



WORKSHOP INSTRUCTOR GUIDEBOOK

WORKSHOP ON
IMPLEMENTING ULTRA
THIN SLURRY SURFACINGS
ON TXDOT ROADWAYS

Texas A&M Transportation
Institute

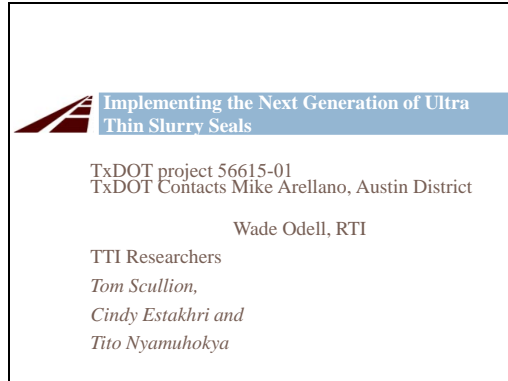
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Overview

The following is intended to serve as an instructor guide for the “Workshop on Implementing Ultra Thin Slurry Surfacing on TxDOT Roadways” as developed in TxDOT Project 5-6615-01. Included is a copy of all of the powerpoint slides developed for the workshop with accompanying speaker notes.

Slide 1



 **Implementing the Next Generation of Ultra Thin Slurry Seals**

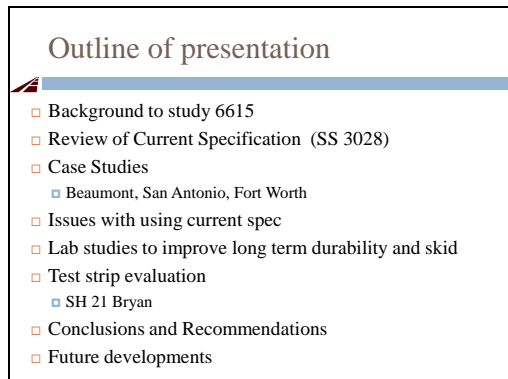
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In research project 0-6615, Use of Fine Graded Asphalt Mixes, which ended on August 31, 2012, the Performing Agency developed a new generation of slurries to be implemented for pavement preservation in test sections around Texas. This new generation of slurries had not been evaluated widely on Texas Highways by the Receiving Agency, but several Receiving Agency districts, including Austin, Fort Worth, and Beaumont, expressed an interest in placing these extra-thin mixes as monitor sections. This workshop will convey the results of this research, recommendations and guidelines regarding implementation of ultra thin slurries for TxDOT.

Slide 2

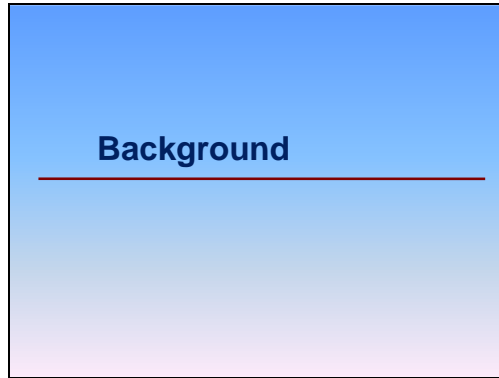


 **Outline of presentation**

- 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

The outline of the presentation is shown here and will be presented in detail in this workshop.

Slide 3



Slide 4

Study 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?

Industry promoted the surface treatment as a high speed, low cost treatment for pavement preservation applications. However, until this research was initiated, no objective evaluation had been performed.

Slide 5

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.



The cost of these treatments make them an attractive alternative to seal coats and overlays, provided they are proven effective.

Slide 6

Original Performance Summary


- Higher skid performance over fog seal.
- Macrotexture, highly dependent on existing surface
- Unknown long-term durability.



Slide 7

Proposed Safety Applications

Under consideration by TxDOT Districts



Blacking Out old lane markings

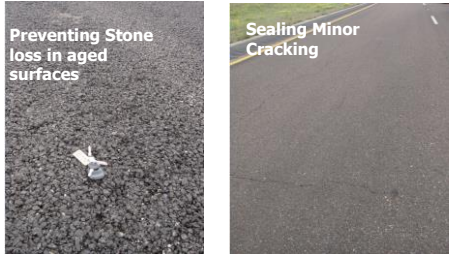
Improving Skid Resistance

The Austin District's primary interest was to use the UT slurry seal to black out pavement markings for rehab projects. Some districts were also interested in looking at the treatment to improve friction.

Slide 8

Pavement Preservation

Under consideration by TxDOT Districts



Preventing Stone loss in aged surfaces

Sealing Minor Cracking

Another potential application was to seal the pavement. This includes cracks in older hot mix pavements or even to seal old PFC pavements which have reached the end of their life and need to be removed or overlaid. Also, there was interest to see if the UT slurry could retard raveling in old PFCs.

Slide 9

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

A workplan was initiated in summer of 2017 to evaluate the UT slurry and the potential applications.

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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

Slide 11

Review of Current Specification

Slide 12

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.

The current spec (SS 3028) was proposed by industry.

Slide 13

High Quality Aggregate required

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

Table 2. Aggregates


Property		Test Procedure ¹		Min.	Max.
Water Absorption, %		T 84		-	4
Micro-Deval, %		D 7428 ²		-	20
Gradation ¹					
Sieve	Standard	Master Grading Band Limits Percent Passing		Target Tolerance	
No. 8	C 136	100			
No. 16	C 136	85-100			
No. 30	C 136	75-100		± 5	
No. 60	C 136	10-40		± 5	
No. 100	C 136	0-10		± 5	
No. 200	C 117	0-5		± 1	

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.

The aggregate used in the slurry is a very fine aggregate (100% passing the No. 8). Industry provided researchers with some of the aggregate and it consists of a slag material which they call "Black Beauty" and helps to retain the black color of the surfacing.

Slide 14

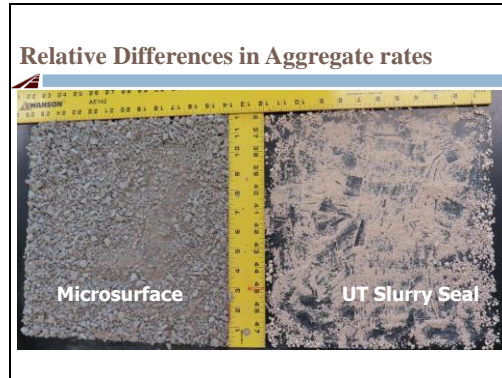
Relative difference in amount of aggregate per sq.yd



Microsurfacing UT Slurry Seal

Researchers compared the quantity of aggregate in microsurfacing vs that in the UT slurry.

Slide 15



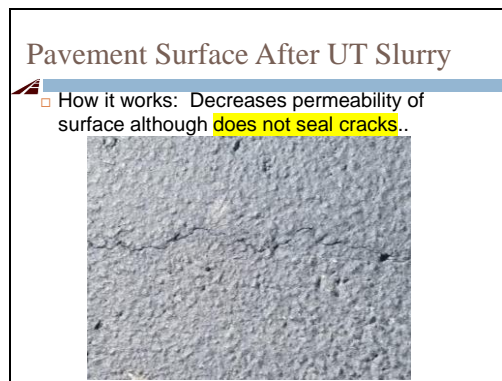
Here is another representation of the quantity and size of aggregate in the microsurfacing compared with that of the UT seal.

Slide 16



This photo shows a HMAC pavement in Beaumont prior to application of the UT slurry seal (in 2017).

Slide 17



Here is the same crack after application of the UT slurry. While the slurry does seem to seal the overall surface and decrease permeability, it clearly does not seal cracks.

Slide 18

Mix Design Criteria

3. MIX DESIGN

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

Table 3. Laboratory Mix Design

Test	Test Procedure	Min	Max
Wet-Track Abrasion Loss, 3 day soak, g/m ²	D 3910 ¹	--	60
Asphalt Content by Ignition Method, %	T 308	30	--
Dynamic Friction Test Number, 20 kph	E 1911 ¹	0.90	--

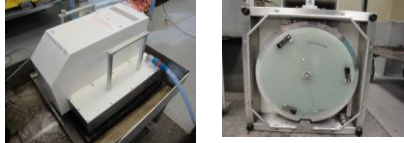
- Use the modified method to account for realistic application depth and fine emulsion mixture.
- Establish base friction value using prepared laboratory compacted slab of approved mix as surface to be tested. The Dynamic Friction Test (DFT) number ratio should indicate that after application of the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

Mix design criteria is shown here. The biggest problem with the mix design criteria is the dynamic friction test which requires a before and after test on the proposed surface it is to be used on. This is complete impractical if not impossible.

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Dynamic Friction Tester (ASTM E 1911)

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



The dynamic friction test is used to measure friction in a spot location at variable speeds and can be used along with CTM to predict skid number (SN).


Slide 20

Wet track abrasion

Model	Running Time	Conversion Constant ¹ g/m ²	Conversion Constant ² g/m ²	C-100 Conversion Factor
C-100	2 min. ± 2 sec.	3.90	23.9	1.00
A-120	6 min. 45 sec. ± 2 sec.	2.70	20.9	1.13
N-50	7 min. 15 sec. ± 2 sec.	3.40	27.5	0.70
Modified N-50	2 min. 15 sec. ± 2 sec.	3.90	32.9	0.70

CALCULATION
Calculate the loss of material abraded in g/m² or g/m² (wear value)
wear value = $(A - B) \times C \times D$

Where:
 A = Initial dry specimen weight
 B = Abraded dry specimen weight
 C = Conversion constant from Table 1
 D = C-100 conversion factor from Table 1



Wet track abrasion is a test also used for microsurfacing and researchers used this test throughout the study.

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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 50°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.

Construction requirements have clear temperature limitations. Cool weather is clearly a detriment to opening to traffic. If too cool, traffic must be held off for hours.

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Recommended Applications Rates

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.

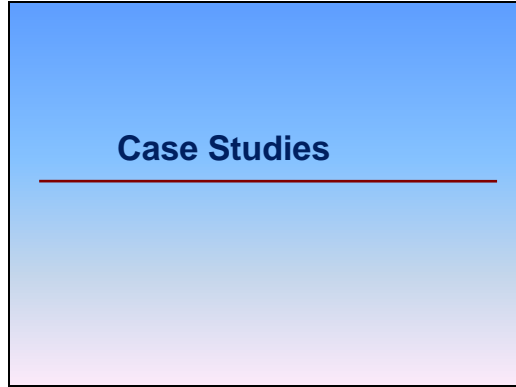
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Opening typically after 2 hours

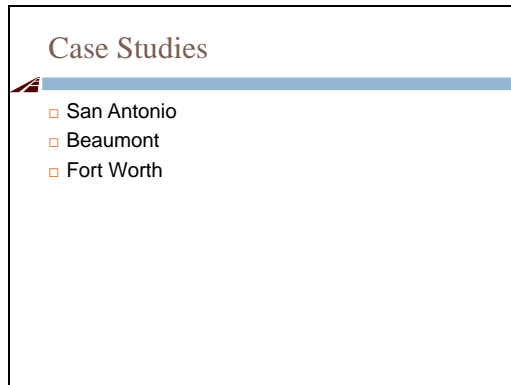
5.6 **Opening to Traffic.** Open the treated surface to traffic when directed. Furnish and uniformly distribute clean, fine sand on the surface to blot the excess when an excessive quantity of mixture is applied. Maintain ingress and egress as directed by applying sand to freshly treated areas.

When weather is hot and dry, traffic opening can usually occur within 2 hours. Shaded areas can be longer.

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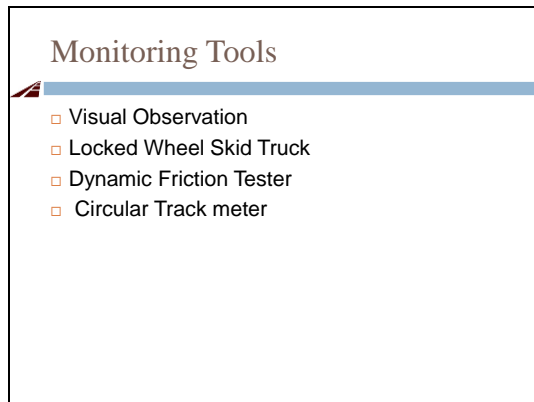


Slide 25



Test sections were constructed and monitored in these 3 districts.

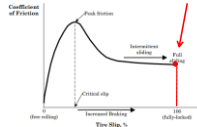

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Slide 27

Locked-wheel (ASTM E 274)

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

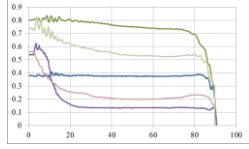



Worst-case scenario for skid loss
Non-continuous measurement

Slide 28

Dynamic Friction Tester

- Requires lane closures
- Spot measurements

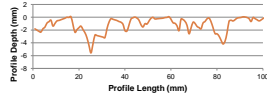



DFT tests were conducted in the field and in the lab along with CTM measurements shown on the next slide to predict Skid Number.

Slide 29

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 measurements



Slide 30

San Antonio IH 35

- UT Slurry Seal applied on raveling old PFC to retain rock

This PFC in San Antonio was exhibiting quite moderate raveling in 2017 and an extra heavy application of the UT slurry seal was applied on a one mile test section to determine if the slurry could arrest the raveling and also the effects on skid were measured. This dilemma of what to do with old PFCs (besides removing the surface by milling) is one of the issues many districts have been facing recently.

Slide 31

San Antonio IH 35

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

After 18 months, much of the surfacing had worn off in the wheel paths and yet raveling within the treated section did not appear to be improved over that in the untreated areas.

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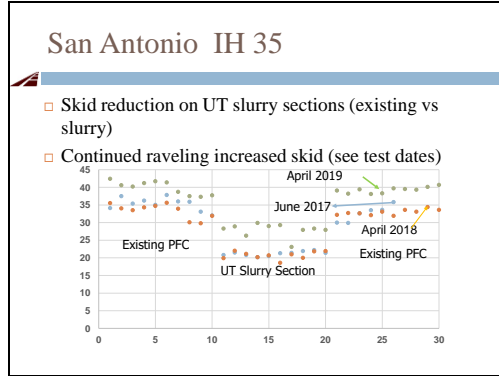
San Antonio IH 35

- Skid reduction on UT slurry sections

Section	Count (0.1 mile interval)	Skid Number (approx.)
Existing PFC	0-5	30-40
	5-10	30-40
	10-15	30-40
	15-20	30-40
	20-25	30-40
	25-30	30-40
	30-35	30-40
	35-40	30-40
	40-45	30-40
	45-50	30-40
UT Slurry Section	0-5	15-20
	5-10	15-20
	10-15	15-20
	15-20	15-20
	20-25	15-20
	25-30	15-20
	30-35	15-20
	35-40	15-20
	40-45	15-20
	45-50	15-20

Skid testing was performed on the UT slurry and the untreated sections at either end. The UT slurry caused a significant reduction in skid which remained the case even one year later.

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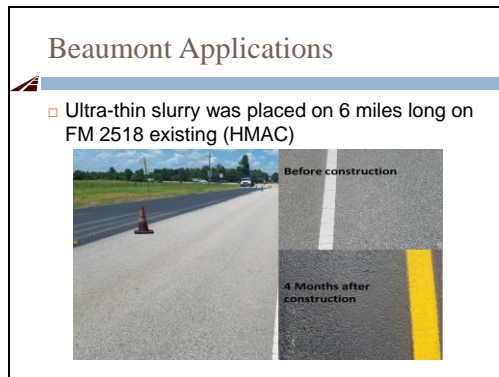


A final skid test was performed after another year and the UT slurry had improved skid but so had the sections had either end. The increase is exhibited to increased raveling in all of the sections which likely resulted in an increase in friction.

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Slide 35



In Beaumont, the UT slurry was placed on 6 miles of FM 2518 existing hot mix. Two layers of about 0.15 gsy were applied. A minimum of about one hour was needed to adequately cure the surface before allowing traffic. Shaded areas required more time to cure. The second pass was made the following day. Four months after construction the surfacing still looked good.

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Beaumont Applications

- Ultra-thin slurry was placed on SH 105 bridge deck

The UT slurry was placed on a number of bridge decks throughout Liberty County and researchers monitored two on SH 105.

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Beaumont Applications

- Skid Numbers on SH 105 bridge deck

		Section	SH 105, K1	SH 105, K6
April 2018	Ultra-Thin Slurry		24.6	24.6
	Pavement between bridges		55.6	55.4
June 2019	Ultra-Thin Slurry		23.9	23.9
	Pavement between bridges		19.6	17.8

Skid testing was performed on untreated areas adjacent to the test sections and in the test sections 4 months after construction.

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Beaumont Applications

- Skid Numbers on FM 2518 existing (HMAC)

		Section	FM 2518, K1	FM 2518, K6
April 2018	Ultra-Thin Slurry		20.1	19.9
	Pavement at end of section		23.7	23.5
June 2019	Ultra-Thin Slurry		16.7	14.9
	Pavement at end of section (new seal)		65.1	61.4

After the end of the 4 months, the researchers determined the skid numbers on the treated section to be about 20. A year after, the skid number dropped down to about 15.5 average.

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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

They believe it serves to seal the shoulders and improve visibility by demarcating the shoulders.

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Fort Worth Applications

- Shoulder Section on Spur 102 near Keene, TX



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Fort Worth Applications

- Fort worth predicted Skid Numbers

	Avg of DFT 20	Avg MPD from CTM	Predicted SN 50
IH 35 Frontage Road			
Treated Shoulder	0.38	0.54	28.8
Untreated Main-lane	0.39	1.03	31.8
Spur 102			
Treated Shoulder	0.36	0.78	26.9
Untreated Main-lane	0.22	0.68	18.9

Approximately 2 weeks after placement of the UT slurry, researchers conducted DFT and CTM testing. The predicted skid numbers were relatively good compared to the main lanes. Since the shoulders are mostly used for emergency vehicles or bicycles, etc., the SN is expected to stay closely the same for a long period.

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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

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Lab Tests

Slide 44

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

Due to the marginal skid values obtained with the UT slurry, researchers initiated a laboratory investigation using an alternate aggregate source (different quantities and sizes) of lightweight aggregate to improve skid.

Slide 45

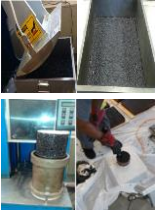
Objectives

- 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

Slide 46

Specimen Fabrication


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



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UT Slurry Application

- Slurry application on Lab prepared slabs

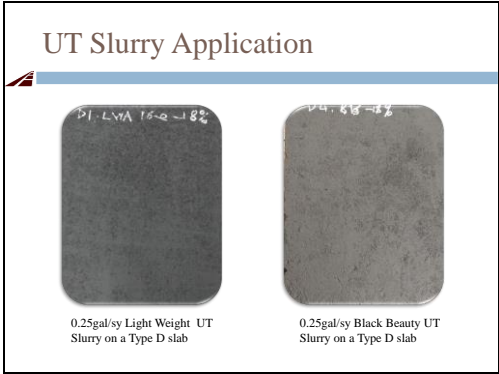


Measuring 0.125/SY with improvised deep stick .@ Red mark = 1 shot

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

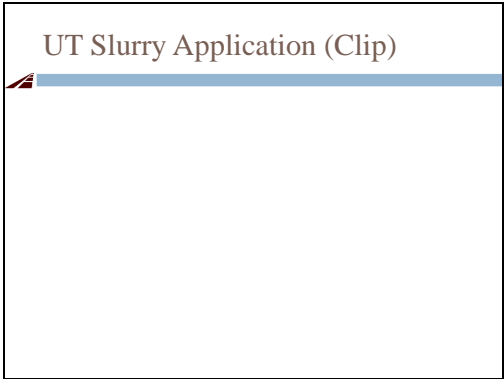
Final look of the Treated slab after 72hrs@60°C curing

Slide 48



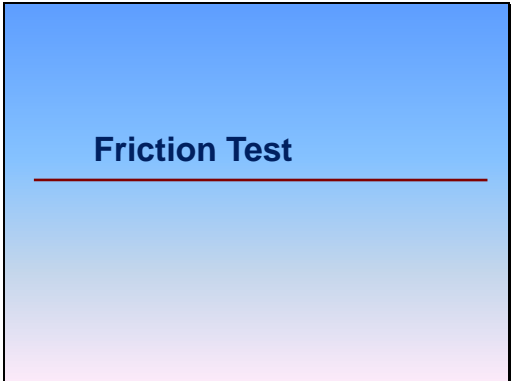
These are photos showing the increase in texture achieved with the lightweight aggregate versus the conventional black beauty aggregate.

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Video showing laboratory application to slabs.

Slide 50



Slide 51

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 %.

A procedure was developed for fabricating samples in the wet track abrasion. The conventional method as used for microsurfacing created a problem. It forced the black beauty aggregate down into the sample and did not represent field conditions.

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Wet Track Abrasion

Thin sample preparation



The procedure included pouring of the slurry into the circular opening of a template resting on roofing felt, followed by oven curing at 60C for 24 hrs. The specimen was soaked in water for one hour and after that mechanically abraded underwater with a rubber hose for 5 minutes and 15 seconds.

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Wet Track Abrasion

□ Wear values

ID	Weight before test (g)	weight after test (g)	weight loss (g)	Wet track value (g/m ²)	Description
BB/18%	80.3	57.2	3.1	80.875	WTV>80 (less binder)
BB/18%	74.3	72.6	1.7	80.725	WTV<80 (Ok)
BB/18%	82.1	79.7	2.4	70.2	WTV<80 (Ok)
LWAB-30/12%	140.3	136.9	3.4	99.45	WTV>80 (less binder)
LWAB-30/18%	114.3	98.7	15.6	456.3	WTV>80 (may be excessive aggregates/less binder)
BB/18%	83.9	78.7	5.2	152.1	WTV>80 (less binder)
BB/18%	129.2	126.2	3	87.75	About right
LWAB-30/12%	140.3	136.9	3.4	99.45	WTV>80 (less binder)
LWA 15-0/12%	132.8	130.5	2.3	67.275	WTV<80 (Ok)
LWA15-0/18%	75.1	72.5	2.6	76.05	WTV<80 (Ok)
LWAB-30/18%	90.8	89.4	1.4	40.95	WTV<<80 (bleeding or excessive binder)
LWAB15-0/12%	82.1	79.7	2.4	70.2	WTV<80 (Ok)
LWA #15-0 7/18%	124.2	122	2.2	64.35	WTV<80 (Ok)

These compare the wear values of the Black Beauty versus various lightweight aggregate (LWA) mixtures. The results varied a lot; this may be due to difficulties in squeegeeing the UT slurry mixture in thin layers on open space with out a guide frame. Moreover bleeding due to squeegeeing could be a problem. In a later stage, the researchers used a brush to spread mixtures on the roofing felt discs. This process was mostly done on the LWA mixtures. This process reduced the variations and produced wear values close to 80.

Slide 54

Impact of UT Slurry on Friction

- The slab is wheel polished
- Fan dried
- MPD determined using CTMeter
- μ determined using DFT

Slide 55

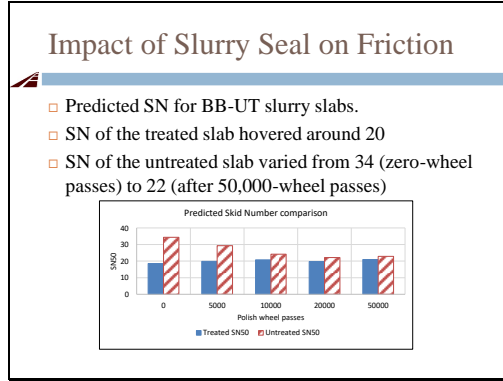
Impact of Slurry Seal on Friction

- 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

Wheel Passes	0	5000	10000	20000	50000
Onyx Treated Slab (D4)					
Untreated Slab (D5)					

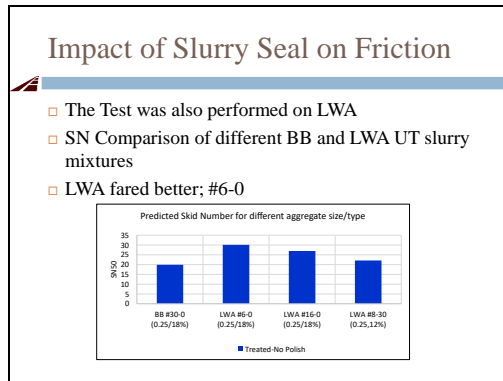
This picture shows the treated an untreated slabs that were polished at different levels of wheel passes. The pictures show a vivid loss of UT slurry treatment for every wheel pass evaluated.

Slide 56



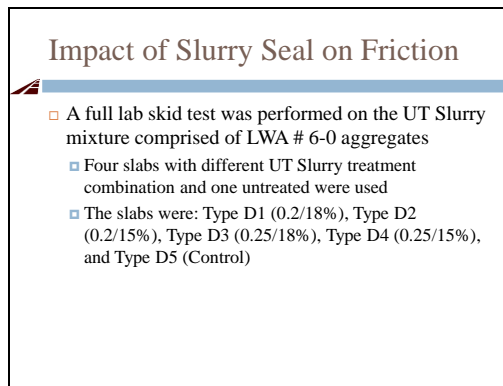
This slide shows the predicted SN vs the polish wheel passes for both treated and untreated slabs. The predicted SNs of the treated slab hovered around 20 for wheel pass levels evaluated, whereas the skid numbers of the untreated slab varied from 34 to 22 (after 50,000 wheel passes). In general, the UT slurry as currently formulated with BB aggregates reduced the SN of the HMA slabs.

Slide 57



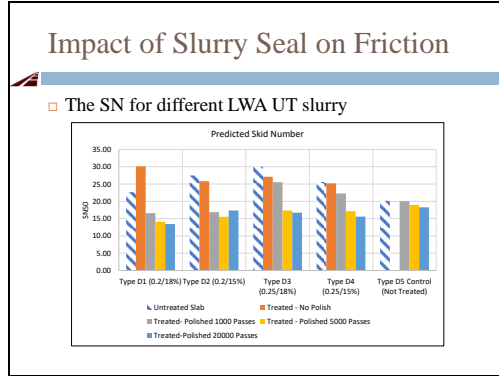
This figure shows the comparison of different UT slurry mixtures based on different aggregate type and size. The LWA #6-0 (0.25/18%) showed the best performance and the BB (#30-0) was the poorest.

Slide 58



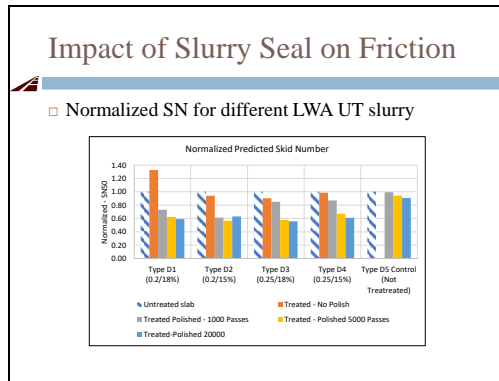
Read the slide

Slide 59



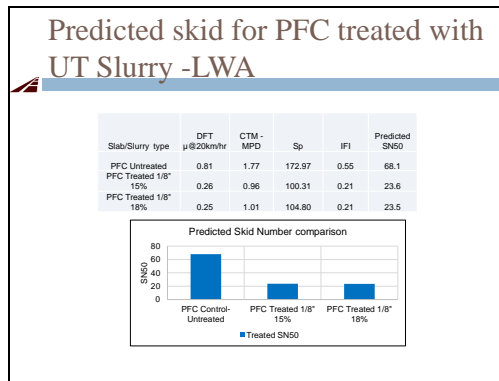
This figure shows the general skid test results. However to identify the best slab treatment, normalization of the data was needed because the slabs initial surface conditions slightly differed.

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This shows the normalized data whereby D4 performed slightly better than the other treated slabs as it offered a steady and slower rate of skid loss. Nevertheless, it was outperformed by the type D5, the new untreated slab.

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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/yd².

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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/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


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Permeability Tests

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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




The lab specimens for permeability experiments were fabricated with 7 and 20 percent air voids for type D and PFC mixtures respectively. Three specimens from each mixture were surfaced coated with varying amounts of UT slurry (BB aggregates) to form an experimental matrix for assessing the amount of UT slurry needed to seal the specimen surface.

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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)

BMA Mixture	UT slurry, g			Surface UT Slurry (g)			
	0	18	27	40	45	54	63
Type D	0	18	27	40	-	-	-
PFC	0	18	27	36	45	54	63

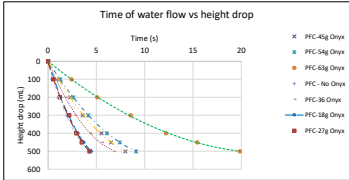


The UT slurry application started at 0.25 gal/sy (about 18 g) followed by an increment of 0.125 gal/sy (about 9 g/surface) as shown. After the UT slurry application, the specimens were kept in an environment room at 60C for about 24 hrs to accelerate the curing.

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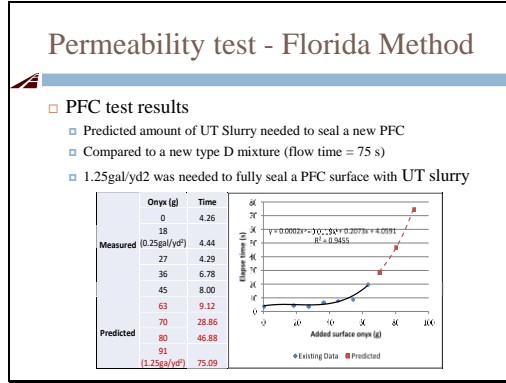
Permeability test - Florida Method

- 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)



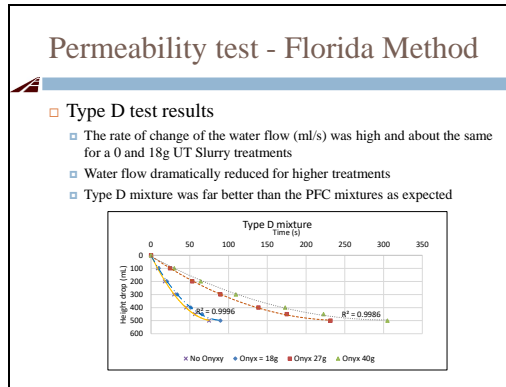
This figure shows the flow of water with time in PFC molds, where the longest time to reach the zero mark was observed for specimens with the higher amount of slurry application. Similarly, the shortest time was observed for samples with less amount of slurry.

Slide 68



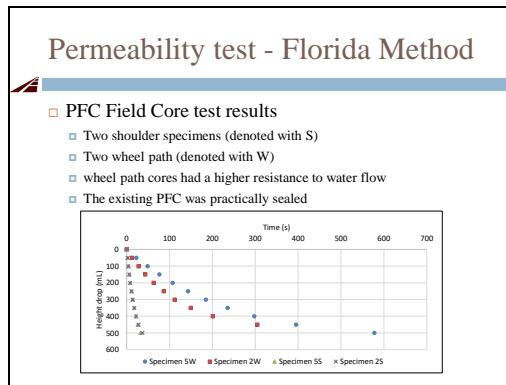
The improvement values show that the PFC molds were not complete sealed for all levels of the added slurry. Therefore, the researchers used a statistical model to predict the amount of slurry needed to seal a new PFC mold to a level equivalent to a new dense HMA mix.

Slide 69



As was for the PFC molds this figure shows the time elapsed for the water to flow through the Type D molded specimen with different amounts of the slurry treatment. The rate of change of the water flow (mL/s) was higher for a 0 and 18 g UT slurry treatment and dramatically reduced for treatments above 27 g as shown.

Slide 70



This figure shows lab permeability flow time for the FM 3959 field cores. Four field core specimens were tested, two from the shoulder and the other two from the wheel path (w). The results show that the specimens cored from the wheel path had a higher resistance to water flow than the shoulder cores. The permeability properties of the assessed HMA mixtures improved with the use of UT slurry treatment

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Permeability – Permeameter Method

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

The water flow on HMA slabs and in the field was performed using the field permeameter in accordance with Tex-246-F.

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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

UT slurry surface finish	-Control -No UT slurry	-BB UT slurry - 18% Aggregates	-LWA UT slurry - 15% Aggregates	-LWA UT slurry - 18% Aggregates
Pictorial view of the PFC Slabs				
Application rate	N/A	single shot = 0.125gal/yd ²	double shots = 0.25gal/yd ²	double shots = 0.25gal/yd ²
Curing	N/A	72hrs @ 60°C	72hrs @ 60°C	72hrs @ 60°C
Time of water flow	19.88 sec	1min, 13.72 sec	4min, 24.30 sec	4min, 14.73 sec

This slide shows the time taken for water to penetrate 2-inch PFC slabs treated on the surface with a different application of UT slurry materials. The researchers observed increased flow time with increased slurry treatment. It also shows that at a double shot application rate, the PFC slabs gained water-resistance to levels above a Type D slab.

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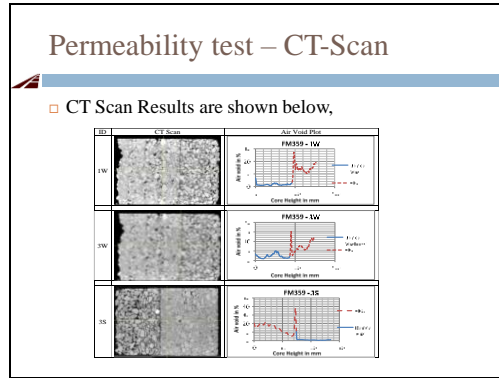
Permeability – Permeameter Method

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

#	PFC Slabs	Time of water flow
1	-Shoulder (S)	13 mins and 56.79 sec
2	-Outer Wheel (W)	11 mins and 48.56 sec
3	-Inner Wheel (WP)	77 mins and 17.50 sec

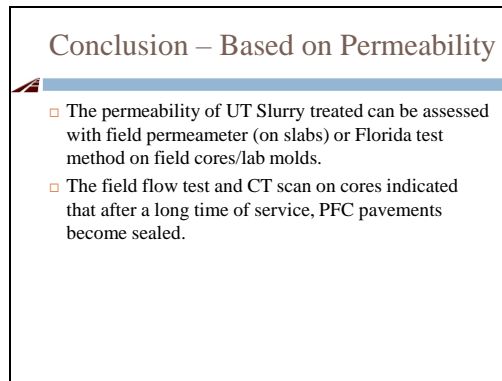
The permeability test was also extended to existing PFC pavement. In this research three locations: shoulder, inner wp and outer wp on US 359 were tested and some cores were taken into the lab for CT scanning to estimate air voids. It took a very long time for the water to percolate into the PFC pavement which means the pavement no longer is effectively draining water from the surface.

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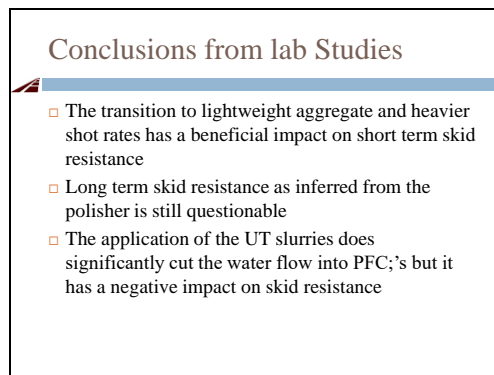


On the other hand, the CT scan showed that the air void is higher at the top half inch of the PFC and reduced towards the center where the air void detected was below 10%. Note that there is a spike at the middle of the air void plot which represents the joint between the pavement bottom dense layer and the surface PFC.

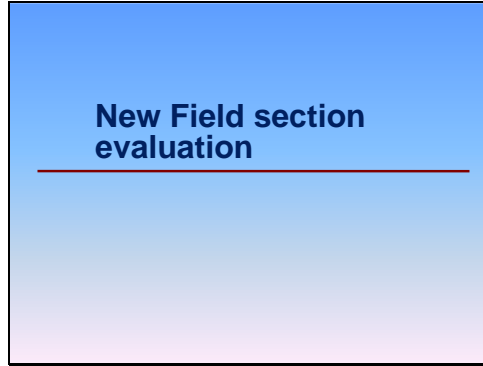
Slide 75



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Slide 77



Slide 78

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

Read the slide

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Field Section Evaluation

- SH21 test section

A map showing the location of the test section on SH 21 in the Bryan District. A red star marks the location, and a red box highlights the text: "Test Section Location - NB Outside Lane - Outside Wheelpath AADT 12359".

Test Section Location
- NB Outside Lane
- Outside Wheelpath
AADT 12359

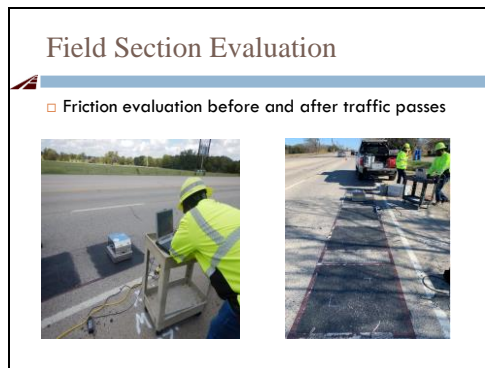
This is the location for the field test patches on SH 21 in the Bryan District.

Slide 80

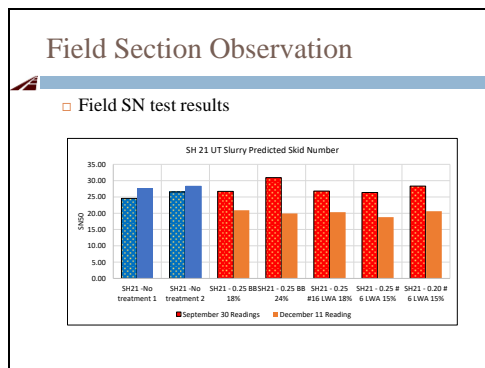


Two layers of the UT mixtures were applied on square sections of 3 ft x 3 ft. The mixture was applied manually and spread very fast before it dried up. Each patch was divided into small 4 equal bays to apply the material. After about two hours of total curing, the DFT and CTM tests were performed.

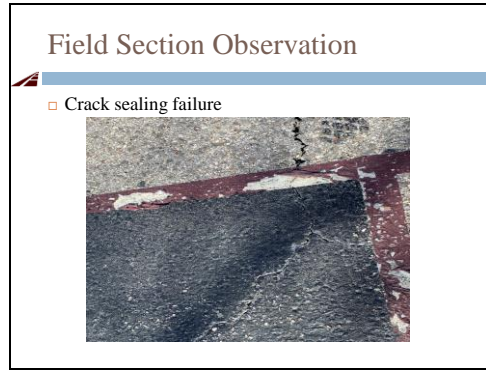
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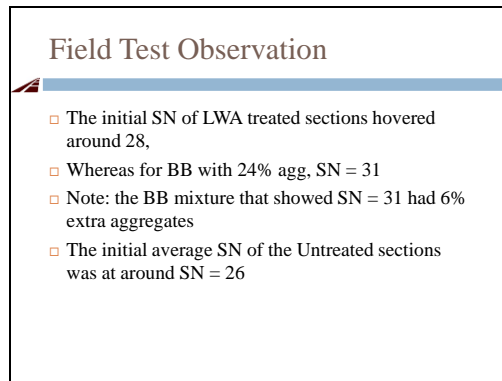


Slide 83



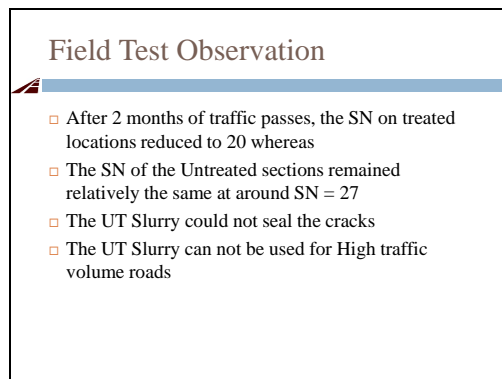
After 3 months of service, it is obvious the cracks were not sealed by the UT slurry.

Slide 84



Read the slide

Slide 85



Read slide

Slide 86

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

Read slide

Slide 87

Future Development

Slide 88

Future developments

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



New application techniques are in the process of being developed by industry. This completely changes the types of aggregates and quantities of aggregates which can be used in this application. As a result of this research, tools have been developed which should make it very easy to evaluate any future changes and/or improvements to the process.

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Future developments (clip)

- Spreader box video from san Antonio

Video Clip

Show video of spreader box which is self explanatory

Slide 90

Thank you
