Chapter 8
Slurry Seals

From… Maintenance Technical Advisory Guide (MTAG)
Managers’ Overview

From… Maintenance Technical Advisory Guide (MTAG)
Slurry Seals

- What are slurry seals?
- Why use slurry seals?
- Where to use slurry seals?
- When to use slurry seals?
What is Slurry Seal?

- A thin maintenance treatment
- A mixture of:
  - asphalt emulsion
  - graded aggregates
  - mineral filler
  - water
  - Additives

- When placed on the pavement surface the mixture breaks and cures creating a new wearing surface.

Chapter 8 – Slurry Seals
Why Use Slurry Seals?

- Cost Effective
- Benefits:
  - minimize oxidation/ageing
  - reduce water infiltration
  - provide skid resistance
  - improve aesthetics
  - correct raveling and weathering
- Average performance life: 3 to 5 years
Where to Use?

- Hot Mix Asphalt Pavements:
  - Roadways (All traffic levels)
  - Parking Lots
  - Taxiways and Runways
  - Bridges and Over-Crossings

- Geographic Regions/Climate Zones:
  - All throughout California

Cape Seal (Slurry over Chip Seal)

Chapter 8 – Slurry Seals
When to Use?

- To correct/improve:
  - raveling and weathering
  - loss of frictional properties
  - aesthetics

- To prevent/reduce:
  - ageing/oxidation of asphalt concrete
  - surface water infiltration
  - pavement degradation due to the elements
When **NOT** to Use?

- On pavements with structural defects:
  - Alligator Cracking
  - Rutting
  - Bumps and Depressions
  - Potholes
- Nighttime construction
# Slurry Seal Vs. Microsurfacing

<table>
<thead>
<tr>
<th>Differences in:</th>
<th>MICROSURFACING</th>
<th>SLURRY SEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Emulsion</td>
<td>always polymer modified, quick set</td>
<td>could be polymer modified</td>
</tr>
<tr>
<td>Aggregate Quality/Gradation</td>
<td>stricter spec. for sand equivalent; use only Type II and Type III</td>
<td>Can use Type I, II or III</td>
</tr>
<tr>
<td>Additives/Break</td>
<td>chemical break largely independent of weather conditions</td>
<td>breaking and curing dependent on weather conditions</td>
</tr>
</tbody>
</table>

Chapter 8 – *Slurry Seals*
# Slurry Seal Vs. Microsurfacing

<table>
<thead>
<tr>
<th>Differences in:</th>
<th>MICROSURFACING</th>
<th>SLURRY SEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix Stiffness/Equipment</td>
<td>stiffer mix, use augers in the spreader box and secondary strike-off</td>
<td>softer mix, use drag box</td>
</tr>
<tr>
<td>Applications</td>
<td>same as slurry seal + rut filling, night work, correction of minor surface profile irregularities</td>
<td>correct raveling, seal oxidized pavements, restore skid resistance</td>
</tr>
</tbody>
</table>
Module 8-1

Design, Materials & Specifications

From… Maintenance Technical Advisory Guide (MTAG)
Slurry Seal Design

- Design Process
- Specification
- Materials
- Laboratory Tests
Mix Design Process

- Pre-screen materials
- Check materials compatibility
- Try different mixing proportions
- Prepare mixes at a range of emulsion contents
- Check for cohesion build-up
- Check for abrasion resistance
- Check for sand adhesion
- Select optimum emulsion content
- Test proposed mix to meet specification requirements

Chapter 8 – Slurry Seals
Specification

- Caltrans
  - 2006 Standard Specifications, Section 37-2 Slurry Seal
- International Slurry Surfacing Association (ISSA):
  - A105 (2005) Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal
- ASTM:
    - [http://www.astm.org](http://www.astm.org)

Chapter 8 – Slurry Seals
Materials

- Asphalt Emulsion
- Aggregate
- Mineral Filler
- Water
- Additives
Asphalt Emulsion

- **Type/Grade**
  - Anionic/Quick Set (QS-1h)
  - Cationic/Quick Set (CQS-1h)

- **Specification**
  - CALTRANS 2006 Standard Specifications Section 94

- **Notes**
  - Could be polymer-modified, CALTRANS standard specification for PMCQS not available at this time

Chapter 8 – Slurry Seals
## Asphalt Emulsion - Tests

<table>
<thead>
<tr>
<th>Tests on Emulsion</th>
<th>Typical Specification (CQS1h)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity, SSF @ 50°C, sec</td>
<td>15 – 90</td>
<td>AASHTO T 59</td>
</tr>
<tr>
<td>Sieve Test, %</td>
<td>&lt; 0.30</td>
<td>AASHTO T 59</td>
</tr>
<tr>
<td>Settlement, 5 days, %</td>
<td>&lt; 5</td>
<td>ASTM D 244</td>
</tr>
<tr>
<td>Storage Stability, 1 day, %</td>
<td>&lt; 1</td>
<td>AASHTO T 59</td>
</tr>
<tr>
<td>Residue by Distillation, %</td>
<td>&gt; 57</td>
<td>California Test 331</td>
</tr>
<tr>
<td>Particle Charge</td>
<td>Positive</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tests on Residue from Distillation Test</th>
<th>Typical Specification</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration, 25°C</td>
<td>40 – 90</td>
<td>AASHTO T 49</td>
</tr>
<tr>
<td>Ductility, 25°C, mm</td>
<td>&gt; 400</td>
<td>AASHTO T 51</td>
</tr>
<tr>
<td>Solubility in trichloroethylene, %</td>
<td>&gt; 97</td>
<td>AASHTO T 44</td>
</tr>
</tbody>
</table>

---

Chapter 8 – Slurry Seals
## Aggregate - Gradations

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 in (9.5mm)</td>
<td>-</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>100</td>
<td>94-100</td>
<td>70-90</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>90-100</td>
<td>65-90</td>
<td>45-70</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>60-90</td>
<td>40-70</td>
<td>28-50</td>
</tr>
<tr>
<td>No. 30 (600-µm)</td>
<td>40-65</td>
<td>25-50</td>
<td>19-34</td>
</tr>
<tr>
<td>No. 200 (75-µm)</td>
<td>10-20</td>
<td>5-15</td>
<td>5-15</td>
</tr>
</tbody>
</table>

Chapter 8 – Slurry Seals
Chapter 8 – Slurry Seals

Slurry Surfacing Systems Aggregate Gradations

- Type I Min
- Type I Max
- Type II Min
- Type II Max
- Type III Min
- Type III Max

Percent Passing vs. Sieve Size (mm)
# Aggregate - Quality

<table>
<thead>
<tr>
<th>Test</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Equivalent (min)</td>
<td>45</td>
<td>55</td>
<td>60</td>
<td>CT 217</td>
</tr>
<tr>
<td>Durability Index (min)</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>CT 229</td>
</tr>
</tbody>
</table>

- Other aspects of interest:
  - Geology
  - Shape
  - Texture
  - Age and Reactivity
  - Cleanliness

Chapter 8 – Slurry Seals
Mineral Filler

- Portland cement, hydrated lime, limestone dust, fly ash or other approved filler meeting the requirements of ASTM D242
- Considered part of the dry aggregate
- Mixing aid, improves cohesion, absorbs water from the emulsion causing it to break faster after placement

Chapter 8 – Slurry Seals
Water

- Water should be of such quality that the asphalt will not separate from the emulsion before the slurry seal is placed.
Additives

- Emulsifier solutions, aluminum sulfate, aluminum chloride, borax
- Generally act as retardants, useful when temperatures rise during the day
Mixing Properties

- ISSA TB 102 (Mixing Test)
  - Determine approximate proportions of component materials by trying different “recipes”
  - The amount of time the slurry can be mixed and retain its homogenous consistency is recorded (mixing time)
  - Foaming and coating are visually assessed
  - The test can be performed at expected field humidity and temperature conditions
  - Select the proportions that results in mixing times over 180 seconds and good coating over the range of humidity and temperature condition expected at placement

Chapter 8 – Slurry Seals
Cohesion Build-Up

- ISSA TB 139 (Modified Cohesion Test)
- Fabricate 3 test specimens:
  1. At selected emulsion content
  2. -2% emulsion content
  3. +2% emulsion content
- Determine the build-up of cohesion with time
- Differentiate between “Quick Set” and “Slow Set”; “Quick Traffic” and “Slow Traffic” mixes

Chapter 8 – Slurry Seals
Cohesion Build-Up

Chapter 8 – Slurry Seals
Abrasion Loss

- ISSA TB 100 (Wet Track Abrasion Test)
- Fabricate 3 test specimens:
  1. At selected emulsion content
  2. -2% emulsion content
  3. +2% emulsion content
- Cure specimens for 16 hrs, than soak for 1 hr
- Determine abrasion loss under water
- Plot abrasion loss versus emulsion content

Chapter 8 – Slurry Seals
Sand Adhesion

- **Fabricate 3 test specimens:**
  1. At selected emulsion content
  2. -2% emulsion content
  3. +2% emulsion content

- **ISSA TB 109 (Loaded Wheel Test)**
  - Measure increase in weight of the specimen due to sand adhesion
  - Plot sand adhesion versus emulsion content

Chapter 8 – Slurry Seals
Emulsion Content Selection

Chapter 8 – Slurry Seals
## CALTRANS Specification Requirements

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency</td>
<td>ISSA TB 106</td>
<td>&lt; 1.2 in.</td>
</tr>
<tr>
<td>Wet Stripping</td>
<td>ISSA TB 114</td>
<td>Pass</td>
</tr>
<tr>
<td>Compatibility</td>
<td>ISSA TB 115</td>
<td>Pass</td>
</tr>
<tr>
<td>Cohesion, 1 hr.</td>
<td>ISSA TB 139</td>
<td>&gt; 200 kg-mm</td>
</tr>
<tr>
<td>Wet Track Abrasion Loss</td>
<td>ISSA TB 100</td>
<td>&lt; 800 g/m²</td>
</tr>
</tbody>
</table>

Chapter 8 – Slurry Seals
Final Notes

- Design is generally performed by outside laboratory, Caltrans will only review and accept
- Designer needs to have extensive experience with slurry systems
Slurry Seal Construction

- Project Selection
- Applications
- Safety and Traffic Control
- Equipment
- Construction
- Quality Control
- Troubleshooting
- Field Considerations

Chapter 8 – Slurry Seals
Project Selection

- A pavement preservation treatment: protect the pavement before distresses appear
- Can correct: raveling, oxidized pavement, friction loss
- Cannot correct: rutting, cracking, base failures, any structural deficiencies
- When applied correctly, it may increase pavement life by 3 – 5 years
## Distress Conditions

### Pavement Distress

<table>
<thead>
<tr>
<th>Condition</th>
<th>Slurry*</th>
<th>Micro*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface cracking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early longitudinal</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hairline</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Full depth cracking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal or Transverse</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fatigue or Alligator</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Reflective</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Late longitudinal</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slippage (tack failure)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Corrugation or Shoving (wash boarding)</td>
<td>-</td>
<td>X</td>
</tr>
</tbody>
</table>

Chapter 8 – **Slurry Seals**
Distress Conditions (cont.)

<table>
<thead>
<tr>
<th>Pavement Distress</th>
<th>Slurry*</th>
<th>Micro*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound base</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Unsound base</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Raveling</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bleeding</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Polishing (loss of skid resistance)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Patched pothole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pavement patch only</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Base repaired patch</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Loss of profile (crown, edge, etc.)</td>
<td>-</td>
<td>X</td>
</tr>
</tbody>
</table>

Chapter 8 – Slurry Seals
# Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Aggregate Type I</th>
<th>Aggregate Type II</th>
<th>Aggregate Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Void Filling</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Wearing Course AADT &lt; 100</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Wearing Course AADT &lt; 1,000</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Wearing Course AADT &lt; 20,000</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Minor Shape Correction 0.4 – 0.8 inch (10 – 20 mm)</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Application Rates in lbs of dry aggregate per square yard</td>
<td>8 - 12</td>
<td>10 - 15</td>
<td>20 - 25</td>
</tr>
</tbody>
</table>
Safety and Traffic Control

- Ensure that the slurry surfacing has had adequate time to cure prior to reopening to traffic - very often drivers assume that the slurry surfacing is drivable despite of the warning signs and cause damage to the fresh placed treatment
- Notify the residents and provide information on how to accommodate the construction activities
- Protect both employees and public
- Have signs/barricades in place before commencing work

Chapter 8 – Slurry Seals
Equipment

- Requirements covered in Caltrans Standard Specification Section 37
- Types:
  - Continuous, self propelled unit
  - Truck-mounted unit
- All equipment should be properly calibrated as per CT 109

Chapter 8 – Slurry Seals
Typical Setup

Chapter 8 – Slurry Seals

1. Aggregate Bin
2. Filler Bin
3. Aggregate Flow Gate
4. Aggregate Conveyor Belt
5. Emulsion Injector
6. Water Injector
7. Pugmill
8. Slurry
9. Spreader Box

[Image of typical setup diagram]
Surface Preparation

- Restore pavement structural integrity and functional performance characteristics:
  - Patching
  - Crack sealing
- Clean pavement surface
  - Sweeping or High Power Pressure Washing
  - Remove rubber crack sealant and thermo-plastic markings
  - Cover utility inlets with heavy paper or roofing felt

Chapter 8 – Slurry Seals
Utility Inlets

BEFORE

AFTER

Chapter 8 – Slurry Seals
Application Conditions

- Humidity: 60% or less
- Temperature: 50°F (10°C) and rising
- Wind: slight breeze beneficial
- Sunlight: necessary, DO NOT apply at night
- DO NOT start work if:
  - Rain is imminent
  - Freezing anticipated within 24 hours

Chapter 8 – Slurry Seals
Starts/Stops

- All starts, stops, and handwork on turnouts should be done on roofing felt to ensure sharp, uniform joints and edges
Longitudinal Joints

- May be overlapped or butt jointed
- Should be straight or curve with the traffic lane
- Overlaps should not be in the wheel paths and should not exceed 3 in (75 mm) in width
- Typically 3 passes required on a 2-lane roadway
Transverse Joints

- Transitions at these joints must be smooth to avoid creating a bump in the surface.
- The joints must be butted to avoid these bumps and handwork should be kept to a minimum.
- Do not over wet - this leads to poor texture and scarring at the joints.
- Start transverse joints on roofing felt to eliminate these problems.

Chapter 8 – Slurry Seals
Transverse Joints Examples

GOOD QUALITY

POOR QUALITY

Chapter 8 – Slurry Seals
Edges and Shoulders

- The edge of the spreader box should be outside the line of the pavement
- Edge boxes should be used when shoulders are covered
Edges and Shoulders Examples

GOOD QUALITY

POOR QUALITY

Chapter 8 – Slurry Seals
Uneven Mix and Segregation

- Non-uniform mixes that appear to be setting very slowly
- Black and flush looking surface with poor texture
- “False Slurry” - where the emulsion breaks onto the fine material
- Causes: too much water or not enough cement
- Result: segregation and delamination

Chapter 8 – Slurry Seals
Smoothness

- Washboarding – mix too stiff or spreader box incorrectly set up
- Drag marks – dirty strike-off
- Original surface too rough
Premature Opening to Traffic

- The slurry seal must build sufficient cohesion to resist abrasion due to traffic. Otherwise, it will ravel off quickly, particularly in high stress areas.
- Early stone shedding is normal, but should not exceed 3%.
- General rule of thumb for a slurry seal is that it can be opened to traffic when it has turned black.

Chapter 8 – Slurry Seals
Post-Construction Treatments

- **Rolling** with pneumatic rollers may be incorporated to limit the amount of stone loss.
- **Sweeping** should be done just prior to opening to traffic and at periods determined by the level of stone loss to avoid windshield damage.
- **Sanding** may be used to reduce the times that cross streets or intersections are closed.
Post-Construction Conditions

- Heavy traffic coupled with heavy rain within hours of placement will most likely damage the slurry surfacing.
- Freezing weather within 2 weeks of placement may cause the water in the system to freeze and damage the slurry surfacing.
Troubleshooting

- Problems addressed:
  - Brown Mix, Whitish Mix
  - Mix Won’t Set
  - Poor Coating
  - Delayed Opening to Traffic
  - Mix Breaks in Spreader Box
  - Mix Ravels
  - Mix Flushes
  - Delamination
  - Segregation
  - Uneven surface, Washboarding
  - Poor joints

Chapter 8 – Slurry Seals
Field Considerations

- See Tables in MTAG, Volume I, 2nd Edition
- Project Responsibilities
  - Project Review
  - Document Review
  - Materials Checks
- Pre-Seal Inspection Responsibilities
  - Surface Preparation

Chapter 8 – Slurry Seals
Field Considerations (Cont’d)

- **Equipment Inspection**
  - Sweeping
  - Slurry Seal Unit (Truck Mounted or Continuous)
  - Rollers
  - Stockpile

- **Site Considerations**
  - Weather requirements
  - Traffic Control

- **Application Considerations**
  - Application Rates

Chapter 8 – **Slurry Seals**
Field Considerations (Cont’d)

- Project Inspection
  - Slurry Surfacing
  - Rolling
  - Truck Operation
  - Longitudinal Joints
  - Transverse Joints
  - Sweeping
  - Opening to Traffic
  - Clean Up
Thank You

Questions?

Chapter 8 – Slurry Seals