Research Update: High RAP

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% VDOT Tonnage Containing RAP

- 2009: 94.6%
- 2010: 95.5%
- 2011: 96.5%
- 2012: No Data
- 2013: 98.2%
Questions About RAP Use

• How does RAP content influence binder grade and mixture performance?
• Are RAP binders activated in mixtures?
• What binders should we use with various RAP contents for best performance?
• How much RAP can we use in a mixture?
Focus Areas

• In 2008, VDOT allowed up to 30% RAP in surface mixes
  – How well have these mixtures performed?

• Recent interest in higher RAP contents – up to 45% RAP
  – Can we design/produce/pave these mixtures?
  – How well will they perform?
Analysis: 20-30% RAP Mixtures

• Anecdotally, early mixtures appeared “dry”
  – RAP does not contribute as much binder as assumed
  – Recent spec changes have addressed this

• Need quantitative answer for performance
  – Visual surveys indicate trial sections performed similarly to controls
  – Performance test results under review
How Much RAP?

- Fredericksburg District, 6/2013
  - 20% (PG 70-22)
  - 30%, **40%**, **45%** (PG 64-22)

- City of Hampton, 8/2013
  - 30%, **40%** (PG 64-22)

- Fredericksburg District, 7/2014
  - **40%** (PG 58-28)

- Lynchburg District, 8/2014
  - 0% (PG 70-22)
  - 30%, **40%**, **45%** (PG 64-22)
Can High RAP Contents Work?

• Sometimes!
  – Depends on the RAP material, contractor, plant, project, etc.

• Issues
  – Can be difficult to produce
    • Plant setup and RAP handling capacity
  – Meeting current volumetric acceptance criteria
    • Controlling / measuring RAP properties
    • Addressing VMA, VFA, voids, and %AC

• Lab performance testing is interesting
• Proof will be in long-term performance
Addressing Challenges

30% RAP

45% RAP
Addressing Challenges
# Extracted RAP Binder

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>6/12</th>
<th>6/13</th>
<th>6/14</th>
<th>6/17</th>
<th>6/18</th>
<th>6/19</th>
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<td><strong>High Failure Temp.</strong></td>
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<td>G*/sin delta</td>
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<td>85.3</td>
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<tr>
<td>m-value</td>
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<th>Performance Grade</th>
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<th>82-16</th>
<th>82-16</th>
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</table>

Rt. 3 King George County, June 2013

• SM-12.5 mix designs
  – 20% RAP, PG 70-22, manufactured sand
  – 30% RAP, PG 64-22, manufactured sand
  – 30% RAP, PG 64-22, manf. & natural sand
  – 45% RAP, PG 64-22, manf. & natural sand

• 5\textsuperscript{th} mixture – adjustment to 45% design
  – 40% RAP, PG 64-22, manf. & natural sand
Dynamic Modulus - onsite
Dynamic Modulus - reheat

![Graph showing dynamic modulus with different RAP PG 64-22 (MS&NS) reheat percentages]
Dynamic Modulus – 40% RAP
City of Hampton, August 2013

- 2 SM-9.5 mixtures
  - 30% RAP, PG 64-22
  - 40% RAP, PG 64-22

- Testing
  - 40% RAP specimens made on site
  - 30% and 40% RAP reheated specimens
  - Cores
Dynamic Modulus

![Graph showing the relationship between Reduced Frequency (Hz) and Modulus (psi) with various RAP reheat and cores configurations.](image-url)
Continued Testing

- Mix Testing
  - Cracking - Texas Overlay Test
  - Rutting – APA Rut Tester
  - Fatigue – Beam Fatigue

- Cores
  - Permeability
  - Dynamic modulus
  - Extraction and recovery
  - Binder grading

- Performance predictions with AASHTO Pavement ME
- Performance monitoring of pavements
Moving Forward

• Additional trial experiences
  – Need variety of contractors/projects

• Continued performance testing and in-service performance evaluation

• Investigation of mix design process and mix acceptance criteria
Thank You!

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