TA 564 Rev 2/01

Prepared By: Jennifer M. Vosburgh, EI
Date: March 28, 2006

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

PRODUCT EVALUATION REPORT P2006-2

INTRODUCTION:

Wintertime maintenance practices and climates experiencing multiple freeze thaw cycles are known to increase the rate of observed distresses within flexible pavements. If pavement distresses are left untreated, the life-cycle of a pavement may occur prematurely with reference to the anticipated design life. One such distress is the development of potholes.

Distresses found in pavements, such as potholes, can be corrected through the application of various preventative maintenance treatments. However, the selection of alternative treatment options substantially declines at temperatures at or below freezing. Within these temperature ranges, the only treatment option available to correct for the phenomenon of potholes is known as "winter patching."

While there are several methods for winter time patching, each with unique advantages and disadvantages, the Vermont Agency of Transportation (VTrans) typically employs the throw-and-roll method. The procedure entails applying a cold mix inside the pothole and then compacting the material by rolling over the repair area several times with truck tires. Typically, this type of repair is not very durable and may only last weeks, days, or even hours. Other conventional methods include edge-seal, semi-permanent and spray injection.

In an effort to canvass a more durable solution for wintertime patching, the Agency experimented with the use of a liquid asphalt hot mix that may be applied at low temperatures. This patching material, comprised of a granular mix and mastic asphalt, was applied to the top of a bridge deck on Interstate 89 in several locations. An evaluation of the material performance is presented herein.

BACKGROUND:

According to the University of New Hampshire Technology Transfer Center, "Potholes form when water becomes trapped beneath the pavement surface. Water can enter the road base through surface cracks or from road sides. The water freezes, often causing frost heaves. The ice melts from the top down, leaving a trapped pool of water. As vehicles run over it, the unsupported surface layer collapses. The pothole expands as traffic hits the hole."

During the summer, highway departments can employ several preventative maintenance treatments to retard the occurrence of potholes such as sealing cracks or constructing drainage improvements. Although hot mix asphalt patches are applied during warmer months and are much more durable as compared to cold mix, it must be maintained at a high enough temperature during the paving operation to achieve proper compaction. Compaction is essential to reduce water infiltration through the pavement matrix. This would be very difficult, if not impossible to accomplish at below freezing as achieving proper compaction requires sufficient time to compact the mix while it is still hot. In addition, the small quantities placed for patching have significant and logistical issues. In addition as a policy consideration, VTrans specifications require ambient temperatures at or above 40^{o}F and rising for placement of pavements.

Winter pothole patching may take place in a myriad of varying weather conditions throughout the winter and spring and may range from harsh winter storms to warm spring days. This requires a more versatile mix than standard hot mix. Comparatively, cold mix utilized for wintertime pothole patching is typically less expensive and easier to apply. In addition, the cold mix may be stockpiled throughout the winter season and may be readily accessed at any time. However, as stated previously, cold mix is much less durable and may wear very quickly.

PRODUCT:

Introduced into the United States in July of 2004, the product has been widely used throughout Russia, Finland and Germany for several years according to the manufacturer, the BAS Corporation. The hot mix asphalt is known as "BASphalt" and is recommended for patching and cross ditch paving. The material is commonly heated to 170^{o}C (340^{o}F) before application to the roadway surface at temperatures which may be below freezing. This is accomplished through the operation of specialized equipment that contains heating elements and internal mixing devices. The material may also be applied at temperatures above freezing and has a manufacturer's projected life expectancy of 25 years.

The general composition of the BASphalt hot mix includes a performance graded mastic asphalt binder, stone, sand and filler. The asphalt binder that is utilized within the mix is specified as a PG 70-28 grade. This classification indicates that the binder should perform satisfactorily at an average 7 day high temperature of 70^{o}C, or 158^{o}F, at 20 mm below the pavement surface and an average one hour low temperature of -28^{o}C, or -18.4^{o}F, at the pavement surface. In reference to the project submittal, aggregate for BASphalt is available in three forms: a sand mix, 3/8" stone and 3/4" stone. The mix type utilized for this project was a sand mix and is described further within the "Lab Test Results" Section below.

MANUFACTURER/DISTRIBUTOR:

BAS Corporation, 39 Snowbridge Road, Barre, VT 05641

INSTALLATION:

On March 10th 2004, a meeting was held with representatives from the BAS Corporation and the Vermont Agency of Transportation to discuss proposed uses for a liquid asphalt hot mix that may be applied at low temperatures and designed to be a more permanent application than cold mix. At this time, the BAS Corporation offered to apply the material to several pot holes during the winter when ambient temperatures were below freezing. Following some additional meetings with the Pavement Management Section and Dave Blackmore from District 5, a candidate site location was identified.

The evaluation began with the application of BASphalt on Monday, January 17th to localized potholes located on the deck of Bridge 61N over route 2A in Williston where there were several areas of pavement which had failed severely enough to expose the waterproofing membrane. The test site location resides on I-89 northbound within the driving lane. According to the Traffic Research Section, the estimated average annual daily traffic or AADT is 38,000. The ambient air temperature, as reported from a local weather station, was 14.9^{o}F with an average wind speed of 10 mph and overcast. The BASphalt hot mix was produced from a small plant in the town of Barre between 6:00 am to 7:45 am. The material was transported to the site and maintained at 185^{o}C. Under typical conditions, the mix would have been maintained at a temperature of 170^{o}C, however given the reported wind chills of -25^{o}F, the contractor felt that the material would adhere to the road surface more readily at the higher temperature.

Prior to application, each of the ten pothole locations was heated through the use of a propane heater in order to remove any excess moisture and any loose pieces of membrane as shown in figure 1 below. This slightly differs from a typical BASphalt installation such that, under normal conditions, the delaminated pavement area would have been prepared by grinding the failed pavement into a square patch to a typical depth of 2”. The BASphalt hot mix was then applied to the delaminated areas from a chute at the back of the transport vehicle. The material was then hand leveled with rakes.

Figure 1: Surface Preparation

According to the producer, the application temperature of the mix heats up the underlying pavement resulting in a bond between the two materials. The product did not require any compaction which can be attributed to the mastic asphalt. Additionally, it contains approximately 10% asphalt as compared to specified amount of 5% +/- 1% for standard hot mixes. During installation, the aggregate appeared to descend down to the bottom of the pothole while the liquid asphalt appeared to remain at the top. According to the manufacturer, this is a normal observation and explained that the asphalt layer would wear off over time, eroding down to the aggregate resulting in a textured surface. The material cured in approximately 15-20 minutes as a function of the ambient air temperature. Figure 2 provided below displays the typical application of the product:

Figure 2: Application

FIELD OBSERVATIONS:

Site visits were conducted on February 3rd, March 15th, July 18th and December 28th of 2005. During the site visits, each pothole was examined for cracking, rutting, delamination, aggregate striping and bleeding. During the first site visit on February 3rd, a survey was conducted to locate all of the pothole patch locations as referenced from the bridge curb. A series of measurements were collected at the interface between the pavement surface and pothole patch to assess the height of the material protruding above the grade of the surrounding material. The difference was determined to vary between a maximum of 5/8” and a minimum of ¼”, with an average height of a 3/8”. By March, aggregate stripping was identified on the leading edge of most patches. It was also noted that pot holes, as great as 2” in depth, had begun to form around two of the patched areas. However, the patched appeared unaffected.

During the July inspection, some bleeding of the mastic asphalt was observed. A pen could easily displace the surface of the patch and the soles of shoes became imprinted on the patches as well. Figure 3, provided below, contains an image of this phenomenon. However, each of the patches continued to retain their shape. In December, there was not much new to report in regards to material performance with the exception of some concerns raised by District personnel relating to winter maintenance of these patches. It was mentioned that the edge of the plow must be lifted when removing snow due to the raised elevations of the patches. There was also some concern regarding lower skid resistance.

Figure 3: Displacing the Pot Hole Patch Material

LAB TEST RESULTS:

A sample of the BASphalt material was collected on January 19th, 2005 during installation directly from the back of the chute into a sample box. The material was transported to the Vermont Agency of Transportation’s Central Laboratory where both the aggregate and binder were evaluated in accordance with standard bituminous concrete test methods. These include a gradation and volumetric assessment, maximum and bulk specific gravity testing, and rotational viscometer analysis. All test results are included in Appendix A.

With regards to the general properties of the BASphalt sample, the air void content was found to be 8.7% which is much higher than the specified 3.0 to 5.0% for standard hot mixes. This result indicates that the mix may be more transmissive to water than a standard mix and would be more susceptible to freeze/thaw cycles resulting in increased failures. The rotational viscometer test, which involves applying a known torque and a constant strain to measured amount of binder, revealed that the mastic asphalt utilized with the mix requires a higher temperature for proper compaction, as the measured resistance was determined to be 11.838 MPa. This is greater than the accepted maximum resistance of 3 MPa in accordance with acceptance testing. This may also indicate that the binder is stiff and would be less prone to rutting at higher temperatures than a standard PG 70-28.

Additional testing suggested that the limits of the performance graded binder were incorrect. While the upper limit of the specification was found to be at least 70^{o}C, the lower limit was approximated to be -22^{o}C or -7.6^{o}F which varies from specification that was provided from the contractor, -28^{o}C. Ambient air temperatures during the wintertime in Vermont may fall below this temperature specification which means that the probability of failure within the material is increased. However, according to the Performance Graded Binder Suppliers, heating of a PG binder above 180^{o}C can alter the material characteristics. As stated within the "Observations" Section, the material was maintained at 185^{o}C during transport and while onsite which may have altered the temperatures specifications of the binder. Finally, a gradation was performed on the material and was found to be similar to a standard Type IV (1/2") mix. Please see Table 1 for gradation results as provided below:

Table 1: Gradation Analysis		
Sieve Designation	**Percentage by Mass (Weight) Passing Square Mesh Sieves**	
All measurements in mm unless noted otherwise	**Type IV**	**BASphalt**
12.5	100	100
9.5	95 to 100	98
4.75	48 to 78	53
2.36	28 to 56	32
1.18	14 to 41	23
600 um	7 to 31	18
300 um	3 to 22	14
75 um	2 to 6	7
Total Aggregate:	92 to 95	91.9
Bitumen (% of total Mix):	5 to 8	8.1

SUMMARY:

A low temperature liquid asphalt hot mix provides a durable alternative to the commonly employed throw and roll method with cold mix. The evaluated material has performed well over the past year with regards to adhesion, fatigue and thermal cracking, and rutting. However, there are some concerns regarding bleeding and snow plow removal which may be attributed to improper installation. A cost analysis could not be performed as there were no costs incurred by the Agency and none was supplied by the distributor. Although the material is not recommended for use as a wearing course, the low temperature liquid asphalt hot mix is recommended for winter time patching with the caveat that proper installation and application is performed and the material is not heated above 180°C. Further evaluation is recommended so that optimized material qualities are achieved.

Reviewed by: William Ahearn
William Ahearn, P.E.
Materials and Research Engineer
Date: 5/25/06

APPENDIX A:
TEST RESULTS

VERMONT AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION
BITUMINOUS CONCRETE UNIT

Corrected Copy No.:
Date:
DISTRIBUTION

REPORT ON SAMPLE OF BITUMINOUS CONCRETE (MARSHALL)

LAB NO:	J0500001	REPORT DATE:	03/29/05
PROJECT:	BASphalt PAVEMENT RESEARCH		
PAY ITEM:		SAMPLED BY:	J. VOSBURGH
MATERIAL NAME/TYPE:	TYPE IV	DATE SAMPLED:	1/19/2005
MATERIAL SPEC NO:		SAMPLED FROM:	ROADWAY
QUANT. REPRESENTED:		DATE RECEIVED:	1/20/2005
SAMPLE TYPE:	INVESTIGATIVE	TESTED BY:	T. LAWSON
SAMPLE SOURCE:		DATE COMPLETE	03/28/05
AGGREGATE SOURCE:		IDENT. NO.:	
BINDER SOURCE:	BITUMAR	COMPARISON SAMPLE:	
COMMENTS:	SAMPLED FROM I-89 BRIDGE #61N		

Design No.: ______ Time: ______ Slip #: ______

Binder Type: PG70-28 Binder Sp.Gr. ______

AASHTO T-209 Maximum Sp.Gr.

Flask ID.	P1
Wt. of Flask & Sample (gm)	3615.3
Wt. of Flask (gm)	2408.7
Wt. of Sample (gm)	1206.6
Wt. of Flask & Water (gm)	1519.1
Wt. of Flask, Water, Sample (gm)	2229.7
Max Sp. Gr.	2.433

AASHTO T-166A Bulk Specific Gravity of Compacted Specimen

Height (mm)	2.75
Wt. in Air (gm)	1213.7
Wt. in Water (gm)	681.2
Wt. SSD (gm)	1227.4
Bulk Sp. Gr.	2.222

AASHTO T-245 Marshall

Stability (N)		
Flow (mm)		

Bulk Specific Gravity of Aggregate

Material		
		=
		=
		=
		=
		=
		=
		=
	Total =	
	BSG =	

Additional AASHTO PP-19 Volumetrics

Effective Sp. Gr.	
% Absorption	
% Effective AC	
% AC by Vol	
Unit Weight (kg/m³)	2222

AASHTO PP-19 Volumetric Analysis

Mixture Properties	Job Aim min	Job Aim max	Report	Out of Tol. low	Out of Tol. high
Mix Temperature					
% Slip Binder					
% VMA					
% VFA					
Dust Proportion	0.50	0.90			
Air Voids	3.0	5.0	8.7		3.7

AASHTO T-164 Extraction, AASHTO T-30 Gradation

Mix Wt. (gm)	Agg. Wt. (gm)	Min. in Filter (gm)	Total Agg. (gm)	% AC
1187.9	1091.7	0.0	1091.7	8.10

Sieve (mm)	Mass Ret. (gm)	Job Aim min	Job Aim max	Report % Pass	Out of Tol. low	Out of Tol. high
50mm						
37.5mm						
25mm						
19mm	0.0			100		
12.5mm	0.0			100		
9.5mm	18.2			98		
4.75mm	499.5			53		
2.36mm	223.1			32		
1.18mm	101.8			23		
600um	51.4			18		
300um	43.5			14		
75um	77.7			7.0		
Pan	76.5					
Total	1091.7					

Comments:

Inspector : Troy A. Lawson

☐ Results of tests performed are in compliance with specifications.

☐ Results of tests performed are outside specifications as noted above.

Reviewed By: T. Domey, Bituminous Concrete Engineer

Mrmarshall.xlt

03/21/05
T. LAWSON

PG 70-28

FINE - SPECIFIC GRAVITY = 1.042

PASS - CLEVELAND OPEN CUP = 341°C ≥ 230°C

FAIL - ROTATIONAL VISCOMETER = 11.838 MPa ≤ 3 MPa

PASS - ORIGINAL DSR @ 70°C = 6.418 KPa ≥ 1.000 KPa

- RAN ADDITION TEMPS. PASSED @ 76°C
  82°C
  88°C
- FAILED @ 100°C

PASS - MASS LOSS = -0.606 % ≤ -1.000 %

PASS - RTFO DSR @ 70°C = 21.34 KPa ≥ 2.2 KPa

- RAN ADDITIONAL TEMPS. PASSED @ 76°C
  82°C
  88°C
  94°C
  100°C

PASS - PAV DSR @ 25°C = 1866 KPa ≤ 5000 KPa

FAIL - CREEP STIFFNESS @ -18°C = 129 MPa ≤ 300 MPa

FAIL - M-VALUE @ -18°C = 0.261 ≥ .300 MPa

- RAN ADDITIONAL TEMPS. - FAILED @ -24°C
  -30°C
  -36°C

HIGH END IS ATLEAST 70°C
NEED MORE MATERIAL TO TEST LOW END.
ALTHOUGH IT IS NOT A -28°C MAYBE A -22°C

VERMONT AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
Full Set MP1 tests data Sheet

Sample ID BASPHALT **Date:** 3/17/05

Specific Gravity:
A) Dry: 38,060 g
B) Wet: ~~62.757~~ g 62.197
C) Bottle/ Sample 52.110 g
D) Bottle/ Sample/ Water 62.757 g
E) Sample: 14.050 g E / E+B-D = 1.042

Cleveland open cup:

P = ambient barometric pressure: 743.8 mm Hg
C = observed flash point: 341 °C

Corrected flash point = C + 0.033(760-P) = ____

Rotational Viscosity:

Test Temperature: 135.0°C C Spindle # 21 Speed 20 RPM
Three readings/ One minute intervals: 11.850 11.838 ____ Average: 11.825

Average: ____ MPas X .001 = ____

Original D.S.R.: G*/ sin(d) = ____ kPa

Rolling Thin Film Oven Residue:

Time in oven: 10:35 (+85 minutes) Time out of oven: 12:00
Oven Temperature: 163.0°C

Bottle Number	1	2
Weight of Bottle	170.792g	166.027g
Weight of Bottle and Asphalt	205.634g	200.656g
Weight of Asphalt before heating	34.842g	34.629g
Asphalt and Bottle after heating	205.415 g	200.454g
Mass loss (-) or gain (+)	-0.219 g	-0.202g
Percent loss (-) or gain (+)	-0.62855%	-0.58332%

Average Percent loss or gain: -0.605935

Rolling Thin Film Oven Residue D.S.R.: G*/ sin(d) = ____ kPa

Pressure Aging Vessel Residue:

Time in: 2:15 (+20 Hours) Time out: 11:00
Starting Pressure: 1000 PSI Ending Pressure: 800 PSI
Aging Test Temperature, nearest 0.1: 100.0°C Display Temperature: 98.4
Time in 163°C Oven: 11:00 (15 min.) Time in 170°C Oven: 11:20
Time Vacuum Applied: 11:30 (30 min.) Time Vacuum Removed: 12:00

Pressure Aging Vessel Residue D.S.R. : G*sin (d) = ____ kPa

Bending Beam Rheometer:

Test Temperature: ____ °C Display Reading: ____ °C

Sample ID:	A	B	D	E	
Time poured:					
Time trimmed:					
Time in bath:					
Time tested:					

60 s Readings
Estimated Stiffness: ____
m-value: ____