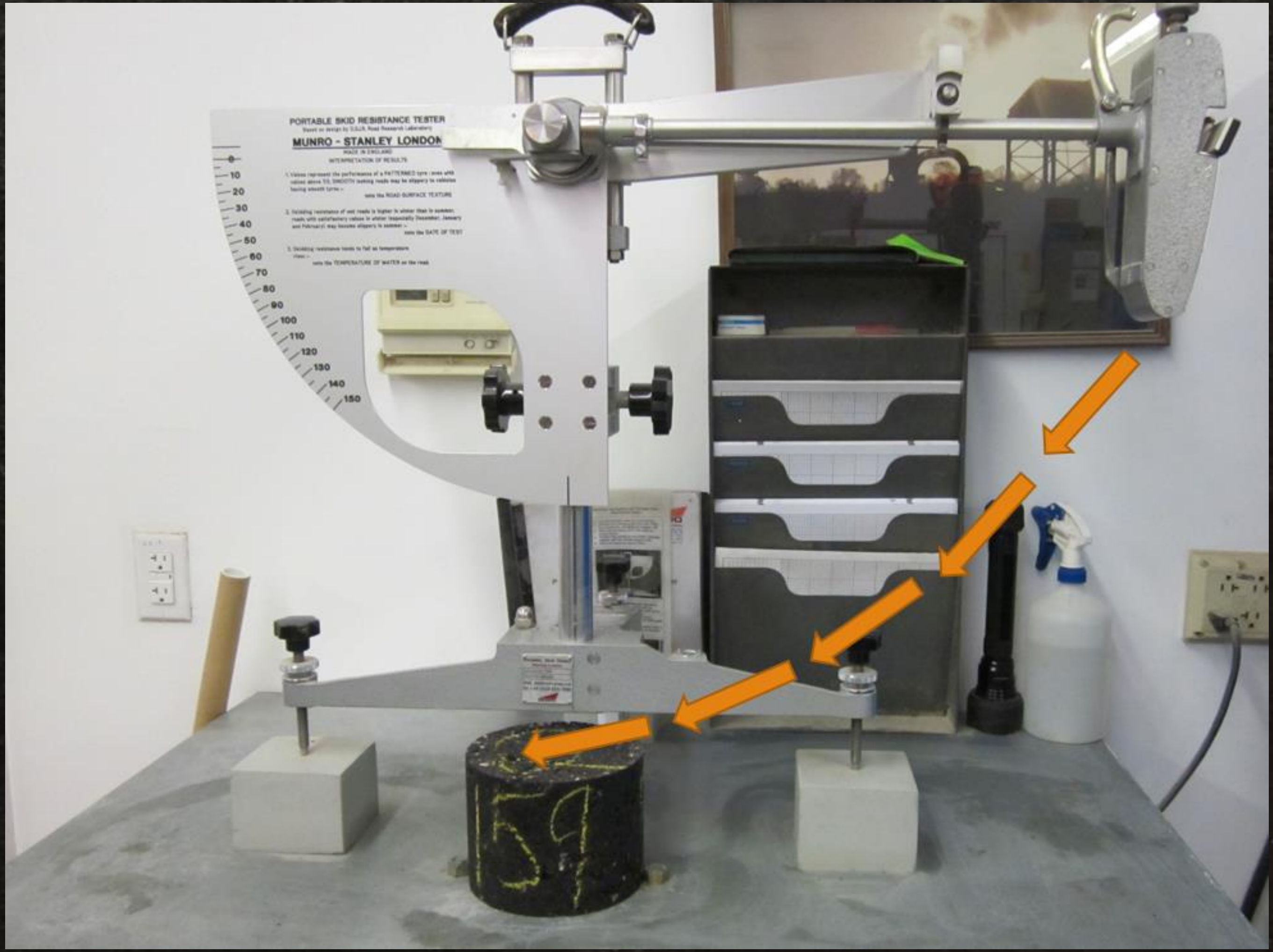
- Water provides cooling during the test.
- The grooves in the rubber disk allows the water to cover the specimen.

Disk after 8 hour test period.

Specimen after polishing test

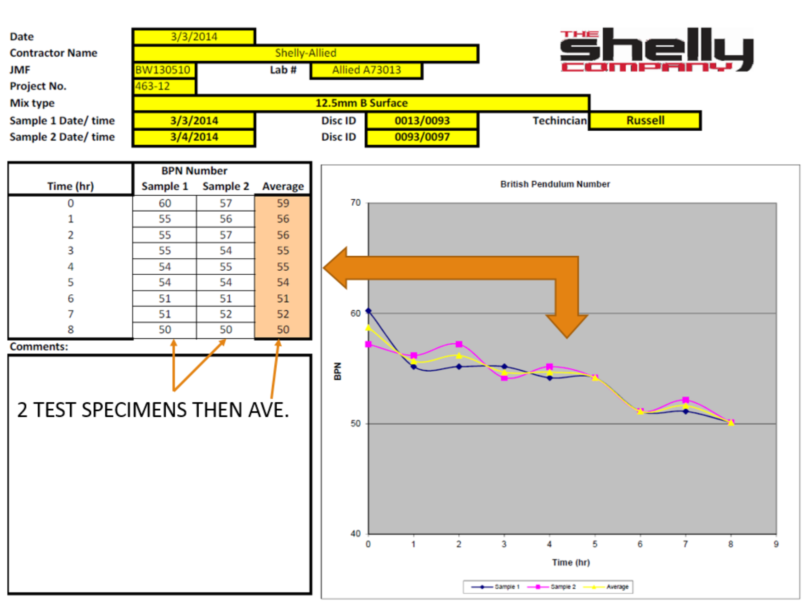
Friction (Polish) Resistance

- Upon the completion of the 8 hour polishing the specimen will be tested using the British Pendulum Device (BPD).
- It reads out as a skid number.



Friction (Polish) Resistance

- The higher the number the more friction or resistance.
- The number is reported as BPN.

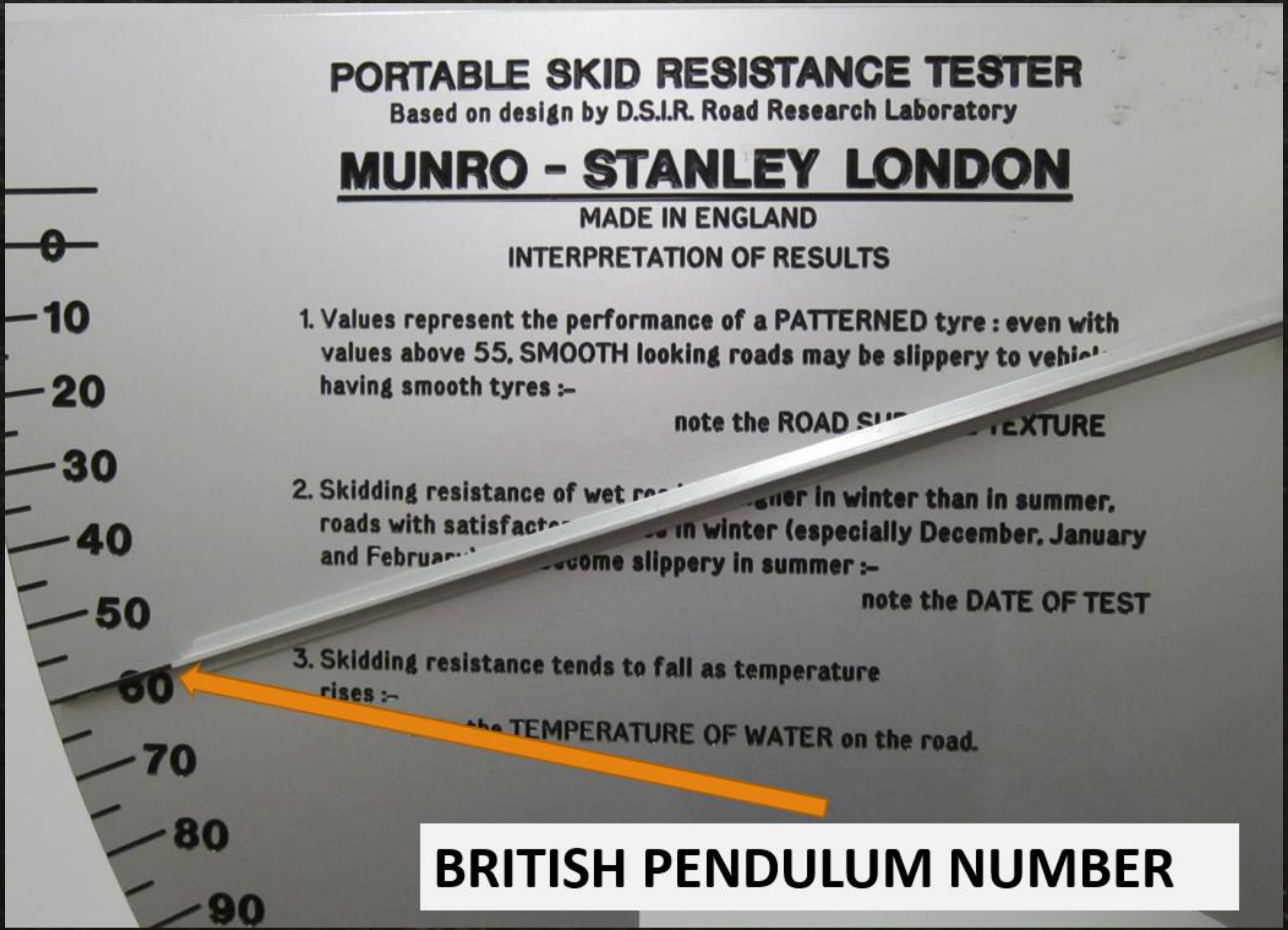


Date	3/3/2014
Contractor Name	Shelly-Allied
JMF	BW130510 — Lab # Allied A73013
Project No.	463-12
Mix type	12.5mm B Surface
Sample 1 Date/ time	3/3/2014 — Disc ID 0013/0093 — Techincian Russell
Sample 2 Date/ time	3/4/2014 — Disc ID 0093/0097

Time (hr)	BPN Number Sample 1	Sample 2	Average
0	60	57	59
1	55	56	56
2	55	57	56
3	55	54	55
4	54	55	55
5	54	54	54
6	51	51	51
7	51	52	52
8	50	50	50

Comments:

2 TEST SPECIMENS THEN AVE.



ORGANIC IMPURITIES IN FINE AGGREGATES T21/C40

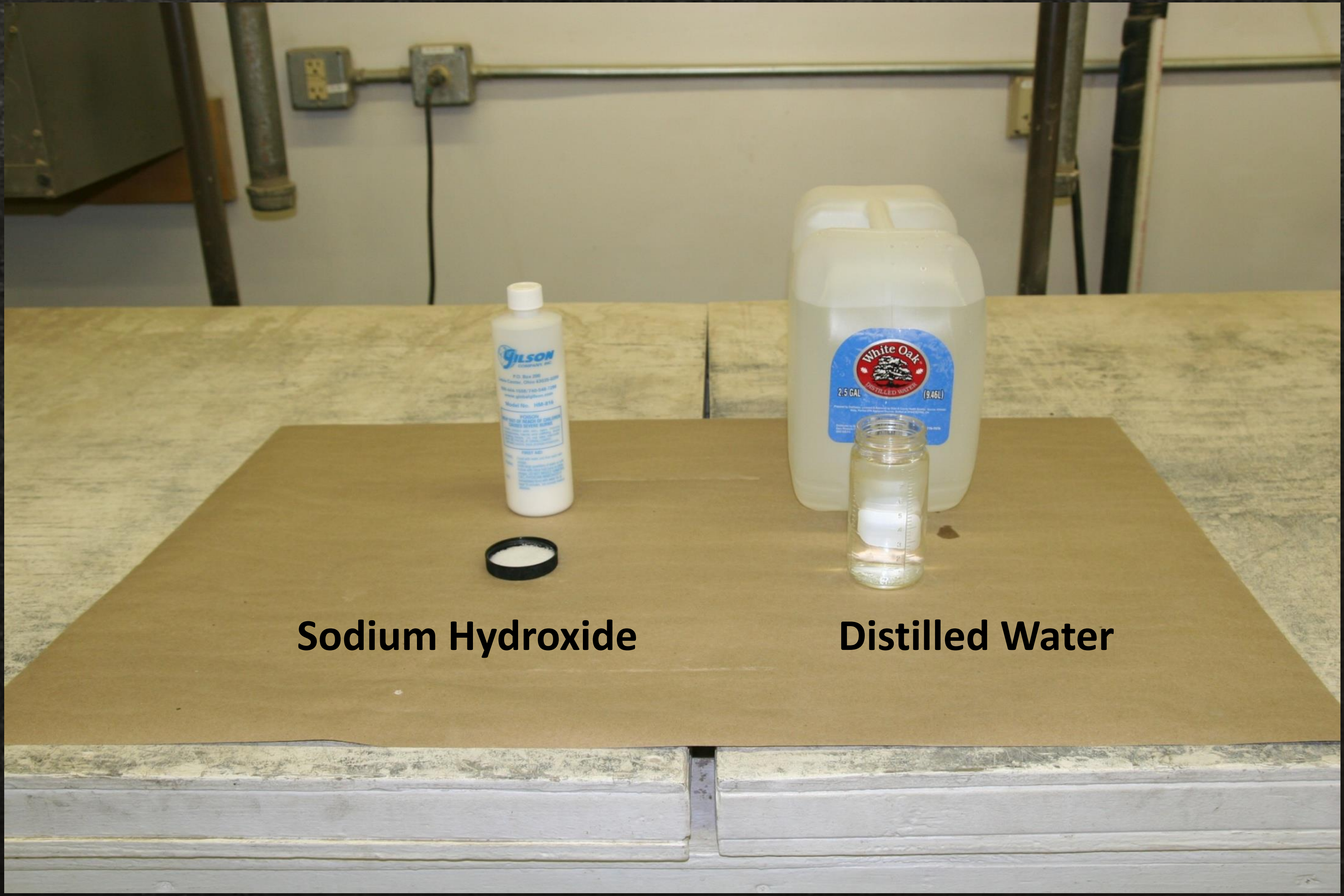
- Normally used for concrete fine aggregate


Glass Bottles
Oval or Round
8-16 oz. (240-470 ml)

Glass Bottles
Oval or Round
8-16 oz. (240-470 ml)

THE shelly COMPANY

Oldcastle® Materials



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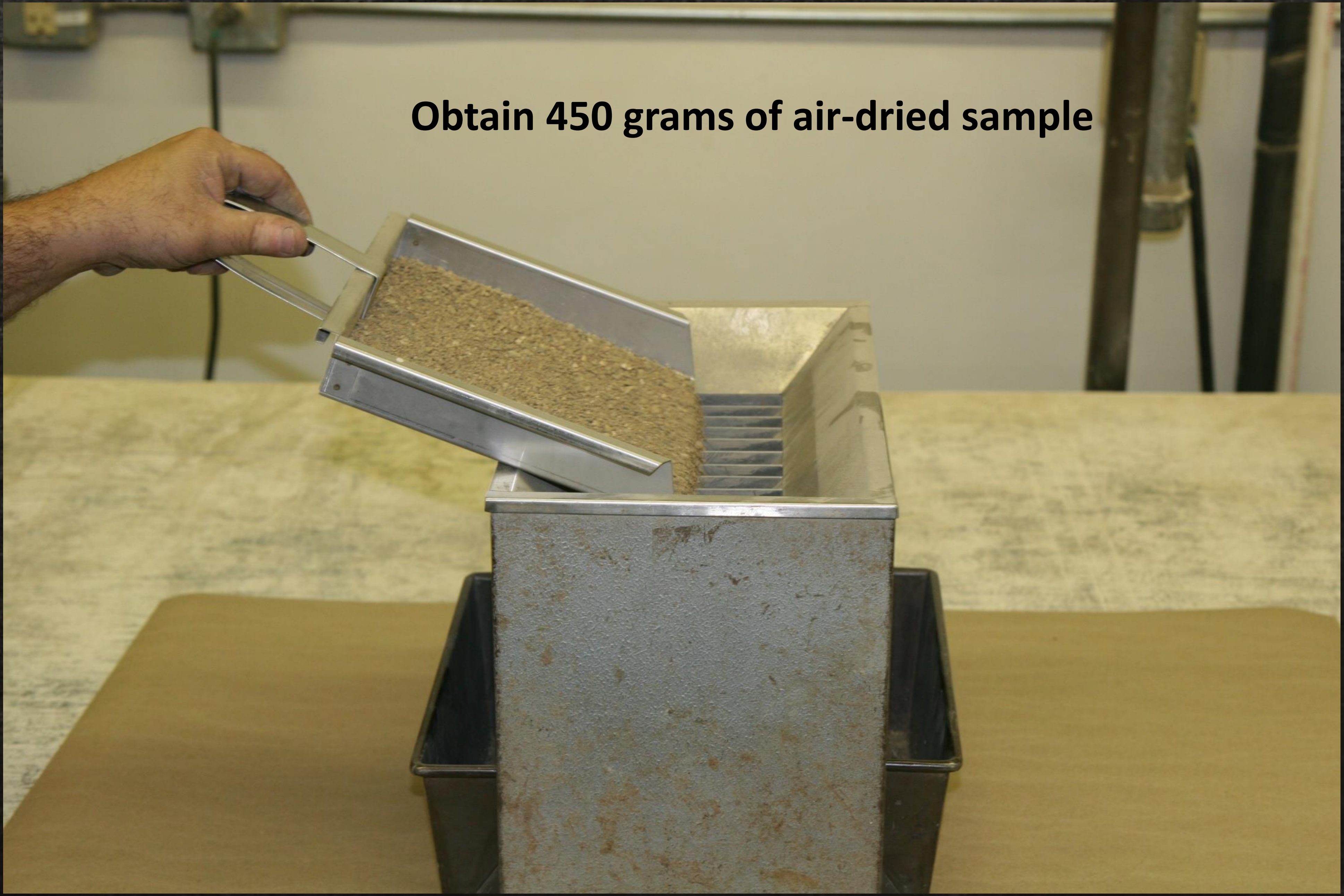
Oldcastle Materials

Sodium Hydroxide (NaOH) 30 grams **Distilled Water 970 ml**

Dissolve 30 grams in 970 ml to prepare 3% NaOH solution

Obtain 450 grams of air-dried sample



THE shelly COMPANY

Oldcastle® Materials

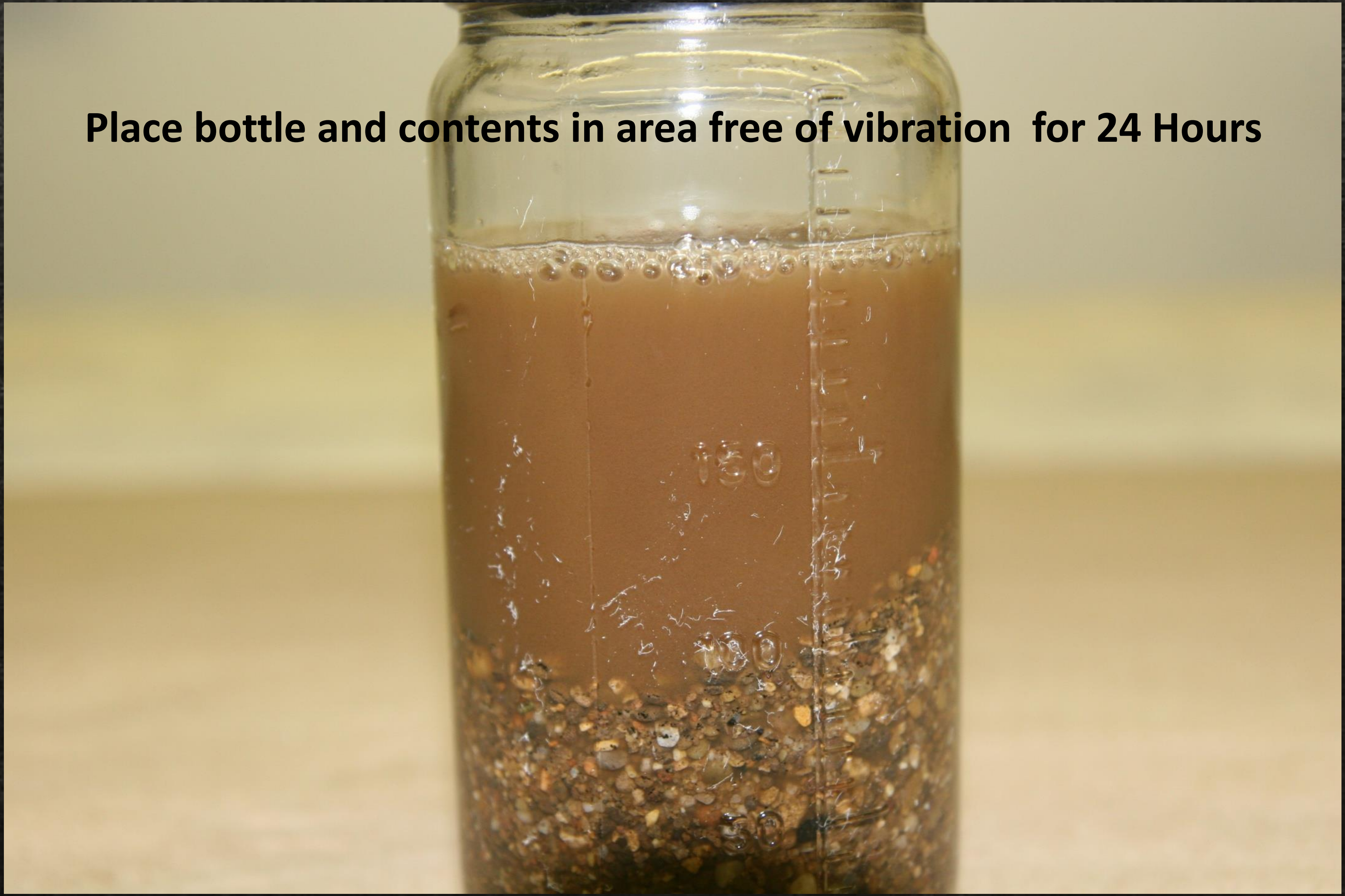
Fill glass bottle to 4.5 oz. (130ml) level with sand

Fill Bottle to 7 oz. (200ml) level with 3% NaOH Solution

Secure Cap on Jar

Shake Vigorously!

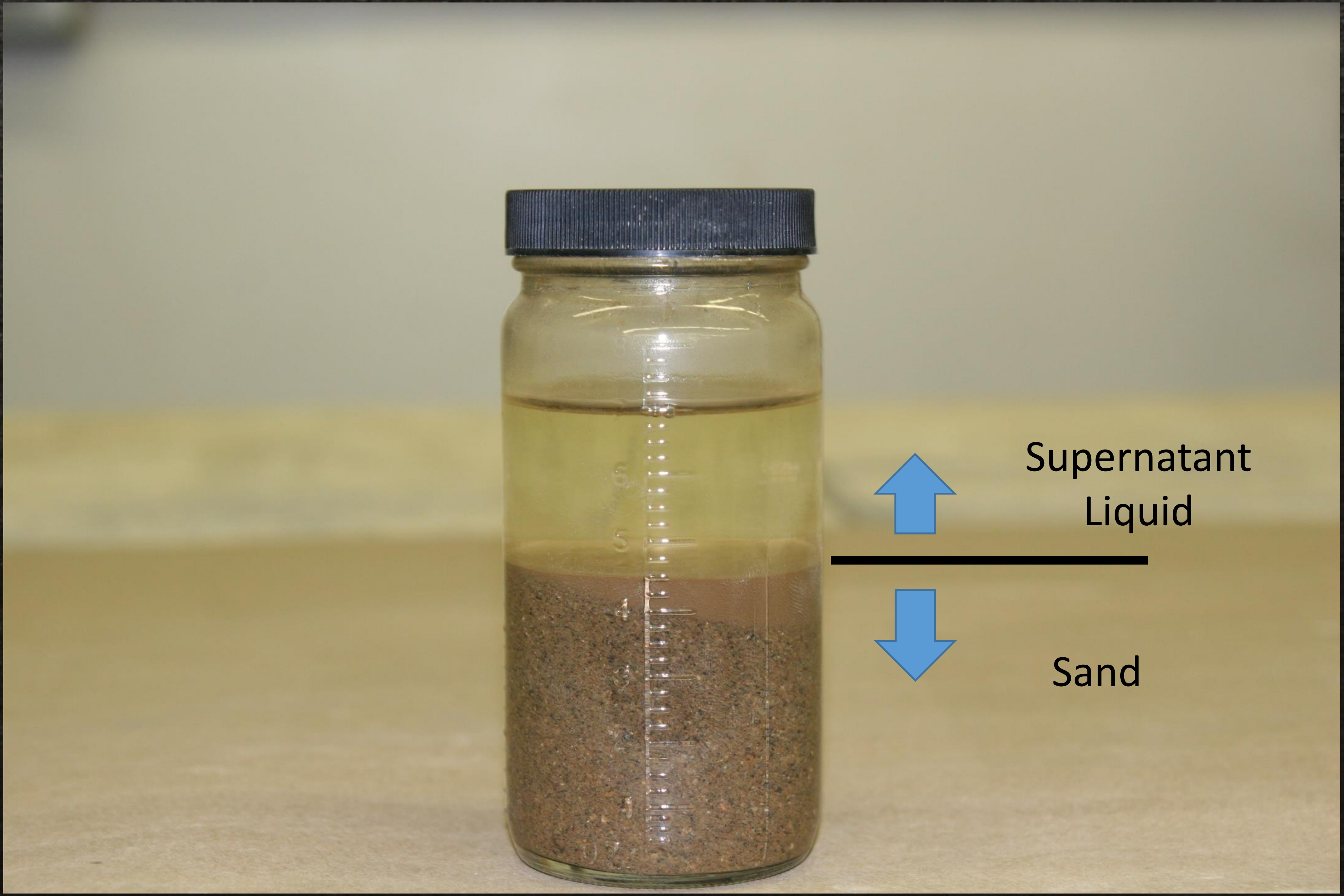
Place bottle and contents in area free of vibration for 24 Hours



THE shelly COMPANY

Oldcastle Materials

Place bottle and contents in area free of vibration for 24 hours


Supernatant
Liquid
Sand

Compare Supernatant liquid to Color Plate

Compare Supernatant Liquid to Color Plate

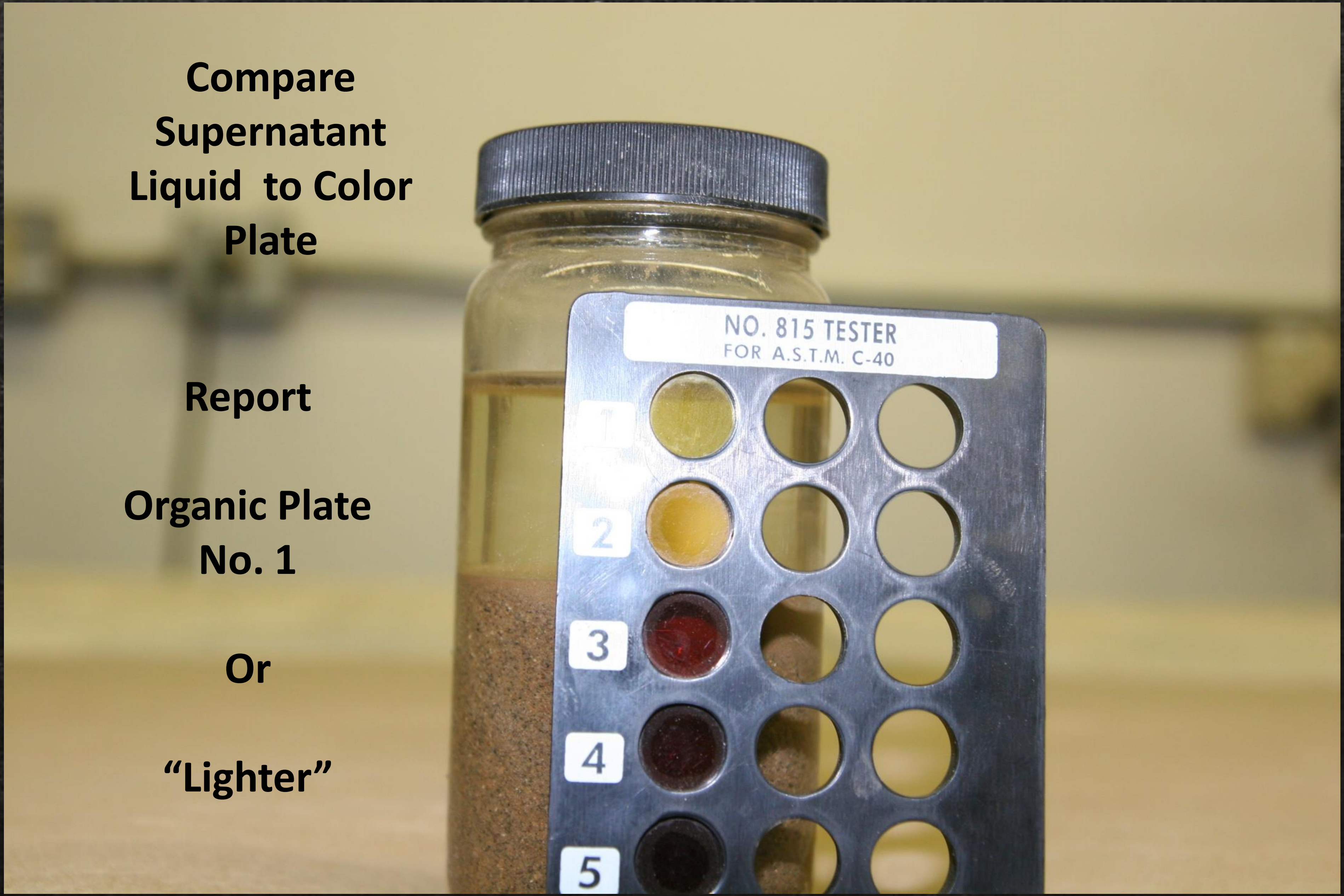
Compare Supernatant Liquid to Color Plate

Report

Organic Plate No. 1

Or

“Lighter”



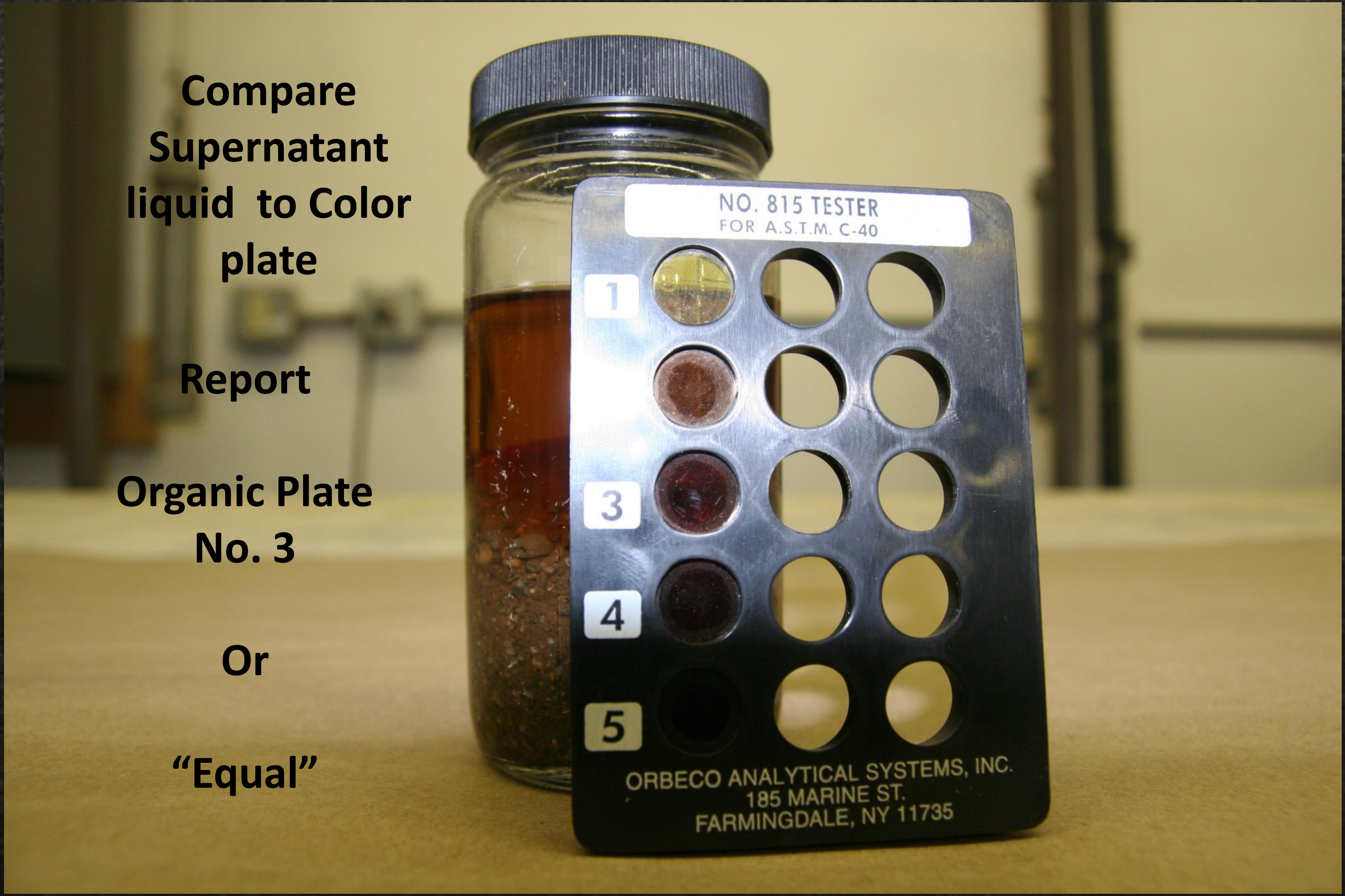
Compare Supernatant liquid to Color plate

Report

Organic Plate No. 3

Or

“Equal”



THE shelly COMPANY

Oldcastle® Materials

Aggregate Testing is not only required for many customers but serves as a very valuable production tool.

QC tests report what is being made, QC tests do not make the product!

Dedicated to the memory of:

Danny Beck, Lab Manager Northeast Division, The Shelly Co. 6-18-2017
Steve Cook, Shelly Company utility operator. 9-30-2017

Please remember:

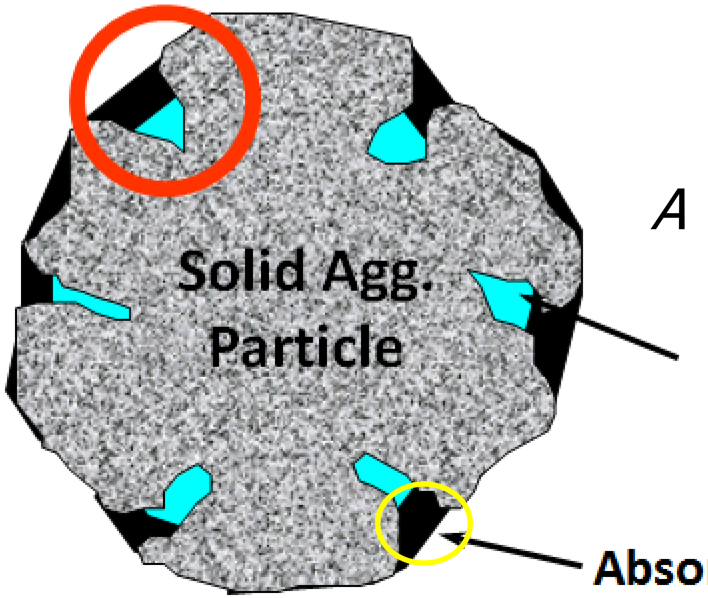
WATCH OUT FOR WORKERS IN OUR WORK ZONES!

THANK YOU

Effective Specific Gravity, G_{se}

Surface Voids

$$G_{se} = \frac{\text{Mass, dry}}{\text{Effective Volume}}$$



A

Vol. of water-perm. voids
not filled with asphalt

Absorbed asphalt
Not included

Effective volume = volume of solid aggregate particle + volume of surface voids not filled with asphalt