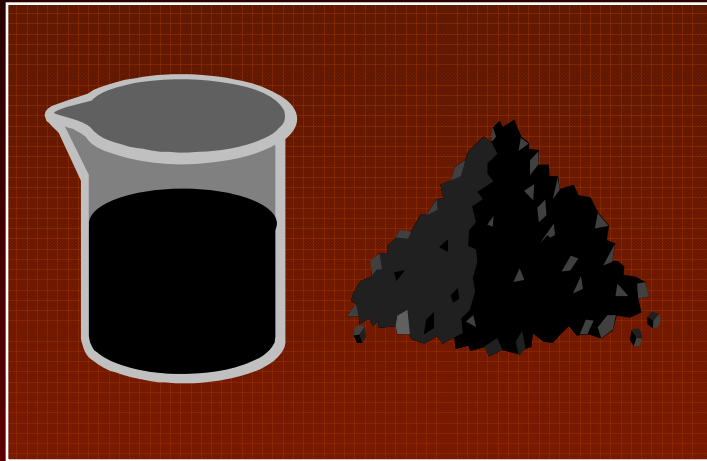


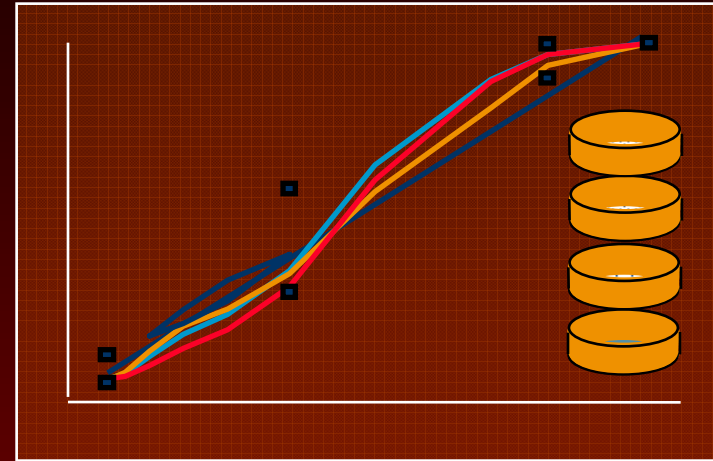


# PHYSICAL PROPERTIES OF AGGREGATES

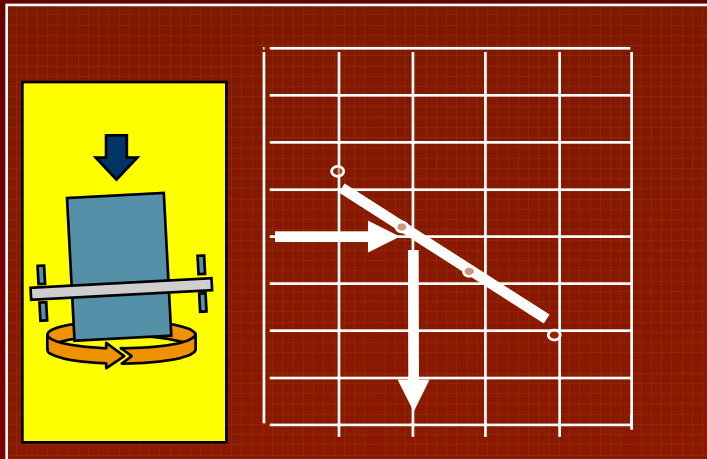
# 4 Steps of Superpave Mix Design



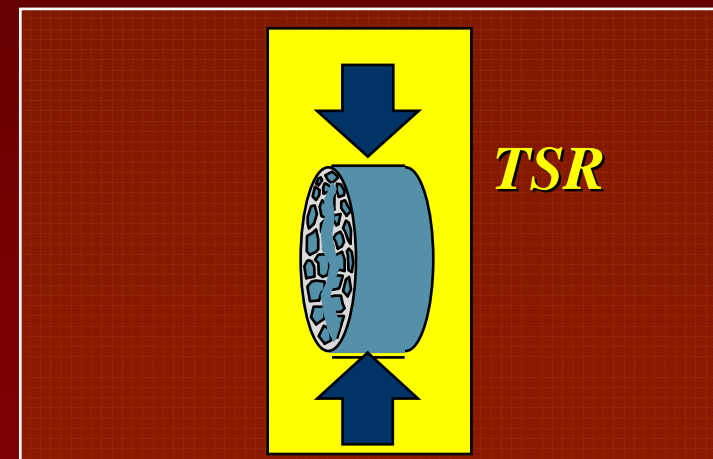
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



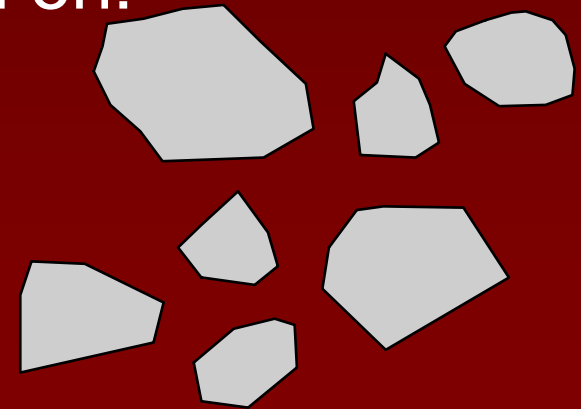
4. Moisture Sensitivity

# Aggregate Properties

- Consensus Properties - *required*
  - coarse aggregate angularity (CAA)
  - fine aggregate angularity (FAA)
  - flat, elongated particles
  - clay content
- Source Properties - *agency option*
  - toughness
  - soundness
  - deleterious materials

# Coarse Aggregate Angularity

- Measured on + 4.75 mm material
- Based on fractured faces
  - fractured surface larger than 25% of aspect ratio
- ASTM D 5821
- Specification requirements depend on:
  - depth of layer within pavement
  - traffic level







# Coarse Aggregate Angularity

Traffic  
ESALs

Depth from Surface

< 100 mm

> 100 mm

•  
•  
•  
**10 - 30 x 10<sup>6</sup>**

•  
•  
•  
**95/90**

•  
•  
•  
**80/75 Minimum**

**95% one fractured face**

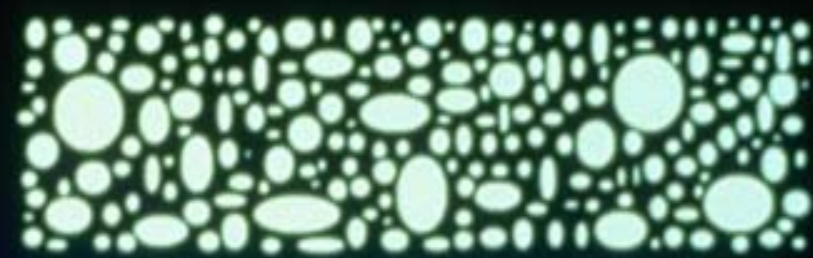
**90% two+ fractured faces**



# Contrasting Stone Skeletons



**Cubical Aggregate**



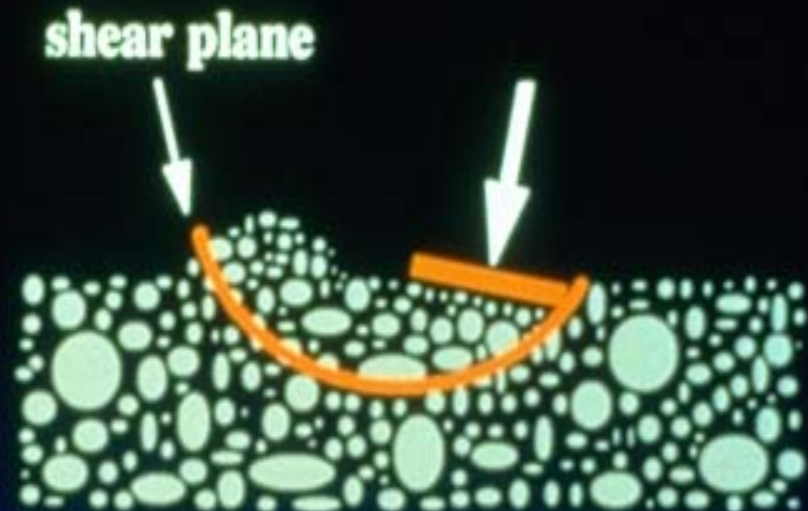
**Rounded Aggregate**



# Shearing Behavior of Aggregate



**Before Load**



**After Load**

# Fine Aggregate Angularity

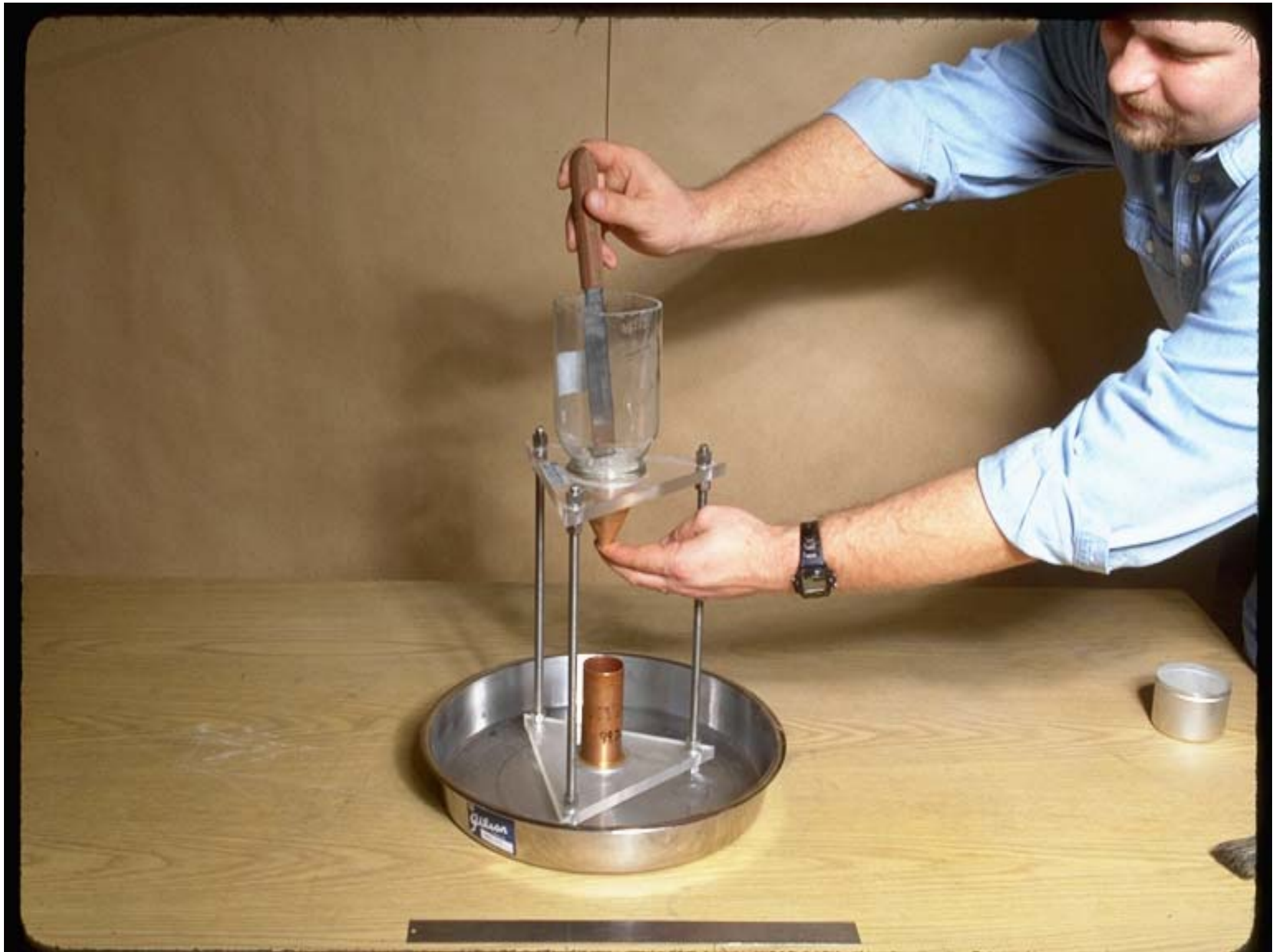
- Measured on - 2.36 mm material
- Based on air voids in loosely compacted sample
- AASHTO T 304, Method A
  - Standard Grading: +1.18 mm to +0.150 mm
- Requirements depend on
  - depth of layer within pavement
  - traffic level











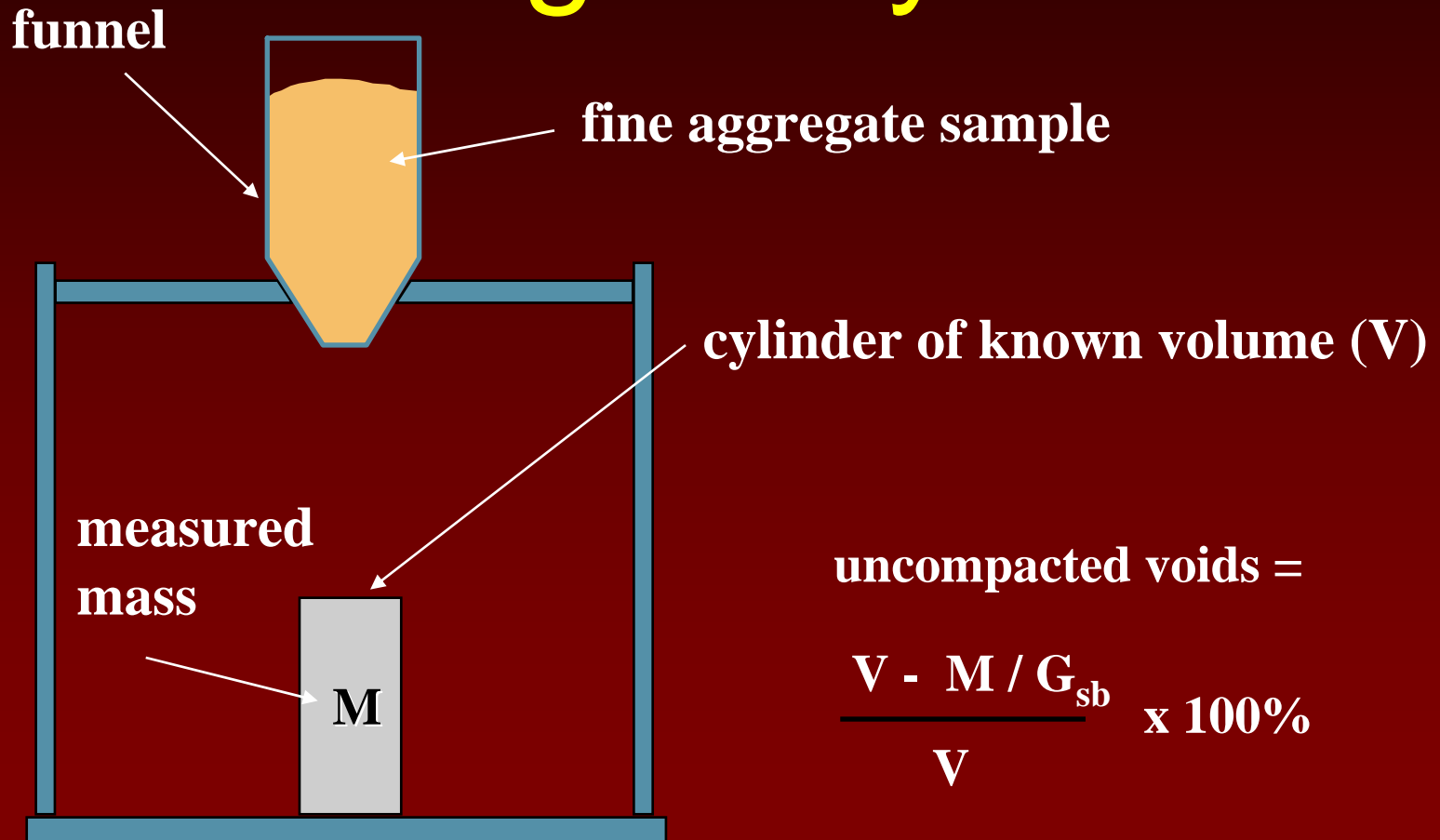








# Fine Aggregate Angularity



# Fine Aggregate Angularity

<u>Traffic</u> <u>ESALs</u>	<u>Depth from Surface</u>	
	<u>&lt; 100 mm</u>	<u>&gt; 100 mm</u>
10 - 30 x 10 <sup>6</sup>	45	40 Minimum
.	.	.
.	.	.

% air voids in loose sample

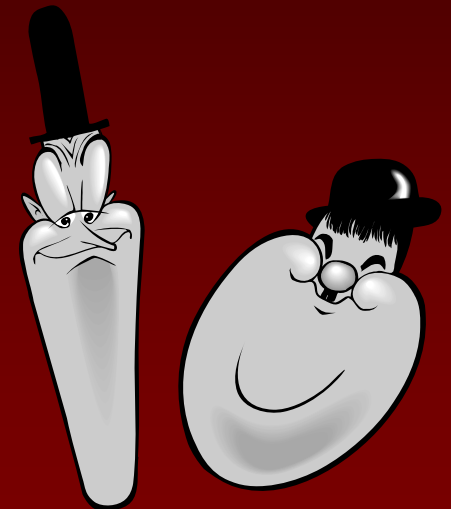
> Rounded particles pack tighter together -- less air

# What Affect Does FAA Have on Performance?

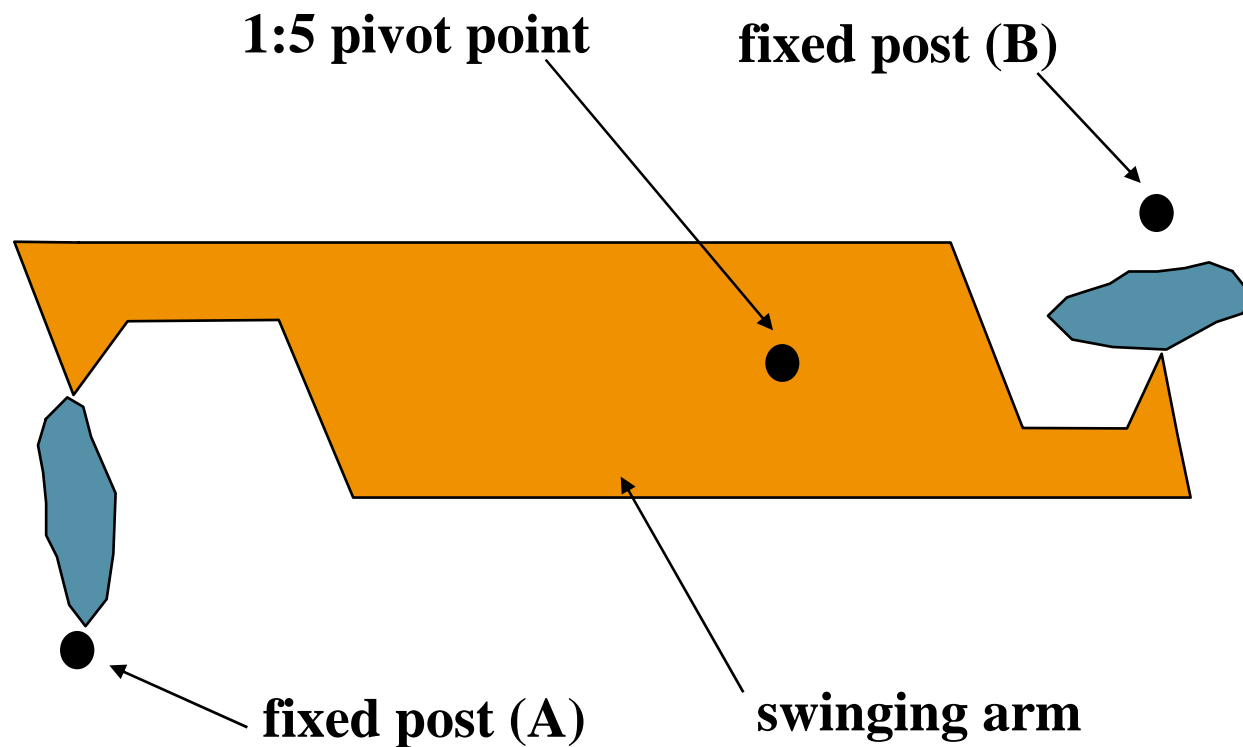
- FAA and restricted zone used to limit the amount of rounded natural sands
- National Rutting Study initiated in 1987 by NCAT evaluated 42 pavements in 14 states. The study identified a minimum FAA value of 43.3% to resist rutting.

# Flat, Elongated Particles

- Measured on + 4.75 mm material
- Based on dimensional ratio of particles
  - ratio of max to min dimension  $< 5$
- ASTM D 4791
- Requirements depend on traffic level



# Flat, Elongated Particles









$-\frac{3}{8}'' + \text{No. 4}$



$-\frac{1}{2}'' + \frac{3}{8}''$



$-\frac{3}{4}'' + \frac{1}{2}''$



$-1'' + \frac{3}{4}''$







PASSED →  
3:1 & 5:1 F&E



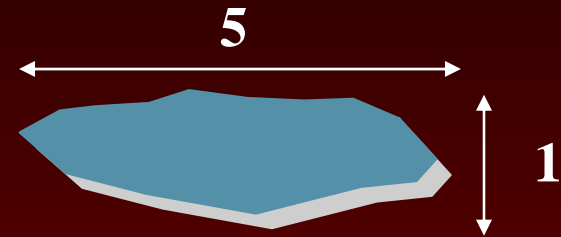
FAILED →  
3:1 F&E



FAILED →  
5:1 F&E



# Flat & Elongated Particles



**Traffic  
ESALs**                      **Percent**

---

•                                      •  
**10 - 30 x 10<sup>6</sup>**                      **10**                      **Maximum**

•                                      •  
•                                      •  
percentage  
of flat and elongated particles

# What Affect Does F&E Have on Performance?

- Tend to break under the roller exposing uncoated faces which may lead to stripping of the asphalt film off the aggregate in the presence of moisture
- Particles tend to orient flat under traffic, reducing pavement voids. May lead to flushing
- Change in shape affects mixture volumetrics

# Clay Content

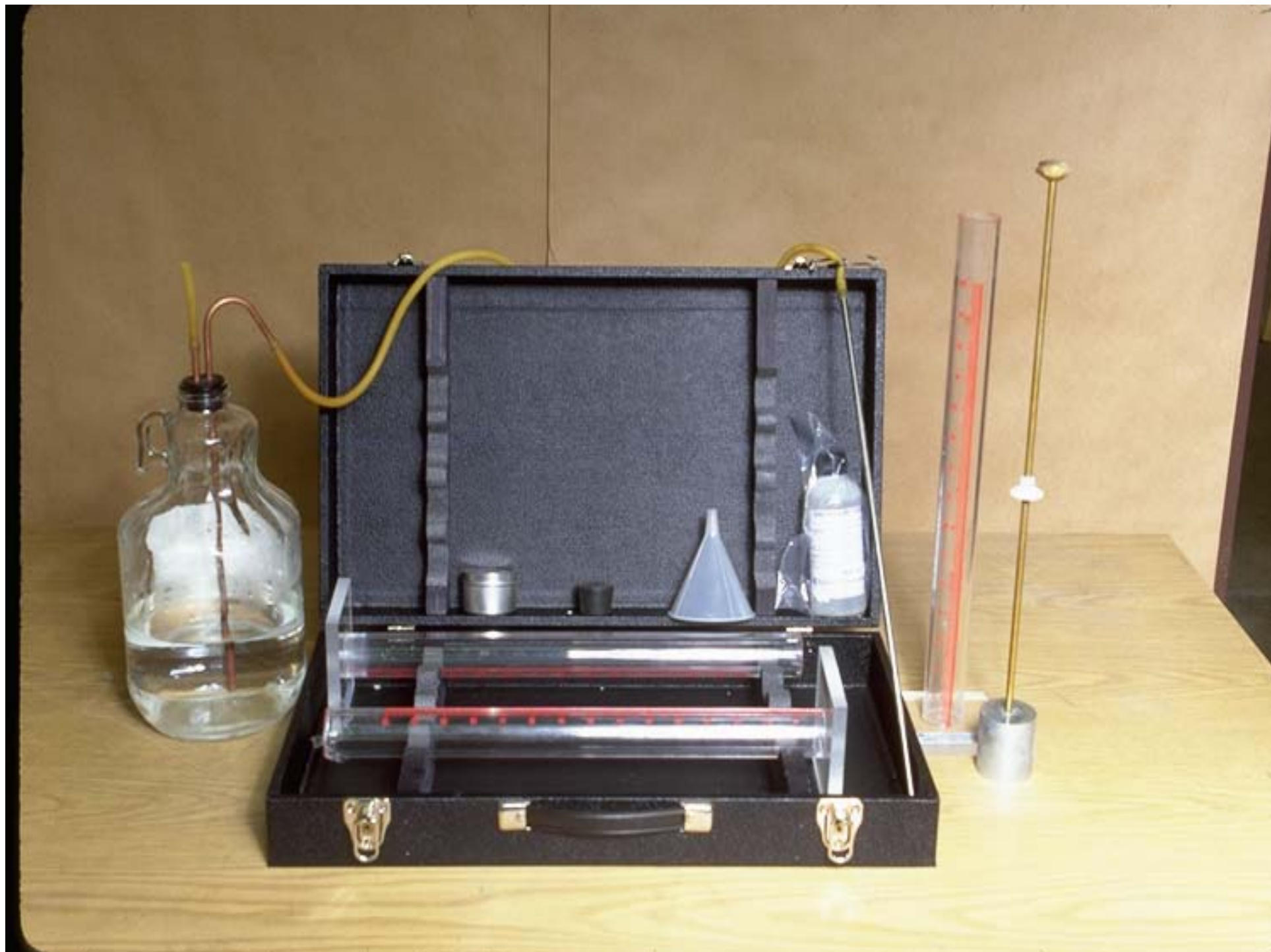
- Measured on - 4.75 mm material
- Based on sand equivalent value
- AASHTO T176
- Requirements depend on traffic level

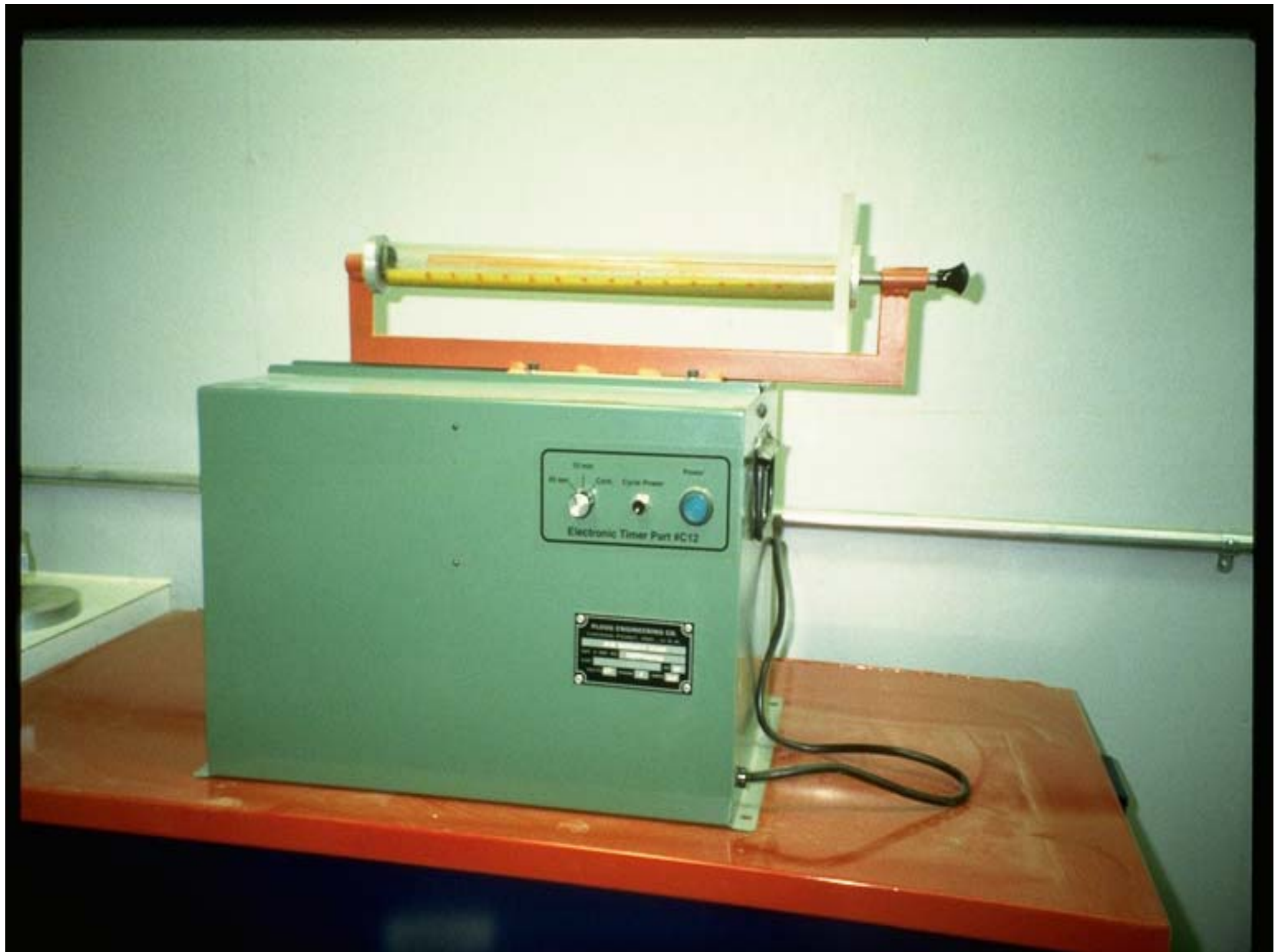
> **How dirty is the sand ?**



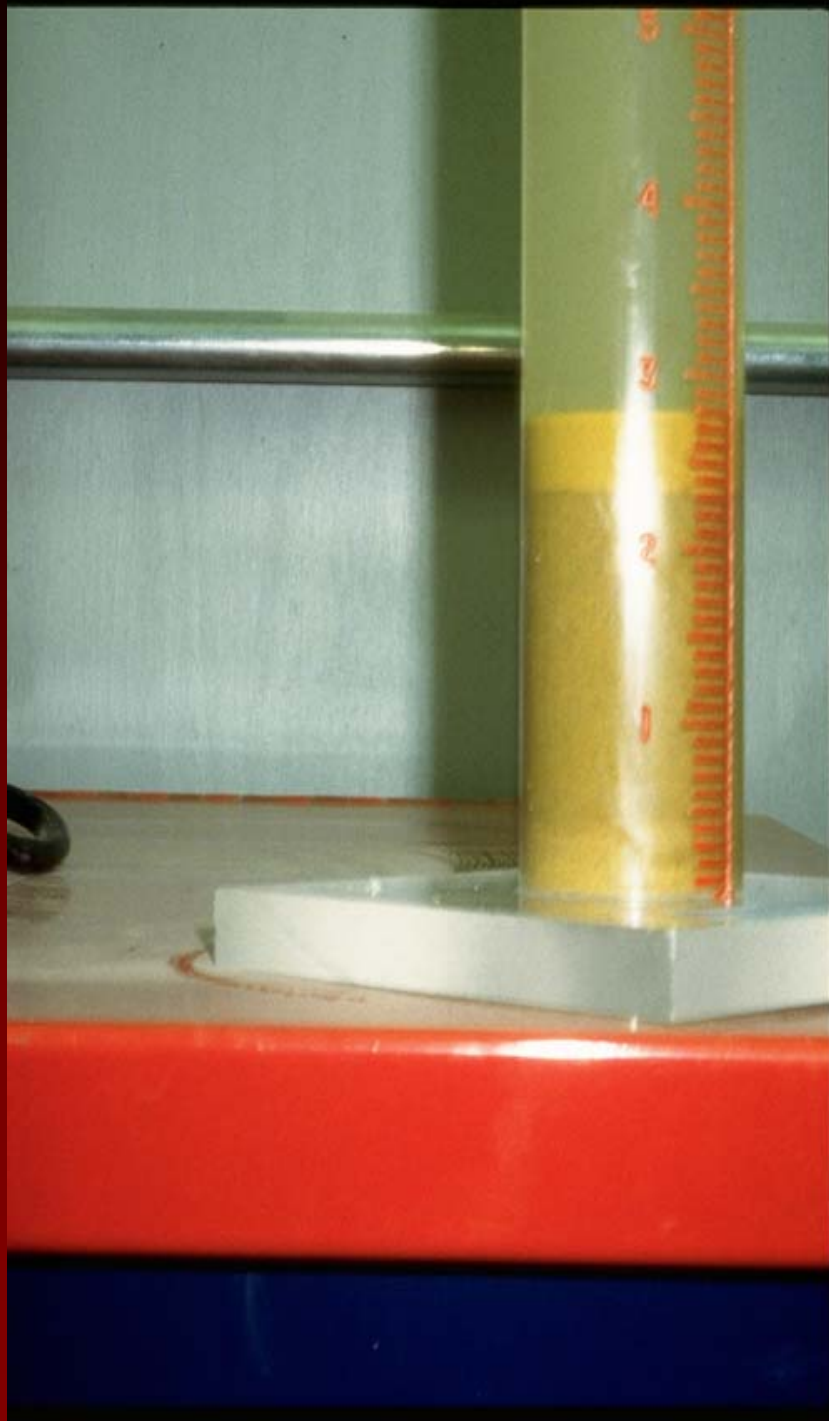


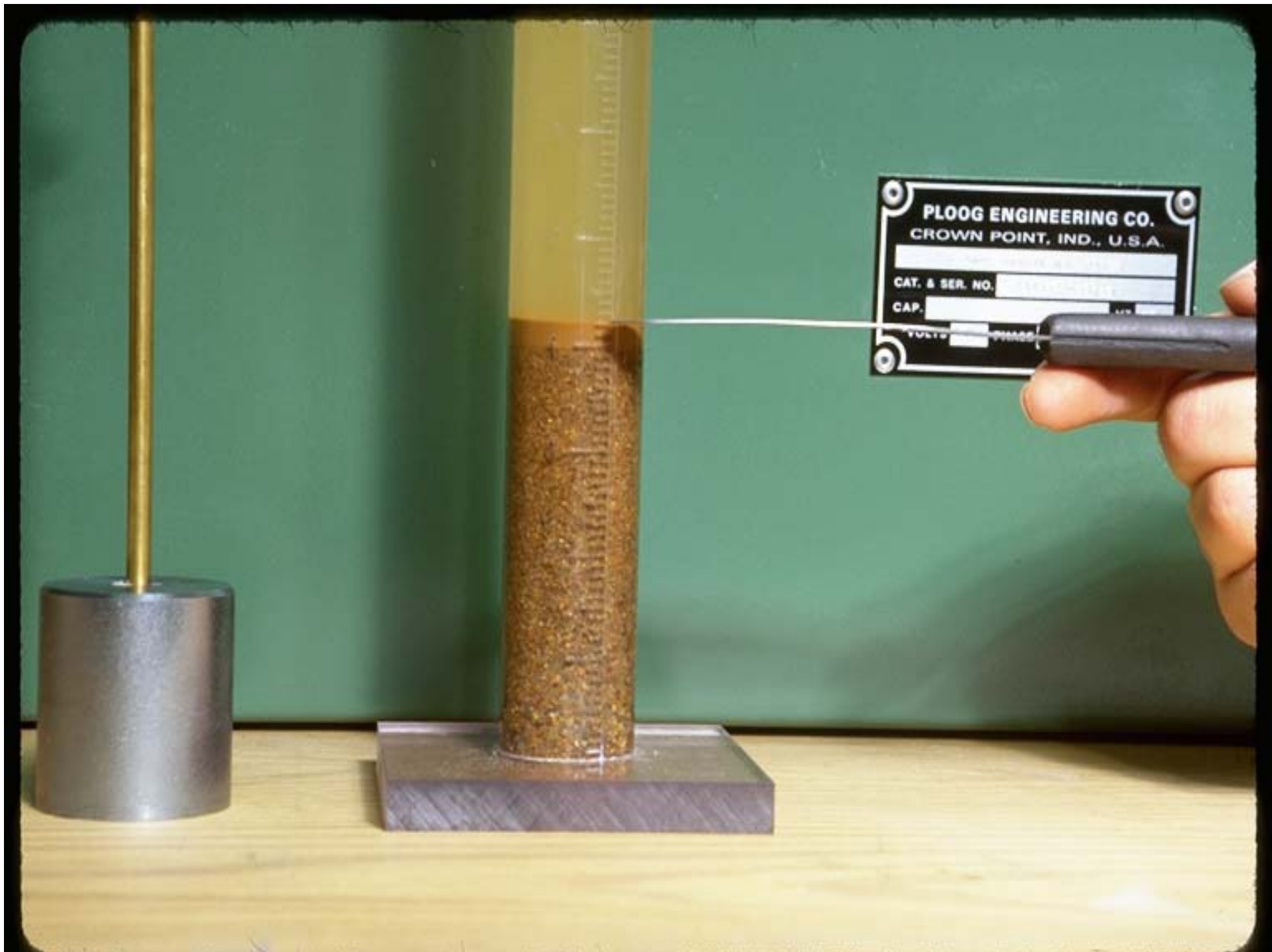




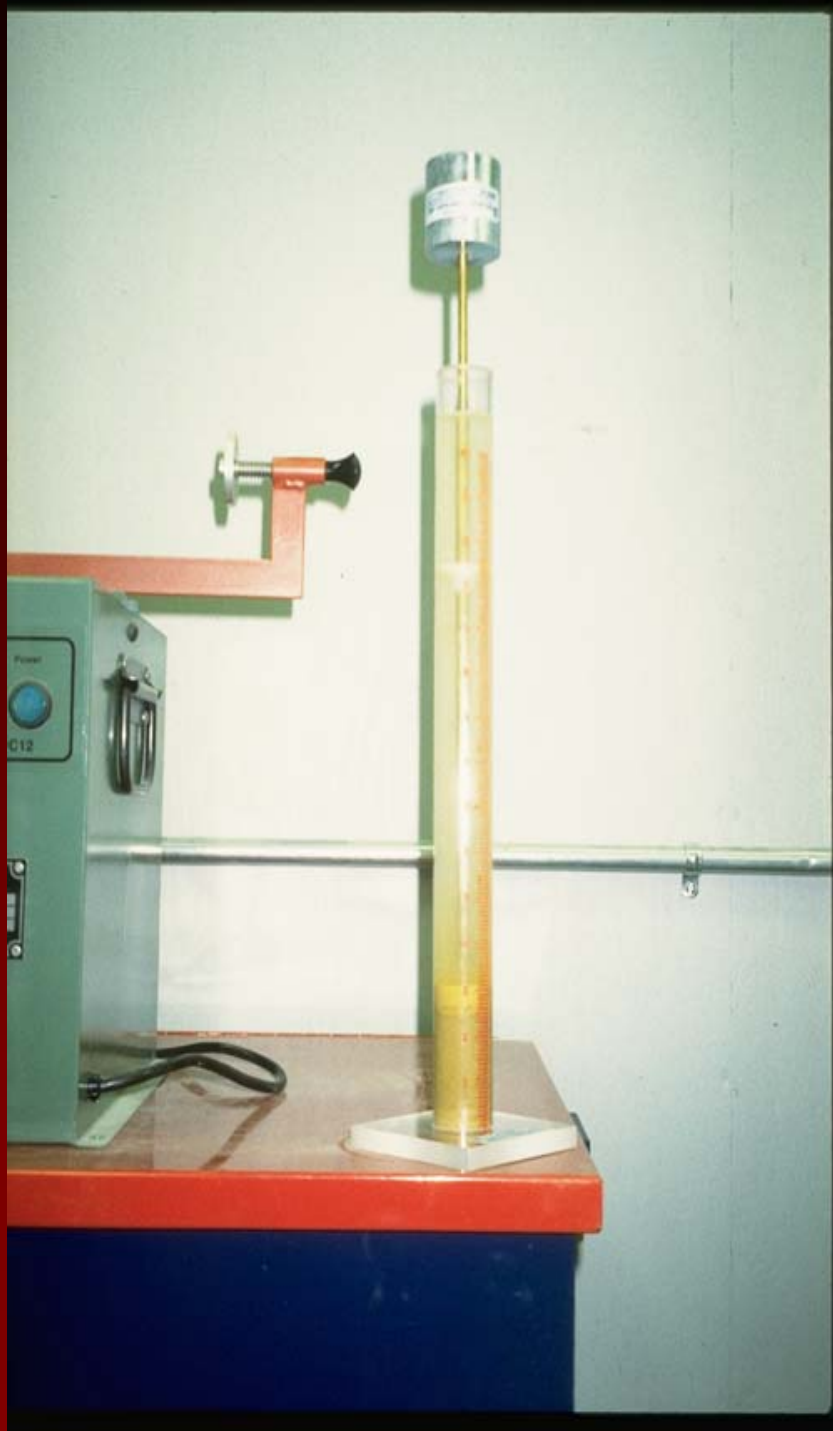






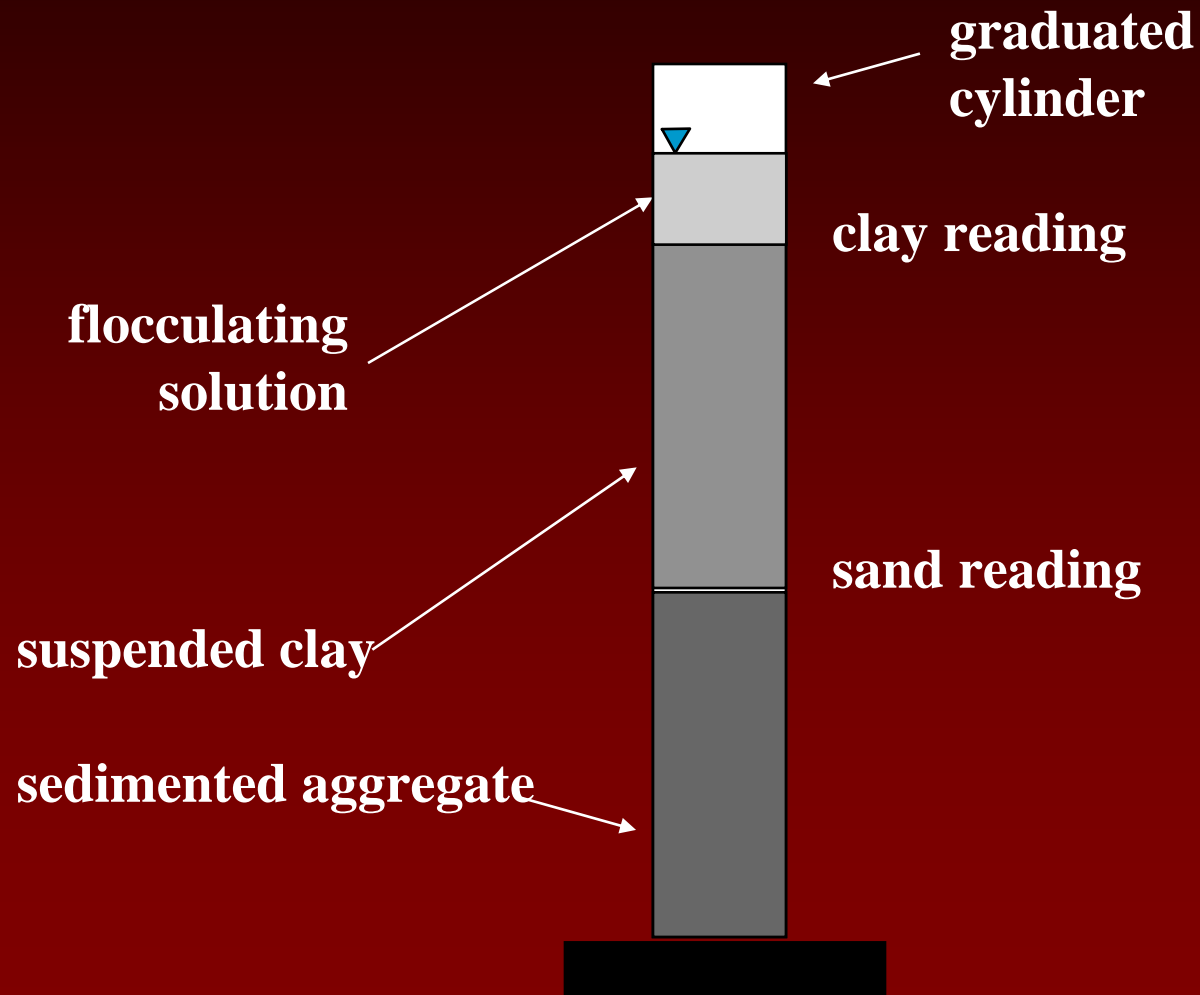


**PLOOG ENGINEERING CO.**  
**CROWN POINT, IND., U.S.A.**  
CAT. & SER. NO. \_\_\_\_\_  
CAP. \_\_\_\_\_





# Clay Content





# Clay Content

**Traffic  
ESALs**

**Percent**

•  
•  
**10 - 30 x 10<sup>6</sup>**  
•

•  
**45**  
•  
•

**Minimum**

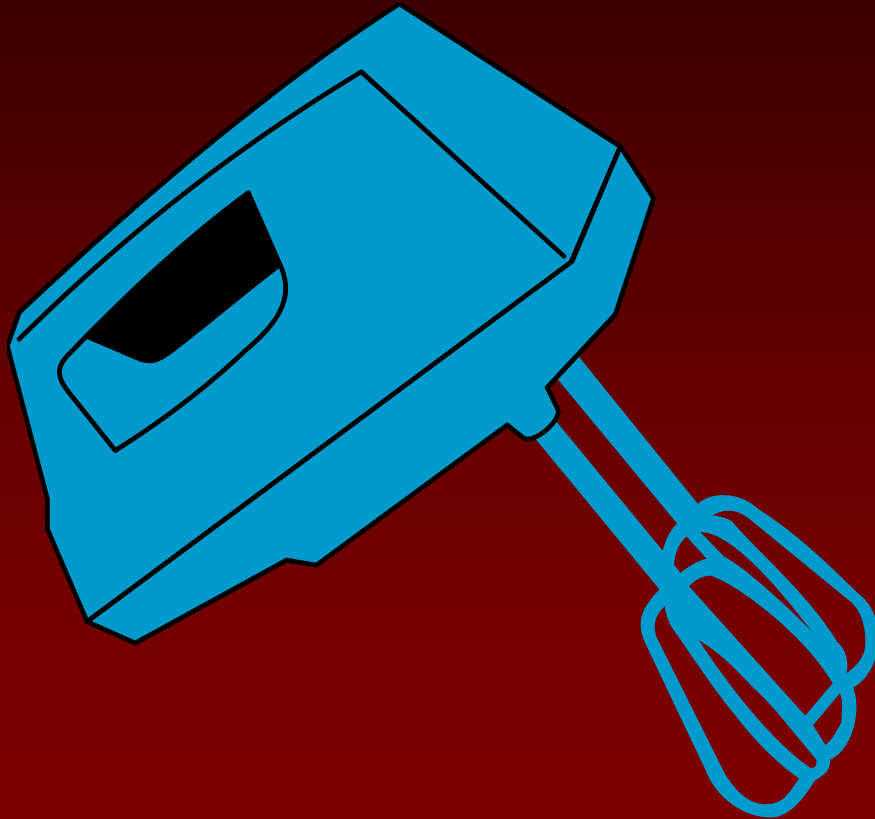
↙  
**sand equivalent value**

**> More sand - Less clay**  
**Clay on aggregate particles**  
**reduces binder adhesion**

# Aggregate Source Properties

- Toughness
  - AASHTO T96 (LA abrasion)
- Soundness
  - AASHTO T104 (Na or Mg sulfate soundness)
- Deleterious materials
  - AASHTO T112 (clay lumps and friable particles)
- Others selected by agency
  - > **Used in Mix Design or for Acceptance Control**

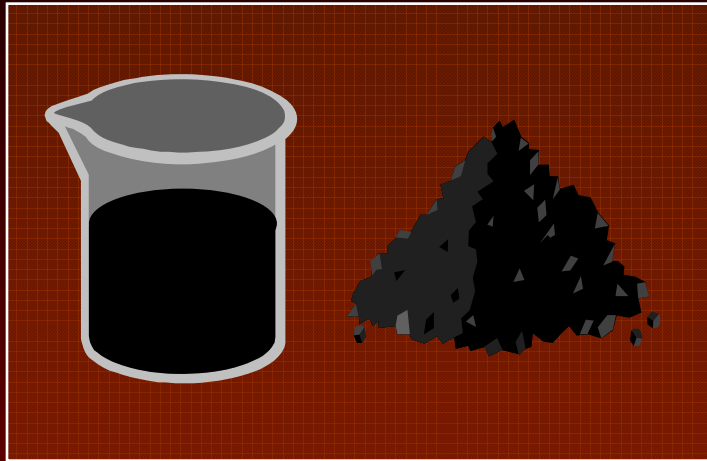
# Superpave Aggregate Specifications



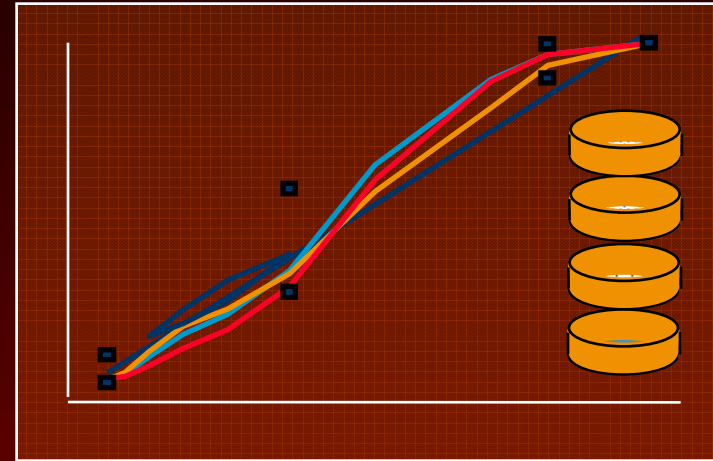
Required on total aggregate blend

Not individual aggregate stockpiles

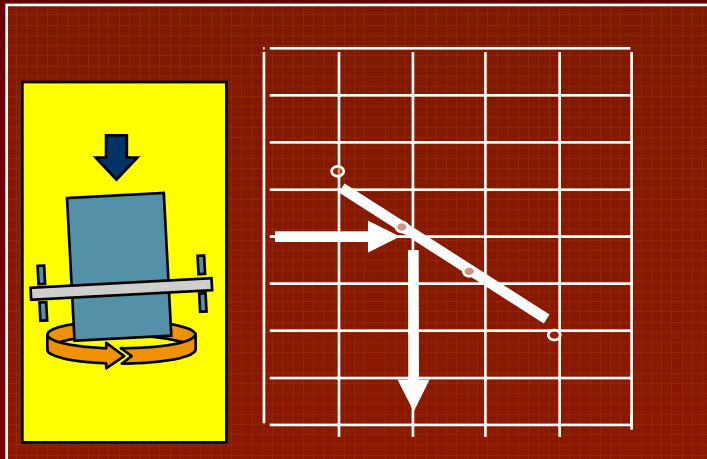
# 4 Steps of Superpave Mix Design



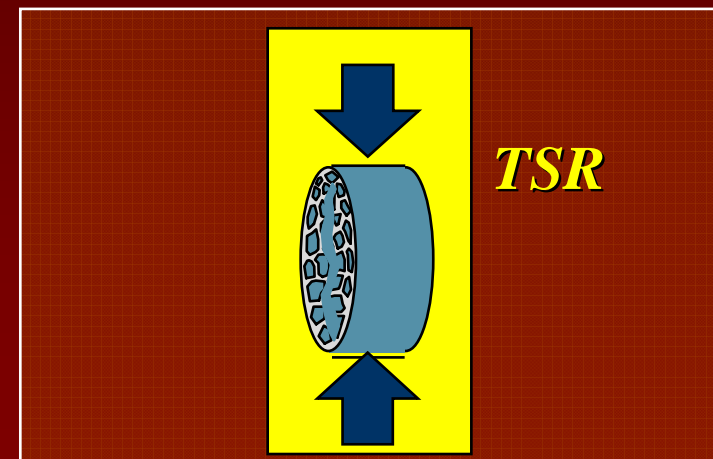
1. Materials Selection



2. Design Aggregate Structure



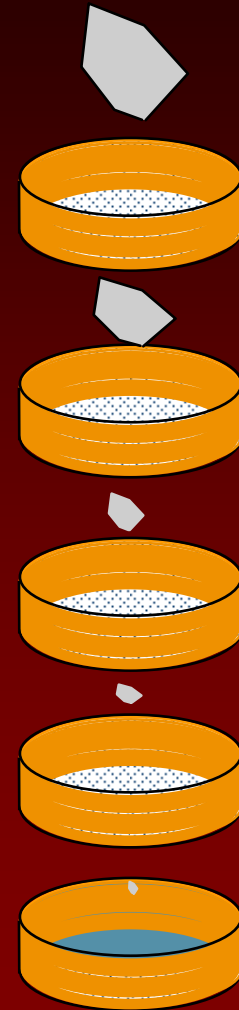
3. Design Binder Content



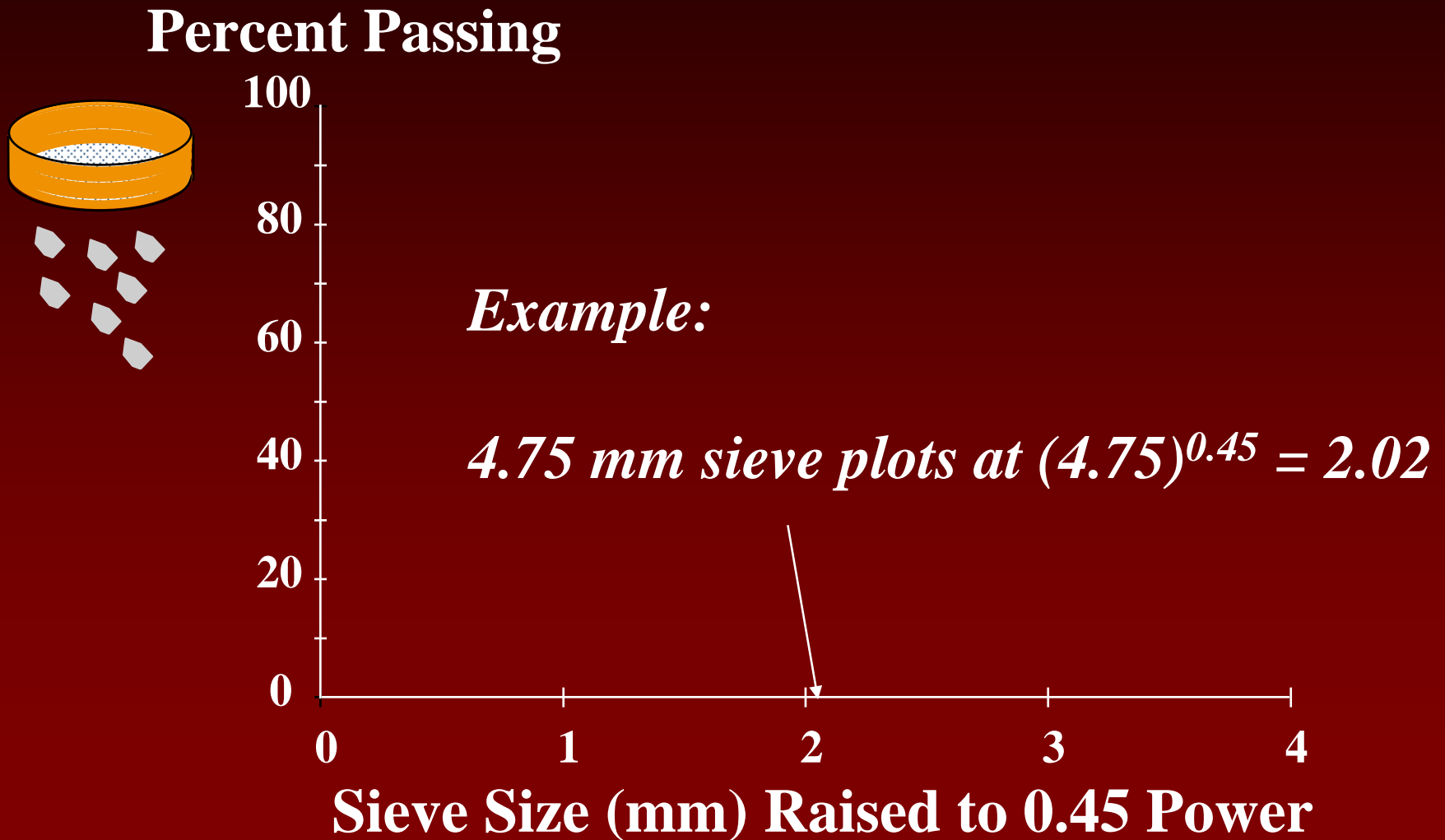
4. Moisture Sensitivity

# Superpave Aggregate Gradation

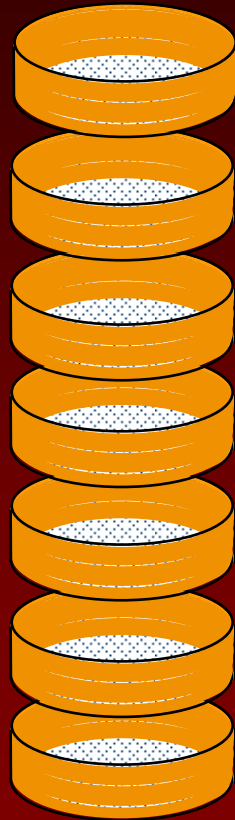
- Use 0.45 power gradation chart
- Blend size definitions
  - maximum size
  - nominal maximum size
- Gradation limits
  - control points
  - restricted zone



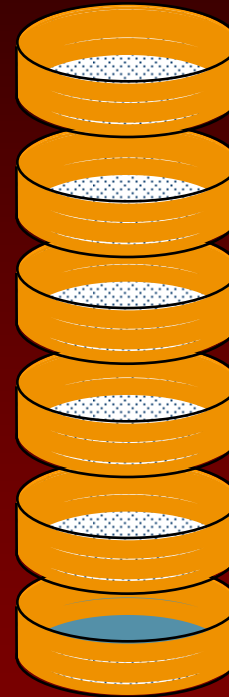
# 0.45 Power Grading Chart



# Standard Aggregate Sieves



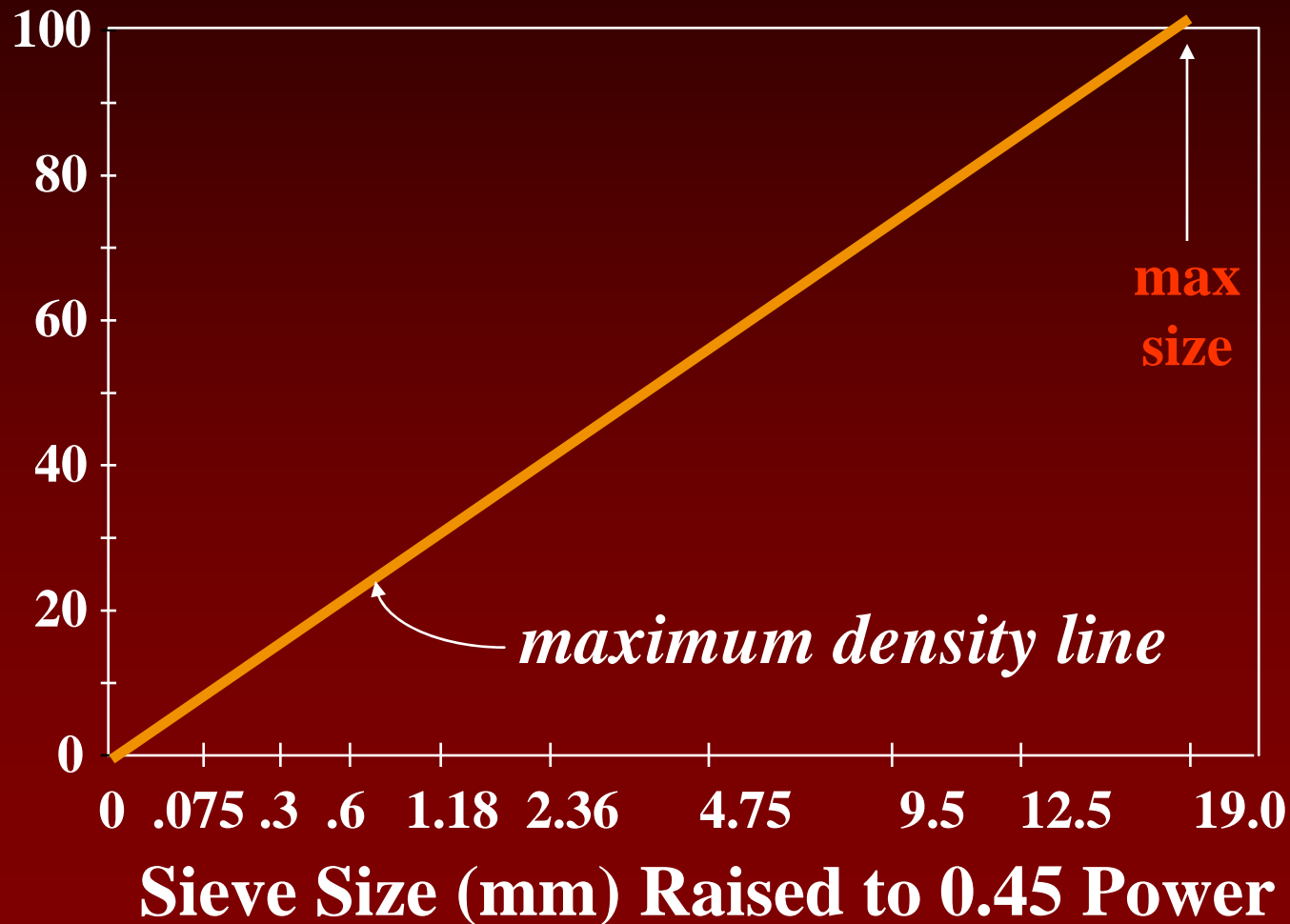
50 mm  
37.5 mm  
25 mm  
19 mm  
12.5 mm  
9.5 mm  
4.75 mm



2.36 mm  
1.18 mm  
0.6 mm  
0.3 mm  
0.15 mm  
0.075 mm

# 0.45 Power Grading Chart

Percent Passing





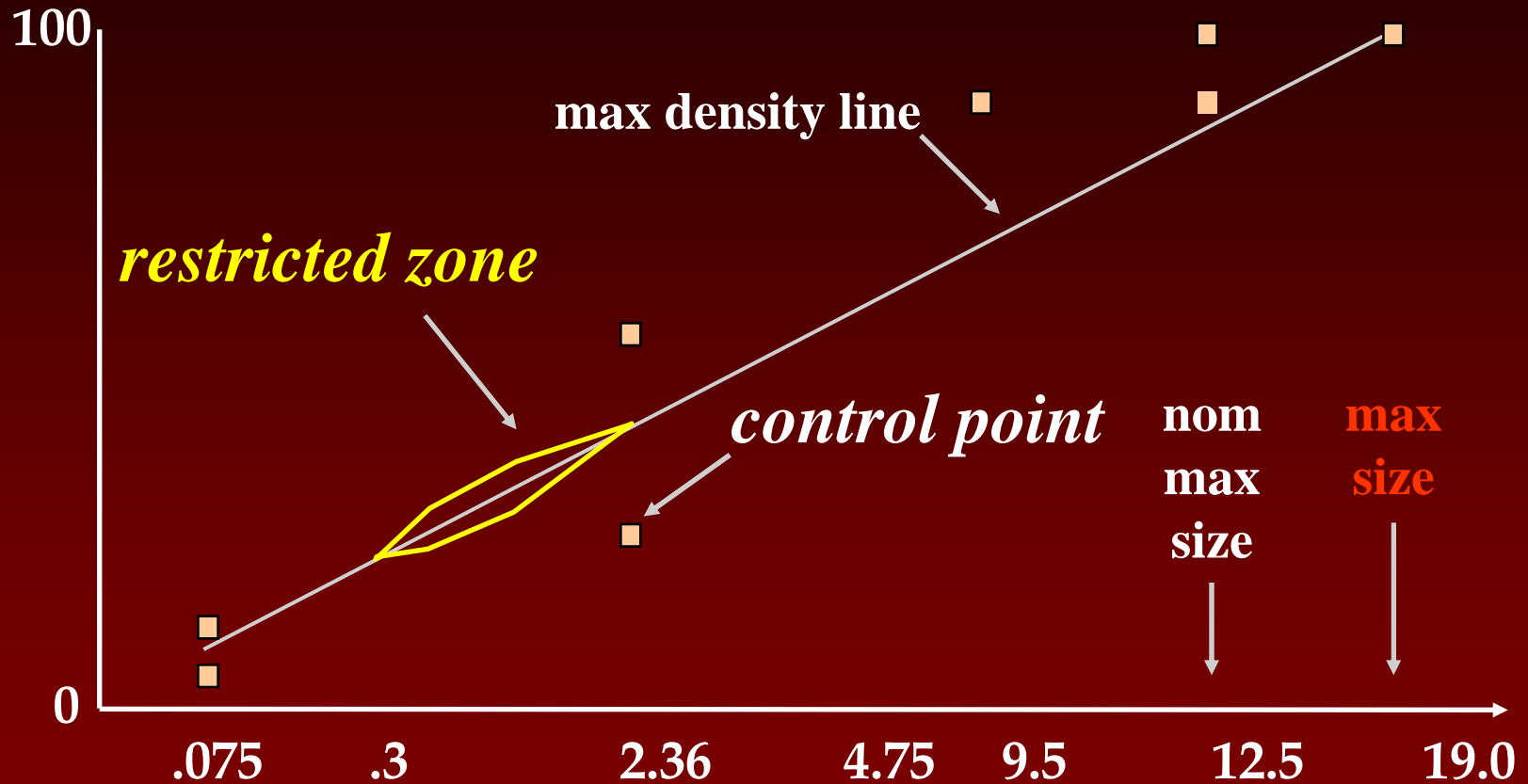
# Aggregate Size Definitions

100  
100  
90  
72  
65  
48  
36  
22  
15  
9  
4

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

100  
99  
89  
72  
65  
48  
36  
22  
15  
9  
4

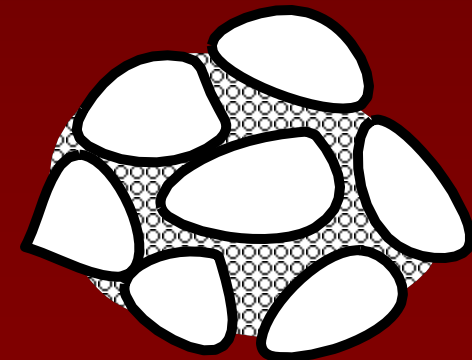
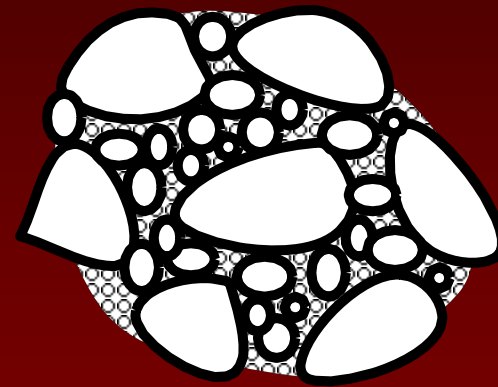
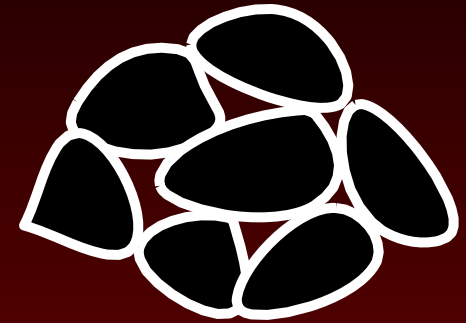
# Percent Passing



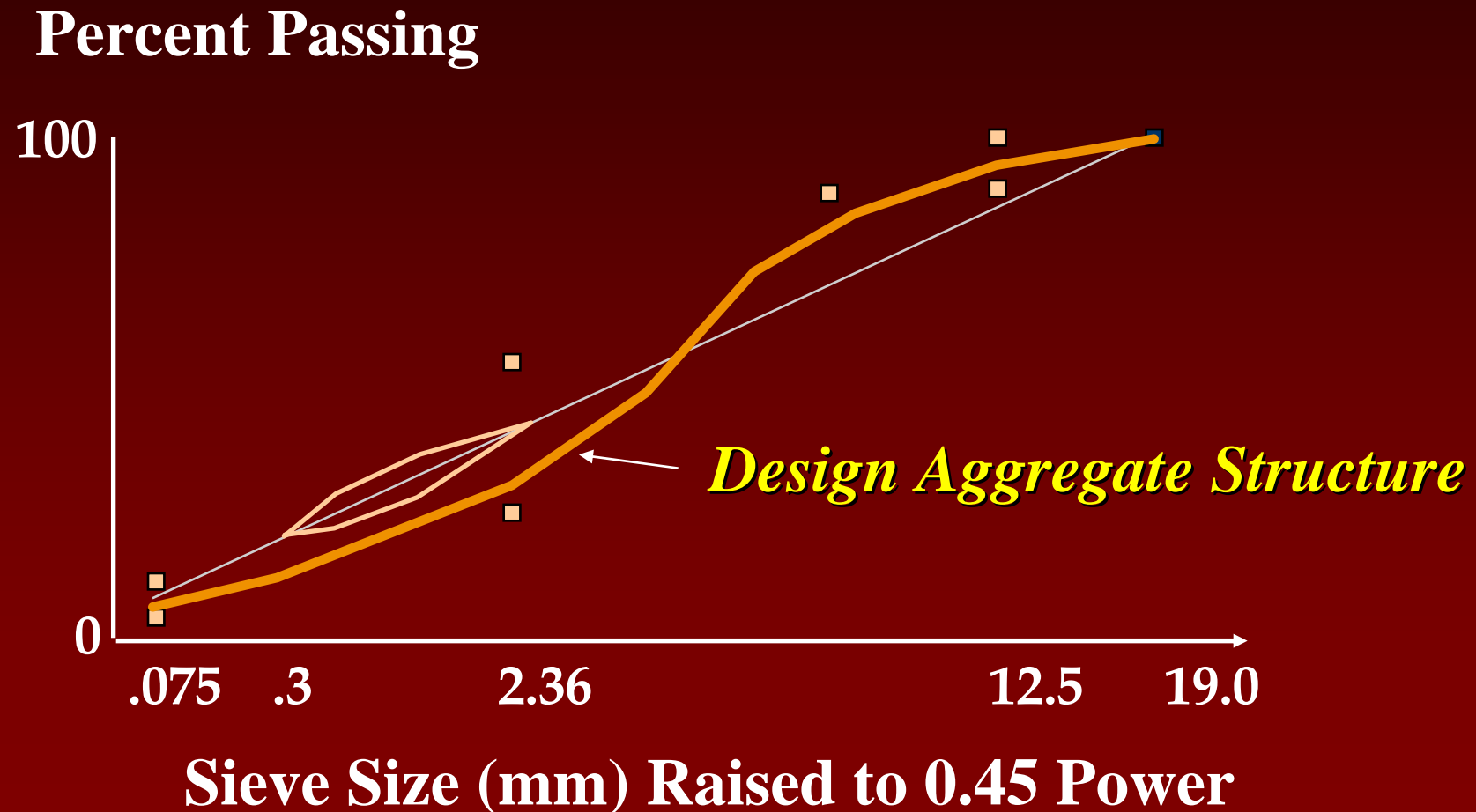
Sieve Size (mm) Raised to 0.45 Power

# Types Of Gradations

- Open graded
  - Few points of contact
  - Stone-on-stone contact
  - High permeability
- Well graded
  - Good interlock
  - Low permeability
- Gap graded
  - Lacks intermediate sizes
  - Good interlock
  - Permeability varies



# Superpave Aggregate Gradation



# Superpave Mix Size Designations

<u>Superpave Designation</u>	<u>Nom Max Size (mm)</u>	<u>Max Size (mm)</u>
37.5 mm	37.5	50
25 mm	25	37.5
19 mm	19	25
12.5 mm	12.5	19
9.5 mm	9.5	12.5

# Superpave Aggregate Tests and Blend Selection

- Aggregate tests
  - Consensus properties - required
  - Source properties - optional
- Aggregate criteria
  - Based on aggregate blend
  - Based on traffic and depth into pavement
- Design aggregate structure
  - 0.45 power chart
  - Controls points and restricted zone

# Effect of Physical Properties on Performance

- Size
- Higher size
  - greater bearing capacity
  - toughness critical to performance
  - poor packing characteristics

# Effect of Physical Properties on Performance

- Shape and Texture
- Flat and elongated versus cubical
  - Cubical: better interlocking and stability
- Rounded versus angular
  - Rounded: poor shear resistance, poor interlocking
  - Angular: low workability



**Questions –  
does it all  
make  
sense?**

