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16. Abstract

In this project, several crack sealant sections were constructed at the Pecos RTC. Six different sealants were applied in routed and non-routed configurations on both older and newer pavement. The following summer, the sections were revaluated including simulated heavy traffic testing. The sealants were also tested in the lab with a sealant adhesion test. Also in this this project three different thin overlays were constructed at the test track, these being the fine-graded permeable friction course, fine stone matrix asphalt and a crack attenuating mix. The fine PFC used at Pecos was also placed on Loop 338 around Odessa. These new thin overlays and crack sealant demonstration projects will be evaluated in coming years for future research projects.

The researchers recommend applying more test sections on regularly trafficked pavements using a standard sealant (TxDOT Class A or B), and the two best performing sealants (AR Plus and Roadsaver 203). These should be applied to pavements with different levels of traffic and different amounts of crack movement.

The thin overlays first demonstrated in these test section have now become widely used around Texas. They are now included in the most several specification (SS 3228 and Item 347) and sections have been constructed in at least half of the Texas Districts

17. Key Words

Pecos Test Track, Crack Seal, Thin Overlays, Water Flow Test, OBSI

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CONSTRUCTION AND MONITORING OF THIN OVERLAY AND CRACK SEALANT TEST SECTIONS AT THE PECOS TEST TRACK

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer(researcher) in charge of the project was Tom Scullion, P.E. #62683.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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FIELD AND LABORATORY EVALUATIONS OF CRACK SEALANT

The Pecos Research and Testing Center (RTC) is an old repurposed test facility, located 20 miles southeast of Pecos, TX. It has several miles of test tracks (high speed, serpentine, skid pads, etc.), most of which have fallen into disrepair. The facilities provide a unique opportunity to apply several experimental pavement preservation products. Because the roads have little to no daily traffic, the stresses will be primarily environmental.

Researchers constructed several crack sealant test sections and monitored their performance for the duration of the project. A total of 12 crack sealant sections (six sealant types each applied with and without routing) were constructed. Sealant performance was evaluated the following summer in terms of adhesion/cohesion and tracking under slow heavy traffic. The sealant was also evaluated with a sealant adhesion test in the laboratory.

EXISTING SITE CONDITIONS

The southeast part of the circular track at the Pecos RTC facilities was used for the crack sealant tests (Figure 1). While most of the circular track was heavily distressed, the pavement in this section only had transverse cracking. Both older and newer pavement sections were evaluated (Figure 2). The older pavement was in the outside lane and had well-developed, deep, 1/4-inch wide transverse cracks every 15 to 20 ft. This lane was also super elevated, which led to some issues during sealant construction. The newer pavement consisted of two mill-and-overlay sections in the center lane. It had a mix of full-width and developing transverse cracks. These cracks were much narrower (1/8-inch wide max) and crack spacing was not consistent. The ground penetrating radar (GPR) data indicate that cracking extends to the bottom of the asphalt (see Figure 3).

Figure 1. Project Location on Testing Facilities.

(a) Outer Lane (Older Pavement) **(b) Middle Lane (Newer Pavement)**

Figure 2. Existing Condition.

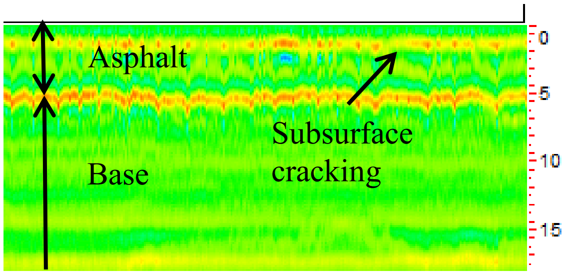


Figure 3. Test Track GPR Profile.

Crack movement was determined by installing survey nails on either side of cracks (Figure 4), and making center-to-center nail spacing measurements in the winter and summer. The pavement temperature was measured with an infrared thermal gun.

Crack movement from winter to summer is summarized in Figure 5. Movement ranged from 0.08 to 0.14 inches over a change in surface temperature of about 100°F. The average crack movement for the newer and older pavements was essentially the same, a little over 0.1 inches. For reference, the definition of an active crack according to the Federal Highway Administration (FHWA) is 0.125 inches of annual movement and is the amount to warrant routing. When testing crack sealant in the Overlay Tester, the maximum opening is set to 0.1 inches, which matches the maximum crack opening observed in the field.

(a) Transverse Crack **(b) Reference Nails for Crack Measurements**

Figure 4. Method for Measuring Crack Widths.

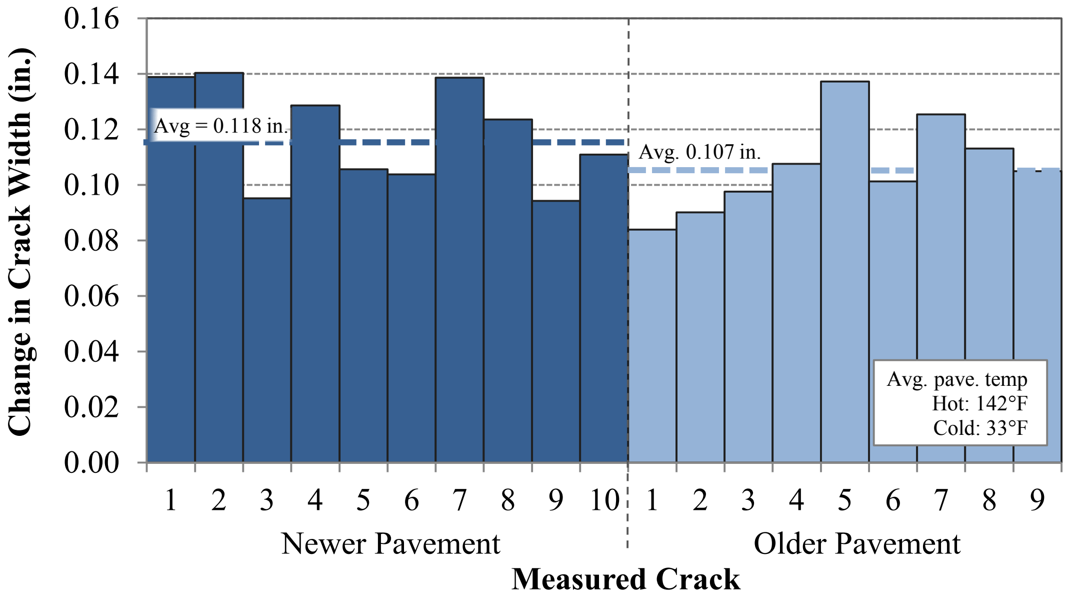


Figure 5. Crack Movement.

TESTING PLAN

The testing plan involved the following:

- Six sealant types:
  - TxDOT Class A (Asphalt rubber 233).
  - TxDOT Class B (Asphalt rubber 541).
  - Polyflex Type II.
  - Polyflex Type III.
  - Roadsaver 203.
  - Asphalt Rubber (AR) Plus.
- Simple overband and routed with overband configurations.
- Applications on older and newer pavement sections.
- 15 transverse cracks evaluated per test configuration.

Figure 6 shows the layout of the test sections. Each section contained 15 full-width transverse cracks with little to no branching. Section length was variable. Each section was evaluated visually the summer after construction. A heavy vehicle was slowly driven over the sealant sections to check for high temperature susceptibility. Sealants were also tested in the laboratory for adhesion properties at 45°F and 33°F.

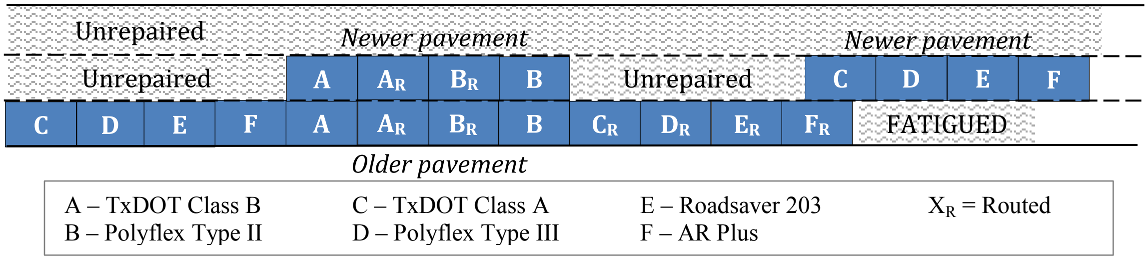


Figure 6. Section Layout.

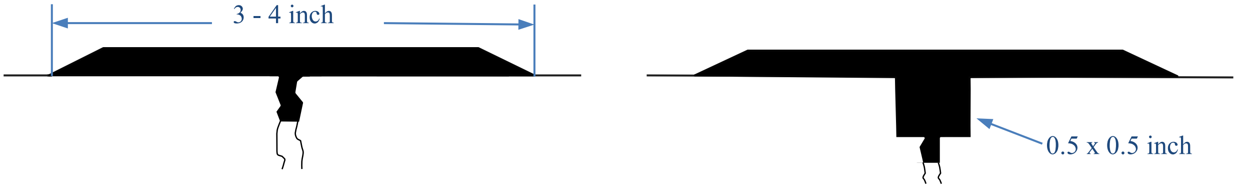
CONSTRUCTION

Construction of the sealant sections took place in February 2013. Designated cracks were routed to a depth of 1/2 inch using the Model 25 Pavement Router, equipped with a 1/2-inch wide-hub cutter. All cracks were then blown out with pressurized air and then sealed (Figure 7). The sealant was allowed to reach 380°F before application and, in all but one case (Roadsaver 203), the sealant temperature did not rise above 400°F. A 4-inch-diamter disk tip was attached to the end of the applicator wand. Figure 8 shows diagrams of the resulting sealant configurations for non-routed and routed sections.

(a) Routing Cracks **(b) Close-up of Route**

(c) Blowing Out Cracks **(d) Placing Sealant**

Figure 7. Crack Sealant Construction.



(a) Simple Overband (Non-Routed) **(b) Reservoir Fill with Overband (Routed)**

Figure 8. Sealant Configurations.

Generally, no problems were encountered during application in the newer inside lane. Application in the outside lane, however, was more difficult. First, the cracks in the older pavement were very deep and the less viscous sealants would drain down after the first application. Additional passes of the applicator wand were necessary to completely fill the cracks, which sometimes resulted in excessive sealant in the overband. In some cases, the cracks were only partially filled and were left with a recessed seal. Also, the outside lane was super elevated causing the less viscous sealants to creep down the slope resulting in a non-uniform seal (Figure 9). The lowest-viscosity sealants were TxDOT Class B, Polyflex Type II, and Roadsaver 203 (applied too hot). In applications over thinner cracks, this could be a desirable property because the material would penetrate creating a better seal.

Throughout the application process, the operators took turns applying the sealant. Some would apply the sealant more liberally, especially in the outside lane. This is demonstrated in some of the photos in Appendix A (see Roadsaver 203 and AR Plus).

Figure 9. Non-Uniform Seal Caused by Sealant Flow.

FIELD PERFORMANCE

In August 2013, less than a year after placement, the researchers returned to assess the sealant condition and to attempt an evaluation of hot-temperature performance.

All sections were intact and had no signs of damage. In the past months, they were subject to little, if any, traffic and were only exposed to environmental stresses. The sealant surfaces were oxidized but the sealant below the surface was still ductile.

A loaded dump truck was driven at 5 mph across the sealant sections in the middle lane (Figure 10). No damage was observed to any of the sections. The test severity was then increased by parking the front axle over the sealant, turning the wheels, waiting 15 seconds, then slowly driving forward. This method was performed only in the outside lane and did extensive damage to the sealants. It was difficult to distinguish if any sealants were more damaged than others. The seals in three sections (Polyflex Type II, Roadsaver 203, and AR Plus) may have lost a little extra material in the routed sections than the other sealants (Figure 11).

Figure 10. Heavy Traffic Test.

Figure 11. Polyflex Type II with Routing after Severe Heavy Traffic Test.

LABORATORY PERFORMANCE

The same crack sealant materials applied in the field were tested in the laboratory with a crack sealant adhesion test. This was developed previously by Dr. Zhou in TxDOT 0-5457 (Development of the Crack Sealant Adhesion Test) and is a modification on the hot mix asphalt Overlay Tester. Crack seal is poured into a stainless steel mold, 3 inches wide, 1 inch deep, and with a 0.5-inch gap (Figure 12). The mold was pre-heated to 140°F to achieve a superior bond. (In preliminary testing, without this step sealants would fail prematurely. This step was a divergence from the proposed test by Dr. Zhou.) Five sets of each sample were tested in the Overlay Tester at 45°F and 33°F (Figure 12). The samples were subject to a repetitive tensile displacement of 0.1 inches, which was nearly identical to the maximum opening measured in the field. Each displacement cycle took 10 seconds and the maximum tensile load was measured for each cycle. The test was terminated at 2,000 cycles or once the sample failed (current maximum load was 20 percent of the initial maximum load).

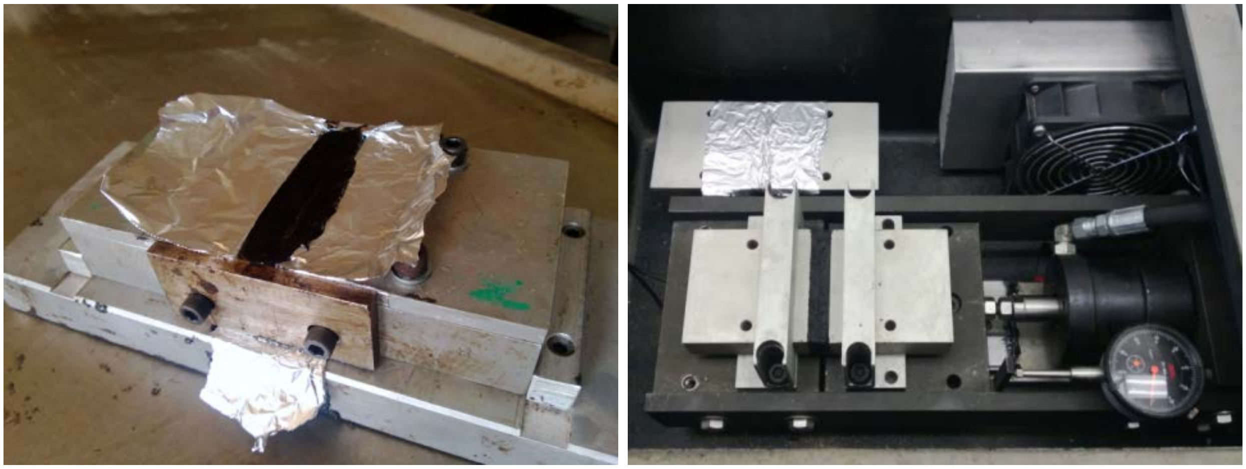

(a) Mold and Sample **(b) Sample during Testing**

Figure 12. Crack Sealant Adhesion Test.

Because the molds were pre-heated, most sealants tested did not fail after 2,000 cycles. To further differentiate among the results, advanced polynomial extrapolation was used to predict when failure would occur for these samples. This type of extrapolation has proven much more reliable than linear, logarithmic, and basic polynomial regression extrapolation.

Statistical tests were performed on the results to compare sealant performance. First, a $\text{Log}_{(10)}$ transformation was applied to each measurement to correct for the strong logarithmic trend in the data. The means of the transformed data were then compared with an analysis of variance (ANOVA) using an α-value of 0.05 (95 percent confidence) to establish statistical significance. When the null hypothesis (means are all the same) was rejected, a Tukey's Honest Significant Difference test was performed to identify the grouping of the means.

The test results are illustrated in Figure 13 and Figure 14, and the data with statistical groupings are in Table 1. The thick horizontal bars in each figure are the geometric averages (as opposed to the arithmetic average), which is most appropriate for logarithmically scaled data. At 45°F, there was minor differentiation among sealants statistically. Sealants AR Plus, Polyflex Type II, and Roadsaver 203 were in the highest performance group A. Group B consisted of all sealants except AR Plus. Therefore, at 45°F, only AR plus had significantly better performance, and there was no statistical difference among sealants in the lower performing group. When testing at 33°F, there was more differentiation among the materials. Roadsaver 203 statistically performed better than all other sealants but AR Plus. The two worst performing sealants were TxDOT Class A and Polyflex Type III, each statistically independent. Other groupings are not discussed here, but are shown in the table. Appendix B contains the complete results of the statistical analysis.

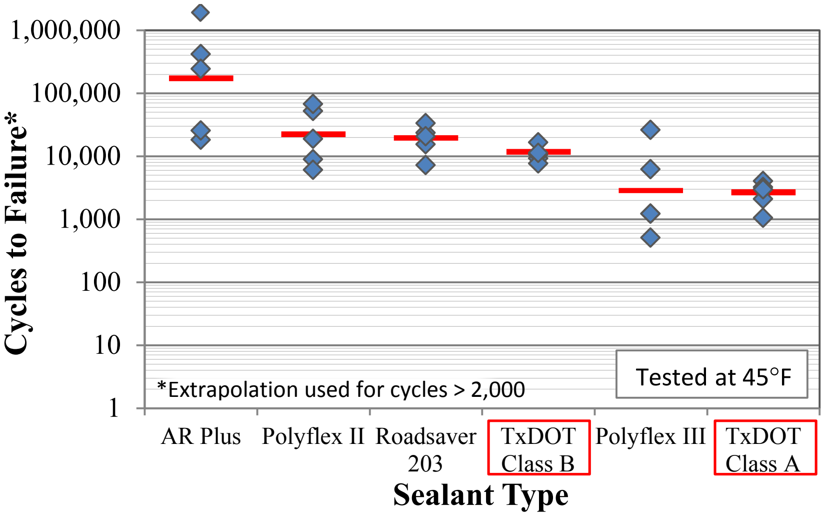


Figure 13. Adhesion Test Results at 45°F.

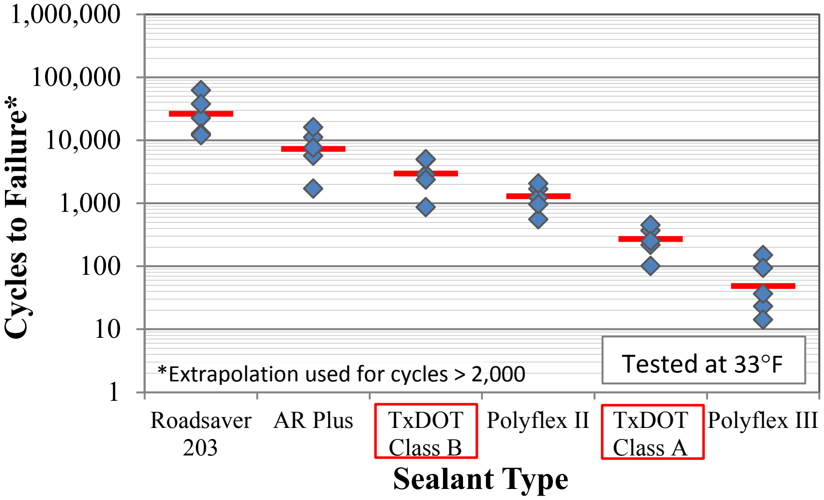


Figure 14. Adhesion Test Results at 33°F.

Table 1. Adhesion Test Results and Statistical Groupings.

Test		Overlay cycles*						
Temperature	Sealant Type	1	2	3	4	5	Geom. Avg.	Grouping**
45°F	AR Plus	2,063,574	411,088	17,951	241,539	25,296	**156,220**	A
	Polyflex II	8,820	51,306	6,020	18,564	66,611	**20,206**	A B
	Roadsaver 203	15,278	23,188	7,117	33,125	20,425	**17,636**	A B
	TxDOT Class B	16,507	9,145	10,478	7,567	11,141	**10,592**	B
	Polyflex III	502	1,217	6,146	25,994	1,208	**2,596**	B
	TxDOT Class A	1,046	3,985	3,189	2,065	2,938	**2,406**	B
33°F	Roadsaver 203	22,319	61,407	37,319	12,526	11,812	**23,757**	A
	AR Plus	5,587	11,084	15,849	1,681	7,497	**6,584**	A B
	TxDOT Class B	2,808	2,341	4,864	4,946	857	**2,669**	B C
	Polyflex II	1,672	1,223	547	2,022	946	**1,164**	C
	TxDOT Class A	216	367	100	444	248	**244**	D
	Polyflex III	148	23	93	36	14	**44**	E

* Extrapolation used for cycles > 2,000 **Tukey's HSD, 95% Confidence All ANOVA P-values = 0.000

These findings suggest that there are sealants on the market that perform better than both current TxDOT crack sealant specifications (Class A and B). At 45°F, that sealant is AR Plus, and at 33°F, Roadsaver 203. In future testing, these sealants should be placed in the field beside current TxDOT sealants for performance comparisons. If these sealants can remain intact a few years longer, maintenance funds could be applied to address other needs.

The sealant adhesion tester is a promising tool to differentiate among sealants, however the test should be further evaluated. In the previous TTI crack sealant study, TxDOT 0-5457, a performance ranking system was proposed, based on the cycles to failure at different temperatures. Applying the same ranking system on these results, however, is not appropriate because of the practice of pre-heating the molds in this study. This had an effect on the results, dramatically increasing the number of cycles to failure. The researchers suspect that several other factors, if not carefully controlled, would play a major role in changing the results, including: sealant application temperature, hot-temperature sealant aging before application, mold cleanliness, uncontrolled variations in testing temperature, delay between molding and testing, etc. A repeatability, sensitivity, and field correlation study is necessary to further refine the test procedures and to determine its reliability as a standardized test.

CONCLUSION

As part of TxDOT Project 9-1529: Rural Preservation and Maintenance, several crack sealant sections were constructed at the Pecos RTC. Six different sealants were applied in routed and non-routed configurations on both older and newer pavement. The following summer, the sections were revaluated including simulated heavy traffic testing. The sealants were also tested in the lab with a sealant adhesion test.

For the most part, sealant application went smoothly. Some issues were encountered for sections in the older, super elevated outer lane. The cracks were very deep and low-viscosity sealants (TxDOT Class B, Polyflex Type II, and Roadsaver 203) had excessive penetration and tended to creep downslope. For applications over narrow cracks, the low-viscosity property could be beneficial. The following summer, all sections were intact and had no signs of damage (traffic was minimal). The surface of the sealants was oxidized but beneath the material was still ductile. Simulated heavy traffic testing was inconclusive.

Laboratory testing suggested that some sealants had significantly better adhesion performance than the current TxDOT classifications. At 45°F, that sealant was AR Plus, and at 33°F, Roadsaver 203. The poorest performing sealants were TxDOT Class A and Polyflex Type III. Polyflex Type II and TxDOT Class B were in the middle and were statistically the same.

The researchers recommend applying more test sections on regularly trafficked pavements using a standard sealant (TxDOT Class A or B), and the two best performing sealants (AR Plus and Roadsaver 203). These should be applied to pavements with different levels of traffic and different amounts of crack movement. Also recommended for further research is a repeatability, sensitivity, and field correlation study of the crack sealant adhesion test. The test should be compared to current sealant tests (low-temp penetration/flexibility/bond tests).

CONSTRUCTION AND MONITORING OF DEMONSTRATION PROJECTS IN TEXAS DISTRICTS

In the past five years Texas has widely implemented the thin overlay technology first demonstrated in this study. All of this development work had it origin in the six test sections constructed at the Pecos Test Track. This has led to the development of two specifications Item 347 for Thin Surface mixes and Item 3269 for Permeable friction courses. The Austin District has moved almost exclusively to the use of thin high performance mixes. For FY 2012/2013 the Austin District alone reported saving over $11 million by moving to these thin lift mixes. Many other districts are testing this thin lift mixes, and several major projects are underway around Texas including the thin overlay currently being placed on US 59 in the Houston District.

This chapter focuses on the construction and monitoring of sections using the fine-graded permeable friction course (PFC) mixtures in TxDOT districts. In addition to the test sections constructed in at Pecos, field trials were conducted in four districts. These include:

- Exit Ramp in the Lufkin District.
- Exit Ramp in the Bryan District.
- US 183 in the Brownwood District.
- Loop 336 in the Odessa District.

BACKGROUND INFORMATION

Figure 15 and Figure 16 show the schematic of the test sections constructed at the Pecos facility. Figure 16 shows a before and after photo of the roadway condition. These sections have all performed very well and the implementation described later was only possible based on the excellent performance of these original sections.

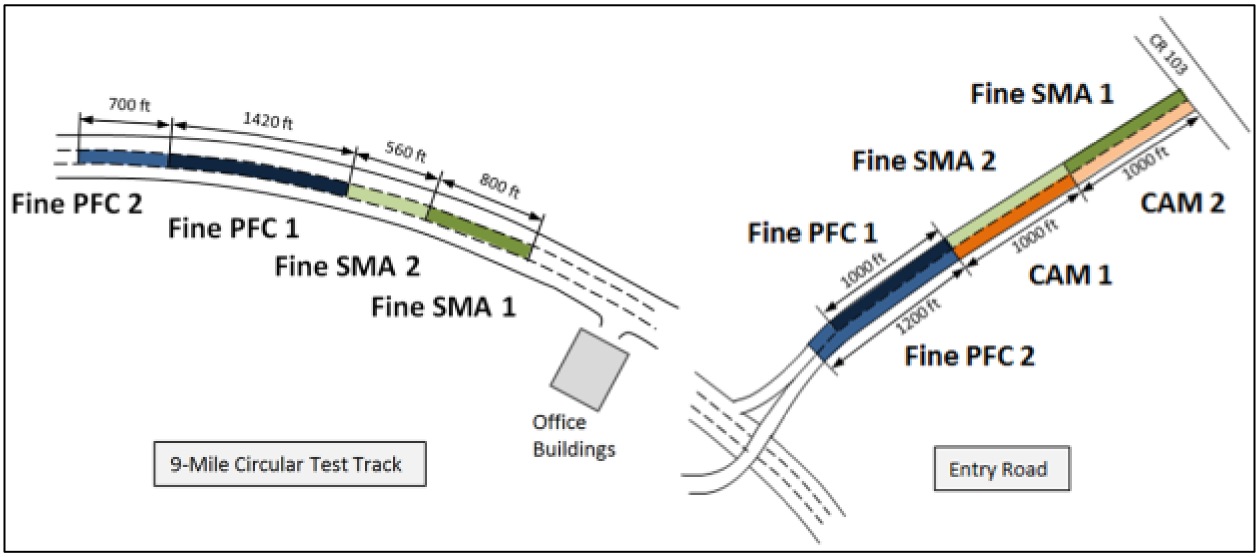


Figure 15. Section Layout.

(a) (b)

Figure 16. Alligator Cracking on Entry Road: (a) before and (b) after.

CONSTRUCTION AND MONITORING OF THE FINE PFC SECTION AT THE PECOS TEST TRACK

Researchers developed specifications and let a contract to Reece Albert Construction of Midland to construct two fine-graded PFC mixtures on the entrance to the facility using a relatively good quality limestone from Vulcan Materials in Eastland and a rhyolite gravel from Capital Aggregates' Hoban Pit.

TTI designed the mixes using a single aggregate fraction from each source. The aggregate gradations for each mix are shown in Table 2. The minimum gradation specification requirement on the No. 3/8 was lowered from 95 percent (as originally proposed) to 94 percent to allow the use of the Hoban material, which could not meet the 95 percent specification. A minimum asphalt content of 6.5 percent was specified and was also selected as optimum for both mixtures; 0.3 percent fibers were used. Lime was not included in the mix design since the capability at the plant was not available. The mixtures were designed according to TxDOT procedure Tex 204-F, Part V.

Table 2. Mix Design Compositions for Field Testing at Pecos.

	PFC Mix Design No. 1	PFC Mix Design No. 2	Draft Specification Lower and Upper Specification Limits	
	Capital Aggregates Hoban	Vulcan Materials Eastland Limestone		
Sieve Size	Cum. % Pass	Cum. % Pass		
No. 1/2	100.0	100.0	100	100
No. 3/8	94.5	97.8	94	100
No. 4	30.2	46.4	20	55
No. 8	4.8	3.4	0	15
No. 16	1.0	1.9	0	12
No. 30	0.4	1.6	0	8
No. 50	0.3	1.5	0	8
No. 200	0.2	1.3	0	4

Asphalt Type: PG 76-22 **Binder Percent:** 6.5% **Lime:** 0% **Fibers:** 0.3%

Selecting Optimum Asphalt Content

As discussed previously, since these mixes had higher air void contents than conventional PFC mixes, additional tests (Hamburg and Overlay) were added to ensure adequate field performance. These tests were also used to aid in selecting the asphalt content. The results are presented in Table 3. Samples were molded at 6.0, 6.5, and 7.0 percent asphalt and evaluated for density, Hamburg, and Overlay Test characteristics. The Hoban Rhyolite mixture failed the Hamburg requirement of no more than 12.5 mm rut depth at 10,000 cycles but passed these criteria at 6.5 percent asphalt. Overlay Test data exceeded the minimum of 300 cycles for all 3 asphalt contents. All 3 asphalt contents met the density requirements of between 70 and 74 percent. So based on the Hamburg criteria, the acceptable asphalt content was selected as 6.5 percent.

The Eastland mix had acceptable Hamburg and Overlay Test results at all three asphalt contents but the least rut depth was at 6.5 percent asphalt. The density results for all three asphalt contents exceeded the proposed specification values of between 70 and 74. This density value is controlled by the aggregate gradation and since the aggregate is from a single fraction (or stockpile) no change in the gradation could be made given this is what was available from this quarry. A goal of the research was to determine if the proposed specifications were acceptable based on field performance characteristics. So allowing a mix to be constructed that was outside of the density specifications provided additional information that may be used to validate and/or modify the specifications. An asphalt content of 6.5 percent was selected for the Eastland limestone mix.

While considered a good quality limestone, the Eastland material still did not meet TxDOT polish value requirements for a Class A in the Surface Aggregate Classification System. A Class A aggregate must also have a Los Angeles Abrasion (LAA) loss of less than 30 and a Magnesium Sulfate Soundness loss of less than 20; both aggregates met these values. The final specification requirement for the fine-graded PFC required 100 percent class A aggregates. Soundness values for the Eastland and Hoban materials were as follows:

- Eastland: LAA = 25 percent, Soundness = 13 percent.
- Hoban: LAA = 20 percent, Soundness = 10 percent.

Table 3. Mix Design Performance Test Results at Different Asphalt Contents.

Mixture Type	Asphalt Content, %	Density, %	Hamburg Results, Rut depth @ No of cycles	Overlay Test Results		Performance Testing Outcome
				Max Load, lb	Number of Cycles to Failure	
PFC-1 Hoban Rhyolite	6.0	73.1	12.5 mm @ 4,900	336.3	402	Fail
	6.5	73.5	8.1 mm @ 10,000	367.0	450	Pass
	7.0	73.7	12.5 @ 7,000	317.0	1000	Fail
PFC-2 Eastland Limestone	6.0	76.3	9.12 @ 10,000	478.4	337	Pass
	6.5	77.8	6.29 @ 10,000	419.0	300	Pass
	7.0	78.4	8.50 @ 10,000	494.5	1000	Pass

The mixtures were placed side-by-side on the entry road to the facility as shown in Figure 17. Standard equipment for asphalt concrete pavement construction was used, including a material transfer vehicle, paver equipped with an infrared monitoring system, and 3 passes with a 13.5-ton tandem steel wheel roller operated in static mode.

Figure 17. PFC Mix on Pecos Facility Entrance Road.

Monitoring Performance

The PFC mixtures were evaluated immediately after construction for drainage characteristics using a field water flow test shown in Figure 18 (Tex 246-F). The test evaluates the time required to discharge a given volume of water channeled onto the pavement surface through a 6-inch diameter opening. The time corresponds to the water flow value (WFV) and is expressed in seconds.

Figure 18. Test Method Tex-246-F, Field Water Flow Test.

For conventional PFC mixtures, TxDOT recommends WFVs of less than 20 seconds. The Hoban PFC had an average WFV of 9 seconds, while the Eastland mix had a WFV of about 27 seconds. This indicates that the higher than desired lab molded density of the Eastland PFC translated to poorer drainability in the field.

TxDOT measured skid resistance on the mixtures a few days after construction. The wet skid number was measured at 50 mph using a smooth tire. Values obtained were 39 for the Hoban mix and 31 for the Eastland mix. These values are expected to increase as the asphalt on the surface is eventually worn away by traffic and weathering.

The direct tire-pavement noise was measured on each section using an on-board sound intensity (OBSI) system. The OBSI measures sound intensity at different frequencies, which can then be used to calculate an overall noise level. The Hoban PFC mix had a noise level of 100.1 dBA, and the Eastland PFC mix had a noise level of 98.7 dBA. Recent measurements made by TxDOT on eight of the conventional coarse graded PFCs using the PG 76 binder produced an average overall noise level of 102.2 dBA. The higher air voids and/or finer texture for the fine graded PFC should be contributing to the lower noise level.

FIELD CONSTRUCTION OF FINE GRADED PFC SECTIONS AROUND TEXAS

To evaluate the constructability and performance of the fine-graded PFC mixture, field trials were conducted in the following four locations and mixtures were designed for each location using materials local to the area:

- Exit Ramp in the Lufkin District.
- Exit Ramp in the Bryan District.
- US 183 in Brownwood.
- Loop 336 around Midland.

Lufkin Construction Project

Researchers worked with the maintenance engineer of TxDOT's Lufkin District to place the experimental fine-graded PFC on an exit ramp of US 59 as shown in Figure 19. This ramp had an existing chip seal surface and a number of accidents had occurred when drivers exited too fast and skidded off the ramp while trying to make the sharp curve during wet weather. The district personnel said they were pulling vehicles out of the ditch every time it rained. None of the surfaces maintenance had tried could withstand these high shear forces exerted by traffic on the surface.

The mixture design for this project was the sandstone design as presented earlier. Traffic speeds on the exit ramp prohibit skid and noise testing.

The mix held up very well in one of the hottest summer's Texas has seen (over 30 consecutive days of 100°F+ temperatures [2013]) and the district was happy to report no accidents even during a 6-inch rain event. An inspection conducted six weeks after placement found the section looked identical to the day it was placed, with no flushing or closing up of the open surface. Testing performed on the mix showed that it met the specification requirements (Table 4).

Table 4. Test Results on Lufkin Fine Graded PFC Plant Mix.

	Lufkin PFC Mix Plant Sampled Material	**Lower and Upper Specification Limits**		**Additional Testing on Field Mix**
	Sandstone			
Sieve Size	**Cum. % Pass (ignition oven sample)**			
No. 1/2	100.0	100	100	Target Asphalt Content: 6.5 % Actual Asphalt Content: 6.1% Hamburg Test: 7.4 mm at 10,0000 cycles Overlay Test: 356 cycles to failure Cantabro loss: 5.4% Field Water Flow: 19 seconds (Avg of 6 readings taken on pavement surface immediately after construction)
No. 3/8	99.2	94	100	
No. 4	37.4	20	55	
No. 8	8.7	0	15	
No. 16	6.2	0	12	
No. 30	5.3	0	8	
No. 50	4.7	0	8	
No. 200	3.2	0	4	

Very Thin, Fine-Graded PFC Placed on Cloverleaf Exit Ramp of US 59 Near Lufkin District Office. Maintenance needed a mix to address the numerous wet weather accidents occurring on this ramp.

Figure 19. Cloverleaf Exit Ramp of US 59 of the TxDOT Lufkin District.

Bryan Exit Ramp PFC

The Bryan District used the fine PFC as a test section to surface the newly constructed exit ramp off of SH 6 to the district office. This design was the same as that used in Lufkin, but was placed with a local Bryan contractor, Knife River. Similar performance to that seen in Lufkin has been observed (Figure 20).

Figure 20. Construction of the Bryan Fine PFC Exit Ramp.

Brownwood US 183 Fine PFC

The Brownwood District let the first full-scale construction project of the fine PFC. This was on US 183 just south of Breckenridge. The existing pavement was a relatively new surface treatment that was prematurely bleeding (Figure 21). Maintenance was continually treating the bleeding surface with lime water and limestone rock asphalt patches so the fine PFC was selected to resurface this roadway since the high air void content of the fine PFC could potentially accommodate the excess underlying bleeding asphalt.

The target thickness was ¾-inch and the shoulders were left unsurfaced. Researchers worked with TxDOT and contractor personnel to set roller patterns and evaluate water flow characteristics.

Figure 21. US 183 Bleeding Surface Treatment prior to PFC Surfacing.

There were no Class A materials available in the area so the specs were written to allow a higher quality Class B material. Local limestone aggregates were used to produce the mix, and water flow measurements taken during construction were less than 20 seconds (Figure 22).

Figure 22. Water Flow Testing on US 183 Fine PFC.

Recent discussions with the district engineer have revealed that after nine months of service, the PFC is in excellent condition and TxDOT is pleased with the performance. The surface has also given the district good public relations with the local citizens since the previous project had performed so poorly and was a source of many public complaints. Figure 23 shows the surface three months after construction.

Figure 23. US 183 PFC Three Months after Construction.

Loop 338 Odessa District

The construction of the fine PFC on Loop 338 was completed in August 2014. The funding for this construction was supplied by project 495294 "Pavement Preservation and Maintenance Practices." Based on discussions with the Odessa District personnel their highest priority was to develop a cost effective overlay mix that could be used to cover up badly bleeding chip seals.

Figure 24 shows the highway selected for the test section. This is on Loop 336 around Odessa and starts just north of the intersection with 87th Street. The concern is the low skid as the existing seal is badly flushed and in many locations there is free asphalt on the surface. There are no easy fixes for this problem as the free asphalt will bleed through any traditional overlay mix and quickly reappear on the surface. Based on the work at Pecos two options are possible:

- **Option 1.** Place a high air void PFC (>20 percent air voids) so that any free asphalt will not migrate to the surface and the PFC will increase skid resistance and reduce noise.
- **Option 2.** Micro-mill the bleeding seal and place a thin lift of Ultra-Thin Dense mix (similar to the mix placed at Pecos).

For Loop 338, the district selected the fine PFC option. It was proposed that the district use the best performing PFC placed on the test track, which was the PFC made with the Grade 5 Hoban rock. This is 100 percent Grade 5 rock with 0.3 percent fibers and 6.5 percent Alon PG 76-22 asphalt.

Figure 24. Pre-Existing Condition for Loop 338, Odessa District.

A contract was awarded to Reece Albert Inc. to place the fine PFCs; this company did the original construction at the test track. The Loop 338 construction was completed on August 8, 2014. Figure 25 shows photos of the construction sequence.

a) Belly dump trucks with RoadTec pick up

b) one pass of two steel wheel rollers, (no backing up)

c) Sprinkling before opening the PFC to traffic

Figure 25. Construction Sequence on Loop 338.

The target lift thickness was 0.75 inches. The contractor assumed there would be some roll down so initially the lift was placed at 1 inch thickness. However there was little or no roll down so the initial lift was slightly thicker than the target. No problems were experienced with the placement. The mix temperatures at the back of the lay down machine where consistent throughout the whole placement and found to be between 260 and 265°F. Only a single forward pass was made with the two rollers in none vibratory mode. The one concern was when to open the PFC to traffic. PFCs have a thicker film thickness than normal mixes and there is concern that they will be problematic if it is opened too early especially if the heavy truck traffic stops on the mat. To cool the mat off a single pass was made with the water truck as shown. After wetting the temperature of the surface of the PFC was found to be 130°F and that was deemed adequate for opening to traffic. As anticipated as soon as the roadway was opened up several large trucks did stop on the mat because of the construction activities; no problems were observed with any rock pick up.

To check the adequacy of the mix the water low test shown in Figure 26 was run. The measured flow time was 9 seconds, which is identical to that measured at the Pecos Test Track. This was evidence that the single pass rolling was adequate.

Figure 26. Water Flow Being Conducted on the New PFC.

The completed surface has the expected open visual appearance shown in Figure 27. It is anticipated that this will have a very good skid resistance and excellent noise characteristics. Skid tests were made on the section 1 week after construction, the skid values as measured by TxDOT's ASTM skid truck in the bleeding section was 6 which is very low. On the new PFC a value of 30 was measured. This is an improvement by a factor of 5. In the near future it is also proposed to make noise measurements.


Figure 27. Final Surface Appearance on Loop 336 in Odessa.

PLACEMENT AND TOP PERFORMING CRACK SEALS IN TEXAS DISTRICTS

PURPOSE

For this project, new thin overlay and crack sealant demonstration projects were constructed. These will be evaluated in coming years in future research projects. The same sealants were tested in the lab for resistance to cycling failure at cold temperatures. This chapter summarizes the site layouts and documents construction.

CRACK SEAL SECTIONS

Two locations were identified for demonstration projects of three different crack sealants. The locations were south of San Antonio (Van Ormy), on SH 16, and in Stanton (Odessa District) on SH 137. Both locations are shown in Figure 28.

Figure 28. Crack Sealant Section Locations: a) Van Ormy (SH 16) and b) Stanton (FM 137).

The sealants selected for application were:

- TxDOT Class A.
- TxDOT Class B.
- Crafco Roadsaver 203/221.
- Crafco Polyflex Type 3.

These particular sealants were chosen to represent a wide range of cold-weather performance properties as observed in laboratory testing. The section below describes the construction of the crack sealant test section on the SH 16 project in San Antonio. The data from the Stanton section is still being collected and processed and will be reported at a later date.

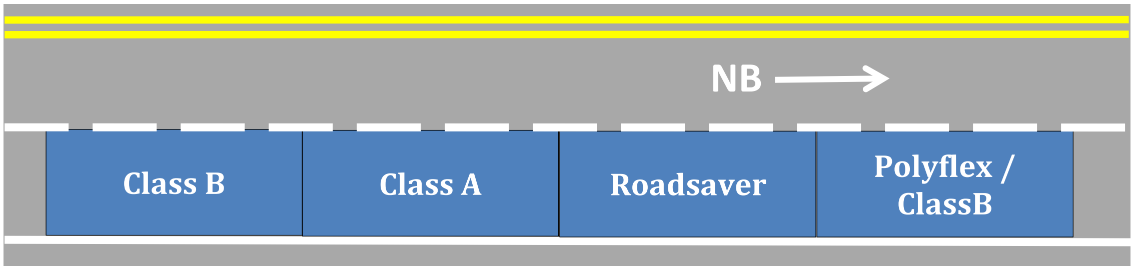
Van Ormy, SH 16

This project was located on SH 16 in the San Antonio District, starting on the Bexar-Atascosa County line. Sealant sections were placed in the northbound, outside-lane. The pavement condition was characterized by low- to moderate-severity longitudinal cracking in the wheel path with occasional transverse cracking, as shown in Figure 29 and Figure 30. The cracks had been sealed previously, but most of the cracks had reappeared. The average crack width was 0.25 inch.

The layout of the test sections is shown in Figure 31. In each section, 15 longitudinal crack segments, 10-ft long, were identified. These segments were sealed with the specific test sealant while all other crack segments in the section were sealed by maintenance crews with their own TxDOT Class B sealant.

Figure 29. Existing Condition.

Figure 30. Existing Crack.



*Each section contains 15 10-ft longitudinal cracks

Figure 31. Section Layout.

Three clean melter pots were available to limit cross contamination. The Class B, Class A, and Roadsaver were applied first, and therefore had no contamination. The Polyflex Type 3 was placed in the same pot as the Class B. All cracks was blown out with pressurized air and then sealed (Figure 32). The sealant was allowed to reach 380°F before application and in all but one case (Roadsaver 203) did not rise above 400°F. A 4-inch-diamter disk tip was attached to the end of the applicator wand. The resulting sealant configurations for non-routed and routed sections are shown in Figure 33.

No significant problems were encountered when sealing cracks in the center lane. Sealant application in the outside line, however, was more difficult. First, the cracks in the older pavement were very deep and some of the sealants would drain down a couple seconds after the first application. Additional passes of the applicator wand were necessary to completely fill the cracks, which sometimes resulted in excessive sealant in the overband. In some cases, the cracks were only partially filled and were left with a recessed seal. Finally, the outside lane was super elevated causing less viscous sealants to creep down the slope resulting in a non-uniform seal (Figure 34).

Figure 32. Crack Sealant Construction.

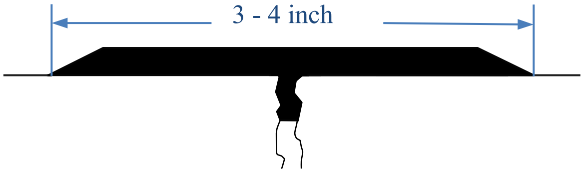


Figure 33. Simple Overband Sealant Configuration.

Throughout the application process, the operators took turns applying the sealant. Some would apply the sealant more liberally, especially in the outside lane. This is demonstrated in some of the photos in Appendix A (see Roadsaver 203 and Asphalt Rubber 233).

Ten transverses cracks from each lane were randomly selected to monitor crack movement with temperature change. Two MAG nails were driven into the pavement on either side of the center of the crack (see Figure 34). In the morning, a caliper was used to measure the center-to-center spacing of the nails and the pavement temperature was measured by an infrared thermal gun. Later in the afternoon, the nail spacing and pavement temperature were again measured.

Figure 34. Reference Nails for Crack Measurements.

Movement ranged from 0.043 to 0.083 inches with a 55°F change. The average crack movement for the newer and older pavements was nearly the same around 0.06 inches. Assuming that crack width is linearly proportional to temperature, crack movement over the full range of expected temperatures would be about 0.09 inches. This movement is below the definition of an active crack according to the FHWA (0.125 inches) and CalTrans (0.25 inches). For reference, when testing crack sealant in the overlay tester, the maximum opening is set to 0.1 in.

CONCLUSION

As part of TxDOT Project 9-1529: Rural Preservation and Maintenance, several crack sealant sections were constructed at the Pecos RTC. Six different sealants were applied in routed and non-routed configurations on both older and newer pavement. These sections will be evaluated tested in the upcoming summer for performance to date and resistance to pullout with heavy slow moving traffic.

For the most part, sealant application went smoothly. Some issues were encountered when for sections in the older, super elevated outer lane (cracks were very deep and low-viscosity sealants tended to creep downslope). Average crack movement observed was 0.06 inches and the expected total crack movement at temperature extremes is around 0.09 inches.

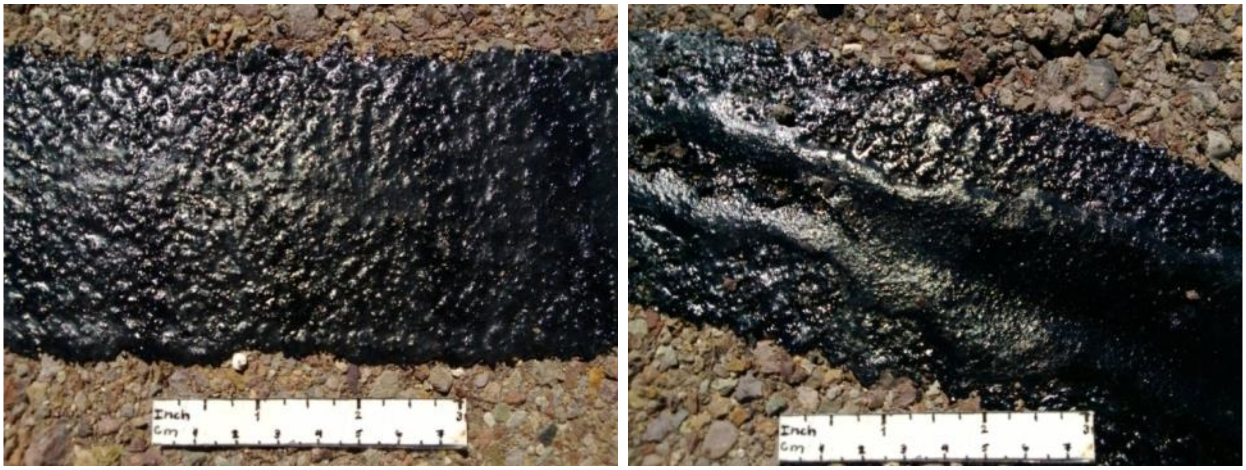
APPENDIX A: CRACK SEALANT PICTURES

(a) New Pavement, No Route

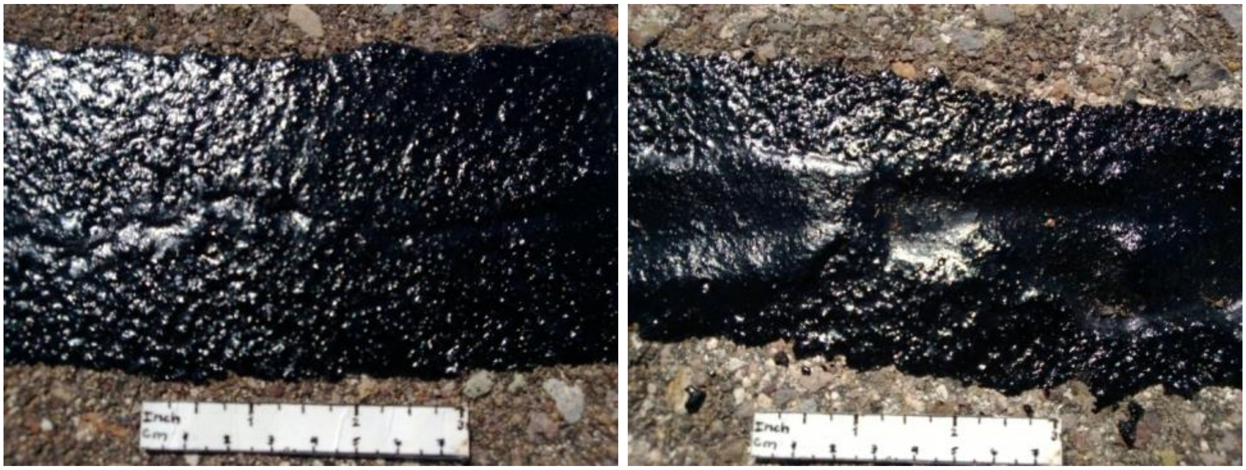
(b) New Pavement, Route

(c) Old Pavement, No Route

Figure A-1. TxDOT Class A.

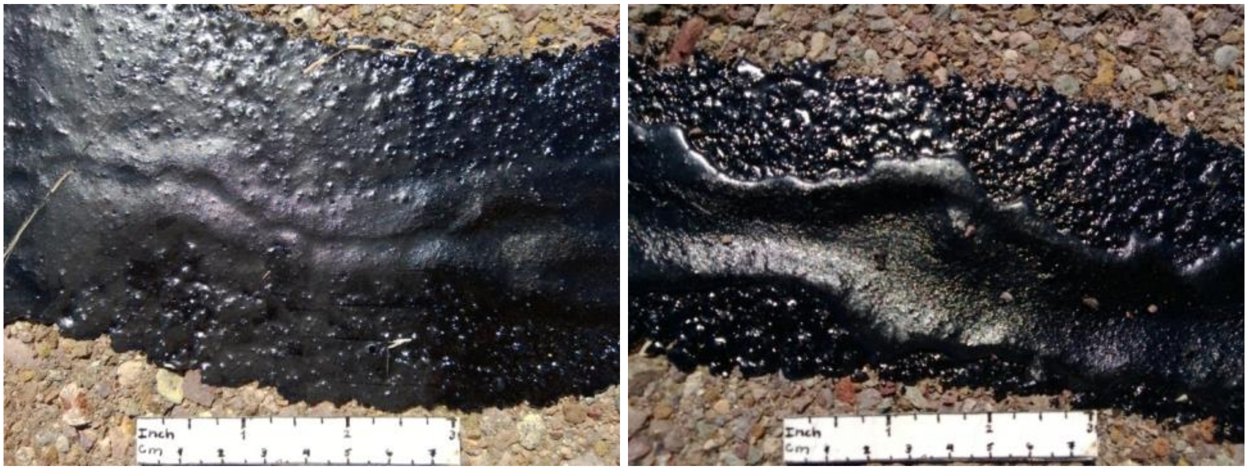


(a) New Pavement, No Route (b) New Pavement, Route

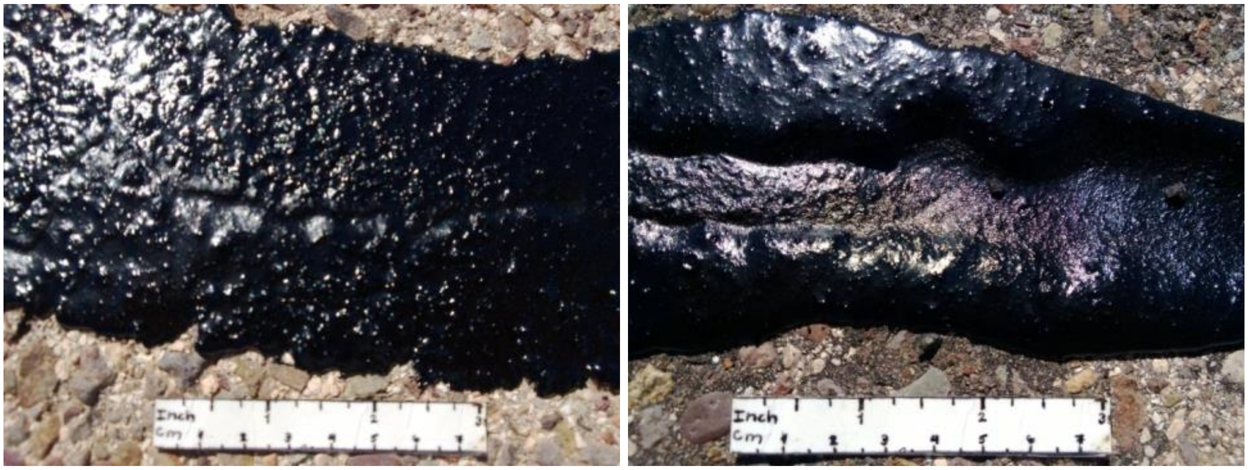


(c) Old Pavement, No Route (d) Old Pavement, Route

Figure A-2. TxDOT Class B.

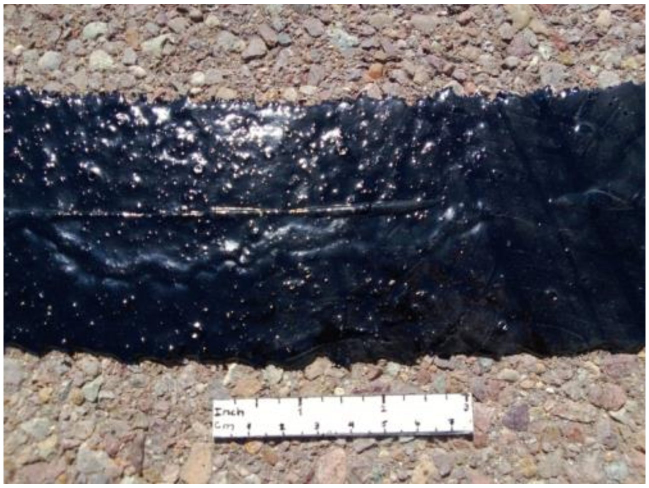


(a) New Pavement, No Route **(b) New Pavement, Route**

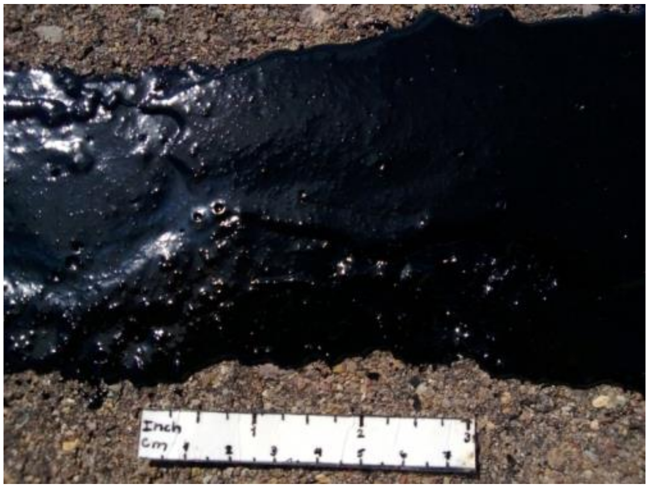


(c) Old Pavement, No Route **(d) Old Pavement, Route**

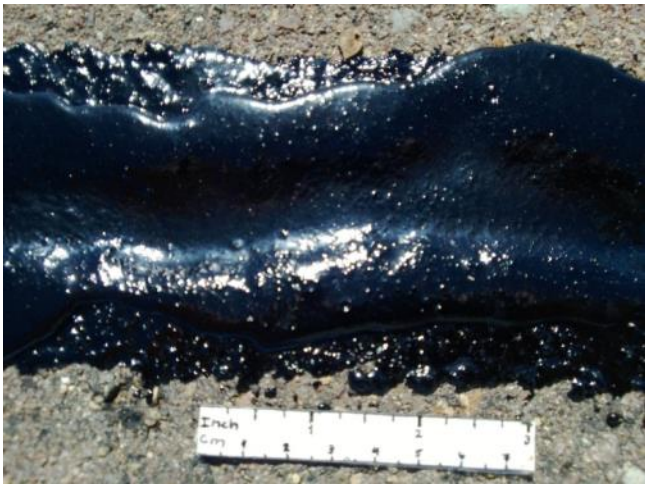
Figure A-3. Polyflex Type II.



(a) New Pavement, No Route



(b) New Pavement, Route

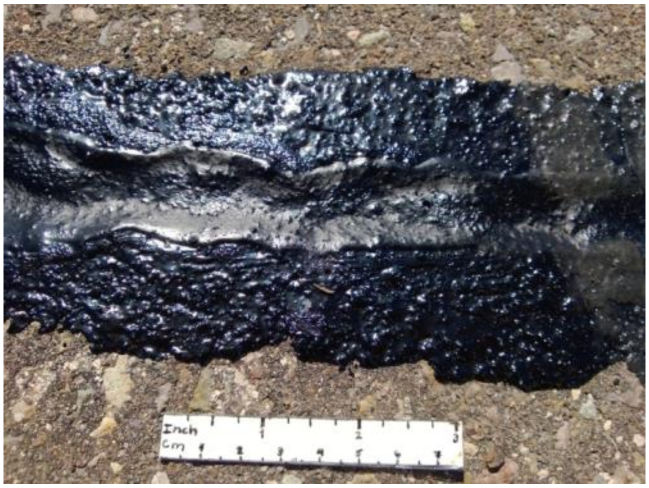


(c) Old Pavement, No Route

Figure A-4. Polyflex Type III.

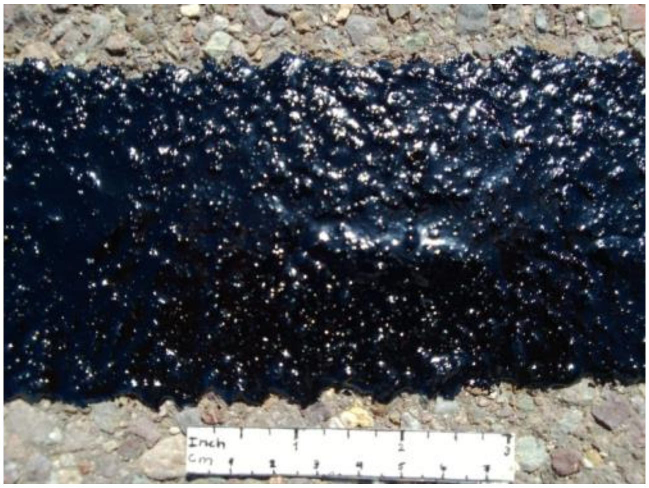
(a) New Pavement, No Route

(b) New Pavement, Route



(c) Old Pavement, No Route

Figure A-5. Roadsaver 203.



(a) New Pavement, No Route

(b) New Pavement, Route

(c) Old Pavement, No Route

Figure A-6. AR Plus.

APPENDIX B: STATISTICAL ANALYSIS

Results for: 45F

One-way ANOVA: PredCyclesLOG versus Sealant

```
Source DF SS MS F P
Sealant 5 11.260 2.252 8.71 0.000
Error 24 6.207 0.259
Total 29 17.467

S = 0.5085 R-Sq = 64.47% R-Sq(adj) = 57.06%


 Individual 95% CIs For Mean Based on
 Pooled StDev
Level N Mean StDev --------+---------+---------+---------+-
ARPlus 5 5.1937 0.8627 (------*------)
Poly2 5 4.3055 0.4582 (------*-----)
Poly3 5 3.4143 0.6836 (------*-----)
RS203 5 4.2464 0.2512 (------*-----)
TxClA 5 3.3813 0.2268 (-----*------)
TxClB 5 4.0250 0.1255 (-----*------)
 --------+---------+---------+---------+-
 3.50 4.20 4.90 5.60

Pooled StDev = 0.5085


Grouping Information Using Tukey Method

Sealant N Mean Grouping
ARPlus 5 5.1937 A
Poly2 5 4.3055 A B
RS203 5 4.2464 A B
TxClB 5 4.0250 B
Poly3 5 3.4143 B
TxClA 5 3.3813 B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sealant

Individual confidence level = 99.50%


Sealant = ARPlus subtracted from:

Sealant Lower Center Upper ---+---------+---------+---------+------
Poly2 -1.8821 -0.8882 0.1056 (--------*-------)
Poly3 -2.7733 -1.7794 -0.7856 (-------*-------)
RS203 -1.9412 -0.9473 0.0465 (-------*-------)
TxClA -2.8063 -1.8124 -0.8186 (-------*-------)
TxClB -2.1626 -1.1687 -0.1749 (-------*--------)
 ---+---------+---------+---------+------
 -2.4 -1.2 0.0 1.2
```

```
Sealant = Poly2 subtracted from:

Sealant Lower Center Upper ---+---------+---------+---------+------
Poly3 -1.8850 -0.8912 0.1027 (--------*-------)
RS203 -1.0530 -0.0591 0.9348 (--------*-------)
TxClA -1.9180 -0.9242 0.0697 (-------*--------)
TxClB -1.2744 -0.2805 0.7134 (--------*-------)
 ---+---------+---------+---------+------
 -2.4 -1.2 0.0 1.2


Sealant = Poly3 subtracted from:

Sealant Lower Center Upper ---+---------+---------+---------+------
RS203 -0.1618 0.8321 1.8259 (-------*-------)
TxClA -1.0268 -0.0330 0.9609 (--------*-------)
TxClB -0.3832 0.6107 1.6046 (-------*-------)
 ---+---------+---------+---------+------
 -2.4 -1.2 0.0 1.2


Sealant = RS203 subtracted from:

Sealant Lower Center Upper ---+---------+---------+---------+------
TxClA -1.8589 -0.8651 0.1288 (-------*-------)
TxClB -1.2153 -0.2214 0.7725 (-------*-------)
 ---+---------+---------+---------+------
 -2.4 -1.2 0.0 1.2


Sealant = TxClA subtracted from:

Sealant Lower Center Upper ---+---------+---------+---------+------
TxClB -0.3502 0.6437 1.6375 (-------*--------)
 ---+---------+---------+---------+------
 -2.4 -1.2 0.0 1.2
```

Results for: 33F

One-way ANOVA: PredCyclesLOG versus Sealant

```
Source DF SS MS F P
Sealant 5 24.429 4.886 47.10 0.000
Error 24 2.490 0.104
Total 29 26.919

S = 0.3221 R-Sq = 90.75% R-Sq(adj) = 88.82%


 Individual 95% CIs For Mean Based on
 Pooled StDev
Level N Mean StDev -------+---------+---------+---------+--
ARPlus 5 3.8185 0.3730 (--*--)
Poly2 5 3.0661 0.2227 (--*--)
Poly3 5 1.6406 0.4235 (--*--)
RS203 5 4.3758 0.3077 (--*--)
TxClA 5 2.3882 0.2510 (--*--)
TxClB 5 3.4264 0.3110 (--*--)
 -------+---------+---------+---------+--
 2.0 3.0 4.0 5.0

Pooled StDev = 0.3221


Grouping Information Using Tukey Method

Sealant N Mean Grouping
RS203 5 4.3758 A
ARPlus 5 3.8185 A B
TxClB 5 3.4264 B C
Poly2 5 3.0661 C
TxClA 5 2.3882 D
Poly3 5 1.6406 E

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sealant

Individual confidence level = 99.50%


Sealant = ARPlus subtracted from:

Sealant Lower Center Upper -------+---------+---------+---------+--
Poly2 -1.3819 -0.7524 -0.1229 (--*--)
Poly3 -2.8074 -2.1779 -1.5484 (--*--)
RS203 -0.0721 0.5573 1.1868 (--*--)
TxClA -2.0597 -1.4303 -0.8008 (--*--)
TxClB -1.0215 -0.3921 0.2374 (--*--)
 -------+---------+---------+---------+--
 -2.0 0.0 2.0 4.0
```

```
Sealant = Poly2 subtracted from:

Sealant Lower Center Upper -------+---------+---------+---------+--
Poly3 -2.0550 -1.4255 -0.7960 (--*--)
RS203 0.6803 1.3097 1.9392 (---*--)
TxClA -1.3073 -0.6779 -0.0484 (---*--)
TxClB -0.2691 0.3603 0.9898 (--*--)
 -------+---------+---------+---------+--
 -2.0 0.0 2.0 4.0


Sealant = Poly3 subtracted from:

Sealant Lower Center Upper -------+---------+---------+---------+--
RS203 2.1057 2.7352 3.3647 (--*--)
TxClA 0.1181 0.7476 1.3771 (--*--)
TxClB 1.1564 1.7858 2.4153 (--*--)
 -------+---------+---------+---------+--
 -2.0 0.0 2.0 4.0


Sealant = RS203 subtracted from:

Sealant Lower Center Upper -------+---------+---------+---------+--
TxClA -2.6171 -1.9876 -1.3581 (--*--)
TxClB -1.5789 -0.9494 -0.3199 (--*--)
 -------+---------+---------+---------+--
 -2.0 0.0 2.0 4.0


Sealant = TxClA subtracted from:

Sealant Lower Center Upper -------+---------+---------+---------+--
TxClB 0.4087 1.0382 1.6677 (--*--)
 -------+---------+---------+---------+--
 -2.0 0.0 2.0 4.0
```