Aggregate Characteristics and Handling
For Asphalt Mixes

Aggregates 102 Seminar
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PFP and QCP Pay Factors

• **Statistical** Based Specs
  – VMA = 30%
  – Air Voids = 30%
  – Density = 40%

• **Aggregate** (as % mix)
  – ~95% by **WEIGHT**
  – ~80% by **VOLUME**

• Consistency
What is **VMA**?

**Voids in the Mineral Aggregate**

- Voids in the **total aggregate** structure
- Function of **aggregate**
- Air Voids are function of:
  - Aggregate
  - *Effective AC Volume*

\[
VMA = 100 - \left\{ \frac{(G_{mb} \cdot P_s)}{G_{sb}} \right\}
\]
What is VMA?

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Why Is **VMA** Important?

- **Essential Asphalt Mix Properties:**
  - Stability
  - Durability

- **VMA** promotes **durability** – it is the room between the aggregate particles for AC and Voids
VMA Drives Air Voids

VMA and Voids per Sample
Variability of VMA and Voids

- Std Dev of VMA = 0.4
- Std Dev of Voids = 0.5
- \( \frac{0.4}{0.5} \times 100 = 80\% \)
- Virtually ALL variability in VMA and MOST variability in Voids is variability in the aggregate structure
Aggregate Packing Characteristics

Drive VMA

- **Gradation**
  - Continuously-Graded, Gap-Graded, etc.

- **Shape**
  - Flat & Elongated, Cubical, Round

- **Strength**
  - Weak vs. Strong, Influence of Particle Shape

- **Texture (micro-texture)**
  - Smooth, Rough
Gradation

- *Primary* factor that controls aggregate packing (VMA)
- Combined blend gradation influences mix sensitivity to gradation fluctuations
Gradation

• Mix size impacts product role
  – FA-22 in 9.5mm mix (CA)?
  – FA-22 in 19.0mm mix (FA)

• Product amount in a mix impacts its influence
Gradation – **Primary Control Sieve**

The **break** between **Coarse** and **Fine** in a combined blend.

<table>
<thead>
<tr>
<th>Mixture NMAS</th>
<th>Primary Control Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 mm (1-1/2”)</td>
<td>9.5 mm (3/8”)</td>
</tr>
<tr>
<td>25.0 mm (1”)</td>
<td>4.75 mm (#4)</td>
</tr>
<tr>
<td>19.0 mm (3/4”)</td>
<td><strong>4.75 mm (#4)</strong></td>
</tr>
<tr>
<td>12.5 mm (1/2”)</td>
<td>2.36 mm (#8)</td>
</tr>
<tr>
<td>9.5 mm (3/8”)</td>
<td><strong>2.36 mm (#8)</strong></td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>1.18 mm (#16)</td>
</tr>
</tbody>
</table>
Shape

- Round, Cubical, or Flat and Elongated
- SIGNIFICANTLY influences agg packing (VMA)!
- Directly impacts particle STRENGTH
Strength

• Related to $G_{sb}$ from a given aggregate source

• SIGNIFICANTLY influenced by particle SHAPE
Texture (aka micro-texture)

Texture reduces thru the HMA Plant
Importance of Aggregate $G_{sb}$

- **Accurate VMA**
- **Virgin Agg’s:**
  - IDOT provides moving average
  - Process to eliminate flyers
- **RAP:**
  - Fixed values (north vs. south) unless slag is involved

\[
VMA = 100 - \left\{ \frac{(Gmb \times Ps)}{Gsb} \right\}
\]
• AC absorption ($P_{ba}$) is typically 65% of water absorption
• Range of 50-80%
• Porosity plays a role too!
• Directly affects total AC content
• Compare water absorption of your products to those of your competitors
### Water and AC Absorption Calcs

- **CA #1** – 35% (H$_2$O abs = 1.2%)
- **CA #2** – 30% (H$_2$O abs = 1.6%)
- **FA #1** – 25% (H$_2$O abs = 2.1%)
- **FA #2** – 10% (H$_2$O abs = 0.9%)

- **Combined** H$_2$O abs = (0.35 x 1.2) + (0.30 x 1.6) + (0.25 x 2.1) + (0.10 x 0.9) = $1.52\%$

- **Asphalt abs (P$_{ba}$)** = 0.65 x 1.52% = $0.98\%$
Can Two Designs at the SAME VMA & Voids Require Different AC Contents?

- **Design 1**
  - VMA = 13.4%
  - Voids = 4.0%
  - Total AC = 4.6%

- **Design 2**
  - VMA = 13.4%
  - Voids = 4.0%
  - Total AC = 4.8%

- The Difference Is **Asphalt Absorption**

- Design AC chosen @ 4.0% voids, so a difference in AC content between two designs is a function of:
  - VMA and/or
  - Asphalt Absorption
Consistency

- **VMA** is a function of:
  - Gradation, Shape, Texture and Strength
- What personnel and equipment *influence* these characteristics in your aggregate products?
- **Everyone** plays a role in Quality Control!
Quality Control

- **Representative** samples are crucial!
- But... **QC** isn’t just **sample** testing!
- Inspection, Analysis and Action:
  - Action occurs before sampling or before testing
  - We react too often – we must be proactive
  - Don’t assume the owner’s minimal requirements will suffice
- **QC** personnel seldom have time to test and oversee the process
- **QC** Managers play a vital role
Issues that Impact the Product

• Management
• Plant superintendents
• Ledge shots / Pit areas
• Primary, secondary and tertiary crushing operations
  – Equipment used
  – Operation rate
  – Equipment maintenance
• Log washer / Classifier operations
Issues that Impact the Product

- Stockpiling operations
  - Radial stacker, loader or trucks?
  - Multiple layers?
  - Location/direction?
  - Identification?
  - Intermingling issues?

- Load out operations
  - Trucks
  - Rail
  - Barge

Build them right
Prevent intermingling
Load out of them right
Issues at the HMA Plant

- Stockpiling and load out just as important!
- *Multiple* Cold Feeds for a *single* aggregate
  - Split if agg > 30%
  - Feed each CF from a different location in stockpile
- Mini Stockpile when multiple CF’s aren’t an option
Communication

• **Ensure communication** between your QC personnel and ours!

• **Communicate** any changes that impact gradation, shape, texture and strength, such as:
  – Personnel
  – Ledges or areas within a pit
  – Shot, mining or dredging methods
  – Crushing and/or classifying equipment
  – Production methods, especially screen decks
  – Stockpiling methods
  – Load out methods
Communication

- Changes will take place – planned or not!
- Impact on our mix results depends on our ability to work together
- Is there time to determine how much the “change” is going to affect our mix?
- What we can do to minimize or negate the effect?
Help Us With **Our** Flaws…

- **Encourage** your QC personnel to visit our asphalt plant:
  - Are we stockpiling correctly?
  - Are our stockpiles clearly identified?
  - Are our stockpiles separated to prevent intermingling?
  - Are we loading out of them in a manner that helps reduce variability?
  - How do our test results compare to yours?
  - Are we having success on our projects where your product is being used?
Segregated Mix

4.75mm and AC Content per Sample

Sample 1 2 3 4 5 6 7 8 9 10

4.75mm Sieve 49 48 47 46 45 44 43 42 41 40

AC Content 4.6 4.5 4.4 4.3 4.2 4.1 4.0 3.9 3.8 3.7 3.6 3.5
Balanced Mix Design (BMD)

• One of the hottest HMA topics around the U.S.
• Two basic characteristics for HMA:
  – Strength (Rutting resistance)
  – Durability (Cracking/Stripping resistance)
• Lot’s of tests being evaluated…
Performance Test Challenges…

• Does the test *clearly* relate to field performance?
• How *easy* is it to perform?
• How much *time* does it take?
• What does the equipment *cost*?
• Recommended specs, mix/specimen aging and parameters *relative to* our mixes/area?
  – Are the acceptance parameters the same for all mix types, sizes and uses?
Balanced Mix Design (BMD)

• Illinois has chosen:
  – Hamburg Wheel (Rutting)
  – I-FIT (Semi-Circular Bend) (Cracking)
What Impacts Performance Tests?

• There are things we:
  – know that we know…
  – know that we don’t know…
  – don’t know that we don’t know…

• We (IDOT and Industry) are learning…

• It’ll come down to:
  – Aggregate properties (recycle included)
  – Asphalt Cement properties (recycle included)
  – How we produce and place the product…
What Are Our Needs?

• Product **consistency:**
  – Gradation
  – Shape
  – Strength
  – Texture (micro-texture)

• Communication and partnership with you:
  – We understand things change and stuff happens…
  – We want to share results, thoughts and concerns
What Are Our Needs?

• ALL HMA aggregates are important to:
  – Achieve VMA
  – Produce consistent HMA
  – Meet Performance Test Requirements

• Angular products:
  – Are here to stay:
    • Stability
    • Durability (VMA)
Thank You!