Florida Department of TRANSPORTATION

Evaluation of Fog Seal Preservation Technique On US 17 and US 27

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Introduction

The Florida Department of Transportation (FDOT) has utilized open-graded friction courses (OGFC) mixtures since the mid-1970's as a method of improving pavement safety by reducing splash and spray and minimizing hydroplaning, particularly on high speed multi-lane facilities (1). The functional purpose of an OGFC is to reduce hydroplaning by increasing pavement texture and porosity. However, the porous texture of an OGFC exposes the thin film of asphalt on the aggregate in the pavement to heat, air, ultraviolet radiation and moisture, all of which cause the binder to oxidize and harden. This oxidative hardening generally makes the binder more brittle, resulting in a less fatigue resistant binder. Under repeated traffic loads the binder continues to fatigue and ultimately cracks, resulting in aggregate particles raveling from the asphalt mixture. Over time, the raveling problem becomes progressively worse. When open graded friction courses were introduced into the United States in 1950's, the FHWA estimated the service life to be from 5 – 7 years. However, in 1990 the FHWA issued a Technical Advisory on Open Graded Friction Courses and estimated the service life to be from 7 – 10 years. As with other states, the primary source of failure with OGFC mixtures in Florida was raveling (2).

In 1998, based on positive feedback of the Georgia Department of Transportation's (GDOT) D-Modified open graded friction courses, FDOT began the development of a similar type of OGFC, called FC-5. The FC-5 mixture has a 1/2" Nominal Maximum Aggregate Size, uses granite or oolitic limestone, and also uses modified asphalt binder (either asphalt rubber or a polymer modified asphalt). The FC-5 is placed at a thickness of 3/4". In order to increase the optimum binder content without an ensuing problem with binder drain-down during construction, the mixture contains fiber stabilizing additives (either mineral or cellulose) at a dosage rate of 0.4% or 0.3% respectively. The Specifications for FC-5 were implemented on all projects beginning in January 2000 (3).

The FDOT Pavement Management Office conducted an analysis of the performance of FC-5 mixtures and indicated the life expectancy of FC-5 mixtures is approximately three years longer than the performance of its predecessor, FC-2 (4). However, the main distresses of FC-5 continue to be raveling and top-down cracking, resulting in a shortened life cycle of FC-5 compared to dense-graded asphalt mixtures in Florida.

A number of national studies nationally have shown that the application of a fog seal can be a helpful preventative maintenance technique to prevent OGFC mixtures from raveling by increasing the binder film on the aggregate particles and subsequently reducing the oxidative hardening that is occurring. To evaluate the potential of this preventative maintenance technique, FDOT placed a number of fog seal test sections on several projects in central Florida in 2013. This report documents the construction and early performance of these test sections.

Products

Three products were selected for evaluation including Reclamite, E-Fog, and SealMaster AsPen AC.

The Reclamite is an emulsion of petroleum oils and resins. It serves as a rejuvenating agent and sealer for the surface asphalt layer. It was reported that the viscosity can be reduced by a minimum 45% or the penetration values increased by a minimum of 25% (5). Technically, this is not a fog seal material but instead a rejuvenator.

The E-Fog supplied by Ergon Asphalt & Emulsion is a CMS-1PF cationic emulsion, and contains a rejuvenator, polymer, base asphalt, and emulsifier.

The AsPen AC is a clay stabilized and mineral-filled asphalt emulsion surface sealer that is used to replenish the binder lost through oxidation, weathering, and aging. It has been used on private roads and parking lots.

Site Information

After discussions with FDOT Pavement Design staff and several material suppliers, the conditions for the test sites were selected based on the following categories:

- Type of Pavement: FC-5 (OGFC)
- Traffic: Level C or D (3 – 30 million ESALs)
- Existing Pavement Age: Preferably 3 years with a maximum of 5 years
- Type of Aggregate: Granite or Limestone
- Length: Approximately 1,000 ft. for each treatment (total 5,000 ft. including two control sections)
- Pavement Distress: None or low severity cracking or raveling and no rutting or pavement friction issues

Among the numerous candidates initially identified, the sites located near larger cities or towns, which have heavy traffic with numerous signalized intersections, were excluded from the list due to issues associated with safety and the need to perform detailed Pavement Condition Surveys (PCS) on a routine basis. In addition, roadway sections with horizontal curves were also eliminated due to concerns associated with a potential drop in pavement friction following the fog seal application and consequential safety issues. Ultimately, roadway sections on US-17 and US-27 in Polk County were selected for the evaluation. Both sites have adequate clear zones outside of the shoulders for work safety and both are located outside of any city limits. The products were applied between the lane stripes of the outside lane for the northbound roadways on US-17 and US-27 as shown in Figure 1. The basic information for the test sites is shown in Table 1.

The existing FC-5 (Mix Design Number SP 09-7030A) on US-17 was paved by Ajax Paving Industries, Inc. and accepted on May 21, 2009. It contains granite aggregate from Nova Scotia, Canada and ARB-12 binder, which is a PG 67-22 modified with 12% ground tire rubber. The existing FC-5 (Mix Design Number SPM 07-5346A) on US-27 was paved by APAC-Southeast, Inc.

and accepted on May 14, 2009. It contains granite aggregate from Nova Scotia and New Brunswick, Canada and a PG 76-22 (PMA) asphalt binder, which is a polymer modified asphalt.

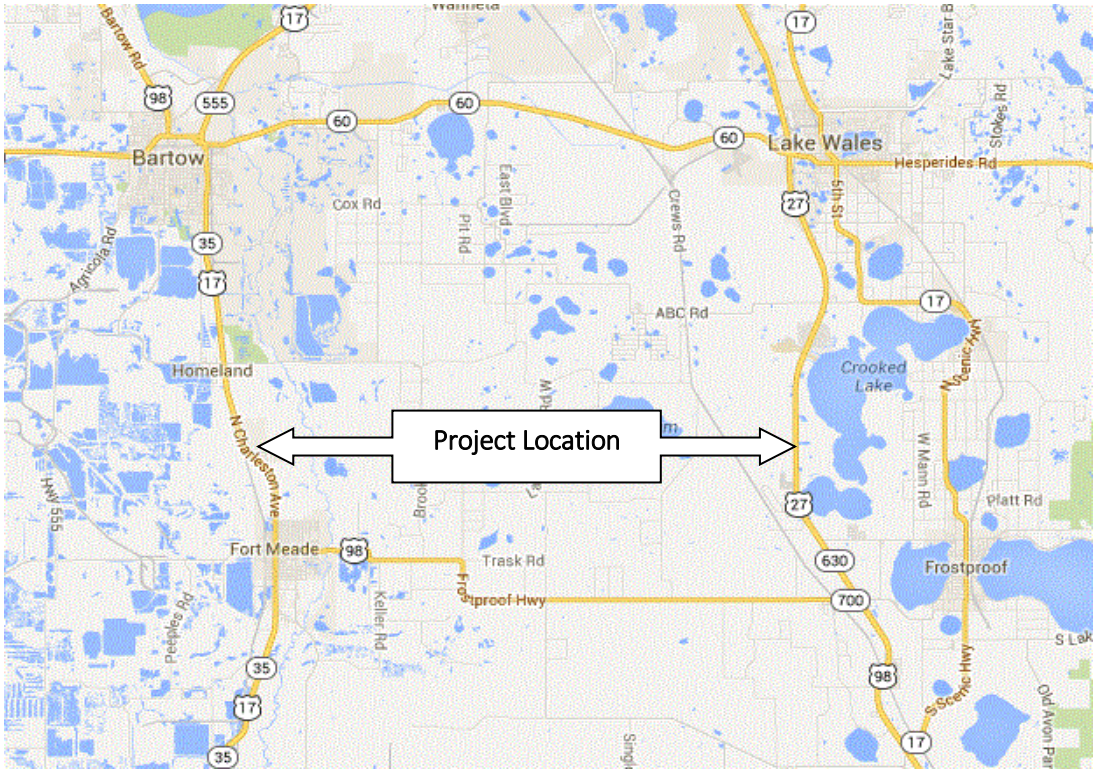

FIGURE 1. Project Location

Each site has 5 test sections (3 fog seal sections and 2 control sections with no treatment), each section approximately 0.3 miles (1,500 ft) in length (Figures 2 and 3). Table 2 shows the exact locations for each section.

TABLE 1. Test Site Information

US	SR	Roadway ID	Lane	AADT	% Trucks	Speed* (mph)	Age (years)	Crack Rating**	Rut Rating**
27	25	16170000	2	16,100	21	65	4	10	10
17	35	16030000	2	14,700	20	60	4	10	10

* Post speed, ** PCS Data collected on August 15, 2012

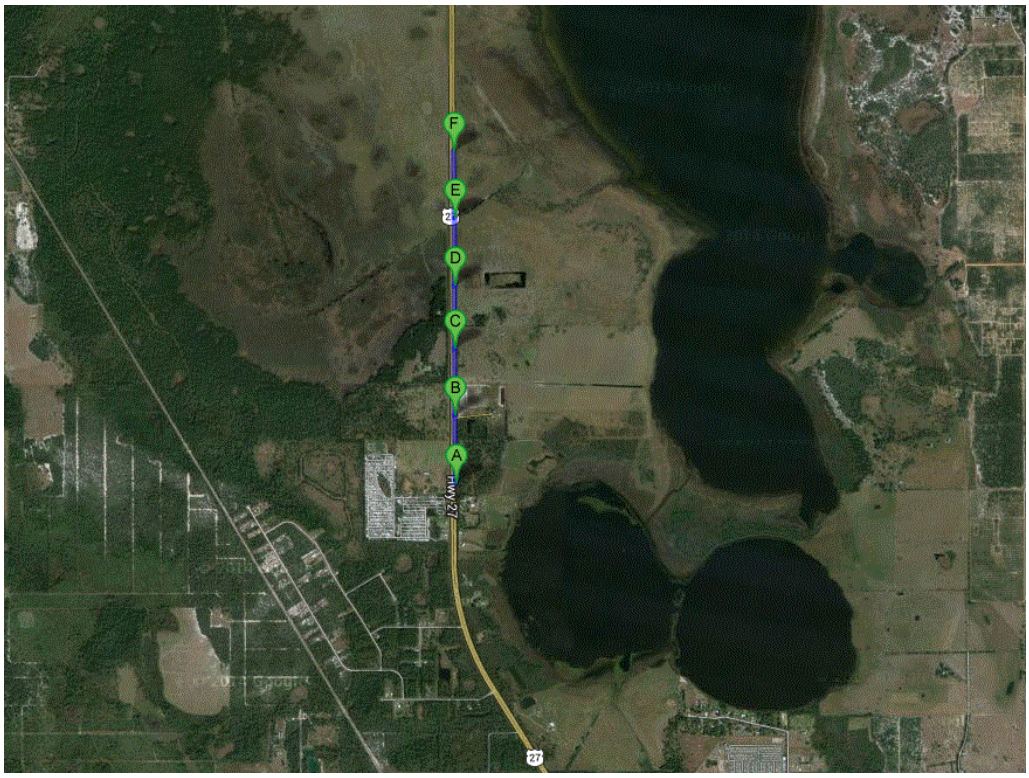

FIGURE 2. Section Map for US 27

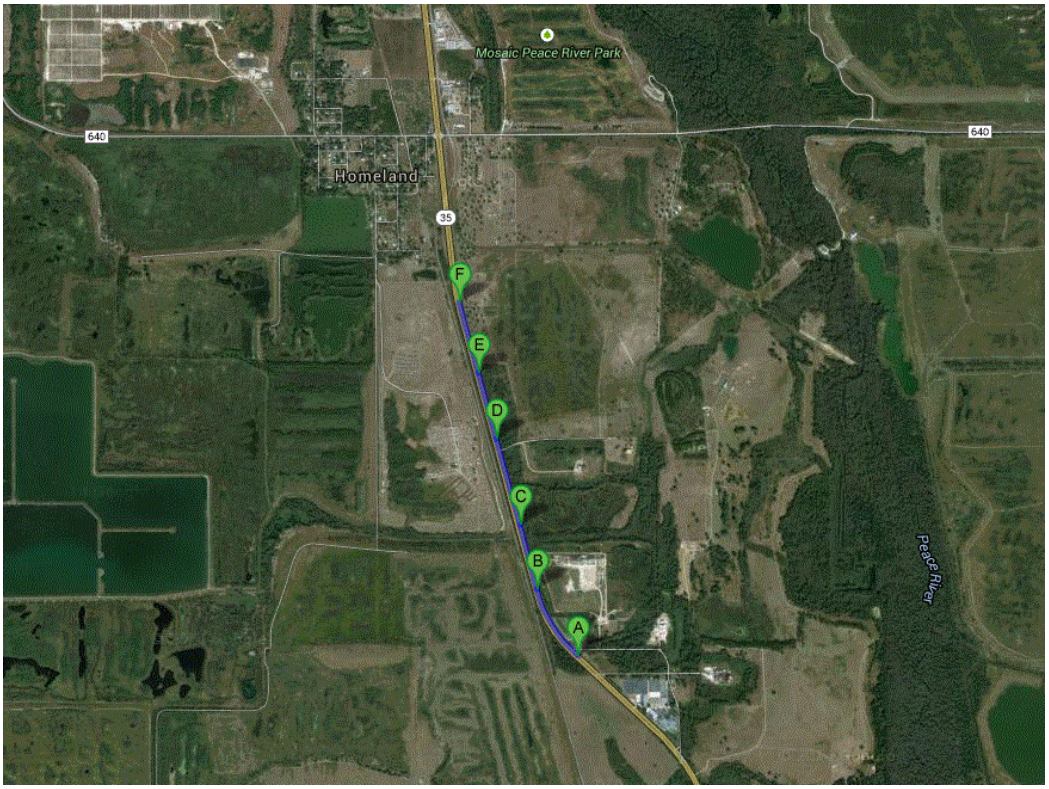

FIGURE 3. Section Map for US 17

TABLE 2. Test Site Location

Test Site	Test Section	Product	Mile Post	
			Begin	End
US-27	TS 1	E-Fog	10.309	10.609
	TS 2	Control	10.609	10.904
	TS 3	AsPen AC	10.904	10.195
	TS 4	Control	10.195	11.495
	TS 5	Reclamite	11.495	11.795
US-17	TS 1	Control	9.959	10.250
	TS 2	E-Fog	10.250	10.597
	TS 3	AsPen AC	10.597	10.890
	TS 4	Reclamite	10.926	11.247
	TS 5	Control	11.283	11.582

TABLE 3. Application Information

Product		E-Fog	AsPen AC	Reclamite
Application Date		4/22/2013	4/23/2013	4/24/2013
Distributor		Palmetto Paving	DuraSeal	Pavement Technologies
Spray Rate (gal/sy^2)	US-27	0.10	0.13	0.07
	US-17	0.10	0.07	0.04
Time to Open to Traffic After Application (min)	US-27	60	120	95
	US-17	65	35	100

Application

The application dates and spray rates are listed in Table 3. In general, the pavement texture appeared to be slightly more closed up on US-17 than on US-27. Because of this, Ergon representatives mentioned they could apply a slightly higher rate of E-Fog for US-27 than US 17

after they applied the same rate for both US 17 and 27. For Reclamite, the product representatives decided to apply a lower rate for US-17. For AsPen, the product representatives initially applied too much fog seal on US-27 since they had minimal experience with OGFC. After discussions with AsPen product representatives about US-27, AsPen product representatives decided to apply a much lower rate on US-17.

Each product was applied with a different distributor. The distributor used to apply the AsPen material had difficulty spraying the material within the lane lines due to the spray nozzles being physically located higher than the other distributor trucks' nozzles. After the US-27 project, AsPen product representatives lowered the nozzle height and used a plate to prevent the end nozzle from spraying over the lane line. The E-Fog material was applied without any problems. The Reclamite product did not have any problems due to the nature of the product, which had a light pink color and didn't mask the lane lines even when spraying on them. Figures 4-6 show the application of each product.

FIGURE 4. Application for AsPen

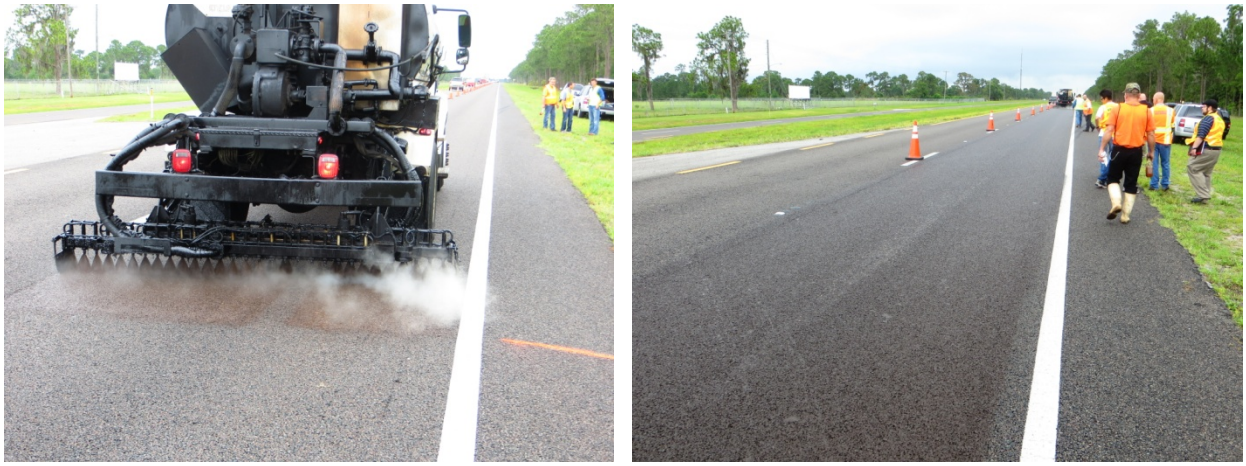

FIGURE 5. Application for E-Fog

FIGURE 6. Application for Reclamite

For the AsPen product, due to the higher application rate on US-27, the curing time was longer than for the other two products, therefore taking longer to open to traffic. For the Reclamite product, a water truck followed the distributor truck and sprayed a small amount of water to help the Reclamite penetrate into the pavement easier. This caused the pavement surface to remain relatively slick for approximately two hours until the residue disappeared.

Pavement Condition Survey Results

After application, the following field evaluations were performed:

- Pavement Condition Survey (PCS): cracking, rutting, and ride ratings
- Friction: ribbed and smooth tires at 40 mph
- Field permeability test: two locations for each section
- Recovered viscosity test: cores taken at two locations for each section

The PCS will be conducted annually to collect cracking, rutting, and ride performance.

Based on the PCS survey completed six months after application, there were no distresses in any of the sections. The results from the friction tests are summarized in Tables 4 and 5, and Figures 7 and 8.

Although having slightly lower pavement friction immediately after application, the Reclamite sections have shown good friction numbers (FN) for all five tests; after one day, two weeks, one month, three months, and six months. The E-Fog FNs dropped slightly at the first evaluation and quickly recovered to be slightly lower than the control sections after a month. After three months,

the FN on the E-Fog section was the same as the control section. The AsPen sections had the largest FN drop initially and recovered somewhat. After three months, the FN is still much lower than the control section on US-27, but similar to the FN for the control section on US-17. In general, for all products as a whole, the FN decreased immediately after application and recovered through the first two weeks to three months, depending on the application rate.

TABLE 4. Friction Test Results for US 17

	Product	FN, Ribbed Tire				
		4/25/2013	5/7/2013	5/21/2013	8/13/2013	10/14/2013
TS 1	Control	35	37	35	36	33
TS 2	E-Fog	28	34	34	36	33
TS 3	Aspen	25	29	29	35	32
TS 4	Reclamite	34	37	36	38	33
TS 5	Control	34	37	37	38	34

TABLE 5. Friction Test Results for US 27

	Product	FN, Ribbed Tire				
		4/24/2013	5/7/2013	5/21/2013	8/13/2013	10/14/2013
TS 1	E-Fog	33	38	38	40	35
TS 2	Control	39	41	41	40	36
TS 3	Aspen	26	30	32	36	32
TS 4	Control	40	41	41	41	37
TS 5	Reclamite	39	41	40	40	37

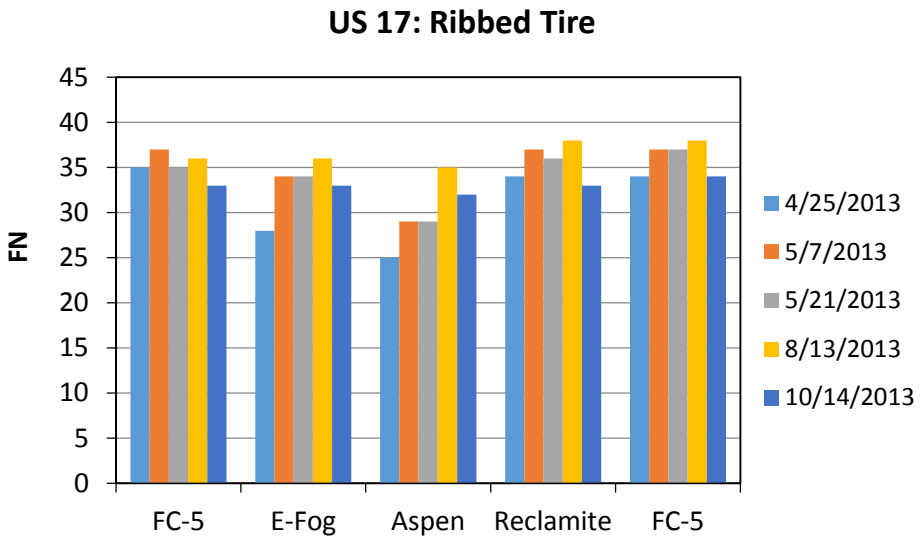

FIGURE 7. Friction Test Results (Ribbed Tire) for US 17

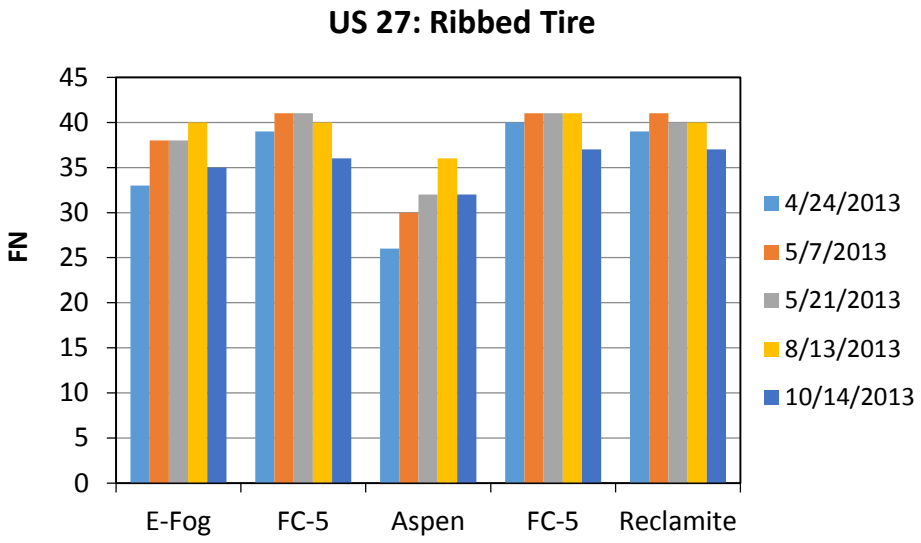

FIGURE 8. Friction Test Results (Ribbed Tire) for US 27

In an effort to determine how much rejuvenation had occurred in the FC-5 mixture, roadway cores were obtained from the sections and the binder was extracted in accordance with FM 5-524, recovered in accordance with FM 3-D5404, and then tested. Four cores were taken from the first 500 ft. and the last 500 ft. of each section. Figures 9 and 10 show the recovered viscosity results from US-17 and 27. The viscosity values from the cores taken on May 7 were from the absolute viscosity test (AASHTO T 202). The viscosity values from the cores taken on November 13 were from the Dynamic Shear Rheometer (DSR) test (AASHTO T 315). The reason why the viscosity was measured by the DSR after the first evaluation done by the absolute viscosity test, is that the PG grade was measured by using the DSR after cores taken on November 13 to determine the binder rejuvenation instead of the absolute viscosity. The control section represents an average of two sections for each site. All of the test sections with the fog seal application showed lower viscosities than the control section.

Tables 6 and 7 show the rate of viscosity reduction for the test sections with the fog seal application compared to the control section. Since the AsPen showed much lower viscosity for US-17 and higher for US-27 from the cores taken November 13, it is difficult to estimate how much softening effect is expected. However, the Reclamite and the E-Fog seem to be more consistent than AsPen in terms of the viscosity reduction. Based upon monitoring for six months, the Reclamite and the E-Fog reduced the viscosity approximately 40 – 50% as compared to the control section.

The continuous Performance Grade (PG) was determined on the recovered binders from the cores taken on November 13. These results are shown in Figure 11. All of the fog seal sections had high temperature PG grades that were 5 - 7°C lower than the control section.

Since the asphalt rubber binder for US-17 cannot be fully extracted through the extraction process, the viscosities and high temperature PGs from US-27 resulted in much higher values than the ones from US-17.

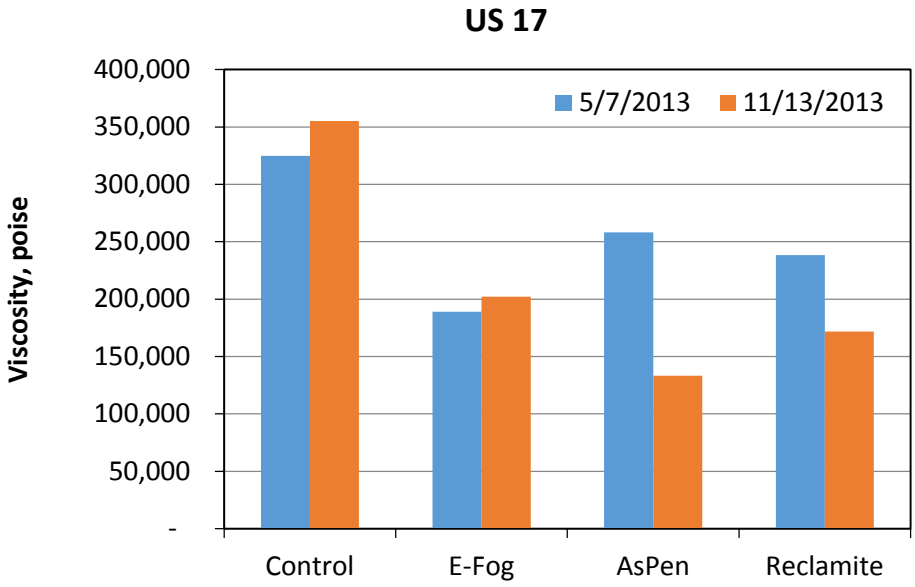

FIGURE 9. Viscosity Test Results for US 17

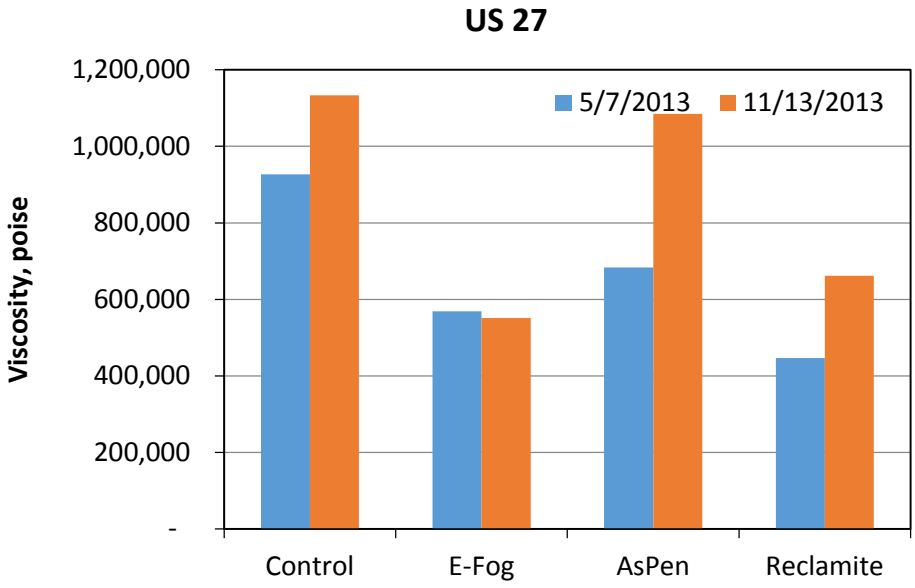

FIGURE 10. Viscosity Test Results for US 27

TABLE 6. Percentage of Viscosity Reduction for US-17

US 17	5/7/2013	11/13/2013
E-Fog	42 %	43 %
AsPen	20 %	62 %
Reclamite	27 %	52 %

TABLE 7. Percentage of Viscosity Reduction for US-27

US 27	5/7/2013	11/13/2013
E-Fog	39 %	51 %
AsPen	26 %	4 %
Reclamite	52 %	42 %

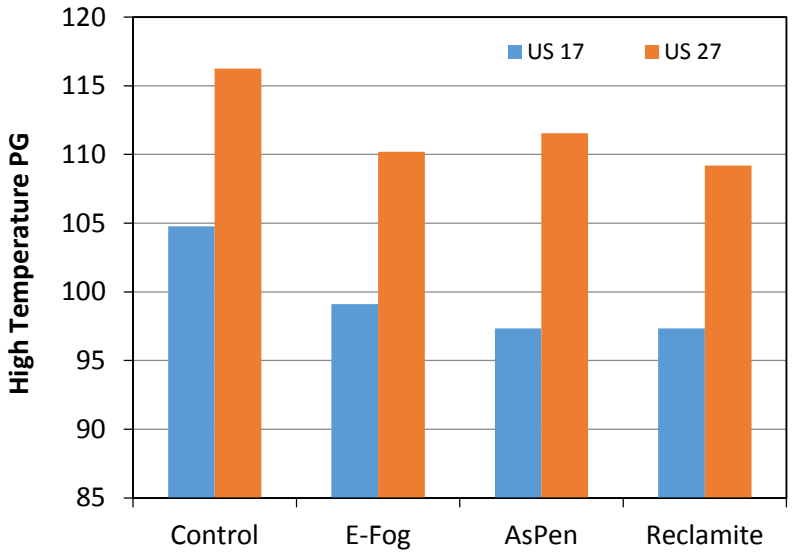

FIGURE 11. Continuous PG Grade Test Results

The field permeability tests were also performed at locations near where cores were taken. For each location, three tests were performed and averaged. Figures 12 and 13 show the permeability test results from US-17 and 27, respectively. In general, US-17 has lower permeability than US-27, possibly due to the tighter aggregate structure. The E-Fog section showed the lowest permeability among the three products for US-17, since they used the same application rate as was used on US-27, while the other producers decided to reduce the application rate for US-17 due to the tighter aggregate structure than US-27. The AsPen product had the higher application rate than the others

on US-27 and it also had the lowest permeability. The Reclamite had minimal effect on permeability.

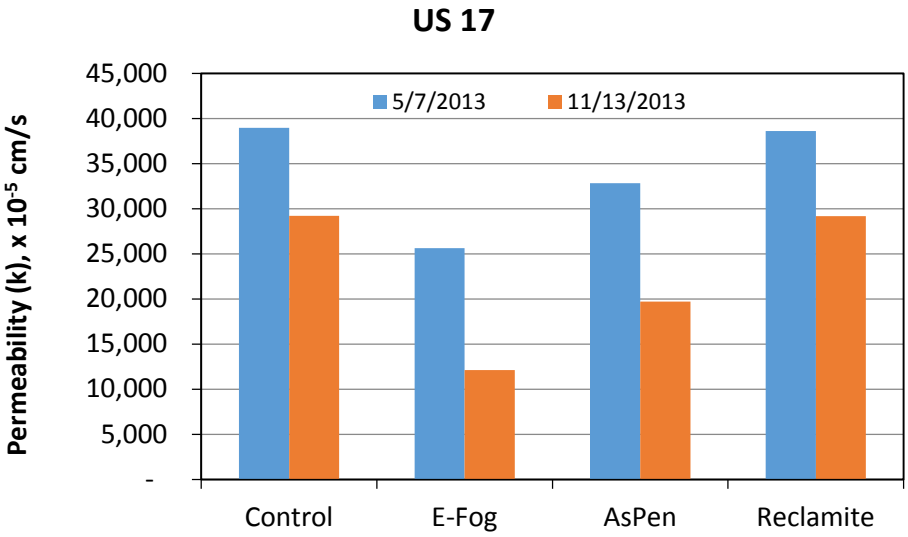

FIGURE 12. Permeability Test Results for US 17

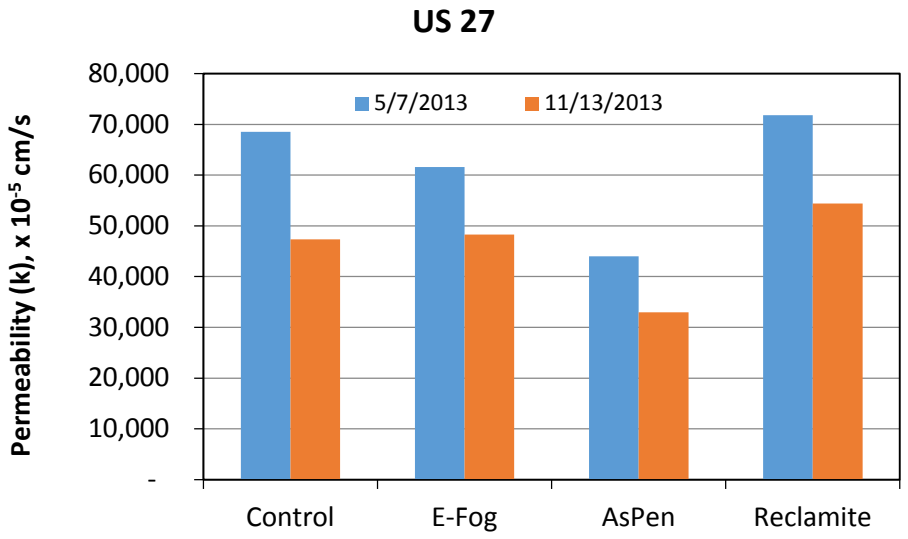

FIGURE 13. Permeability Test Results for US 27

Conclusions

Based on the field evaluation of the three fog seal products placed on US-17 and US-27, the following conclusions can be made:

- Pavement friction values dropped on all of the products immediately after application, but recovered after two weeks to three months. The recovery time varied by the product and application rate.
- The products with a rejuvenating agent (Reclamite and E-Fog) reduced the absolute viscosity by approximately 40 to 50% as compared to the control sections. Although the product without a rejuvenating agent also showed a viscosity reduction, the values are more varied than those from the other products. It is difficult to determine whether the softening is from rejuvenation or simply from dilution due to the addition of new materials.
- With the exception of the Reclamite, the fog seal applications all reduced the permeability. The reductions appear to be dependent upon the application rate.

The test sections will continue to be monitored annually.

Acknowledgements

The work represented herein was the result of a team effort. The authors would like to acknowledge personnel from the FDOT State Materials Office and District One for their assistance with the application, data collection, field and laboratory testing, and technical advice, and would also like to thank the manufacturers for their support and supplying their products.

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