Turning RAP into a value added pavement asset

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Overview

- What is the value of RAP
- Barriers to using RAP
- USA experience with RAP
- NSW experience with up to 30% RAP
- RAP monitoring
- Performance properties
- Environmental benefits
- Conclusions
What is the value of RAP

• Mixture of aged bitumen and sound mineral aggregates
• The value of RAP is that of the materials it replaces
  – Bitumen
  – Mineral aggregates
• Extract best value by optimising use by replacing bitumen and aggregates in upper pavement layers
• Key driver for using RAP is economics
  – Reduces demand for new bitumen and aggregates
• RAP is an appreciating asset and a hedge against rising bitumen prices
• Cost of transporting and processing RAP must be cheaper than virgin aggregates and bitumen including savings on transporting and heating bitumen
• Using RAP will reduce cost of asphalt which will ensure asphalt remains a competitive pavement material

‘Trade in your old pavement for a new one’
Barriers to using RAP

- Perception that RAP will have an adverse impact on the performance of asphalt
- Concern that variability of RAP and aged binder will:
  - Lead to premature cracking and ravelling in wearing courses due to binder hardening
  - Reduced skid resistance of wearing courses
  - Negate the benefits of using PMBs
- Lack of QC by contractors
- Difficulty in procuring and processing RAP
- Limitations of asphalt plants to heat RAP and handle >10% RAP
- Road authorities specifications which restrict the usage of RAP
## Max % RAP in SRA specs

<table>
<thead>
<tr>
<th>SRA</th>
<th>Surface</th>
<th>Intermediate</th>
<th>Base</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>WA</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Considering 15% in non surface</td>
</tr>
<tr>
<td>QLD</td>
<td>Nil</td>
<td>15</td>
<td>15</td>
<td>Recent amendment</td>
</tr>
<tr>
<td>SA</td>
<td>Nil</td>
<td>15/20</td>
<td>15/20</td>
<td>&gt;15% use C170</td>
</tr>
<tr>
<td>NSW</td>
<td>15/20</td>
<td>15/25₂/30₂</td>
<td>15/25₂/30₃/40₅</td>
<td>Based on 2/3/5 year experience</td>
</tr>
<tr>
<td>VIC</td>
<td>10/20</td>
<td>20</td>
<td>30/40</td>
<td>&gt;15% use C170 in local wc &lt;br&gt;30% additional testing + years</td>
</tr>
</tbody>
</table>
80% of RAP is recycled which equates to 17% of all HMA

States that *Permit* More than 25% RAP in HMA Layers

Jones 2009 survey
USA experience with RAP

Studies conducted the National Centre for Asphalt Technology showed that:

- Increasing % RAP reduces rutting potential of mix
- Adding RAP stiffens the binder to a high performance grade
- Increasing % RAP up to 40% does not increase variability of the mix provided the RAP is properly managed

Long term pavement performance monitoring of 18 test sections across USA over 17 years showed that:

- Mixes with >30% RAP were performing equally to virgin mixes in respect to rutting
- Transverse and fatigue cracking was observed more frequently in some mixes with RAP
  - could be due to lower binder or high filler contents and freeze/thaw cycles
USA experience with RAP

Latest thinking to decide on maximum RAP % should be based on the net effect that aged binder will have on the new mix

- Properties of recovered binder and binder content
- Coarse RAP will have much lower binder content than finer RAP eg 4% vs 7%
  - can use higher % coarse RAP in base courses and lower % fine RAP in wearing courses
- <15% RAP use normal grade binder(<25%)
- >15%<25% use one grade softer(<25< 35%)
- >25% use blending charts(>35%)

(Warm mix)
Boral Asphalt embarked on plant trials to evaluate the performance of AC14 mix with:

- varying % RAP up to 30%
- Astec double drum plant in Sydney
- C450 grade bitumen

Collected data to improve understanding on the impact RAP would have on the performance of asphalt by:

- Monitoring consistency of processed RAP
- Conducting performance tests on plant mix
- Monitoring in-service performance of mix after 2 years
Processing RAP

Fractionated RAP into 3 sizes by passing over a vibratory multi-deck screening plant

- < 19mm
- < 14mm
- < 7mm

Monitored variability in following RAP properties for:

- Binder content
- Moisture content
- % passing < 0.075mm
- % passing < 2.36mm
- Other sieve sizes as needed
Binder content variability

I-MR Chart, RAP <14mm Bitumen (% TM)

Bitumen Content (% tm) - 15% RAP

Bitumen Content (% tm) - 20% RAP

Bitumen Content (% tm) - 30% RAP

I-MR Chart, RAP <14mm Bitumen (% TM)
Mix design

- Incorporate RAP into mix by adjusting proportions of coarse and fine particles
- Make allowance for RAP binder and filler to achieve target air voids and binder film thickness
- Binder film thicknesses increased with % RAP while maintaining same air voids
Lab performance tests

**Resilient Modulus (Mpa)**

<table>
<thead>
<tr>
<th>RAP %</th>
<th>Resilient Modulus (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4000</td>
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<td>15</td>
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</tr>
<tr>
<td>25</td>
<td>7000</td>
</tr>
<tr>
<td>30</td>
<td>8000</td>
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</table>

**Fatigue Life (cycles to Failure @ 400 micr-strain)**

<table>
<thead>
<tr>
<th>RAP %</th>
<th>Cycles to Failure</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>20000</td>
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<tr>
<td>15</td>
<td>40000</td>
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<tr>
<td>30</td>
<td>60000</td>
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</table>

**Wheel Tracking - RAP Mixes**

- Superior Performance
- Good Performance
- Cycles to Failure
- Wheel Tracking (mm)
Lab performance tests

**Viscosity @ 60°C (Pa.s)**

- **Boral Result**
- **RTA Result**

Specified Visc @ 60°C after RTFO for Multigrade binder
Lab performance tests

### Tensile Strength Ratio Testing - AC14 Wearing Course

- **Dry Core Modulus (MPa)**
- **Wet (Conditioned) Core Modulus (MPa)**
- **Wet (Conditioned) Core Tensile Strength (kPa)**
- **Specified Min Tensile Strength = 600kPa**

<table>
<thead>
<tr>
<th>% RAP</th>
<th>Dry Core Modulus</th>
<th>Wet (Conditioned) Core Modulus</th>
<th>Wet (Conditioned) Core Tensile Strength</th>
<th>Specified Min Tensile Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8000</td>
<td>6000</td>
<td>4000</td>
<td>2000</td>
</tr>
<tr>
<td>15</td>
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</tr>
<tr>
<td>30</td>
<td>8000</td>
<td>6000</td>
<td>4000</td>
<td>2000</td>
</tr>
</tbody>
</table>

Testing at Trial Placement
Testing at 2 Years

### Tensile Strength Ratio Testing - AC14 Base Course

- **Dry Core Modulus (MPa)**
- **Wet (Conditioned) Core Modulus (MPa)**
- **Wet (Conditioned) Core Tensile Strength (kPa)**
- **Specified Min Tensile Strength = 600kPa**

<table>
<thead>
<tr>
<th>% RAP</th>
<th>Dry Core Modulus</th>
<th>Wet (Conditioned) Core Modulus</th>
<th>Wet (Conditioned) Core Tensile Strength</th>
<th>Specified Min Tensile Strength</th>
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<tbody>
<tr>
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<td>6000</td>
<td>4000</td>
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<td>6000</td>
<td>4000</td>
<td>2000</td>
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Testing at Trial Placement
Testing at 2 Years

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**Note:** The graphs illustrate the tensile strength ratio testing results for AC14 wearing and base courses, showing the modulus and tensile strength values under dry and wet conditions, along with the specified minimum tensile strength of 600kPa.
Lab performance tests

Our observation is that because the mineral aggregates are pre-coated with bitumen, the potential for moisture damage is not increased and in some cases improved.
In-service performance

After 2 years in service the high RAP mix placed on Henry Lawson Drive is performing the same as normal asphalt with no visible signs of any distress

Note: The test sections are subjected to very heavy loading and high traffic volumes
Environmental benefits

Based on 123,163 tonnes of asphalt produced for RTA in 2009/10
Conclusions

• Results obtained with up to 30% RAP are in-line with USA experience
  – Equivalent performance to virgin HMA with regard to rutting, fatigue, stiffness & moisture sensitivity
• Use up to 25% RAP in wearing course without changing grade of bitumen
• Increasing use of RAP will help
  – reduce energy consumption
  – reduce GHG emissions
  – conserve scarce raw materials
  without compromising performance of HMA
• Use of RAP will help industry meet sustainability targets

‘Trade in your old pavement for a new one’