TPF-5(230)
Evaluation of Plant-Produced High-Percentage RAP Mixtures in the Northeast

Dr. Jo Sias Daniel

Northeast Asphalt User/Producer Group Meeting
October 23, 2013

Research Team

University of New Hampshire
Dr. Jo Sias Daniel, PE (Project PI)

University of Massachusetts Dartmouth
Dr. Walaa Mogawer, PE

Rutgers University
Dr. Tom Bennert, PE

NC State University
Dr. Y. Richard Kim, PE
Current Participants

• New Hampshire (NHDOT) - Lead Agency
• Maryland (MDOT)
• New Jersey (NJDOT)
• New York (NYSDOT)
• Pennsylvania (PennDOT)
• Rhode Island (RIDOT)
• Virginia (VDOT)
• Federal Highway Administration (FHWA)

Project Objectives

• Evaluate the performance of plant-produced RAP mixtures (in the laboratory and field) in terms of low temperature cracking, fatigue cracking and moisture sensitivity.

• Provide further understanding of the blending that occurs between RAP and virgin binder in plant-produced mixtures.
Testing

- Recovered Binder
  - PG grade
  - CCT
  - $G^*$ master curve
- Mixture
  - Dynamic Modulus
  - Hamburg & TSR
  - Low Temperature Creep & Strength
  - Fatigue (AMPT S-VECD protocol): crack initiation
  - Overlay Tester: crack propagation
  - Beam Flexure

Project Status

- Phase I (2010 season): All mixture testing completed. Binder testing being redone. Research team doing detailed analysis on all sets of mixtures for an interim report.
- Phase III (2013 season): laboratory study to evaluate effect of bumping binder grade and increasing virgin asphalt content. Testing underway.
- Future Phases: based on results of Phase III, and questions remaining from Phase II
# Phase I Mixtures: 2010 Production

<table>
<thead>
<tr>
<th>Plant</th>
<th>NMAS (mm)</th>
<th>PG Grade</th>
<th>RAP Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Callanan NY (drum)</td>
<td>12.5</td>
<td>64-22</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58-28</td>
<td>x</td>
</tr>
<tr>
<td>Pike VT (batch)</td>
<td>9.5</td>
<td>58-28</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52-34</td>
<td>x</td>
</tr>
<tr>
<td>Pike NH (drum)</td>
<td>12.5</td>
<td>64-28</td>
<td>x</td>
</tr>
</tbody>
</table>

## High PG: NY Mixtures

- **Callanan (NY)**
  - Tank 7/30/10: 60.3°C
  - Tank 9/7/10: 61°C
  - Extracted 30% RAP 58-28: 67.3°C
  - Extracted 40% RAP 64-22: 67°C
  - Extracted 0% RAP 64-22: 75.5°C
  - Extracted 20% RAP 64-22: 78.3°C
  - Extracted 30% RAP 64-22: 78.4°C
  - Extracted 40% RAP 64-22: 80.9°C
High PG: NH Mixtures

High PG: VT Mixtures
High PG Trend with RAP

\[ y = 0.2629x + 72.058 \]

\[ y = 0.1318x + 75.464 \]

\[ y = 0.283x + 66.317 \]

\[ y = 0.1208x + 66.036 \]

Low PG: NY Mixtures

<table>
<thead>
<tr>
<th>Tank</th>
<th>58-28</th>
<th>Callanan (NY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/30/10</td>
<td>Extracted - 30% RAP</td>
<td>Extracted - 0% RAP</td>
</tr>
<tr>
<td>9/7/10</td>
<td>Extracted - 40% RAP</td>
<td>Extracted - 20% RAP</td>
</tr>
<tr>
<td></td>
<td>Extracted - 40% RAP</td>
<td>Extracted - 30% RAP</td>
</tr>
</tbody>
</table>

- \( S \) value
- \( m \) value
Low PG: NH Mixtures

Pike (Portsmouth, NH)

- Low Temp Continuous PG Grade (°C)
- S value
- m value

Low PG: VT Mixtures

Pike (Williston, VT)

- Low Temp Continuous PG Grade (°C)
- S value
- m value
Low PG Trends

\[
y = 0.1164x - 22.857
\]
\[
y = 0.1281x - 27.889
\]
\[
y = 0.1849x - 29.581
\]
\[
y = 0.1188x - 28.315
\]

CCT and Low PG Comparison

\[
\text{Low Temperature PG Grade, AASHTO R29 (°C)}
\]

\[
\text{Critical Grading Temperature, AASHTO R99 (°C)}
\]
Phase I Conclusions

• Specimen preparation matters (PMLC vs PMPC)
• Softer binder grade effective in some cases, not in others
• Impact of plant production parameters
  – Mixing temperature
  – Silo storage time

Phase II Mixtures: 2011 Production

• Silo Storage Study
  – NY 12.5 mm mixture with PG 64-22
  – Virgin: 0, 2.5, 5.0, 7.5 hours storage (~340 F)
  – 25% RAP: 0, 2.5, 5.0, 7.5, 10.0 hours storage (~340 F)
• NH mixtures – field sections
  – PG 58-28: 0%, 15%, 25% RAP
  – PG 52-34: 25%, 30%, 40% RAP
• VA mixtures
  – PG 76-22: 0% RAP
  – PG 70-22: 20% RAP
  – PG 64-22: 30%, 40% RAP
Silo Storage Study

• 25% RAP mixtures
  – Increase in stiffness with longer storage times
  – Observed in binder and mixture testing
  – Implies additional aging is occurring in silo
  – Can’t separate aging vs additional blending

Phase III Testing Plan

• Controlled laboratory study
• Examine impact of binder grade and total asphalt content
• Use NH mixtures from Phase I to compare with plant produced mixtures
Phase III Testing Plan

Mixture | Asphalt content | RAP Content (total weight)  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NH Phase I</td>
<td>optimum</td>
<td>PG 64-28</td>
</tr>
<tr>
<td></td>
<td>+0.5%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>+1.0%</td>
<td>-</td>
</tr>
</tbody>
</table>

Phase III Testing Plan

- **Binder Testing**
  - PG grading including CCT
  - G* master curves
- **Mixture Testing**
  - Volumetrics at $N_{des}$
  - $|E^*|$
  - S-VECD fatigue
  - Triaxial Stress Sweep for rutting
  - TSRST
Phase III Air Voids

Phase III VMA
Phase III VFA

Additional Phases

- Additional laboratory studies on other mixtures based on results of Phase III
- Additional plant produced mixtures based on results of Phase III
- New silo storage study
- Combination of warm mix technologies and high RAP