Performance Mix Design

Stacey Diefenderfer, Ph.D., P.E.

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What Is PMD?

- 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
Why PMD?

• Volumetrics do not tell the whole story
  – Change performance without changing volumetrics

• Goal of PMD
  – Design mixes for the application and service requirement
PMD for Innovation

• Address technologies / methodologies in mix design that cannot be handled within current specs

• Tailor mixtures for in-service applications

• Designers can have space to innovate
MIX DESIGN APPROACHES
Select trial gradation

Perform volumetric analysis; select design binder content and volumetric properties

Conduct performance tests

Performance passed?

No → Redesign mix

Yes → Perform moisture damage test

Moisture damage passed?

No → Improve moisture susceptibility

Yes → Validate JMF. Go to production
Volumetric Design w/ Performance Verification

• Superpave design approach
• Verification of performance properties
  – If do not meet performance properties, re-design the mix
Select trial gradation

Perform volumetric analysis; select initial binder content

Conduct performance tests

Performance passed?

Yes

Perform moisture damage test

Moisture damage passed?

Yes

Verify volumetric properties

No

Adjust mix proportions and/or binder content

Perform moisture damage test

Moisture damage passed?

No

Improve moisture susceptibility

Yes

Validate JMF. Go to production
Performance-Modified Volumetric Design

- Use Superpave approach to select initial design binder content
- Performance test results could modify mixture proportions and/or adjust the binder content
- Final volumetric properties may be allowed to fall outside volumetric spec
Select trial gradation

Conduct performance tests; select design binder content

Perform moisture damage test

Moisture damage passed?

- No
  - Improve moisture susceptibility

- Yes
  - Perform volumetric analysis; determine & report volumetric properties at design binder content
  - Validate JMF. Go to production
Performance Design

- Run performance tests at varying binder contents and select the design binder content from results
- Volumetrics determined afterward and reported
- No spec requirements on volumetrics
MOVING FROM VOLUMETRIC DESIGN TO PMD
Developing PMD Specifications

- Know mix/pavement performance
- Develop a baseline for performance
- Select appropriate test procedure
- Develop testing and specification structure
- Re-evaluate and validate
Selecting Test Procedures

- Correlates to field performance
- Sensitivity to mix properties
- Repeatability
- Ease of use
- Availability/cost
Where Are We Going?
VTRC Projects

• PMD – Phase I
  – Benchmark current mixtures
  – Shadow testing during production
  – Develop & validate spec recommendations
  – Validate process during design

• High RAP Trials
  – Trial production of >40% RAP mixtures
  – Use PMD for design and production evaluation
PMD – Phase I

- Benchmarking / Shadow testing
  - Cracking test
    - IFIT/SCB, Overlay test, Nf lex, IDEAL-CT
  - Rutting
    - APA, Hamburg
  - Other
    - Cantabro - durability
    - Volumetrics
    - Binder grading

Photo: Cox et al. (2017)
PMD – Phase I

• Mix Design Shadowing
  – Cracking test
    • IDEAL-CT, IFIT/SCB, Overlay test, Nflex
  – Rutting
    • APA
  – Other
    • Cantabro – durability
    • Volumetrics
    • Binder grading
High RAP Trials

• Focused on mixes with RAP ≥ 40%

• Mix Types
  – Control
  – Volumetric design + Performance testing
  – Performance design

• Mix acceptance still based on volumetrics
  – Performance will be evaluated
# High RAP Trials – Performance Testing

<table>
<thead>
<tr>
<th>Test</th>
<th>Procedure</th>
<th>Specimens</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>APA rutting</td>
<td>8,000 passes</td>
<td>4 pills (APA Jr)</td>
<td>Rutting ≤ 8.0mm</td>
</tr>
<tr>
<td></td>
<td>64°C</td>
<td>150 mm dia.</td>
<td></td>
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<tr>
<td></td>
<td>120lb, 120psi</td>
<td>75 ± 2 mm ht.</td>
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<td></td>
<td></td>
<td>7±0.5% air voids</td>
<td></td>
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<tr>
<td>Cantabro</td>
<td>300 rotations</td>
<td>3 pills</td>
<td>Mass loss ≤ 7.5%</td>
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<tr>
<td></td>
<td>30-33 rot/min</td>
<td>150 mm dia.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>115 ± 5 mm ht.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>N_{design}, report air voids</td>
<td></td>
</tr>
<tr>
<td>IDEAL-CT</td>
<td>Condition (25±1°C for 2±0.5 hr)</td>
<td>3 pills</td>
<td>CT_{index} ≥ 70</td>
</tr>
<tr>
<td></td>
<td>Contact load - 0.1kN at 0.05 kN/s</td>
<td>150mm dia.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Load to failure - 50 mm/min</td>
<td>62 ± 2mm ht.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7±0.5% air voids</td>
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</tr>
</tbody>
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Future Considerations in PMD

• Acceptance protocols

• Aging (laboratory vs. in-service)

• Relationships between performance criteria and service life

• Calibrating performance criteria to mixture/pavement type (traffic level)
Thank you!

For more information:
stacey.diefenderfer@vdot.virginia.gov