Experiences with Nontraditional Fog Sealants

CTS Transportation Research Conference
Graduate Minneapolis
East Bank Campus University of Minnesota
Minneapolis, MN

Ed Johnson | MnDOT Office of Materials and Road Research
3:15 PM, 1 November 2018

RESEARCH SPONSORS

• Funding: Minnesota Local Road Research Board and MnDOT Transportation Research and Innovation Group

• Local Participation:
  • Tim Plath, City of Eagan (Champion)
  • Bruce Hasbargen, Beltrami County (Technical Liaison)
  • Virgil Hawkins, Wright County (Host Test Sections)

• Lab Research Project: University of Minnesota
  • Dr. Mihai Marasteanu and Dr. Debaroti Ghosh
Participants

• Materials:
  • MnDOT District 3
  • Bargen Inc., Midstates Equipment, and Biospan Technologies
  • Bituminous Roadways and Asphalt Systems Inc.
  • Pavetech, Inc.

FOG SEALING

• Traditional sealcoat: fog or chip seal
  • Like painting a house
• Treatment Idea for Worn-out Roads
  Saturate
  Aromatic
  Asphaltene
  Resin
  Aphaltene
TWO PROJECTS: OBJECTIVES

• Lab Study – University of Minnesota (Marasteanu and Ghosh)
  • Effects of adding sealants to the Asphalt Mixture and the Asphalt Binder – How does this improve performance?
  • Proposed binder strength testing method: Select for crack resistance (Thesis)
  • 2-year, final report June 2016

• Field Study – MnDOT Materials and Road Research
  • Furnish-install, application, equipment, sampling, field reviews and performance evaluations.
  • 4-year, final report May 2018
### Application Rates

#### Table 3 Treatment Rate Measured With Two Methods

<table>
<thead>
<tr>
<th>Section (Target Rate)</th>
<th>Rate on 2x2 Collection Pad Gallon/sy</th>
<th>Metered Rate on Treatment Area Gallon/sy</th>
</tr>
</thead>
<tbody>
<tr>
<td>RePlay A (0.015)</td>
<td>0.014</td>
<td>0.01998</td>
</tr>
<tr>
<td>RePlay B (0.015)</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>Biorestor A (0.015)</td>
<td>0.010</td>
<td>0.01557</td>
</tr>
<tr>
<td>Biorestor B (0.015)</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Biorestor C (0.020)</td>
<td>0.011</td>
<td>0.02092</td>
</tr>
<tr>
<td>Biorestor D (0.020)</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>CSS-1h dilute (0.10)</td>
<td>Not Measured</td>
<td>0.1</td>
</tr>
<tr>
<td>Jointbond A</td>
<td>0.061</td>
<td>0.073</td>
</tr>
<tr>
<td>Jointbond B</td>
<td>0.068</td>
<td></td>
</tr>
</tbody>
</table>

- Beware collection pad material
- Mass may be lost through freezer bags during transport as product vaporizes
- Wind condition may affect deposit of fog product (0.01 gallon = 1.28 oz = 37.9 ml)
- Systematic error
ALLOW CURE - Sensitive after Installation

FT-IR Spectroscopy

Figure 4 FTIR of Don't Pave

Figure 5 FTIR of Stabilized

Figure 6 FTIR of Macadam

Figure 7 FTIR of Bitumene
### Initial Road Condition

**2014 Crack Survey of CSAH 75**

<table>
<thead>
<tr>
<th>Date</th>
<th>Direction</th>
<th>Section</th>
<th>Length, ft</th>
<th>Cracks</th>
<th>Lineal ft Cracking</th>
<th>Average Spacing, ft</th>
<th>Segregation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/18/2014</td>
<td>EB</td>
<td>Biorestor 0.015</td>
<td>1334</td>
<td>5</td>
<td>21</td>
<td>267</td>
<td>Yes</td>
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<tr>
<td>9/18/2014</td>
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<td>Biorestor 0.020</td>
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<td>1</td>
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<tr>
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<td>WB</td>
<td>CSS-1h dilute</td>
<td>1000</td>
<td>8</td>
<td>64</td>
<td>125</td>
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<tr>
<td>9/18/2014</td>
<td>EB</td>
<td>Replay</td>
<td>2680</td>
<td>3</td>
<td>12</td>
<td>893</td>
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<tr>
<td>9/18/2014</td>
<td>EB</td>
<td>Control</td>
<td>500</td>
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<td>0</td>
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<td>30</td>
<td>215</td>
<td>95</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- **SPWE304C (PG 58-34)**
  - 64-34
- **4 inch**
- **8-ft shoulders**
- **Paved 2013**

### Distress Record

**2015 Overall**

<table>
<thead>
<tr>
<th>Date</th>
<th>Direction</th>
<th>Section</th>
<th>Survey Length, ft</th>
<th>Cracks</th>
<th>Lineal ft Cracking</th>
<th>Average Spacing, ft</th>
<th>Segregation</th>
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<td>23</td>
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<tr>
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<tr>
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<td>505</td>
<td>3</td>
<td>11</td>
<td>268</td>
<td>Noted</td>
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<tr>
<td>4/14/2016</td>
<td>WB</td>
<td>Control</td>
<td>2641</td>
<td>4</td>
<td>30</td>
<td>660</td>
<td>Noted</td>
</tr>
</tbody>
</table>

- **2016 Overall**

<table>
<thead>
<tr>
<th>Date</th>
<th>Direction</th>
<th>Section</th>
<th>Survey Length, ft</th>
<th>Cracks</th>
<th>Lineal ft Cracking</th>
<th>Average Spacing, ft</th>
<th>Segregation</th>
</tr>
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<tbody>
<tr>
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<td>Jointbond</td>
<td>2949</td>
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<td>212</td>
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<td>Noted</td>
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</table>

- **2017 Overall**

<table>
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<th>Lineal ft Cracking</th>
<th>Average Spacing, ft</th>
<th>Segregation</th>
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<td>91</td>
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<tr>
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<td>EB</td>
<td>Replay</td>
<td>2680</td>
<td>4</td>
<td>15</td>
<td>303</td>
<td>Located/rated L or M</td>
</tr>
<tr>
<td>4/14/2017</td>
<td>EB</td>
<td>Control</td>
<td>505</td>
<td>3</td>
<td>18</td>
<td>168</td>
<td>Located/rated L or M</td>
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<tr>
<td>4/14/2017</td>
<td>WB</td>
<td>Control</td>
<td>2641</td>
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<td>30</td>
<td>660</td>
<td>Located/rated L or M</td>
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</table>

- **2018 Overall**

<table>
<thead>
<tr>
<th>Date</th>
<th>Direction</th>
<th>Section</th>
<th>Survey Length, ft</th>
<th>Cracks</th>
<th>Lineal ft Cracking</th>
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<th>Segregation</th>
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<tr>
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<td>EB</td>
<td>Jointbond</td>
<td>2949</td>
<td>31</td>
<td>237</td>
<td>89</td>
<td>Located/rated L or M</td>
</tr>
</tbody>
</table>

* Raveling, square foot
Cracking Count and Rate

Friction
Texture (Mean Profile Depth)

![Graph showing MPD, mm (ASTM E2157) over years]

Retroreflectivity

![Graph showing Retroreflectivity, mcd/m²/lux before and after fog]

Before Fog
After Fog
Retroreflectivity Recovery

Recovery period with traffic
Less than 2,000 passes

- Not Measured: CSS-1h dilute

Permeability

- Missing: CSS-1h
### Binder Recovery and Testing – Year 3

#### High Temperature (DSR)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Slice, Core</th>
<th>DSR G*/Sin d, kPa</th>
<th>BBR Stiffness, MPa</th>
<th>BBR, m-Value</th>
<th>% AC</th>
<th>High PG</th>
<th>Low PG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Middle C1 C2</td>
<td>2.83</td>
<td>206</td>
<td>0.322</td>
<td>5.1</td>
<td>66.1</td>
<td>-36.0</td>
</tr>
<tr>
<td>CSS-1h</td>
<td>Middle C1 C2</td>
<td>2.90</td>
<td>274</td>
<td>0.311</td>
<td>4.2</td>
<td>66.3</td>
<td>-34.6</td>
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<tr>
<td>Jointbond</td>
<td>Middle J1 J2</td>
<td>2.29</td>
<td>226</td>
<td>0.336</td>
<td>4.9</td>
<td>64.3</td>
<td>-36.3</td>
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<tr>
<td>RePlay</td>
<td>Middle R1 R2</td>
<td>2.67</td>
<td>220</td>
<td>0.323</td>
<td>4.7</td>
<td>66.6</td>
<td>-35.8</td>
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<tr>
<td>Control</td>
<td>Top C1 C2</td>
<td>3.74</td>
<td>255</td>
<td>0.319</td>
<td>4.5</td>
<td>68.3</td>
<td>-35.4</td>
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<tr>
<td>CSS-1h</td>
<td>Top C1 C2</td>
<td>3.88</td>
<td>249</td>
<td>0.322</td>
<td>4.7</td>
<td>68.7</td>
<td>-35.5</td>
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<tr>
<td>Jointbond</td>
<td>Top J1 J2</td>
<td>2.92</td>
<td>252</td>
<td>0.317</td>
<td>4.8</td>
<td>66.3</td>
<td>-35.6</td>
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<tr>
<td>RePlay</td>
<td>Top R1 R2</td>
<td>3.80</td>
<td>228</td>
<td>0.310</td>
<td>4.5</td>
<td>68.5</td>
<td>-35.0</td>
</tr>
</tbody>
</table>

#### Low Temperature (BBR)

- **Stiffness**
- **M-value**

![Graph showing DSR G*/Sin d, BBR Stiffness, and BBR m-Value for different treatments.](image)
Findings from Binder Testing

- The simple mixing procedure results in significant changes in the PG of the original binder.
  - Clear indication that direct mixing procedure cannot simulate the blending mechanisms that occur in field conditions.
- The brushing procedure appears to be a much better indicator of the effect of the sealant application in field conditions.
- Oil-based sealants (RePlay and Biorestor) were observed to have the largest softening effect on binder.
- Storage time may affect the softening effect.

Field Project Take-Away’s

- Survey responses from Minnesota agencies experienced with non-traditional fog seals found:
  - Performance varied between “showing wear after 2 years” to “equal to control after 6 years”
  - Recommend additional trials

- APPLICATION: Few concerns when installing non-traditional products where distributor trucks can be used.
  - Perform acceptance checks of application rates and compare to the vendors metered volume or tank level. This study did not evaluate broom-applied or wand-applied methods.
  - Use the product at rates recommended by the manufacturer.
Field Project Take-Away’s

- **PAVEMENT MARKINGS:** All of the non-traditional products in the study caused reductions of retroreflectivity.
  - Recovery was observed on the marking tapes used in the study.
  - Agencies should consider the condition of their marking materials prior to application.

- **PAVEMENT PERMEABILITY, TEXTURE, AND FRICTION:** Measurements showed that all products in the study reduced the permeability of areas with and without mixture segregation. All of the products in the study also caused an increase in MPD surface texture over two years while the control section remained unchanged.
  - The cause of texture change has not been studied, the authors speculate it may be related either to loss of fog coating material or the exposure of aggregate texture due to mild solvent properties of some products.
  - All of the products in the study caused a temporary reduction in friction. The non-traditional products caused relatively smaller reductions, and showed more rapid recovery without benefit of traffic.
  - Agencies should consider the current condition of their candidate roads, and posted speeds prior to installing the products in this study.

Field Project Take-Away’s

- **EFFECT ON ASPHALT BINDER PERFORMANCE:** For a mixture containing PG 64-34.
  - Spray applied fog sealers did not affect the high temperature performance.
  - CSS-1h dilute fog treatment showed better low temperature performance relative to the control and non-traditional sections.

- **EFFECT ON CRACKING PERFORMANCE:** Based on this study, agencies considering applications over similar dense-graded asphalt mixtures may find reduced cracking during the first several years of service.

- **COMPATIBILITY WITH FUTURE BITUMINOUS TREATMENTS:** Agencies should not expect to encounter problems when using an emulsified asphalt to over-seal sections treated with non-traditional fog sealers. No problems were observed at 8-months.
During Project Timeframe

- **Simultaneous Research**
  - Ohio DOT – Effectiveness of Penetrating Sealers (H. Von Quintus)
  - Manufacturer-sponsored case studies
    - Shared nationally via papers and presentations
- **Ongoing research**
  - Agricultural Utilization Research Institute (AURI)
  - Continued experimentation by local and state
- **National interest in rejuvenating materials for asphalt**
  - Spray applied for preservation
  - Incorporated at plant to modify recycled binder component
ELEMENTS OF THE INVESTIGATIONS

• Lab Study
  • Binder Testing
    • Rheology (G* from DSR and Creep Stiffness & m-value from BBR)
    • Aged material: RTFO short-term and PAV long-term
  • Mixture Testing
    • Stiffness, m-value, Strength

• Field Study
  • Site and Product Selection
  • Field Installation, Testing and Monitoring, End-of-project Mixture Test
  • Agency Survey
How are they performing? Year 2

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Control</th>
<th>CSS-1h dilute</th>
<th>Replay</th>
<th>Biocem 0.015</th>
<th>Biocem 0.02</th>
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<tr>
<td>SHED WATER</td>
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<tr>
<td>RETARD INFILTRATION</td>
<td>1 min</td>
<td>13 min</td>
<td>4 min</td>
<td>2 min</td>
<td>3 min</td>
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<td>Recovery documented, YEAR 1</td>
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<td>Appearance</td>
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<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
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<tr>
<td>RETROREFLECTIVITY (marking tape)</td>
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</tr>
</tbody>
</table>

- **Year 3 Traditional Bituminous Fog Seal** over sections
  - No problems with coverage
  - Look good after 1st winter
  - CSS-1h and Jointbond “show through” new fog

\[
K = \left( \frac{a_1}{a_0} \right) \ln \left( \frac{h_1}{h_2} \right)
\]

Where:
- \( K \) is the coefficient of permeability (cm/s), and
- \( a \) = inside cross-sectional area of standpipe, or tier (cm²)
- \( L \) = length of the sample (thickness of the asphalt mat) (cm)
- \( A \) = contact area of permeameter and pavement (cm²)
- \( t \) = Elapsed time between \( h_1 \) and \( h_2 \) (s)
- \( h_1 \) = Initial head (cm)
- \( h_2 \) = Final head (cm)

\[ y = 0.1317e^{0.0394} \]

\[ R^2 = 0.7889 \]