Virginia’s Progress in Implementing Balanced Mix Design

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Acknowledgements

• Ilker Boz, Jhony Habbouche, VTRC
• VTRC Lab Staff
• VDOT Materials Division
• VDOT Districts
  – Fredericksburg, Lynchburg, Northern Virginia, Richmond, Salem
• Virginia Asphalt Association
• Industry partners
  – Superior Paving, Boxley Materials, Colony Construction, Lee Hy Paving
Virginia’s Approach to Implementation

- Develop lab-testing specs for cracking and rutting
- Lab equipment acquisition
- Research – Pilot project construction / evaluations
- Research – Refine specification requirements
- Develop and execute training
- Statewide implementation
Departmental & Industry Collaboration

• BMD Advisory Group
  – Executive level stakeholders

• BMD Technical Advisory Committee
  – Research, operations, industry, FHWA
  – Technical guidance and feedback

• Workshops, training, round robin efforts
Research In Progress

- Performance Mix Design – Phase I
- Balanced Mix Design Field Trials
- Impact of Production Variability on BMD in VA
- Feasibility of Using Monotonic Loading-Based Tests to Evaluate Rutting Performance of Asphalt Mixtures
- IDT Cracking Test Round Robin
- Evaluating Recycling Agents’ Acceptance for Virginia: Test Protocols and Performance-Based Threshold Criteria
- VDOT Heavy Vehicle Simulator
Initial BMD Trials: 2019-2020

• Location
  – ~2000T per mix
  – Uniform traffic, pavement condition/structure

• JMF submittal and approval
  – High RAP mixes (>30% RAP)
  – Dense-graded surface mixes (≤ 30% RAP)

• Production
  – Volumetric and density acceptance
  – Modified sampling rate
  – Performance test pills provided by contractor
  – Loose mix sampling
  – Coring
### Performance Test Criteria

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Temp.</th>
<th>Specimens</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>APA rutting (AASHTO T340)</td>
<td>64°C</td>
<td>4 specimens</td>
<td>Rutting ≤ 8.0mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.0 ± 0.5% voids</td>
<td></td>
</tr>
<tr>
<td>Cantabro (AASHTO TP108)</td>
<td>25°C</td>
<td>3 specimens</td>
<td>Mass loss ≤ 7.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Report air voids</td>
<td></td>
</tr>
<tr>
<td>CT&lt;sub&gt;index&lt;/sub&gt; (ASTM D8225)</td>
<td>25°C</td>
<td>5 specimens</td>
<td>CT&lt;sub&gt;index&lt;/sub&gt; ≥ 70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.0 ± 0.5% voids</td>
<td></td>
</tr>
</tbody>
</table>

Lab-produced mix: loose mix shall be aged at the design compaction temperature prior to compacting

- APA and Cantabro - 2 hours
- CT<sub>index</sub> - 4 hours
Balanced Mix Design Approval

• Design submitted to District for approval
• Performance testing
  – 5 CT\textsubscript{index} pills – standard 4hr short term aging
  – 5 CT\textsubscript{index} pills – additional 8hrs @135\degree C long term aging
  – 3 Cantabro pills
  – 4 APA rut pills
• Beginning in 2020:
  – Cantabro mass loss: at design AC and design AC–0.5%
  – CT\textsubscript{index} : at design AC and design AC±0.5%
  – APA rut depth: at design AC and design AC+0.5%
  – Aged CT\textsubscript{index} : at design AC
CT_index Long Term Aging

• Need to consider aged performance of mixes
• Rejuvenator/additive performance can change drastically after aging

• Long-Term Oven Aging (LTOA)
  – Apply short term aging (4hrs at compaction temp for lab-made mix)
  – Then, apply LTOA:
    • Spread loose mix in shallow pans
    • Age in forced draft oven 8hrs @ 135°C (275°F)
    • Heat to compaction temperature and compact
# Trial Production Sampling/Testing

## Producer Testing & Pills

<table>
<thead>
<tr>
<th>Tonnage</th>
<th>Gradation / AC</th>
<th>Volumetrics</th>
<th>APA pills (7±0.5% AV)</th>
<th>Cantabro pills</th>
<th>CT\textsuperscript{index} pills (7±0.5% AV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-500</td>
<td>X</td>
<td>X</td>
<td>4*</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>500-1000</td>
<td>X</td>
<td>X</td>
<td>4*</td>
<td>6**</td>
<td>10**</td>
</tr>
<tr>
<td>1000-1500</td>
<td>X</td>
<td>X</td>
<td>4*</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>1500-2000</td>
<td>X</td>
<td>X</td>
<td>4*</td>
<td>6**</td>
<td>10**</td>
</tr>
</tbody>
</table>

* APA pills will be tested by VTRC.

** Half of pills are for producer testing, half are to be turned over to VDOT/VTRC for testing.
# Trial Production Sampling/Testing

## VDOT/VTRC Testing

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<th>Volumetrics</th>
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<td>500-1000</td>
<td>X</td>
<td>X</td>
<td>4*</td>
<td>3**</td>
<td>5**</td>
</tr>
<tr>
<td>1000-1500</td>
<td>X</td>
<td></td>
<td>4*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1500-2000</td>
<td>X</td>
<td>X</td>
<td>4*</td>
<td>3**</td>
<td>5**</td>
</tr>
</tbody>
</table>

* APA pills will be made by Contractor and tested by VTRC

** Cantabro & CT\textsubscript{index} pills will be made by Contractor and tested by VTRC/VDOT
Trial Production Sampling/Testing

- **VTRC Sampling / Testing**
  - Once per mix
    - 2 quarts of binder
  - Every 500T loose mix sample for:
    - Gradation/AC - Volumetrics
    - APA rut test - Cantabro
    - CT_{index}
  - Extra sampling at 500-1000T for additional testing - PavementME

<table>
<thead>
<tr>
<th>Tonnage</th>
<th>Boxes</th>
<th>Cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-500</td>
<td>6</td>
<td>10*</td>
</tr>
<tr>
<td>500-1000</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>1000-1500</td>
<td>6</td>
<td>10*</td>
</tr>
<tr>
<td>1500-2000</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

* Maximum 10 cores per day.
2019-2020 Trials

• Contractor 1
  – Plant 1: 40% RAP + PG 58-28 / 40% RAP + PG 64S-22 + RA 1 (2019)
  – Plant 2: 40% RAP + PG 58-28 / 40% RAP + PG 64S-22 + RA 2 (2020)
  – Plant 3: 40% RAP + PG 58-28 / 40% RAP + PG 64S-22 + RA 3 (2020)
• Contractor 2 (2019)
  – 26% RAP + PG 64S-22 + RA 1
  – 26% RAP + PG 64S-22 + RA 2
• Contractor 3 (2020)
  – Plant 1: 35% RAP + PG 58-28 + RA 4
  – Plant 1: 35% RAP + PG 58-28 + softener + fibers
  – Plant 2: 40% RAP + PG 58-28
• Contractor 4 (2020)
  – 35% RAP + PG 58-28
BMD – Mass Loss and Rut Depth

**Mass Loss**

- **Plant Compacted**
- **Reheat Sample A**
- **Reheat Sample B**

**Rut Depth**

- **Plant Compacted**
- **Reheat Sample A**
- **Reheat Sample B**

<table>
<thead>
<tr>
<th>Mass Loss %</th>
<th>26% RAP PG64S-22 Control</th>
<th>26% RAP PG64S-22 RA - A</th>
<th>26% RAP PG64S-22 RA - B</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rut Depth, mm</th>
<th>26% RAP PG64S-22 Control</th>
<th>26% RAP PG64S-22 RA - A</th>
<th>26% RAP PG64S-22 RA - B</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
BMD - CT\textsubscript{index}

![Graph showing CT\textsubscript{index} values for different samples](image-url)

- Plant Compacted
- Reheat Sample A
- Reheat Sample B

CT\textsubscript{index}

- 26% RAP
  - PG64S-22 Control
  - PG64S-22 RA - A
  - PG64S-22 RA - B
High RAP BMD - Cantabro Mass Loss

- 30% RAP PG 64S-22
- BMD 40% RAP PG 58-28
- BMD 40% RAP PG 64S-22 RA

Mass Loss, %

Design Sample A Sample B Sample C Sample D

Lab - Contractor
Lab - VTRC
Reheat
High RAP BMD - CT$_{index}$
High RAP BMD – Rut Depth

- 30% RAP PG 64S-22
- 40% RAP PG 58-28
- 40% RAP PG 64S-22 RA
Takeaways from 2019

• Important details to consider
  – Specimen preparation
  – Test variability
  – Reheating impacts
  – Differences between design and production

• Any factors that contribute to variability are magnified in performance testing

• Source material differences can be significant
VDOT Heavy Vehicle Simulator

• BMD Experiment
  – Control 30% RAP PG 64S-22
  – BMD 30% RAP PG 64S-22
  – BMD 45% RAP PG 64S-22
  – BMD 45% RAP PG 64S-22 + recycling agent
  – BMD 45% RAP PG 58-28
  – BMD 60% RAP PG 58-28 + recycling agent

• Evaluating rutting and cracking
2021 BMD Trials

• Oriented toward standard production
• Include BMD in contracts
• Still research focused:
  – Appropriate cracking, rutting, and Cantabro criteria?
  – Accounting for heating/re-heating of samples
  – Developing aging protocols – predicting performance
• Incorporate district staff into testing efforts
  – Support research and gain experience
2021 BMD Trials

• Assess BMD under typical production conditions
• BMD mixes in certain contracts
  – 2 contracts with stand-alone BMD projects (~13,500T)
  – 8 contracts in 4 Districts with BMD routes (~58,000T)
• BMD mixes are separate pay items
• Acceptance still per current processes using volumetrics and density
# 2021 Sampling and Testing

<table>
<thead>
<tr>
<th>Property/Test</th>
<th>Frequency (2,000T / lot)</th>
<th>Frequency (4,000T / lot)</th>
<th>No. of Specimens (per lot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{T_{\text{index}}}$ – Contractor QC</td>
<td>500 T</td>
<td>1,000 T</td>
<td>20</td>
</tr>
<tr>
<td>Cantabro – Contractor QC</td>
<td>500 T</td>
<td>1,000 T</td>
<td>12</td>
</tr>
<tr>
<td>$C_{T_{\text{index}}}$ – VDOT QA</td>
<td>1,000 T</td>
<td>2,000 T</td>
<td>10</td>
</tr>
<tr>
<td>Cantabro – VDOT QA</td>
<td>1,000 T</td>
<td>2,000 T</td>
<td>6</td>
</tr>
<tr>
<td>Rutting – VDOT QA</td>
<td>500 T</td>
<td>2,000 T</td>
<td>8</td>
</tr>
<tr>
<td>Loose mix sample – VTRC</td>
<td>500 T</td>
<td>2,000 T</td>
<td>12 boxes</td>
</tr>
</tbody>
</table>

- VDOT QA specimens are fabricated by the Contractor and submitted to the Department.
Moving Forward

• Develop training and certification process
• Additional trials in 2022
  – More industry participation
• Address aging
• Define implementation for 2023
  – What mix designations/traffic levels will be addressed
  – Will acceptance and pay be based on performance test results
Thank you!

For more information:
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