Slurry Seal and Micro Surfacing Systems
Definition of an emulsion

An emulsion is a homogeneous mixture of two immiscible liquids.

- **Immiscible liquids:**
  - Liquids that normally don’t mix
    - Oil (or, in our case, asphalt) and water

- **Homogeneous:**
  - Mixture must have the same composition, throughout
  - No layering
Example: Salad dressing

Not an emulsion

Unstable emulsion
Roles of the emulsifier

- Imparts stability
  - Prevents layers from forming

- Imparts charge
  - Cationic vs. Anionic (Positive vs. Negative)

- Imparts mixing and curing characteristics
  - Slow Set vs. Quick Set
Cationic emulsifier structure

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2
\end{align*}
\]

\[
\begin{align*}
\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2
\end{align*}
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\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2
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\begin{align*}
\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2
\end{align*}
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\[
\begin{align*}
\text{NH}_2\text{CH}_2\text{CH}_2
\end{align*}
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\[
\begin{align*}
\text{NH}_2\text{CH}_2\text{CH}_2
\end{align*}
\]

\[
\begin{align*}
\text{NH}_2\text{CH}_2\text{CH}_2
\end{align*}
\]
Cationic emulsifier structure

Head group: Polar, water loving (or hydrophilic)
Cationic emulsifier structure

Head group: Polar, water loving (or hydrophilic)
Cationic emulsifier structure

Tail group: Hydrocarbon, oil loving (or lipophilic)

Head group: Polar, water loving (or hydrophilic)
Cationic emulsifier structure

Tail group: Hydrocarbon, oil loving (or lipophilic)

Head group: Polar, water loving (or hydrophilic)
Emulsion production

Soap Solution → Colloid Mill → Asphalt → Emulsion
Inside the colloid mill

Rotor

Mill gap
1 mm (0.039”)
OR
1000 microns

5 micron asphalt droplet

Stator
Polymer in micro emulsions:

Latex

- Add latex external to asphalt
  - Methods
    - Add to soap batch
    - Co-milling – soap line
    - Co-milling – asphalt line
  - Polymers – SBR, natural latex
  - Lower asphalt process temp.
  - No special mill, handling
- Polymer in water phase
- Continuous polymer film formation on curing
Polymer in micro emulsions: SBS

- Add SBS to the asphalt before milling (produce the emulsion with PMA base)
  - Polymers – SBS
  - PMA production requires special mill for production
  - PMA requires high process temperature
    - Emulsion plant needs a heat exchanger

- Polymer in asphalt phase
  - Stiffer residue may lead to slower film formation/curing
  - Softer starting base may mitigate that issue
Benefits of adding latex

- SBR latex polymer
  - Mixture
    - Tougher surface
    - More resistant to abrasion
    - Improved adhesion and water resistance
  - Data
    - One-hour soak
      - 50% reduction in loss
    - Six-day soak
      - 67% reduction in loss

![Graph showing loss comparison between unmodified and SBR after 1 hour and 6 days.](image-url)
Aggregate charge

Limestone
Dolomite

Granite
Basalt

pos.
0
negative
The chemistry of mix time
- Add retarder to the mix
- Increase emulsifier dosage in the emulsion
Chemical break
Residue – Latex modified vs. polymer modified

Dried emulsion residues (coalesced asphalt particles)

Neat asphalt

Latex modified emulsion

Asphalt rheology only

Improved binder properties
• Improved low temperature fatigue properties
• Reduced rutting at high temperature
• Improved early strength development
Latex morphology

Texas State Highway 84
Near Waco, TX
• Paved in 1998
• Samples taken in 2001
Mineral filler chemistry

Two Competing Reactions

\[ \text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O} \]

Cement (or lime) reacts with acidic emulsion

\( \text{CaCl}_2 \) is formed - Calcium ions stabilize the system

More stable system mixes longer

The Other Reaction = Chemical Break

Cement (or lime) has high pH - When combined with acidic emulsion having a low pH - System is destabilized

Destabilized systems break
Factors that affect curing

- Water content
  - More in → More out → Longer cure time

- Mix time
  - More stable emulsion → More mix time → Longer cure time

- Emulsion pH

- Particle size of the emulsion
Emulsion pH and curing

- Siliceous aggregate systems
  - Negatively charged aggregates
    - Granite, trap rock, basalt

Emulsion pH $\rightarrow$ Faster cure rates
Siliceous aggregates:
Lower emulsion pH $\rightarrow$ Faster cure rate
Siliceous aggregates:
Lower emulsion pH → Faster cure rate
Emulsion pH and curing

- Calcareous aggregate systems
  - Positively charged aggregates
    - Limestone, dolomite

Emulsion pH → Faster cure rates

\[ \text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O} \]

**Limestone** reacts with **acidic emulsion**

**CaCl}_2 is formed** - Calcium ions stabilize the system

Reducing the acid, reduces the stabilizing effect - Speeds the cure rate
Emulsion particle size and curing

- Smaller particle size emulsions
  - Faster cure time

- Target particle sizes
  - Average ~ 4-6 microns
  - 90% less than 7-8 microns

- Tight particle size distribution
  - Narrow bell-shaped curve
Particle size distributions

**Very small**
- $mv = 2.8$
- $90\% < 4.0$

**Larger than target**
- $mv = 8.1$
- $90\% < 17.7$
## Micro surfacing testing summary

<table>
<thead>
<tr>
<th>Test</th>
<th>ISSA TB No.</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix Time @ 77°F, seconds</td>
<td>113</td>
<td>120 minimum</td>
</tr>
<tr>
<td>Wet Cohesion, kg-cm</td>
<td>139</td>
<td>12 minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 minimum or Near Spin</td>
</tr>
<tr>
<td>Wet Stripping, %</td>
<td>114</td>
<td>Pass (90% minimum)</td>
</tr>
<tr>
<td>Wet-Track Abrasion Loss, g/ft²</td>
<td>100</td>
<td>50 maximum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75 maximum</td>
</tr>
<tr>
<td>Lateral Displacement, %</td>
<td>147</td>
<td>5 maximum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.10 maximum</td>
</tr>
<tr>
<td>Specific gravity after 1,000 Cycles of 125 lb.</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Excess Asphalt by LWT Sand Adhesion, g/ft²</td>
<td>109</td>
<td>50 maximum</td>
</tr>
<tr>
<td>Classification Compatibility, Grade Points</td>
<td>144</td>
<td>11 minimum</td>
</tr>
</tbody>
</table>
Application equipment

#1: Aggregate
#2: Fines Feeder
#3: Water (and additive)
#4: Emulsion
Mix time test – ISSA TB 113

- **Purpose**
  To measure the amount of time a specific combination of materials will mix before breaking

- **Importance**
  Sufficient mix time will ensure the contractor has the time needed to apply the mixture and complete hand work before the mix breaks.
Cohesion test – ISSA TB 139

- **Purpose**
  To determine initial set and cure development of slurry surfacing systems as a function of torque over time

- **Importance**
  This test will give the buyer agency an idea of when traffic may be returned to the pavement under given curing conditions.
Wet track abrasion test
ISSA TB 100

- **Purpose**
  To measure the wearing qualities of slurry surfacing systems under wet abrasion conditions

- **Importance**
  This test is used to determine the minimum residual binder content needed to hold the system together.
Lateral displacement & Sand adhesion - ISSA TB 147 & 109

**Purpose**

To measure the rut resistance and/or flushing potential of slurry surfacing systems under simulated rolling traffic

**Importance**

This test is used to determine the maximum residual binder content a slurry surfacing system can support without rutting and/or bleeding.
Thank you!

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