Summary

- **Sponsored by FHWA (~2006)**
  - Administered by NCPP
  - G. King – Program manager

- **Extensive PME literature review completed**
  - J. Johnston – NCPP – White paper

- **Deliverable – Proposed spec for PME’s**
  - Field projects – Central Bureau Fed Lands
  - Report-only data – BASF, PRI, Paragon
PME Specification Targets

- Low temperature recovery method
  - Preserves polymer morphology/structure
  - Requires Supplier Certification Program
- All residue testing completed on DSR
- Includes performance testing
  - Chip seal
  - Polymer-modified slurry
  - Micro surfacing
<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>SPEC</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Emulsion as Received</td>
<td>Standard AASHTO or ASTM tests:</td>
<td>AASHTO M-140 Emulsified Asphalt or AASHTO M-208 Cationic Emulsified Asphalt</td>
<td></td>
</tr>
<tr>
<td>Field Viscosity Test</td>
<td>WYDOT 538.0</td>
<td>Report</td>
<td></td>
</tr>
<tr>
<td><strong>Residue Recovery (24 hours @ 25°C, 24 hours @ 60°C, For ced Draft Oven)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 10% Strain)</td>
<td>HTG*</td>
<td>AASHTO T 315</td>
<td>Frequency Sweep (G*, δ, etc…)</td>
</tr>
<tr>
<td>Multiple Stress Creep Recovery (100, 1000, 3200 &amp; 10,000Pa)</td>
<td></td>
<td>TP 70-08</td>
<td>% Recovery &amp; Jnr at each stress level</td>
</tr>
<tr>
<td>Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 10% Strain)</td>
<td>HTG - 6°C</td>
<td>AASHTO T 315</td>
<td>Frequency Sweep (G*, δ, etc…)</td>
</tr>
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<td>Multiple Stress Creep Recovery (100, 1000, 3200 &amp; 10,000Pa)</td>
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</tr>
<tr>
<td>Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 10% Strain)</td>
<td>HTG -12°C</td>
<td>AASHTO T 315</td>
<td>Frequency Sweep (G*, δ, etc…)</td>
</tr>
<tr>
<td>Multiple Stress Creep Recovery (100, 1000, 3200 &amp; 10,000Pa)</td>
<td></td>
<td>TP 70-08</td>
<td>% Recovery &amp; Jnr at each stress level</td>
</tr>
<tr>
<td>Test Strain Sweep, 1 – 50% strain, 10 rad/s</td>
<td>25°C</td>
<td></td>
<td>• Resistance to Deformation: G*/sind @ 12% Strain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Strain Tolerance: Strain Level at which G* &lt; 90% G* initial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Failure Properties: Strain Level at which G* &lt;50% G* initial</td>
</tr>
</tbody>
</table>
# Strawman PME Specification Intermediate and Low T Testing

## Pressure Aging Residue (100°C, 300 psi, 20 hours) R 28
(PAV run on residue obtained by Forced Draft Oven Method run in PAV pan)

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Temperature</th>
<th>Strain or Stress Level</th>
<th>Report</th>
</tr>
</thead>
</table>
| Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 1% Strain) | HTG* | AASHTO T 315 | Frequency Sweep (G*, δ, etc…)
| Multiple Stress Creep Recovery (100, 1000, 3200 & 10,000Pa) | TP 70-08 | % Recovery & Jnr at each stress level |
| Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 1% Strain) | HTG - 6°C | AASHTO T 315 | Frequency Sweep (G*, δ, etc…)
| Multiple Stress Creep Recovery (100, 1000, 3200 & 10,000Pa) | TP 70-08 | % Recovery & Jnr at each stress level |
| Frequency Sweep (25 mm, 0.1 – 100 rad/sec, 1% Strain) | HTG -12°C | AASHTO T 315 | Frequency Sweep (G*, δ, etc…)
| Multiple Stress Creep Recovery (100, 1000, 3200 & 10,000Pa) | TP 70-08 | % Recovery & Jnr at each stress level |
| Frequency Sweep (8 mm, 0.1-100 rad/sec, % Strain (TBD)) | 0°C | AASHTO T 315 | Frequency Sweep (G*, δ, etc…)
| Frequency Sweep (8 mm, 0.1-100 rad/sec, % Strain (TBD)) | 10°C | AASHTO T 315 | Frequency Sweep (G*, δ, etc…)
| Frequency Sweep (8 mm, 0.1-100 rad/sec, % Strain (TBD)) | 20°C | AASHTO T 315 | Frequency Sweep (G*, δ, etc…)
| Test Strain Sweep, 1 – 50% strain, 10 rad/s | 25°C | | • Resistance to Deformation: G*/sind @ 12% Strain
| Bending Beam Rheometer | -12°C + -18°C | AASHTO T 313 | Stiffness + m-value
| | | | • Strain Tolerance: Strain Level at which G* < 90% G* initial
| | | | • Failure Properties: Strain Level at which G* <50% G* initial
### Performance tests for Chip Seals

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Method</th>
<th>Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweep Test</td>
<td>Modified ASTM D-7000</td>
<td>Report</td>
</tr>
</tbody>
</table>

### Performance tests for Polymer Modified Slurry Seals and Micro-Surfacing

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Method</th>
<th>Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal Surfaces</td>
<td>ISSA A105</td>
<td>ISSA</td>
</tr>
<tr>
<td>Recommended Performance Guidelines for Polymer Modified Micro-Surfacing</td>
<td>ISSA A143</td>
<td>ISSA</td>
</tr>
<tr>
<td>Tests recommended by Caltrans Slurry/Micro-Surface Mix Design Procedure Project /Contract 65A0151</td>
<td>TBD</td>
<td></td>
</tr>
</tbody>
</table>

* High Temperature Performance Grade as selected for local climate (LTPPBind version 3.1)
Central Bureau Fed Lands Projects Strawman – Report-Only Data

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
<th>System(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utah Parks</td>
<td>September, 2008</td>
<td>Chip Seal - CRS-2P (SBR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Micro Surfacing (NRL, Ralumac)</td>
</tr>
<tr>
<td>Dinosaur Natl. Monument</td>
<td>September, 2008</td>
<td>Chip Seal - PASS - CRS-2P (Latex)</td>
</tr>
<tr>
<td>Death Valley</td>
<td>November, 2008</td>
<td>Chip Seal (SBR, SBS?)</td>
</tr>
<tr>
<td>Crater Lake</td>
<td>Spring 2009</td>
<td>Chip Seal (TBD)</td>
</tr>
</tbody>
</table>

Testing Labs (Third Party + Industry):

- PRI Asphalt Technologies, Inc (Tampa, FL)
- Paragon Technical Services, Inc. (Richland, MS)
- BASF Corporation (Charlotte, NC)
Emulsions 101
Polymer-Modified Emulsions for Surface Treatments

RMPPP Meeting
October 29, 2008

Chris Lubbers
Sr. Technical Service Engineer
BASF Corporation
(704) 587-8145
christopher.lubbers@basf.com
Outline

- Asphalt emulsion primer
- What are polymers?
- Why polymers for asphalt emulsions?
- Modification of asphalt emulsions
- Polymer networks in asphalt emulsions
- Impact on performance + properties
Asphalt Emulsions - Formulation

### Components
- Asphalt
- Surfactant (surface active agents, emulsifiers)
- Water
- Mechanical energy (colloid mill)

### Other Ingredients
- Additives (calcium chloride, cutback agents, …)
- Modifiers – *Polymers*
Dispersion of asphalt in water

- Water – continuous phase
- Asphalt – non-continuous or dispersed phase
  - Stabilized by surfactant

Surfactant emulsion class.

- Cationic
- Anionic
- Nonionic
Asphalt Droplets

Volume %

Particle Size, µm
What are Polymers?

- Comprised of many small molecules
  - Poly = many
  - Monomers = small molecules or repeat units

- Monomers chemically react → larger molecules
  - Water-based polymers – latex form (SBR, NRL)
  - Solvent-based polymers – pellets, bale (SB-, SBS)

- Properties are determined by:
  - Types and sequence of monomers
  - Molecular weight
Polymer Types for Asphalt Mod.

- **SBR Latex** – Chip Seals, Slurry and Micro Surfacing
- **SB/SBS** – Chip Seals
- **Natural Rubber Latex** – Ralumac (Micro Surfacing)
- **Other** – Neoprene, EVA, GTR (REAS), Fibers
- **Hot-Applied Chip Seal** – GTR and/or SB/SBS
Typical Monomers

Styrene

Butadiene

Isoprene (NR)
Viscoelastic Behavior
Cured Latex Modified Asphalt Emulsion

- \( G^* = f(T) = \text{deform. resist.} \)

### Asphalt
- High \( G^* \) at low \( T \) – brittle
- Low \( G^* \) at high \( T \) – viscous
- \( \Delta G^*(80^\circ C - 20^\circ C) = 1000 \times \)

### SBR Polymer
- Lower \( G^* \) at low \( T \) – flexible
- Higher \( G^* \) at high \( T \) – elastic
- \( \Delta G^*(80^\circ C - 20^\circ C) = 10 \times \)
Polymer Modification of Asphalt Emulsions

- Emulsify polymer modified asphalt
  - “Pre-modified” emulsion
  - Polymers – SBS, SB-
  - Higher mod. asphalt viscosity
    - higher asphalt + mill temp.
  - Exit temp. > 100°C
  - Heat exchanger, back press.

- Polymer inside asphalt droplet
Polymer Modification of Asphalt Emulsions

- **Add latex external to asphalt**
  - Methods
    - soap batching
    - co-milling – asphalt line
    - co-milling – soap line
  - Polymers – SBR, NR latex
  - Lower asphalt process T
  - No special mill, handling
- **Polymer in water phase**
  - Continuous polymer film formation on curing
Latex Polymer-Modified Asphalt Emulsion

- Optimum for Fine Polymer Network Formation
Chip Seal – Field Application
Chip Seal Surface Treatment

Near Taos, NM
### CRS-2 vs. CRS-2P(LM) – Physical Props.

<table>
<thead>
<tr>
<th>Test Method</th>
<th>CRS-2</th>
<th>CRS-2P</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;B Softening Point (°F)</td>
<td>ASTM D 36</td>
<td>115</td>
</tr>
<tr>
<td>Ductility (4°C, cm)</td>
<td>ASTM D 113</td>
<td>21</td>
</tr>
<tr>
<td>Elastic Recovery (10°C, %)</td>
<td>AASHTO T 301</td>
<td>5</td>
</tr>
</tbody>
</table>

**3 wt.% SBR latex polymer (on asphalt)**

- **Residue**
  - ASTM D 6934 - Oven evaporation at 163°C

- **Polymer**
  - Raises SP, drastically increases ductility and ER
Sweep Testing – CRS-2P vs CRS-2
ASTM D7000 - 04
Chip Seal with Latex Modified CRS

- Latex polymers accumulate at optimum location
  - Act to glue aggregate together!!!
Curing of CRS-2LM Emulsion

- Water in asphalt emulsion wicks the aggregate surface.
  - Order of migration = Water, latex particles, asphalt droplets
Latex Polymer Distribution – Unstable CRS-2L Emulsion

- Latex particles migrate together with water???
  - Polymer rich regions around aggregate = NO
Latex Polymer Distribution – Stable CRS-2L Emulsion

- Latex particles migrate together with water!
  - Polymer rich regions around aggregate = YES
Micro Surfacing Operation

1 min < Mix Time < 3 min

Cohesion Development < 1 hr
Micro Surfacing – High ADT + ESAL’s

Paved in Oct. 2001
Photo from Sept. 2003
**Micro Surfacing Mix Formulation**

- **Blade Coating Operation**
  - 2 m wide + <1 cm thick
  - 4-5 km/hour
  - Traffic within 1 hour

- **Latex Polymer Binds**
  - Asphalt
  - Fines to Aggregates

Latex Polymer = 3% of Asphalt
Micro Surfacing – Polymer Morphology Field Application

Texas State Highway 84
- Near Waco, TX
- Paved in 1998
- Samples taken in 2001
Cured Latex Polymer Network

Micro Surfacing

Latex Foam
SBR latex polymer

- 50% reduction in loss
  - one hour soak
- 67% reduction in loss
  - six day soak

- Surface of mix
  - tougher
  - more abrasion res.

- Adhesion + water resistance
  - improved
Micro Surfacing Residue – SHRP Grade

- Emulsion Only
- Emulsion + Cement
- Emulsion + Cement + SBR Latex

Rutting resistance temperature, °C vs. Curing Time, day

Phase Angle at G* sin(δ) = 1 kPa, degree

30 days Cured

Emulsion only + Cement + 3% Latex
Summary – Polymer Modified Emulsions

- **Chip seals**
  - Early and long term chip retention
  - High temperature strength
  - Low temperature flexibility

- **Slurry seal and micro surfacing**
  - Improved mix cohesion
  - Reduction in abrasion loss of aggregate
  - Resistance to deformation