Reacted and Activated Rubber
- The new frontier in improved pavements

Dr. Jorge B Sousa
The Issue:

- For about 50 years the paving industry has been trying to take advantage of the elastomeric material and of the carbon black and silica included in recycled tires.

- Those elastomeric materials are known to improve elastic recovery on bitumen. The carbon black and silica improve aggregate interlock
The Problem:

- A crumb rubber alone cannot be placed directly into the mixes (dry method) in significant qualities because it will swell and absorb the bitumen causing raveling in the roads.

- The wet method (about 20% crumb rubber blended with bitumen and reacted over 1 hour at about 175 C) works well but requires that every contractor buys expensive equipment... around 700 000 USD (only cost effective for large projects).

- If crumb rubber is used in terminal blends it is essentially a waste of product because over time it becomes all digested. Actual improvements on mix properties are only a fraction of what they could be.
The Solution:

- **USE OF REACTED AND ACTIVATED RUBBER**…that it can be used directly into the plugmill of a contractor’s plant.

- A proper reacted and activated treatment will insure that the rubber is already swelled with bitumen so it will not absorb any more bitumen.

- It will also be treated to blend well and disperse very well and effectively into bitumen.

- Large quantities can then be used without any real limitation beyond the need of enough bitumen to wet all surfaces, does really making the binder much more “elastic”.

SHRP Corporation
REACTED and ACTIVATED RUBBER
(components in optimized proportions and activating environment)

Bitumen  Crumb Rubber  FILLERS
RAR X

–

Dry powder granulate

SHRP Corporation
RAR X CAN BE PLACED DIRECTLY INTO THE CONTRACTORS PUGMILL

SHRP Corporation
RAR X Concept

Best of both worlds:

a) Easy to apply and use as in the “dry method”... directly in to the pug mill

b) Performance and cost effectiveness beyond that of the “wet method”
RAR creates an elastomeric network in the binder.

SHRP Corporation
BINDER EVALUATIONS
- Traditional
- PG Graded (USA)
Hundreds of formulations have been evaluated
New Formulations

**Viscosity**

**Ring and Ball - Softening Point**

**Penetration**

**Resilience**

SHRP Corporation
BINDERS IMPROVE WITH INCREASED RAR CONTENT

SHRP Corporation
LOW TEMPERATURE PROPERTIES IMPROVE WITH INCREASE RAR CONTENT

SHRP Corporation
JNR VALUES SHOW IMPROVED ELASTIC RECOVERY PROPERTIES

SHRP Corporation
EVEN HARD TO MODIFY BITUMENS SHOW AMAZING PROPERTIES WITH 21% RAR CONTENT
Viscosity - Bitumen 35/50 + RAR X

- RAR X 30%
- RAR X 24%
- RAR X 20%
- RAR X 26%
- RAR X 15%

SHRP Corporation
MIX EVALUATIONS
### RAR X

**content in mixes:**

- **By Weight of Mix:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Dense</th>
<th>SMA</th>
<th>GAP</th>
<th>THINGAP</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>3 to 4%</td>
<td>4 to 5%</td>
</tr>
<tr>
<td>(Binder)</td>
<td>(14%)</td>
<td>(25%)</td>
<td>(30%)</td>
<td>(35%)</td>
<td>(40%)</td>
</tr>
</tbody>
</table>

**SHRP Corporation**
RAR X IN DENSE GRADED MIXES

Marshall Stability (N)

% RAR

SHRP Corporation
RAR X in SMA

**Marshall Values**

- **SBS**: 7000 kg
- **BITRACK**: 8000 kg
- **RIAZAN**: 6000 kg
- **RIAZAN+RUBIND**: 9000 kg

**flow value**

- **SBS**: 2.5 mm
- **BITRACK**: 3 mm
- **RIAZAN**: 2.5 mm
- **RIAZAN+RUBIND**: 2 mm

**30% RARX modification**

*SHRP Corporation*
<table>
<thead>
<tr>
<th>Air Voids</th>
<th>Density</th>
<th>Samples iB0-1TA160iB0-1-H-C</th>
<th>Samples IB0-0.5STA160IB0-0.5HC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4 5 6 1 2 3</td>
<td>4 5 6 1 2 3</td>
</tr>
<tr>
<td>6.0</td>
<td>2414</td>
<td>7.0 6.5 6.3 8.1 7.0 7.5</td>
<td></td>
</tr>
<tr>
<td>5.9</td>
<td>6.8 6.9 5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.9</td>
<td>7.0 6.5 6.3 8.1 7.0 7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.8</td>
<td>6.9 5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.9</td>
<td>7.0 6.5 6.3 8.1 7.0 7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td>8.1 7.0 7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average: 705</td>
<td>Average: 639</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TSR: 90.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average: 814</td>
<td>Average: 594</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TSR: 73.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RAR X in GAP and THINGAP GRADED MIXES (about 30 to 40% of binder content....!!!)
RUTTING
### Table: Mix Properties

<table>
<thead>
<tr>
<th></th>
<th>B6.19RAR3.04</th>
<th>B5.45RAR3.78</th>
<th>B4.71RAR4.52</th>
<th>iBind</th>
<th>Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Voids</strong></td>
<td>4.3 3.9 4.7 5.6 5.3 5.4 6.0 6.7 3.9 4.9 4.1 4.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Density Gr/cm³</strong></td>
<td>2418</td>
<td>2446</td>
<td>2452</td>
<td>2547</td>
<td>2527</td>
</tr>
<tr>
<td><strong>Deformation at 120 min (mm)</strong></td>
<td>1.17 1.30 2.58 1.77 1.47 1.64 1.23 1.45 2.36 2.24 2.71 3.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AVG. Deformation at 120 min (mm)</strong></td>
<td>1.24 2.18 1.56</td>
<td>1.34</td>
<td>2.30</td>
<td>2.87</td>
<td></td>
</tr>
</tbody>
</table>

### Diagram: Rutting - Deformation (mm)

**120 min**

RAR MIXES RUT LESS THEN ANY OTHER MIX EVER TESTED
## Results of Laboratory Tests

<table>
<thead>
<tr>
<th>Slab</th>
<th>Bulk Specific Gravity (g.cm(^{-3}))</th>
<th>BMT</th>
<th>Porosity</th>
<th>Average Deformation Speeds (10(^3) mm.min(^{-3}))</th>
<th>Deformation (rutting) (mm)</th>
<th>Hours at 60°C</th>
<th>% of permanent deformation</th>
<th>% Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V35/46</td>
<td>V75/91</td>
<td>V105/121</td>
<td>120 min After Test</td>
<td>After Hours at 60°C</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>REACTED AND ACTIVATED RUBBER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>B6.19RA R3.04</td>
<td>2.314</td>
<td>4.3</td>
<td>7.5</td>
<td>6.0</td>
<td>5.5</td>
<td>1.17</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2.324</td>
<td>3.9</td>
<td></td>
<td></td>
<td></td>
<td>1.30</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Asphalt Rubber</td>
<td>2.305</td>
<td>4.7</td>
<td>12.8</td>
<td>6.5</td>
<td>5.8</td>
<td>2.58</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>18% Rubber</td>
<td>2.282</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td>1.77</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>SMA -0.4% iBind</td>
<td>2.253</td>
<td>6.2</td>
<td>19.0</td>
<td>9.8</td>
<td>8.2</td>
<td>3.06</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>5.2% Bitumen</td>
<td>2.401</td>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
<td>4.39</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>SMA - 0.4% Fibers</td>
<td>2.362</td>
<td>2.534</td>
<td>17.0</td>
<td>14.0</td>
<td>11.3</td>
<td>3.07</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>6.4% Bitumen</td>
<td>2.350</td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
<td>2.12</td>
<td>6</td>
</tr>
</tbody>
</table>

MIXES WITH HIGH RAR PERCENTAGE SHOW RECOVERY AFTER DEFORMATION

SHRP Corporation
MIXES WITH HIGH RAR PERCENTAGE SHOW RECOVERY AFTER DEFORMATION

- Just after testing at 60 C (rut 2.8 mm)
- A few minutes after testing and at room temperature already recovered back
- 24 hours after at room temp. about 24 C
- 48 hours later about 40% recovery
MIXES WITH HIGH RAR PERCENTAGE SHOW RECOVERY AFTER DEFORMATION

SHRP Corporation
FATIGUE
RAR MIXES HAVE BETTER FATIGUE LIFE THEN ANY OTHER MIX EVER TESTED

SHRP Corporation
Russian Bitumen

RAR MIXES HAVE BETTER FATIGUE LIFE THEN ANY OTHER MIX EVER TESTED

SHRP Corporation
THINGAP with RARX has incredible fatigue life !!!!
Torsional Device (30 Degrees)
y = 14.86x + 32.385
R² = 0.97

- Dense
- Dense RuBind
- Gap
- Gap RuBind
- Open
- Open RuBind
- SMA
- SMA RuBind
- ThinGap

% Recovery 35°C vs. % Crumb rubber
$R^2 = 0.9394$

**Graph:**

- **Y-axis:** Impedance (Z)
- **X-axis:** EXP (CR)*(AIR VOID)^2

Legend:
- Thingap RuBind
- SMA Fibers
- SMA RuBind
- OPEN - BMB
- OPEN 10.5% - RuBind
- GAP RuBind
- Gap BMB
- Dense
- Dense RuBind
- OPEN 10%- RuBind

Log. (Series11)
Demonstration Projects with RAR

- 2 in Russia (1 Dense and 1 Gap)
- 7 in Italy (3 Dense, 2 SMA, 2 Gap)
- 3 in Israel (1 SMA, 2 dense mix)
- 2 in France (2 SMA)
- 1 in Bulgaria (SMA)
- 3 in Sweden (3 THINGAP)
COMO, ITALY, Dec, 2014
FRANCE (dense graded 1.5% weight of mix)
Advantages of **RAR X**

(With GAP or THINGAP graded gradations)

- MORE RUT RESISTANT THEN ANY SMA MIX
- MORE FATIGUE LIFE THEN ANY ASPHALT RUBBER MIX
- IMPROVES NOISE REDUCTION

SHRP Corporation
Advantages of RAR X

✓ Easy storage and Easy transport.
✓ No need for AR blenders or SBS blenders
✓ Improve on asphalt and mix properties.
✓ Less energy spent in the production of Asphalt Rubber.
✓ No more Re-heat cycles on the job site.
✓ Can make new improved mixes with even more crumb rubber. Great fatigue and rutting resistance, great recovery, self healing.
✓ At other lower percentages can reach just about any PG grade (*positive side as negative side controlled by the base crude*).
✓ COST EFFECTIVE!!!
RAR X

• A product that can REPLACE and improve bitumen with great economical and environmental advantages

• Profitable business producing RAR X and selling it at 5% below normal bitumen prices
THANK YOU

Dr. Jorge B. Sousa
jbs@shrp.biz
Tm EU: +351 917549971
Tm USA: +1 925 206 0198

RARX™
Enhanced Elastomeric Asphalt Extender

SHRP Corporation