Oregon Chip Seal
Design and Specifications

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Project Acknowledgements

- Oregon Department of Transportation
- Jon Lazarus and Larry Ilg.
- Binder suppliers for these projects
- Chip seal contractors for their help on the construction site.
- R. Christopher Williams, Paul Ledtje, Ben Claypool, Marie Grace Mercado, Jinhua Yu, and Jesse Studer at Iowa State University
Objectives

- Document methods of chip sealing
- Report the performance of chip seals
- Apply Chip Seal Design
- Identify best practices for implementation
**Benefits**

- Improve the cost effectiveness of chip seals by increasing performance
- Improved roadway surfaces
- Integrate a rational method for binder and aggregate application rates
Project Introduction

- Literature Review and Best Practices
  - Design Methods
  - NCHRP Synthesis 342
  - Performance Specifications
  - Specification Review and Comparison
- Experimental Plan
  - Hot Applied and Emulsified Chip Seal
  - Various Regions in Oregon
  - Variety of ADT
Map of 2014 Chip Seal Projects
Chip Seal Locations

- Map of All Project Locations

OREGON DEPARTMENT OF TRANSPORTATION
REGION MAP

- Lewis & Clark Rd. (L&C)
- Sunset Beach Rd. (Seaside)
- Heppner
- Condon
- Parkway Rd. (Jasper)
- Prairie Rd.
- Units A-H
Map of All Project Locations and Rainfall

Average Annual Precipitation (1981-2010)

Rainfall Map developed by: PRISM Climate Group. Oregon State University.
Types of Chip Seals

- ADT for 2014 Sections

**Emulsion**

- Klamath Unit A
- Klamath Unit F
- Klamath Unit G
- Klamath Unit H

**Hot Apply**

- Klamath Unit B
- Klamath Unit C
- Klamath Unit D
- Klamath Unit E
- *Prairie Road South Section
- Parkway Section

Klamath Falls

Eugene
Types of Chip Seals

- ADT for 2015 Sections – Emulsion

<table>
<thead>
<tr>
<th>ADT, vehicles per day</th>
<th>Heppner</th>
<th>Condon</th>
<th>Sunset Beach</th>
<th>Lewis &amp; Clark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000</td>
<td>400</td>
<td>1600</td>
<td>200</td>
</tr>
</tbody>
</table>

Types of Chip Seals

- Single Layer Chip Seals Studied
  - Hot Applied
  - Emulsified Asphalt
  - All sections used polymer modified binders
Chip Seal Performance

- Characterization of Existing Pavement
  - Pavement Condition Surveys
  - Oregon DOT Pavement Management System Rating
- Chip Seal Surface Characteristics

Macro-texture

Micro-texture
Chip Seal Performance

- Macro-texture – Sand Circles

(i) Measured quantity of sand poured on road

(ii) Sand spread to form circular patch

Average texture depth = \[ \frac{57300}{D^2} \text{ mm} \]  \( (D \text{ in mm}) \)

NB: Abnormal large chips should be ignored when spreading sand
Chip Seal Performance

- Micro-texture – Dynamic Friction Tester

- [Graph showing friction performance vs. speed]

- [Image of the micro-texture dynamic friction tester and related equipment]
Can a Macrotexture performance specification be applied in Oregon?

**New Zealand Performance Specification**

*New Zealand Transport Agency – P/17 Performance Specification for chip seal macrotexture deterioration*

\[
Td_1 = 0.07 \times ALD \times \log Y_d + 0.9
\]

Where:
- \( Td_1 \) = texture depth in one year (mm)
- \( Y_d \) = design life in years
- \( ALD \) = average least dimension of the aggregate (mm)

0.9 mm is considered failure
Chip Seal Specification

- New Zealand Performance Specification
  - Blue is the performance specification
  - Red is shown for illustration

Graph showing Mean Texture Depth (mm) for different units and locations with various trend lines indicating average values over different time periods.
Macrotexture Changes over Time - Between WP

- Hot Apply Sections

Change in Mean Texture Depth, mm

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F
- Unit G
- Unit H

Initial Improvement

Net Improvement
Macrotecture Changes over Time – In the WP
Macrotexture Changes over Time – Unit A

UNIT A Summary
Binder: CRS-2P, 0.48 gal/sy
Aggregate: Least uniform gradation and finest gradation in the study, gravel, 0.013 cy/sy
Traffic: 460 AADT
Macrotexture Changes over Time – Units B and C

UNIT B Summary
- Binder: AC-15P
- Aggregate: 18-20 lbs/sy, Pre-coat (PC)
- Traffic: 2300 AADT

UNIT C Summary
- Binder: AC-15P
- Aggregate: 18 lbs/sy, PC
- Traffic: 2900 AADT

Mean Texture Depth, mm

- UNIT B WP
- Unit C WP
- Units B-E 4-year design life
- Units B-E 7-year design life

Pre-Construction  | Post-Construction  | One-Year Post-Construction  | Two-Year Post-Construction
Performance Surveys

- Transverse Cracking

![Bar chart showing Transverse Cracking](chart.png)

Legend:
- Blue: Pre-Construction
- Orange: 1-Year Post-Construction
- Green: 2-Year Post-Construction

Units compared:
- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F
- Unit G
- Unit H
- Parkway
- Prairie
- Sunset
- Lewis
- Heppner
- Condon
Performance Surveys

Longitudinal Cracking

- Pre-Construction
- 1-Year Post-Construction
- 2-Year Post-Construction
Performance Surveys

- Longitudinal Cracking

![Bar chart showing fatigue cracking in ft²/100 ft. for units A to Condon, with data for pre-construction, 1-year post-construction, and 2-year post-construction.](chart.png)
Fatigue Cracking
Performance Surveys

- Patching Area

![Patching Area Chart]

- Pre-Construction
- Two-Years Post-Construction
Performance Surveys

- **Bleeding**

  Unit B had highest pre-construction fatigue cracking and longitudinal cracking

Bleeding Area (ft²) per 100 ft. of Roadway

- Pre-Construction
- One-Year Post-Construction
- Two-Year Post-Construction
**Performance Surveys**

- **Chip Seal - Loss of Aggregate**

![Bar chart showing loss of aggregate for different units](image)

- **Loss of Aggregate Area (ft²) per 100 ft. of Roadway**
  - **Unit A**, **Unit B**, **Unit C**, **Unit D**, **Unit E**, **Unit F**, **Unit G**, **Unit H**, **Parkway**, **Prairie Road**
  - **One-Year Post-Construction**
  - **Two-Year Post-Construction**
Back calculate the chip seal design using:

- McLeod Method (MnDOT Seal Coat Design Manual)
- New Zealand Design Method
- Optimal one-stone thick

Compare with actual applied rates
Laboratory Investigation

- Aggregate Properties

1. Unit A New Zealand: 17 lb/SY
2. Unit A McLeod: 21 lb/SY
3. Unit A Actual: 30.5 lb/SY
4. Unit A Optimum: 17.6 lb/SY
Micro-Deval Testing

- Similar Values for all aggregates tested
- Compared with previous Oregon Aggregate Study

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Percent Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit A Klamath Chips</td>
<td>6.09</td>
</tr>
<tr>
<td>Unit F Klamath Chips</td>
<td>7.45</td>
</tr>
<tr>
<td>Unit H Klamath Chips</td>
<td>8.60</td>
</tr>
<tr>
<td>Hot Applied Klamath Chips</td>
<td>7.21</td>
</tr>
<tr>
<td>Parkway Eugene Chips</td>
<td>6.76</td>
</tr>
</tbody>
</table>
**Aggregate Gradation and PUC**

- **Performance Uniformity Coefficient**
  - Indicates Aggregate Size Uniformity
  - Lower PUC = More Uniform Gradation

![0.45 POWER CHART]

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>PUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit A</td>
<td>0.41</td>
</tr>
<tr>
<td>Unit F</td>
<td>0.12</td>
</tr>
<tr>
<td>Unit H</td>
<td>0.12</td>
</tr>
<tr>
<td>Klamath HM</td>
<td>0.20</td>
</tr>
<tr>
<td>Parkway</td>
<td>0.11</td>
</tr>
</tbody>
</table>
# Aggregate Gradation and PUC

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Aggregate contributing to bleeding ($P_{EM}$), %</th>
<th>Aggregate contributing to loss ($100-P_{2EM}$), %</th>
<th>PUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit A</td>
<td>33</td>
<td>20</td>
<td>0.41</td>
</tr>
<tr>
<td>Unit F and G</td>
<td>11</td>
<td>10</td>
<td>0.12</td>
</tr>
<tr>
<td>Unit H</td>
<td>11</td>
<td>6</td>
<td>0.12</td>
</tr>
<tr>
<td>Klamath Hot Applied Sections (Units B-E)</td>
<td>16</td>
<td>18</td>
<td>0.20</td>
</tr>
<tr>
<td>Parkway</td>
<td>11</td>
<td>2</td>
<td>0.11</td>
</tr>
</tbody>
</table>
## McLeod: Flakiness Index

<table>
<thead>
<tr>
<th>Test Section</th>
<th>Flakiness Index</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>5.2</td>
<td>4000</td>
</tr>
<tr>
<td>Unit A</td>
<td>13.1</td>
<td>460</td>
</tr>
<tr>
<td>Unit B</td>
<td>5.2</td>
<td>2300</td>
</tr>
<tr>
<td>Unit C</td>
<td>5.2</td>
<td>2900</td>
</tr>
<tr>
<td>Unit D</td>
<td>5.2</td>
<td>1280</td>
</tr>
<tr>
<td>Unit E</td>
<td>5.2</td>
<td>1345</td>
</tr>
<tr>
<td>Unit F</td>
<td>6.4</td>
<td>2650</td>
</tr>
<tr>
<td>Unit G</td>
<td>6.4</td>
<td>670</td>
</tr>
<tr>
<td>Unit H</td>
<td>12.1</td>
<td>690</td>
</tr>
</tbody>
</table>
New Zealand and Austroads measure each aggregate particle.

- Flakiness index provides relationship.

The average least dimension is determined by:

- \( H = \frac{M}{1.139285} + (0.011506)\times FI \)
- \( H = \) Average Least Dimension (ALD)
- \( M = \) Median Particle Size
- \( FI = \) Flakiness Index

(California Division of Maintenance 2003; FHWA 1992)
A metal cylinder with a known volume of is loosely filled with aggregate until full. The weight of the aggregate was determined.

Find Voids in Loose Aggregate

<table>
<thead>
<tr>
<th>Test Section</th>
<th>LUW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>89.3</td>
</tr>
<tr>
<td>Unit A</td>
<td>86.9</td>
</tr>
<tr>
<td>Unit B</td>
<td>85.4</td>
</tr>
<tr>
<td>Unit C</td>
<td>85.4</td>
</tr>
<tr>
<td>Unit D</td>
<td>85.4</td>
</tr>
<tr>
<td>Unit E</td>
<td>85.4</td>
</tr>
<tr>
<td>Unit F</td>
<td>87.7</td>
</tr>
<tr>
<td>Unit G</td>
<td>87.7</td>
</tr>
<tr>
<td>Unit H</td>
<td>82.6</td>
</tr>
</tbody>
</table>
Traffic Volume

Factor accounts for the role that traffic volumes play in achieving the ultimate embedment of 80 percent (20 percent void space).

<table>
<thead>
<tr>
<th>Test Section</th>
<th>AADT</th>
<th>McLeod Traffic Correction Factor</th>
<th>Traffic whip-off factor, E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>4000</td>
<td>0.60</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit A</td>
<td>460</td>
<td>0.75</td>
<td>1.05</td>
</tr>
<tr>
<td>Unit B</td>
<td>2300</td>
<td>0.60</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit C</td>
<td>2900</td>
<td>0.60</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit D</td>
<td>1280</td>
<td>0.65</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit E</td>
<td>1345</td>
<td>0.65</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit F</td>
<td>2650</td>
<td>0.60</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit G</td>
<td>670</td>
<td>0.70</td>
<td>1.1</td>
</tr>
<tr>
<td>Unit H</td>
<td>690</td>
<td>0.70</td>
<td>1.1</td>
</tr>
</tbody>
</table>

(Wood et al. 2006)
Traffic Considerations

- Traffic Whip-Off (Similar to NZ)
  - Assume 5% for low volume, residential type traffic
  - Assume 10% for higher speed roads such as county roads.
**McLeod Aggregate Design Equation**

- **Aggregate Application Rate:**
  - \( C = (1 - 0.4V) \times H \times G \times E \)
  - \( C = \) Cover Aggregate (kg/m²)
  - \( V = \) Voids in Loose Agg. (%)
  - \( H = \) ALD (mm)
  - \( G = \) Bulk Specific Gravity
  - \( E = \) Wastage Factor (%)

- **Values based on LUW**

<table>
<thead>
<tr>
<th>Test Section</th>
<th>McLeod Cover Aggregate Rate (lbs/yd²)</th>
<th>Actual Rate (lbs/yd²)</th>
<th>Rates given in CY/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>26</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Unit A</td>
<td>21</td>
<td>30.5**</td>
<td>0.013</td>
</tr>
<tr>
<td>Unit B</td>
<td>27</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Unit C</td>
<td>27</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Unit D</td>
<td>27</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Unit E</td>
<td>27</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Unit F</td>
<td>25</td>
<td>30.8**</td>
<td>0.013</td>
</tr>
<tr>
<td>Unit G</td>
<td>25</td>
<td>30.8**</td>
<td>0.013</td>
</tr>
<tr>
<td>Unit H</td>
<td>23</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
For Single Coat Seals (Chipsealing in New Zealand)

\[ \text{Rate} = \frac{750}{ALD} \text{ } m^2/m^3 \]

<table>
<thead>
<tr>
<th>Test Section</th>
<th>ALD (mm)</th>
<th>Rate m2/m3</th>
<th>Chip Rate lbs/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>5.9</td>
<td>127.5</td>
<td>21</td>
</tr>
<tr>
<td>Unit A</td>
<td>5.0</td>
<td>149.8</td>
<td>17</td>
</tr>
<tr>
<td>Unit B</td>
<td>6.3</td>
<td>119.4</td>
<td>21</td>
</tr>
<tr>
<td>Unit C</td>
<td>6.3</td>
<td>119.4</td>
<td>21</td>
</tr>
<tr>
<td>Unit D</td>
<td>6.3</td>
<td>119.4</td>
<td>21</td>
</tr>
<tr>
<td>Unit E</td>
<td>6.3</td>
<td>119.4</td>
<td>21</td>
</tr>
<tr>
<td>Unit F</td>
<td>5.8</td>
<td>128.5</td>
<td>20</td>
</tr>
<tr>
<td>Unit G</td>
<td>5.8</td>
<td>128.5</td>
<td>20</td>
</tr>
<tr>
<td>Unit H</td>
<td>5.5</td>
<td>136.5</td>
<td>18</td>
</tr>
</tbody>
</table>
McLeod suggests an absorption correction factor, $A$, of 0.02 gal/yd$^2$ if the aggregate absorption is around 1%.

MnDOT Seal Coat Handbook recommends if absorption is 1.5 percent or higher.

(Wood et al. 2006)
New surfaces will not absorb much binder
Older surfaces can absorb a lot of binder
Must be included in design
Not all roads in a project will need same amount of asphalt binder

(Wood et al. 2006)

<table>
<thead>
<tr>
<th>Existing Pavement Texture</th>
<th>S.I. Metric (L/m²)</th>
<th>U. S. Customary (gal/yd²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, flushed asphalt</td>
<td>-0.04 to -0.27</td>
<td>-0.01 to -0.06</td>
</tr>
<tr>
<td>Smooth, non-porous</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Slightly porous &amp; oxidized</td>
<td>+0.14</td>
<td>+0.03</td>
</tr>
<tr>
<td>Slightly pocked, porous &amp; oxidized</td>
<td>+0.27</td>
<td>+0.06</td>
</tr>
<tr>
<td>Badly pocked, porous &amp; oxidized</td>
<td>+0.40</td>
<td>+0.09</td>
</tr>
</tbody>
</table>
## Comparison of All Chip Application Rates

<table>
<thead>
<tr>
<th>Test Section</th>
<th>New Zealand Chip Rate Lbs/SY</th>
<th>McLeod Cover Aggregate Rate (lbs/yd²)</th>
<th>Actual Applied Rate (lbs/yd²)</th>
<th>Rates given in CY/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>21</td>
<td>26</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Unit A</td>
<td>17</td>
<td>21</td>
<td>30.5**</td>
<td>0.013</td>
</tr>
<tr>
<td>Unit B</td>
<td>21</td>
<td>27</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Unit C</td>
<td>21</td>
<td>27</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Unit D</td>
<td>21</td>
<td>27</td>
<td>20</td>
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<tr>
<td>Unit E</td>
<td>21</td>
<td>27</td>
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<td></td>
</tr>
<tr>
<td>Unit F</td>
<td>20</td>
<td>25</td>
<td>30.8**</td>
<td>0.013</td>
</tr>
<tr>
<td>Unit G</td>
<td>20</td>
<td>25</td>
<td>30.8**</td>
<td>0.013</td>
</tr>
<tr>
<td>Unit H</td>
<td>18</td>
<td>23</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
## Comparison of All Binder Application Rates

<table>
<thead>
<tr>
<th>Test Section</th>
<th>Binder Application Starting Rate in Field (gal/sy) (Different surface factors: S=0.06 / S=0.09)</th>
<th>New Zealand Method (gal/sy)</th>
<th>Actual Binder Rate (gal/sy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkway</td>
<td>0.24/0.25</td>
<td>*</td>
<td>0.41 gallons / sy</td>
</tr>
<tr>
<td>Unit A</td>
<td>0.43/0.44</td>
<td>0.36</td>
<td>0.48 gallons / sy</td>
</tr>
<tr>
<td>Unit B</td>
<td>0.25/0.27</td>
<td>0.37</td>
<td>0.37 gallons / sy</td>
</tr>
<tr>
<td>Unit C</td>
<td>0.25/0.27</td>
<td>0.36</td>
<td>0.37 - 0.38 gallons / sy</td>
</tr>
<tr>
<td>Unit D</td>
<td>0.26/0.28</td>
<td>0.40</td>
<td>0.37 gallons / sy</td>
</tr>
<tr>
<td>Unit E</td>
<td>0.26/0.28</td>
<td>0.39</td>
<td>0.36 gallons / sy</td>
</tr>
<tr>
<td>Unit F</td>
<td>0.39/0.42</td>
<td>0.34</td>
<td>0.50 gallons / sy</td>
</tr>
<tr>
<td>Unit G</td>
<td>0.44/0.46</td>
<td>0.39</td>
<td>0.50 gallons / sy</td>
</tr>
<tr>
<td>Unit H</td>
<td>0.44/0.45</td>
<td>0.41</td>
<td>0.52 gallons / sy</td>
</tr>
</tbody>
</table>
Chip Seal Design Findings

Chip Rate, Lbs/SY

- Parkway
- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F
- Unit G
- Unit H

- New Zealand
- McLeod
- Actual
- Optimum
Binder Application Rate on a Hot-Applied Chip Seal

- **ALD and Percent Waste**

![Graph showing the relationship between Chip Application Rate (lbs/sy) and Percent Waste Allowed (5%, 7.5%, 10%, 12.5%, 15%) for different ALD sizes: ALD 3/8 inch, ALD 5/16 inch, ALD 1/4 inch, Parkway Design, ALD No. 4, Parkway Field. Actual ALD = 0.23 inch]
Binder Application Rate on a Hot-Applied Seal

- Traffic and Surface Texture

<table>
<thead>
<tr>
<th>Embedment (%)</th>
<th>85%</th>
<th>75%</th>
<th>70%</th>
<th>65%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Volume (AADT)</td>
<td>Under 100</td>
<td>100-500</td>
<td>500-1000</td>
<td>1000-2000</td>
<td>Over 2000</td>
</tr>
<tr>
<td>Binder Application Rate, gal/sy</td>
<td>0.4</td>
<td>0.35</td>
<td>0.3</td>
<td>0.25</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Actual AADT = 4000
Actual Field Rate = 0.41 gal/sy
Binder Application Rate on a Hot-Applied Chip Seal

- **ALD and Percent Waste**

![Graph showing the relationship between Chip Application Rate and Percent Waste Allowed for different ALD sizes.]

- Actual ALD = 0.22 inch

<table>
<thead>
<tr>
<th>ALD</th>
<th>Percent Waste Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td></td>
</tr>
<tr>
<td>5/16 inch</td>
<td></td>
</tr>
<tr>
<td>1/4 inch</td>
<td></td>
</tr>
</tbody>
</table>

- ALD No. 4
- UNIT H Design
- Unit H Field
Binder Application Rate for an Emulsified Chip Seal

- Traffic and Surface Texture

<table>
<thead>
<tr>
<th>Embedment:</th>
<th>85%</th>
<th>75%</th>
<th>70%</th>
<th>65%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Volume, (AADT)</td>
<td>85%</td>
<td>75%</td>
<td>70%</td>
<td>65%</td>
<td>60%</td>
</tr>
<tr>
<td>Under 100</td>
<td>0.5</td>
<td>0.45</td>
<td>0.4</td>
<td>0.35</td>
<td>0.3</td>
</tr>
<tr>
<td>100-500</td>
<td>0.45</td>
<td>0.4</td>
<td>0.35</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>500-1000</td>
<td>0.4</td>
<td>0.35</td>
<td>0.3</td>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>1000-2000</td>
<td>0.35</td>
<td>0.3</td>
<td>0.25</td>
<td>0.2</td>
<td>0.15</td>
</tr>
<tr>
<td>Over 2000</td>
<td>0.3</td>
<td>0.25</td>
<td>0.2</td>
<td>0.15</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Actual AADT = 690
Field Rate = 0.52 gal/sy

- Badly Pocked, Porous & Oxidized
- Slightly Porous & Oxidized
- Unit H Design
- Smooth, Non-Porous Surface
Preliminary Findings

- All three chip seals with chip-seal related distresses are hot-apply
- Both chip seal types show an overall improvement in pavement condition
- Dynamic Friction Data was consistent between sections- inconsistent between years.
- All chip seals passed the New Zealand one-year performance specification
- Emulsified chip seals tended to be over-chipped whereas Hot-apply were close to the design
Recommendations

- Know the materials
- Pre-seal pavement condition plays a key role
- Projects demonstrate performance specification proof of concept
- Design methods provide engineering approach and a framework for chip seal education
Next Steps

- Finalize Design Guide
- Phase II Implementation Phase
  - Chip Seal Workshops
  - Teach Chip Seal Design Methodology
  - Design Lab-Field Validation
  - Introduce New Zealand Performance Specification
Thank you!