Presentation Outline

- Processes
- Research
- Successful long-term performance
- New programs build on success
- Future Applications
The Processes

The Wet Process – adds rubber to the binder, gets the rubber wet
Field Blend – Coarse rubber added to binder at the hot plant, a binder and mix modifier
Terminal Blend – Fine rubber added to the binder at the asphalt terminal, rubber is mostly dissolved, used to promote polymer linking
Dry Process – Rubber replaces some of the fine aggregate
The Processes

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Dry Process – Rubber replaces some of the fine aggregate.
Advantages of Asphalt Rubber Binder

The increased viscosity allows for increased asphalt film thickness which enhances:

- Aggregate retention
- Eliminates drain-down problems
- Increases resistance to moisture damage
- Increases resistance to bleeding, flushing and deformation
- Reduces aging of the mix.
Whole Tire Shredded Down to 2 Inch Chips
Secondary Granulation ¾ Inch Being Reduced to 3/8 Inch While Separating Fabric and Steel
Finish Product and Bagging
Rubber is delivered to the jobsite in Super Sacks
Rubber is added to the weigh hopper
Rubber is fed from the weigh hopper into a high shear mixer.
Rubber is blended with liquid asphalt heated in excess of 350° F.
Once blended, the Asphalt-Rubber binder is reacted in agitated tanks for 45-60 minutes depending on specifications.
An aerial view of a portable Asphalt-Rubber Plant setup at a Hotplant.

- Virigin AC Tank
- Rubber Staging Area
- AR Blend Tank
- Blender
- Hotplant
Augers keep the material blended and the rubber in suspension.
Reaction Stages of Asphalt & Rubber

Asphaltene

Light Fractions

Asphalt Cement

Rubber Particle

Stage 1

Gel

Asphalt Cement

Stage 2
Rubber Particle Before Interaction
Rubber Particle After Interaction
Binder Quality Control Monitored by the Handheld Viscometer
Field Blend Rubber Hot Mix - Rubber Modifies Binder and Mixture

Gap Graded Aggregate

Rubber Granules
# Metric Ton of Mix

<table>
<thead>
<tr>
<th>Mix Type</th>
<th>Kgs of Asphalt</th>
<th>Kgs of Rubber</th>
<th>Kgs of Stone</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMA</td>
<td>42</td>
<td>0</td>
<td>958</td>
</tr>
<tr>
<td>Gap Graded</td>
<td>48</td>
<td>12</td>
<td>940</td>
</tr>
<tr>
<td>Open Graded</td>
<td>66</td>
<td>16</td>
<td>918</td>
</tr>
</tbody>
</table>
Asphalt Is Good!

Rubber Mixes Use More Of It!
30-60% More in Hot Mixes
I-17 2.5 cm ARFC over PCCP
Advantages of Asphalt Rubber OGFC

- Increased skid resistance
- Noise reduction
- Reduced vehicle spray on wet surfaces
- Increased draining characteristics
- Increased durability
- Resistance to cracking
- Improved smoothness
Heavy Vehicle Simulator Testing 1993

- UC Berkeley
- Dynatest
- Caltrans
- South Africa Council of Scientific and Industrial Research
Heavy Vehicle Simulator
# Performance

<table>
<thead>
<tr>
<th>Repetitions</th>
<th>Wheel Load</th>
<th>AC Overlay Section (75mm)</th>
<th>ARHM-GG Section (38mm)</th>
<th>ARHM-GG Section (25mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-100,000</td>
<td>40kN</td>
<td>Fine cracks at 100,000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>100,000 to 175,000</td>
<td>40kN</td>
<td>Block cracks at 175,000</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Wheel load Changed to 80 kN**

| 175,000 to 200,000 | 80kN       | Completely cracked        | —                      | Fine cracks            |
| 200,000 to 237,000  | 80kN       | Test stopped              | —                      | Completely cracked     |

**Surface Temperature Reduced to –5 C**

| 237,000 to 250,000 | 80kN       | Test stopped              | 1/2 of section cracked | Test stopped           |
## CALTRANS Structural Equivalency Tables (Thickness in feet)

<table>
<thead>
<tr>
<th>DGAC</th>
<th>ARHM-GG1</th>
<th>ARHM-GG w/SAMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>0.10(^a)</td>
<td>----</td>
</tr>
<tr>
<td>0.20</td>
<td>0.10</td>
<td>----</td>
</tr>
<tr>
<td>0.25</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>0.30</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>0.35</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>0.40</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>0.45</td>
<td>0.15(^b)</td>
<td>0.20</td>
</tr>
<tr>
<td>0.50</td>
<td>0.15(^c)</td>
<td>0.20</td>
</tr>
<tr>
<td>0.55</td>
<td>0.20(^b)</td>
<td>0.15(^b)</td>
</tr>
<tr>
<td>0.60</td>
<td>0.20(^c)</td>
<td>0.15(^c)</td>
</tr>
</tbody>
</table>

**Notes:**
- The minimum allowable ARHM-GG lift thickness is 0.10’.
- Place 0.15’ of new DGAC first.
- Place 0.20’ of new DGAC first.

**Notes:** The maximum allowable non-experimental equivalency for ARHM-GG is 2:1, ARHM-GG may not prevent cold weather induced transverse cracks.
**CALTRANS Crack Reflection Retardation Equivalencies**

<table>
<thead>
<tr>
<th>DGAC</th>
<th>ARHM-GG</th>
<th>ARHM-GG w/SAMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>0.10</td>
<td>***</td>
</tr>
<tr>
<td>0.20</td>
<td>0.10</td>
<td>***</td>
</tr>
<tr>
<td>0.25</td>
<td>0.15</td>
<td>***</td>
</tr>
<tr>
<td>0.30</td>
<td>0.15</td>
<td>***</td>
</tr>
<tr>
<td>0.35</td>
<td>0.15 or 0.20</td>
<td>0.10</td>
</tr>
</tbody>
</table>

a - The minimum allowable thickness is 0.10’
b - A DGAC thickness of 0.35’ is the maximum recommended by Caltrans for reflection crack retardation
c - Use 0.15’ if the crack width is < 1/8” and 0.20’ if the crack is >= 1/8”
d - Use if the crack width is >= 1/8”. If < 1/8”, use another strategy

ARHM-GG may not prevent cold weather induced transverse cracks
Recent Projects

- Mechanistic Overlay Design Method for Hot Mix - Sousa, Pias
- Influence of Aging on Fatigue Behavior - Raad
- A-R Design and Construction Guidelines – Hicks, Stonex
- LCCA of Asphalt Rubber Materials – Hicks, Epps
- Traffic Noise Analysis Before and After Paving with AR – Zhu, Carlson
- Stack Emissions with AR and Conventional AC – Stout, Carlson
<table>
<thead>
<tr>
<th>Grading Type</th>
<th>Percentage</th>
<th>Material</th>
<th>Micron</th>
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</thead>
<tbody>
<tr>
<td>Dense Graded</td>
<td>4.6%</td>
<td>HMA</td>
<td>9</td>
</tr>
<tr>
<td>Gap Graded</td>
<td>7.4%</td>
<td>Asphalt Rubber</td>
<td>18</td>
</tr>
<tr>
<td>Open Graded</td>
<td>9.2%</td>
<td>Asphalt Rubber</td>
<td>36</td>
</tr>
</tbody>
</table>
Long Term Performance
Aged Project Performance Evaluations

- Arizona
- California
- Texas
Arizona A-R Project Review 2000

- 20 projects 10 years or older
- OGFC and GG over PCCP and AC
- Almost all performing with very little maintenance
- I-19, I-40 and I-17 most notable
California A-R Project Review

- Only 11 with any distress, most non-binder related.
- Caltrans now routinely specifying 1.6 million tons each year.
Texas A-R Project Review

- Projects built after 1992 (patents expired) examined in 2001
- 18 Seal Coats
- 10 Hot Mix Projects
- 5 Porous Friction Courses
- Aggregate Gradation is key to Binder Success in the mixture.
New Program Developments

- Nebraska 2001
- Alberta, Canada 2002
- Colorado 2003
Nebraska Demonstration 2001
Highway 2 - Lincoln, Nebraska

STATE RESEARCH
ROAD BUILT WITH
16,400 RECYCLED TIRES
84TH TO 56TH STREET
Alberta Demonstration Project 2002
Future Applications

- Continued use in conventional paving applications
- Quiet Pavements Program very promising
- Dust Control on dirt roads in urban areas –Bituminous Surface Treatments
ADOT Uses ARFC to Provide Quiet Pavements

- The ARFC is Minus 9.5mm & 9-9.5% Binder
- 12.5 mm Thick When Used on Flexible Pavement
- 25 mm Thick When Used on PCCP
- ADOT Uses Pavement Type (ARFC) as a Noise Mitigation Strategy (4 dBA)
<table>
<thead>
<tr>
<th>Noise Level</th>
<th>Surface Type Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>104.9</td>
<td>Random Transverse (Wisconsin Method)</td>
</tr>
<tr>
<td>102.5</td>
<td>Uniform Transverse (ADOT Method-3/4”)</td>
</tr>
<tr>
<td>99.1</td>
<td>Longitudinal (ADOT Method-3/4”)</td>
</tr>
<tr>
<td>95.5</td>
<td>Whisper Grind (Industry Method)</td>
</tr>
<tr>
<td>91.8</td>
<td>ARFC (ADOT Method)</td>
</tr>
</tbody>
</table>
BST Program Purpose To Reduce Dust
Asphalt-Rubber Application Over Dirt Surface
Phoenix BST Program

- Paved 65 miles of dirt roads and alleys within the City of Phoenix to reduce dust.
- 65,000 old tires were used
- The roads are expected to last 5-7 years
- Project cost $ 4 million.
Bituminous Surface Treatment
Thank You!

Resources online at:

www.rubberpavements.org

Cliffa@fnfinc.com