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Overview of Rubberized Asphalt Technology

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Human Being

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EPA Scrap Tire Work Group Webinar
February 21, 2013
Presentation Overview

- Introduction to Rubberized Asphalt
- History
- Terminologies
- Crumb Rubber Issues
- Different Technologies
- Advantages and Disadvantages
- Specifications
- Research Findings
- Conclusions
303 million scrap tires generated annually (1 tire/person)

- 258 Million Passenger and Light Truck Tires (85%)
- 45 Million Heavy Truck and Commercial Tires (15%)
Passenger Car Tires

- Rubber: 60%
- Steel: 20%
- Other Materials*: 20%

*Other Materials include fiber, oils, waxes, and pigment
Typical Composition of a Tire

- Synthetic Rubber
- Natural Rubber
- Sulfur and sulfur compounds
- Silica
- Phenolic resin
- Oil: aromatic, naphthenic, paraffinic
- Fabric: Polyester, Nylon, Etc.
- Petroleum waxes
- Pigments: zinc oxide, titanium dioxide, etc.
- Carbon black
- Fatty acids
- Inert materials
- Steel Wire
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Whole Tire Processing

- Not a new industry, processing/reclaiming has existed as long as tires have existed
- Ambient systems: 1930s
- Cryogenic systems: 1970s
- Wet grind processing 1970s
- Cryogenic/Ambient processing
Cryogenic Crumb Rubber Process

- Whole tire size reduced by various means
- Fed into cryo chamber
- Frozen with liquid nitrogen to -184º C (-300º F)
- Hammer mill reduces crumb to particles of various sizes
- Steel removed magnetically throughout process
- Sorted and screened to specified size
- Fine grinding to reduce further particle size if needed
Ambient Crumb Rubber Process

- Whole tire fed through shredder
- Shreds processed through grinding mill
- Steel removed by magnets throughout system
- Product sorted to size by screening process
- Fabric removed by shaker tables and vacuum
- Product reduced further by grinding mills
Schematic of Ambient Processing

A – Preliminary shredder
B – Granulator
C – Steel and fibre removal
D – Consecutive fine grinding steps
E – Pneumatic conveying system
F – Windsifter
G – Secondary magnetic separation
H – Fibre and dust removal
Particle Morphology

Cryogenic:
Angular or prismatic shape, smooth surfaces, low surface area.

Ambient Grind:
Rough irregular shape with high surface area.
Scanning Electron Microscopy (SEM) of Crumb Rubber Modifiers

Ambient CRM

Cryogenic CRM
Quality Control: Crumb Rubber

- Size
- Percentages in the Mix
- Amb vs. Cryo
- Binder Source: Compatibility Issues
- Fiber Content
- Steel Content
- Moisture Content
Introduction to Rubberized Asphalt

- Virgin Asphalt Binder + Crumb Rubber

Factors to consider:
- Grade of Virgin Asphalt Binder
- Crumb Rubber Content
- Crumb Rubber Source
- Process (Dry vs. Wet)
Historical Overview of Rubberized Asphalt

- 1960’s: Charles McDonald
- 1970’s: Phoenix and ADOT (SAM); FDOT develops specifications for DGFC and OGFC wearing courses; European system (Dry Process)
- 1980’s HMA applications, Industry Group develops
- 1990’s ISTEA controversy, Patents expire, Industry Grows
Rubberized Asphalt History

- SAM
- SAMI
- Dense-Graded Hot Mix
- Open Graded Hot Mix
- Gap Graded Hot Mix

Florida Legislative Mandate

SB 1192 in 1988 directed that
- FDOT should expand its use of GTR
- FDOT should review and modify its specs to accommodate use of GTR
- Construct demonstration projects
Terminologies

- Wet Process
- AR Binder (ASTM, Min 15%)
- On Site Blending
- Rubberized Asphalt
- Terminally Blended
- Dry Process
- Crumb Rubber
- RM Binder: Rubber Modified Binder
- CRM (Crumb Rubber Modifier)
- GTR (Ground Tire Rubber)
- GTR Modifiers
- RAC: Rubberized Asphalt Concrete
Types of Applications

- Rubber-modified surface course (R-M SC)
  - Dense-graded friction course (DGFC)
  - Gap graded friction course (GGFC)
- Rubber-modified open-graded friction course (R-M OGFC)
- Stress absorbing membrane (SAM)
- Stress absorbing membrane interlayer (SAMI)
Methods of Application

- Dry Process
- Modified Dry Process
- Wet Process
- Modified Wet Process
- Terminal Blending
- New Technologies: Pellets!!
Wet Process

- CRM + binder: HMA plant or provided by a supplier
- Anywhere from 5% to >20% CRM by weight of binder
- ASTM: Minimum 15% CRM: Asphalt Rubber (AR)
- Different amounts are used in various states, depending on the type of mix and size of CRM used
Dry Process

- **Dry process (i.e., PlusRide)**
  - CRM + aggregate
  - 2% to 4% CRM by weight of the asphalt concrete mixture

- **Modified Dry Process (e.g., GA DOT)**
  - Example: 9.5 mm mix:
    - 10% CRM (Binder wt)+4.5% Vestenamer (wt of CRM)
Terminal Blending

- Off site
- Transported by agitated trucks
- Fine CRM: 3% to over 10% is used
- Sometimes, other additives are added to the matrix
The Why Part (one of them)!!

Significantly higher binder content without drain down

Thicker film thickness on aggregate
Reduced oxidation - Increased durability - Increased resistance to reflective cracking

<table>
<thead>
<tr>
<th>Grading Type</th>
<th>Binder Content</th>
<th>Micron Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Graded 4.6%</td>
<td>HMA</td>
<td>9 Micron</td>
</tr>
<tr>
<td>Gap Graded 7.4%</td>
<td>Asphalt Rubber</td>
<td>18 Micron</td>
</tr>
<tr>
<td>Open Graded 9.2%</td>
<td>Asphalt Rubber</td>
<td>36 Micron</td>
</tr>
</tbody>
</table>
Other Specific Considerations

- Size of the rubber (fine vs coarse)
- Percentages of the rubber (5 vs 20%)
- Compatibility of the binder (i.e., source)
- Reaction (curing) time (15 min vs 2 hrs)
- Amb vs. cryo CRM
- Blending techniques (low vs high shear)
- MANY more!!
Not only one option/answer!!
Many options/solutions!!
A Tool in Your Toolbox!!
Rubber-Modified Surface Course

- Roughly 5% asphalt binder and 95% aggregate
- Rubber-modified dense-graded friction course (R-M DGFC)
  - 5% to 10% rubber by weight of virgin binder
- Rubber-modified gap-graded friction course (R-M GGFC)
  - 18% to 20% rubber by weight of virgin binder
- 500 to 2,000 tires per kilometer of a two-lane highway
Paving with R-M Surface Course
Compaction of R-M Surface Course
Rubber-Modified Open-Graded Friction Course

- Used to decrease noise, increase skid resistance, and increase surface drainage
- Roughly 93% aggregate, 7% asphalt binder, and NO fibers
- 12% to 20% rubber by weight of virgin binder
- 700 to 1,200 tires per kilometer of a two-lane highway
Stress Absorbing Membrane Interlayer

- Used to prevent reflective cracking
- Consists of:
  - Layer of rubber-modified asphalt binder
  - Layer of crushed stone
  - Layer of new HMA
- 20% to 23% rubber by weight of virgin binder
- 1,500 to 1,700 tires per kilometer of a two-lane highway
Stress Absorbing Membrane Interlayer

Surface Course

Asphalt-Rubber Membrane and Aggregate Chips

Existing Pavement
Stress Absorbing Membrane Interlayer
Applying Asphalt Binder Layer
Stress Absorbing Membrane Interlayer
Applying Aggregate to Asphalt Binder Layer
Stress Absorbing Membrane Interlayer Seating Aggregate with Rubber-Tire Rollers
Stress Absorbing Membrane Interlayer
Placing HMA Surface over Aggregate Layer
Lubbock Texas - 2000
(After 15 Years of Performance)
Before SAMI Application
After 16 Years of Performance
Average Tires Used
(Per Kilometer of Two-Lane Highway)
SAMI: Stress Absorbing Membrane Interlayer; R-M: Rubber Modified Mix; Conv.: Conventional HMA Mix; OGFC: Open Graded Friction Course

- SAMI + R-M: 2,300
- SAMI + Conv.: 1,000
- R-M OGFC: 1,000
- R-M: 1,300
Advantages of Rubberized Asphalt

- Longer overall pavement life
- Increased crack resistance
- Increased rut resistance
- Reduced oxidation (slower aging)
- Reduced maintenance needs/cost
- Increased skid resistance
- Standard HMA production, paving, and compaction equipment can be utilized
ARFC: Asphalt Rubber Friction Course

Concrete 109.2

Tire/Pavement Noise Sound Intensity
California & Arizona Highways
### ADOT I-19, Asphalt Rubber Project Tucson, AZ MP 58-60
#### Maintenance Cost Comparison

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Values Before Overlay</th>
<th>14 Years After Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ride inches/mile</td>
<td>172</td>
<td>70</td>
</tr>
<tr>
<td>Skid (Mu Meter)</td>
<td>38</td>
<td>64</td>
</tr>
<tr>
<td>Rutting (inches)</td>
<td>N/A</td>
<td>0.11</td>
</tr>
<tr>
<td>Percent Cracking</td>
<td>N/A (Trans Joint)</td>
<td>1%</td>
</tr>
<tr>
<td>Maintenance Cost/Lane Mi/Year</td>
<td>$857</td>
<td>$59</td>
</tr>
</tbody>
</table>
Why Rubberized Asphalt?

Good For The Environment!

*Eliminates Waste Tires*

Safe!!

*Better Skid Resistance*

Durable!!!

*Longer Lasting*
Rubberized Asphalt: Safety

- Less Susceptible To Icing
- Less Water Spray & Better Skid Resistance
Safety
Disadvantages of Rubberized Asphalt

- Higher initial cost
- Lack of experienced contractors in early stages of implementation
- Requires either use of blending unit or use of terminally blending process
- Requires agitated binder storage tank like using a polymerized binder
<table>
<thead>
<tr>
<th>State</th>
<th>Applications Used</th>
<th>% Rubber by Weight of Binder</th>
<th>Crumb Rubber Particle Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>GGFC and OGFC</td>
<td>20%</td>
<td>2.0 mm (#10 mesh)</td>
</tr>
<tr>
<td>California</td>
<td>3-Layer System (OGFC, SAMI, OGFC)</td>
<td>14% to 23%</td>
<td>-</td>
</tr>
<tr>
<td>Florida</td>
<td>ARMI (SAMI), DGFC, and OGFC</td>
<td>5% to 20%</td>
<td>425 μm (#20 mesh) to 850 μm (#40 mesh)</td>
</tr>
<tr>
<td>South Carolina</td>
<td>DGFC, SAMI, and OGFC</td>
<td>10% to 20%</td>
<td>850 μm (#40 mesh)</td>
</tr>
<tr>
<td>Texas</td>
<td>GGFC and OGFC</td>
<td>15% to 20%</td>
<td>2.0 mm (#10 mesh) to 1.18 mm (#16 mesh)</td>
</tr>
</tbody>
</table>

Key:
- GGFC = Gap Graded Friction Course
- SAMI = Stress Absorbing Membrane Interlayer
- OGFC = Open Graded Friction Course
- ARMI = Asphalt Rubber Membrane Interlayer
- DGFC = Dense Graded Friction Course
Material Considerations

- Physical Aspects
- Chemical Compatibility
- Present & Future Environmental Issues
- Views of Public, Engineers, & Decision Makers
- Life-Cycle-Cost Issues
- Proper and Easy to Follow Specs!!
Too much information!!
Confusing Information!!
Research

- Many years and many countries
- RAP
- Warm Mix
- High and Low T Susceptibility
- Effects of Percentages & Types of CRM
- Chemical Compatibility
- Effects of CRM Size
Conclusions

- NOT a New Topic Anymore!!
- Environmental Issues (Green, LEED)
- Cost Issues (Initial and LCCA)
- Compatibility Issues
- Recycling of the New Pavement
- Public Perceptions
- Acceptance by Governmental Agencies
I am so glad that he is finished with his boring talk!! You can wake up now.
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Thank you!!