**Industrial Materials Use in Sustainable Pavement Systems: State of the Practice**

November 28-29, 2012 - Sheraton Indianapolis City Centre
Indianapolis, Indiana

**SCRAP TIRE USE IN QUIET PAVEMENTS**

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**Our Small Erosion Problem in Arizona**

ADOT is the leading state in use of Scrap Tires for Rubberized Asphalt and Quiet Pavements since 1988

ADOT has used more than 40 Millions tires since 1988 and Annually 1.5 to 2 million tires

Scrap Tire Use in Quiet Pavements

Asphalt Rubberized Friction Course (ARACFC)
- Sometimes referred to as AR-FC
- ADOT spec 414 mix
- 1” thick surface layer on PCCP
- 3/8” minus, open graded aggregate
- 9.0% - 9.6% Binder
- 20% Rubber by weight

Benefits of AR-ACFC
- Resists rutting under traffic
- Provides a smooth, skid resistant riding surface
- Popular with the public as it reduces noise
What is Noise?
How is it Controlled?
How Does it Affect Our Lives?

Presentation Message---
Vehicle Tires Traveling Over the Roadway Surface Produces the Noise You Hear in Your Car and in Your Homes

The source of most highway noise is generated at the tire/pavement interface

Tire Noise Begins to Dominate at speeds above 35 MPH.

Effect of speed on vehicle noise (Donovan, 2003)
Scrap Tire Use in Quiet Pavements

How Is It Controlled?

- At the Source
  - Vehicle & Tire/Pavement Interface
- Through Distance
  - 3 dBA Reduction for Each Doubling of Distance
- Through Barriers
  - Berms, Walls, and a Combination of Both

Doubling Traffic adds 3dBA

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Controlled At the Source
Scrap Tire Use in Quiet Pavements

Adding Distance

- 25ft = 70dBA, 50ft = 67dBA, 100ft = 64dBA
- X feet = 61 dBA

Controlled Through Barriers
1 dBA for each 2 ft of Wall

The Decibel Scale

Increasing the decibel level by 10 doubles the noise intensity!
Scrap Tire Use in Quiet Pavements

**Quiet Pavement Program Facts**

- Started in 2003
- 1000 Lane Miles Phoenix Urban Freeways
- 1” AR-ACFC Overlay on PCCP
- $40,000,000 Program
- 10 planned phases

Since 2003

- All 10 Phases have been completed
- 2,500,000 Tires Recycled

The roads are silenced

AND Citizens are very pleased with quieter freeways

ADOT has enjoyed the national/international reputation

**ARIZONA QUIET PAVEMENT PROGRAM**

Reason for Quiet Pavement Program

Reduce the Level of Noise by 4 dBA of the Urban Concrete Freeways in the Phoenix Area by Overlaying PCCP with 1” AR-ACFC

Open Graded Asphalt Rubber

**Ways of Measuring Sound**

- Wayside (Far Field)
- Close Proximity (Near Field)
- Noise Intensity (Near Field)

**ADOT ISO CPX Trailer**
CPX Noise Measurements dBA at the tire/pavement interface and estimated noise 15 meters away from tire.

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>CPX Noise Tire/Pavement</th>
<th>Noise 15 m Wayside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Trans</td>
<td>104.9</td>
<td>81.1</td>
</tr>
<tr>
<td>Transverse</td>
<td>102.5</td>
<td>78.7</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>99.1</td>
<td>75.3</td>
</tr>
<tr>
<td>Whisper Grind</td>
<td>95.5</td>
<td>71.7</td>
</tr>
<tr>
<td>ARFC</td>
<td>91.8</td>
<td>68</td>
</tr>
</tbody>
</table>

Noise Intensity

ADOT US 60

<table>
<thead>
<tr>
<th>Location</th>
<th>Before</th>
<th>After</th>
<th>Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder (12m)</td>
<td>75.6</td>
<td>42.6</td>
<td>33.0</td>
</tr>
<tr>
<td>Soundwell (20m)</td>
<td>70.6</td>
<td>57.1</td>
<td>13.5</td>
</tr>
<tr>
<td>Residential (120m)</td>
<td>53.7</td>
<td>42.0</td>
<td>11.7</td>
</tr>
</tbody>
</table>
Scrap Tire Use in Quiet Pavements

Concrete vs. AR-ACFC

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

- **Concrete**
- **AR-ACFC**

![I-10, Phoenix-LA Freeway 75th Ave-Dysard Rd October 2006]

![Loop 101 Scottsdale Area July 2003]

![I-17 Phoenix Area May 2005]
Comparison of the CPX tire/pavement noise for different surfaces

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Sound Intensity, dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt-Rubber-Open Graded</td>
<td>96-97</td>
</tr>
<tr>
<td>Asphalt-Rubber-Gap Graded</td>
<td>98-99</td>
</tr>
<tr>
<td>HMA Dense Graded</td>
<td>100-102</td>
</tr>
<tr>
<td>Chip Seal</td>
<td>105-107</td>
</tr>
<tr>
<td>Concrete</td>
<td>101-109</td>
</tr>
</tbody>
</table>

Purpose of the QPPP Research Data

- The research data must answer two basic questions:
  #1 Does an ARFC overlay reduce noise levels by at least 4 decibels in neighborhoods adjacent to freeways?
  #2 Is the reduction sustained over the life of overlay?
- Conduct pre- and post-overlay monitoring at three types of study sites (Question 1)
- Collect post-overlay noise readings periodically for up to ten years (Question 2)
- Determine noise level reductions
- Present findings in progress reports
Scrap Tire Use in Quiet Pavements

**Project Area**

- The QPPP research involves 115 miles (Phases I to X) of the Regional Freeway System in Maricopa County, Arizona.
- The Maricopa Association of Governments (MAG) is the metropolitan planning organization (MPO).
- The project area includes Phoenix, Scottsdale, Mesa, Glendale, Tempe, Chandler (members of MAG).
- ADOT placed ARFC overlay on 18 segments during Construction Phases I through V.
- ARFC will overlay the entire Maricopa Regional Freeway System when Phase X is complete.

**Types of Noise Measurements**

- **Site 1:** Noise reduction at the tire/pavement interface (source measurements).
- **Site 2:** Noise reduction in residential neighborhoods (wayside measurements).
- **Site 3:** Noise reduction at research quality sites (wayside measurements).

**Noise Measurement Positions**
Noise Measurement Methodologies

Site 1
Source Measurement
(Close Proximity Method)

Site 1
Source Measurement
(Sound Intensity Method)

Site 2 and Site 3
Wayside Measurement
Initial Noise Reductions

Site 1
Range of Noise Reductions -4.1 dBA to -13.2 dBA
Average Noise Reduction 8.3 dBA

Site 2 Positions

- Represent residential subdivisions
- Ability to conduct follow-up noise measurements
- Real-world conditions:
  - With and without intervening noise barriers
  - Elevated, depressed, and at-grade segments
  - Proximity to non-ARFC arterial roads
  - Variations in adjacent topography

Noise Measurement

Site 2 Measurement Criteria

- Continuously monitor each segment for 24 hours
- Measure each Site 2 position during peak traffic noise conditions
- Complete three consistent 20-minute measurements at each Site 2 position
- Document weather conditions during measurement
- Determine traffic mix and volumes using video
- Measure vehicle speeds using radar
Scrap Tire Use in Quiet Pavements

Examples of Site 2 Measurement Positions

<table>
<thead>
<tr>
<th>Pre-Overlay Leq</th>
<th>Post-Overlap Leq</th>
<th>Adjusted Post-Overlap Leq</th>
<th>Noise Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.8 dBA</td>
<td>60.8 dBA</td>
<td>60.5 dBA</td>
<td>7.3 dBA</td>
</tr>
<tr>
<td>64.9 dBA</td>
<td>59.1 dBA</td>
<td>58.8 dBA</td>
<td>6.3 dBA</td>
</tr>
</tbody>
</table>

Initial Noise Reductions

Site 2
- Range of Noise Reductions: +1.3 dBA to –12.3 dBA
- Average Noise Reduction: 5.3 dBA

Site 2 Findings to Date
- Average noise reduction exceeds 4 dBA in adjacent areas
- ARFC overlay extends noise reduction benefits to more receivers and affects larger areas, when compared to noise barriers
- Initial public response is favorable

<table>
<thead>
<tr>
<th>Phase #</th>
<th>Total Miles</th>
<th>Number of Positions</th>
<th>Average Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>37</td>
<td>44</td>
<td>4.8 dBA</td>
</tr>
<tr>
<td>Phase 2</td>
<td>29</td>
<td>25</td>
<td>5.9 dBA</td>
</tr>
<tr>
<td>Phase 3</td>
<td>25</td>
<td>12</td>
<td>5.0 dBA</td>
</tr>
<tr>
<td>Phase 4</td>
<td>19</td>
<td>5</td>
<td>3.7 dBA</td>
</tr>
<tr>
<td>Phase 5</td>
<td>5</td>
<td>2</td>
<td>9.6 dBA</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>88</td>
<td>5.3 dBA</td>
</tr>
</tbody>
</table>

Site 3 Positions
- Research Grade, 5 sites 3A,3B,3C,3D and 3E
- Closer to Freeway 50 to 250 ft with Clear Line of sight to freeway
- Vehicle Volumes determined using Videos
- Traffic Volume breakdown to types
- Traffic Speed using Radar
- Meteorological data: wind speed, direction
- Geometric Info by ADOT
- Real-world conditions:
  - With and without intervening noise barriers
  - Elevated, depressed, and at-grade segments
  - Proximity to non-ARFC arterial roads
  - Variations in adjacent topography
Initial Noise Reductions

**Site 3**
Range of Noise Reductions: -4.4 dBA to -12.4 dBA
Average Noise Reduction: 8.3 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!!!