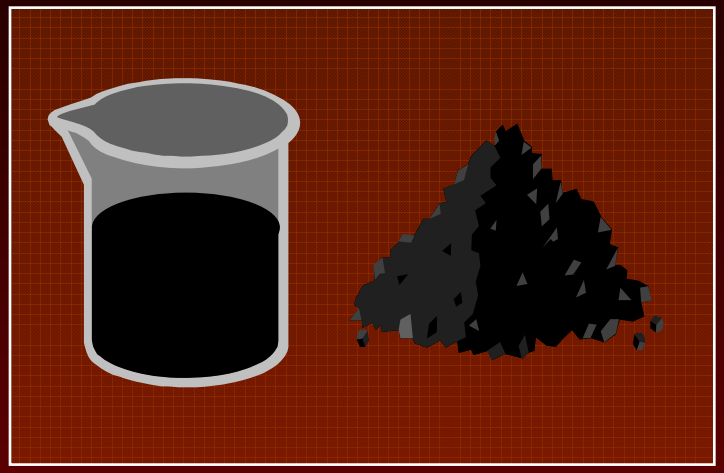
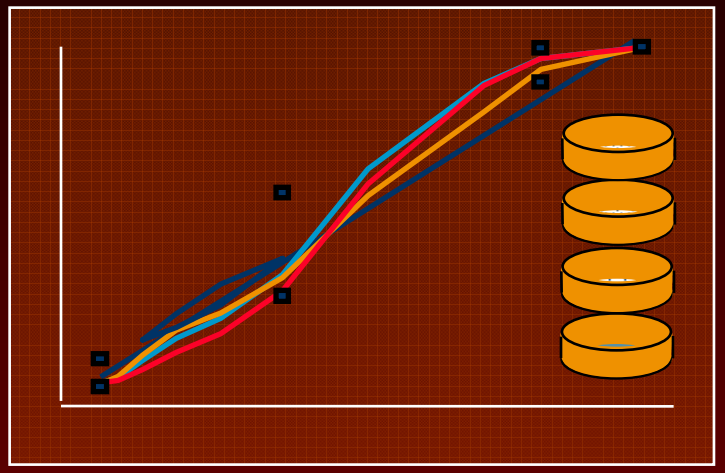
PHYSICAL PROPERTIES OF AGGREGATES

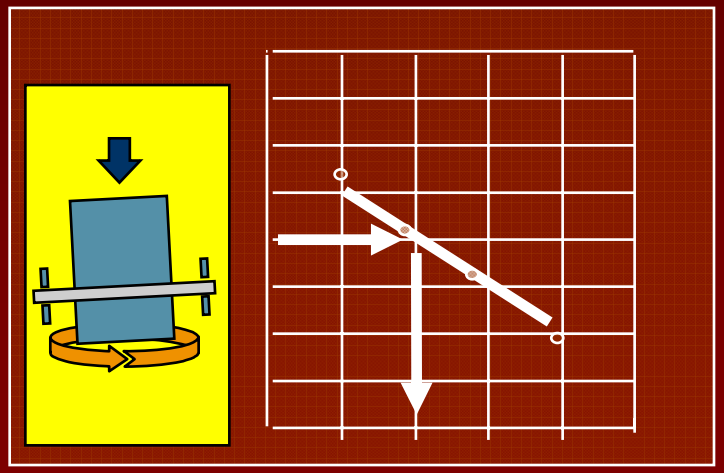
4 Steps of Superpave Mix Design



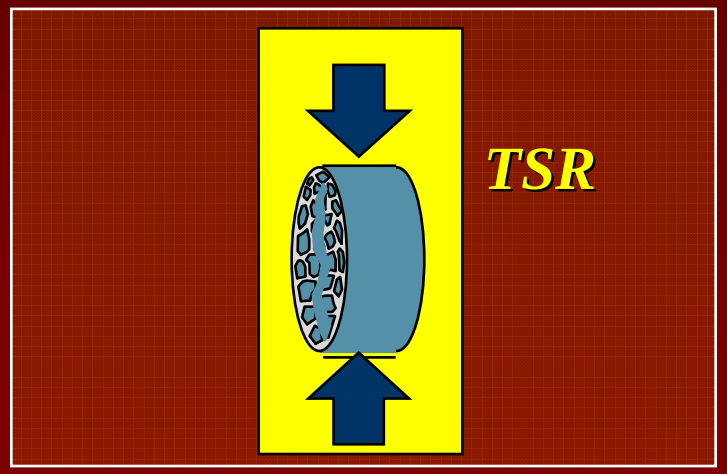
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



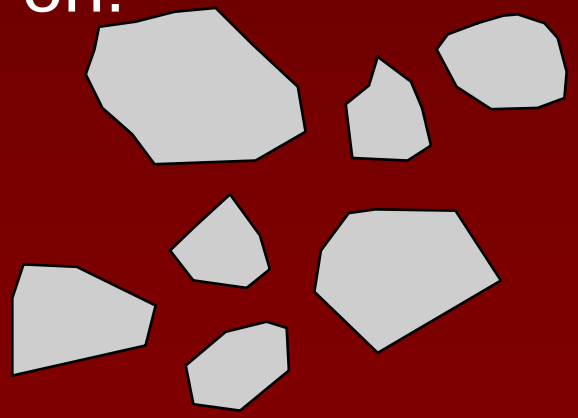
4. Moisture Sensitivity

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

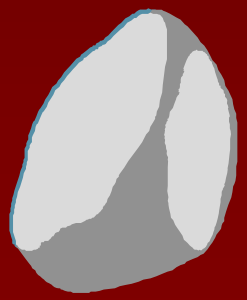


Coarse Aggregate Angularity

Traffic ESALs	Depth from Surface < 100 mm	Depth from Surface > 100 mm
$10 - 30 \times 10^6$	95/90	80/75 Minimum

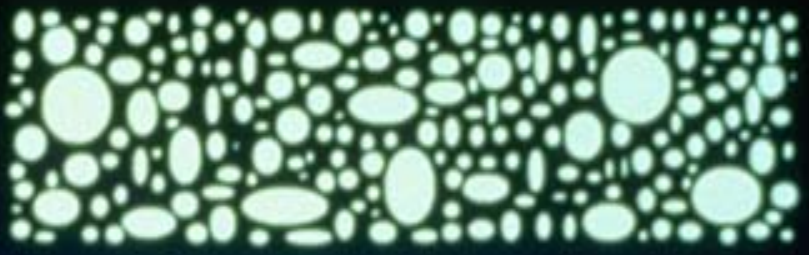
95% one fractured face

90% two+ fractured faces



Contrasting Stone Skeletons

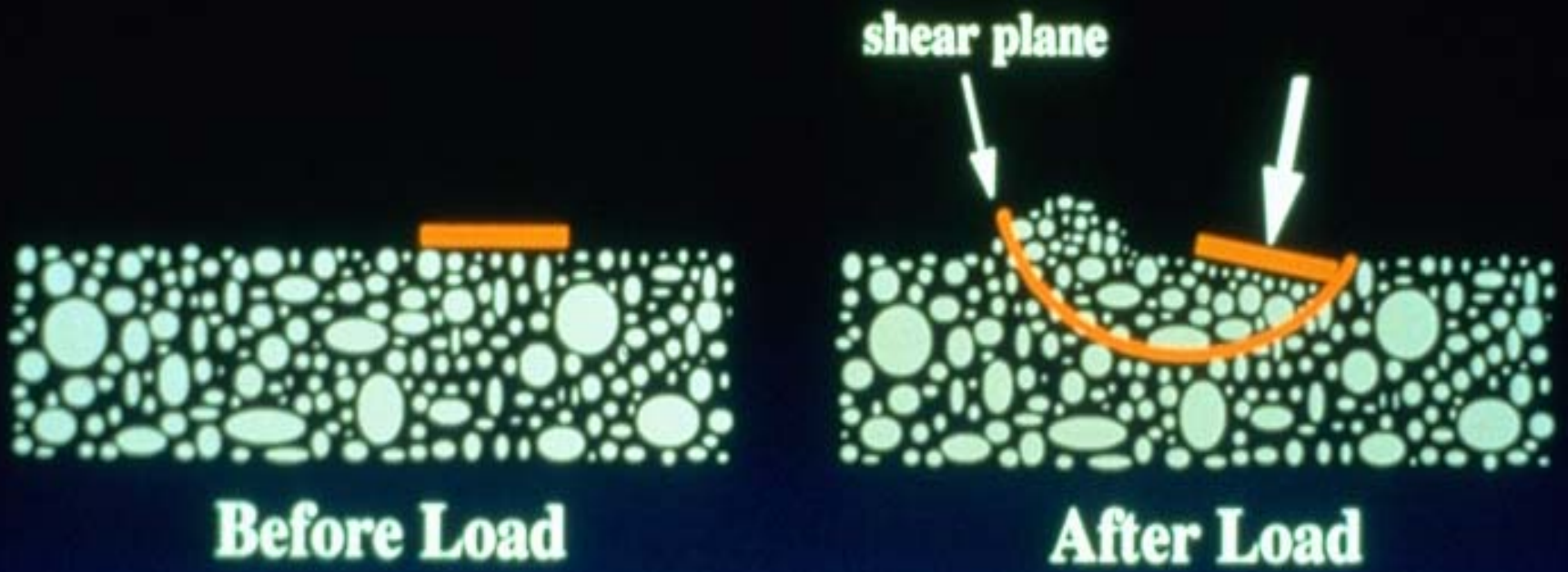
Cubical Aggregate



Rounded Aggregate

NATC

Shearing Behavior of Aggregate



NATC

Fine Aggregate Angularity

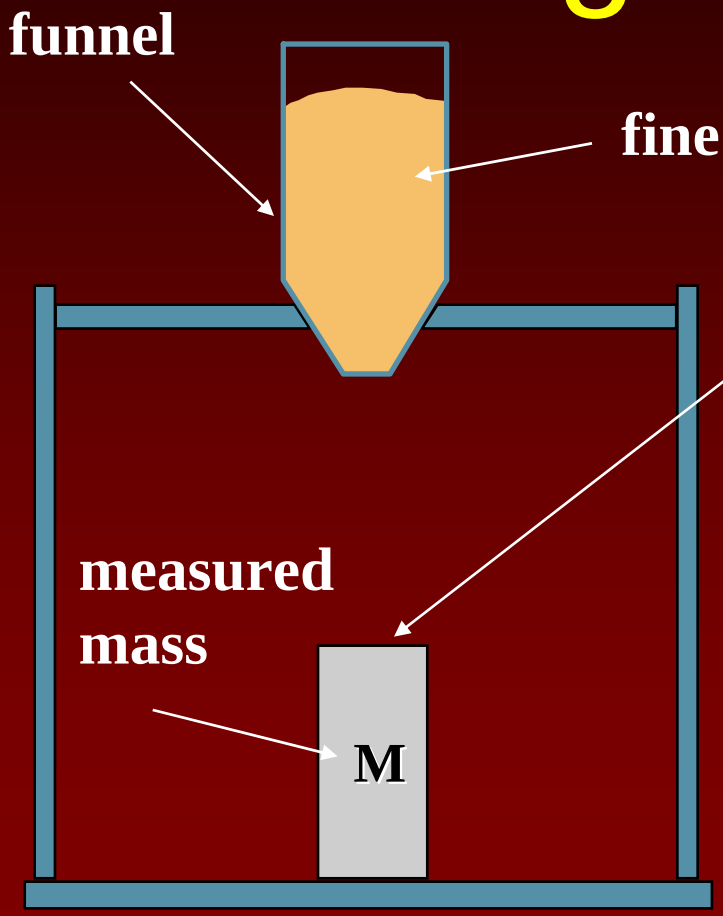
- Measured on - 2.36 mm material
- Based on air voids in loosely compacted sample
- AASHTO T 304, Method A
  - Standard Grading: +1.18 mm to +0.150 mm
- Requirements depend on
  - depth of layer within pavement
  - traffic level


Gilson


99.7mL


Gilson

Fine Aggregate Angularity



uncompacted voids =

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

Fine Aggregate Angularity

Traffic ESALs	Depth from Surface < 100 mm	> 100 mm	
$10 - 30 \times 10^6$	45	40	Minimum

% air voids in loose sample

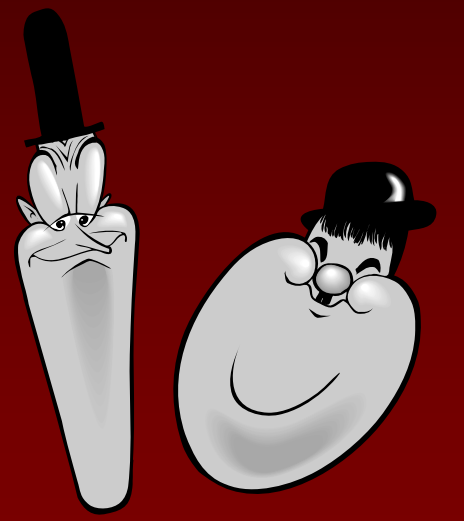
> Rounded particles pack tighter together -- less air

What Affect Does FAA Have on Performance?

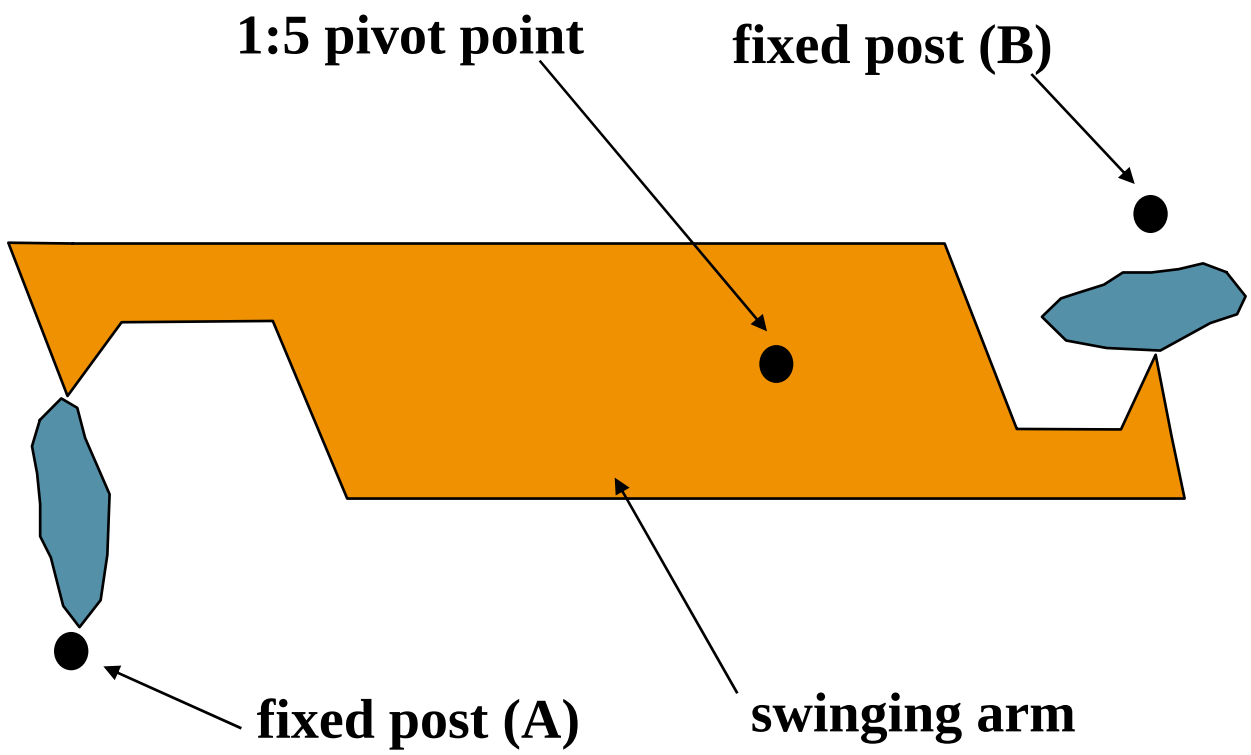
- FAA and restricted zone used to limit the amount of rounded natural sands
- National Rutting Study initiated in 1987 by NCAT evaluated 42 pavements in 14 states. The study identified a minimum FAA value of 43.3% to resist rutting.

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

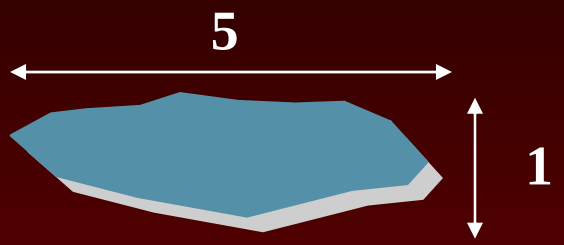



3/4
3/4
1/2
1/2
3/8


-3/8" + No. 4
-1/2" + 3/8"
-3/4" + 1/2"
-1" + 3/4"


PASSED →
3:1 & 5:1 FtE
FAILED →
3:1 FtE
FAILED →
5:1 FtE

Flat & Elongated Particles



Traffic ESALs	Percent	
10 - 30 x 10^6	10	Maximum

percentage
of flat and elongated particles

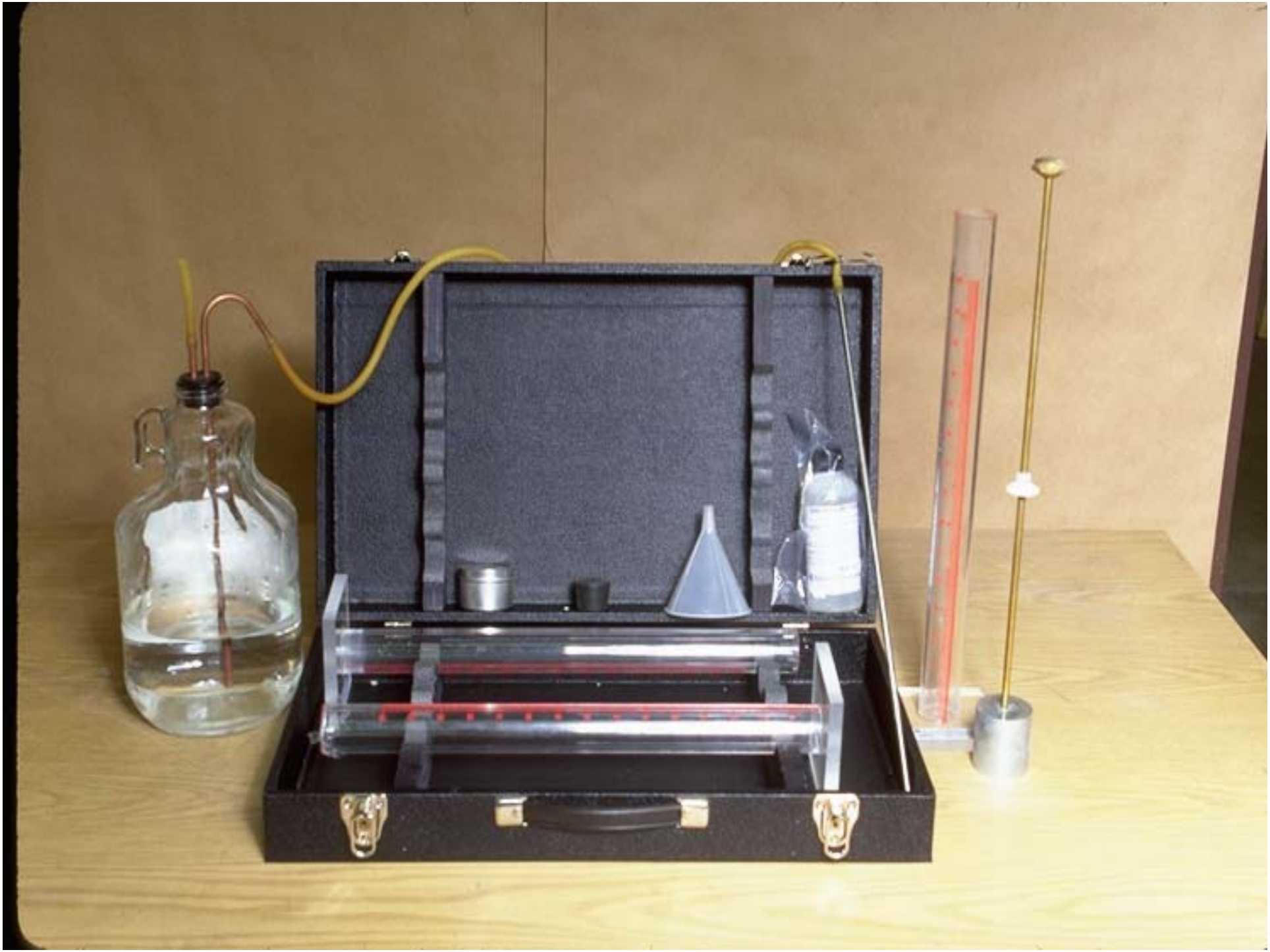
What Affect Does F&E Have on Performance?

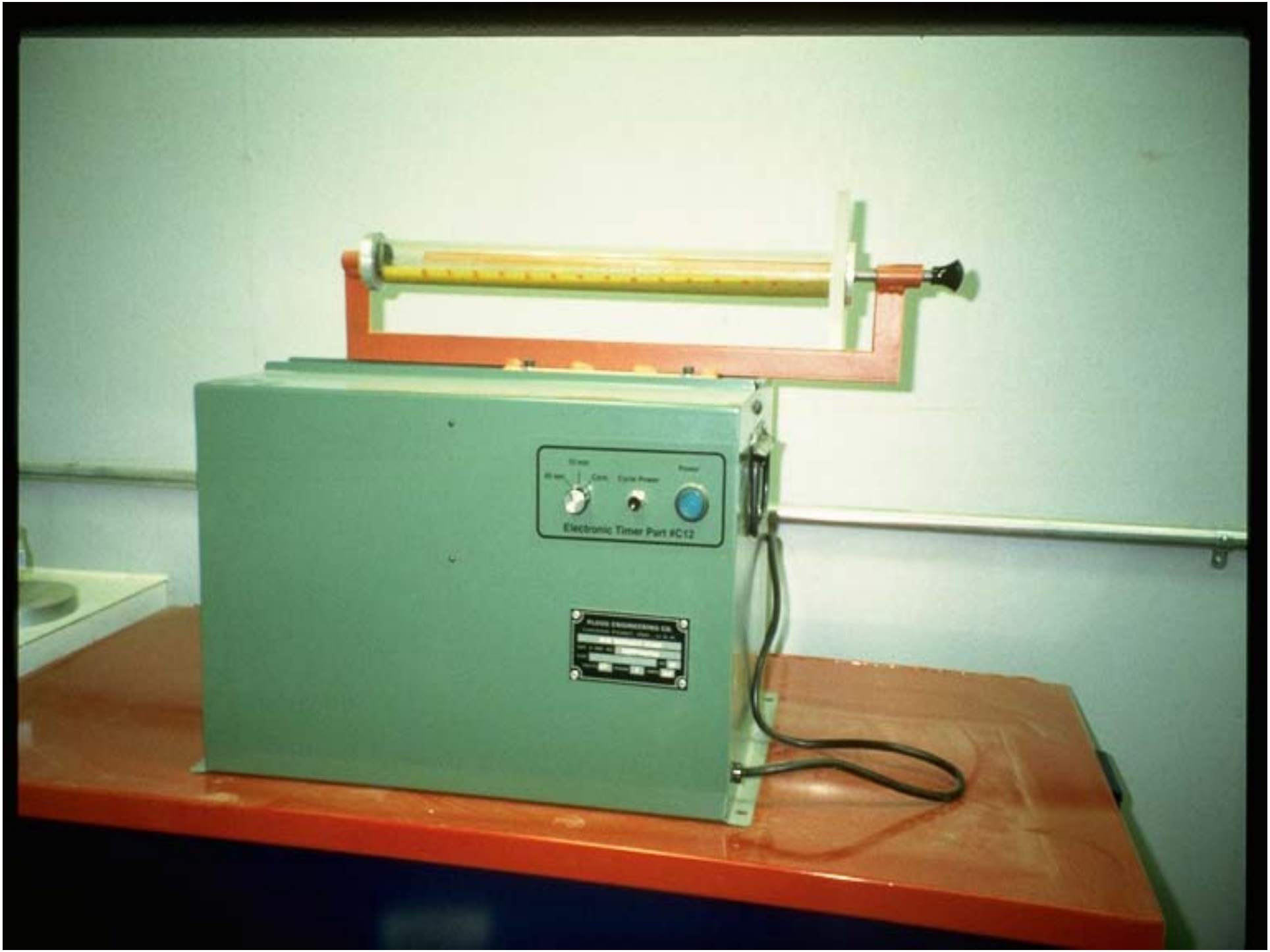
- Tend to break under the roller exposing uncoated faces which may lead to stripping of the asphalt film off the aggregate in the presence of moisture
- Particles tend to orient flat under traffic, reducing pavement voids. May lead to flushing
- Change in shape affects mixture volumetrics

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 ?**



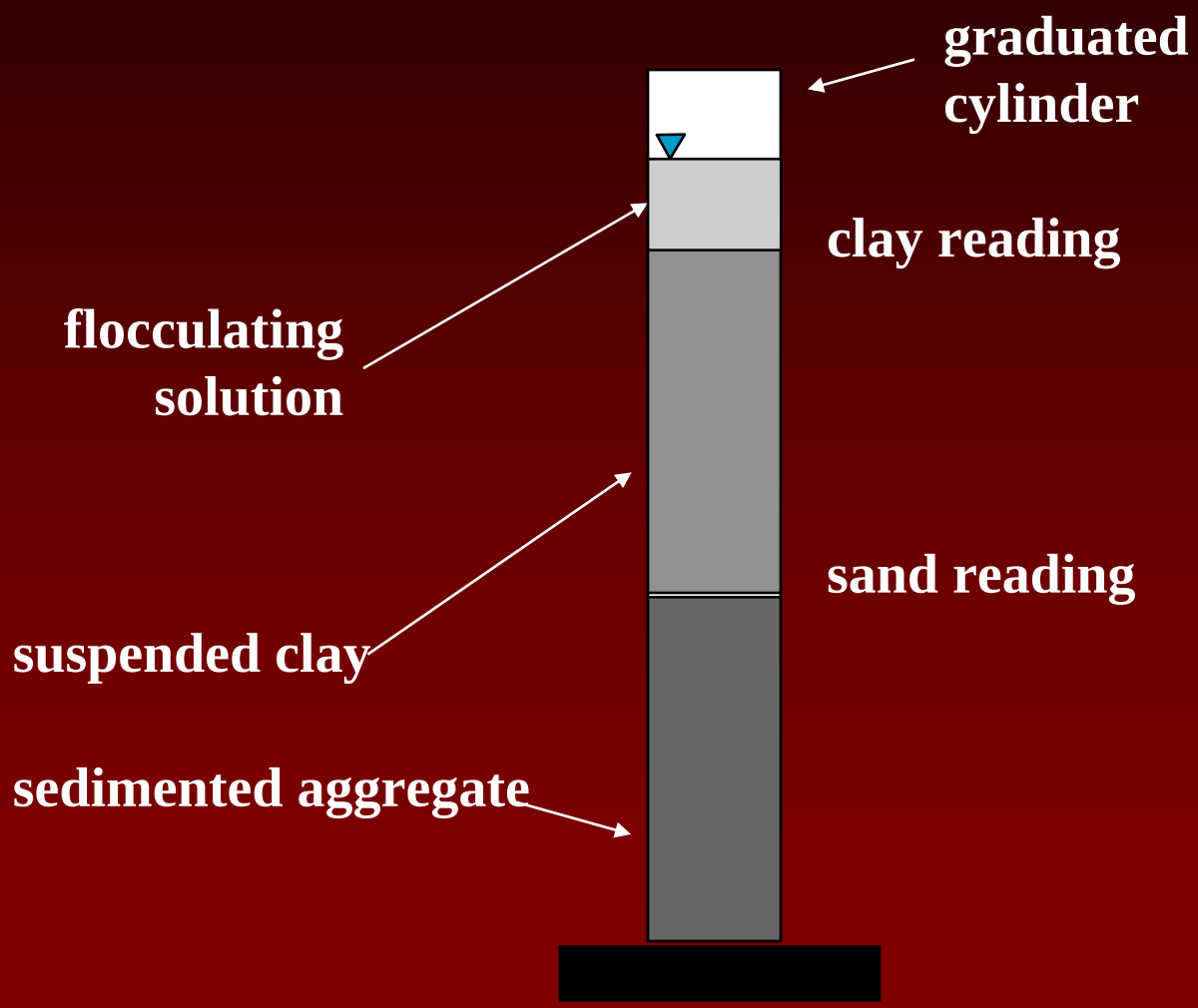

Electronic Timer Part #C12


4
3
2
1


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


10 min
45 sec
Cont.
Electronic Timer

Clay Content



Clay Content

Traffic ESALs	Percent	
10 - 30 x 10^6	45	Minimum

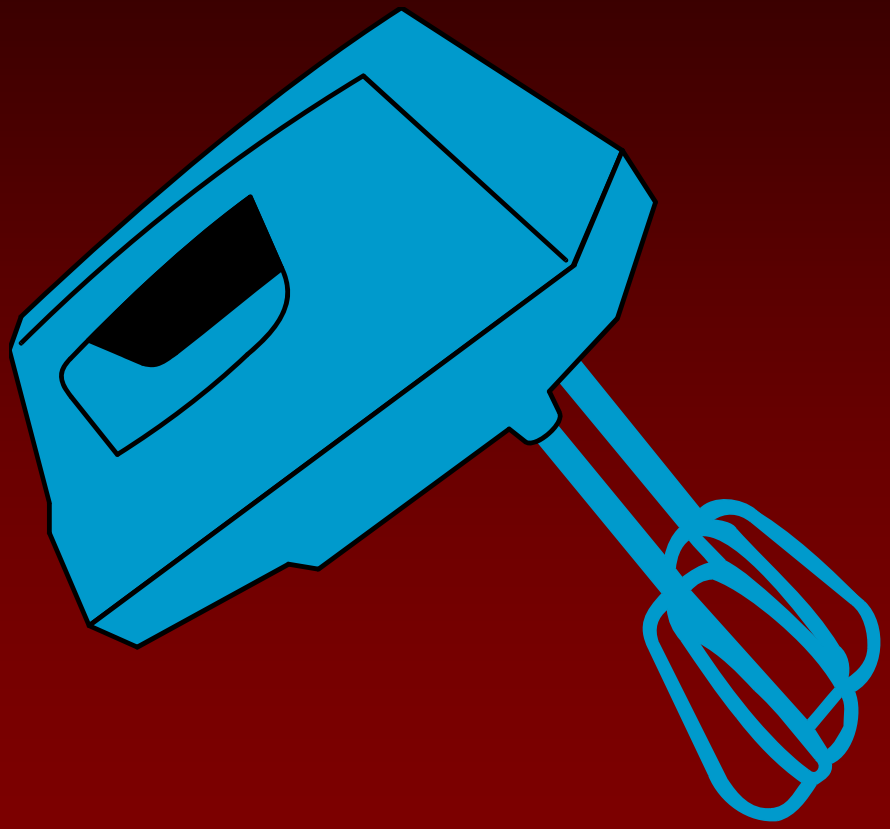
sand equivalent value

> 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**

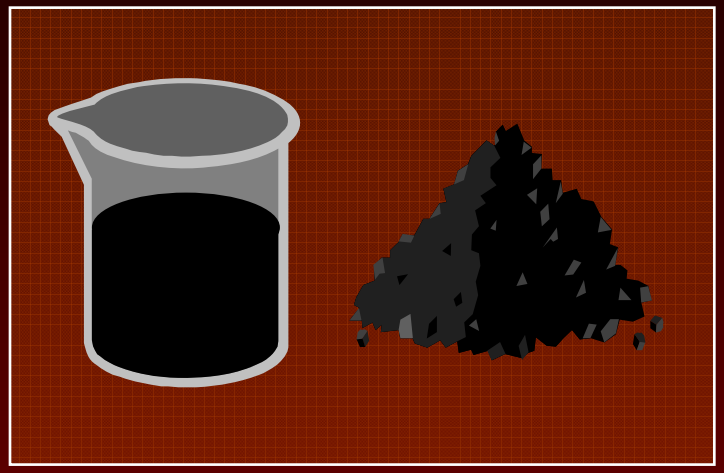
Superpave Aggregate Specifications



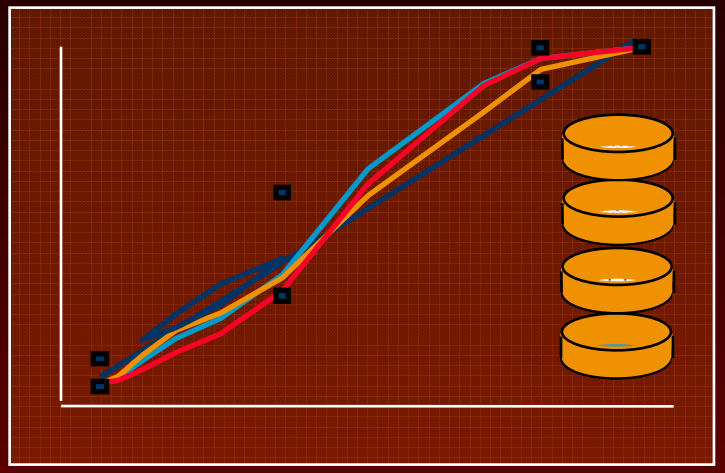
Required on total aggregate blend

Not individual aggregate stockpiles

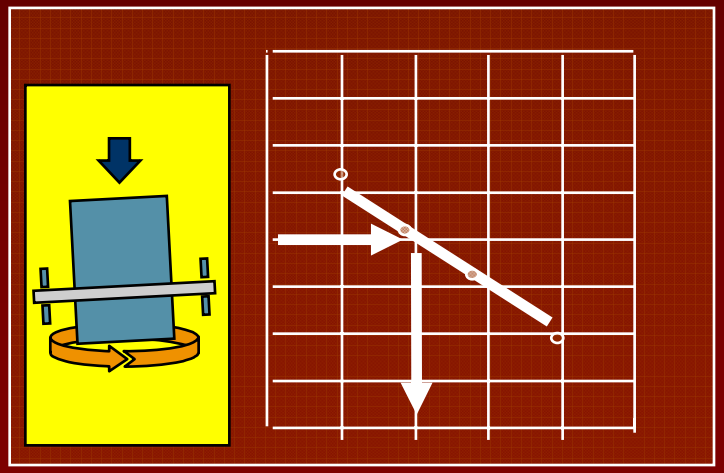
4 Steps of Superpave Mix Design



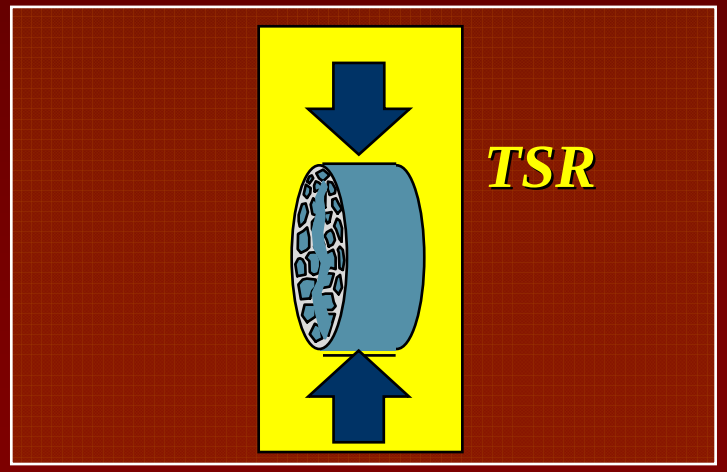
1. Materials Selection



2. Design Aggregate Structur



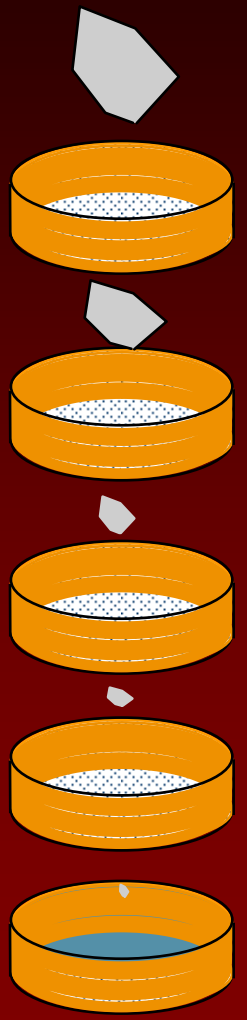
3. Design Binder Content



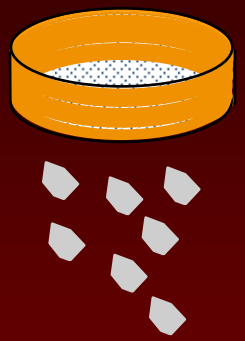
4. Moisture Sensitivity

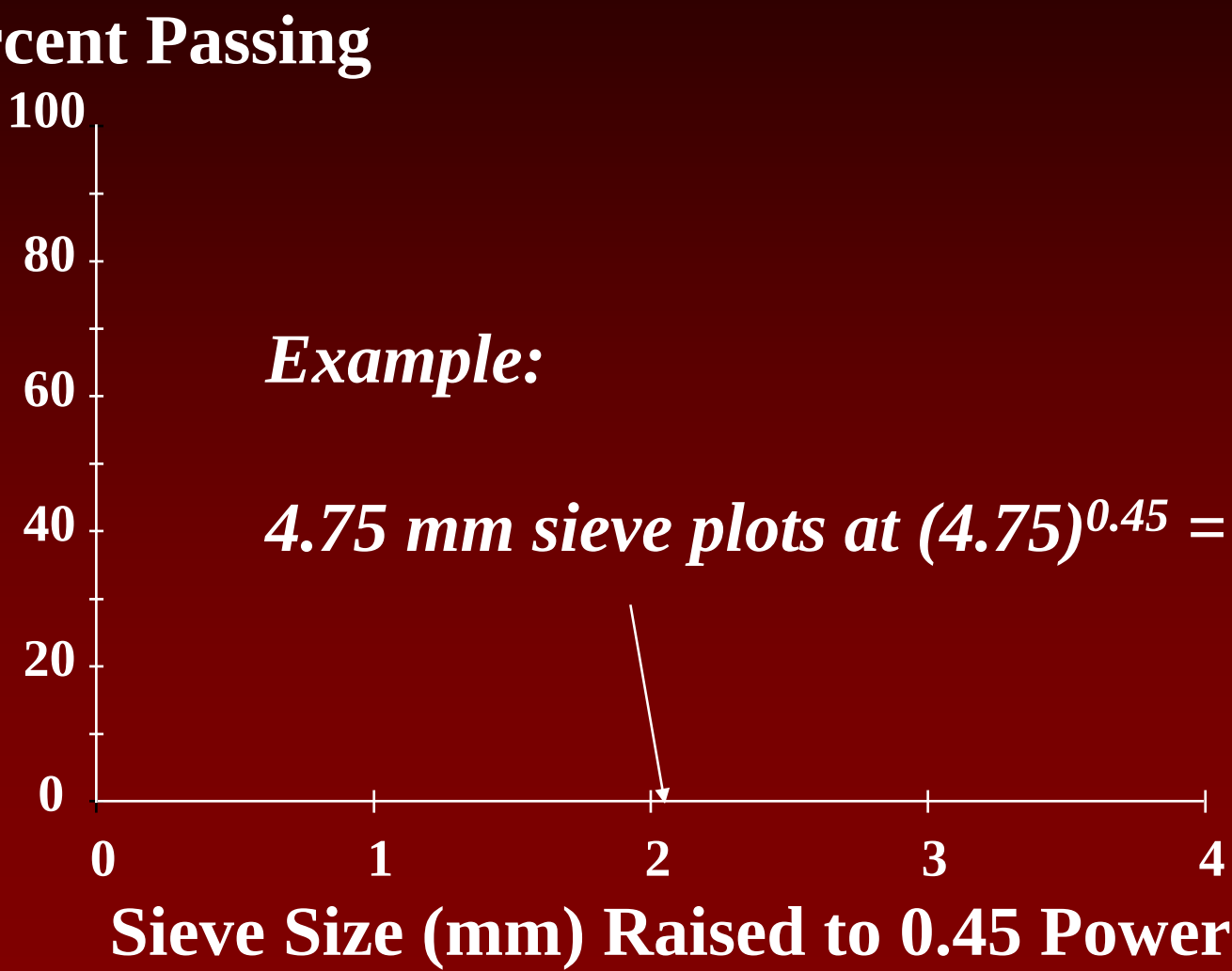
Superpave Aggregate Gradation

- 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

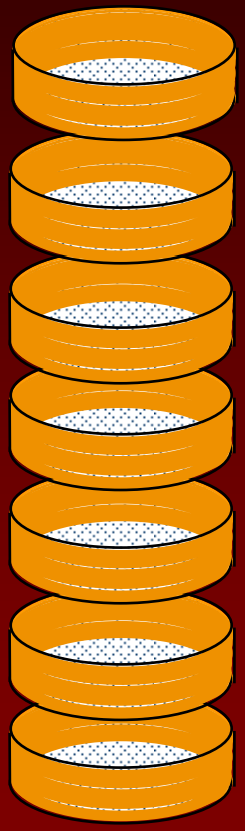




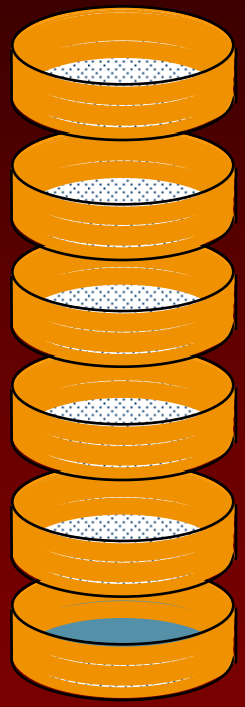
Example:

4.75 mm sieve plots at $(4.75)^{0.45} = 2.02$

Standard Aggregate Sieves

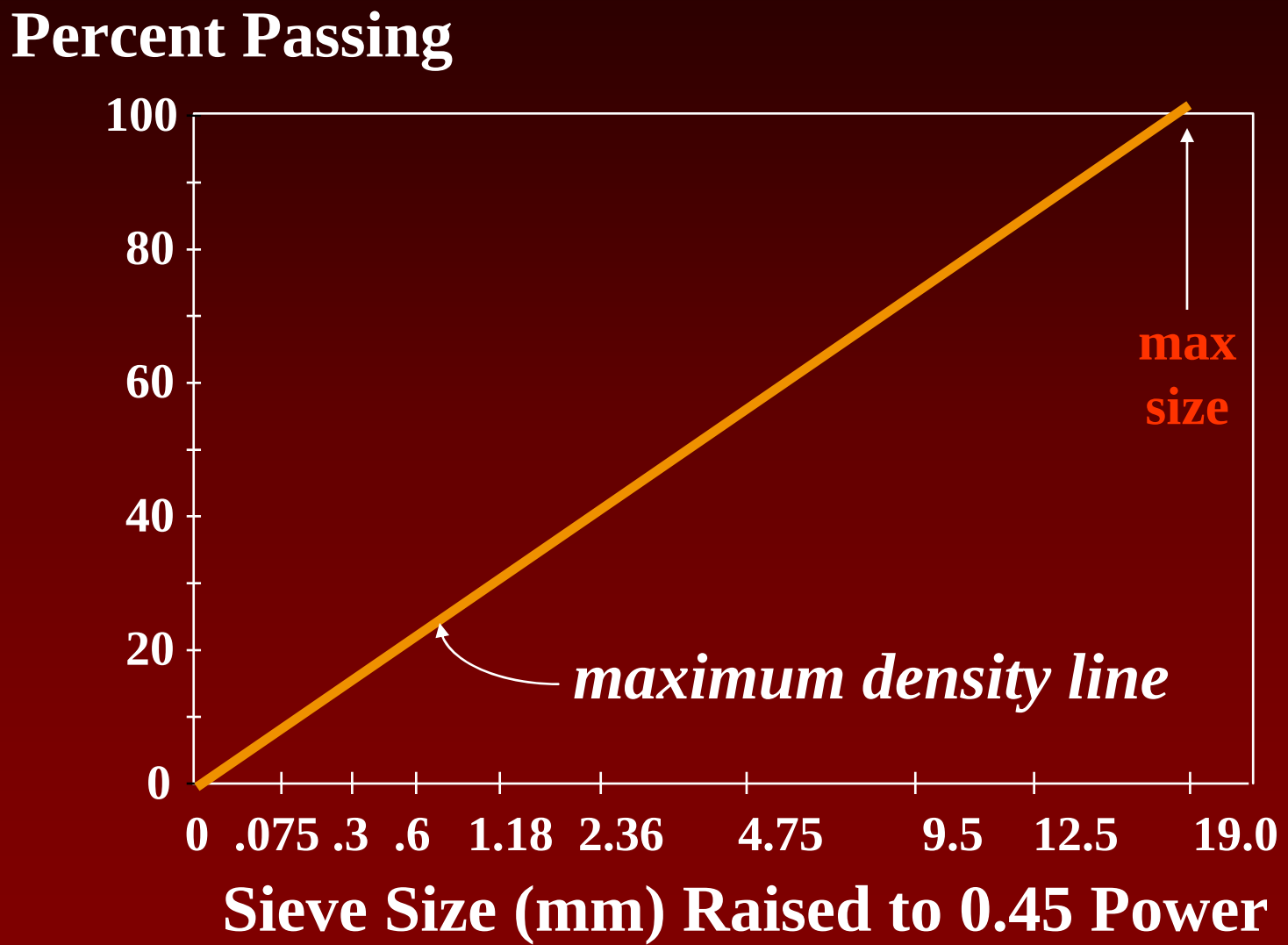


50 mm
37.5 mm
25 mm
19 mm
12.5 mm
9.5 mm
4.75 mm



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

0.45 Power Grading Chart

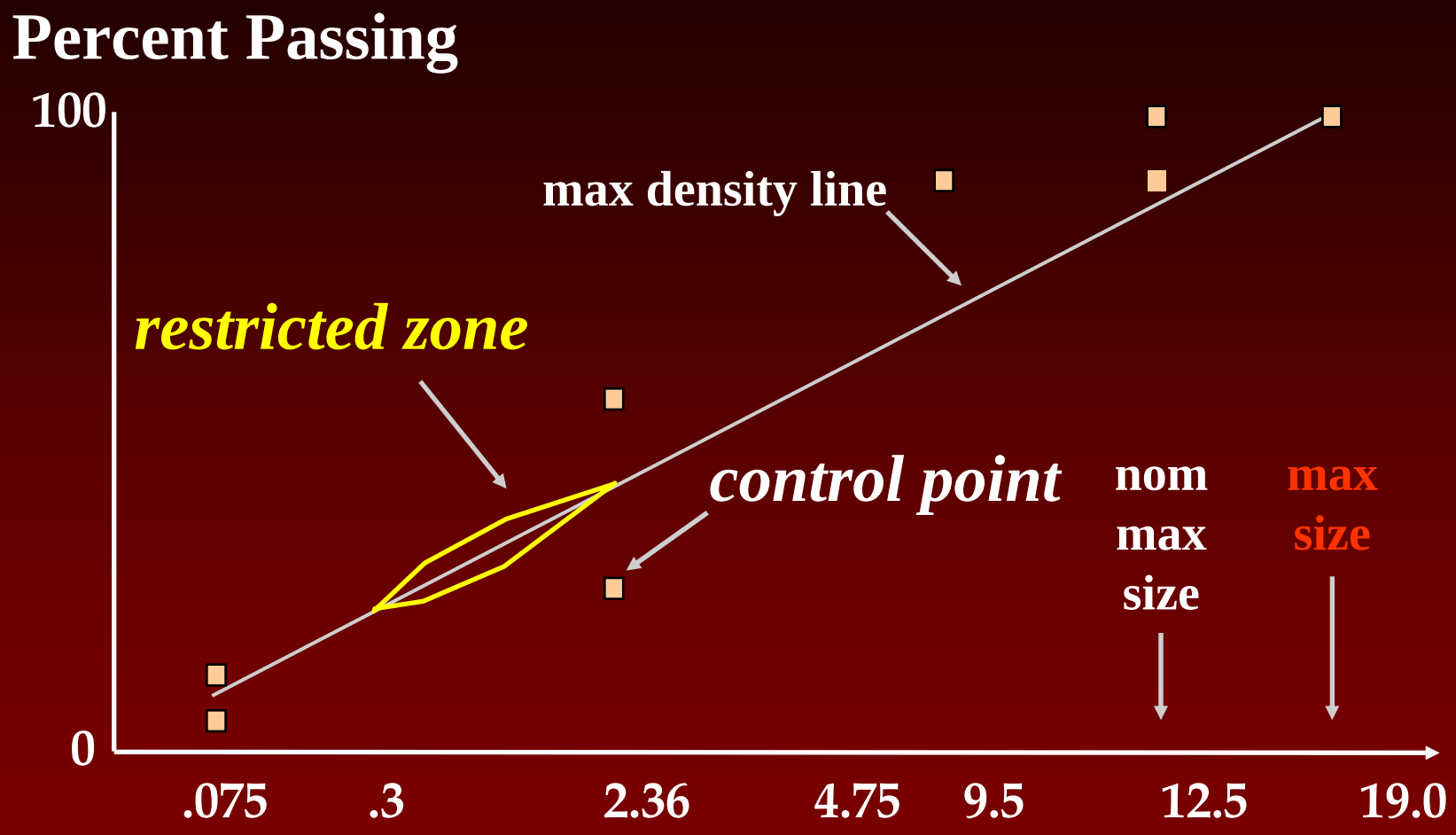


Aggregate Size Definitions

100
100
90
72
65
48
36
22
15
9
4

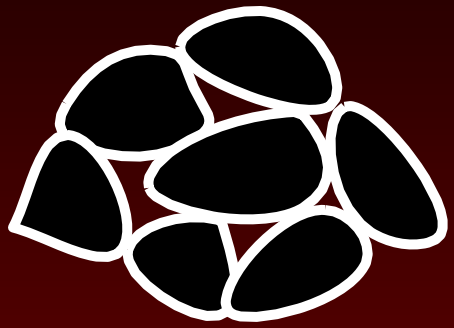
- *Nominal Maximum* Aggregate Size
  - one size larger than the first sieve to retain more than 10%
- *Maximum* Aggregate Size
  - one size larger than nominal maximum size

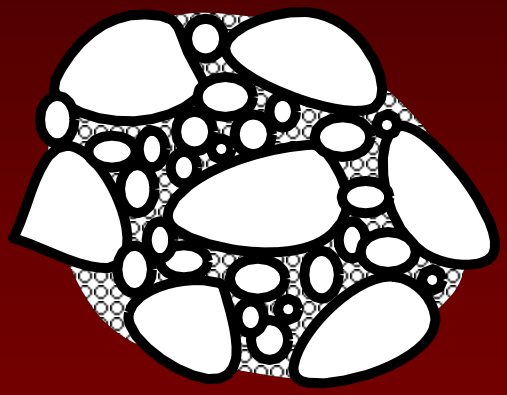
100
99
89
72
65
48
36
22
15
9
4

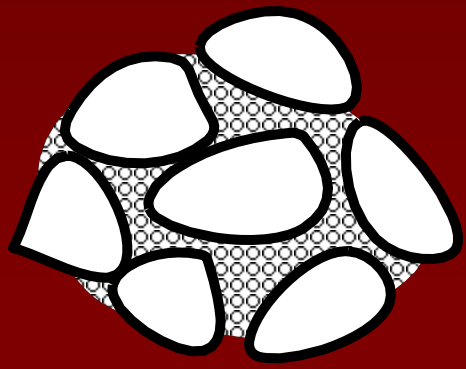

Percent Passing
100
0
max density line
restricted zone
control point
nom
max
size
max
size
.075
.3
2.36
4.75
9.5
12.5
19.0
Sieve Size (mm) Raised to 0.45 Power

Types Of Gradations

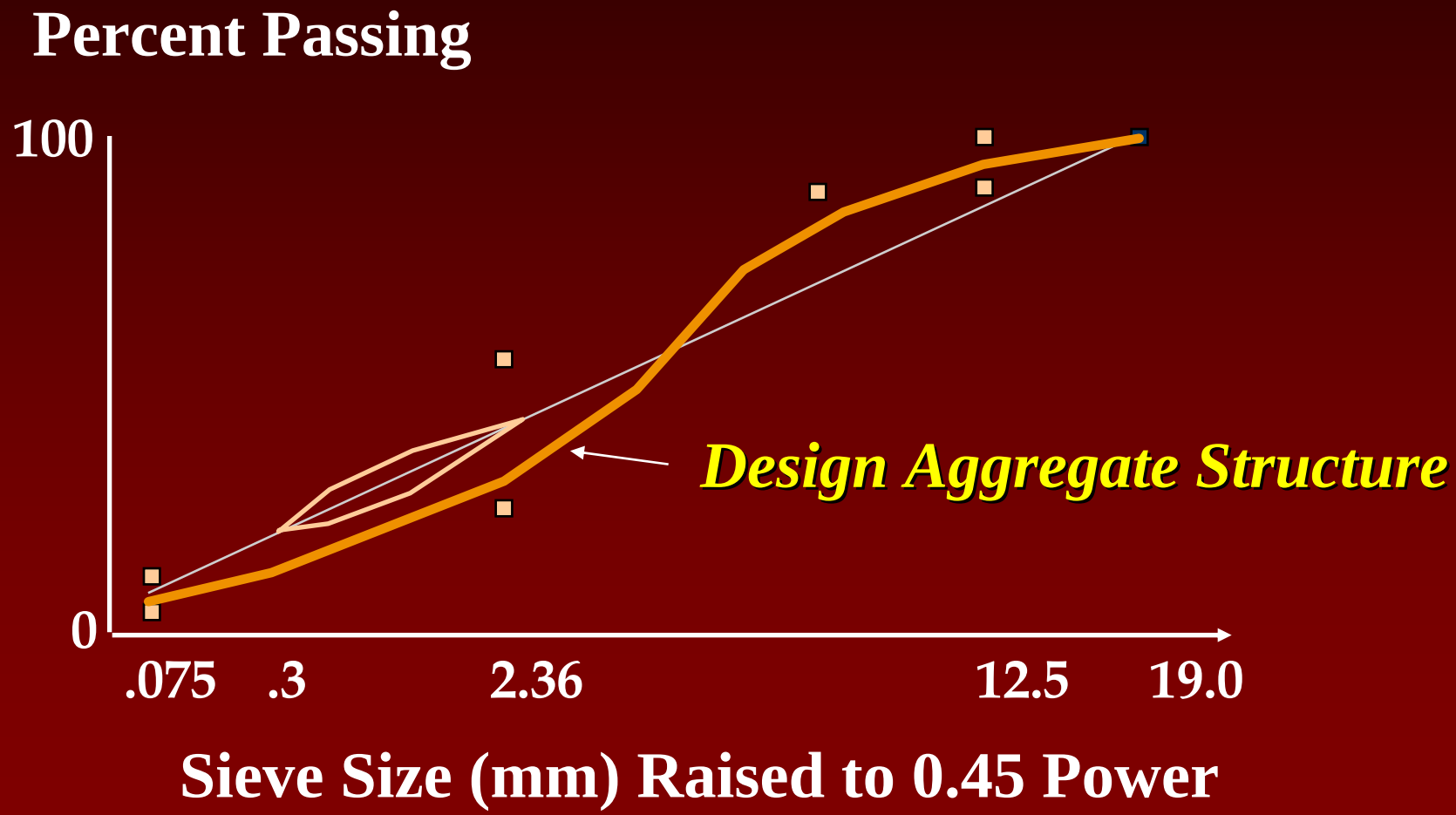
- Open graded
  - Few points of contact
  - Stone-on-stone contact
  - High permeability
- Well graded
  - Good interlock
  - Low permeability
- Gap graded
  - Lacks intermediate sizes
  - Good interlock
  - Permeability varies







Superpave Aggregate Gradation



Superpave Mix Size Designations

Superpave Designation	Nom Max Size (mm)	Max Size (mm)
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?