**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

<table>
<thead>
<tr>
<th>Traffic ESALs</th>
<th>Depth from Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 100 mm</td>
<td>&gt; 100 mm</td>
</tr>
<tr>
<td>10 - 30 x 10^6</td>
<td>95/90</td>
</tr>
<tr>
<td></td>
<td>80/75 Minimum</td>
</tr>
</tbody>
</table>

- 95% one fractured face
- 90% two+ fractured faces

### 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

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**Contrasting Stone Skeletons**

- Cubical Aggregate
- Rounded Aggregate

**Shearing Behavior of Aggregate**

- Before Load
- After Load

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Fine Aggregate Angularity

- Cylinder of known volume ($V$)
- Uncompacted voids = \( \frac{V - M}{G_{so}} \times 100\% \)

Funnel

Fine Aggregate Angularity

- Traffic ESALs < 100 mm > 100 mm
- 10 - 30 x 10^6 45 40 Minimum
- > Rounder particles pack tighter together -- less air

What Affect Does FAA Have on Performance?

- FAA 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

- 1:5 pivot point
- Fixed post (A)
- Fixed post (B)
- Swinging arm
Flat, Elongated Particles

Traffic

<table>
<thead>
<tr>
<th>ESALs</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 30 x 10⁶</td>
<td>10 - 30%</td>
</tr>
<tr>
<td>100 - 300 x 10⁶</td>
<td>Maximum</td>
</tr>
</tbody>
</table>

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?
Clay Content

flocculating solution

suspended clay

sedimented aggregate

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

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Superpave Aggregate Gradation

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

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0.45 Power Grading Chart

**Example:**

4.75 mm sieve plots at 

\[ (4.75)^{0.45} = 2.02 \]

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Standard Aggregate Sieves

- 50 mm (2 in)
- 37.5 mm (1.5 in)
- 25 mm (1 in)
- 19 mm (3/4 in)
- 12.5 mm (1/2 in)
- 9.5 mm (3/8 in)
- 4.75 mm (# 4)
0.45 Power Grading Chart

Percent Passing

Sieve Size (mm) Raised to 0.45 Power

Aggregate Size Definitions

- **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

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

Percent Passing

Sieve Size (mm) Raised to 0.45 Power

Superpave Mix Size Designations

<table>
<thead>
<tr>
<th>Superpave Designation</th>
<th>Nom Max Size (mm)</th>
<th>Max Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 mm</td>
<td>37.5</td>
<td>50</td>
</tr>
<tr>
<td>25 mm</td>
<td>25</td>
<td>37.5</td>
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<tr>
<td>19 mm</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>12.5</td>
<td>19</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>9.5</td>
<td>12.5</td>
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<tr>
<td>Superpave Aggregate Tests and Blend Selection</td>
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<tr>
<td>-----------------------------------------------</td>
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<tr>
<td>• Aggregate tests</td>
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<tr>
<td>– Consensus properties - required</td>
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<tr>
<td>– Source properties - optional</td>
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<tr>
<td>• Aggregate criteria</td>
<td></td>
<td></td>
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<tr>
<td>– Based on aggregate blend</td>
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<td></td>
</tr>
<tr>
<td>– Based on traffic and depth into pavement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Design aggregate structure</td>
<td></td>
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<tr>
<td>– 0.45 power chart</td>
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</tr>
<tr>
<td>– Controls points</td>
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Questions?

The Beginning
Keeping roads good with asphalt paving materials

http://www.cp2info.org/center