Chip Seal – Part I

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Class Outline

Topic 1: Introduction to Chip Seals

Topic 2: Project Selection

Topic 3: Materials

Topic 4: Design Inputs
Introduction to Chip Seals

Benefits

• Increase skid resistance

• Seal minor cracks (less than \(\frac{1}{4}\)"")

• Extend the average service life of the existing pavement for 5 to 10 years
Introduction to Chip Seals

Benefits

• Correct deficiencies such as:
  – Raveling
  – Flushing
  – Aged or oxidized pavements
Introduction to Chip Seals

Limitations

• Chip Seals Do Not:
  – Strengthen the existing pavement
  – Increase load-bearing capacity
  – Smooth rough pavement
Introduction to Chip Seals

Limitations

• Chip Seals Do Not:
  – Bridge cracks wider than $\frac{1}{4}$ inch
  – Address ruts greater than $\frac{3}{8}$ inch in depth
  – Eliminate the need for maintenance or reconstruction
Introduction to Chip Seals

Single Chip Seal

- Bituminous Binder
- Uniformly Graded Aggregate
- Existing Asphalt Pavement
Introduction to Chip Seals

Double Chip Seal

Smaller Aggregate Application

2nd Binder Application

Uniformly Graded Aggregate

1st Binder Application

Existing Asphalt Pavement
Introduction to Chip Seals

Racked-in Chip Seal

Existing Asphalt Pavement

Uniformly Graded Aggregate

Binder Application

Choke Stone (applied dry)
Introduction to Chip Seals
Introduction to Chip Seals

Second Binder Application

Larger Aggregate Application

Existing Asphalt Pavement

Initial Binder Application

Smaller Aggregate Application

Inverted Seal
Introduction to Chip Seals

Sandwich Seal  
(Dry Matting)
Introduction to Chip Seals

Geotextile-Reinforced Seal
Introduction to Chip Seals

Chopped Fiberglass Strands

Bituminous Binder

Uniformly Graded Aggregate

Existing Asphalt Pavement

Fiber-Reinforced Seal
Chip Seal Selection
Chip Seal Selection
Chip Seal Selection

Unacceptable Candidates

Rutted Pavement

Poor Ride
Chip Seal Selection

Unacceptable Candidates

- Cracks >1/4"
- Structural Issues
Chip Seal Selection

Unacceptable Candidate
Low Severity Fatigue Cracking
Chip Seal Selection

Unacceptable Candidate
Medium Severity Fatigue Cracking
Chip Seal Selection

Unacceptable Candidate
High Severity Fatigue Cracking
Chip Seal Selection

Unacceptable Candidate
Corrugation
Chip Seal Selection

Unacceptable Candidate
Joint Reflective Cracks
Chip Seal Selection

Unacceptable Candidate
Joint Reflective Cracks
Chip Seal Selection

Unacceptable Candidate
Joint Reflective Cracks
Chip Seal Selection

Unacceptable Candidate
Asphalt Pavement Stripping
**Chip Seal Selection**

### Preventive Maintenance Applied to HMA Pavements

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Life Extension (yr.)</th>
<th>Treatment Life (yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Filling</td>
<td>1 - 3</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Crack Sealing</td>
<td>2 - 4</td>
<td>3 - 8</td>
</tr>
<tr>
<td>Chip Seal - Single</td>
<td>5 - 6</td>
<td>3 – 7</td>
</tr>
<tr>
<td>Chip Seal - Double</td>
<td>8 - 10</td>
<td>5 – 10</td>
</tr>
</tbody>
</table>

### Treatment Selection by Condition

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Good Condition (PCI=80)</th>
<th>Fair Condition (PCI=60)</th>
<th>Poor Condition (PCI=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Fill</td>
<td>1 - 3</td>
<td>0 - 2</td>
<td>0</td>
</tr>
<tr>
<td>Crack Seal</td>
<td>2 - 4</td>
<td>1 - 3</td>
<td>0</td>
</tr>
<tr>
<td>Chip Seal - Single</td>
<td>5 - 6</td>
<td>3 - 5</td>
<td>0 - 3</td>
</tr>
</tbody>
</table>
Chip Seal Selection

Good Candidates

- Minor Cracking
- Loss of Fines
- Flushing
- Oxidation
- Loss of Friction
**Chip Seal Selection**

**Conditions Addressed**
- Moisture Infiltration
- Longitudinal cracking
- Transverse cracking
- Block cracking
- Friction Loss
- Bleeding

**Limitations**
- Longer set time

**Costs (yd²)**
$1.50 - 2.50

**PCI**
85 - 70

**IRI**
<95
Emulsified Asphalts

Anionic
- RS-2
- HFRS-2
- HFRS-2P

Cationic
- CRS-2
- CRS-2P
- CRS-2L
- CHFRS-2P
Materials

Asphalt Emulsion

Water & Asphalt

67% Residual
Emulsified Asphalts Storage

• Storage temperatures generally range from 52°C to 85°C (125°F to 185°F) depending on the intended use and specific product

• Do not heat above 85°C (185°F) due to evaporation of water

• Do not let emulsion freeze
Materials

Emulsified Asphalts Handling

- Provide adequate ventilation
- Agitate gently when heating asphalt
- Avoid repeated pumping and re-circulating
Terminology

• **Breaking** (curing) the process by which the asphalt emulsion expels the water and dries to an integral film / layer on the aggregate.
Terminology

• **Surface texture** – The macroscopic and microscopic characteristics of the pavement surface. Surface texture depth is a metric that influences material application rates, design life, skid resistance, and road noise.
Materials

- Bituminous Binder
- Uniformly Graded Aggregate
- Existing Asphalt Pavement

Single Chip Seal
Materials

Dense Graded

Single Size
Materials

Single-size aggregate

Graded aggregate
**Materials**

**Cleanliness**

- Dusty Aggregate
  - Will prevent bonding with binder
  - Should have 1% or less passing the #200 sieve
  - Emulsified asphalts – wash aggregate or change to a medium set emulsion

Before sweeping

After sweeping
Advantages of Single Sizing

- More uniform height
- Weighs less per cubic foot
  - 47% passing the #4 95.7 lbs/ft³
  - 8% passing the #4 84.5 lbs/ft³
- More room for binder
  - Increased Voids
Cost of Single Sizing

- **Dense Graded** $22.80 ton
  - 18.5 lbs/yd² needed = $0.21 per yd²
- **Single Sized**
  - 14.5 lbs/yd² needed = $0.16 per yd²
- **Can pay $6.30 a ton more for single sized aggregate at the same square yard cost as dense graded aggregate.**
Best Aggregate Performance when:

- Single sized
- Minimum fines
- Clean
- Free of clay
- Cubical
- Crushed faces
- Abrasion < 30%
- Binder compatible
- Damp for emulsions
- Dry for hot binders
Basic Design Principle

1. Application rate of cover aggregate is one-stone thick.

2. Voids in aggregate layer need to be 70 percent filled with asphalt binder.
Design

Before Curing:

Average Chip Height

Binder is ~ 100% of chip height

After Curing:

Average Chip Height

Binder is ~ 70% of chip height
Design

Chip Seal Design Inputs

- Existing Pavement Texture
- Traffic Volume
- Aggregate Surface Charge
- Emulsified Asphalt Designation
- Aggregate Absorption
- Aggregate Bulk Specific Gravity
- Aggregate Particle Shape
Chip Seal Design Inputs

- Gradation
  - Median Particle Size
  - Flakiness Index
  - Average Least Dimension
- Loose Unit Weight of Cover Aggregate
- Wastage Factor of Sweeping Operation
### Existing Pavement Texture Input

<table>
<thead>
<tr>
<th>Existing Pavement Texture</th>
<th>Surface Correction Factor (gal/yd²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, Flushed Asphalt</td>
<td>-0.01 to -0.06</td>
</tr>
<tr>
<td>Smooth, Non-Porous</td>
<td>0.00</td>
</tr>
<tr>
<td>Slightly Porous &amp; Oxidized</td>
<td>+0.03</td>
</tr>
<tr>
<td>Slight Pocked, Porous &amp; Oxidized</td>
<td>+0.06</td>
</tr>
<tr>
<td>Badly Pocked, Porous &amp; Oxidized</td>
<td>+0.09</td>
</tr>
</tbody>
</table>
## Design

### Traffic Volume Input

<table>
<thead>
<tr>
<th>Traffic Factor, $T$</th>
<th>Annual Average Daily Traffic (AADT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 100</td>
</tr>
<tr>
<td>1.20</td>
<td>1.15</td>
</tr>
</tbody>
</table>
Design

Aggregate Surface Charge

Limestone  Dolomite  Granite  Basalt

pos.  0  negative
Design

Emulsified Asphalt Designation

- Always use rapid setting type emulsions
- Use polymer-modified cationic and anionic emulsified asphalt
  - Benefits: Early stone retention, less bleeding, longer-term performance
## Aggregate Absorption Input

<table>
<thead>
<tr>
<th>Aggregate Type</th>
<th>Granite</th>
<th>Quartzite</th>
<th>Trap Rock</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent Absorption</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0.40</td>
<td>0.61</td>
<td>0.31</td>
<td>1.75</td>
</tr>
<tr>
<td>Max</td>
<td>0.92</td>
<td>0.72</td>
<td>0.59</td>
<td>5.44</td>
</tr>
<tr>
<td>Avg.</td>
<td>0.59</td>
<td>0.67</td>
<td>0.43</td>
<td>2.80</td>
</tr>
</tbody>
</table>
# Aggregate Bulk Specific Gravity Input

<table>
<thead>
<tr>
<th>Aggregate Type</th>
<th>Granite</th>
<th>Quartzite</th>
<th>Trap Rock</th>
<th>Limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bulk Specific Gravity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>2.60</td>
<td>2.59</td>
<td>2.95</td>
<td>2.40</td>
</tr>
<tr>
<td>Max</td>
<td>2.75</td>
<td>2.63</td>
<td>2.98</td>
<td>2.67</td>
</tr>
<tr>
<td>Avg.</td>
<td>2.68</td>
<td>2.61</td>
<td>2.97</td>
<td>2.54</td>
</tr>
</tbody>
</table>
## Aggregate Particle Shape Input

<table>
<thead>
<tr>
<th>Fracture Property</th>
<th>Chip Seal AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 500</td>
</tr>
<tr>
<td>1 Face</td>
<td>70 %</td>
</tr>
<tr>
<td>2 Faces</td>
<td>60 %</td>
</tr>
</tbody>
</table>
### Aggregate Gradation

<table>
<thead>
<tr>
<th>Sieve Size (T27)</th>
<th>Passing, %</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>19 mm ¾ &quot;</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.5 mm ½ &quot;</td>
<td>90 - 100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>9.5 mm ⅜ &quot;</td>
<td>5 - 30</td>
<td>90 - 100</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm No. 4</td>
<td>0 - 10</td>
<td>5 - 30</td>
<td>90 - 100</td>
</tr>
<tr>
<td>2.36 mm No. 8</td>
<td>0 - 10</td>
<td>5 - 30</td>
<td></td>
</tr>
<tr>
<td>1.18 mm No. 16</td>
<td>0 - 2</td>
<td></td>
<td>0 - 10</td>
</tr>
<tr>
<td>0.595 mm No. 30</td>
<td>0 - 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 μm No. 50</td>
<td></td>
<td></td>
<td>0 - 10</td>
</tr>
<tr>
<td>75 μm No. 200</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 1</td>
</tr>
</tbody>
</table>
# Design

## Aggregate Properties Input

- **Flakiness Index**

### Slotted Sieve Sizes

<table>
<thead>
<tr>
<th>Aggregate Fractions</th>
<th>1</th>
<th>3/4</th>
<th>1/2</th>
<th>3/8</th>
<th>1/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retained on Sieve</td>
<td>3/4</td>
<td>1/2</td>
<td>3/8</td>
<td>1/4</td>
<td>No. 4</td>
</tr>
</tbody>
</table>

**Note:**
1. Not to Scale. Slot dimensions shown in inches.
2. U.S. standard Sieve Sizes

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**Notation:**
- 1 Not to Scale. Slot dimensions shown in inches.
- 2 U.S. standard Sieve Sizes
Flakiness Index

- Aggregates retained on each sieve which comprise at least 4% of the total sample, shall be tested.
- Wash and oven dry samples to a constant weight.
- Test each of the particles in each size fraction using the proper slot opening for each sieve size.
- Separate the particles passing through the slot from those that do not pass through the slot.
Design

Aggregate Properties Input

• **Flakiness Index**
  - Calculation for Flakiness Index

\[
\text{Flakiness Index (\%)} = \left( \frac{A_1 + A_2 + A_3}{A_1 + A_2 + A_3 + B_1 + B_2 + B_3} \right) \times 100
\]

*Where:*
\[A_1 + A_2 + A_3 = \text{Weight passing a given slot}\]
\[B_1 + B_2 + B_3 = \text{Weight retained on the given slot}\]
## Aggregate Properties Input

<table>
<thead>
<tr>
<th>Property</th>
<th>Chip Seal AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 500</td>
</tr>
<tr>
<td>LA Abrasion, max</td>
<td>37 %</td>
</tr>
<tr>
<td>Flakiness, max</td>
<td>35 %</td>
</tr>
</tbody>
</table>
**Design**

**Loose Unit Weight of Cover Aggregate**

- Fill a 0.50 ft³ metal cylinder with loose aggregate
- Weigh the aggregate
- Process repeated a total of 3 times
- The average of 3 weights is the “Loose Unit Weight of Cover Aggregate”
## Design

### Wastage Factor Input

<table>
<thead>
<tr>
<th>Percentage of Waste Allowed for Sweeping</th>
<th>Wastage Factor, E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.01</td>
</tr>
<tr>
<td>2</td>
<td>1.02</td>
</tr>
<tr>
<td>3</td>
<td>1.03</td>
</tr>
<tr>
<td>4</td>
<td>1.04</td>
</tr>
<tr>
<td>5</td>
<td>1.05</td>
</tr>
<tr>
<td>6</td>
<td>1.06</td>
</tr>
<tr>
<td>7</td>
<td>1.07</td>
</tr>
<tr>
<td>8</td>
<td>1.08</td>
</tr>
<tr>
<td>9</td>
<td>1.09</td>
</tr>
<tr>
<td>10</td>
<td>1.10</td>
</tr>
</tbody>
</table>
Design

- Knowing and understanding the material properties is the first step for better chip seals.
End Result
Part 2 will cover -

Design Formulas
Calibration
Equipment
Construction
Questions
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