Mix Troubleshooting Considerations

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CRH Americas Materials
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Let’s Get Started…

we’ve got a long way to go, and a short time to get there
Discussion Items

- Material Variability
- Troubleshooting Basics
- Production vs JMF – What Could Go Wrong?
- Education and Training
- Effective Communication
Material / Process Variability

Standard Deviation

Accuracy and Precision
Components of Test Result Variability

- **Material**: True inherent variability lies in the material, which the contractor can’t control.
- **Process**: Production and Construction variability.
- **Sampling**: Sample to sample variability attributable to sampling technique variation.
- **Testing**: Operator (new, unskilled, etc.), equipment, calibration, poorly written test procedure.

Variability of Interest

Sampling and testing can account for 50% or more of the test variability!
Hitting the Target with Low Variation is KEY

Typical Material Variability Data

**Aggregate Blend Grading**

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Typical Range for Overall Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 mm</td>
<td>1.5 to 4.5%</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>2.5 to 5.0%</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>2.5 to 5.0%</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>2.5 to 5.0%</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>2.5 to 4.0%</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>2.5 to 4.0%</td>
</tr>
<tr>
<td>0.60 mm</td>
<td>2.0 to 3.5%</td>
</tr>
<tr>
<td>0.30 mm</td>
<td>1.0 to 2.0%</td>
</tr>
<tr>
<td>0.15 mm</td>
<td>1.0 to 2.0%</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>0.6 to 1.0%</td>
</tr>
</tbody>
</table>

**Mix Volumetrics**

<table>
<thead>
<tr>
<th>Property</th>
<th>Typical Range of Value for Overall Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt content</td>
<td>0.15 to 0.30%</td>
</tr>
<tr>
<td>Air void content, from field cores</td>
<td>1.3 to 1.5%</td>
</tr>
<tr>
<td>Laboratory air void content</td>
<td>0.9%</td>
</tr>
<tr>
<td>VMA</td>
<td>0.9%</td>
</tr>
<tr>
<td>VFA</td>
<td>4.0%</td>
</tr>
</tbody>
</table>


- **Lower values indicate a more controlled operation and an easier job for the QC personnel!**
- **As a producer, you MUST know these variabilities for YOUR mixes!**
- **As an owner, these variabilities should be considered when establishing specifications.**
You MUST Know Your Materials/Process Variability

- Designing and producing an asphalt mix without knowing associated materials and process variability is a disaster in the making.
- Local experience is the most valuable and needed item available.

1. Know your materials
2. Know your equipment
3. Know your people

Recipe for Total Disaster

- 2 Cups of Unknown Aggregate Variability
- 3 TSP of Variable Aggregate Moisture
- 1 TSP of Variable Plant Cold Feed
- 1 Cup of Variable Aggregate Gravity
- ½ TSP of Personnel Not Adequately Trained
- 3 TBP of Complacency
- Lack of Effective Communication to Taste

- Blend Together, Do Nothing and Watch the Disaster Take Place!
Prioritization Matrix for Variability

1. Understand all potential causes of variability
2. Prioritize them based on impact (value provided) and ability to control (effort required).

https://www.nngroup.com/articles/prioritization-matrices/
Basic Troubleshooting Tips
What is Troubleshooting?

- **Troubleshooting** involves the evaluation AND adjustment of a process to correct the problem.

  - **Evaluation** is reviewing the data and taking action.
    - `e·val·u·ate`
    - *verb*
    - form an idea of the amount, number, or value of; assess.

  - **Adjustments** are meant to be small changes, not a complete mix over haul.
    - `ad·just`
    - *verb*
    - 1. alter or move (something) slightly in order to achieve the desired fit, appearance, or result.
### Adjustment Tips

- Avoid having multiple people making adjustments.
- Define the responsible party
- Make only one adjustment at a time.
- Multiple adjustments can make cause and effect impossible.
- Can prolong or exacerbate the problem.

- Product sufficient mix after adjustment to make accurate determination on the adjustment impact.
- Let the plant adjust to the adjustment (50 to 100 tons minimum)
- Maintain adjustment diary or log.
- Don’t …1) make same mistake twice and 2) forget what worked!
Remember the WHY!

• Steps in adjustment
  1. Identify a need.
  2. Determine what adjustment is needed.
  3. Remember the Why?

For example, lowering the P200 by cutting the screenings may help raise air voids, BUT what is the real reason for the P200 increase?
Air Voids Troubleshooting

Figure 3

START HERE

Check AV

Meets JMF?

Yes

Produce Mix

Difference < 0.5%

Yes

Adjust P200. Decrease to Increase AV

No

Adjust AC. Decrease to Increase AV

Still not meeting requirements?

Consider redesign.

Field Management of Hot Mix Asphalt

VMA = Voids in Mineral Aggregate
AV = Air Voids
P200 = Percent passing 0.075 mm (#200) sieve

NOTE: This flow chart is intended to provide guidance for adjustment of AV. Due to differences in properties of specific mixes, the effect of the adjustments may be variable.
VMA Troubleshooting

Adjust P200. 1%Δ = 0.3 to 1% VMA Δ

START HERE

Check VMA

Meets JMF?

Yes

No

Still not meeting requirements?

Consider redesign.

Produce Mix

Yes

Difference < 0.3%

No

Adjust P200. Decrease by 1% to increase VMA by 0.3%

Does Mix Have Natural Sand?

Yes

No

Adjust the Percent Passing No. 8 to Deviate from the Maximum Density Line.

Decrease amount of Natural Sand to Increase VMA

http://store.asphaltpavement.org/index.php?productID=754

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## General Rules of Thumb

- Develop a master "IF/THEN" chart for **YOUR** mixes.
- Valuable resource if developed correctly!

<table>
<thead>
<tr>
<th>IF</th>
<th>THEN</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gmm</td>
<td>Asphalt Binder</td>
<td>0.015 to 0.020 change for 0.5% binder</td>
</tr>
<tr>
<td>Gmm</td>
<td>Asphalt Binder</td>
<td></td>
</tr>
<tr>
<td>Gmb</td>
<td>Asphalt Binder</td>
<td></td>
</tr>
<tr>
<td>Gmb</td>
<td>Asphalt Binder</td>
<td></td>
</tr>
<tr>
<td>P200</td>
<td>Air Voids/VMA</td>
<td>1.0%Δ P200 = 0.3% to 1%Δ VMA</td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>Air Voids</td>
<td>0.1%Δ AC = 0.25%Δ Air Voids</td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>VMA</td>
<td>Vbe = VMA - Va</td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>No. 8 x No 200</td>
<td>Fine graded mixes</td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>No. 8 x No 200</td>
<td>Fine graded mixes</td>
</tr>
<tr>
<td>Gmb</td>
<td>Asphalt Binder</td>
<td>P200</td>
</tr>
<tr>
<td>Gmb</td>
<td>Asphalt Binder</td>
<td>P200</td>
</tr>
</tbody>
</table>
**Prior to Making an Adjustment, Ensure the Following**

1. Mix design is correct.
2. Mix design is correctly input into the plant.
3. Plant components are properly calibrated.
4. Lab equipment is properly calibrated.
5. Personnel are properly educated / certified.
6. Personnel roles and responsibilities are assigned.
7. Sample is random and representative.
8. Sample is processed correctly (e.g., split).
9. Proper test procedures are being utilized.
10. Results are double checked.
Main Level Focus Areas
Main Focus Areas

1. Aggregate
2. Recycle
3. Binder
4. Plant

- The key to quality control is to accurately determine the cause of the current difference and minimize the frequency and magnitude of future occurrences.
Main Aggregate Focus Areas

1. Stockpile moisture excessive / variable
2. Gravities different / variable from design
3. Segregation (stockpiling and loadout)
Stockpile Moisture

- Water quantities falling on a stockpile during a rain event is very significant.
- Example: 100 ft. x 100 ft. stockpile will collect 26 tons of water after a 1” rainfall event.

<table>
<thead>
<tr>
<th>Stockpile Footprint (sf)</th>
<th>Approximate Dimensions, ft</th>
<th>Water Tonnage Over Footprint After Given Rainfall Events (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>5000</td>
<td>70 x 70</td>
<td>7</td>
</tr>
<tr>
<td>10000</td>
<td>100 x 100</td>
<td>13</td>
</tr>
<tr>
<td>15000</td>
<td>125 x 125</td>
<td>20</td>
</tr>
<tr>
<td>20000</td>
<td>140 x 140</td>
<td>26</td>
</tr>
<tr>
<td>25000</td>
<td>160 x 160</td>
<td>33</td>
</tr>
<tr>
<td>30000</td>
<td>175 x 175</td>
<td>39</td>
</tr>
</tbody>
</table>
Stockpile Moisture

- Water retention is maximized with well graded fine aggregate with high minus 200 content (i.e., screenings)
- Fine aggregate, RAP and RAS stockpiles are very prone to holding moisture
- Cover and pave under + slope stockpiles to minimize moisture.
- Rule of Thumb: 1% increase in moisture…
  - Decreases plant production by 11%
  - Increases energy consumption by 11%
- Uncontrolled moisture = uncontrolled volumetrics!
Aggregate Specific Gravity Relationships

G_{se} is an aggregate property. For a given mix design, the relationship between G_{se} to G_{sa} and G_{sb} should not change (within test variability).
Segregation

- MUST prevent segregation of material when stockpiling and loadout!
Main Recycle Focus Areas

- Consistent supply
- Binder content accuracy
Incorrect or Inconsistent Aggregate / Recycle Supply

- Incorrectly calibrated cold feed bin feed or weigh bridge can result in substantial errors.
  - Recycle feed issues will double issues: grading and binder content.
  - Properly calibration procedures must be utilized on a routine basis.
Incorrect Recycled Materials Binder Content

- Accurate binder content is required for the recycled products.
- Design value must be the “true” stockpile value!
  - Assume 30% RAP in a mix
  - Design RAP binder content used = 5.0%
  - Binder from RAP = 0.30 (5.0) = 1.5%
  - Actual Stockpile RAP = 4.5%
  - Error in virgin binder addition = (4.5 – 5.0) x 0.30 = - 0.15%
    (too little binder added, dry mix issues)
- Proper recycled stockpile process control is a MUST!
Main Asphalt Binder Focus Areas

- Binder different than design (even though using the “same” PG)
- Variable binder addition
Crude sources used for binder manufacture are constantly changing.

Two binders with the same PG classification can act differently.

Should obtain / monitor the true PG classification from the binder manufacturer to help ensure consistent source from production relative to design.
Asphalt binder addition errors can be caused by a multitude of reasons.

- Plant operator error
- Incorrect asphalt pump operation / calibration
- Weighing issues on conveyor
- Incorrect adjustment for aggregate moisture
Variable Binder Addition

- The plant moisture setting should match the actual moisture content of the aggregate/recycle blend.
- **Case 1: Actual moisture > Plant moisture**
  - Plant thinks the difference is aggregate and adds too much binder
- **Case 2: Actual moisture < Plant moisture**
  - Plant thinks the difference is moisture and adds too little binder
- Too little or too much binder will result in volumetric property, compaction, and cost issues!

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**YTD Moisture Effect On Binder**

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division</td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td></td>
</tr>
<tr>
<td>Plant</td>
<td></td>
</tr>
<tr>
<td>Plant Name</td>
<td></td>
</tr>
<tr>
<td>Combined Moisture Setting</td>
<td>2.0%</td>
</tr>
<tr>
<td>Combined Actual Moisture</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant Performance Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Cost of Binder</td>
<td>$486.86</td>
</tr>
<tr>
<td>Sold Tons</td>
<td>103,809</td>
</tr>
<tr>
<td>Average Virgin Binder %</td>
<td>4.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculated</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in Moisture</td>
<td>1.0%</td>
</tr>
<tr>
<td>Difference in Binder %</td>
<td>0.04%</td>
</tr>
<tr>
<td>Actual Binder %</td>
<td>4.16%</td>
</tr>
<tr>
<td>Extra Cost of Binder per Ton Sold</td>
<td>$0.20</td>
</tr>
<tr>
<td>Extra Cost for Sold Tons</td>
<td>$20,805</td>
</tr>
</tbody>
</table>
Main Plant Focus Areas

- Excessive mix switchovers
- Inconsistent temperature / storage time
Production of a single mix for the entire day highly desirable, but unrealistic, for consistency considerations.

Concern with continuous mix (drum) facilities where the mix is changed “on the fly”.

Tips
1. Maximize production runs of a particular mix.
2. Minimize / consolidate the number of mixes produced in a particular plant. Especially critical for high profile mixes with stringent acceptance requirements/specifications (e.g., interstate SMA project).
3. Don’t treat all plants as a “grocery store”, “cafeteria”, “buffet”, or “vending machine”.
4. Communicate with customers to let them know about similar mixes.
Mix Storage Impact on Absorbed Binder + Gse

Binder Absorption, Pba

Effective Specific Gravity, Gse

Properly Educated / Trained Personnel
Education vs Training

Education ≠ Training

- Education is a concept based, long term, wider scope learning system.
- Training is focused on learning or gaining a particular skill.

- Both are critical for a successful project.
- Must be 1) educated to understand the total picture concept of a project, but 2) trained well enough to accomplish specific tasks.
Training Importance

- Proper training help ensure personnel perform task in a correct, repeatable manner.
- People should be taught to truly understand the what, why and how during training and not just generic procedures.
  - What’s happening?
  - Why is it happening?
  - How can I stop it from / keep it happening?
“Effective” Communication
What is Effective Communication?

- Communication is a process of transferring information from one entity to another.
- **Effective Communication** is a process where a message is received and understood by the receiver in the manner that the sender intended it to be.

http://www.people-communicating.com/what-is-communication.html
Three Key Activities of Effective Communication

- Speaking
  - Clear and concise
- Listening
  - Active process requiring your full attention and concentration
- Feedback
  - Confirms an understanding of the sender’s message

*Best tool for communication is a good set of ears!*
Summary…

1. Understand **WHY** the adjustment is needed, not just that it is needed.
2. Develop local experience to drive correct adjustments for your mixes.
3. Known your variability components and take action to limit variability.
4. Focus on the main level areas that can make production different from the JMF.
5. Acknowledge that Education and Training are not equal. Train personnel for task specific areas to limit variability.
6. Effectively communicate between design/production/construction.
7. **ENJOY YOUR JOB, BE THANKFUL!**
Thank you