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

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Research Team

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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 Objective

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

• Phase I (2010 season): Interim report completed.

• Phase II (2011 season): Testing and data analysis almost completed. Interim report will be completed late winter.

• Phase III (2013 season): laboratory study. Testing and analysis almost completed. Interim report will be completed by end of the year.

• Silo Storage Study Additional Task: Testing new set of virgin mixtures from Phase II, will be completed next year.
## 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</td>
<td>12.5</td>
<td>64-22</td>
<td>x</td>
</tr>
<tr>
<td>(drum)</td>
<td></td>
<td>58-28</td>
<td></td>
</tr>
<tr>
<td>Pike VT</td>
<td>9.5</td>
<td>58-28</td>
<td>x</td>
</tr>
<tr>
<td>(batch)</td>
<td></td>
<td>52-34</td>
<td>x</td>
</tr>
<tr>
<td>Pike NH</td>
<td>12.5</td>
<td>64-28</td>
<td>x</td>
</tr>
</tbody>
</table>
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

- **FAIL**
Additional Silo Storage Study Task

• Replacement NY PG 64-22 virgin mixture has been produced
  – 0, 2.5, 5, 7.5 hr silo storage times
• Mixture: Plant compacted and lab compacted (reheated) specimens
  – \(|E^*|\), S-VECD fatigue, TSRST
• Binder: Extracted and recovered from mixtures and RAP, and virgin binder
  – Continuous PG grading, CCT
• Pavement performance analysis using LVECD approach developed under FHWA PRS project
# Phase III Laboratory Mixtures

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Asphalt content</th>
<th>RAP Content (total weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>NH Phase I</td>
<td>-0.5%</td>
<td>PG 64-28</td>
</tr>
<tr>
<td></td>
<td>optimum</td>
<td>PG 64-28</td>
</tr>
<tr>
<td></td>
<td>+0.5%</td>
<td>-</td>
</tr>
</tbody>
</table>
Phase III Testing

• Binder Testing
  – PG grading including CCT
  – G* master curves

• Mixture Testing
  – Volumetrics at $N_{\text{des}}$
  – $|E^*|$
  – S-VECD fatigue
  – Triaxial Stress Sweep for rutting
  – TSRST

• Pavement Performance Analysis using LVECD
Pavement Analysis

<table>
<thead>
<tr>
<th></th>
<th>ESAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td></td>
</tr>
<tr>
<td>Design Velocity (mph)</td>
<td>60</td>
</tr>
<tr>
<td>AADTT</td>
<td>2000</td>
</tr>
<tr>
<td>Pressure Distribution</td>
<td>Constant</td>
</tr>
<tr>
<td>Contact Area</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Aspect Ratio (length/width)</td>
<td>11/7</td>
</tr>
<tr>
<td>Tire Pressure (psi)</td>
<td>110</td>
</tr>
<tr>
<td>Growth Type</td>
<td>No Growth</td>
</tr>
<tr>
<td>Lane Distribution Factor</td>
<td>1</td>
</tr>
</tbody>
</table>
Thin Pavement-RAP% Effect

(a) Graph showing the number of failure points over time for NH6400-opt-Thin, NH6420-opt-Thin, and NH6440-opt-Thin.

(b) Graph showing the number of failure points over time for NH5820-opt-Thin and NH5840-opt-Thin.

Graphs represent the trend of failure points over time for different thin pavement RAP% effects.
Thin Pavement-Binder Content Effect

(c) NH6420-opt-Thin
(d) NH6440-opt-Thin

Number of failure points vs. Time (Month)
Thin Pavement—Softer Base Binder Effect

![Graph showing number of failure points over time for NH5820-opt-Thin and NH6420-opt-Thin.](e)

![Graph showing number of failure points over time for NH5840-opt-Thin and NH6440-opt-Thin.](f)
Thick Pavement-RAP% Effect

(a) NH6400-opt-Thick
(b) NH5820-opt-Thick
(c) NH6420-opt-Thick
(d) NH6440-opt-Thick

Number of failure points vs. Time (Month) for different RAP percentages:
- 0% RAP
- 40% RAP

Graphs showing the effect of RAP percentage on the number of failure points over time.
Thick Pavement-Binder Content Effect

(c) NH6420-opt-Thick
NH6420opt-Thick
Optimum

(d) NH6440-opt-Thick
NH6440opt-Thick
NH6440+opt-Thick
Optimum+0.5%
Optimum

Optimum
Thick Pavement - Softer Base Binder Effect

(e) PG 58-28

(f) PG 58-28
Phase III Preliminary Conclusions

• Factors that improved fatigue resistance decreased rutting resistance
• Balance possible to produce mix that performs well
• Softer base binder and thicker layers accommodate higher RAP levels
Future Work

• Silo Storage Study
  – additional task
  – more extended study in future

• Additional plant produced mixtures and evaluation of field performance