Outline of Presentation

- Why Asphalt Rubber- (AR)
- AR Properties
- History of AR HMA
- AR Mix Types
- AR Mix Applications
- AR Warm Mix
- Summary
Why Asphalt Rubber?

Rubber contains polymers which...

• **Raises softening point** to above 140° F.
  – Resistance to rutting and shoving
  – Resistance to asphalt migration and drain-down

• **Increases low temperature flexibility** of residue.
  – Resistance to cracking

• **Increases high temperature viscosity.**
  – Thicker film coatings on aggregate particles
  – Higher asphalt content mixes / applications
  – More asphalt = greater resistance to oxidation
  – Increased long term durability
  – Top PG Grading above 80

• Contains no water.
ASTM D6114, Type II (Wet Process)

- **15-20% Crumb Rubber**
  - Typically 30-40 Mesh
  - Processed from Scrap Tires

- **Performance Graded Asphalt**
  - PG58-28 (or) PG 64-22
  - Blend of the two to meet spec requirements

- **On Site blending or at a facility**

- **Reaction process**
  - Elevate Temperature
  - Mix for 1 hour

  - Rubber particles swell, Suspension in Asphalt
Rubberized AC Products

Asphalt-Rubber Binder

Terminal Blend Binder

From Shakir Shatnawi
# Asphalt Comparisons

<table>
<thead>
<tr>
<th>Criteria</th>
<th>AR</th>
<th>TB</th>
<th>PG</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Crumb Rubber</td>
<td>15+</td>
<td>3-15</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typically: 5-10</td>
<td></td>
</tr>
<tr>
<td>Specification</td>
<td>ASTM D-6114</td>
<td>Local</td>
<td>AASHTO M320</td>
</tr>
<tr>
<td>cP@375 F</td>
<td>1500-5000</td>
<td>500-</td>
<td>100-</td>
</tr>
<tr>
<td>Softening Pt. F</td>
<td>140+</td>
<td>130+</td>
<td>115- Typical</td>
</tr>
<tr>
<td>ALF Cycles</td>
<td>300,000+</td>
<td>100,000</td>
<td>100,000</td>
</tr>
</tbody>
</table>
Two ALF’s with 12 Pavement Lanes Constructed in the Summer and Fall of 2002
## ALF Project Test Sections

<table>
<thead>
<tr>
<th>CRMA</th>
<th>70-22</th>
<th>AB</th>
<th>SBS</th>
<th>TB</th>
<th>Elvo</th>
<th>70-22 + Fibers</th>
<th>70-22 SBS 64-40</th>
<th>AB</th>
<th>SBS</th>
<th>Elvo</th>
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<tbody>
<tr>
<td>70-22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

**Notes:**
- CRMA: 70-22
- AB: 70-22
- SBS: 64-40
- Elvo: 70-22 + Fibers
- TB: CR

**Key:**
- ALF: **ALF Project Test Sections**

**Conference:**
- 2012 National Pavement Preservation Conference
- Road Trip: Driving the Message for Change
AR Background

- First developed in 1960’s
- Initially used in SAM and SAMI’s
- Now used in HMA
  - AR OGFC
  - AR Gap Graded
- ASTM D-6114 Binder Specification
- Not Proprietary
History of AR HMA Usage

• National uses
  – Arizona, California
  – Florida, South Carolina
  – Texas

• ASMG Experience
  – MassDOT
    • Several AR Gap Graded Projects (2008 – 2011)
  – NJ projects
    • 2009 – NJDOT I-78 AR OGFC
    • 2010 – NJTA, Garden State Parkway AR OGFC
  – NH DOT
    • 2011 – AR Gap Graded Project
  – Local Agencies
Why AR Mixes?

• **Benefits**
  – **Longer Pavement Life**
    • Reduced Rutting
      – AR = Higher Softening Point of PG Binder
    • Reduced Oxidation
      – Thicker Film Coatings = More Binder in Mix
  • Reduced Cracking
    – AR Properties = Greater Flexibility at Cold Temperatures
  • Increased Long Term Durability
  • Reduced Thickness
  – **Noise Reduction**
    • AR Properties Absorb Tire Noise
    • Economic Alternative to Sound Barriers
  – **“Green” Process – Reuses Scrap Tires**
Asphalt Rubber Binder – Blending

- Rubber Hopper
- Mixing Chamber
- 2 Compartment Reaction Tank
- Computerized Controls
- Super Sacks of CR
- Heat Exchanger
- Computer Interlock

2009/06/16
Asphalt Rubber – Processed Tire
Asphalt Rubber Binder – Blending
I-78 NJ – AR OGFC
Overlay Tester

- Sample size: 6” long by 3” wide by 1.5” high
- Loading: Continuously triangular displacement 5 sec loading and 5 sec unloading
- Definition of failure
  - Discontinuity in Load vs Displacement curve

![Diagram of Overlay Tester setup with sample, fixed plate, movable plate, and ram direction.]
Typical Preservation Overlay Mixes

Surface Course Mixes

59°F, 0.025" Horizontal Deflection

Cycles to Failure in Overlay Tester

<table>
<thead>
<tr>
<th>Material</th>
<th>Cycles to Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPTO</td>
<td>296</td>
</tr>
<tr>
<td>9.5H76</td>
<td>27</td>
</tr>
<tr>
<td>9.5mm SMA</td>
<td>710</td>
</tr>
<tr>
<td>12.5M76</td>
<td>9,5</td>
</tr>
<tr>
<td>12.5H76</td>
<td>39</td>
</tr>
<tr>
<td>12.5mm SMA</td>
<td>12</td>
</tr>
<tr>
<td>MOGFC-1</td>
<td>33</td>
</tr>
<tr>
<td>AR-OGFC</td>
<td>756</td>
</tr>
<tr>
<td>AR GG JMF</td>
<td>1,136</td>
</tr>
<tr>
<td>NHDOT Rt. 38</td>
<td>2,363</td>
</tr>
</tbody>
</table>

NJ I-95 AR OGFC
NJTA Design
NHDOT Rt. 38 AR GGFC

2012 National Pavement Preservation Conference
Road Trip: Driving the Message for Change
ON-BOARD SOUND INTENSITY (OBSI) EVALUATION
What is Warm-Mix Asphalt (WMA)?

- Asphalt Mix **produced at 40-100°F less than conventional HMA**
  - Various technologies and additives
    - Chemical Additive (Surfactants)
    - Organic Additives (Waxes – long chain hydrocarbons)
    - Foaming Processes
- Typically Produced @ 212-280°F vs. 320°F
- Produced and placed with conventional HMA equipment
- Can be used as **Workability/Compaction aide**
Why Use WMA?

- Environmentally Sound
- Reduces green house gas emissions
- Reduces energy use
- Reduces opacity and odor
- Improves workability
- Reduces binder aging
- Reduces paving temperatures
- Offers the potential to increase the % of RAP used in mix
- Offer the potential to extend the paving season
Overlay Tester Cracking Results

NJ I78, 2009
Horizontal Deflection = 0.025 Inches

Test Temperatures (F) vs. Overlay Tester (cycles)

- AR-OGFC WMA
- AR-OGFC

Overlay Tester (cycles)

Test Temperatures (F):
- 40
- 55
- 77

Overlay Tester Cracking Results

Overlay Tester (cycles)
Emissions Testing

• Looked at quantifying emission reduction at paver with and without WMA

• Used portable emissions tester mounted to railing on back of paver (where workers would stand)
I-78 AR OGFC with Evotherm
I-78 AR OGFC with Evootherm
I-78 AR OGFC with Evotherm

Trefl=68 Tatm=68 Dst=6.6 FOV 24
8/ 6/09 9:20:13 PM -40 - +250 e=0.96
NJTA Garden State Parkway
Amherst, MA- AR GG
Amherst, MA - AR GG WMA
Amherst - ARGG WMA Air Data

Test started to pick up increased HC before

First HM Truck (31)

Tester Issues?
NHDOT Data

- AR GG mix
- 12.5 mm Conventional mix control section
- Evaluating noise, crack resistance and durability over time
- Article about project in *Pavement Preservation Journal*, Summer 2012 issue
Overview of Tested Pavements

- Total Average DGA 6/3 @ 45mph (Impala): 98.7
- Total Average DGA 7/13 @ 45mph (Impala): 97.4
- Total Average ARGG 7/13 @ 45mph (Impala): 96.9
MassDOT Data

- Several projects on high volume roads
- AR GG Mix
- Over 400,000 tons bid or placed to date
- Consumed over 1 million tires
- Requires warm mix additive in all AR mixes
- Plan to do AR OGFC project
- Evaluating noise and performance
Overview of Tested Materials in MA

Overall OQSL Level, (A)

- I-295 Novachip 2008
- I-295 Novachip w/AR 2008
- Rt. 2 19mm Superpave
- I-290 OGFC 2006
- I-495 OFGC 2009
- I-95 8 Year Old OGFC
- I-295 North AR-GG w/Advera WM 2008
- I-495 OGFC 2008
- I-95 Lynch AR-GG 2009
- I-95 7 Year Old OGFC
- I-295 North AR-GG 2008
- I-495 North AR-GG 2010
- I-95 Aggregate Industries AR-GG 2009
- I-495 Superpave 9.5mm+2% Latex

2012 NATIONAL PAVEMENT PRESERVATION CONFERENCE  ROAD TRIP: DRIVING THE MESSAGE FOR CHANGE
Plymouth, MA Rt. 3

- AR GG mix – 1/2 “nominal maximum size
- 7.5% ASTM D-6114 AR Binder
- 1 ¼” compacted over micro-milled surface
- 20,000 tons
- Current spec requires 55F pavement temperature
- With MassDOT pavement temperature was reduced to 45F for last 5,000 tons
- Night Paving
- Resulted in reducing spec to 45 F
Hamburg Test Results - PA Landers Lab Produced ARGG Mix (Rt.3) 
Samples from All States Asphalt

- Control NO ECOBIT
- 1.0% ECOBIT

Average Rut Depth (mm)
Number of Passes
PaveCool (Minnesota DOT program)
**Plymouth, MA Rt. 3**

**PaveCool 2.4 - Simulation Results**

**Input File:** PaveCool  
**Project:**  PA Landers Asphalt Rubber GP Graded + 1% ECORBIT

<table>
<thead>
<tr>
<th>Project Date &amp; Time</th>
<th>Start Rolling*</th>
<th>Stop Rolling*</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/02/09 12:10 PM</td>
<td>1 min. (272 °F)</td>
<td>22 min. (154 °F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HMA Mix Type</th>
<th>Binder Grade</th>
<th>Thickness</th>
<th>Delivery Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse/SMA</td>
<td>PG 82-28</td>
<td>1.50 in.</td>
<td>300 °F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air Temp.</th>
<th>Wind Speed</th>
<th>Sky</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.0 °F</td>
<td>10 mph</td>
<td>Clear &amp; Dry</td>
<td>42.0 ° North</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Existing Surface</th>
<th>Moisture</th>
<th>State</th>
<th>Surface Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>N/A</td>
<td>MA</td>
<td>35.0 °F</td>
</tr>
</tbody>
</table>

* Some material contents will make interpretation start and stop times different from those represented by the program. Users should judge events and stop times according to the weather. Input conditions should not be used for design or other traffic-handling decisions. Users should be aware of the limitations and assumptions of the data provided by this project. Contact the HMA for further details. As a matter of safety, do not enter the Minnesota Department of Transportation, the University of Minnesota or their representatives in the changes or corrections arising out of the use of this program.

**Simulation Time:** 09/02/09 2:51 PM

**Cooling Curve**

- HMA Temperature, °F
- Cooling Curve
- Start Temp/Time
- Stop Temp/Time

![Cooling Curve Graph](image-url)
Summary – Asphalt Rubber Mixes

- AR and Terminal Blend have completely different properties
- AR Binder enhances the performance of mixes by stiffening the binder, increasing elasticity (crack resistance), and are resistant to migration
- AR mixes typically have 20% higher binder contents
- AR OGFC and ARGG mixes have been used successfully in many states and climates with great success
- AR mixes reduce rutting, oxidation, cracking and pavement noise and provide smooth surfaces
Summary – continued

• Utilizing best practices, AR mixes are user friendly
• AR mixes can easily be adapted to warm mix applications reducing mix temperatures, emissions and binder aging

• AR mixes consume old tires and are environmentally friendly
THANK YOU

All States Materials Group®

Products & Services

- **ECOBIT™** WMA Binder
- CRMB for HMA
- PG Graded Binders
- Asphalt Rubber SAM & SAMI
- FiberMat® SAM & SAMI
- Bonded Pavements
- Chip Seals
- Liquid Calcium/Magnesium Chloride
- Full Depth Reclamation
- Hot & Cold Mix Asphalt

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