Asphalt Treated Permeable Base, I-89 Georgia, Vermont

> Report 2005-1 September 2005

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State of Vermont Agency of Transportation Materials and Research Section

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| 16. Abstract<br>This report discusses the co<br>experimental asphalt treated<br>Georgia, VT, as compared wit<br>recrushed and recompacted in   | nstruction and<br>permeable base<br>h a section tha<br>place.   | 6 year performan<br>e on an intersta<br>at had its base n | nce of an<br>te highway in<br>material |  |  |  |
| Evaluative criteria included<br>observations. After six year<br>somewhat low roughness value<br>degree of roughness in the A<br>cracking evident in the expe<br>evident in any of the sectio | whness and field<br>the both sections<br>are appears to be<br>the is also more low<br>with no transverse<br>of the test | exhibited<br>e a greater<br>ongitudinal<br>se cracking    |  |  |  |  |
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#### **Introduction:**

In the early 1990's the Vermont Agency of Transportation determined that a section of Interstate 89 was in need of rehabilitation. To facilitate this process, a project was developed that was designed with full depth rehabilitation of the bituminous pavement between MM 106.90 and 111.00 in both the northbound and southbound barrels of the highway. This section had been in service for 30 years, having been constructed initially in 1968, with a 1" maintenance treatment of bituminous concrete installed in 1982. Since that time, the pavement had developed thermal related fatigue, which was evident by regularly spaced transverse cracking. The situation has also been aggravated by retention of moisture in the aggregate layer below the pavement. As a result the highway experienced distress due to frost action that negatively affected ride. The combination of poor ride and accelerated rate of deterioration were instrumental in determining a need rehabilitation on this section of highway

During the design stage of this particular rehabilitation project, designated as Georgia-Fairfax IM 089-3(26), the Vermont Agency of Transportation (VTrans) determined that this would be an opportune time to examine the performance of asphalt treated permeable base (ATPB) as a solution to the pavement distress, such as was experienced in this section of highway. Encouraged by reports of New York State DOT's success with this treatment, VTrans elected to use New York's material specifications and incorporate a 0.80-km (½ mile) test section of the material into a particularly troublesome area of the project, from MM 109.00 to 109.50 in the northbound lane (Appendix A, pages 10 -13)

#### Material Description

The ATPB layer placed on this project was designed in accordance with New York State DOT specification (see Appendix B, page 14). The planned pavement structure consisted of the following courses of materials (in ascending order):

- 6" Sand
- 24" Dense Graded Crushed Stone
- 4" Asphalt Treated Permeable Base
- 6" Bituminous Pavement (Type I S) (binder course)
- 3.5" Bituminous Pavement (Type III S over Type II S) (surface courses)

Drainage was designed into the project by placement of a 200-mm diameter perforated PVC underdrain located under the edge of each shoulder. (See Appendix A, pages 11-13). Theoretically, the stable voids of the permeable base course creates a porous layer where moisture can freely flow to the edge drains. Should this treatment prove successful it could become a useful addition to the state's pavement treatment inventory.

The rest of the northbound lane was designed using a reclaimed base method. This entailed remixing and compacting eight inches of the existing bituminous concrete and base course in both the travel and passing lanes. Two 3 inch layers of Type IS bituminous binder course were placed on top of the lifts. This was followed by a 2 inch layer of Type IIS and a 1½ inch wearing course of Type IIIS bituminous concrete. This design as well as the shoulder design is shown in the typical sections in the project plans in Appendix A (pages 11 to 13). The asphalt binder used was PG 64-28

## **Project Description**

This project, Georgia- Fairfax IM 089-3(26), was constructed during the summer of 1998. It initially consisted of a full depth removal and reclamation of the existing bituminous pavement to the subbase, in order to improve the drainage patterns and the frost and moisture related distresses inherent to this section highway. The project extended from MM 106.90 to MM 111.00 in both the northbound and southbound lanes, with the experimental ATPB section being installed across both lanes and most of the shoulder (see typical in Appendix A) between MM 109.00 to MM 109.50 in the northbound lane only.

## **Initial Pavement Condition**

The performance of the ATPB treatment has been evaluated by observing the pavement condition over time, identifying any developing crack patterns using procedures detailed in the *Distress Identification Manual for the Long-Term Pavement Performance Project* (SHRP-P-338). Prior to construction, three test sites were established in the ATPB treatment area, as well as three control sites outside of the test section for comparison. The control sites were reconstructed with a standard unbound base material. The test sites are 100 feet in length and within each test site the rate of cracking, expressed in feet of cracking per 100 feet, are measured. However, because of safety concerns, rutting data was not collected as part of this evaluation. In addition, International Roughness Index (IRI) values, expressed in inches per mile of roughness have also been collected to document pavement roughness. These data are being used to evaluate the performance of ATPB test section. Further evaluations may include rutting readings to better describe the pavement's condition.

| 1997 Pre Construction Cracking Data (feet/100feet) |          |          |          |           |          |          |  |  |  |
|--|----------|----------|----------|-----------|----------|----------|--|--|--|
|  | Control  | Control  | ATPB     | ATPB      | ATPB     | Control  |  |  |  |
| 1997 Cracking                                      | MM 108.5 | MM 108.7 | MM 109.1 | MM 109.25 | MM 109.4 | MM 109.7 |  |  |  |
| Centerline   | 0        | 0        | 0        | 0         | 0        | C        |  |  |  |
| Longitudinal                                       | 153      | 261      | 63       | 147       | 102      | 128      |  |  |  |
| Tranverse  | 82       | 94       | 78       | 92        | 142      | 85       |  |  |  |
| Miscelleanous                                      | 27       | 10       | 43       | 79        | 45       | 36       |  |  |  |
| Total  | 262      | 365      | 184      | 318       | 289      | 249      |  |  |  |

Before removal of the existing pavement, a crack survey was performed in the test sites, with the following results:

Table 1- Pre Construction Cracking

As shown in Table 1, the study area of the project had considerable cracking, with longitudinal cracking being predominate. However the most severe cracks noted were those that were transverse and occurring in roughly three meter intervals. Rutting also appeared to be severe through much of the roadway, however it was not measured. International Roughness Index (IRI) values appear in Table 2: (For comparison, locations one-half mile north and south of the experimental section were used).

| Preconstruction IRI Readings I-89 Georgia Fairfax - 1997 |            |               |                |         |  |  |  |
|--|------------|---------------|----------------|---------|--|--|--|
| From   | То         | IRI Left Lane | IRI Right Lane | Average |  |  |  |
| Contro   | I South    |               |                |         |  |  |  |
| 108.5  | 108.6      | 143           | 182            | 162     |  |  |  |
| 108.6  | 108.7      | 134           | 164            | 149     |  |  |  |
| 108.7  | 108.8      | 112           | 127            | 120     |  |  |  |
| 108.8  | 108.9      | 119           | 178            | 148     |  |  |  |
| 108.9  | 109        | 152           | 179            | 165     |  |  |  |
| Experime   | ental Area |               |                |         |  |  |  |
| 109  | 109.1      | 192           | 212            | 202     |  |  |  |
| 109.1  | 109.2      | 133           | 190            | 162     |  |  |  |
| 109.2  | 109.3      | 129           | 197            | 163     |  |  |  |
| 109.3  | 109.4      | 119           | 156            | 137     |  |  |  |
| 109.4  | 109.5      | 134           | 179            | 156     |  |  |  |
| Contro   | I North    |               |                |         |  |  |  |
| 109.5  | 109.6      | 185           | 231            | 208     |  |  |  |
| 109.6  | 109.7      | 164           | 173            | 169     |  |  |  |
| 109.7  | 109.8      | 151           | 152            | 151     |  |  |  |
| 109.8  | 109.9      | 158           | 179            | 169     |  |  |  |
| 109.9  | 110        | 166           | 182            | 174     |  |  |  |

Table 2- Preconstruction IRI Readings, I-89, Georgia-Fairfax -1997

## Cost Data

In 1998, the ATPB treatment was placed at a cost of \$30 per ton or \$6.67 per square yard. The bid price appears to be in line with standard bituminous concrete (\$33/ton) materials installed on interstate highway projects during this construction year.

## **Construction**

The project commenced with a full removal by milling of the existing pavement in the summer of 1998. As discussed earlier, the project design called for using reclaimed stabilized base (RSB), however it was discovered that the substructure contained a significant percentage of cobbles in a fine aggregate matrix in north and south bound lanes. As these were too large to be incorporated into the reclaimed stabilized base, it was decided that instead of proceeding as designed that it would be better to increase the amount of subbase material and not use reclaimed stabilized base. The final structure consisted of the addition of 6" dense graded crushed stone followed by a 6" base course of bituminous concrete Type I Superpave pavement which was placed in two 3" lifts. This was followed by a 2" Type II Superpave overlain with a 1.5" Type III Superpave wearing course.



Figure 1 Application of ATPB

Throughout the project in the place of the RSB, six inches of the 18 inches subbase material was removed and recrushed offsite. It was then replaced on the top of the original subbase material. The experimental section was constructed as planned with the exception of the <sup>3</sup>/<sub>4</sub> inch open graded friction course. The structure consisted of an additional six inches of new subbase material was placed on top of this lift the existing base and compacted (Figure 1). In the experimental area the four inch ATPB layer was placed next, after which two 3" lifts of Type IS bituminous concrete were applied. A 2" binder course of Type IIS was placed next, with the final layer being a 1.5

inch wearing course of Type IIIS bituminous concrete. The project was completed by the end of the 1998 season.

# Laboratory Testing

Bituminous Concrete samples were obtained as acceptance samples and transported back to the VTrans' Materials Laboratory for analysis. These included the ATPB sections as well as the standard bituminous concrete. All samples met contract specifications in gradation and asphalt content. PG 64-28 asphalt cement was also sampled and analyzed at the laboratory. These materials also met contract specifications.

# **Field Observations - Cracking**

The project site was visited in October 2002. The results of these observations are listed in Table 3 (the centerline paving joint is not included in the totals):

| 2002 Cracking Data (feet/100feet)    |             |             |             |              |             |             |  |
|--------------------------------------|-------------|-------------|-------------|--------------|-------------|-------------|--|
| Control Control ATPB ATPB ATPB Cont  |             |             |             |              |             |             |  |
|                                      | MM<br>108.5 | MM<br>108.7 | MM<br>109.1 | MM<br>109.25 | MM<br>109.4 | MM<br>109.7 |  |
| Centerline (Paving Joint)            | 28          | 59          | 21          | 9            | 100         | 48          |  |
| Longitudinal                         | 0           | 0           | 16          | 143          | 80          | 72          |  |
| Transverse                           | 0           | 0           | 0           | 0            | 0           | 0           |  |
| Miscellaneous                        | 0           | 0           | 0           | 0            | 3           | 0           |  |
| Total (Distress Related<br>Cracking) | 0           | 0           | 16          | 143          | 83          | 72          |  |
|                                      | <b>T</b> 11 | 2 2002 0    |             |              |             |             |  |

 Table 3 -2002 Cracking Data

Very little cracking was evident in the first two control test sites, with only centerline/paving joint cracking noted. Cracks were not significantly evident in the shoulders as well. Limited longitudinal cracking appeared in the third test site (MM109.10, the first in the experimental area); with more significant longitudinal cracking in the second and third ATPB sites as well as the final control site. This can be identified as an 88-foot long crack located 1 to 1.5 feet from the centerline paving joint in test site 109.25. Few other types of cracks were noted within the test area. All of these cracks had also been sealed as part of the statewide crack seal project, and appear to be related to the center and right edge paving joints (Se Figures 2 and 3).



Figure 2 - Typical Control Site (MM 108.70)

Figure 3- ATPB Site (MM 109.25) (note paving joints and sealed crack locations)

The project was reinspected after two additional years of service both in October 2004. These results of these inspections are listed in Table 4:

| 2004 Cracking Data(feet/100feet)     |         |          |       |        |       |         |
|--------------------------------------|---------|----------|-------|--------|-------|---------|
|                                      | Control | Control  | ATPB  | ATPB   | ATPB  | Control |
|                                      | MM      | MM       | MM    | MM     | MM    | MM      |
|                                      | 108.5   | 108.7    | 109.1 | 109.25 | 109.4 | 109.7   |
| Centerline (Paving Joint)            | 100     | 100      | 100   | 100    | 100   | 100     |
| Longitudinal                         | 100     | 108      | 122   | 153    | 143   | 104     |
| Transverse                           | 0       | 0        | 0     | 0      | 0     | 0       |
| Miscellaneous                        | 4       | 5        | 0     |        |       |         |
| Total (Distress Related<br>Cracking) | 100     | 108      | 122   | 157    | 148   | 104     |
| 5/                                   | <br>    | 4 3004 0 |       |        |       |         |

Table 4- 2004 Cracking Data

The pattern exhibited in 2002 continues to become more apparent when these results are reviewed. A large majority of this cracking noted in this inspection is incidental to the paving joints at both the centerline and the right edge of the pavement. In each of the sections cracks incidental to the right edge line and the center line paving joints were evident through the entire 100 feet sections. When these results are removed from the data table the results indicates a trend of increased cracking in the ATPB area, although the counts are low.

| 2004 Cracking Data (no joint or centerline cracking) |         |         |       |        |       |         |
|--|---------|---------|-------|--------|-------|---------|
|  | Control | Control | ATPB  | ATPB   | ATPB  | Control |
|  | MM      | MM      | MM    | MM     | MM    | MM      |
|  | 108.5   | 108.7   | 109.1 | 109.25 | 109.4 | 109.7   |
| Centerline (Paving Joint)                            | 0       | 0       | 0     | 0      | 0     | 0       |
| Longitudinal   | 0       | 8       | 22    | 53     | 43    | 4       |
| Transverse   | 0       | 0       | 0     | 0      | 0     | 0       |
| Miscellaneous  | 0       | 0       | 0     | 4      | 5     | 0       |
| Total (Distress Related<br>Cracking)                 | 0       | 8       | 22    | 57     | 48    | 4       |

Table 5 – 2004 Cracking data (minus paving joint and centerline cracking)

One of the major problems of this section of interstate highway before reconstruction was the earlier mentioned thermal related transverse cracking and frost related heaves. As of the inspection of October 2004 there is no evidence of any transverse cracking throughout the any of the test sites in this project. This includes both the experimental area and the control location immediately to north and south of the test section. Therefore at this point, it is unclear if the ATPB treatment has had any effect on reducing these types of cracks.

# **Roughness**

Roughness was measured using a Dynatest 5051 Mark II Road Surface Profiler. Roughness measurements were taken every tenth of a mile. As discussed earlier the IRI values were very comparable throughout the control and experimental areas prior to construction. The control areas averaged 162 in/mi (average of both sections), ranging from a low of 120 in/mi to a high of 208 in/mi. The experimental area (MM 109.00 to 109.50) was very comparable with an average of 164 in/mi and a range of 137 to 202 in/mi over its half mile length. However the values measured varied greatly over this 1.5 mile section. This is illustrated in the graph in Figure 4.

At the 4 year inspection, the roughness values exhibited a consistent pattern in both the control and experimental areas. This pattern is shown in Figure 4 and Table 6. The IRI values in the control sections averaged 52 in/mi with a low of 41 and a high of 60 in/mi, with the experimental area exhibiting similar values and averaging 50 in/mi with the same sample range of 41 to 60 in/mi.

Figure 4 also shows the six year (2004) data for roughness in the experimental and two control areas. While the graph indicates that, on the average, the 2004 and 2002 readings are comparable, this can be misleading. Table 6 shows that, most all of the recorded roughness values decreased from the 2002 survey. This includes all values recorded in the travel lane and 10 of 15 values recorded in the passing lane.

In order to make additional conclusions, more data both in frequency of sampling and number of datasets, will be needed. When comparing the various roughness values with each other it is difficult, due to the small sample size, to make any inferences about trends



Figure 4- IRI comparison data

# Follow Up

As of 2004, the data indicates a number of trends. Of primary concern is the crack counts results, which infer that increased cracking of the ATPB over the standard control section could be expected as the projects ages. One area of note is at MM 109.10, where pavement distress, though not yet a crack, was evident near the centerline paving joint. This is shown in both Figures 5 and 6. Areas like these were not present in the control areas north and south of the experimental location.





Figure 5 - Overview of Cracking in ATPB

Figure 6 - Distress in Test Site at MM 109.10

Assessing the roughness on this section of highway is difficult at this time. On interstate highways data is typically obtained in both the travel and passing lanes at 0.10 mile intervals. After carefully examining the IRI data collected for I-89 northbound between MM 108.5 through 110, it is clear that additional data is needed to make an assessment. IRI values are expected in increase in value over time due to typical aging and wear on the pavement surface. In addition, any cracking or rutting is also expected to increase over time which will affect IRI values.

While the half mile segment of ATPB and the control areas were somewhat comparable both prior to construction and four years after the project was completed, the data collected shows an unanticipated downward trend as the majority of the IRI values decreased between 2002 and 2004(see Table 6). The only increases occurred in the left, or passing, lane. All IRI decreased on the travel lane for both the control and experimental sections. Due to the unexpected downward trend it is recommended that additional IRI values be collected. Therefore, in an effort to better describe this trend, the frequency of the readings will be increased to gather at least 50 values each in the experimental and two control sections.

The ATPB section of I-89 will continue to be examined on a biennial basis to track the performance of this experimental material. Additional test locations in adjacent projects may also be included in the study. The focus of this investigation will be to determine if the ATPB treatment will prolong the service life to the bituminous pavement. Data collection of crack counts will be gathered in the 2005 constructions season. Increased frequency of IRI measurements will be undertaken to better describe roughness. Rutting measurements may also be taken to better describe the performance of the experimental and control treatments. Particular attention will be placed on the performance of the entire ATPB and control areas and their relationship to the test sites.

|           | IRI Values for I-89 SB Bewtween MM 108.5 through MM 110 |           |                   |         |              |                   |         |           |                   |         |
|-----------|---|-----------|-------------------|---------|--------------|-------------------|---------|-----------|-------------------|---------|
| Collectio | n Year:   | 1997 (    | Preconstruc       | tion)   |              | 2002              |         |           | 2004              |         |
| From MM   | To MM   | Left Lane | <b>Right Lane</b> | Average | Left Lane    | <b>Right Lane</b> | Average | Left Lane | <b>Right Lane</b> | Average |
|           |   |           |                   | C       | ontrol Secti | on                |         |           |                   |         |
| 108.50    | 108.60  | 143.19    | 181.84            | 162.20  | 69.06        | 79.20             | 74.13   | 52.00     | 45.00             | 48.50   |
| 108.60    | 108.70  | 133.69    | 164.10            | 148.90  | 70.33        | 67.80             | 69.06   | 54.00     | 40.50             | 47.25   |
| 108.70    | 108.80  | 112.15    | 126.72            | 119.75  | 58.92        | 55.12             | 57.02   | 53.50     | 47.50             | 50.50   |
| 108.80    | 108.90  | 119.12    | 178.04            | 148.26  | 49.42        | 56.39             | 52.91   | 53.00     | 53.00             | 53.00   |
| 108.90    | 109.00  | 152.06    | 179.31            | 165.37  | 67.16        | 72.86             | 70.01   | 67.00     | 50.00             | 58.50   |
| Ave       |   | 132.04    | 166.00            | 148.90  | 62.98        | 66.27             | 64.63   | 55.90     | 47.20             | 51.55   |
| StDev     |   |           |                   | 18.02   |              |                   | 9.14    |           |                   | 4.45    |
|           |   |           |                   | Expe    | rimental Se  | ection            |         |           |                   |         |
| 109.00    | 109.10  | 191.98    | 212.26            | 202.12  | 65.89        | 79.83             | 72.86   | 67.00     | 49.50             | 58.25   |
| 109.10    | 109.20  | 133.06    | 190.08            | 161.57  | 55.12        | 65.26             | 60.19   | 64.50     | 61.50             | 63.00   |
| 109.20    | 109.30  | 129.25    | 197.05            | 162.84  | 62.09        | 83.64             | 72.86   | 56.00     | 52.00             | 54.00   |
| 109.30    | 109.40  | 119.12    | 155.87            | 137.49  | 67.16        | 83.64             | 75.40   | 59.50     | 49.00             | 54.25   |
| 109.40    | 109.50  | 133.69    | 179.31            | 156.50  | 58.29        | 73.50             | 65.89   | 87.50     | 45.00             | 66.25   |
| Ave       |   | 141.42    | 186.91            | 164.10  | 61.71        | 77.17             | 69.44   | 57.75     | 51.40             | 59.15   |
| StDev     |   |           |                   | 23.55   |              |                   | 6.27    |           |                   | 5.40    |
|           |   |           |                   | C       | ontrol Secti | on                |         |           |                   |         |
| 109.50    | 109.60  | 185.01    | 231.26            | 207.82  | 58.29        | 74.13             | 66.21   | 62.50     | 48.00             | 55.25   |
| 109.60    | 109.70  | 164.10    | 172.97            | 168.54  | 63.99        | 91.87             | 77.93   | 50.00     | 54.00             | 52.00   |
| 109.70    | 109.80  | 150.80    | 152.06            | 151.43  | 55.12        | 70.96             | 63.04   | 52.00     | 56.50             | 54.25   |
| 109.80    | 109.90  | 157.77    | 179.31            | 168.54  | 73.50        | 89.34             | 81.42   | 71.00     | 59.50             | 65.25   |
| 109.90    | 110.00  | 166.00    | 181.84            | 174.24  | 53.86        | 62.09             | 57.97   | 59.00     | 49.00             | 54.00   |
| Ave       |   | 164.74    | 183.49            | 174.11  | 60.95        | 77.68             | 69.32   | 57.67     | 53.40             | 56.15   |
| StDev     |   |           |                   | 20.69   |              |                   | 9.98    |           |                   | 5.22    |

Table 6 - Rollup of IRI Values (All Values in in/mi)

<u>Notes:</u> **Bold** - Denote IRI values that decrease from previous collection yr.

•



APPENDIX A







47. (Continued)

The scarified surface shall then be regraded and recompacted in accordance with section <u>301.04</u>, <u>SPECIFIC CONSTRUCTION REQUIREMENTS</u>, subsection (c) <u>Subbase of Dense Graded Crushed Stone</u> and section <u>301.05</u>, <u>SURFACE TOLERANCE</u>.

- 48. <u>212.03, METHOD OF MEASUREMENT</u>, is hereby modified by deleting the word "pavement" in the second line and replacing it with the work "subbase."
- 49. <u>212.04, BASIS OF PAYMENT</u>, is hereby modified by adding the word "modified" between the words "pavement" and "will" in the first line.
- 50. <u>212.04, BASIS OF PAYMENT</u>, is hereby further modified by adding the following pay item:

Pay Item

Pay Unit

212.20 Scarifying Pavement (Modified) Square Yard

#### SECTION 303 - PLANT MIXED BASE COURSE

51. <u>303.02</u>, <u>MATERIALS</u>, (b) <u>Gradation</u>, is hereby modified by being deleted in its entirety and replaced with the following:

| <u>Screen Size</u>                           | <u>General</u>         | GRADATION<br>Design<br>Limits, % Pas            | Production<br>sing Tolerance        |
|--|------------------------|---|-------------------------------------|
| 1 1/2"<br>1"<br>1/2"<br>#4<br>#8<br>#200     |                        | 95-100<br>80-95<br>30-60<br>6-20<br>3-14<br>0-3 | _<br>±5<br>±6<br>±7<br>             |
| Asphalt Cont<br>Asphalt Ceme<br>Mixing Temp. | ent, %<br>nt,<br>Range | 1.5<br>PG<br>200                                | 5 - 3.0 ±0.4<br>64-28<br>)° - 275°F |

- 52. <u>303.17, BASIS OF PAYMENT</u>, is hereby modified by adding the words "or Plant Mixed Base Course (Modified)" after the comma in the second line of the first paragraph.
- 53. <u>303.14, BASIS OF PAYMENT</u>, is hereby further modified by adding the following:

Payment will be made under:

<u>Pay Item</u>

Pay Unit

303.25 Plant Mixed Base Course (Modified) TON

#### SECTION 310 - RECLAIMED STABILIZED BASE

SUPPLEMENTAL SPECIFICATION SECTION 310 - RECLAIMED STABILIZED BASE dated May 15, 1995 is hereby made a new section of the specifications, superseding all previous editions and their modifications.

Modification to this Supplemental follow.

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