Physical Tests

LA Abrasion
Soundness
Sand Equivalent
Fine Aggregate Angularity
Flat and Elongated

L.A. Abrasion (Wear)

AASHTO T96

What is L.A. Abrasion?

- Indication of coarse aggregate resistance to abrasion and mechanical degradation during handling, construction, and use

Test Procedure Basics

- Standard gradation
- Charge drum with prescribed number of steel balls and aggregate
- Aggregate and steel balls subjected to specified number of rotations
- Sieve all material over specified size
- Result expressed as % changes in original weight

LA Abrasion Test

Specifications
Section 805.03.02

	Max %
• Wear (except slag and sandstone)	40%
• Wear (sandstone)	50%
• Wear (slag)	60%

Summary

- Indication of resistance to mechanical degradation
- Charge drum with steel balls and specified gradation
- Measure amount abraded during test
- Calculate loss

Sodium Sulfate Soundness

KM 64-610

Soundness Test

- Soundness loss is total percent loss over various sieve intervals
- Simulates weathering action by successively wetting and drying aggregate in sodium sulfate solution
  - One immersion and drying is considered one cycle
  - Typically 5 cycles specified

Sulfate Chemicals

Soundness

Before

After

Sodium sulfate penetrates vulnerable aggregates

SOUNDNESS LIMITS

(Max Loss)

• Fine Aggregate	Section
– Concrete 10%	(804.03)
– Hot mix asphalt 15%	(804.04.01)
• Coarse Aggregate	(805.03.01)
– Concrete 9-12%	
– Hot mix asphalt mixtures 9-15%	
– Other Uses 12-18%	

Summary

- Why soundness?
- Sodium sulfate
- 5 wet/dry cycles
- Specification limits

Sand Equivalent

AASHTO T176

Overview

- Purpose of test
- Equipment
- Procedure
- Calculations

Purpose of S.E. Test

- Used to estimate the relative proportions of fine aggregate and clay-size materials on a minus #4 portion of a sample
- Superpave requirements
  - Excessive clay can contribute to stripping in asphalt mixtures
  - The Department may waive the S.E. requirement provided the portion of the combined aggregate passing the No. 40 sieve is non-plastic according to AASHTO T-90.

Superpave Criteria

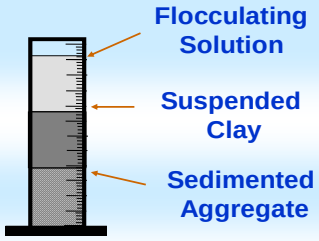
SECTION 804.04.04

ESAL Class 1 applicable to projects let before December 31, 2005.

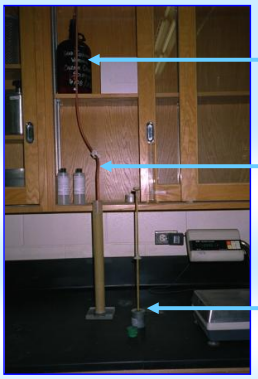
ESAL Class	Design ESALs (millions)	Uncompacted Voids Minimum (Method A) (Depth from Surface) ≤ 100mm	> 100mm	Sand Equivalent Minimum
1	< 0.3	40	40	45
2	0.3 to < 3	40	40	45
3	3 to < 30	45	40	45
4	≥ 30	45	45	50

Equipment

- Graduated cylinder
- Flocculating solution
- Measurement Rod



Equipment

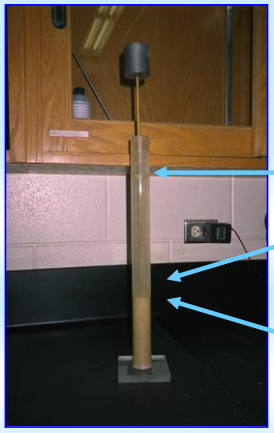


Bottle of Solution on Shelf Above Top of Cylinder

Hose and Irrigation Tube

Measurement Rod

Test



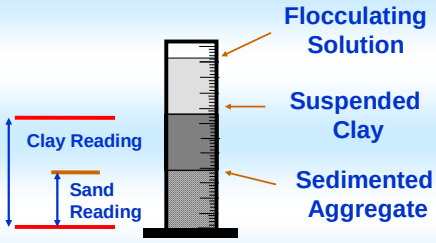
Marker on Measurement Rod

Top of Suspended Material

Top of Sand Layer

Calculations

$$SE = \frac{\text{Sand Reading}}{\text{Clay Reading}} * 100$$



Summary

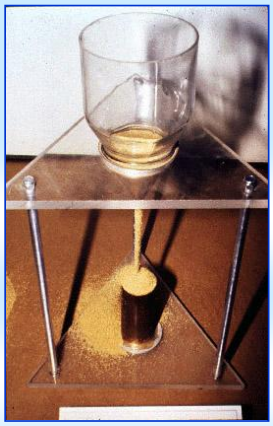
- Determine relative proportion of clay-size material in a fine aggregate
- Limits on Superpave
- Settle materials in a graduated cylinder
- Calculate the sand equivalence

Fine Aggregate Angularity

AASHTO T304

Overview

- Purpose of test
- Equipment
- Procedure
- Calculations



Purpose of FAA Test

- Indirect measure of the following:
  - Particle shape
  - Surface texture
  - Angularity

SUPERPAVE Criteria

SECTION 804.04.04
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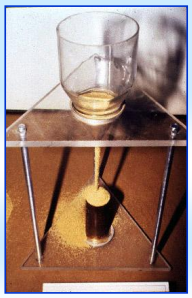
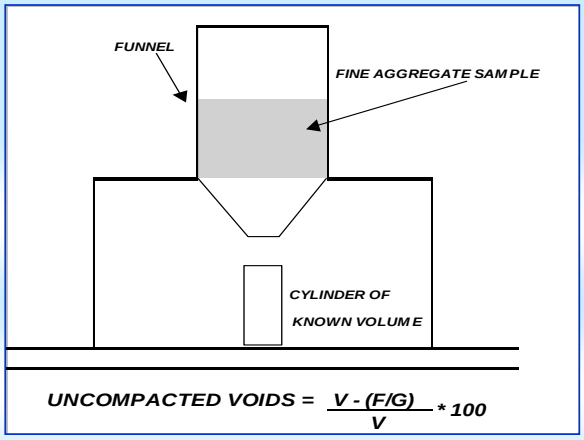
3	3 to < 30	45	40	45
4	≥ 30	45	45	50

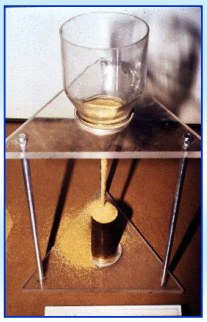
Equipment

- 100mL Cylinder
- Mason Jar with funnel
  - 115mm from cylinder
- Spatula
- Scale



Apparatus





Sample

- Method A – Standard Graded Sample
  - Used for SUPERPAVE mix design
    4 size fractions (see next slide)
- Method B – Individual Size Fractions
- Method C – As Received Grading

Sample

- Method A – Standard Graded Sample

Individual Size Fraction	Mass, g
1.18mm (No.16)	44
0.60mm (No.30)	57
0.30mm (No.50)	72
0.15mm (No.100)	17
Total	190

Procedure

- Pour sample into jar (restricting flow)
- Allow sample to fall freely
- Strike off excess heaped fine aggregate
- Weigh material in cylinder
- Repeat test using same recombined sample
- Average 2 results to report voids

Calculation

$$U = \frac{V - \left(\frac{F}{G}\right)}{V} * 100$$

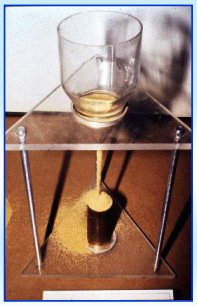
- V = volume of cylinder, 100mL
- F = mass of fine aggregate in cylinder, g
- G = BOD gravity of aggregate
- U = uncompacted voids, %

Understanding Results

- Rounded natural sands will have lower uncompacted voids than crushed sands
- Uncompacted voids increase with increased angularity
- Typical values
  - Natural sands: 36% to 43%
  - Crushed sands: 43% to 52%

Summary

- Purpose of test
- Procedure
- Understanding results

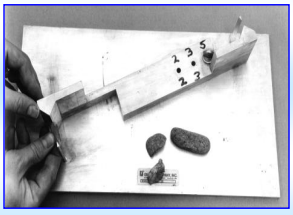


Flat and Elongated

ASTM D4791

Overview

- Purpose of the Test
- Overview of Test Procedure



Purpose of Test

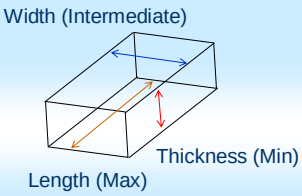
- To determine % of *Flat*, *Elongated,* or *Flat and Elongated* Pieces
  - Specified in asphalt
  - Excessive F & E particles can break under compaction and change mix properties in roadway
  - Excessive F & E particles may contribute to lower concrete breaks

Definitions

- Length -- Long Dimension
- Thickness -- Narrow Dimension
- Width -- Intermediate Dimension

Definitions

- ASTM D4791
  - Flat
    - Width-to-Thickness
  - Elongated
    - Length-to-Width
  - Total Flat and Elongated
    - Length-to-Thickness (max-to-min)



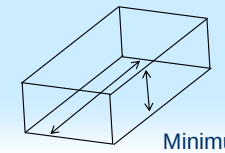
SUPERPAVE

- Flat and Elongated
- Maximum to minimum dimension
  - 5:1
  - 3:1
  - 2:1
- Superpave specification is maximum of 10% Flat and Elongated at a 5:1 ratio Section 805.05.02.

Test Procedure

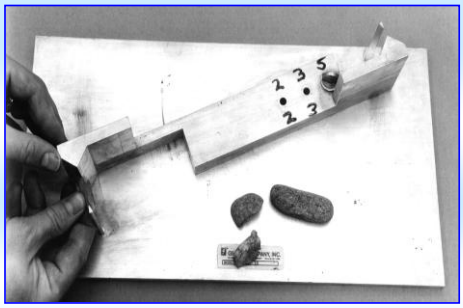
- Test + #4 size materials
- Separate 100 pieces of distinct size fractions
  - 1 1/2 x 1
  - 1 x 3/4
  - 3/4 x 1/2
  - 1/2 x 3/8
- Set the caliper to the desired ratio in question
  - 5:1
  - 3:1
  - 2:1
- Set caliper to large dimension of stone
- Check smaller dimension through opposite end caliper
- Calculate a weighted average based on mass or count

Flat and Elongated

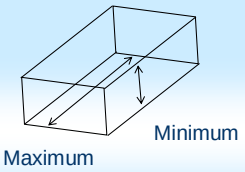


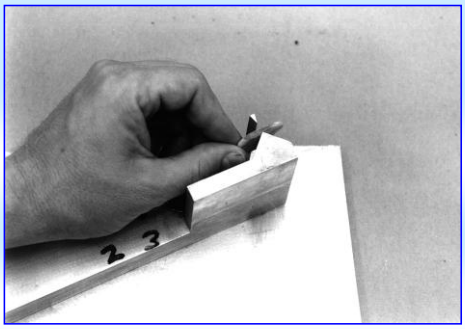
Minimum

Maximum



Flat and Elongated





Summary

- Separate materials into specified size fractions
- Set calipers at desired ratio
- Calculate results based on weighted average
- Report F & E by weight or by count
- Current Specs use 5:1 Flat and Elongated Ratio

Physical Tests

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