Outline Guide Design Procedure for Slurry Seal

The following guide is presented to aid designers of Slurry Mixes and contains excerpts from papers presented by Huffman, Benedict, Gordillo and others at the ISSA World Congress in Madrid and at the AEMA convention in Phoenix, February 1977. Tests to be used may be selected by the check list provided. Limits or values to each test must be established by the designer or engineer.

Part 1
Preliminary Design Considerations
1. Describe the Pavement to be treated
   a. Surface condition—macrotexture, absorbivity, surface and structural cracks, surface contamination, longitudinal and transverse geometry, rutting, vegetation.
   b. Climate and weather conditions - temperature, rainfall, shade, wind
   c. Average Daily Traffic (ADT), speed limits
2. State Objectives of the Treatment
   a. Skid numbers required, surface macrotexture
   b. Sealing, raveling correction, crack filling, wedging, rut correction, preparation for overlay, slipperiness correction, etc.
   c. Life expectancy requirements
3. Evaluate and Select Materials
   a. Evaluation of proposed Aggregate
      1. Field Durability record
      2. Skid Resistance Level (SRL), polish susceptibility
      3. Gradation, void content, quality of fines, sand equivalent, particle shape microtexture
      4. Mechanical properties resistance to mechanical abrasion, L.A. Rattler Shaker loss, British Wheel abrasion, hardness, crush resistance, freeze-thaw, friability
      5. Chemical properties acid insolubility, sodium sulfate soundness, water solubility
      6. Mineralogy/petrology, geology
      7. Economics—location, availability, transportation, cost
   b. Select Aggregate and Gradation to Meet Objectives
   c. Evaluation of proposed Emulsion
      1. Field Durability record
      2. Base asphalt source and type-oxidation/hardening resistance
      3. Emulsion particle size-stability, shear sensitivity, sieve
      4. Climate/penetration- viscosity requirements
      5. Weather-shade, sun, wind, ice, salt, traffic time required
      6. Quick-set/slow-set requirements
      7. Compatibility/adhesion characteristics of the aggregate-filler-retard-accelerator system, re-emulsification

Part 2
Job Mix Formula Procedures
1. Estimate the Theoretical Pure Asphalt Requirements (PAR) or Bitumen Requirement (BR) by Surface Area Method for an 8μm coating
   a. Aggregate Sand Equivalent
   b. Aggregate Apparent Specific Gravity
   c. Aggregate Gradation (dry sieving)
   d. Aggregate Centrifuge Kerosene Equivalent
   e. Calculate Total Surface Area
   f. Emulsion percent asphalt residue
   g. Calculate the theoretical PAR/BR for an 8μm thickness coating of the calculated surface area and record as:
      1. Percent asphalt added to dry weight of aggregate
      2. Percent emulsion added to dry weight of aggregate @ % asphalt residue
      3. Percent asphalt of total dry solids
2. System Compatibility Determination
   a. Estimate filler/additive requirements
      1. Run 100-gram trial cup mixes using 100% PAR to estimate optimum water content, filler requirement and mix-set-traffic/cure time characteristics (ISSA TB #102)
      2. Adjust PAR for added filler if required
   b. Cone Consistency Test run to obtain 2.5 centimeter consistency, ISSA TB #106
      1. Determine optimum mix-water content for three levels of emulsion content, e.g., 100%, 85%, 70% PAR for 2.5cm consistency
      2. Adjust filler content, mix-water content and PAR for changes in mix-set-traffic time if required
      3. Construct 3-point consistency/mix-water curve for consistency ranges of 2-3 cm., 4-5 cm., and 6–7 cm. ranges for each of the three PAR levels selected. Air dry at ambient and save each specimen.
   c. Compatibly Test
      1. Examine cross-sections of centrally split consistency specimens for evidence asphalt or aggregate migration or existence of excessively sticky surfaces.
2. If suspicious disuniformity is observed, run Cup Compatibility Test
   a. Mix 100 grams of each formulation in a small, plastic-lined drinking cup, cure in the cup for 12 hours. Separate into upper and lower halves, dry, run asphalt extraction by reflux and split median gradation of extracted aggregate. Substantial variation (10 to 15%) from top and bottom halves indicates and incompatible system.

3. Wet Stripping Test-10 grams cured slurry in 400 ml. Moderately boiling water for 3 minutes. Decant and place on absorbent paper towel. Low asphalt retention can indicate lack of adhesion, low film coalescence, poor emulsion formulation, re-emulsification or possible false slurry.

3. Traffic/Cure Time by Slurry Cohesion tester
   a. Mix and set time by ISSA TB #102 at job temperature conditions
   b. Traffic Time by Slurry Cohesiometer at job temperatures, e.g. 50°(10°), 80°(26.7°), and 110°F(43.3°C) or 60°(15.6°), 80°(26.7°), 100°F(37.8°C). (Proposed ASTM D04.24)

4. Physical Tests on Cured Slurry
   a. Wet Track Abrasion Test (WTAT)- measurement of resistance to mechanical abrasion, kick-out, internal mat adhesion
   b. Loaded Wheel Test (LWT)- traffic simulation, measurement of resistance to flushing under heavy traffic loads

5. Selection of Optimum Design
   a. State Maximum limits to WTAT = minimum asphalt content (75g/ft²?) (807.3g/m² ?)
   b. State Maximum limits to LWT = maximum asphalt content or State Maximum LWT limits for Traffic Counts
      Light = 0 to 500 ADT (70g/ft²?)(753.5 g/m² ?) sand adhesion, 1000 Ø @ 125 lbs. (56.7 kg)
      Medium = 250 to 1500 ADT (60 g/ft²?)(645.8 g/m² ?) Heavy = 1500 to 3000 + (50 g/ft²?)(538.2 g/m² ?)
   c. State Job Tolerance Limits (Contractor Proficiency)
   d. Draw graphs of the physical test data and superimpose the stated limits and read optimum asphalt content.

Graphical Determination of Optimum Asphalt Content
After the optimum design suggested is established, it is necessary to translate this design into field control quantities. One suggested method is described in ISSA TB #107, "A Method for Unit Field Control of Slurry Seal Quantities." The objective of this method is to aid operators and inspectors to control the field material quantities and application rates so that design results are obtained. The method is essentially to translate laboratory design into field units of gallons, tons and bags and to measure these during application. The following is an example of the laboratory design translation into the essential field control quantities:

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### Laboratory Design for Field Control

- **Example -**

#### Optimum Lab Design Control Quantities

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td><strong>a) Aggregate</strong></td>
<td>100.0%</td>
</tr>
<tr>
<td><em><em>b) Filler</em> Type PC-11</em>*</td>
<td>1.0%</td>
</tr>
<tr>
<td></td>
<td>2 bags/ 10 tons ± 1/2 bag</td>
</tr>
<tr>
<td><strong>c) Mix Water</strong>*</td>
<td>12.0%</td>
</tr>
<tr>
<td></td>
<td>29 gals./ton (121 l/t) ± 1%</td>
</tr>
<tr>
<td><strong>d) Cone Flow Consistency</strong></td>
<td>2.5cm.</td>
</tr>
<tr>
<td></td>
<td>± 0.75 cm</td>
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<tr>
<td><strong>e) AC Target Extraction</strong></td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>± 1.5%</td>
</tr>
<tr>
<td><em><em>f) Emulsion</em> @ 61.0% Res. AC</em>*</td>
<td>17.2%*</td>
</tr>
<tr>
<td></td>
<td>41.0 gals./ton (171 l/t) ± 1.7%</td>
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<tr>
<td><strong>g) Design Width</strong></td>
<td>20.0 ft.(6.6 m)</td>
</tr>
<tr>
<td></td>
<td>2 lanes x 10 ft.(3.05 m) ± 0.5' (.152 m) OA</td>
</tr>
<tr>
<td><strong>h) Spread Rate</strong></td>
<td>15.0 lbs./SY (8.14 kg/m²)</td>
</tr>
<tr>
<td></td>
<td>133 SY/ton(123 m²/t) ± 2.0 lbs./SY (1 kg/m²)</td>
</tr>
<tr>
<td><strong>i) Lineal Ft./ton @ Lane Width</strong></td>
<td>120 LF/ton (40.3 m/t)</td>
</tr>
<tr>
<td><strong>j) Aggregate Specific Weight vs, Moisture Content:</strong></td>
<td></td>
</tr>
<tr>
<td>Moisture Content</td>
<td>Moist Lbs./ft³ Loose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>0%</td>
<td>96.4 (1544.1 kg/m³)</td>
</tr>
<tr>
<td>1</td>
<td>95.4 (1528.1 kg/m³)</td>
</tr>
<tr>
<td>2</td>
<td>83.6 (1339.1 kg/m³)</td>
</tr>
<tr>
<td>3</td>
<td>79.7 (1276.6 kg/m³)</td>
</tr>
<tr>
<td>4</td>
<td>79.0 (1265.4 kg/m³)</td>
</tr>
<tr>
<td>5</td>
<td>78.0 (1249.4 kg/m³)</td>
</tr>
<tr>
<td>6</td>
<td>77.9 (1247.8 kg/m³)</td>
</tr>
</tbody>
</table>

Note: % Dry/Wet = Dry weight of the aggregate at 0% moisture content / Dry weight of the aggregate at the different moisture contents

* Percent added to the dry weight of the aggregate  Note: Unit (t) = metric ton
Slurry Seal and Microasphalt Design Test Checklist

Materials Analysis

Aggregate, Primary Design Tests:
- Gradation (Dry) ASTM C136
- Gradation (Wet) ASTM C136, C117
- Sand Equivalent ASTM D 2419

Aggregate; Auxiliary Tests:
- Specific Gravity (Dry) - ASTM C128
- Apparent Specific Gravity, Sat. Surf. Dry - ASTM C128
- Absorption - ASTM C128
- Centrifuge Kerosene Equivalent - CALTRANS 303
- Methylene Blue Absorption - ISSA TB #145
- Methylene Blue Factor - Prop., ISSA TB #145
- pH 10:1 Initial/Delayed - Prop.
- Unit Weight, Loose, ISSA-TB #126
- Unit Weight, Compacted - ASTM C29, Prop.
- Voids, Loose & Compact (Total Liquids Capacity)
- Soundness, Sodium or Magnesium Sulfate - ASTM C88
- Durability, Los Angeles Rattler - ASTM C131, C535
- Durability Index - ASTM D3744
- Shaker Wear Test Traffic Count Gradation - ISSA TB #123
- Polished Stone Value (PSV)(SRL) - ASTM D3319
- Acid Solubility - ASTM D3042, PROP.
- Mineralogy & Petrology - ASTM C294, C295

Asphalt Emulsion Primary Design Tests:
- Residue, % (by Evaporation) - ASTM D244
- Sieve - ASTM D244
- Stability - Subjective Settlement - ASTM D244

Asphalt Emulsion Auxiliary Tests
- pH Prop.
- Particle Charge - ASTM D244
- Viscosity - ASTM D88
- Penetration of Residue - ASTM D5
- Ductility of Residue - ASTM D113
- Specific Gravity - ASTM D70, D3289
- Ring & Ball Softening Point - ASTM D36, AASHTO T-53
- Plastic Interval - Prop.
- Specifications for Emulsified Asphalt - ASTM D977, D3497
- Specifications for Slow Set Systems - ISSA TB #117
- Specifications for Quick Set Systems - ISSA TB #116
- Specifications for Quick Traffic Systems - ISSA TB #140

Chemical Filler, Primary Tests
- Portland Cement - ASTM C150, AASHTO M85
- Hydrated Lime - AASHTO M216

Mineral Filler
- Specifications for Mineral Filler - ASTM D242
- Filler Sieve Analysis - ASTM D546

Water
- Chemical, Biological and Physical Analysis of Water - AASHTO T263

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Mix Design Tests

Trial Mixes for Mix Characteristics and Compatibility
- Mix, Time, Clear Water Set Time - ISSA TB #102,
- #113
- Set & Traffic Time Additive by 30’ & 60’ Wet Cohesion - ISSA TB #139
- Optimum filler content by 30’ & 60’ Wet Cohesion
- Subjective Appearance, Toughness, Wet Adhesion, Substrate Adhesion - Prop.
- Boiling Water Adhesion - ISSA TB #114, #149
- High Temperature, 140°F(60°C) Cured Cohesion Classification - Prop, TB #139
- Consistency, Total Liquids Content - ISSA TB #106
- Compatibility - ISSA TB #115, #149
- Compatibility Classification by Schulze-Breuer - ISSA TB #144

Field Simulation Tests at 3 Emulsion Contents
- Wet Track Abrasion Test One-hour Soak (Duplicates) - ISSA TB #100
- Wet Track Abrasion Test 6-day Soak (Single) - ISSA TB #100
- Monolayer Loaded Wheel Sand Adhesion - Uncompacted (Single) - ISSA TB #109
- Multilayer Loaded Wheel Displacement - ISSA TB #147A
- Low Temperature Flexural Tension Cracking Resistance Test - ISSA TB #146
- High Temperature Wheel Tracking Test, Rate of Compaction, Compacted Density - ISSA TB #147B
- Voids Analysis - Prop. ISSA Tb #150
- Surface Area Analysis - ISSA TB #118
- Graphical Selection of Optimum Job Mix Formula - ISSA TB #111
- Spreadrate - ISSA TB #112

Report
- Discussion, Tabulation & Graphs of Test Results
- Job Mix Formula Recommendation with Field Control Units