High RAP Research Studies

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Current Projects Related to RAP

• High RAP Mixtures (VTTI contract)
  – Goal: Address binder contents of high RAP mixes

• In-Service Binder Aging and Performance: RAP Mixtures (VCTIR)
  – Goal: Investigate binder aging and performance of RAP mixtures

• TPF-5(230) Evaluation of Plant Produced High Percentage RAP Mixtures in the Northeast (pooled fund)
  – Goal: Understand how RAP interacts with the virgin materials in a mixture
  – Develop proper techniques and procedures to design & construct RAP mixtures with equal or better performance than all-virgin mixtures
High RAP Mixtures

• Objective: Evaluate the effect of increasing binder content (+0.5% and +1.0) on the performance of high RAP content surface mixes

• Four mixes: 0%, 20%, 40%, and 100% RAP

• Mix performance evaluated using
  – Dynamic modulus
  – Flow number and APA (for rutting)
  – Beam fatigue (for cracking)
High RAP Mixtures

• Results
  – 0% and 20% RAP mixes were VDOT-approved: for both mixes, performance improved with +0.5% binder
  – 40% RAP mix was not VDOT-approved: adding binder worsened rutting performance of the mix
  – 100% RAP mixes were very stiff even after +1.5% binder was added
High RAP Mixtures

• Conclusion:
  – Adding additional binder improved lab performance of mixtures, except 40% RAP mix
  – Additional binder content has the potential to improve mix field performance
  – However, new volumetric specifications for mix design are needed or adjusted mixes will not pass specs
In-Service Binder Aging and Performance: RAP Mixtures

• Purpose and Scope
  – Part 1 – ’07 high RAP sites
  – How does RAP content influence binder grade and mixture performance?

• Evaluation
  – 15 individual locations paved with 11 high RAP mixes
  – 7 locations paved with 7 non-high-RAP mixes
In-Service Binder Aging and Performance: RAP Mixtures

• Planned Testing
  – Visual Survey of Pavement Surface
  – Cores
    • Volumetrics
    • Dynamic modulus
    • Extraction & recovery (top and bottom $\frac{1}{2}$ of each core)
    • Performance grading, multiple stress creep recovery (MSCR) test, shear modulus mastercurve ($G^*$)
    • Modulus mastercurve generation (binder and mixture)
In-Service Binder Aging and Performance: RAP Mixtures

• Purpose and Scope
  – Part 2 – new high RAP sites
  – Can we design, produce, and place mixtures with RAP contents ≥40%?

• Evaluation
  – Construct field projects
  – Document processes and collect materials for testing
  – Laboratory analysis and performance testing
  – Long-term field performance monitoring
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

• 5th mixture – adjustment to 45% design
  – 40% RAP, PG 64-22, manf. & natural sand
On-site Specimens
Reheated Specimens

Dynamic Modulus, psi

Reduced Frequency, Hz

- 20% RAP PG70-22 (MS) reheat
- 30% RAP PG 64-22 (MS) reheat
- 30% RAP PG 64-22 (MS&NS) reheat
- 40% RAP PG 64-22 (MS&NS) reheat
- 45% RAP PG 64-22 (MS&NS) reheat
Reheated Specimens

- 20% RAP PG70-22 vs. 30% RAP PG64-22 (MS)
- Manf. Sand vs. Manf. & Nat. Sand (30% RAP)
- 30% RAP vs 40% RAP (MS&NS)
- 30% RAP vs. 45% RAP (MS&NS)
- 40% RAP vs. 45% RAP (MS&NS)

- Line of Equality
- 20% difference

Dynamic Modulus, psi vs. Dynamic Modulus, psi plot.
On-site Specimens

<table>
<thead>
<tr>
<th>Flow Number</th>
<th>Air Void Content</th>
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<tbody>
<tr>
<td>297</td>
<td>7.0%</td>
</tr>
<tr>
<td>219</td>
<td>7.0%</td>
</tr>
<tr>
<td>222</td>
<td>6.9%</td>
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<tr>
<td>252</td>
<td>7.3%</td>
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</tbody>
</table>

20% RAP PG 70-22 (MS)
30% RAP PG 64-22 (MS)
30% RAP PG 64-22 (MS&NS)
40% RAP PG 64-22 (MS&NS)
45% RAP PG 64-22 (MS&NS)
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
Next Steps…

• 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
So What Does It Mean? (So far…)

- Good design is important for RAP mixtures
  - Especially binder content
- Successful 40% RAP mixtures are possible
  - Design, production, and construction
- Need to look at:
  - Effects of reheating
  - Understanding dynamic modulus/flow number values
  - Long term performance
Thank You!

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