Can We Make More Use of RAP?
A Study of Extracted Binder Properties in NH, VT and Maine RAP Mixes

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NEAUPG Meeting       October 8, 2009
Objective

- To determine what effect the increase of RAP/Millings in HMA has on the PG Binder
- Motivating Factors
  - Private customer mixes were using greater RAP percentages
  - DOT’s are requiring the bumping of grades
  - Increasing cost of binders
  - Customers are looking for ways to reduce cost without jeopardizing quality
HMA Plant Protocol

- Choose a mix that was frequently produced (12.5 mm)
- Set cold feeds to produce Virgin mix and appropriate PGB content
PIKE– Hooksett NH
HMA Plant Protocol (con’t)

- Produce mix and record temperatures and sample
  - 28 samples obtained for processing
- Increase RAP to 15% while maintaining temperature and PGB content
- Repeat this process for as many different percentages as required (20 %, 25%)
Waterford VT
Other Sample Sources

- Brox Industries
  - Rochester, NH
  - Hooksett, NH

- Continental Paving Co.
  - Londonderry, NH
  - Litchfield, NH
Testing Procedures

- Samples were allowed to cool, boxed and transported to the Pike’s Belmont Central Lab* where the samples were processed according to AASHTO’s relevant procedures and according to relevant DOT methodology.
- NHDOT tested companion samples for most mixtures.

* AMRL Accredited Laboratory
## Mixtures Tested

<table>
<thead>
<tr>
<th>Producer</th>
<th>Plant</th>
<th>Virgin ac grade</th>
<th>% ac in mix</th>
<th>RAP percentages</th>
<th>RAP ac grade</th>
<th>% ac in RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brox</strong></td>
<td>Rochester, NH</td>
<td>PG 64-28</td>
<td>5.8</td>
<td>0, 15, 20, 25</td>
<td>PG 94-10</td>
<td>3.5</td>
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<tr>
<td></td>
<td>Hooksett, NH</td>
<td>PG 70-22</td>
<td>6.0</td>
<td>0, 15, 20, 25</td>
<td>PG 88-10</td>
<td>3.9</td>
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<tr>
<td><strong>CPI</strong></td>
<td>Londonderry, NH</td>
<td>PG 64-28</td>
<td>6.0</td>
<td>0, 15, 20</td>
<td>PG 82-10</td>
<td>5.2</td>
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<tr>
<td></td>
<td>Litchfield, NH</td>
<td>PG 64-28</td>
<td>6.1</td>
<td>15, 20</td>
<td>PG 88-10</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Pike</strong></td>
<td>Hooksett, NH</td>
<td>PG 64-28</td>
<td>5.1, 5.3, 5.4, 5.3</td>
<td>0, 15, 20, 25</td>
<td>PG 88-10</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Poland, ME*</td>
<td>PG 64-28</td>
<td>6.3, 5.8, 5.9, 6.0</td>
<td>0, 15, 20, 25</td>
<td>PG 76-22</td>
<td>5.0</td>
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<tr>
<td></td>
<td>Hooksett, NH, Mix 2</td>
<td>PG 58-28</td>
<td>5.1, 5.3, 5.4, 5.3</td>
<td>0, 15, 20, 25</td>
<td>PG 82-16</td>
<td>4.3</td>
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<td>Waterford, VT</td>
<td>PG 58-34</td>
<td>4.8, 5.2, 5.8</td>
<td>0, 15, 25</td>
<td>unknown</td>
<td>unknown</td>
</tr>
</tbody>
</table>
Effect of Plant Mixing

- Properties of virgin binder from tank
- Properties of extracted binder from virgin mix
- Compare:
  - High PG grade
  - Low PG grade/failure temperatures
  - Critical cracking temp
Increase of at least one grade after mixing

G*/sinδ = 0.93 kPa
• Not much change
• Not much change
Comparison of RAP Mixtures

- Properties of extracted binder from virgin mix
- Properties of extracted binder from RAP mixes
- Compare:
  - High PG grade
  - Low PG grade/failure temperatures
  - Critical cracking temp
• One PG bump, mostly >20%
• One PG bump in some cases
• Trends?
Percent Binder Replacement

- Normalizes with respect to
  - Asphalt content in RAP
  - Asphalt content in mix

\[
\text{%binder replacement} = \frac{\text{%ac in RAP} \times \text{% RAP in mix}}{\text{%ac in mix}}
\]
Change in $T_{cr}$

- 15% RAP
- 20% RAP
- 25% RAP

Virgin CCT - RAP CCT

Percent Binder Replacement

Values range from -4 to 3 on the Y-axis.

Percentages range from 5 to 25 on the X-axis.
Conclusions

- The high PG grade up to one grade increase
- The low PG grade stays same or only one grade increase
- Failure temps/$T_{cr}$ only change a few degrees
- Change in high/low failure temp has decreasing trend with % binder replacement
- This data shows increasing trend of $T_{cr}$ with % binder replacement
Future Work

- More batch & drum plants
- Various binder grades
- Higher RAP contents (% binder replacement)
- Performance testing on mixtures
Acknowledgements

- **Associate Researchers**
  - Dave Duncan, Pike Ind. Inc
  - Dennis Boisvert, NHDOT

- **Lead Binder Technicians**
  - Peter Moore, Pike Ind. Inc
  - Alan Lugg & Melissa Sytek, NHDOT
Questions?