WORKSHOP ON IMPLEMENTING ULTRA THIN SLURRY SURFACINGS ON TXDOT ROADWAYS

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Workshop Objectives

- To present findings of research study 5-6615-01 “Implementing the Next Generation of Ultra Thin Slurry Seals”
- To present the benefits and limitations of ultra thin slurry seals.
- To provide guidelines and recommendations on the use of ultra thin slurry seals.
- To discuss future directions for these types of surfacings.

Research Performed

The ultra thin surfacing which was evaluated in this study was based on a special specification introduced within TxDOT in the last few years known as SS 3028 “Frictional Asphalt Surface Treatment”. It is a spray applied fog seal which contains very fine aggregate to enhance friction. Potential applications include

- Sealing pavement surfaces,
- Blacking out obsolete pavement markings,
- Demarcating shoulders for visual safety improvements, and
- Reducing raveling for seal coats, HMA or PFC.

A few districts have tried the surfacing and so researchers evaluated some field sections documenting performance and monitoring skid. Researchers also sampled the product in the field for laboratory evaluation and attempted to improve the formulation by introducing different types of aggregates and quantities.

Field sections were evaluated using TxDOT’s skid trailer. Laboratory studies were conducted to measure permeability of PFC and dense-graded mixtures after treatment. In addition, slabs were made for conducting dynamic friction tests (DFT) and circular texture meter (CTM) for prediction of skid number after polishing in the 3-wheel polisher.

Findings

Field sections were evaluated in San Antonio, Beaumont and Fort Worth. The San Antonio section was placed to try to save a raveling PFC. The Beaumont sections were used to seal a HMAC FM pavement and bridge decks. The Fort Worth district routinely uses the product on shoulders.
Findings from these field projects indicated:

- No matter what the existing skid resistance of the roadway, the after treated skid number is around 20 until the product completely wears off which appears to be within about 12 to 16 months.
- Where only the shoulders were treated, the products held up better since there is minimal traffic.
- These results initiated further studies in the laboratory to attempt to get more rock into the slurry and improve friction.

Laboratory studies indicated

- The skid performance of ultra thin slurry mixtures can be assessed in the lab using the Polisher, DFT and CTmeter.
- The current formulation provided by the manufacturer which uses an aggregate known as “Black Beauty (BB)” and is a type of slag does not improve the skid of HMA pavement surface which corroborates what we saw with the field sections.
- Researcher evaluated TXI lightweight aggregates in different sizes and quantities as an alternative to the BB aggregate.

Based on the additional lab work, the research team determined that the following mixtures be subjected to further assessment in the field. Researchers worked with the Bryan district to place square yard test patches on SH 21 in the outside wheel path:

- 18% Black Beauty Aggregate at 0.25 gsy, (current manufacturer formulation)
- 24% Black Beauty Aggregate at 0.25 gsy,
- 18% #16 lightweight aggregate at 0.25 gsy,
- 15% #6 lightweight aggregate at 0.25 gsy, and
- 15% #6 lightweight aggregate at 0.20 gsy.

While some of the patches showed an initial improvement in friction (as measured with DFT/CTM), after 2½ months of traffic, most of the aggregates in the slurry had worn off and the predicted SN for all of the patches was 20.

Based on these results, this product in its current form cannot be recommended for use by TxDOT in the main travel lanes due to skid concerns. However, it appears that industry is in the process of upgrading the process to apply it with new equipment which has the potential to incorporate more and larger aggregate which may alleviate friction concerns.
Implementing the Next Generation of Ultra Thin Slurry Seals

TxDOT project 5-6615-01
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Wade Odell, RTI
TTI Researchers
Tom Scullion,
Cindy Estakhri and
Tito Nyamuhokya

Outline of presentation

- Background to study 6615
- Review of Current Specification (SS 3028)
- Case Studies
  - Beaumont, San Antonio, Fort Worth
  - Issues with using current spec
- Lab studies to improve long term durability and skid
- Test strip evaluation
  - SH 21 Bryan
- Conclusions and Recommendations
- Future developments

Background
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Study 0-6615

- 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?

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Ultra-Thin Slurry Overlays

- Spray applied maintenance treatment.
- Cross between slurry and fog seal.
- Cost $1.60 – $1.80 Sq. yard
  - Chip Seals $2.50
  - Overlays $6 - $8
- Properties:
  - Polymer-mod emulsion.
  - Embedded aggregate.
  - Rapid cure time.
  - Long-term black color.

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Original Performance Summary

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

- Blacking Out old lane markings
- Improving Skid Resistance

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Pavement Preservation
Under consideration by TxDOT Districts

- Preventing Stone loss in aged surfaces
- Sealing Minor Cracking

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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

Review of Current Specification

- Largely proposed by Industry

Special Specification 3028
Frictional Asphaltable 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.
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High Quality Aggregate required

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Min.</th>
<th>Max.</th>
<th>Target Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content, %</td>
<td>T 1</td>
<td>9</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Absorption, %</td>
<td>T 1</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Water Retention, %</td>
<td>T 1</td>
<td>45</td>
<td>60</td>
<td>-</td>
</tr>
</tbody>
</table>

1. Water retention ratio of aggregates that are selected before blending into mix.
2. Microsurfacing aggregate larger than No. 20 sieve U.S.
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Pavement surface before UT Slurry

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Pavement Surface After UT Slurry
- How it works: Decreases permeability of surface although does not seal cracks.

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Mix Design Criteria

3. MIX DESIGN
2.1 Formal laboratory mix design meeting the requirements shown in Table 3

Table 3: Laboratory Mix Design

<table>
<thead>
<tr>
<th>Type</th>
<th>Tan</th>
<th>Virtue</th>
<th>Mix</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot-Mix</td>
<td>1.25</td>
<td>2.00</td>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>Gravel-Gravel</td>
<td>2.00</td>
<td>2.50</td>
<td>20</td>
<td>2.0</td>
</tr>
<tr>
<td>Gravel-Asphalt</td>
<td>3.00</td>
<td>3.50</td>
<td>25</td>
<td>3.0</td>
</tr>
</tbody>
</table>

1. Select modifier material meeting the specific application depth and free water content.
2. Establish specification using the minimum laboratory compactability of approved mix or surface to be tested. The Dynamic Modulus (DPM) number ratio should indicate that after application of the needed layer, the surface retains required minimum percentage DPM number of the original paved surface.
Dynamic Friction Tester (ASTM E 1911)

- Micro-texture
- Variable speeds (typical max @80 km/h)
- Wet or dry testing
- Standard for IFI calculation

Wet track abrasion

<table>
<thead>
<tr>
<th>Speed</th>
<th>Percentage Loss of Weight</th>
<th>Cylindrical Abrasion</th>
<th>True Abrasion</th>
<th>45° Slow</th>
<th>45° Fast</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 m/s</td>
<td>1.5 %</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>3.2 m/s</td>
<td>1.5 %</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>6.4 m/s</td>
<td>1.5 %</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Key Construction Requirements

1. Atmosphere: Conditions. Direct place mixes within 48 h of mixing. Mixes cured for 7 days. Mixes with water temperature of 15° C. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days.

2. Standard Temperature and Humidity: All mixes are cured in a room with a temperature of 20° C and a humidity of 60%. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days.

3. Curing: Mixes are cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days.

- Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days. Mixes with mixes cured for 7 days.
**Recommended Applications Rates**

3. Application: apply the mixture when the air temperature is at or above 60°F, or above 50°F and drying. Measure the air temperature in the shade away from artificial heat. The Engineer will determine when conditions are suitable for application.

- Initial application: 1 to 1.5 lbs/100 ft²
- Second application: 1.5 to 3 lbs/100 ft²
- Total application after the second application: 2.5 lbs/100 ft² minimum

4. Ragge: apply the material at the same time of day and maintain the traffic control plan. Take care that after completion, the microsurfacing material is not exposed to the sun for more than a few hours as it may require a curing time if necessary to keep the edge straight and sufficient pressure to force the mixture fully.

**Opening typically after 2 hours**

5. Opening to Traffic: open the treated surface to traffic when directed. Fertilize and uniformly distribute the desired rate on the surface to hold the mixture in place after an excessive amount of mixture is applied. Maintain ingress and egress as directed by applying sand to lightly 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
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**Dynamic Friction Tester**
- Requires lane closures
- Spot measurements

![Dynamic Friction Tester](image)

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**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

![Circular-Track Meter](image)

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

![San Antonio IH 35](image)
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San Antonio IH 35

- Condition after 18 months of service
- Wear off in wheel paths – raveling continued

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San Antonio IH 35

- Skid reduction on UT slurry sections
- June 2017
- April 2018

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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

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Beaumont Applications

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

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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></th>
<th>SH 105, K1</th>
<th>SH 105, K6</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra-Thin Slurry</td>
<td>20.6</td>
<td>24.6</td>
</tr>
<tr>
<td>Pavement between bridges</td>
<td>10.6</td>
<td>10.4</td>
</tr>
<tr>
<td>June 2019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra-Thin Slurry</td>
<td>23.9</td>
<td>23.9</td>
</tr>
<tr>
<td>Pavement between bridges</td>
<td>19.4</td>
<td>17.8</td>
</tr>
</tbody>
</table>

Beaumont Applications

- Skid Numbers on FM 2518 existing (HMAC)

<table>
<thead>
<tr>
<th></th>
<th>FM 2518, K1</th>
<th>FM 2518, K6</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra-Thin Slurry</td>
<td>28.1</td>
<td>19.9</td>
</tr>
<tr>
<td>Pavement at end of section</td>
<td>23.5</td>
<td>23.3</td>
</tr>
<tr>
<td>June 2019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra-Thin Slurry</td>
<td>16.7</td>
<td>14.9</td>
</tr>
<tr>
<td>Pavement at end of section (new seal)</td>
<td>60.1</td>
<td>64.4</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 Skid</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 (potentially more rock - better skid)
- Evaluate application of slurry seals to clog PFC’s prior to overlaying them

Objectives
- Develop lab test procedures to measure the impact of UTSS 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 0.125/0.25 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/syd Light Weight UT Slurry on a Type D slab
- 0.25gal/syd Black Beauty UT Slurry on a Type D slab
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UT Slurry Application (Clip)

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Friction Test

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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 as application spray limited the agg %.
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**Wet Track Abrasion**

Thin sample preparation

**Slide 53**

**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>68.9</td>
<td>57.2</td>
<td>11.7</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>88.750</td>
<td>WTV&gt;80 (less binder)</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>BB/18%</td>
<td>72.9</td>
<td>72.6</td>
<td>0.3</td>
<td>49.725</td>
<td>WTV&lt;80 (0k)</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>87.750</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>99.450</td>
<td>WTV&gt;80 (less binder)</td>
</tr>
<tr>
<td>LWA8 30/18%</td>
<td>114.3</td>
<td>98.7</td>
<td>15.6</td>
<td>456.3</td>
<td>WTV&gt;&gt;80 (may be excessive</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>
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<tr>
<td>LWA#16 0/18%</td>
<td>75.1</td>
<td>72.5</td>
<td>2.6</td>
<td>76.050</td>
<td>WTV&lt;80 (0k)</td>
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<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>122.0</td>
<td>2.2</td>
<td>64.350</td>
<td>WTV&lt;80 (0k)</td>
</tr>
</tbody>
</table>

**Slide 54**

**Impact of UT Slurry on Friction**

- The slab is wheel polished
- Fan dried
- MPD determined using CTMeter
- $\mu$ determined using DFT
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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 (SN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treated Slab (D4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated Slab (D5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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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)

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Impact of Slurry Seal on Friction

- The Test was also performed on LWA
- SN Comparison of different BB and LWA UT slurry mixtures
- LWA fared better: #6-0
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

![Bar chart showing the predicted skid number for different slurry treatments and polishing passes.]

Impact of Slurry Seal on Friction

- Normalized SN for different LWA UT slurry

![Bar chart showing the normalized predicted skid number for different slurry treatments and polishing passes.]

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**Predicted skid for PFC treated with UT Slurry -LWA**

<table>
<thead>
<tr>
<th>Slab/Slurry Type</th>
<th>DFT µg@20km/hr</th>
<th>CTM MPD</th>
<th>Sp 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>
</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>
</tr>
<tr>
<td>PFC Treated 1/8&quot; 18%</td>
<td>0.25</td>
<td>1.07</td>
<td>104.80</td>
<td>0.21</td>
</tr>
</tbody>
</table>

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**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 0.125gal/ycd2.

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**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/ycd2 each
  - #16-0LWA) based UT Slurry (18% aggregates) at two shots of 0.125gal/ycd2 each
  - #60-0 BB - based UT Slurry (18% aggregates) at two shots of 0.125gal/ycd2 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
- No UT Slurry was applied on Field Specimens (FM 359)
Permeability test - Florida Method

- PPC 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)

- 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 PPC mixtures as expected
**Permeability test - Florida Method**

- 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

![Graph showing permeability test results]

**Permeability – Permeameter Method**

- Performed on PFC in accordance with Tex-246-F

![Image of permeameter setup]

**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</th>
<th>Rill UT Slurry</th>
<th>LWA UT Slurry</th>
<th>LWA UT Slurry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Rate</td>
<td>N/A</td>
<td>LWA 15%</td>
<td>LWA 15%</td>
<td>LWA 18%</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>1 min, 13.72 sec</td>
<td>4 min, 24.30 sec</td>
<td>4 min, 14.73 sec</td>
</tr>
</tbody>
</table>
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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>

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Permeability test – CT-Scan
- CT Scan Results are shown below,

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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.
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.

New Field section evaluation

Field Section Evaluation

- The UT Slurry was applied on 5 sections of 30 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

- SH21 test section

Friction evaluation before and after traffic passes
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Field Section Observation

- Field SN test results

<table>
<thead>
<tr>
<th>Field SN test results</th>
<th>0.00</th>
<th>5.00</th>
<th>10.00</th>
<th>15.00</th>
<th>20.00</th>
<th>25.00</th>
<th>30.00</th>
<th>35.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH21 - No treatment 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH21 - No treatment 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH21 - 0.25 BB</td>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH21 - 0.25 BB</td>
<td>24%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH21 - 0.25 #16 LWA 18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH21 - 0.25 #6 LWA 15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH21 - 0.20 #6 LWA 15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SN50

SH 21 UT Slurry Predicted Skid Number

September 30 Readings

December 11 Reading

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Field Section Observation

- Crack sealing failure

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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 passes, the 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 could not seal the cracks
- The UT Slurry can not be used for High traffic volume roads

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 10,000-15,000 polishing passes
- 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

Future Development
Future developments

- Improved Construction techniques developed by Industry - offers potential for improvement.

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