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°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°C (340°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°C, or 158°F, at 20 mm below the pavement surface and an average one hour low temperature of -28°C, or -18.4°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 10\textsuperscript{th} 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 17\textsuperscript{th} 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°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°C. Under typical conditions, the mix would have been maintained at a temperature of 170°C, however given the reported wind chills of -25°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.
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:
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](image)

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°C, the lower limit was approximated to be -22°C or -7.6°F which varies from specification that was provided from the contractor, -28°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°C can alter the material characteristics. As stated within the “Observations” Section, the material was maintained at 185°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>
<thead>
<tr>
<th>Table 1: Gradation Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage by Mass (Weight) Passing Square Mesh Sieves</td>
</tr>
<tr>
<td>Sieve Designation</td>
</tr>
<tr>
<td>All measurements in mm unless noted otherwise</td>
</tr>
<tr>
<td>12.5</td>
</tr>
<tr>
<td>9.5</td>
</tr>
<tr>
<td>4.75</td>
</tr>
<tr>
<td>2.36</td>
</tr>
<tr>
<td>1.18</td>
</tr>
<tr>
<td>600 um</td>
</tr>
<tr>
<td>300 um</td>
</tr>
<tr>
<td>75 um</td>
</tr>
<tr>
<td>Bitumen (% of total Mix):</td>
</tr>
</tbody>
</table>
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, P.E.
Materials and Research Engineer
Date: 5/25/06
APPENDIX A:
TEST RESULTS
**REPORT ON SAMPLE OF BITUMINOUS CONCRETE (MARSHALL)**

<table>
<thead>
<tr>
<th>LAB NO:</th>
<th>J0500001</th>
</tr>
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<tbody>
<tr>
<td>PROJECT:</td>
<td>BASphalt PAVEMENT RESEARCH</td>
</tr>
<tr>
<td>PAY ITEM:</td>
<td></td>
</tr>
<tr>
<td>MATERIAL NAME/TYPE:</td>
<td>TYPE IV</td>
</tr>
<tr>
<td>MATERIAL SPEC NO:</td>
<td></td>
</tr>
<tr>
<td>QUANT. REPRESENTED:</td>
<td></td>
</tr>
<tr>
<td>SAMPLE TYPE:</td>
<td>INVESTIGATIVE</td>
</tr>
<tr>
<td>SAMPLE SOURCE:</td>
<td></td>
</tr>
<tr>
<td>AGGREGATE SOURCE:</td>
<td></td>
</tr>
<tr>
<td>BINDER SOURCE:</td>
<td>BITUMAR</td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>SAMPLED FROM I-89 BRIDGE #61N</td>
</tr>
</tbody>
</table>

**AASHTO PP-19 Volumetric Analysis**

<table>
<thead>
<tr>
<th>Material</th>
<th>Job Aim</th>
<th>Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix Temperature</td>
<td>min</td>
<td>max</td>
</tr>
<tr>
<td>% Slip Binder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% VMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% VFA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust Proportion</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Air Voids</td>
<td>3.0</td>
<td>5.0</td>
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</table>

**AASHTO T-164 Extraction, AASHTO T-30 Gradation**

<table>
<thead>
<tr>
<th>Mix Wt (gm)</th>
<th>App Wt. (gm)</th>
<th>Min. in. (gm)</th>
<th>Total Agg. (gm)</th>
<th>% AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1187.9</td>
<td>1091.7</td>
<td>0.0</td>
<td>1091.7</td>
<td>8.10</td>
</tr>
</tbody>
</table>

**AASHTO T-245 Marshall**

<table>
<thead>
<tr>
<th>Stability (N)</th>
<th>Flow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Effective Sp. Gr.**

<table>
<thead>
<tr>
<th>% Absorption</th>
<th>% Effective AC</th>
<th>% AC by Vol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit Weight (kg/m³)</th>
<th>2222</th>
</tr>
</thead>
</table>

**Additional AASHTO PP-19 Volumetrics**

- Stability (N): [Signature]
- Flow (mm): [Signature]

- 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
**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

**FAIL**
- 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
  - M-VALUE @ -18°C = 0.261 ≥ 0.300 MPa
  - RAN ADDITIONAL TEMPS. - FAILED @ -24°C
    - -30°C
    - -36°C

High end is at least 70°C.

Need more material to test low end.

Although it is not a -28°C maybe a -22°C
Sample ID: ASPHALT

Date: 3/17/05

Specific Gravity:
A) Dry: 38.060 g
B) Wet: 62.197 g
C) Bottle/ Sample: 52.110 g
D) Bottle/ Sample/Water: 62.751 g
E) Sample: 4.050 g

E / E+B-D = 1.042

Cleveland open cup:

P = ambient barometric pressure: 743.8 mm Hg
C = observed flash point: 391 °C

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

Rotational Viscosity:

Test Temperature: 135.0°C
Spindle #: 21
Speed 20 RPM

Three readings/ One minute intervals: 11.860 11.820 11.820

Average: 11.825

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

Rolling Thin Film Oven Residue:

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

<table>
<thead>
<tr>
<th>Bottle Number</th>
<th>Weight of Bottle</th>
<th>Weight of Bottle and Asphalt</th>
<th>Weight of Asphalt before heating</th>
<th>Asphalt and Bottle after heating</th>
<th>Mass loss (-) or gain (+)</th>
<th>Percent loss (-) or gain (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>170.792 g</td>
<td>2.05.634 g</td>
<td>34.842 g</td>
<td>200.454 g</td>
<td>-0.219 g</td>
<td>-0.58332%</td>
</tr>
</tbody>
</table>

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)
Starting Pressure: 1000 psig
Aging Test Temperature, nearest 0.1: 100.0°C
Display Temperature: 98.4

Ending Pressure: 800 psig

Time in 163°C Oven: 11:00 (15 min.)
Time in 170°C Oven: 11:20 (30 min.)

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

Bending Beam Rheometer:

Test Temperature: °C
Sample ID: A B D E

Time poured:

Time trimmed:

Time in bath:

Time tested:

60 s Readings

Estimated Stiffness:

m-value: