

**Physical Tests**

LA Abrasion  
Soundness  
Sand Equivalent  
Fine Aggregate Angularity  
Flat and Elongated

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**L.A. Abrasion  
(Wear)**

AASHTO T96

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## What is L.A. Abrasion?

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

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## Test Procedure Basics

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- 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

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## LA Abrasion Test



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## Specifications Section 805.03.02

	<u>Max %</u>
• Wear (except slag and sandstone)	40%
• Wear (sandstone)	50%
• Wear (slag)	60%

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## Summary

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

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## Sodium Sulfate Soundness

KM 64-610

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## 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

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



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## Sand Equivalent

AASHTO T176

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## 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)		Sand Equivalent Minimum
		≤ 100mm	> 100mm	
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

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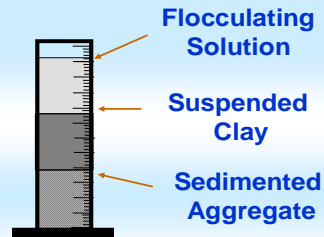
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### Equipment

- Graduated cylinder
- Flocculating solution
- Measurement Rod




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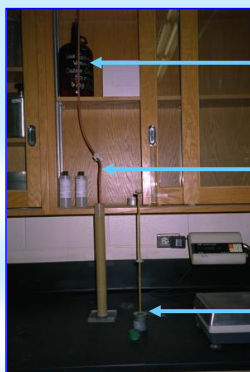


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## Equipment

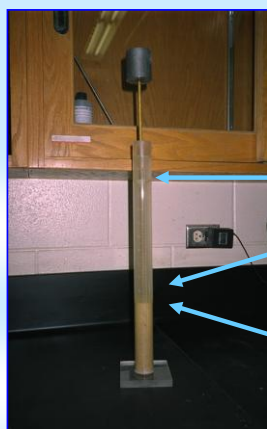


Bottle of Solution on Shelf  
Above Top of Cylinder

Hose and Irrigation Tube

Measurement Rod

## Test



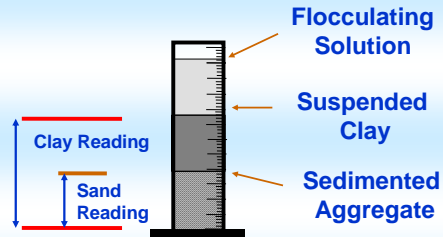
Marker on Measurement Rod

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

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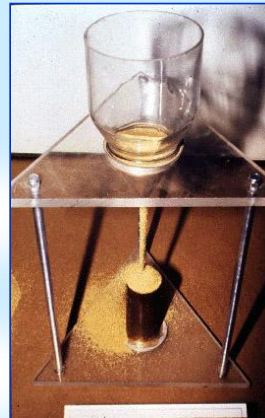
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## Overview

- Purpose of test
- Equipment
- Procedure
- Calculations



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## Purpose of FAA Test

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

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## SUPERPAVE Criteria

SECTION 804.04.04  
ESAL Class 1 applicable to projects let before December 31, 2005.

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ESAL Class	Design ESALs (millions)	Uncompacted Voids Minimum (Method A) (Depth from Surface)		Sand Equivalent Minimum
		≤ 100mm	> 100mm	
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

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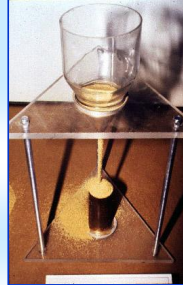
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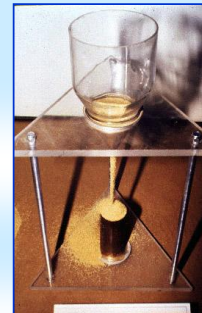
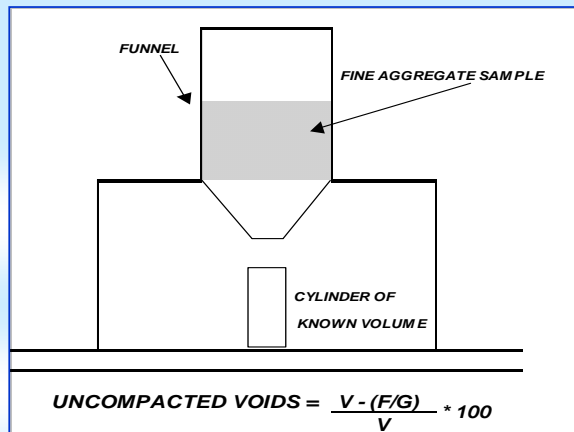
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## Equipment

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



## Apparatus



## Sample

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- 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

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## Sample

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- Method A – Standard Graded Sample

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

## Procedure

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- 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
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## Calculation

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

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

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- 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%

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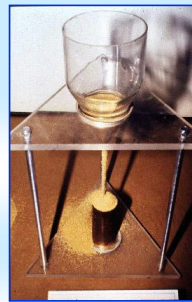
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## Summary

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- Purpose of test
- Procedure
- Understanding results



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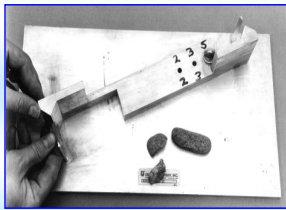
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# Flat and Elongated

ASTM D4791

## Overview

- Purpose of the Test
- Overview of Test Procedure



## Purpose of Test

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- 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

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## Definitions

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

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## Definitions

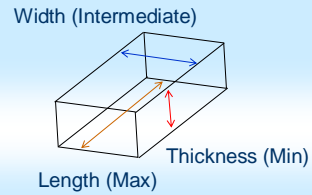
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- ASTM D4791

- Flat
  - Width-to-Thickness

- Elongated
  - Length-to-Width

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



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## SUPERPAVE

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- 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.

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## 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

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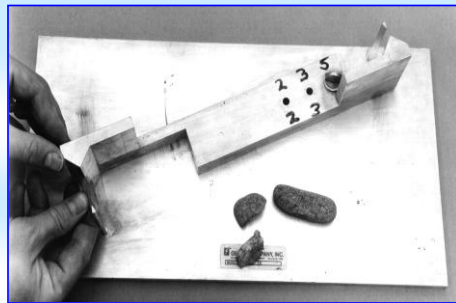
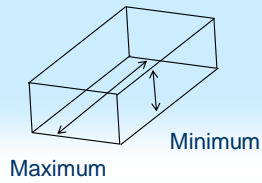
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## Flat and Elongated



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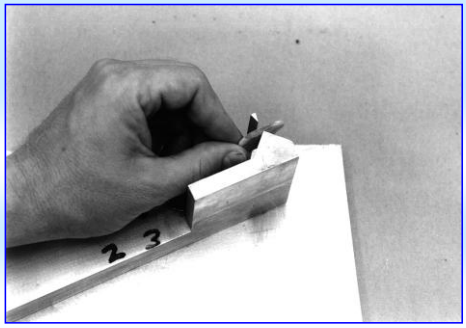
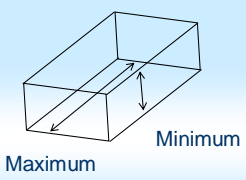
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# Flat and Elongated



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# 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

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