Implementing the Next Generation of Ultra Thin Slurry Seals

TxDOT project 5-6615-01
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Background
Study 5-6615-01 Evaluation of UT Slurries

- Designed and constructed under SS 3028 “Frictional Asphaltic Surface Preservation Treatment”
- Promoted as a high speed, low cost maintenance treatment with both safety and pavement preservation applications
- Used widely on shoulders but is the treatment appropriate for travel lanes applications?
Ultra-Thin Slurry Overlays

- Spray applied maintenance treatment.
- Cross between slurry and fog seal.
- Cost $1:10 – $2:00 Sq. yard
  - Chip Seals $2:50
  - Overlays $6 - $8

- Properties:
  - Polymer-mod emulsion.
  - Embedded aggregate.
  - Rapid cure time.
  - Long-term black color.
Background

Test Section Construction 2014 at TTI

Placed on Riverside campus

X1, X2, X3

UT Slurry R1

Fog seal squeegee applied
Original Performance Summary

- Higher skid performance over fog seal.
- Macrotexture, highly dependent on existing surface
- Unknown long-term durability.
Proposed Safety Applications
Under consideration by TxDOT Districts

Blacking Out old lane markings

Improving Skid Resistance
Pavement Preservation
Under consideration by TxDOT Districts

Preventing Stone loss in aged surfaces

Sealing Minor Cracking
Work Plan

- Task 1 Plan Construction of Test Sections
  - Three Districts  Austin, Fort Worth and Beaumont
  - Document upfront condition

- Task 2 Update Specifications
  - Existing SS 3028  (largely industry recommendations)

- Task 3 Construct and Monitor test Sections
  - Skid measurements for duration of study
  - Collect samples/Lab testing
  - Performance evaluation
Work Plan Continued

- Task 4 Prepare Workshop training materials
  - Guidelines to TxDOT Districts on where and how to use these Findings of study

- Task 5 Present Training materials Workshop
  - Two training schools
Review of Current Specification
Review of Current Specification

- Largely proposed by Industry

Special Specification 3028
Frictional Asphaltic Surface Preservation Treatment

1. DESCRIPTION

Apply a surface preservation treatment consisting of one or more applications of a single layer of asphaltic and aggregate material.
High Quality Aggregate required

Aggregate. Furnish aggregate meeting Item 302, “Aggregates for Surface Treatments,” of the grade shown in Table 2.

Table 2. Aggregates

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Procedure</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Absorption, %</td>
<td>T 84</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Micro-Deval, %</td>
<td>D 7428</td>
<td>-</td>
<td>20</td>
</tr>
</tbody>
</table>

Gradation

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Standard</th>
<th>Master Grading Band Limits Percent Passing</th>
<th>Target Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 8</td>
<td>C 136</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>No. 16</td>
<td>C 136</td>
<td>85-100</td>
<td>± 5</td>
</tr>
<tr>
<td>No. 30</td>
<td>C 136</td>
<td>75-100</td>
<td>± 5</td>
</tr>
<tr>
<td>No. 60</td>
<td>C 136</td>
<td>10-40</td>
<td>± 5</td>
</tr>
<tr>
<td>No. 100</td>
<td>C 136</td>
<td>0-10</td>
<td>± 5</td>
</tr>
<tr>
<td>No. 200</td>
<td>C 117</td>
<td>0-5</td>
<td>± 1</td>
</tr>
</tbody>
</table>

1. Perform physical property tests on aggregates that are received before blending into sealer.
2. Micro-Deval on aggregate larger than No. 60 sieve U.S.
Relative difference in amount of aggregate per sq.yd

Microsurfacing

UT Slurry Seal
Relative Differences in Aggregate rates

Microsurface  UT Slurry Seal
Pavement surface before UT Slurry
Pavement Surface After UT Slurry

- How it works: Decreases permeability of surface although does not seal cracks.
3. **MIX DESIGN**

3.1 Furnish a laboratory mix design meeting the requirements shown in Table 3:

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Procedure</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet-Track Abrasion Loss, 3 day soak, g/m²</td>
<td>D 3910¹</td>
<td>--</td>
<td>80</td>
</tr>
<tr>
<td>Asphalt Content by Ignition Method, %</td>
<td>T 308</td>
<td>30</td>
<td>--</td>
</tr>
<tr>
<td>Dynamic Friction Test Number, 20 kph</td>
<td>E 1911²</td>
<td>0.90</td>
<td>--</td>
</tr>
</tbody>
</table>

1. Use the modified method to account for realistic application depth and fine emulsion mixture.
2. Establish base friction value using prepared laboratory compacted slab of approved mix as surface to be tested. The Dynamic Friction Test (DFT) number ratio should indicate that after application of the mastic seal, the surface retains required minimum percentage DFT number of the original pavement surface.
## Wet track abrasion

<table>
<thead>
<tr>
<th>Model</th>
<th>Running Time</th>
<th>Conversion Constant - g/ft²</th>
<th>Conversion Constant - g/m²</th>
<th>C-100 Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-100</td>
<td>5 min. ± 2 sec.</td>
<td>3.06</td>
<td>32.9</td>
<td>1.00</td>
</tr>
<tr>
<td>A-120</td>
<td>6 min., 45 sec. ± 2 sec.</td>
<td>2.78</td>
<td>29.9</td>
<td>1.17</td>
</tr>
<tr>
<td>N-50</td>
<td>5 min., 15 sec. ± 2 sec.</td>
<td>3.48</td>
<td>37.5</td>
<td>0.78</td>
</tr>
<tr>
<td>Modified N-50</td>
<td>5 min., 15 sec. ± 2 sec.</td>
<td>3.06</td>
<td>32.9</td>
<td>0.78</td>
</tr>
</tbody>
</table>

### CALCULATION

Calculate the loss of material abraded in g/ft² or g/m² (wear value):

\[
wear \text{ value} = (A - B) \cdot C \cdot D
\]

Where:
- \( A \) = Initial dry specimen weight
- \( B \) = Abraded dry specimen weight
- \( C \) = Conversion constant from Table 1
- \( D \) = C-100 correction factor from Table 1.
Dynamic Friction Tester (ASTM E 1911)

- Variable speeds (typical max @80 km/h)
- Wet testing
- Predict Skid Number
Key Construction Requirements

5. CONSTRUCTION

5.1 Adverse Weather Conditions. Do not place mixture when, in the Engineer’s opinion, general weather conditions are unsuitable. Meet the requirements for air and surface temperature shown below.

5.1.1 Standard Temperature Limitations. Apply mixture when air temperature is above 50°F and rising. Do not apply mixture when air temperature is 60°F and falling. In all cases, do not apply mixture when surface temperature is below 60°F.

5.1.2 Cool Weather Night Air Temperature. The Engineer reserves the right to review the National Oceanic and Atmospheric Administration (NOAA) weather forecast and determine if the nightly air temperature is suitable for mixture placement.

5.1.3 Cold Weather Application. When mixture application is allowed outside of the above temperature restrictions, the Engineer will approve the mixture and the air and surface temperatures for application. Apply mixture at air and surface temperatures as directed.
5.3. **Application.** Apply the mixture when the air temperature is at or above 60°F, or above 50°F and rising. Measure the air temperature in the shade away from artificial heat. The Engineer will determine when weather conditions are suitable for application.

Distribute material at the following rates or as directed:

- First application: 1.0 to 1.5 lbs per SY.
- Second application: 1.0 to 1.5 lbs per SY.
- Total application after the second application: 2.5 lbs per SY minimum.

5.4. **Edges.** Adjust the shot width so operations do not encroach on traffic or interfere with the traffic control plan, as directed. Use paper or other approved material at the beginning and end of each shot to construct a straight traverse joint. Unless otherwise approved, match longitudinal joints with the lane lines. The Engineer may require a string line if necessary to keep the edge straight. Use sufficient pressure to flare the nozzles fully.
Opening typically after 2 hours

5.6. **Opening to Traffic.** Open the treated surface to traffic when directed. Furnish and uniformly distribute clean, fine sand on the surface to blot the excess when an excessive quantity of mixture is applied. Maintain ingress and egress as directed by applying sand to freshly treated areas.
Case Studies
Case Studies

- San Antonio
- Beaumont
- Fort Worth
Monitoring Tools

- Visual Observation
- Locked Wheel Skid Truck
- Dynamic Friction Tester
- Circular Track meter
Locked-wheel (ASTM E 274)

- 100% slip
- Tire oriented in direction of travel (no side friction)
- Tested at 40 or 50 mph
Dynamic Friction Tester

- Requires lane closures
- Spot measurements
Circular-Track Meter (ASTM E 2157)

- Macro-texture
- Laser-based measurement
- Measures same track as DFT
- Correlates with sand patch
- Standard to compute IFI
- Lane closures/spot measure
San Antonio  IH 35

- UT Slurry Seal applied on raveling old PFC to retain rock
San Antonio  IH 35

- Condition after 18 months of service
- Wear off in wheel paths – raveling continued
Skid reduction on UT slurry sections

San Antonio IH 35

Existing PFC

UT Slurry Section

Existing PFC

June 2017

April 2018
San Antonio  IH 35

- Skid reduction on UT slurry sections (existing vs slurry)
- Continued raveling increased skid (see test dates)
Beaumont Applications

- Ultra-thin slurry treatment @ Beaumont District
Beaumont Applications

- Ultra-thin slurry was placed on 6 miles long on FM 2518 existing (HMAC)
Beaumont Applications

- Ultra-thin slurry was placed on SH 105 bridge deck
## Beaumont Applications

- Skid Numbers on SH 105 bridge deck

<table>
<thead>
<tr>
<th>Month</th>
<th>Section</th>
<th>SH 105, K1</th>
<th>SH 105, K6</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2018</td>
<td>Ultra-Thin Slurry</td>
<td>24.6</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>Pavement between bridges</td>
<td>55.6</td>
<td>55.4</td>
</tr>
<tr>
<td>June 2019</td>
<td>Ultra-Thin Slurry</td>
<td>23.9</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>Pavement between bridges</td>
<td>19.6</td>
<td>17.8</td>
</tr>
</tbody>
</table>
Beaumont Applications

- Skid Numbers on FM 2518 existing (HMAC)

<table>
<thead>
<tr>
<th></th>
<th>Section</th>
<th>FM 2518, K1</th>
<th>FM 2518, K6</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2018</td>
<td>Ultra-Thin Slurry</td>
<td>20.1</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td>Pavement at end of section</td>
<td>23.7</td>
<td>23.5</td>
</tr>
<tr>
<td>June 2019</td>
<td>Ultra-Thin Slurry</td>
<td>16.7</td>
<td>14.9</td>
</tr>
<tr>
<td></td>
<td>Pavement at end of section (new seal)</td>
<td>65.1</td>
<td>61.4</td>
</tr>
</tbody>
</table>
Fort Worth Applications

- Fort Worth District has been using the Thin Slurry mixes on highway shoulders

- In July of 2018, TTI researchers assessed newly installed sections of Ultra-thin slurry on Spur 102 near Keene, Tx and IH 35 Frontage Road

- Used DFT & CTMeter to predict SN50

- DFT and CTM were taken soon after application
Fort Worth Applications

- Shoulder Section on Spur 102 near Keene, TX
Fort Worth Applications

- Fort worth predicted Skid Numbers

<table>
<thead>
<tr>
<th></th>
<th>Avg of DFT 20</th>
<th>Avg MPD from CTM</th>
<th>Predicted SN 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>IH 35 Frontage Road</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treated Shoulder</td>
<td>0.38</td>
<td>0.84</td>
<td>28.8</td>
</tr>
<tr>
<td>Untreated Main-lane</td>
<td>0.39</td>
<td>1.03</td>
<td>31.8</td>
</tr>
<tr>
<td>Spur 102</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treated Shoulder</td>
<td>0.36</td>
<td>0.78</td>
<td>26.9</td>
</tr>
<tr>
<td>Untreated Main-lane</td>
<td>0.22</td>
<td>0.68</td>
<td>18.9</td>
</tr>
</tbody>
</table>
Issues Current applications

- No matter what the existing skid resistance of the highway, the after treated skid will be around 20. Which is a problem on high speed roadways.

- Based on experience the treatment appears to wear off in 12 to 16 months.

- Need to investigate in the lab methodologies to get more rock into these slurries.
Lab Tests
Overview

- Evaluate the benefits of changing to Light Weight Aggregate (more rock - better skid)
  - Design in lab
  - Validate in Field
- Evaluate application of slurry seals to clog PFC’s prior to overlaying them
Objectives

- Develop lab test procedures to measure the impact of UT Slurry Seal on skid resistance
- Develop UT Slurry Seals mixtures for field evaluation
- Validate skid numbers measured in the lab with field performance
Specimen Fabrication

- Used plant prepared mixtures for Slabs & 6-inch molds
- Specimen Mixture types
  - Dense-graded (type D)
  - Permeable friction course (PFC)
  - 7±1% air voids (20 ± 2% air void for PFC)
- Slurry Aggregates mixture
  - Black beauty (BB) and
  - Lightweight aggregates (LWA)
  - passing #6 (1/8”), #8, #16 and #30
UT Slurry Application

- Slurry application on Lab prepared slabs

Measuring 0.125/SY with improvised deep stick. @
Red mark = 1 shot

Applying and uniformly spreading the Slurry on slab surface using a brush

Final look of the Treated slab after 72hrs@60°C curing
UT Slurry Application

0.25gal/sy Light Weight UT Slurry on a Type D slab

0.25gal/sy Black Beauty UT Slurry on a Type D slab
UT Slurry Application
Friction Test
Wet Track Abrasion

Thin sample preparation

- For determination of the wear value
- Intended to check if the binder is enough or adhere well to the aggregates (Wear <80)
- Other factors such application spray limited the agg %.
Wet Track Abrasion
Thin sample preparation
## Wet Track Abrasion

### Wear values

<table>
<thead>
<tr>
<th>ID</th>
<th>Weight before test (g)</th>
<th>weight after test (g)</th>
<th>weight loss (g)</th>
<th>Wet track value (g/m²)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB/18%</td>
<td>60.3</td>
<td>57.2</td>
<td>3.1</td>
<td>90.675</td>
<td>WTV&gt;80 (less binder)</td>
</tr>
<tr>
<td>BB/18%</td>
<td>74.3</td>
<td>72.6</td>
<td>1.7</td>
<td>49.725</td>
<td>WTV&lt;80 (0k)</td>
</tr>
<tr>
<td>BB/18%</td>
<td>82.1</td>
<td>79.7</td>
<td>2.4</td>
<td>70.2</td>
<td>WTV&lt;80 (0k)</td>
</tr>
<tr>
<td>LWA8-30/12%</td>
<td>140.3</td>
<td>136.9</td>
<td>3.4</td>
<td>99.45</td>
<td>WTV&gt;80 (less binder)</td>
</tr>
<tr>
<td>BB/18%</td>
<td>83.9</td>
<td>78.7</td>
<td>5.2</td>
<td>152.1</td>
<td>WTV&gt;80 (less binder)</td>
</tr>
<tr>
<td>BB/18%</td>
<td>129.2</td>
<td>126.2</td>
<td>3</td>
<td>87.75</td>
<td>About right</td>
</tr>
<tr>
<td>LWA8-30/12%</td>
<td>140.3</td>
<td>136.9</td>
<td>3.4</td>
<td>99.45</td>
<td>WTV&gt;80 (less binder)</td>
</tr>
<tr>
<td>LWA 16-0/18%</td>
<td>132.8</td>
<td>130.5</td>
<td>2.3</td>
<td>67.275</td>
<td>WTV&lt;80 (0k)</td>
</tr>
<tr>
<td>LWA16-0/18%</td>
<td>75.1</td>
<td>72.5</td>
<td>2.6</td>
<td>76.05</td>
<td>WTV&lt;80 (0k)</td>
</tr>
<tr>
<td>LWA8-30/18%</td>
<td>90.8</td>
<td>89.4</td>
<td>1.4</td>
<td>40.95</td>
<td>WTV&lt;&lt;80 (bleeding or excessive binder)</td>
</tr>
<tr>
<td>LWA#16-0/18%</td>
<td>82.1</td>
<td>79.7</td>
<td>2.4</td>
<td>70.2</td>
<td>WTV&lt;80 (0k)</td>
</tr>
<tr>
<td>LWA #16-0/18%</td>
<td>124.2</td>
<td>122</td>
<td>2.2</td>
<td>64.35</td>
<td>WTV&lt;80 (0k)</td>
</tr>
</tbody>
</table>
Impact of UT Slurry on Friction

- The slab is wheel polished
- Fan dried
- MPD determined using CTMeter
- $\mu$ determined using DFT
Impact of Slurry Seal on Friction

- Performed on Type D slabs
- First tests was performed on BB based UT Slurry
- Treated and Untreated slabs were compared at different polish wheel passes

<table>
<thead>
<tr>
<th>Wheel Passes</th>
<th>0</th>
<th>5000</th>
<th>10000</th>
<th>20000</th>
<th>50000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onyx Treated Slab (D4)</td>
<td><img src="image1" alt="Sample Image" /></td>
<td><img src="image2" alt="Sample Image" /></td>
<td><img src="image3" alt="Sample Image" /></td>
<td><img src="image4" alt="Sample Image" /></td>
<td><img src="image5" alt="Sample Image" /></td>
</tr>
<tr>
<td>Untreated Slab (D5)</td>
<td><img src="image6" alt="Sample Image" /></td>
<td><img src="image7" alt="Sample Image" /></td>
<td><img src="image8" alt="Sample Image" /></td>
<td><img src="image9" alt="Sample Image" /></td>
<td><img src="image10" alt="Sample Image" /></td>
</tr>
</tbody>
</table>
Impact of Slurry Seal on Friction

- Predicted SN for BB-UT slurry slabs.
- SN of the treated slab hovered around 20.
- SN of the untreated slab varied from 34 (zero-wheel passes) to 22 (after 50,000-wheel passes).
Impact of Slurry Seal on Friction

- SN Comparison of different BB and LWA-UT slurry mixtures
- LWA fared better; #6-0

![Predicted Skid Number for different aggregate size/type](image)
Impact of Slurry Seal on Friction

- A full lab skid test was performed on the UT Slurry mixture comprised of LWA # 6-0 aggregates
  - Four slabs with different UT Slurry treatment combination and one untreated were used
  - The slabs were: Type D1 (0.2/18%), Type D2 (0.2/15%), Type D3 (0.25/18%), Type D4 (0.25/15%), and Type D5 (Control)
Impact of Slurry Seal on Friction

- The SN for different LWA UT slurry

- Predicted Skid Number

- Untreated Slab
- Treated - No Polish
- Treated- Polished 1000 Passes
- Treated - Polished 5000 Passes
- Treated-Polished 20000 Passes
Impact of Slurry Seal on Friction

- Normalized SN for different LWA UT slurry
Conclusion on Friction Tests

- The skid performance of UT Slurry mixtures can be assessed in the lab using the Polisher, DFT and CTmeter.
- The current UT Slurry mixture based on BB aggregates does not improve the skid of HMA pavement surface.
- An alternative to BB aggregates could be the LWA based UT Slurry applied in two shots of 0.125 gal/yd².
- No known correlation between lab polisher and field performance!!.
Recommendation - Friction Tests

- The research team recommended the following mixtures for further assessment in the Field.
  - #6-0 LWA based UT Slurry (15% aggregates) at two shots of 0.125gal/yd² each
  - #16-0LWA) based UT Slurry (18% aggregates) at two shots of 0.125gal/yd² each
  - #60-0 BB - based UT Slurry (18% aggregates) at two shots of 0.125gal/yd² each. Though it showed relatively poor results in TTI lab, it will give a good comparison in the field.
Permeability Tests
Recommendation - Friction Tests

- Varied amount of UT Slurry on lab produced specimens
- Specimens were saturated before testing
- Reported flow time and coefficient of permeability, k
Permeability test - Florida Method

- Performed accordance with Florida Test Method FM 5-565 on 2.5-inch Type D, PFC and Field specimens

<table>
<thead>
<tr>
<th>HMA Mixture</th>
<th>UT slurry, g</th>
<th>UT slurry, g</th>
<th>UT slurry, g</th>
<th>Surface UT Slurry (g)</th>
<th>UT slurry, g</th>
<th>UT slurry, g</th>
<th>UT slurry, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type D</td>
<td>0</td>
<td>18</td>
<td>27</td>
<td>40</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PFC</td>
<td>0</td>
<td>18</td>
<td>27</td>
<td>36</td>
<td>45</td>
<td>54</td>
<td>63</td>
</tr>
</tbody>
</table>

- No UT Slurry was applied on Field Specimens (FM 359)
PFC test results

- Water flow time increased with increased amount of UT Slurry
- Initial UT Slurry treatment disappeared into its large voids as such no change was observed at UT Slurry <27 g (= 0.4 gals/yd²)
PFC test results

- Predicted amount of UT Slurry needed to seal a new PFC
- Compared to a new type D mixture (flow time = 75 s)
- 1.25gal/yd² was needed to fully seal a PFC surface with UT slurry

<table>
<thead>
<tr>
<th>Onyx (g)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.26</td>
</tr>
<tr>
<td>18</td>
<td>4.44</td>
</tr>
<tr>
<td>27</td>
<td>4.29</td>
</tr>
<tr>
<td>36</td>
<td>6.78</td>
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<td>45</td>
<td>8.00</td>
</tr>
<tr>
<td>63</td>
<td>9.12</td>
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<tr>
<td>70</td>
<td>28.86</td>
</tr>
<tr>
<td>80</td>
<td>46.88</td>
</tr>
<tr>
<td>91</td>
<td>75.09</td>
</tr>
</tbody>
</table>

Predicted amount of UT Slurry needed to seal a new PFC compared to a new type D mixture (flow time = 75 s).

1.25gal/yd² was needed to fully seal a PFC surface with UT slurry.

Graph showing the relationship between added surface onyx and elapsed time (s), with a trend line and equation for the prediction model.
Type D test results

- The rate of change of the water flow (ml/s) was high and about the same for a 0 and 18g UT Slurry treatments.
- Water flow dramatically reduced for higher treatments.
- Type D mixture was far better than the PFC mixtures as expected.

![Graph showing Type D mixture results with R² values of 0.9996 and 0.9986.](Image)
PFC Field Core test results

- Two shoulder specimens (denoted with S)
- Two wheel path (denoted with W)
- Wheel path cores had a higher resistance to water flow
- The existing PFC was practically sealed
Permeability

Permeameter Method

- Performed on PFC in accordance with Tex-246-F
Permeability
Permeameter Method

- On the slabs,
  - flow time increased with increased UT Slurry treatment and increased number of applications.
  - At the same application rate the research did not observe the difference in time flow for slabs treated with 15% and 18% aggregates UT Slurry.

<table>
<thead>
<tr>
<th>UT slurry surface finish</th>
<th>-Control -No UT slurry</th>
<th>-BB UT slurry - 18% Aggregates</th>
<th>-LWA UT slurry - 15% Aggregates</th>
<th>-LWA UT slurry - 18% Aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pictorial view of the PFC Slabs</td>
<td><img src="image1" alt="Control" /></td>
<td><img src="image2" alt="BB Slurry - 18% Aggregates" /></td>
<td><img src="image3" alt="LWA Slurry - 15% Aggregates" /></td>
<td><img src="image4" alt="LWA Slurry - 18% Aggregates" /></td>
</tr>
<tr>
<td>Application rate</td>
<td>N/A</td>
<td>single shot ≈ 0.125gal/yd²</td>
<td>double shots ≈ 0.25gal/yd²</td>
<td>double shots ≈ 0.25gal/yd²</td>
</tr>
<tr>
<td>Curing</td>
<td>N/A</td>
<td>72hrs @60°C</td>
<td>72hrs @60°C</td>
<td>72hrs @60°C</td>
</tr>
<tr>
<td>Time of water flow</td>
<td>19.88 sec</td>
<td>1min, 13.72 sec</td>
<td>4min, 24.30 sec</td>
<td>4min, 14.73 sec</td>
</tr>
</tbody>
</table>
Permeability
Permeameter Method

- **In the Field, US 359**
  - Three locations (shoulder (S), inner (WP) and outer wheel (W))
  - The pavement is practically sealed

<table>
<thead>
<tr>
<th>#</th>
<th>PFC Slabs</th>
<th>Time of water flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shoulder (S)</td>
<td>13 mins and 56.79 sec</td>
</tr>
<tr>
<td>2</td>
<td>Outer Wheel (W)</td>
<td>11 mins and 48.56 sec</td>
</tr>
<tr>
<td>3</td>
<td>Inner Wheel (WP)</td>
<td>77 mins and 17.50 sec</td>
</tr>
</tbody>
</table>
## Permeability

### CT-Scan

- **CT Scan Results are shown below,**

<table>
<thead>
<tr>
<th>ID</th>
<th>CT Scan</th>
<th>Air Void Plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1W</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="graph1.png" alt="Graph1" /></td>
</tr>
<tr>
<td>3W</td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="graph2.png" alt="Graph2" /></td>
</tr>
<tr>
<td>3S</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="graph3.png" alt="Graph3" /></td>
</tr>
</tbody>
</table>
Conclusion – Based on Permeability

- The permeability of UT Slurry treated can be assessed with field permeameter (on slabs) or Florida test method on field cores/lab molds.
- The field flow test and CT scan on cores indicated that after a long time of service, PFC pavements become sealed.
# Predicted Skid Number

## PFC Slabs Treated with UT Slurry -LWA

<table>
<thead>
<tr>
<th>Slab/Slurry type</th>
<th>DFT µ@20km/hr</th>
<th>CTM - MPD</th>
<th>Sp</th>
<th>IFI</th>
<th>Predicted SN50</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFC Untreated</td>
<td>0.81</td>
<td>1.77</td>
<td>172.97</td>
<td>0.55</td>
<td>68.1</td>
</tr>
<tr>
<td>PFC Treated 1/8&quot; 15%</td>
<td>0.26</td>
<td>0.96</td>
<td>100.31</td>
<td>0.21</td>
<td>23.6</td>
</tr>
<tr>
<td>PFC Treated 1/8&quot; 18%</td>
<td>0.25</td>
<td>1.01</td>
<td>104.80</td>
<td>0.21</td>
<td>23.5</td>
</tr>
</tbody>
</table>

---

![Predicted Skid Number comparison](chart.png)

- Treated SN50
Conclusions from lab Studies

- The transition to lightweight aggregate and heavier shot rates has a beneficial impact on short term skid resistance.
- Long term skid resistance as inferred from the polisher is still questionable.
- The application of the UT slurries does significantly cut the water flow into PFC’s but it has a negative impact on skid resistance.
- Testing of old PFC’s in Houston found them to be already closed up with water flow over 10 minutes.
New Field section evaluation
Field Section Evaluation

- The UT Slurry was applied on 5 sections of 3ft x 3ft
- Different UT Slurry mixture combinations were applied manually on each of the sections
- Each application was split in small 4 equal bays to avoid the temperature effects and setting
- Two shots were applied (spaced at about 1hrs)
- 2-hours after applying the last coat on the sections, friction and profile data were collected using the DFT and CTmeter respectively
Field Section Evaluation

- SH21test section

Test Section Location
- NB Outside Lane
- Outside Wheel path
AADT 12359
Field Section Evaluation
Field Section Evaluation

- Friction evaluation before and after traffic passes
Field Section Observation

- Field SN test results

![SH 21 UT Slurry Predicted Skid Number](chart.png)

- SH21 - No treatment 1
- SH21 - No treatment 2
- SH21 - 0.25 BB 18%
- SH21 - 0.25 BB 24%
- SH21 - 0.25 #16 LWA 18%
- SH21 - 0.25 #6 LWA 15%
- SH21 - 0.20 #6 LWA 15%

- September 30 Readings
- December 11 Reading
Field Section Observation

- Crack sealing failure
Field Test Observation

- The initial SN of LWA treated sections hovered around 28,
- Whereas for BB with 24% agg, SN = 31
- Note: the BB mixture that showed SN = 31 had 6% extra aggregates
- The initial average SN of the Untreated sections was at around SN = 26
Field Test Observation

- After 2 months of traffic, the Skid Number (SN) on treated locations reduced to 20 whereas
- The SN of the Untreated sections remained relatively the same at around SN = 27
- The UT Slurry did not seal the cracks
- The UT Slurry in its current form should not be used for High traffic volume roads because of loss of skid
Field Test Conclusion

- The SN of the Ultra-thin slurry always dropped to 20 after traffic passes; in the lab the SN = 20 was reached after about 1,000-10,000 polishing passes
  - For different mixtures (agg. type and percentage)
  - Existing surface

- The Ultra-thin slurry could not seal cracks

- The Ultra-thin slurry can not be used for High traffic volume roads

- The Ultra-thin slurry improved the black top surface of the pavement
New Developments
New developments

- Improved Construction techniques developed by Industry - offers potential for improvement
New developments

Spreader box video from San Antonio
Topics for Discussion

- In its current form the UT slurry even with the use of Light-Weight and heavier shot rate has a negative impact on skid and wears off within a few months.
- The new construction technique offers potential to radically increase the amount of rock in this product.
- More work is needed to redesign these slurries.
- Specifications need to be revised to include a DFT/Polisher requirement. For example “50,000 passes of the polisher with less than a 10% loss in skid”
- Will it be cost effective?
- Will it look the same as a grade 5 chip seal?
Thank you