Use of Recycled Shingles in Asphalt Mixtures

Dr. J. Richard Willis
National Center for Asphalt Technology at Auburn University
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Outline

- Background
- RAS Characterization and mix design
  - RAS asphalt
  - Aggregate
- RAS at the plant
- Conclusions

Typical Shingle Composition

<table>
<thead>
<tr>
<th>Component</th>
<th>Organic Felt</th>
<th>Fiberglass Mat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>30-36%</td>
<td>19-22%</td>
</tr>
<tr>
<td>Felt (Fiber)</td>
<td>2-15%</td>
<td>2-15%</td>
</tr>
<tr>
<td>Mineral aggregate (#30)</td>
<td>20-38%</td>
<td>20-38%</td>
</tr>
<tr>
<td>Mineral filler/stabilizer</td>
<td>8-40%</td>
<td>8-40%</td>
</tr>
</tbody>
</table>

RAS History

- First considered in the early 1980s
- Research completed on Manufacturer’s Waste RAS
- Preliminary specs in 1990s
- Today: 11 million tons of shingles/yearly
  - 10 million Post-Consumer
  - 1 million Manufacturer’s Waste
Uses of Shingles

- HMA
- Alternative fuel used in power plants and cement kilns
- Cold patch
- Pothole patch
- Dust control
- Additive for shingles

RAS ≠ RAP

**RAP**
- 3 – 6% asphalt binder
- 94 – 97% stone

**RAS**
- 19 – 36% asphalt
- 2 – 15% fibers
- 20 – 38% mineral aggregate
- 8 – 40% mineral filler

Shingle Type

**Manufacturer’s Waste**
- New shingles with less oxidation
- No contaminants
- No asbestos

**Post-Consumer**
- Commonly 20-40 years old
- Oxidized asphalt
- Nails and other deleterious materials
- Might contain asbestos
  - Must conform to EPA’s NESHAP and other local requirements

RAS CHARACTERIZATION AND MIX DESIGN
Use of Recycled Shingles in Asphalt Mixtures

Shingles prior to grinding

Shingle Gradation
- Oversized shingles affect:
  - Asphalt mobilized
  - Mixture consistency

<table>
<thead>
<tr>
<th>State</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>½”</td>
</tr>
<tr>
<td>Texas</td>
<td>100%</td>
</tr>
<tr>
<td>Missouri</td>
<td>--</td>
</tr>
<tr>
<td>GA/VA/AASHTO</td>
<td>100%</td>
</tr>
<tr>
<td>Iowa</td>
<td>100%</td>
</tr>
<tr>
<td>Oregon</td>
<td>100%</td>
</tr>
<tr>
<td>South Carolina</td>
<td>100%</td>
</tr>
<tr>
<td>Minnesota</td>
<td>100%</td>
</tr>
</tbody>
</table>

Shingle Aggregate Gradation

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 in (9.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>95</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>85</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>70</td>
</tr>
<tr>
<td>No. 30 (600 μm)</td>
<td>50</td>
</tr>
<tr>
<td>No. 50 (300 μm)</td>
<td>45</td>
</tr>
<tr>
<td>No. 100 (150 μm)</td>
<td>35</td>
</tr>
<tr>
<td>No. 200 (75 μm)</td>
<td>25</td>
</tr>
</tbody>
</table>

- RAS Aggregate must be accounted for in new mix design
- AASHTO – Assumes gradation
- Does it matter if your RAS has a different gradation?

RAS Quantity
- Most states use between 3 – 5 percent RAS
- AASHTO Recommendations
  - If greater than 30 percent is shingle binder, must evaluate the blended binder to ensure performance grade (MP 15-09)
  - Possibly effected by grind size

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Deleterious Materials

- Material retained on #4 sieve
- AASHTO
  - Total deleterious < 3%
  - Lightweight < 1.5%
- Some states < 0.5%
- Cleaner stockpiles = better mixtures

Deleterious Materials

- Example specification (TEX-217-F Part III)
  - Oven dry sample
  - Sample 1000 g = W
  - Weigh Pan and pour sample over pan
  - Magnet on pan catches metal pieces in shingle
  - Weigh metal pieces = M

Deleterious Materials

- Sieves Used: 3/8", No. 4, No. 8, No. 30
- Shake sample for 10 minutes
- Discard – No. 30 material
- Test material retained on each sieve for deleterious materials (wood, paper, plastic, felt paper)
  - Manual separation
- Weigh material removed from RAS for each sieve
  - Deleterious materials on 3/8" sieve = N_{3/8}

Deleterious Materials

\[ p = \frac{M + N_{3/8} + N_{4} + N_{8} + N_{30}}{W_T} \times 100 \]

- P = percent of deleterious matter by weight
- M = weight of material retained by magnet, g
- N = weight of deleterious substance on sieve, g

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**Design Considerations**

- How do I determine the specific gravity of the RAS?
- How much binder is in the RAS?
- How much of that binder am I actually getting?

**Shingle Specific Gravity**

- Determine $G_{sb}$ of RAS by calculating its theoretical maximum specific gravity
  \[
  G_{sb} = \frac{100 - P_{hr}}{100 \times \frac{G_{agg}}{1.08}}
  \]
- $G_{sb} = G_{se}$
- Very low absorption of shingle aggregate

**How Much Binder is in the RAS?**

- Chemical extraction vs. Ignition Oven
  - Chemical Extraction: Do I get all of the RAS?
  - Ignition oven: Do I burn off other organic matter?
- AASHTO – Must use chemical extraction
- Virginia – Developed ignition oven correction factor

**Table 15: Comparison between Ignition Method and Extraction Method.**

<table>
<thead>
<tr>
<th>Sieve size</th>
<th>RAS-B (manufacture waste)</th>
<th>RAS-C (manufacture waste)</th>
<th>RAS-E (Tear-off)</th>
<th>RAS-F (Tear-off)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ignition</td>
<td>Extraction</td>
<td>Ignition</td>
<td>Extraction</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>#4</td>
<td>99</td>
<td>99</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>#8</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>96</td>
</tr>
<tr>
<td>#16</td>
<td>83</td>
<td>83</td>
<td>81</td>
<td>72</td>
</tr>
<tr>
<td>#30</td>
<td>63</td>
<td>63</td>
<td>62</td>
<td>50</td>
</tr>
<tr>
<td>#50</td>
<td>53</td>
<td>54</td>
<td>56</td>
<td>44</td>
</tr>
<tr>
<td>#100</td>
<td>40</td>
<td>41</td>
<td>47</td>
<td>37</td>
</tr>
<tr>
<td>#200</td>
<td>30</td>
<td>29</td>
<td>36</td>
<td>27</td>
</tr>
</tbody>
</table>

Binder content:
- 20%
- 20%
- 22%
- 21%
- 26%
- 24%
- 28%
- 26%
### Shingle Binder Contribution

<table>
<thead>
<tr>
<th>Organization</th>
<th>How Much RAS Binder Is Available for Mix?</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>Shingle Binder Availability</td>
</tr>
<tr>
<td>Alabama Department of Transportation</td>
<td>100 of RAS binder</td>
</tr>
<tr>
<td>Iowa Department of Transportation</td>
<td>66.7 percent of RAS binder</td>
</tr>
<tr>
<td>Missouri Department of Transportation</td>
<td>100 Percent of RAS Binder</td>
</tr>
<tr>
<td>Texas Department of Transportation</td>
<td>100 Percent of RAS Binder</td>
</tr>
<tr>
<td>Oregon Department of Transportation</td>
<td>100 Percent of RAS Binder</td>
</tr>
</tbody>
</table>

### What Can Affect Binder Availability?
- Size of RAS
- Where is the RAS introduced
- Aggregate temperature
- Binder temperature
- Mixing time
- Moisture content!

### Performance Grade
- Challenge:
  - How do I determine the Performance Grade?
  - Too stiff for water controlled DSRs
    - PG 130s – 170s
  - BBRs can be difficult to make
    - Binder is soft, but does not relax
Handling RAS at the Plant

- Prepare RAS “on demand” to avoid clumping
- Mix with RAP or sand, test consistency
- Keep equipment off of RAS stockpiles
- Cover RAS stockpiles to avoid additional moisture from precipitation

The Plant Matters

- RAS needs heat and time in order to soften the stiff binder
- Some contractors reconfigure/redesign plants or operation in order to use RAS more effectively
  - Add additional virgin binder to mix
  - Increase drum length
  - Reduce production rate to have more time in drum

THANK YOU!