Optimum Time for Application of Slurry Seal to Asphalt Concrete Pavements

UNR Pavement/Materials Engineering
Cooperative Agreement

University of Nevada Reno (UNR)
Western Regional Superpave Center
Problem Statement and Objective

- The time of Slurry Seal (SS) application is left to the Project Engineer judgment and practice.
  - SS right after construction
  - SS after 1, 3, 5 etc. years of service
  - ...

- **Objective:** Evaluate the field performance & effectiveness of SS on asphalt pavements in Truckee Meadows Region
Research Phases

- **Phase I:**
  - Evaluate *effectiveness* & *optimum time* for *single* application of slurry seal

- **Phase II:**
  - Evaluate *effectiveness* & *optimum time* for *sequential* application of slurry seal
Phase I: Research Approach

- Collect & evaluate performance data of asphalt pavements
  - *without* slurry seal
  - *receiving* single slurry seal at various times: 0, 1, 3, 5, 7, and 9.

- Identify *effectiveness* & *optimum time* for SS application.
Asphalt pavement sections were identified within the jurisdictions of: WCED, COR and COS.

<table>
<thead>
<tr>
<th>Initial Construction Pavement Type</th>
<th>Road Classification</th>
<th>ADT</th>
<th>Total number of sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Construction</td>
<td>Arterial</td>
<td>≥ 10,000</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Collector</td>
<td>&lt; 10,000</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>&lt; 6,000*</td>
<td>525</td>
</tr>
<tr>
<td>Overlay</td>
<td>Arterial</td>
<td>≥ 10,000</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Collector</td>
<td>&lt; 10,000</td>
<td>226</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>&lt; 6,000*</td>
<td>1,848</td>
</tr>
</tbody>
</table>

*With a high percentage of trucks (> 4%)
Phase I: Evaluated Sections (Cont’d)

- Within each group (i.e. Road class), pavement sections were broken into three categories:
  - **Do – Nothing**: SS was not applied to the pavement
  - SS applied immediately after construction (referred to as 0)
  - SS applied at: 1, 3, 5, 7, and 9 years after construction

- Performance was measured in terms of PCI.
Performance Models for Newly Constructed Pavements without Slurry Seal

PCI = -0.0058Age^4 + 0.1863Age^3 - 1.7141Age^2 - 0.6472Age + 99.752

PCI = 0.001Age^4 - 0.0312Age^3 + 0.2715Age^2 - 4.4837Age + 100.77

PCI = -0.0026Age^4 + 0.0891Age^3 - 0.9833Age^2 - 0.8446Age + 99.24

R² = 0.98

R² = 0.98

R² = 0.91
Performance Models for Pavements that Received Overlay without Slurry Seal

Overlay - Arterials
PCI = -0.0185Age^4 + 0.5036Age^3 - 4.0695Age^2 + 3.6796Age + 98.809
R² = 0.97

Overlay - Collectors
PCI = -0.0004Age^4 + 0.0099Age^3 - 0.2232Age^2 - 3.7809Age + 99.192
R² = 0.96

Overlay Residential
PCI = -0.0048Age^4 + 0.1177Age^3 - 0.9078Age^2 - 1.9824Age + 98.666
R² = 0.91

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Performance Models for Pavements with Slurry Seal:

- Similar models were developed for:
  - Slurry seal for newly constructed pavements
    - Arterial
    - Collectors
    - Residential
  - Slurry seal for pavements that received overlay
    - Arterial
    - Collectors
    - Residential
Prediction Performance Models

New Construction - Arterial

- Slurry Seal at year 0
- Slurry Seal at year 1
- Slurry Seal at year 3
- Slurry Seal at year 5
- Slurry Seal at year 7
- Slurry Seal at year 9
Prediction Performance Models

Overlay - Arterial

Overlay

Slurry Seal at year 0

Slurry Seal at year 1

Slurry Seal at year 3

Slurry Seal at year 5

Slurry Seal at year 7

Slurry Seal at year 9

PCI

Age in Years

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Prediction Performance Models

New Construction - Collectors

![Graphs showing PCI vs Age in Years for New Construction and Slurry Seal at different years (0, 1, 3, 5, 7, 9).](image-url)
Prediction Performance Models

*Overlay - Collector*

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*Overlay* - *Collector*

- Slurry Seal at year 0
- Slurry Seal at year 1
- Slurry Seal at year 3
- Slurry Seal at year 5
- Slurry Seal at year 7
- Slurry Seal at year 9

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Prediction Performance Models

New Construction - Residential

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Prediction Performance Models

**Overlay - Residential**

![Graphs showing PCI versus Age in Years for different treatments: New Construction, Slurry Seal at year 0, 1, 3, 5, 7, and 9.](image-url)
Application of slurry seal at years 0 and 1 did not show a significant change in the shape of the performance curve neither in the initial PCI.

Application of slurry seal at years 3 and 5 show significant jumps in the PCI value at the time of application and in the shape of the performance curve for future years.

Application of slurry seal at years 7 and 9 show significant jumps in the PCI value at the time of application coupled with a steeper decay in the performance curve for future years.
Slurry Seal Performance Life & Extension in Pavement Service Life

- Performance Life ~ 2 yrs
- Performance Life ~ 3 yrs
- Extension in Pavement Service Life ~ 2 yrs

Age in Years

New Construction
- Slurry Seal at year 3
- Slurry Seal at year 7
SS Performance Life & Extension in Pavement Service Life

- In general performance life ranged between 2 and 4 years.

- Except when slurry seal was applied at year 0 and 1, performance life ranged from 0 to 1 year.

- Except few cases, the pavement service life was not extended by application of the slurry seal.
Slurry Seal Effectiveness

Relative Benefit = \(100 \times \frac{B}{B_0}\)  

Benefit Cost Ratio = \(\frac{B}{C}\)

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Effectiveness Analysis – New Construction

Year of Slurry Seal Application

Benefit (PCIyrs)

Year of Slurry Seal Application

Relative Benefit

Year of Slurry Seal Application

Benefit-Cost Ratio (x1000)

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Effectiveness Analysis – Overlay

- Benefit (PCI yrs) vs Year of Slurry Seal Application
- Relative Benefit vs Year of Slurry Seal Application
- Benefit-Cost Ratio (x1000) vs Year of Slurry Seal Application

Legend:
- OL-Arterial (A)
- OL-Collector (B)
- OL-Residential (C)
Phase I: Conclusion

- Application of SS immediately or one year after construction of asphalt layer is not effective in terms of:
  - the benefit to the users and
  - the benefit-cost ratio for the agency.

- Allow asphalt pavement to age for the first 3 years prior to the application of any surface treatment.
  - allow asphalt mix to gain strength & built-up its resistance to early rutting and shoving.
  - protect the asphalt mix from excessive aging and improves its resistance to cracking.
Phase I: Conclusion

- Optimum time for application of SS:
  - Newly constructed pavements: 3 years after construction.
  - Pavements subjected to overlays: 3-5 years after construction.

- For uniformity purposes, it is recommended that the agency applies SS 3 years after the construction of the asphalt layer for both new and overlay constructions.
Phase II: Sequential Slurry Seal Applications

- Collect & evaluate performance data of asphalt pavements
  - With a *first* slurry seal application at: 0, 1, 3 and 5 years
  - receiving a *second* slurry seal at either: 7 or 9 years.

- Identify effectiveness & optimum time for sequential SS application.

- PMS data from WCED, COR and COS
## Phase II: Double Slurry Seal Application

<table>
<thead>
<tr>
<th>Initial Construction Pavement Type</th>
<th>Year of the 1(^{st}) Slurry Seal Application</th>
<th>Total Number of Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2(^{nd}) Slurry Seal Applied at year 7</td>
</tr>
<tr>
<td>New Construction</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>Overlay</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Total Number of Sections**: 85, 87
**Newly Constructed** Pavements:  
1\textsuperscript{st} SS at year 3, 2\textsuperscript{nd} SS at year 7
Newly Constructed Pavements:
1\textsuperscript{st} SS at year 3, 2\textsuperscript{nd} SS at year 9

Age in Years

Present Condition Index (PCI)

1\textsuperscript{st} slurry seal

Predicted Do-Nothing performance curve

2\textsuperscript{nd} slurry seal

Predicted SS at year 3 performance curve

4 yrs

2.5 yrs

3 yrs

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Overlay Pavements:
1st SS at year 3, 2nd SS at year 7

Present Condition Index (PCI) vs. Age in Years

Predicted Do-Nothing performance curve

1st slurry seal

2nd slurry seal

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Overlay Pavements: 1st SS at year 3, 2nd SS at year 9

Present Condition Index (PCI)

0 20 40 60 80 100

Age in Years

0 2 4 6 8 10 12 14 16 18 20

1st slurry seal

2nd slurry seal

Predicted Do-Nothing performance curve

Predicted SS at year 3 performance curve
Phase II: Slurry Seal Effectiveness

Relative Benefit = 100 × B / B₀

Benefit-Cost Ratio = B / C
Phase II: Effectiveness

<table>
<thead>
<tr>
<th>Code</th>
<th>Relative Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>OL-0-7</td>
<td>15%</td>
</tr>
<tr>
<td>OL-0-9</td>
<td>8%</td>
</tr>
<tr>
<td>OL-1-7</td>
<td>12%</td>
</tr>
<tr>
<td>OL-1-9</td>
<td>11%</td>
</tr>
<tr>
<td>OL-3-7</td>
<td>56%</td>
</tr>
<tr>
<td>OL-3-9</td>
<td>46%</td>
</tr>
<tr>
<td>OL-5-9</td>
<td>26%</td>
</tr>
<tr>
<td>NC-0-7</td>
<td>25%</td>
</tr>
<tr>
<td>NC-0-9</td>
<td>21%</td>
</tr>
<tr>
<td>NC-1-7</td>
<td>17%</td>
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<tr>
<td>NC-1-9</td>
<td>23%</td>
</tr>
<tr>
<td>NC-3-7</td>
<td>88%</td>
</tr>
<tr>
<td>NC-3-9</td>
<td>77%</td>
</tr>
<tr>
<td>NC-5-9</td>
<td>32%</td>
</tr>
</tbody>
</table>
PHASE II: Conclusions

- Application of first SS immediately or one year after construction is not effective in terms of both the benefit to users and benefit cost ratio for the agency.

- Regardless of construction activity, optimum time for a sequential slurry seal is when first SS is applied in year 3 & second SS is applied in year 7.

- Pavement service life was extended by 2.0 to ~4.0 years when first SS was applied in years, 3 or 5 and second SS in either year 7 or 9. For those application conditions, the sequential SS was effective in delaying the time for reconstruction.
OVERALL SUMMARY

- For both new and overlay constructions, it is recommended that the agency applies
  - the single slurry seal application three years after construction.
  - the first slurry seal three years after the construction of the asphalt layer and the second slurry seal seven years after the construction.
Acknowledgment

- RTC Support gratefully acknowledged.

- Thank you for City of Reno, City of Sparks and Washoe County Engineering Department for providing access to their pavement management data.
THANK YOU FOR YOUR ATTENDANCE

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