Development of Quality Standards for Inclusion of High Recycled Asphalt Pavement Content in Asphalt Mixtures

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Low temperature cracking is a main concern with high RAP/RAS mixtures.

Average RAP percent used in asphalt pavement was 21.1% (19% in Iowa).

Softer asphalt was used for 18% of RAP mixtures (5% in Iowa) and rejuvenator was used for 4% of RAP mixtures (3% in Iowa).

Softer asphalt was used for 20% of RAS mixtures (0% in Iowa) and rejuvenator was used for 8% of RAS mixtures (0% in Iowa).
### Maximum Allowable RAP/RAS Usage Specifications from Five Surrounding States

<table>
<thead>
<tr>
<th>State</th>
<th>RAP No-Additives</th>
<th>RAP With Softer binder</th>
<th>RAS No-Additives</th>
<th>RAS With Softer binder</th>
<th>RAP and RAS together No-Additives</th>
<th>RAP and RAS together With Softer binder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wisconsin</td>
<td>25</td>
<td>N/A</td>
<td>20</td>
<td>N/A</td>
<td>25</td>
<td>N/A</td>
</tr>
<tr>
<td>Illinois</td>
<td>30</td>
<td>30</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Missouri</td>
<td>30</td>
<td>50</td>
<td>30</td>
<td>40</td>
<td>30</td>
<td>50</td>
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<tr>
<td>Nebraska</td>
<td>N/A</td>
<td>65</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Minnesota</td>
<td>20</td>
<td>&gt;20</td>
<td>N/A</td>
<td>N/A</td>
<td>20</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Iowa</td>
<td>20</td>
<td>30</td>
<td>15</td>
<td>15-25</td>
<td>15</td>
<td>15-25</td>
</tr>
</tbody>
</table>
Test Sections of Invigorate (A) and Tufftrek (B) by Heartland Asphalt, in Cerro Gordo County, August 3-4, 2020
# Evaluation of 34% and 45% RAP Mixtures with Invigorate (A) and Tufftrek (B) and Softer Asphalt

<table>
<thead>
<tr>
<th>No</th>
<th>ID</th>
<th>Binder</th>
<th>RAP</th>
<th>Rejuv.</th>
<th>AC (%)</th>
<th>Lab Tests</th>
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<tbody>
<tr>
<td>1</td>
<td>R22</td>
<td>PG58-28S</td>
<td>22%</td>
<td>-</td>
<td>5.3</td>
<td>HWT,</td>
</tr>
<tr>
<td>2</td>
<td>R34bump</td>
<td>PG52-34S</td>
<td>34%</td>
<td>-</td>
<td>5.18</td>
<td>HWT, DCT</td>
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<tr>
<td>3</td>
<td>R34A3</td>
<td>PG58-28S</td>
<td>34%</td>
<td>A 3%</td>
<td>5.18</td>
<td>HWT, SCB-IFIT, DCT</td>
</tr>
<tr>
<td>4</td>
<td>R34B3</td>
<td>PG58-28S</td>
<td>34%</td>
<td>B 3%</td>
<td>5.18</td>
<td>HWT, SCB-IFIT, DCT</td>
</tr>
<tr>
<td>5</td>
<td>R45A5</td>
<td>PG58-28S</td>
<td>45%</td>
<td>A 5%</td>
<td>5.39</td>
<td>HWT, SCB-IFIT, DCT</td>
</tr>
<tr>
<td>6</td>
<td>R45B4.5</td>
<td>PG58-28S</td>
<td>45%</td>
<td>B 4.5%</td>
<td>5.39</td>
<td>HWT, SCB-IFIT, DCT</td>
</tr>
<tr>
<td>7</td>
<td>R34 (Lab)</td>
<td>PG58-28S</td>
<td>34%</td>
<td>-</td>
<td>5.18</td>
<td>HWT, SCB-IFIT</td>
</tr>
<tr>
<td>8</td>
<td>R45 (Lab)</td>
<td>PG58-28S</td>
<td>45%</td>
<td>-</td>
<td>5.39</td>
<td>HWT, SCB-IFIT</td>
</tr>
</tbody>
</table>
Continuous PG Grading of Rejuvenated Asphalt: Tufftrek was more effective than Invigorate.
Field Densities of 8 Cores from Each Mix Type: 45% RAP with Invigorate highest
Rejuvenators Improved Hamburg Test Results: Tufftrek performed better than Invigorate
Softer Asphalt Performed better than Rejuvenators in DCT Tests - low temp. cracking
Rejuvenators Improved SCB-IFIT Test Results: Decreased Cracking Potential
Good Correlation between DCT and SCB-IFIT test results

\[ y = 0.0093x + 0.5765 \]
\[ R^2 = 0.8823 \]
Rejuvenators Delayed Initiation of Cracking in the Field after One Year since Construction

22% RAP without rejuvenator

34% RAP with softer binder
Aged Mixes with Rejuvenators Performed Better than without Ageing in Hamburg tests
Aging Increased Cracking Potential of All 45% RAP Mixes but Less with Tufftrek in SCB-IFIT Tests

![Graph showing the effect of aging on cracking potential and fracture energy for different RAP mixes.](image-url)
34% and 45% RAP with Fractionation Performed Better than without in Hamburg
34% and 45% RAP with Fractionation Performed Better than without in SCB-IFIT
11% RAS with Rejuvenator Performed Worse than without in Hamburg
11% RAS with One Rejuvenator Performed Better but Two Rejuvenators Worse than without in SCB-IFIT Test
Summary and Conclusions

- 34% and 45% High RAP mixtures with Rejuvenators exceeded 93% field density (Invigorate produced a higher field density than Tufftrek).
- Tufftrek was more effective in lowering critical low temperature of asphalt PG grade than Invigorate.
- In Hamburg test, Tufftrek performed better than Invigorate.
- In DCT test, softer asphalt performed better than rejuvenators.
- In SCB-IFIT test, rejuvenators were effective in decreasing cracking.
- There was a good correlation between DCT and SCB-IFIT test results.
- Aging of 45% RAP with rejuvenators decreased rutting in Hamburg tests and increased cracking potential but less with Tufftrek in SCB-IFIT tests.
- Both 34% and 45% RAP mixtures with rejuvenators were successfully implemented in the field and rejuvenators were effective in delaying initiation of cracking after one year since construction.
Develop an approval process for rejuvenators that incorporates long-term aging of the material.

Consider increasing RAM up to 50% for some mixes for economic, sustainability and a greater flexibility to contractors and binder suppliers.

Evaluate WMA with high RAM to verify if it meets both economic and sustainability requirements.

Consider a test procedure like SCB-IFT test for high RAM mixtures up to 50% as a performance test.

Monitor high RAM projects to determine their effectiveness and limitations of design, construction and performance and develop QA/QC of using soft binders and rejuvenators.

Develop comprehensive asphalt recycling strategy encompassing high RAM, CIR and HIR in consideration of both economic and sustainability analyses.
Appreciate Guidance from Technical Advisory Committee

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  - Iowa DOT

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