Ground Tire Rubber and Trans-Polyoctenamer as Asphalt Binder Additives

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Presentation to the Western Research Institute 2004 Symposium on Additives in Roadway Asphalts
Cheyenne, Wyoming
June 23-25, 2004
Outline

I. Further Studies of Asphalt Rubber/Rubber Aggregate for paving of paths and trails (non-motorized use); Vestenamer® effects.

II. Asphalt-Rubber Binder viscosity: Field Measurement Standardization.

III. Progress with Asphalt-Rubber Chip Seal instalments in Colorado – performance after one year and 2004 sites.

IV. Tire-Roadway Noise Generation and the “Quiet Pavements Pilot Programs” (QP3).
What is **VESTENAMER® Polyoctenamer**?

VESTENAMER® *trans-polyoctenamer rubber (TOR)* is a mixture of linear and macrocyclic polymers that exhibit four special structural features when added to rubberized asphalt concrete:

1. Low initial viscosity during the initial mixing operation
2. Increased viscosity after polymerization to prevent drain down
3. Chemical bonding of the GTR to the asphalt
4. Chemical bonding of the final rubberized asphalt to the aggregate to reduce stripping
5. Conversion of the thermoplastic asphalt to a thermoset polymer, which reduces cracking and rutting
## COST CALCULATION for 1 Mile, Dual Lanes, 22-feet Wide

**Case #1** A 3-inch standard PG 76-28 modified asphalt overlay

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>2,178 tons</td>
<td>$12,306</td>
</tr>
<tr>
<td>76,-28 Asphalt</td>
<td>131 tons</td>
<td>$38,551</td>
</tr>
<tr>
<td>Total</td>
<td>2,309 tons</td>
<td>$50,857</td>
</tr>
</tbody>
</table>

**Case #2** A 3-inch 10% GTR + VESTENAMER modified (PG76,-28) asphalt overlay

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>2,178 tons</td>
<td>$12,306</td>
</tr>
<tr>
<td>64,-28 Asphalt</td>
<td>131 tons</td>
<td>$24,235</td>
</tr>
<tr>
<td>10% GTR (14-)</td>
<td>13 tons</td>
<td>$4,680</td>
</tr>
<tr>
<td>VESTENAMER 8012</td>
<td>0.6 ton</td>
<td>$2,400</td>
</tr>
<tr>
<td>Total</td>
<td>2,322.6 tons</td>
<td>$43,621</td>
</tr>
</tbody>
</table>
Conclusions:

1. Vestenamer® definitely reacts with the ground tire rubber, and has a significant effect on the appearance and workability of the modified binder.

2. Two increases in binder PG grade were observed for some blends; both GTR and GTR + Vestenamer provide higher rutting resistance compared to the control binder (PG58-28, Koch Pavement solutions).

3. Five percent GTR provides one grade bump in the performance grade (PG) of the binder.
Macrostructure of ARRA
Size distribution of the crumb rubber particles
Dry Process for manufacturing ARRA
Dimensions of Tested Samples (compaction pressure: 140 kPa)
Blending effect on tension testing. (5% vestenamer modified ARRA 50-50, Testing temperature: 210°C, compaction pressure: 140 kPa, Strain rate: 0.091/min)
Smother surface of vestenamer modified ARRA
Vestenamer Effect on Mechanical behavior of ARRA (Testing temperature: 21 °C; Compaction pressure: 140 kPa)

Vestenamer ratio effect on the compression behavior of ARRA,
Strain rate: -0.091 /min

Vestenamer ratio effect on the tension behavior of ARRA,
Strain rate: 0.091 /min
Low temperature behavior of ARRA (Compaction pressure: 140 kPa)

Low temperature effect on tension behavior of 5\%wt vestenamer modified ARRA, Strain rate: 0.091 /min

Low temperature effect on compression behavior of 5\% wt vestenamer modified ARRA, Strain rate: -0.091 /min
T=190°C (374°F)

Viscosity (Poise)

Time (Sec)

y = 7E-07x^4 - 0.0002x^3 + 0.0152x^2 - 0.8388x + 147.6

y = 6E-08x^4 - 2E-05x^3 + 0.0026x^2 - 0.1972x + 29.157

y = 1E-06x^4 - 0.0001x^3 + 0.006x^2 - 0.1089x + 3.7758

10% CRM x 15% CRM ▲ 20% CRM
Summer 2004 AR Projects

- Demonstrate an “ARRA” Trail for C-DOT and for state parks;
- Demonstrate 6 or 7 new Asphalt-Rubber Chip-Seal projects at sites with varying climates (one project may involve Vestenamer®) totaling ca. 700,000 yd²;
- Initiate sound level measurements for chip seals;
- Initiate skid resistance measurements on wet and dry AR chip-seal surfaces.
Portable Sound Pressure Level System

Diagram:
- Preamplifier
- Spectrum Analyzer (HP3580A)
- Recorder
- Nicolet 490
- A/D Converter
- Laptop computer
- Printer
Rubber Modified Asphalt Binders

Blackidge Emulsions, Inc. is the major producer of Rubber Modified Asphalt Binders in Florida, which is specifying Rubber Modified Asphalt Binders for use on all Department of Transportation friction coarses (dense-graded and open-graded).

Blackidge Emulsions, Inc. has participated in many of the SHRP demonstrations and research projects throughout the United States. Particularly in the Southeastern United States, the SHRP 76-22 performance graded asphalt binder has been selected by various Department of Transportations. Blackidge Emulsions, Inc. has generally been able to meet this binder specification by the addition of 9-12% 40 mesh rubber using Blackidge Emulsions' blending technique with the addition of special additives. Generally, Blackidge Emulsions has found that using tire rubber instead of latex or SBS polymers is less expensive. The addition of tire rubber will improve the low and high end and temperature ranges of the SHRP specifications.

http://www.blacklidgeemulsions.com/rubber.htm
Streets to undergo rubbery facelift
Rubberized asphalt will help reduce road noise on busiest streets

By Rick Davis
The Desert Sun
March 8th, 2004

RANCHO MIRAGE -- A mid-valley street project is expected to reduce the sound of cars on roads by putting asphalt with car parts, specifically old tires, in the roads.

Sometime in July, Rancho Mirage will start another phase of its long-term project to deaden traffic noise by resurfacing all the city's streets with rubberized asphalt.

The latest phase will include resurfacing sections of Frank Sinatra Drive (1 1/4 miles), Gerald Ford Drive (1 1/2 miles) and Highway 111 (1 1/4 miles). The overall estimated cost is $1.93 million.

In a staff report distributed last week, city Director of Public Works Bruce Harry noted that once the phase is completed, 40 percent of the city's main streets will be resurfaced with rubberized asphalt, including all of Highway 111 within the city limits.

The city's residential streets (about 49 miles) are surfaced and resurfaced with a product called rubberized emulsion aggregate slurry, by applying a coat that's 1/8 to 1/4 of an inch thick.

Harry noted that some municipalities aren't using the pricier product because of financial constraints. A city can resurface 4.2 miles of streets with non-rubberized asphalt for the same cost as resurfacing three miles with rubberized asphalt.

"It's more expensive, by about $20 a ton," Harry said. "But it's supposed to be stronger by up to a 2-1 ratio. Added strength means it will last longer and you can put down a thinner coat."
New Mexico Wants Quiet Pavements

A New Mexico citizen concerned about traffic noise has prepared a point paper on the subject. He is attempting to get the local paving authority to explore asphalt rubber surface as part of a regular maintenance activity to take advantage of the material's noise reducing properties. The Tempe, AZ-based Rubber Pavements Association (RPA) reports the concerned citizen has made use of a Sacramento County noise study and recent Arizona Department of Transportation research to answer questions about the comparative noise reduction between Dense Graded Asphalt Concrete and Asphalt-Rubber mixes. Another resource for comparative noise reduction is the NCHRP synthesis 268 which was completed in 1998 and shows as much as a 9db reduction with open graded mixes.
I-80 DAVIS OGAC PAVEMENT NOISE STUDY

TRAFFIC NOISE LEVELS ASSOCIATED WITH AN AGING OPEN GRADE ASPHALT CONCRETE OVERLAY

December 1, 2002

Prepared for:

California Department of Transportation
Environmental Program – Noise and Vibration Studies
1120 N St. 4th Floor
Sacramento, California 95814

Prepared by:

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

505 Petaluma Blvd South
Petaluma, CA 94952
Figure 4-2a  Westbound Reference Traffic Noise Spectra

SUMMARY OF WB REF SPECTRA
A-Weighted Levels

Baseline
1-Month Old
11-Month Old
23-Month Old
35-Month Old
48-Month
What is Noise, How is it Controlled, and How Does it Affect Our Lives
Common Indoor and Outdoor Noise Levels

Common Outdoor Noises

- Jet Flyover at 1000 feet
- Gas Lawn Mower at 3 feet
- Diesel Truck at 50 feet
- Urban Daytime
- Gas Lawn Mower at 100 feet
- Heavy Traffic at 300 feet
- Typical Urban Daytime
- Urban Nighttime
- Rural Nighttime

Common Indoor Noises

- Threshold of pain
- Rock Band at 15 feet
- Food Blender at 3 feet
- Garbage Disposal at 3 feet
- Vacuum Cleaner at 10 feet
- Normal speech at 3 feet
- Dishwasher next room
- Library
- Bedroom at night
- Threshold of hearing

Note: Sound is perceived differently by every individual
Doubling Traffic adds 3dBA

65 Decibels

68 Decibels
Effect of Distance On Noise Levels for Site 3D

Comparison of the Leq Data Relative to 50 ft away, 5 ft high
AZ 202 Preproject PCCP

Sound Level at Varying Dist, dBA

Sound Pressure Level at 50x5 ft, dBA

R² = 0.981
R² = 0.9711
R² = 0.994
How Is It Controlled

- At the Source
  - Vehicle & Tire Emissions
- Through Distance
  - 3 dBA Reduction for Each Doubling of Distance
    - 25 ft = 70 dBA, 50 ft = 67 dBA, 100 ft = 64
- Through Obstructions
  - Berms, Walls, And Combination of both
The *Technical Journey*?

- Development of Improved OGFC for Use in Snow Country (1970s-80s)
- Improved OGFC Used to Resist Reflective Cracking (1980s-90s)
- Improved OGFC Used as PCCP Overlay (1980s-2000s)
- Benefit For Smoothness (1990s)
- Benefit for Noise (1990s-2000s)
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)
Controlled At the Source
Arizona Quiet Pavement Research Effort

- FHWA/ADOT Quiet Pavement Pilot Program (QP3) or Composite Program—Ten Year, Multi Million Dollar Effort
- Flexible Pavement Program
- Rigid Pavement Program
- Study of Environmental Effects
Development of the Arizona Quiet Pavement Pilot Program

- ADOT Receives a 4 dBA Credit for ARFC
- Ten Year, Multi Million Dollar Research Program Underway
  - Composite
  - Flexible
  - Rigid
- Program Intended to Evaluate the Efficacy of Quiet Pavement Solutions
Ways of Measuring Sound

- Wayside (Far Field)
- Close Proximity (Near Field)
- Noise Intensity (Near Field)
ADOT ISO CPX Trailer
Noise Intensity
Network Level Evaluation of ARFC Surfaces

AR_ACFC Noise Levels Versus Pavement Age

\[ y = 0.5453x + 93.279 \]

\[ R^2 = 0.5805 \]
Evaluation of PCCP Tining Methods

Longitudinal

Uniform Transverse

Random Transverse
SR 101 Before and After Results
Tining Experiment Roadside Measurement Results at 50 ft

- RS1 random transverse, autos
- RS2 uniform longitudinal, autos
- RS3 uniform transverse
- RS1 random transverse, medium truck
- RS2 uniform longitudinal, medium truck
- RS3 uniform transverse
- RS1 random transverse, heavy trucks
- RS2 uniform longitudinal, heavy trucks
- RS3 uniform transverse

- Linear (RS1 random transverse, autos)
- Linear (RS2 uniform longitudinal, autos)
- Linear (RS3 uniform transverse)

\[ R^2 = 0.3435 \]
\[ R^2 = 0.4014 \]
\[ R^2 = 0.5732 \]
More Before and After Comparison for Site 3A Location

Arizona 101 Wayside Data at 50 ft - Pre & Post Project OGFC
Uncorrected for Traffic Volume/Speed/Mix

1/3 Octave Band Center Frequency, Hz

Sound Pressure Level, dB

PCC Avg (82.2 dBA)
OGRFC Avg (74.3 dBA)
In Summary

- Surface Type Does Matter-Noise Should be Controlled at the Source
- Noise Should be Managed Just Like Friction, Roughness, Rutting, and Cracking
- People Do Care How They Live-It’s a Quality of Life Issue!!!
Acknowledgments

- Arizona DOT; Larry Scofield
- Rubber Pavements Association; Doug Carlson, executive director (www.rubberpavements.org)
- Colorado Scrap Tire Fund (Colo. Commission on Higher Education)