Asphalt Rubber

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Jacobs Engineering

With assistance from:
The California Department of Resources Recycling and Recovery
(CalRecycle)
TECHNOLOGY TRANSFER
THROUGH
• Seminars
• Field Assistance
• Information Sharing
• Guidelines
• Grant Assistance
Presentation Summary

- What is RAC
- Reduced Thickness Design
- Life Cycle & Cost Factors
- Noise Reduction
- Best Practices
- Specifications
- Mix Design Forensics & Case Studies
Presentation Summary

- Inspection
- Grants/Cooperative Purchase Program
Why should an agency choose asphalt rubber strategies?

- Has a long term performance history (over 30 years)
- Allows for higher binder contents in mixes
- Greater film thickness leads to improved durability and longer life
- Higher viscosity (Rut resistant)
- Higher softening point
Why choose asphalt rubber?

- Less maintenance leading to increased safety
- Better resistance to reflective cracking
- Established life cycle cost-effectiveness
- Can be used in reduced thickness
- Less oxidation
- Proven alternative to costly reconstruction
Why choose asphalt rubber?

- Excellent color contrast for striping
- Quieter pavements
2,000 recycled tires per lane mile for a 2-inch overlay

2.4 tires per ton
Asphalt-Rubber as defined by ASTM D8-88

“Asphalt-Rubber is a blend of asphalt cement, reclaimed tire rubber and certain additives, in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles.”
Viscosity is what defines Asphalt-Rubber Binder

Asphalt-Rubber
1,500 to 2,500 Centipoises At 375°
Extremely Viscous

Rubberized Asphalt Terminal Blend
300 to 600 Centipoises At 325°
Significantly Less Viscous Than AR
Design of Asphalt Rubber Pavements

• Uses a deflection based design method
• Up to 50% reduction in thickness compared to conventional AC design thickness
• Over 1000 reduced thickness projects
Heavy Vehicle Simulator – UC Davis
Heavy Vehicle Simulator – UC Davis
## Performance

<table>
<thead>
<tr>
<th>Repetitions</th>
<th>Wheel Load</th>
<th>AC Overlay Section (3”)</th>
<th>ARHM-GG Section (1.5”)</th>
<th>ARHM-GG Section (1”)</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>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheel load Changed to 80 kN</td>
<td></td>
</tr>
<tr>
<td>175,000 to 200,000</td>
<td>80kN</td>
<td>Completely cracked</td>
<td>—</td>
<td>Fine cracks</td>
</tr>
<tr>
<td>200,000 to 237,000</td>
<td>80kN</td>
<td>Test stopped</td>
<td>—</td>
<td>Completely cracked</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Surface Temperature Reduced to –5 C</td>
<td></td>
</tr>
<tr>
<td>237,000 to 250,000</td>
<td>80kN</td>
<td>Test stopped</td>
<td>1/2 of section cracked</td>
<td>Test stopped</td>
</tr>
</tbody>
</table>
Cost Factors

- When AR is in production the plant can not make conventional
- Small Projects = LARGE COSTS!!
  - Move-in costs
  - Fixed daily costs
- Haul distance and ambient temperatures
- Traffic control for cooling time
• Agencies can save $$ with coordination/procurement
• Rubber Plant may limit Production Rate
• Look for Caltrans projects
• Bidding in the Winter will allow efficient scheduling for the upcoming season
• Be flexible
Terminal Blend Modified Binder with Recycled Tire Rubber

www.paramountasphalt.com
WHAT ARE WE TALKING ABOUT?

Terminal Blended Tire Rubber Asphalt (TBTRA)

- Processing takes place at the manufacture’s location. (the supplier’s terminal)

- A process that completely integrates tire rubber particles into an asphalt binder.

- Tire rubber is at a micron size within the asphalt medium
Terminal Blended Tire Rubber Asphalt (continued)

- Additional polymer modifiers can also be added to produce, certify and ship finish graded products from the manufacturer’s location.
- This material comes ready to use upon arrival
- Non proprietary product
Terminal Blended Tire Rubber Asphalt System

At 20 to 25 % Tire Concentration
7,000 tons of TBTRA sold in 1993
125,211 liquid tons of TBTRA sold in 2009
1,503,786 tons since 1993
Applications

- Hot Applied Chip Seal Binder
  - PG70-22TR and PG76-22TR
  - Chip seal binder made up of 20% tire rubber fully digested and polymer

- Binders for Dense Graded Hot Mix Asphalt
  - Binders that are PG 64-28TR and PG76-22TR Graded
  - Similar spec as PG64-28PM and PG76-22PM
  - Binder that contains 10% up to 15% tire rubber
  - This binder can also be further modified with SBS co-block polymers
Applications (continued)

Binders for Open, Gap and PFC Graded Hot Mix Asphalt:
- Surface wearing course application PG64-28TR and PG76-22TR
- Similar spec as PG64-28PM and PG76-22PM
- Greenbook MAC-10TR and MAC-15TR
- Binders that are PG Graded and can meet any Plus Specification
- Binder that contains 10% up to 15% tire rubber
- This binder can also be further modified with SBS co-block polymers
• Significant Projects completed in 2010:

- Siskiyou County  PG64-28TR  18%TR 15% RAP
- Contra Costa  PG76-22TR  18%TR Grant $
- District 1  PG64-28TR  18%TR WMA
- District 2  PG64-28TR  18%TR Open & Dense
- San Diego County  PG76-22TR  18%TR Porous
- Riverside  MAC-15TR  15%TR GAP Grade
- Lake Forest  TRMSS  10% TR Emulsion

Complete listed of 2010 projects (Pic & Videos) can be found on www.ParamountAsphalt.com
Cost Effectiveness of AR and Life Cycle Analysis UNR & Oregon State
LCCA Process

- Establish strategies for analysis period
- Establish M&R activity timing
- Estimate agency costs
- Estimate user and non-user costs
- Develop expenditure streams
- Compute net-present value
- Analyze results
Analysis Period

Include at least one Rehab.
Typical Expenditure Stream

- Initial Construction
- Rehabilitations
- Analysis Period
- Salvage Value
Net Present Value

Costs ($1,000)

$1,100 Initial Cost

$300 User Costs

$269 User Cost

$325 Rehab #1

$361 User Cost

$325 Rehab #2

Salvage Value $217
## Results - Deterministic Approach

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Present Worth ($/yd)</th>
<th>Total</th>
<th>Savings w/ AR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preservation - Chip Seal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>18.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR</td>
<td>15.87</td>
<td></td>
<td>2.52</td>
</tr>
<tr>
<td><strong>Preservation - Thin HMA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>20.69</td>
<td></td>
<td>3.36</td>
</tr>
<tr>
<td>AR</td>
<td>17.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Structural Overlay</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>21.97</td>
<td></td>
<td>7.34</td>
</tr>
<tr>
<td>AR</td>
<td>14.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Results - Probabilistic Model

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Percentage of times savings result using AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preservation - chip seal</td>
<td>86</td>
</tr>
<tr>
<td>Preservation - thin HMA</td>
<td>82</td>
</tr>
<tr>
<td>Structural Overlay</td>
<td>86</td>
</tr>
</tbody>
</table>
Noise Reduction with RAC
<table>
<thead>
<tr>
<th>Noise Source</th>
<th>Decibel Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thunder Clap, Live Rock Music, Chain Saw</td>
<td>120</td>
</tr>
<tr>
<td>Steel Mill, Riveting, Auto Horn (1M)</td>
<td>110</td>
</tr>
<tr>
<td>Jet Take Off, Lawn Mower, Jack Hammer</td>
<td>100</td>
</tr>
<tr>
<td>Busy Urban Street, Diesel Truck, Food Blender</td>
<td>90</td>
</tr>
<tr>
<td>Garbage Disposal, Dishwasher, Freight Train</td>
<td>80</td>
</tr>
<tr>
<td>Freeway Traffic (15), Vacuum Cleaner</td>
<td>70</td>
</tr>
<tr>
<td>Conversation in Restaurant, Office, Background Music</td>
<td>60</td>
</tr>
<tr>
<td>Quiet Suburb, Conversation at Home</td>
<td>50</td>
</tr>
<tr>
<td>Library</td>
<td>40</td>
</tr>
<tr>
<td>Quiet Rural Area</td>
<td>30</td>
</tr>
</tbody>
</table>
• Vehicle-generated noise comes from:
  – engine,
  – exhaust system,
  – aerodynamic noise
  – tire noise.

• For $\geq 40$ mph, pavement/tire noise dominates.
Walls
Effective only for those in line-of-sight.

Do not reduce noise at source.
A reduction of 3 dB(A) is like doubling the distance from the noise, reducing traffic volume by 50%, or reducing traffic speed by 25%

$$67 \text{ dB(A)} - 3 \text{ dB(A)} = 64 \text{ dB(A)}$$
Hot Mix with Asphalt Rubber Binder Reduces Tire Noise

- Gap Graded Mix Design
  - Aggregate Structure with more binder
- Binder Strength
  - Film Thickness
  - Resists Oxidation Longer
  - Suppleness of mat
## 6-year Noise Study

Reduction compared to pre-overlay condition

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Period</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alta Arden</td>
<td>AR</td>
<td>1 month</td>
<td>-6dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 months</td>
<td>-5dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 years</td>
<td>-5dB</td>
</tr>
<tr>
<td>Antelope*</td>
<td>AR</td>
<td>6 months</td>
<td>-4dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 years</td>
<td>-3dB</td>
</tr>
<tr>
<td>Bond</td>
<td>CA</td>
<td>1 month</td>
<td>-2dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 year</td>
<td>0dB</td>
</tr>
</tbody>
</table>

* (speed increase)
Specifications, Best Practices, Mix Design Forensics

Michael Robinson, PE
Kleinfelder
QUALITY CONSTRUCTION THROUGH QUALITY INSPECTION

YOU ARE THE KEY!
Mixing of paving asphalt and CRM

CRM PROPORTIONING:
- Scrap Tires (3 bags)
- High Natural (1 bag)

BLENDER
CONTROL PANEL

MIXING/REACTION TANK

BLENDING PAVING ASPHALT & CRM
Sampling combined aggregate

DRUM PLANT BELT SAMPLE
INSPECTION AT THE PLANT (Cont.)

- Viscosity of asphalt rubber binder..
- Temperature of ARHM
- Samples of CRM, paving asphalt, asphalt rubber binder, aggregates, and ARHM
Haake Field Viscosity Test

1500 – 4000 Centipoise At 375°F
TEMPERATURE OF ARHM

SHOULD BE A MINIMUM OF 315F LEAVING PLANT
INSPECTION AT THE JOB SITE PRIOR TO PAVING

- Pre-Construction Meeting:
  - Approved mix design
  - Surface preparation
  - Delivery method
  - Rate of delivery & route
  - Staging
  - Other Issues (Refer to A-R Design Guide)

- Ambient temperatures (>55°F and rising)
INSPECTION OF JOB SITE DURING PAVING

- R& R distressed areas (dig-outs) complete?
- Cracks over ¼ -inch wide sealed?
- Cold milling complete?
- Surface cleaned?
- Tack properly applied?
Acceptance Testing

• 92 – 97% of Rice density
• Reduced payment for missing target
• 500 tons (or portion thereof) per lot
  – One lab-compacted sample per lot
  – At least three cores for density per 500 Ton Lot
Asphalt-Rubber Binder in Chip Seal and Spray Apply Applications
ARCS (SAM)—Asphalt Rubber Chip Seal

Pre-existing Pavement
SAMI - Stress Absorbing Membrane Interlayer

Also known as a Two Layer System
Double Chip Seal – First Layer (PMAR Binder Application .62 GSY)
Double Chip Seal – First Layer (3/8" Hot Pre-Coated Aggregate)
Double Chip Seal – Second Layer (Modified Binder .23 GSY)
Double Chip Seal – Second Layer (1/8" Hot Pre-Coated Aggregate Application)
Double Chip Seal Two Layer System
Finished SAM/ARCS Surface
1) Higher Binder Application Rates (.55 to 1.25 gallons per square yard)
2) Resistance to Reflective Cracking
3) Resistance to Aging = Longer Life
4) Higher Percentage of Aggregate Embedment/Retention
5) Alternative to Reconstruction
RAC Grants and Cooperative Purchasing Program
Two RAC Grant programs: (Up to $250,000 per jurisdiction)

1) the Targeted RAC Incentive Grant program, Based on the differential cost of using RAC versus conventional

Project(s) must use a minimum of 3,500 tons of RAC.

2) the RAC Chip Seal Grant program, aimed at new and limited users of rubberized chip seal material

Project(s) must use a minimum area of 35,000 square yards of RAC chip seal material.

Allows terminal blend
Reimbursement will be based on the following:

<table>
<thead>
<tr>
<th>Category Grant Program</th>
<th>Number of Previous CalRecycle RAC Grants</th>
<th>Grant Award Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Targeted</td>
<td>0</td>
<td>Total grant based on a 100 percent differential (RAC versus conventional asphalt cost) reimbursement rate.</td>
</tr>
<tr>
<td>2: Targeted</td>
<td>1</td>
<td>Total grant based on a 70 percent differential (RAC versus conventional asphalt cost) reimbursement rate.</td>
</tr>
<tr>
<td>3: Targeted</td>
<td>2</td>
<td>Total grant based on a 40 percent differential (RAC versus conventional asphalt cost) reimbursement rate.</td>
</tr>
<tr>
<td>4: Chip Seal</td>
<td>0-1</td>
<td>Total grant award is based on $1.00 per square yard reimbursement rate.</td>
</tr>
<tr>
<td>5: Chip Seal</td>
<td>2-3</td>
<td>Total grant award is based on $0.50 per square yard reimbursement rate.</td>
</tr>
</tbody>
</table>
Savings*: Incentives and Cost Share Allocations for Tiered RAC Tonnage Goals
Successful RCPP Pilot foundation for future RCPAs and gaining lessons learned

Champion for a RAC Cooperative Purchase Agreement (RCPA) - Agreement between multiple jurisdictions or partners to procure RAC

Technical Support – Design, Inspection, Testing, Shadow Field Inspections

Reduced Costs through Incentives and Cost Share Allocations Tied to Tiered RAC Tonnage Goals

Facilitating cooperative purchasing agreements between local jurisdictions

RAC volumes attractive to
- Hot Plants (sufficient volumes and ‘runs’)
- Blender Units parked in NorCal
- New Haul and Placement Contractors
RCPP Pilot – Next Steps

1. Let us know if you’re interested in participating by completing a “RAC Interest Survey”

2. Request a Technology Transfer Presentation

3. Attend Pilot Kick Off Session
Questions?

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