Virginia’s Experience with Balanced Mix Design

Kevin McGhee, P.E.
Associate Director - Pavements
Asphalt Mix Design
– Once Upon a Time
Asphalt Mix Design – not that long ago
Asphalt Mix Design – Today Moving Forward
Our Objectives Remain...
Produce  Deliver  Finish

Construct-able
Balanced Material Performance

- Crack Resist.
- Deform Resist.
- Wear-Durable
- Construct-able
What is Balanced Mix Design?

Designing mixes using performance tests on appropriately conditioned specimens to address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure.

– from FHWA Balanced Mix Design Task Force
What does BMD Mean – Practically?

• Designing mixtures to meet performance criteria:
  – Rutting
  – Cracking
  – Durability

Ultimately can use volumetrics as a tool, rather than a requirement
Why Use BMD?

• Achieve improved pavement performance
  – Optimization of cracking and rutting resistance

• Foster innovation
  – Mix performance approach vs. totally prescriptive specifications
  – Incentivize quality attributes
Building a BMD Specification

- Know existing mix/pavement performance*
- Determine baseline/expectation for performance
- Select appropriate test procedure
- Develop testing and specification structure
- Re-evaluate and validate

* Yeah, easily said, but done??
Virginia’s Approach to BMD

- Assume BMD Framework
- Select Performance Tests
- Develop Initial Specification Limits
- Validate Using Actual Performance
- Select Final QC/QA Acceptance Criteria
Selecting Test Procedures

• Correlates to field performance
• Sensitivity to mix properties
• Repeatability
• Ease of use
• Availability/cost
Deformation – Lab Performance

APA Rutting
AASHTO T340
Toughness

Stiffness

Strength

Crack Resistance

Aging Effects

Temperature

Traffic

IDEAL CT

ASTM D8225
Developing Initial Spec Targets

Benchmarking/Shadow Testing

• Surface mixtures with 9.5mm & 12.5mm NMAS
• 2015 - 11 field projects
• 2018 - 13 mixtures
  – 6 field projects
  – 7 plant sampling only

See - “Initial Approach to Performance (Balanced) Mix Design: The Virginia Experience”, TRR Vol. 2673, Jan, 2019
APA Rutting – 2018 Mixes

Average Rut Depth, mm

Solid bar: 9.5mm NMAS
Hashed bar: 12.5mm NMAS

Unreheated
Reheated
CT$_{\text{index}}$ – Reheated Mix

- Solid bar: 12.5mm NMAS
- Hashed bar: 9.5mm NMAS

Bars represent different years (2015 and 2018) with error bars indicating variability.
Cantabro Mass Loss

Average Mass Loss, %

Average Air Voids, %

X - 2015 reheated
Solid shape - 2018 plant compacted
Open shape - 2018 reheated
VDOT BMD Experiments (2019)

1. Control (traditional design)
   - Meets current volumetric specs

2. Volumetric + Performance
   - Meets current volumetric specs AND performance requirement

3. Performance Only
   - Current volumetric requirements waived
   - *Design* must meet performance requirements
   - Producer maintains *design* volumetrics during production
# Performance Criteria

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Temp.</th>
<th>Specimens</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO T340 (APA rutting)</td>
<td>64°C</td>
<td>2 replicates of 2 pills (APA Jr) [Note: Plant-mix shall not be reheated when producing APA rut specimens.]</td>
<td>Rutting ≤ 8.0mm</td>
</tr>
<tr>
<td>AASHTO TP108 (Cantabro mass loss)</td>
<td>25°C</td>
<td>3 replicates Report air voids</td>
<td>Mass loss ≤ 7.5%</td>
</tr>
<tr>
<td>ASTM D8225 2019 (CT&lt;sub&gt;index&lt;/sub&gt;)</td>
<td>25°C</td>
<td>3 replicates</td>
<td>CT&lt;sub&gt;index&lt;/sub&gt; ≥ 70</td>
</tr>
</tbody>
</table>

Lab-produced mix – loose mix shall be aged at the design compaction temperature prior to compacting.
Production Testing Frequency

Table 2. Production Testing Frequency

<table>
<thead>
<tr>
<th>Entity</th>
<th>Gradation/AC</th>
<th>Volumetrics</th>
<th>APA rutting</th>
<th>Cantabro</th>
<th>$CT_{\text{index}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer</td>
<td>500T</td>
<td>500T</td>
<td>-</td>
<td>500T</td>
<td>500T</td>
</tr>
<tr>
<td>VDOT</td>
<td>500T</td>
<td>1,000T</td>
<td>-</td>
<td>1000T ²</td>
<td>1000T ²</td>
</tr>
<tr>
<td>Research</td>
<td>500T</td>
<td>500T</td>
<td>500T ²</td>
<td>500T (reheat)</td>
<td>500T (reheat)</td>
</tr>
</tbody>
</table>

¹ With a minimum of 1 sample per day, per entity, per test.
² Minimize any cooling of the plant-produced mix and bring the specimens to the compaction temperature ad compact immediately, to the specimen size requirements in Table 1. Specimens shall be fabricated and provided to the Department by the Contractor.
BMD Special Provision Use

• BMD (optimized dense-graded) Projects
  – Apply BMD concepts to typical dense-graded mixtures
  – Assess impact of binder grade changes and additives

• High-RAP BMD Projects
  – Apply BMD concept to mixes with 40%+ RAP content
  – Assess impact of binder grade changes and additives
# 2019 BMD Projects

<table>
<thead>
<tr>
<th>Date</th>
<th>Mixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 27-28</td>
<td>SM-9.5 30% RAP PG 64S-22</td>
</tr>
<tr>
<td></td>
<td>SM-9.5 30% RAP PG 58-28</td>
</tr>
<tr>
<td>July 15-18, 24-25</td>
<td>SM-9.5 40% RAP PG 64S-22</td>
</tr>
<tr>
<td></td>
<td>SM-9.5 40% RAP PG 58-28</td>
</tr>
<tr>
<td></td>
<td>SM-9.5 40% RAP PG 64S-22, rejuv.</td>
</tr>
<tr>
<td>August 22, 26-27</td>
<td>SM-9.5 26% RAP PG 64S-22</td>
</tr>
<tr>
<td></td>
<td>SM-9.5 26% RAP PG 64S-22, rejuv.</td>
</tr>
<tr>
<td></td>
<td>SM-9.5 26% RAP PG 64S-22, rejuv. 1</td>
</tr>
<tr>
<td></td>
<td>SM-9.5 26% RAP PG 64S-22, rejuv. 2</td>
</tr>
</tbody>
</table>
Example Performance Space

- 30% RAP PG64S-22
- 40% RAP PG64S-22
- Rejuvenator
- 40% RAP PG58-28

**Crack-resistant, rut-resistant**

**Crack-susceptible, rut-susceptible**

APA Rut Depth, mm
Challenges/Opportunities

• Meeting BMD performance test criteria
  ▪ What changes need to be made to mixes for performance?
  ▪ What additives are effective?
  ▪ What impact do plant/production characteristics (production temp., plant type, production rate) have?
  ▪ What role(s) do traditional QA measures play?
  ▪ Acceptance/payment?
Moving Forward

• Relating design to production (to as-placed)
  – Aging procedure(s) for cracking tests
• Relating laboratory to in-service performance
• Precision and bias statements for tests
• Understanding of how normal production variability impacts performance measures
• Production QA – tests, frequency, etc.
• Accepting/understanding rejuvenators
Status of Virginia “Experiments”

• Ongoing:
  – Trial projects – year 2 / “Shadow” testing – year 3
  – Statewide (at least) round-robin for $CT_{\text{index}}$
  – Evaluating production variability (NCAT contract)

• Upcoming:
  – IDT rutting test evaluation (e.g., IDEAL RT)
  – Rejuvenator evaluation process for acceptance

• Enduring:
  – Relating design/production to actual performance
Agency Timeline

- Develop lab testing specs for cracking and rutting
- Lab equipment acquisition
- Develop and execute training
- Statewide implementation


Research - Pilot project construction / evaluations
Research - Refine spec requirements

VDOT Materials:
- Andy Babish, State Materials Engineer
- Rob Crandol, Assist. State Materials Engr. & BMD Project Manager
Thank You!

Also see - “Initial Approach to Performance (Balanced) Mix Design: The Virginia Experience”, TRR Vol. 2673, Jan, 2019

For further info: stacey.diefenderfer@vdot.virginia.gov