pennsylvania
DEPARTMENT OF TRANSPORTATION

Research Project # 2008-035
Evaluation of RePlay Soy-Based Sealer for Asphalt Pavement

Final Report
July 2009

Prepared By:
J. Alberto Medina & Tyson R. Clouser P.E.

Evaluations and Research Section
Engineering Technology and Information Division
Bureau of Construction and Materials

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16. Abstract

BioSpan Technologies has developed a product named RePlay. The product is a soy derivative and has been marketed to drastically reduce the infiltration of air and water into pavement. The company further claims that the oils increase the flexibility of aged, brittle pavement, deterring reflective cracking. The product contains approximately 15% polymers, which the company claims increase the resistance to raveling, rutting, and cracking. This research project will evaluate RePlay's effectiveness at reducing permeability without unacceptably reducing durability or skid resistance.

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DISCLAIMER

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METRIC CONVERSION FACTORS		
Convert From	**To**	**Multiply By**
Length		
Foot	Meter (M)	0.3048
Inch	Millimeter (mm)	25.4
Yard	Meter (M)	0.9144
Mile (Statute)	Kilometer(KM)	1.609
Area		
Square Foot	Square Meter (M^2)	0.0929
Square Inch	Square Centimeter (CM^2)	6.451
Square Yard	Square Meter(M^2)	0.8361
Volume		
Cubic Foot	Cubic Meter (M^3)	0.02832
Gallon (U.S. Liquid)	Cubic Meter (M^3)	0.003785
Gallon (CAN. Liquid)	Cubic Meter (M^3)	0.004646
Ounce (U.S. Liquid)	Cubic Centimeter (CM^3)	29.57
Mass		
Ounce-Mass (AVDP)	Gram(G)	28.35
Pound-Mass (ADVP)	Kilogram (KG)	0.4536
Ton (Metric)	Kilogram (KG)	1,000
Ton (Short, 2,000 LBM)	Kilogram (KG)	907.2
Density		
Pound-Mass/Cubic Foot	Kilogram/Cubic Meter (KG/M^3)	16.02
Mass/Cubic Foot	Kilogram/Cubic Meter (KG/M^3)	0.5933
Pound-Mass/Gallon (U.S.)	Kilogram/Cubic Meter (KG/M^3)	119.8
Pound-Mass/Gallon (CAN)	Kilogram/Cubic Meter (KG/M^3)	99.78
Temperature		
Degree Celsius (C)	Kelvin (K)	$T_K = (T_C + 273.15)$
Degree Fahrenheit (F)	Kelvin (K)	$T_K = (T_F + 459.67)/1.8$
Degree Fahrenheit (F)	Degree Celsius (C)	$T_C = (T_F – 32)/1.8$
Illumination		
Foot-Candles	Lux (LX)	10.76
Foot-Lamberts	Candela/Meter sq. (CD/M^2)	3.426
Force and Pressure or Stress		
Pound-Force	Newton (N)	4.45
Pound-Force/sq. in.	Kilopascals (KPA)	6.89

EXECUTIVE SUMMARY

The Pennsylvania Department of Transportation in its efforts for maintaining and preserving Commonwealth roads, is always looking for new technologies and products to extend the life of pavements.

Pavement sealers and surface rejuvenating agents have been on the market for many years especially in western states. The purpose of these products is to rejuvenate dry or aged pavements without heating, scarifying, or mixing the existing pavement.

Problems associated with the use of some of these products include decreases in friction, flushing, poor penetration, and failure to improve the physical properties of the bitumen.

RePlay Agricultural Road Treatment is a Soybean Oil based, polymer enhanced, and liquid penetrating agent for asphalt pavements which, Biospan claims to reverse the oxidation process, introduce new polymers into the pavement, and reduce the infiltration of air and water into pavement to prevent further oxidation.

The Objective of this Research is to evaluate the benefits of using RePlay in asphalt pavements. As a result of an interest survey a site was selected by the Engineering District 11-0 and the Manufacturer's representative. The site was targeted as a good candidate to evaluate the qualities of RePlay.

To evaluate the benefits of using RePlay a series of skid tests, field observations and a permeability test were used to determine the performance of this product. All testing was conducted by Department forces.

The conclusion for this research is that no tangible benefits were found with the use of RePlay. There was no change in the permeability of the pavement in the experimental site and one year after the application there is no visible difference with the untreated pavement.

Possible safety concerns were found with the use of RePlay. Testing revealed a temporary decrease in pavement friction and a reduction of reflectivity on pavement markings.

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INTRODUCTION

Rutting and raveling have historically been two common failure modes of asphaltic concrete pavement in Pennsylvania. The previously-utilized Marshall Mix design method produced mix designs which generally contained more asphalt binder than current mixes. As a result, Marshall mixes were more resistant to raveling, but more susceptible to rutting. For this reason, asphaltic concrete pavement sealers have not historically been viewed as cost-effective in Pennsylvania.

With the advent and utilization of the Superpave pavement design method, failure due to rutting has been delayed or prevented. However, raveling and freeze/thaw related distresses have become more prevalent failure modes. The infiltration of air and water into existing asphaltic pavements induces oxidation and stripping of the asphalt binder from the aggregate. One mitigation practice for raveling is to apply a sealer or surface treatment. Sealing of existing pavement deters the infiltration of air and water into the pavement.

BioSpan Technologies of Washington, Missouri has developed a product named RePlay. The product is a soy derivative and has been marketed to drastically reduce the infiltration of air and water into pavement. The company further claims that the oils increase the flexibility of aged, brittle pavement, deterring reflective cracking. The product contains approximately 15% polymers, which the company claims increase the resistance to raveling, rutting, and cracking. The objective of this research project was to evaluate RePlay's effectiveness at reducing permeability without unacceptably reducing durability or skid resistance.

PROJECT SUMMARY

The experimental project site is located in Marshall Township, Allegheny County, Engineering District 11-0. The site location is on State Route 0019, northwest of Warrendale. See location maps, Figures 1 and 2 below.

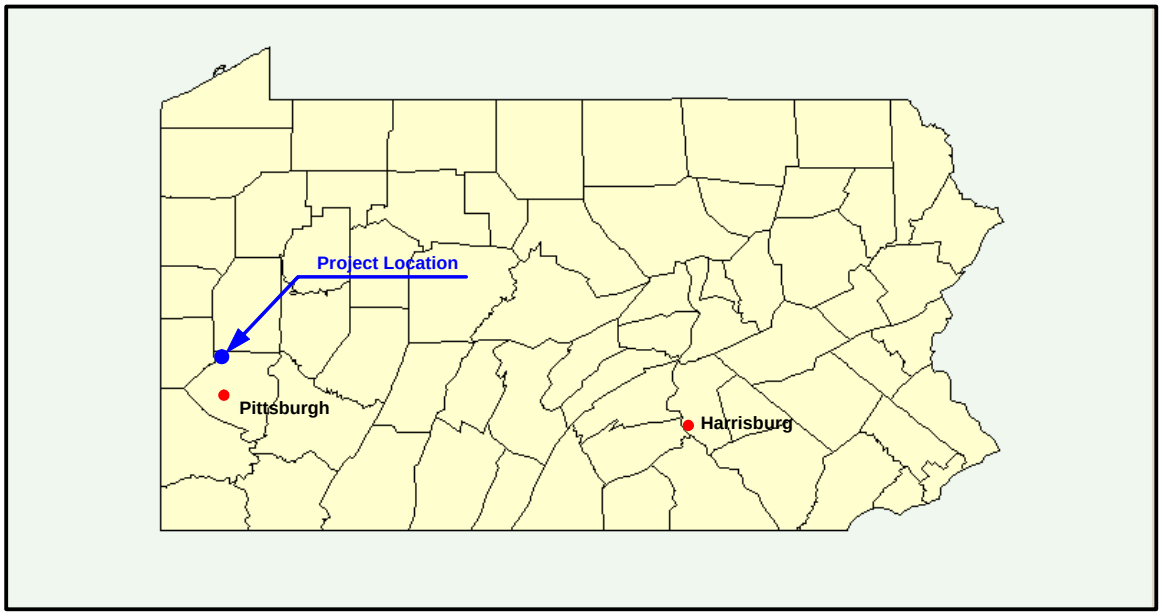

Figure 1, **General Location Map, Allegheny County, State Route 19**

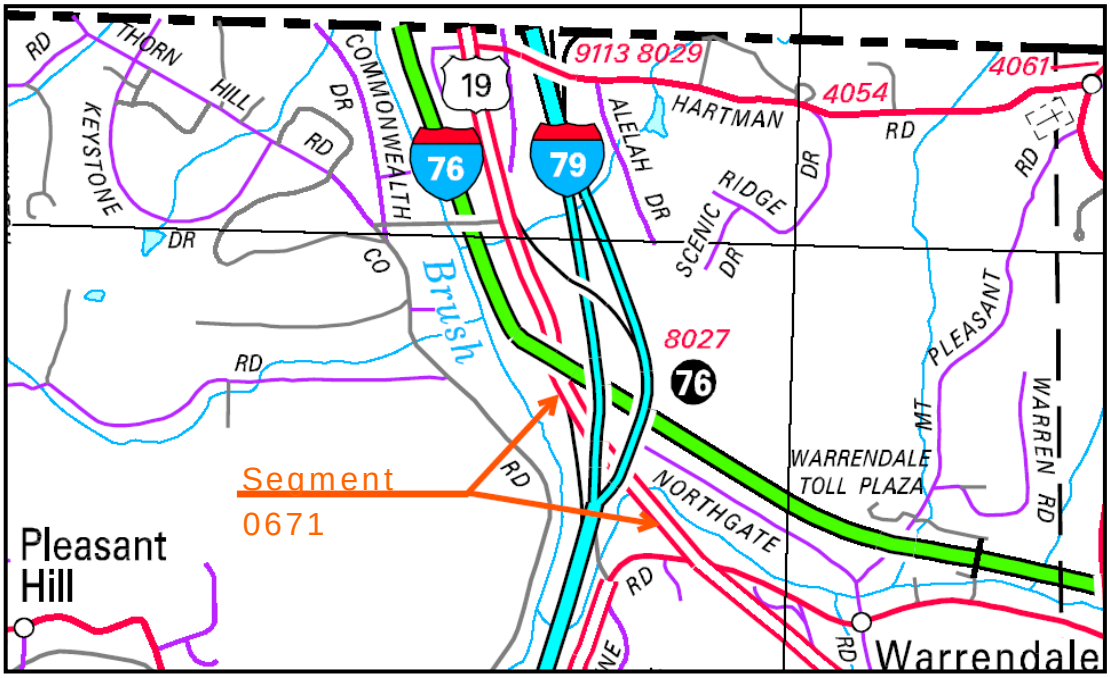

Figure 2, **Location map, Allegheny County, State Route 19, Segment 0671**

The product was applied at a rate of 0.015 gallons per square yard on the traveling lane to segment 0671, between offset 0000 and offset 1700 (Experimental Section). SR 0019 segment 0671 currently has an ADT of 16,562 vehicles and an ADTT of 1159, or 7.0% truck traffic. The control section was the passing lane at the same segment and offsets (Control Section).

In 2002, both the Experimental Section and Control Section 1 had a "mill and fill" operation where 1.5" of pavement was removed and 2.0" of pavement was placed. The wearing surface is a 12.5 mm Superpave containing a PG 76-22 binder and an aggregate skid resistance level "E", figure 3 below.

```
RMSRT451          ROADWAY MANAGEMENT INFORMATION SYSTEM  06/12/2009
                            PAVEMENT HISTORY

                        -SEGMENT- --OFFSET-- ----LANES-----  | - NOTES:  NO   -
COUNTY NO/NAME       SR   NO. LENG FROM   TO  THRU PARK TURN  | --RANGE  TO---
-- --------------  ---- ---- ---- ----  ---- ---- ---- ----  | SEGMNT:  N.A.
02 ALLEGHENY       0019 0671 3319 0000  1831  02    N    N   | OFFSET:  N.A.
S                                                             |  SURF..: 62
E                                                  DEPTH WIDTH|  TRTMT.: H
L NO TYPE CODE  -----LAYER DESCRIPTION------ YEAR   (IN)  (FT)|  SN....: 7.0
  01  BW  SPWE7 SPAV,HMA WRG,76-22,12.5MM,E  2002  +2.00  21  | VERIFICATION INFO
  02  **  MILL0 MILLING (AVERAGE DEPTH)      2002  -1.50  21  |  DATE:
  03  BW  SPWE1 SPAV,HMA WRG,12.5MM,E        1998  +1.50  21  |     /    /
  04  BB  SPB20 SPAV,HMA BNDR, 25 MM         1998  +2.00  21  |  VER IND:
  05  **  MILL0 MILLING (AVERAGE DEPTH)      1998  -1.50  21  |  VER ID.:
  06  BW  ID2E0 BITUMINOUS WEARING CRSE ID-2 1986  +1.50  21  |  --- MAXIMUM ---
  07  BB  ID2B0 ID-2 BINDER COURSE           1986  +2.00  21  |  AADT..:  16,562
  08  CW  RCC00 REINFORCED CEMENT CONC PVMT  1951  +9.00  21  |  TRK %.: 07
  09  WL  RCC00 REINFORCED CEMENT CONC PVMT  1935  +9.00  12  |  ESAL..: 000744
  10  CW  PCC0P PARABOLIC PCCP               1900  +8.00  09  |  IRI...: 084
                              TOTAL +23.00 PAVED +23.00
```

Figure 3, Pavement history and traffic data

The evaluation of BioSpan RePlay was proposed to be conducted for a period of eighteen (18) months after placement. Representatives from RePlay applied the product using their own equipment and according with the manufacturer's specifications. The two main areas of evaluation for this research project were permeability and skid resistance of the pavement.

Cores were taken from the Experimental Section and the Control Section on November 5, 2008. An hydraulic permeability test was conducted to determine the rate of allowable water infiltration. Permeability testing was conducted to the ASTM PS 129 method.

Skid testing values were obtained prior to application of the product, two weeks after placement, and again in April of 2009. All the testing was performed by Department forces, figure 4.

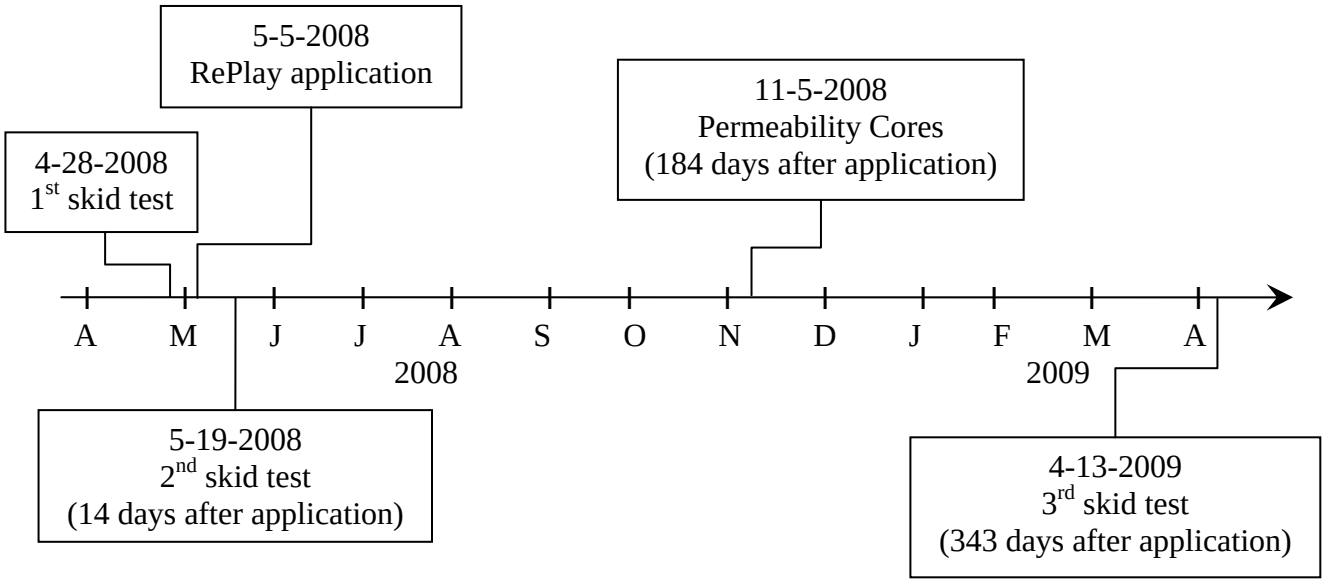

Figure 4, Testing timeline

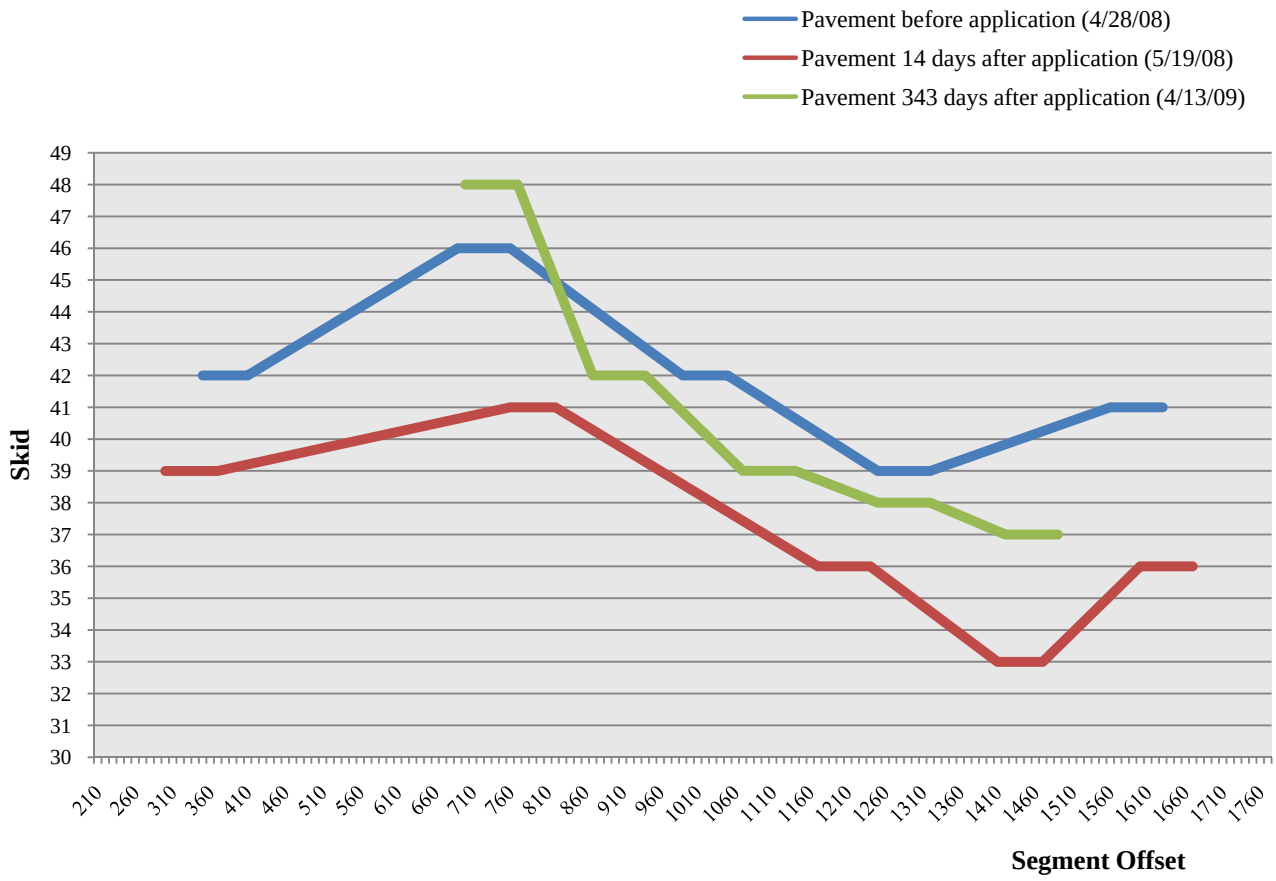

Figure 5, Skid Test Graph

In November 2008 three cores were taken in the treated lane (traveling lane) with Biospan-RePlay and three cores were taken from the adjacent untreated lane (passing lane). The cores were tested to determine a change in permeability.

Photo 1, Taking permeability cores, November 5, 2008 (184 days after application)

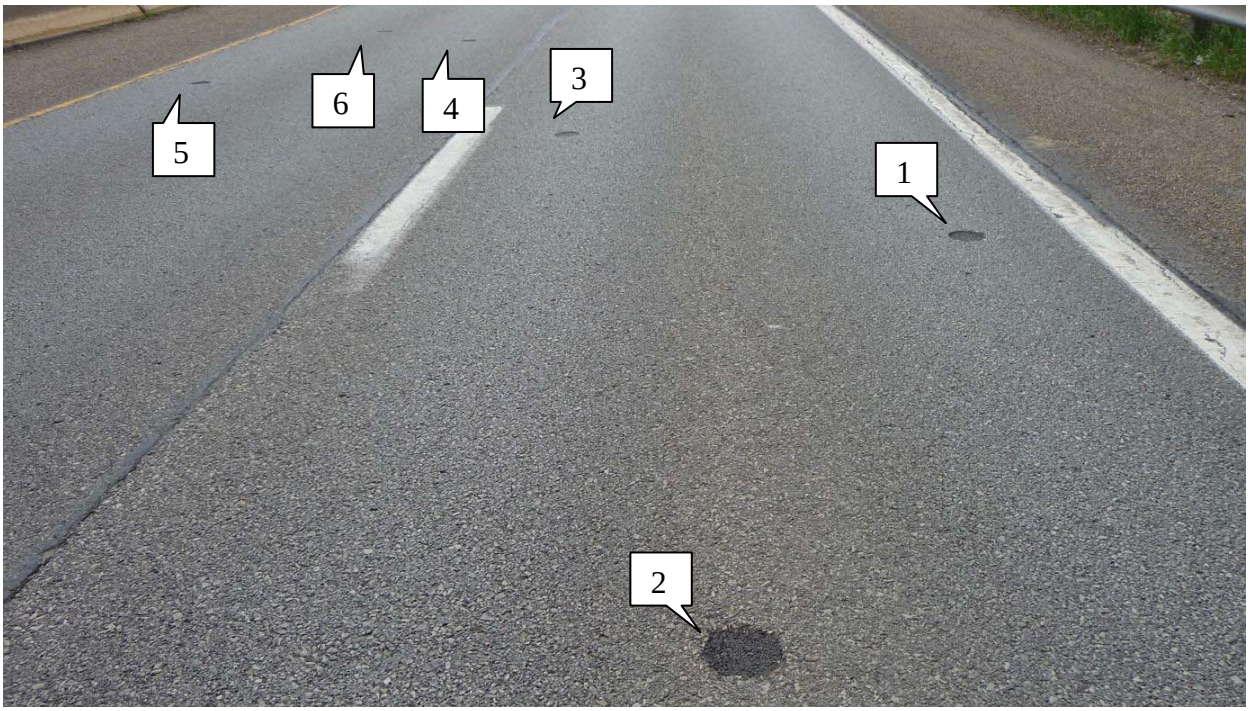

Photo 2, Core locations as April 28, 2009 (358 days after the application)
Cores 1, 2 , 3 in the treated lane (traveling lane). Cores 4, 5, 6 in the untreated lane (passing lane)

The PS 129-01 "Standard Provisional Test Method for Measurement of Permeability of Bituminous Paving Mixtures Using a Flexible Wall Permeameter" was used. This provisional test provides an indication of water permeability of water-saturated samples.

It was found that both the treated (from the Experimental Section) and untreated (from the Control Section) cores were impermeable. The specification of the Florida Department of Transportation (FM 5-565*) gives 125 x 10^{-5} cm/s (3.54 ft/day) as an unacceptable permeability for pavements. In our testing we obtained values of under 1 x 10^{-5} cm/s (3.54 ft/day) for all the cores taken at the Experimental Section and Control Section.

These cores were taken at the right wheel path, center lane and left wheel path, where the pavement didn't present cracks and had an even texture which represents the condition of the majority of the pavement of the site. The specific location of the cores taken can be found at the Table 1, and are shown in the Figure 6.

A detailed summary of the permeability tests is given in Table 2 (Experimental Section) and Table 3 (Control Section).

Table 1, Core location table

SR 0019, Allegheny County(02), Segment Length 3,319 ft			
Core Nº	Location	Treated	Segment/ Offset
1	Traveling Lane, Right Wheel path	Yes	671/2,302
2	Traveling Lane, Center	Yes	671/2,293
3	Traveling Lane, Left Wheel Path	Yes	671/2,310
4	Passing Lane, Right Wheel Path	No	671/2,326
5	Passing Lane, Left Wheel Path	No	671/2,319
6	Passing Lane, Center	No	671/2,330

*3 Florida's DOT Specification includes a factor for temperature correction (t_c) as well as the procedure used in this report to obtain the coefficient of water permeability

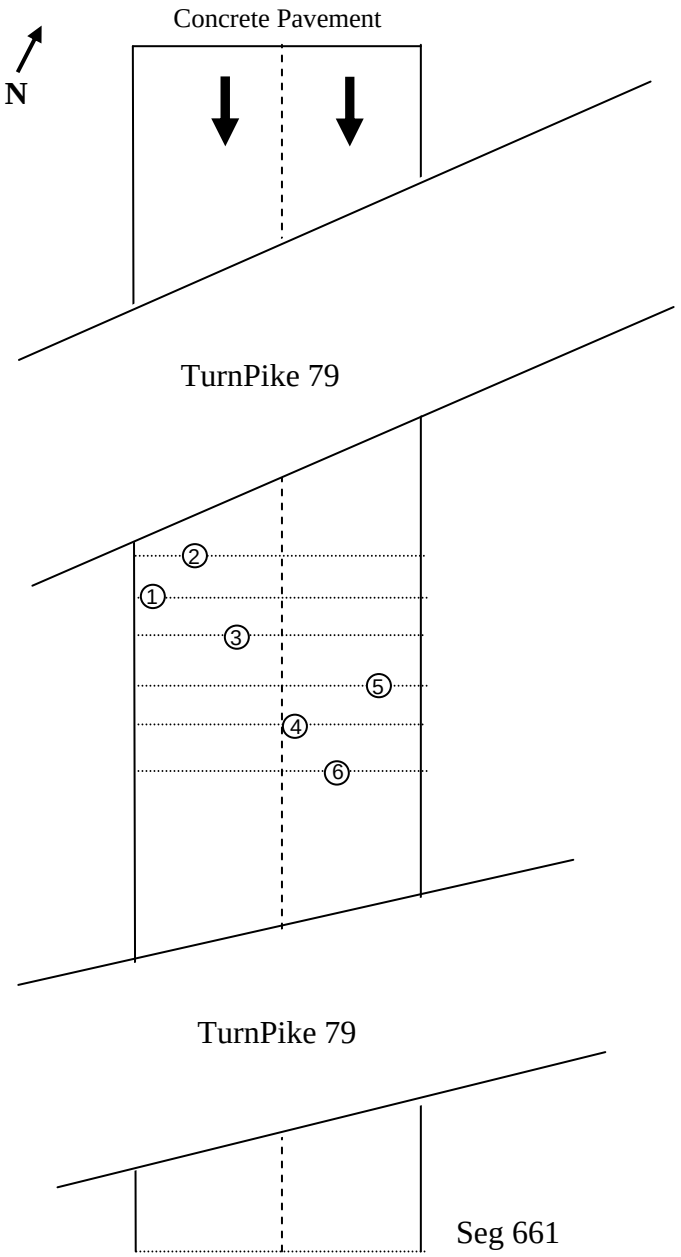

Figure 6, Core location diagram

Table 2, Permeability test summary of "Experimental Section"

Lab #	08-28135		08-28135		08-28135	
Increment	1		2		3	
	Pre Cut	**After Cut, Test Run 1**	**Pre Cut**	**After Cut, Test Run 1**	**Pre Cut**	**After Cut, Test Run 1**
Thickness 1 (mm)	49.42	39.65	48.53	34.62	50.56	40.56
Thickness 2 (mm)	51.08	41.42	48.11	35.28	50.14	43.88
Thickness 3 (mm)	48.74	41.14	49.43	34.75	50.85	42.08
l (cm)		**4.07**		**3.49**		**4.22**
Diameter 1 (mm)	144.47	144.47	144.07	144.07	144.37	144.37
Diameter 2 (mm)	144.43	144.43	144.7	144.7	144.54	144.54
Diameter 3 (mm)	143.96	143.96	143.9	143.9	144.04	144.04
Avg Diameter (cm)	144.29	144.29	144.22	144.22	144.32	144.32
A (cm2)		**16350.92**		**16336.57**		**16357.72**
t_c (sec)		**1800**		1800		**1800**
h1 (cm)		**63.1**		63.1		**63.1**
h2 (cm)		**62.4**		**55.8**		**62.7**
Water Temp C		25		25		25
a (cm2)		8		8		8
k		**0**		**0**		**0**

where:

k = coefficient of water permeability, cm/s,

a = inside cross-sectional area of inlet standpipe, cm2,
l = thickness of test specimen, cm,
A = cross-sectional area of test specimen, cm2,
t = average elapsed time of water flow between timing marks, sec,
h1 = hydraulic head on specimen at time t1, cm, and
h2 = hydraulic head on specimen at time t2, cm.

$$k = \frac{al}{At} \ln\left(\frac{h_1}{h_2}\right) t_c$$

Table 3, Permeability test summary of "Control Section"

Lab #	08-28134			08-23134		08-23134		
Increment	1			2		3		
	Pre Cut	**After Cut Test Run 1**	**After Cut Test Run 2**	**Pre Cut**	**After Cut Test Run 1**	**Pre Cut**	**After Cut Test Run 1**	**After Cut Test Run 2**
Thickness 1 (mm)	66.33	36.62	36.62	85.78	39.2	45.3	29.16	29.16
Thickness 2 (mm)	54.25	37.57	37.57	83.91	39.78	45.09	28.97	28.97
Thickness 3 (mm)	59.84	38.7	38.7	86.11	34.82	45.74	30.12	30.12
l (cm)		**3.76**	**3.76**		**3.79**		**2.94**	**2.94**
Diameter 1 (mm)	144.15	144.15	144.15	144.11	144.11	143.49	143.49	143.49
Diameter 2 (mm)	144.97	144.97	144.97	144.24	144.24	144.87	144.87	144.87
Diameter 3 (mm)	144.32	144.32	144.32	143.78	143.78	144.4	144.4	144.4
Avg Diameter (cm)	14.45	14.45	14.45	14.40	14.40	14.43	14.43	14.43
A (cm2)		**163.95**	**163.95**		**162.96**		**163.43**	**163.43**
t_c (sec)		**1800**	**1800**		**1800**		**1800**	**1800**
h1 (cm)		**63.1**	**63.1**		**63.1**		**63.1**	**63.1**
h2 (cm)		**61**	**61**		**61.1**		**56.2**	**56.7**
Water Temp C		26	26		25		26	25
a **(cm2)**		8	8		8		8	8
k		**0**	**0**		**0**		**1**	**1**

where:

k = coefficient of water permeability, cm/s,

a = inside cross-sectional area of inlet standpipe, cm2,

l = thickness of test specimen, cm,

A = cross-sectional area of test specimen, cm2,

t = average elapsed time of water flow between timing marks, sec,

h1 = hydraulic head on specimen at time t1, cm, and

h2 = hydraulic head on specimen at time t2, cm.

$$k = \frac{al}{At} \ln\left(\frac{h_1}{h_2}\right) t_c$$

CONSTRUCTION SUMMARY

The RePlay material was applied on May 5, 2008 by Asphalt Systems, Inc. of Sidney, Ohio. The sealer was dispensed from a spray bar connected to two, two hundred seventy five (275) gallon polyethylene tanks mounted to the back of a truck. The application of the product began at approximately 10:15 AM. The air temperature at the time of placement was 60 degrees Fahrenheit and the relative humidity was 45%. The material was applied at ambient temperature and at a target application rate of 0.015 gallons per square yard of pavement surface.

The RePlay had an aroma similar to that of a citrus degreaser. It also developed a glossy surface which was slippery when walked on.

Photo 3, RePlay application, May 5, 2008

Within minutes, the surface asphalt and the joint seals had softened noticeably. When the joint seal material was depressed with a finger, a portion of the seal material adhered to the finger (see Photo 4). After application, the road surface immediately changed colors from a light gray to a dark gray (see Photo 5).

Photo 4, Softening of Joint Sealant

Photo 5, Darkening of surface

After 15 minutes, only some coarse aggregate still appeared to be wet. The pavement surface under the boot felt similar to a typical wet pavement. After approximately 35 minutes, researchers drove over the treated surface and braked aggressively several times. The anti-lock feature of the brakes engaged only once, at the end of the project that was treated last. The roadway was re-opened to traffic at approximately 11:20 a.m.

The estimated cost to treat a lane mile given by the producer was $3,500 at a rate of 0.015 Gallons per Sq Yd.

FIELD PERFORMANCE

The following were found to be critical components for an effective and a safer application of this product;

Project Review
Not all the roads are good candidates for the use of a rejuvenator seal. Questions like “Has friction been tested?”, “Is the expected reduction of skid acceptable?”, “Has an assessment been made of the surface absorption?”, “Does bleeding or flushing exists?” should be answered before the use of this product and any rejuvenator.

Traffic Control
For the need of the temporary lane closure during the application, all the traffic setup has to comply with the Federal Manual on Uniform Traffic Control Devices (MUTCD).
Lane is not to be opened to traffic until the friction has been tested and judged to be at an acceptable level, this may vary depending of environmental conditions such as sun radiation, air temperature, humidity, wind, etc. as well as rate of the application.

Spraying Equipment
Nozzles have to be uniformly angled and free of clogs, spray pattern for uniformity has to be checked as well as application pressure. An excess in the application could extend the lane closure due to the loss of friction.

CONCLUSIONS

Two weeks after the application of RePlay there was still a noticeable loss in friction in the treated pavement. No benefit to improve permeability was found in the cores taken at the project site. Permeability was found not to be an issue on the untreated pavement. The coefficient of water permeability was the same in the Control Section and the Experimental Section. Similar results were duplicated in a District 9-0 application (Blair County SR 0036 Seg 240, 2004 Superpave, HMA wearing, 64-22, 12.5mm SRL H) that was followed in parallel with this research project. In the District 9-0 application it was also found a significant loss in reflectivity of pavement markings (not in the scope of this research).

After 18 months from the application of RePlay there is no visible evidence that the product was used, the adjacent pavement present the same deterioration over the winter (some aggregate loss) and appearance, see Photos 6 and 7 below. Pavement and joints present the same aspect and apparent flexibility.

The safety concerns (loss of skid and loss of reflectivity in pavement markings) associated with the use of RePlay as pavement sealers along with the inconclusive evidence of having a benefit to extend the pavement life outweigh the benefits of its use.

Photo 6, General view of the site in April 28, 2009 (358 days after the application)
Traveling lane (right in the Photo) was treated with RePlay, passing lane (left in the Photo) was untreated

Photo 7, Close-up view of the pavement in April 28, 2009 (358 days after the application)
Traveling lane (right in the Photo) was treated with RePlay, passing lane (left in the Photo) was untreated

RECOMMENDATIONS

Future research projects involving pavement rejuvenating agents should consider the following tests:

- Reflectivity testing on pavement markings,
- Penetration tests on treated and untreated cores,
- Viscosity comparison of asphalt extracted from treated and untreated cores
- Percentage of aggregate loss from Pellet Abrasion Test on treated and untreated samples

Given the safety concerns and inconclusive evidence of obtaining benefits for extending the pavement life it is not recommended to use RePlay by the Department as a pavement rejuvenator at this time.

REFERENCES

1. Brian D. Prowell, P.E., Investigation of Pavement Permeability: Old Bridge Road. Virginia Department of Transportation and the University of Virginia, October 2001.

2. Robert E. Boyer, Ph.D., P.E, Asphalt Rejuvenators “Fact, or Fable”. Asphalt Institute, February 28 to March 3, 2000.

3. Florida Department of Transportation, “Florida Method of Test for MEASUREMENT OF WATER PERMEABILITY OF COMPACTED ASPHALT PAVING MIXTURES, Designation: FM 5-565”, 2006, June 2009. <http://www.dot.state.fl.us/statematerialsoffice/administration/resources/library/publications/fstm/methods/fm5-565.pdf >