Utilization of Very High RAP Contents

Lessons Learned from the Japan Scan Tour

Japan Tour Delegates and Hosts at Maeda Road Asphalt Plant
December 2014
### Ryoan-ji Zen Rock Garden
Kyoto, Japan

**Outline**

- Comparisons of Japan and USA
- Motivations to Recycling
- Performance of Recycled Mixes
- RAP Management Practices
- Mix Design Practices
- Plant Operations
- Other Technologies

### Comparisons

<table>
<thead>
<tr>
<th>Category</th>
<th>U.S.</th>
<th>Japan</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Area</td>
<td>3,806,000 mi²</td>
<td>145,925 mi²</td>
<td>3.8%</td>
</tr>
<tr>
<td>Population</td>
<td>321 million</td>
<td>128 million</td>
<td>40%</td>
</tr>
<tr>
<td>Miles of Paved Roads</td>
<td>2,605,331</td>
<td>791,189</td>
<td>30.4%</td>
</tr>
<tr>
<td>No. of Asphalt Plants</td>
<td>~3000</td>
<td>1150</td>
<td>38%</td>
</tr>
<tr>
<td>Asphalt Mix Tons/Yr.</td>
<td>350 million</td>
<td>55 million</td>
<td>15.7%</td>
</tr>
</tbody>
</table>
RAP Performance Studies

Conducted by Ministry of Construction from 1982 to 1984

Production of Asphalt Mixes in Japan

Virgin Mixes
Recycled Mixes

Virgin Asphalt Pavement

RAP Pavement

Cumulative commercial vehicles volume

Rut depth (mm)
RAP Performance Studies

Conducted by Ministry of Construction from 1982 to 1984

Virgin Asphalt Pavement

RAP Pavement

RAP Management

1. RAP source is not restricted
2. Processing achieves uniformity and low moisture contents
3. RAP is tested for quality standards
4. RAP is fractionated
5. RAP stockpiles are covered
## RAP Quality Specifications

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Spec. Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. Asphalt Content</td>
<td>3.8%</td>
</tr>
<tr>
<td>Min. Pen. of Recovered AC</td>
<td>20</td>
</tr>
<tr>
<td>Max. $P_{200}$ of Unextracted RAP</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

### Mix Design Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Voids (%)</td>
<td>3–6</td>
</tr>
<tr>
<td>Voids Filled with Asphalt (%)</td>
<td>70–85</td>
</tr>
<tr>
<td>Stability (kN)</td>
<td>Traffic ≥1000 vpd</td>
</tr>
<tr>
<td></td>
<td>Traffic &lt;1000 vpd</td>
</tr>
<tr>
<td>Flow (1/100 cm)</td>
<td>20–40</td>
</tr>
</tbody>
</table>

### Typical Surface Mix Gradation

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Design Gradation</th>
<th>Expected Plant Gradation</th>
<th>Specification Gradation Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 mm</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>13.2 mm</td>
<td>99.2</td>
<td>97.5</td>
<td>95–100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>64.4</td>
<td>62.5</td>
<td>55–70</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>44.1</td>
<td>42.5</td>
<td>35–50</td>
</tr>
<tr>
<td>0.60 mm</td>
<td>26.0</td>
<td>24.0</td>
<td>18–30</td>
</tr>
<tr>
<td>0.30 mm</td>
<td>17.7</td>
<td>15.5</td>
<td>10–21</td>
</tr>
<tr>
<td>0.15 mm</td>
<td>9.7</td>
<td>11.0</td>
<td>6–16</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>5.5</td>
<td>6.0</td>
<td>4–8</td>
</tr>
</tbody>
</table>

---

**Diagram:**

The diagram illustrates the gradation of 12.5 mm nominal sieve size. The graph shows the percentage retained on each sieve size (in mm) across different materials. Each material is represented by a different line color, indicating their gradation characteristics.
IDT “modulus” Performance Test

- Marshall specimen
- 20°C
- load @ 50 mm/min.

\[
\frac{P}{x} = \frac{d}{\Delta L}
\]

<table>
<thead>
<tr>
<th>Project Type</th>
<th>IDT Modulus (MPa/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Use</td>
<td>0.60 - 0.90</td>
</tr>
<tr>
<td>Cold and Snowy regions</td>
<td>0.40 - 0.60</td>
</tr>
</tbody>
</table>

Soft Asphalts and Rejuvenators

High Pen. Asphalts
- Penetration-based blending charts

Rejuvenators
- Formulations are Trade Secrets
- Typical dosage rates: 5 to 10% of RAP binder, based on target IDT modulus
- Spec ranges on viscosity, flash point, TFOT viscosity ratio and mass loss.
Asphalt Plants in Japan

- 1150 total plants
- 84% are batch plants
- Plants visited in Tokyo were very sophisticated
2/3 of Batch Plants use Parallel Heating System for RAP
Parallel RAP Dryer

- Low moisture content of RAP prior to drying/heating
- RAP dryer at one site was 8 ft. diameter by 33 m long with a capacity of 110 tph
- Exhaust gases thru thermal oxidizer to eliminate smoke
- RAP exit temp. ~330°F
- Hot RAP mixed immediately with rejuvenator and stored for 2-3 hours prior to mixing with virgin materials

Mixes were produced for us with all virgin materials, 45% RAP and 60% RAP. All of the mixes looked and handled the same.
Hybrid SMA-PFC “POSMAC”
Double Layer PFC

Cooling Pavement Technologies
Key Takeaways

- Motivation to use high RAP contents in Japan is primarily from a conservation perspective.
- Specifications are fairly simple and include a simple IDT test to avoid brittle mixes.
- RAP dried separately, rejuvenator added and allowed time to condition the RAP.
- Japan has culture of quality, and integrity.
- Limited number of contractors who are willing to heavily invest in sophisticated plants and R&D.
What keeps us from using higher RAP contents?

NCAT Test Track
Thank you!

Randy West, PhD, PE
Director
westran@auburn.edu

Arigato