RESEARCH AND DEVELOPMENT

"Implementing research findings"

METHODS AND MATERIALS FOR REDUCING CRACK REFLECTANCE
This study was initiated to study methods, procedures and/or materials that may reduce premature pavement failures of asphaltic concrete overlays on pcc pavement caused by excessive reflective cracking. Methods included in this study were reducing the existing pcc pavement panel size by saw cutting, full coverage fabrics, strip fabrics and Rubber-Asphalt Interlayer as a stress absorbing membrane interlayer (SAMI).

No material or method was found that would totally eliminate reflective cracking. Reducing the existing pcc pavement panel size and the use of the Rubber-Asphalt Interlayer were the two procedures that provided the best results.

**Abstract**

Reflective Cracking

Unlimited Availability

**Key Words**

Unclassified

Unclassified

32
METHODS AND MATERIALS FOR REDUCING CRACK REFLECTANCE

Investigation No. 202
Report No. 2
Final Report
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Office of Research and Development
Minnesota Department of Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration
ABSTRACT

This study was initiated to study methods, procedures and/or materials that may reduce premature pavement failures of asphaltic concrete overlays on pcc pavement caused by excessive reflective cracking. Methods included in this study were reducing the existing pcc pavement panel size by saw cutting, full coverage fabrics, strip fabrics and rubber-asphalt interlayer treatment.

No material or method was found that would totally eliminate reflective cracking. Reducing the existing pcc pavement panel size and the use of the rubber-asphalt interlayer were the two procedures that provided the best results.

DISCLAIMER

The contents of this report reflect the views of the author and do not necessarily reflect the official views or policies of the Minnesota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard specification or regulation.
FOREWORD

This investigation was undertaken to study methods, procedures and/or materials that may reduce premature pavement failures of asphaltic concrete overlays. This study was conducted at two locations and this report is report 2 of 2.

The portion of the investigation covered by this report was located in Northwestern Minnesota on U.S. T.H. 10 from the City of Hawley to the City of Detroit Lakes. The project included twelve (12) research sections used to evaluate various methods and materials that may reduce reflective cracking. These methods included reduced pcc pavement panels by saw cutting, full width fabric interlayer, strip fabric interlayer and rubber-asphalt interlayer.

The study was rendered invaluable assistance by District 4; Materials, Design and Construction personnel; the Office of Materials Engineering; Roger Olson, Research Operations Engineer; and Research Assistants, Karl Keel and Gerald Teig.
SUMMARY

Objective

The objective of this investigation was to evaluate methods, procedures and/or materials that may reduce premature failure of asphalt concrete overlays caused by excessive reflective cracking.

Scope

This investigation was divided into two parts. This first part covered asphalt concrete overlays on existing asphaltic concrete pavement and is reported by others. The second part covered asphaltic concrete overlays on existing pcc pavements and is the subject of this report.

Twelve research sections were included in the construction of this project. The planned bituminous overlay thickness (5-1/4 inches) was held constant over the length of the project.

The existing pcc pavement is an 8-inch thick reinforced (temperature mesh) structure. Panel length is 39 feet 4 inches. The existing pavement was damaged by “D” cracking and many of the joint locations had been patched with bituminous mixture.

The existing panel size was reduced by sawing skewed transverse cuts between existing joints. One area was saw cut five times per panel to create new panel lengths of approximately 6.5 feet. The remaining portions of the project had two saw cuts per panel creating a new panel length of approximately 13 feet. The saw cuts were approximately four inches deep which severed the steel reinforcing fabric.

Full width pavement fabric was placed at two different depths within the new bituminous overlay. The existing pcc pavement had been saw cut, two cuts per panel, prior to the full width fabric treatment installations. Two different widths (24 and 27 ft.) of fabric were installed at one pavement depth, thereby making the three full width fabric test sections.

Three sections were constructed with full width rubber-asphalt interlayer treatment. This Stress Absorbing Membrane Interlayer (SAMI) was constructed at three different depths in the new bituminous overlay. The rubber-asphalt interlayer was placed on top of the existing pcc pavement (bottom of overlay), at one inch above the pcc pavement, and at three inches above the pcc pavement.
Three test sections were constructed with strip fabrics placed over the transverse joints. Two different types of strip fabric made by the same manufacturer were installed. In addition, some saw cuts and longitudinal joints within the test sections were covered with strip fabric prior to bituminous overlay. One strip fabric test section was constructed adjacent to the control section and did not have the existing pcc panels saw cut.

A control section was constructed with only the 5-1/4 inch bituminous overlay (no saw cuts or other treatments). In addition, two more control sections were constructed with the existing pcc panels being sawed with either 2 or 5 saw cuts/panel. Crack count surveys were made at various times over a four-year period after construction. This data was used to evaluate the effectiveness of the different methods, procedures and materials in reducing the amount of reflective cracking in the new asphalt concrete overlay.
SUMMARY OF FINDINGS AND CONCLUSIONS

The most significant findings and conclusions to be noted in this study are:

1. None of the materials or methods were totally successful in preventing reflective cracking in the bituminous overlay.

2. The Rubber Asphalt interlayer was more effective when placed on the existing pcc pavement when compared to placing it within the bituminous overlay layers.

3. In the test sections with saw cutting of the pcc panels, reflective cracking developed over the new saw cuts rather than over old joints.

4. Of the methods and materials evaluated, the five saw cuts per panel and the Rubber Asphalt interlayer on the pcc pavement were the most successful in reducing reflective cracking.

5. At this time, all reflective cracks are generally narrow with very little spalling in all test sections including the control section.
RECOMMENDATIONS

1. A limited number of additional rubber asphalt sections should be constructed and evaluated to confirm the results of this study.

2. The length of future experimental tests should be a minimum of 1000 linear feet.

3. Full width fabric as a cost effective means of reducing transverse reflective cracking is not recommended at this time.

4. Strip fabrics should continue to be evaluated on future projects.

5. This project should be periodically surveyed to gather additional data.
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INTRODUCTION

Investigation No. 202 was initiated to study methods, procedures and/or materials that might reduce premature pavement failures caused by excessive reflective cracking in asphaltic concrete overlays. The investigation was to consider both asphalt concrete overlays on existing asphaltic concrete and on pcc pavements.

The sections were constructed on several highways. A number of test sections for this investigation were constructed in 1980 on Trunk Highway 10 in northwestern Minnesota. The project location is shown in Figure 1. The State Project No. is 0301-30 (T.H. 10=2) and was constructed by Mn/DOT District 4. The project is located on T.H. 10 from the City of Hawley to the City of Detroit Lakes. This report (No. 2) presents data from these test sections. Report No. 1 presents data from the other test sections which were located on T.H. 63 in the southeast corner of Minnesota.
T.H. 10 is a four-lane divided roadway. The existing pavement structure was constructed in 1957 and 1958. The structure consists of an 8-inch thick pcc pavement with from 3 to 9 inches of aggregate base, depending on the location. Panel length is 39 feet, 4 inches and the panels are reinforced with a 6-inch by 12-inch steel fabric (612-34). Subsoils are variable and range from granular soils to mixtures of silt, clay and sands.

The 1980 Traffic Flow Map listed the traffic volume from 5700 to 6500 AADT with 18 to 20 percent of that being truck traffic. This traffic volume could be expected to generate in excess of four million equivalent standard axle loads (ESAL) over a 20-year time period.

Rehabilitation of this highway was needed because the existing pcc pavement was severely “D” cracked and required continual maintenance.

METHODS AND MATERIALS

Methods and materials to reduce reflective cracking in the bituminous overlay being evaluated on this construction project are as follows:

1. Saw cut the pcc pavement to reduce panel size.
2. Full width fabric treatment (Petromat).
3. Strip fabric treatment (Owens-Corning Roadglas)
4. Stress Absorbing Membrane Interlayer (SAMI).

Table No. 1 lists the materials being evaluated.

<table>
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<tr>
<th>Product</th>
<th>Method</th>
<th>Manufacturer</th>
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<td>Petromat</td>
<td>Full Width Coverage</td>
<td>Phillips Fibers Corp.</td>
</tr>
<tr>
<td>Roadglas Spot Repair</td>
<td>Strip Fabric</td>
<td>Owen-Corning Fiberglas</td>
</tr>
<tr>
<td>Rubber-Asphalt (SAMI)</td>
<td>Full width Interlayer</td>
<td>Sahuaro Petroleum</td>
</tr>
</tbody>
</table>

Table No. 1 - Products Evaluated to Reduce Reflective Cracking

Reducing the existing concrete pavement panel size by sawing new skewed transverse joints is a method done to reduce the joint movement caused by changes in temperature. The theory is that with more frequent joints (reduced panel size), the joint openings, due to thermal stresses, will be smaller and therefore the stresses on the asphalt concrete overlay
at the joint will be reduced. A relationship between joint opening and slab length was published by Witczak and Yoder\textsuperscript{1} and is shown below:

\[ Z = L (12) \ [ \in \Delta t + \delta ] \]

where \( L \) = slab length and \( Z \) is joint opening. This relationship shows that joint opening \((Z)\) is proportional to panel length \((L)\).

The saw cuts were made at a skew to the existing longitudinal joint. This skew is shown in Figure 2. The saw cuts were skewed so that any reflective cracks that developed over these cuts will have a minimum impact on the rideability of the new surface. The saw cut depth was approximately four inches, which would cut the existing reinforcement steel. A research section was constructed with five (5) cuts per panel (new panel length approximately 6.5 feet) in addition to the project design section which has two (2) saw cuts per panel. This was done to determine the benefit of reduced panel size. After the saw cuts were made the asphalt overlay was placed. Figure 3 shows the typical overlay thickness of the various bituminous layers.

\[ \text{SAW CUT PANEL DETAIL} \]

\[ \pm 13.1' \]

\[ C-4 \text{ Dowelled Contraction Joints In Place} \]

\[ \text{Roadway} \]

\[ \text{INPLACE 39'-4' PANEL} \]

\[ (8'\text{ Concrete Pavement}) \]

Figure No.2 1:6 Skew Saw Cuts
The full width fabric coverage (Petromat) is advertised as protecting the subgrade from surface water intrusion, retarding reflective cracks, and improving fatigue life of the pavement. This research project will evaluate only its success in retarding reflective cracking. The fabric was placed at two depths within the asphaltic concrete overlay, as shown in Figure 4. The fabric was installed at two different widths when located on top of the first inch of bituminous overlay. Test Sections 5, 8 and 9 are located within the Petromat construction area. The specifications and materials descriptions are in the appendix of this report.

The strip fabrics are advertised to retard reflective cracks and to waterproof the repaired areas. The strip fabric was placed over the joints and cracks on the pcc pavement prior to the asphaltic concrete overlay. This study will evaluate the effectiveness of the strip fabric to reduce transverse reflective cracks in the new bituminous overlay. Two types of strip fabrics were installed on this project. The One-Step fabric consists of Roadglas (TM) fabric pre-coated with Roadbond (TM) binder. A primer was placed on the pcc pavement prior to hand placing the pre-coated fabric. The Two-Step fabric was installed by placing hot Roadbond (TM) binder on the pcc pavement, hand placing the Roadglas (TM) fabric and then placing another layer of hot Roadbond (TM) binder layer over the fabric. The fabric manufacturer's specifications are as follows:
Figure No. 4 Full Width Fabric Section

Roadglas Spot Repair System (Strip Fabric)

Roadbond (TM) binder
- Penetration, ASTM D5-73 ........................................ 40-82 0.1 max
- Softening Point, ASTM D36-76 .................................. 155 degrees (min.)
- 380° F. Viscosity, ASTM 03236 .................................. 1000-1800 cps
- Low Temperature Flexibility
- Modified Vermont DOT method .................................. 0 degrees F (max)

Roadglas (TM) Reinforcement
- Tensile Strength, ASTM D1682-64 .............................. 1,000 lb/in (min.)
- Weight ................................................................. .24 oz./S.Y.

Petromat (Full Coverage Fabric)

Fabric
- Weight ................................................................. 3.8 oz./S.Y.
- Tensile Strength, ASTM D1682-64 .............................. 90 lb./in. (min.)
- Elongation-at-break, ASTM D1682-64 ........................... 55% (min.)
- Asphalt Retention (Phillips Procedure) ....................... 0.20 gals/sq.yd.
- Color ................................................................. Black
- Width, inches ..................................................... .75 and 150
- Length/Roll, yds. .................................................. 100
The Rubber-Asphalt Interlayer Treatment placed as a stress absorbing membrane interlayer (SAMI) was included in this research because of its reported ability to reduce and retard the development of reflective cracking in bituminous overlays. Stresses that develop at the existing joints and cracks because of temperature changes and traffic loads may be dissipated at the interface of the SAMI and the bituminous mixture course. This effect has been reported by recent research\textsuperscript{2}. The SAMI was installed at three different depths in the structure: on the existing pcc pavement, on the first inch of bituminous leveling course, on three inches of bituminous leveling course. (See Figure 5).

Appendix A includes the special provisions from this construction project for Sawing Concrete Pavement, Full Coverage Fabric, and the Rubber-Asphalt Interlayer Treatment (SAMI). The strip fabric was included in this project at the request of the manufacturer as a demonstration of the product, at no cost to the State. Therefore, the strip fabric specifications used are those of the manufacturer.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{rubber-asphalt-treatment.png}
\caption{Rubber Asphalt Treatment}
\end{figure}
TEST SECTIONS

Twelve test sections are being evaluated in this part of Investigation 202. These sections are listed in Table 2.

<table>
<thead>
<tr>
<th>Test Section</th>
<th>Method</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control, 5 Saw Cuts/Panel</td>
<td>1762+57 to 1766+87</td>
</tr>
<tr>
<td>2</td>
<td>SAMI on pcc pavement</td>
<td>1819+12 to 1823+45</td>
</tr>
<tr>
<td>3</td>
<td>SAMI on 1” Bituminous</td>
<td>1869+92 to 1874+25</td>
</tr>
<tr>
<td>4</td>
<td>SAMI on 3” Bituminous</td>
<td>1922+50 to 1926+88</td>
</tr>
<tr>
<td>5</td>
<td>Petromat on 3” Bituminous</td>
<td>2000+16 to 2004+09</td>
</tr>
<tr>
<td>6</td>
<td>Control, 2 Saw Cuts/Panel</td>
<td>2081+30 to 2085+63</td>
</tr>
<tr>
<td>7</td>
<td>2-step Roadglas Strip</td>
<td>2134+15 to 2138+48</td>
</tr>
<tr>
<td>7A</td>
<td>1-step Roadglas Strip</td>
<td>2138+62 to 2143+17</td>
</tr>
<tr>
<td>7B</td>
<td>1- and 2-step Roadglas Strip</td>
<td>2228+30 to 2332+60</td>
</tr>
<tr>
<td>8</td>
<td>Petromat on 1” Bituminous</td>
<td>2187+66 to 2191+99</td>
</tr>
<tr>
<td>9</td>
<td>Petromat on 1” Bituminous</td>
<td>2239+25 to 2243+96</td>
</tr>
<tr>
<td>10</td>
<td>Control, No Saw Cuts, no Treatments</td>
<td>2320+00 to 2323+95</td>
</tr>
</tbody>
</table>

Table No. 2 Test Section Locations

Most test sections are between four and five hundred feet in length and were selected at random within a particular type of construction.

A photographic record of each test section was made showing the existing pavement surface condition prior to construction. The University of Minnesota was contracted to take aerial photographs utilizing a camera suspended from a tethered, hydrogen-filled balloon. The 11-foot diameter balloon and camera were suspended over the roadway centerline by three manned tether lines. The camera floated approximately 50 feet above the roadway surface and was activated by a radio transmitter controlled from the ground. Figure 6 shows the camera and balloon system. Figures 7 and 8 are examples of the existing pcc pavement condition after saw cutting.

The location of each joint, crack, and saw cut was determined from the aerial photographs. These locations were used to determine whether a crack in the new bituminous overlay was a reflective crack or not. This record is the basis for determining the success of the various methods and products in retarding reflective cracking. A detailed crack count survey was conducted twice during the first year following construction. Thereafter, crack count surveys were made once each year. Results are included in this report under Crack Survey.
Figure No. 6 - Balloon and Camera
CONSTRUCTION

The construction project was begun and completed during the 1980 construction season. The construction started in May and all of the bituminous overlay was placed by the 5th of August. All other construction was completed by October 15, 1980.

The major portion of the construction project was the bituminous overlay of the eastbound roadway. The project is 22 miles in length, with 24.7 miles of two-lane construction. Two small segments of the westbound roadway were overlayed with bituminous mixture and the project included some turn lane construction. Prior to the overlay, the existing pcc panels were saw cut, as specified.

Table No. 3 shows the length of each type of construction on this project.
Two minor problems were reported in the rubber-asphalt interlayer (SAMI) construction. The first involved the picking up of the interlayer by the trucks during bituminous paving operations in areas where traffic had removed some of the cover aggregate. This problem was solved by spreading a small amount of bituminous mixture on the problem areas in advance of the paving operations. The second problem occurred where the application of rubber-asphalt was too thick. The result was that the second layer of bituminous overlay (binder course) was unstable during paving operations and the two layers of bituminous mixture had to be removed. The SAMI was removed and the bituminous mixture replaced.

This problem area was 175 feet in length and was approximately one percent of the work. The problem was solved by careful application of the rate of rubber-asphalt material.

CRACK SURVEYS

The number of existing joints, saw cuts and transverse cracks in the pcc pavement in each test section were counted prior to the bituminous overlay. This data is shown in
Table No. 4. The analysis included in this report was made using the total sum of existing joints, new saw cuts and existing transverse cracks as having the potential to cause reflective cracks in the new bituminous overlay. The analysis was also made using joints only or saw cuts and cracks only. This was done to show which type was causing the reflective cracks.

<table>
<thead>
<tr>
<th>Test Section</th>
<th>Method</th>
<th>Cuts or Cracks</th>
<th>Joints</th>
<th>Joints and Cuts or Cracks</th>
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<tr>
<td>1</td>
<td>Control 5 cuts/panel</td>
<td>55</td>
<td>12</td>
<td>67</td>
</tr>
<tr>
<td>2</td>
<td>SAMI on pcc</td>
<td>25</td>
<td>12</td>
<td>37</td>
</tr>
<tr>
<td>3</td>
<td>SAMI on 1” level</td>
<td>23</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>SAMI on 3” level</td>
<td>22</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td>5</td>
<td>Petromat on 3” level</td>
<td>21</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td>6</td>
<td>Control 2 cuts/panel</td>
<td>26</td>
<td>12</td>
<td>38</td>
</tr>
<tr>
<td>7</td>
<td>Owens Corning 2 step</td>
<td>23</td>
<td>12</td>
<td>35</td>
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<td>7a</td>
<td>Owens Corning 1 step</td>
<td>28</td>
<td>12</td>
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<td>7b</td>
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<td>12</td>
<td>14</td>
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<tr>
<td>8</td>
<td>Petromat on 1” level</td>
<td>22</td>
<td>13</td>
<td>35</td>
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<td>Petromat on 1” level</td>
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<td>10</td>
<td>Control no cuts</td>
<td>4</td>
<td>11</td>
<td>15</td>
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Table No. 4 Existing Joints, Saw Cuts and Cracks

After construction, periodic crack surveys were made to record the development of the reflective cracks. The number of reflective cracks that developed over the existing transverse joints were tabulated, as were the number of reflective cracks that developed over the new saw cuts and existing transverse cracks. Figure 9 shows a typical reflective crack over a new saw cut.

These tabulations were made separately because the joints contained dowels, whereas the saw cuts and cracks are similar to undoweled contraction joints. Table No. 5 lists the percentage of both the reflective cracks over transverse joints and saw cuts.

At some of the locations of reflective cracks, a mounding in the surface was noticeable. This mounding has occurred at random locations throughout the project and does not appear to be associated with any single type of experimental construction. Cores were taken in some of these locations and it was found that the existing pcc pavement had been
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<td>cuts &amp; cracks</td>
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<td>2</td>
<td>31</td>
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<td>66</td>
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<td>75</td>
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<td>53</td>
<td>57</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

Table No. 5 Crack Survey Data
partially patched with a bituminous mixture. The mounding appears to be due to the con-
tinual lengthening (pushing) of the old pcc pavement. Maintenance restored the ride 
smoothness (grade profile) by heating the surface and scraping off the mounded bituminous 
surface. A repaired area is shown in Figure 10.

Table No. 5 also lists the combined percentage of reflective cracks over transverse 
joints, saw cuts and cracks. This data is presented graphically in Figures 11 through 22. 
Figure 23 shows the total reflective cracks versus time of all test sections.
Figures 17 through 19 (Strip Fabric) show the amount of each type of reflective cracking in Test Sections 7, 7A and 7B. Not all of the transverse joints, cracks and saw cuts were repaired with strip fabric in these sections. When only the repaired areas are considered, the strip fabric appears to be much more effective. The percentage of reflective cracks over the repaired areas is 14% for the Two-Step Roadglas in Test Section 7 and 3% for the One-Step Roadglas in Test Section 7A indicating One-Step being more effective than Two-Step. In Test Section 7B the percentage of reflection cracks over repaired transverse joints were 50% and 92% for Two-Step Roadglas and One-Step Roadglas, respectively. This section indicates that the Two-Step is more effective than the One-Step. Factors that contribute to this conflicting data are the effects of saw cutting (in Test Sections 7 and 7A; no saw cuts in 7B) and only partial repair of all potential cracks and saw cuts that may cause reflection cracking.

In addition to the crack surveys of the test sections, the district personnel made yearly crack counts on the entire length of the project. This data is shown in Table No. 6 and is presented in terms of the number of cracks per mile within the limits of each type of construction. Where the district counted partial cracks (1/4, 1/2, 3/4, etc.), the data was combined to provide the single unit of measure--full width cracks per mile.

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Number of Cracks/Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMI over 1” of bituminous overlay</td>
<td>90</td>
</tr>
<tr>
<td>SAMI over existing pcc pavement</td>
<td>91</td>
</tr>
<tr>
<td>5 saw cuts/panel</td>
<td>123</td>
</tr>
<tr>
<td>Control Section - No saw cuts</td>
<td>125</td>
</tr>
<tr>
<td>SAMI over 3” of bituminous overlay</td>
<td>126</td>
</tr>
<tr>
<td>Petromat over 3” of bituminous overlay</td>
<td>130</td>
</tr>
<tr>
<td>Control Section - 2 saw cuts/panel</td>
<td>132</td>
</tr>
<tr>
<td>Petromat over 1” of bituminous overlay</td>
<td>133</td>
</tr>
<tr>
<td>Strip fabric over existing pcc pavement</td>
<td>171</td>
</tr>
</tbody>
</table>

Table 6  District 1984 Crack Count Data

DISCUSSIONS

When comparing the district crack counts and the detail crack surveys of the test sections there is good agreement between the three types of construction that have the least amount of cracking. There is general agreement in comparing the remaining sections, with the differences being due to the method of analyzing the data.
Percent Reflected vs Time
S.P.0301-30 Test Section 1

Control, 5 Saw Cuts/Panel

Figure No. 11
Percent Reflected vs Time
S.P.0301-30 Test Section 2

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

100~------~----~----------~------------~--------~~------~

SAMI on pcc

Figure No. 12
Percent Reflected vs Time
S.P.0301-30 Test Section 3

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

SAMl on 1in. Bit.

Figure No. 13 Date
Percent Reflected vs Time
S.P.0301-30 Test Section 4

Joints
Cuts, Cracks
Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

SAMI on 3in. Bit.

Figure No. 14
Percent Reflected vs Time
S.P.0301-30 Test Section 5

Joints
---

Cuts, Cracks
---

Joints, Cracks, Cuts
---

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

Petromat on 3in. Bit.

Figure No. 15
Percent Reflected vs Time
S.P.0301-30 Test Section 6

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81  8/19/81  6/30/82  6/23/83  5/03/84

100
80
60
40
20

Control, 2 Saw Cuts/Panel

Figure No. 16
Percent Reflected vs Time
S.P.0301-30 Test Section 7

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

2-step Roadglas Strip

Figure No. 17 Date
Percent Reflected vs Time
S.P.0301-30 Test Section 7A

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

100 80 60 40 20

1-step Roadglas Strip

Figure No. 18

Date
Figure No. 19

Percent Reflected vs Time
S.P.0301-30 Test Section 7B

Joints
---

Cuts, Cracks
---

Joints, Cracks, Cuts

1 & 2-step Roadglas Strip
no Saw Cuts

Date

Percent Reflected

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

100

80

60

40

20

0

20 Jan Apr Jul Oct Jan Apr Jul Oct

81 82 83 84
Percent Reflected vs Time
S.P.0301-30 Test Section 8

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

100

80

60

40

20

Petromat on 1 in. Bit.
24 ft. wide

Figure No. 20
Percent Reflected vs Time
S.P.0301-30 Test Section 9

Joints

Cuts, Cracks

Joints, Cracks, Cuts

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

Petromat on 1 in. Bit.
27 ft. wide

Figure No. 21
Date
Figure No. 22

Percent Reflected vs Time
S.P.0301-30 Test Section 10

Joints

Cracks

Joints, Cracks

2/25/81 8/19/81 6/30/82 6/23/83 5/03/84

100~------~----~----------~------------~--------~------~

80~------~----~-----------~----------~--------~--------~

60~------~----~-------------------~------------~-------~---------~

40~------~----~-------------------~------------~-------~---------~

20~------~----~-------------------~------------~-------~---------~

Control, no Saw Cuts, no Treatments

Figure No. 22
When drawing inferences from crack survey data, care must be taken because of variables that may influence the amount and types of stresses that may develop in a given test section. These variables include variations in the soil types, soil moisture content and material properties of existing and new structural layers. Figure 24 shows the soils' boring data gathered in the test section areas. The crack surveys show that crack patterns within a given test section are not always consistent for the entire length of the test section. For example, the crack survey in Test Section 6 showed that the first half of the section had almost no reflective cracks. In the second half, almost all potential cracks and saw cuts had reflected through the new bituminous overlay. The variations in sub grade soils are shown in Figure 24, borings TS 6 and TS 6a, respectively.

For these reasons, the author feels that only those test sections that show a marked difference from the control sections in the amount of reflective cracking can be considered as being caused by the particular method or material under consideration.

Cost Comparison

Cost of the various types of construction are given in Table 7.

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Cost</th>
<th>Unit</th>
<th>Cost/Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawing Concrete Pavement 5/panel</td>
<td>$0.90</td>
<td>L.F.</td>
<td>$14,797.62</td>
</tr>
<tr>
<td>Sawing Concrete Pavement 2/panel</td>
<td>$0.90</td>
<td>L.F.</td>
<td>$5,909.40</td>
</tr>
<tr>
<td>Full Width Petromat plus AC.</td>
<td>$0.90</td>
<td>S.Y.</td>
<td>$13,657.60</td>
</tr>
<tr>
<td>Rubber Asphalt Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubber Asphalt</td>
<td>$497.00</td>
<td>Ton</td>
<td></td>
</tr>
<tr>
<td>Cover Aggregate</td>
<td>$13.00</td>
<td>Ton</td>
<td></td>
</tr>
<tr>
<td>SAMI (26' wide)</td>
<td>$1.43</td>
<td>S.Y.</td>
<td>$21,817.48</td>
</tr>
<tr>
<td>Strip Fabric</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Table 7 Cost of Treatments

The cost of the strip fabrics are not given because the cost of materials and labor was done by the manufacturer. Cost on other construction projects where the Two-Step Roadglas was installed in Minnesota varied from $1.18 sq. ft. to $1.88/sq. ft.
INV 202 TH10
TEST SECTIONS

- all soil about optimum unless otherwise stated
- all borings taken on left shoulder

Figure No. 24 - Soil Boring Data
SUMMARY OF FINDINGS AND CONCLUSIONS

The results of the crack surveys provide the following findings:

1. None of the methods or materials evaluated on this project were totally successful in preventing reflective cracking in the bituminous overlay.

2. The rubber-asphalt interlayer (SAMI) is more effective when placed on the existing pcc pavement when compared to placing it within the bituminous overlay layers.

3. In the test sections with saw cutting of the pcc panels, reflective cracking developed over the new saw cuts rather than over old joints.

4. The rubber-asphalt treatment on the pcc pavement and the 5 saw cuts per panel were the two most effective procedures in terms of ability to reduce the amount of reflective cracking.

5. All test sections performed better than the control section without saw cuts, in terms of the percentage of reflective cracks that developed over transverse joints, saw cuts and transverse cracks.

6. The effectiveness of the strip fabric could not be determined because not all saw cuts and transverse cracks were repaired. Where repairs were made the strip repair is effective.

7. At this time, reflective cracks are generally narrow with very little spalling in all test sections, including the control section.

8. The existing pcc pavement continued to expand at some locations of bituminous patching and caused mounding in the new bituminous overlay.

9. The amount of reflective cracking can vary within a given test section with changes in subgrade soil type.

RECOMMENDATIONS

Based on the data collected to date on the different experimental sections on this project, the following recommendations are made:
1. Some additional projects should be constructed utilizing the rubber-asphalt treatment (SAMI) to confirm the results of this evaluation.

2. Full coverage fabric as a means of reducing transverse reflective cracking is not recommended at this time.

3. Additional data should be collected on these experimental sections to determine the long term effects of the various materials and methods being evaluated on this project.

4. Future experimental sections should be a minimum of 1,000 feet in length to increase the reliability of the data.

5. The Roadglas Two-Step fabric should be evaluated on future projects on a limited basis.

6. The Roadglas One-Step fabric is not recommended.

7. The local district should keep a record of future maintenance cost on each type of construction (by mile points) so that an economical analysis can be made.

8. Methods to prevent the mounding in the new bituminous overlay due to the expansion of the existing pcc pavement should be considered on future overlay project.

9. This project should be periodically surveyed to gather additional data.
REFERENCES


APPENDIX
S-18  (301) SAWING CONCRETE PAVEMENT
    This work shall consist of sawing a 1/8 inch wide and a 4 inch deep joint on a 6 to 1 skew in accordance with the details shown on Plan Sheet No.6. The exact location of the joints to be as directed by the Engineer.

S-18.1  Saw cuts shall be made on one-half of the roadway at one time.

S-18.2  Measurement will be made by the length of joints sawed as specified. Payment will be made under Item 301.604 (Sawing Concrete Pavement) at the Contract bid price per linear foot which price shall be compensation in full for all costs incidental thereto.

S-19  (2331) PLANT MIXED BITUMINOUS PAVEMENT
    A plant mixed bituminous pavement shall be constructed in accordance with the provisions of Mn/DOT 2331, except as modified below, using Asphalt Cement 120-150 penetration for the mixtures. Asphalt Cement 200-300 penetration may be used as an option in the production of the shoulder mixture.

S-19.1  The following modification shall apply in conjunction with Bituminous Mixture Production:

    (A) Mn/DOT 2331.4B is revised to read:

        "Bituminous material will be measured by weight of the material furnished and used in all mixtures."

    (B) The third paragraph of Mn/DOT 2331.5 is revised to read as follows:

        "Payment for the Item of Bituminous Mixture Production at the Contract price per ton of mixture produced shall be compensation in full for all costs of producing the mixture and loading it on board the Department's trucks at the mixing plant, except for the bituminous material for mixture, which will be measured and paid for separately."

S-19.2  After removal of all loose concrete spalls, the bituminous leveling course shall be placed in (2) layers. A one inch bituminous leveling course shall be placed with a motor grader with a minimum of 2 passes so that the mixture is tight-bladed into all joints, cracks and spalled areas cleaned in prior operations.
331.1 DESCRIPTION

This work shall consist of preparing and treating the top one inch lift of leveling and the top of the first three inches of leveling.

Work shall be performed in accordance with the specification described herein and close conformance with line and grades shown in the plans.

331.2 MATERIALS

A. Fabric

The fabric shall be a non-woven polypropylene, Petromat. The fabric shall have the following properties (ASTM Method D 1682-64, Grab Method):

- Tensile Strength, either direction: 90 Pounds Minimum
- Elongation, warp direction, at break, percent: 55 Minimum
- Elongation, fill direction, at break, percent: 55 Minimum
- Weight: 3-5 Ounces/Square Yard
- Color: Black

B. Bituminous Material

The bituminous material shall conform to the requirements of Mn/DOT Specification 3151 and shall be AC-1, 120/150 penetration grade asphalt cement.

C. Blotter Material

The need for blotter material shall be determined by the Engineer. Equipment tires may tend to stick to the fabric during paving in hot weather (greater than 85°F.). Blotter material shall conform to the aggregate requirements of Mn/DOT Specification 2361, a surface dry sand (Mn/DOT 3127), a small quantity of fine hot mix (1/2 inch minus), or other material as prior approved by the Engineer.

331.3 CONSTRUCTION REQUIREMENTS

A. General

The following construction requirements provide for the placement of the fabric as specified below. The four areas to be treated with the fabric shall be as designated by the Engineer, but shall be approximately as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Approximate Location (Eastbound)</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Station 1300 to 1340 (Place on top of 1 inch tight blade leveling)</td>
<td>27 Feet Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12' Lt. to 15' Rt.)</td>
</tr>
<tr>
<td>2</td>
<td>Station 1990 to 2030 (Place on top of 3 inches of leveling)</td>
<td>24 Feet Total (Mainline)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12' Lt. to 12' Rt.)</td>
</tr>
<tr>
<td>3</td>
<td>Station 2170 to 2210 (Place on top of 1 inch tight blade leveling)</td>
<td>24 Feet Total (Mainline)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12' Lt. to 12' Rt.)</td>
</tr>
</tbody>
</table>
(Continued)

<table>
<thead>
<tr>
<th>Area</th>
<th>Approximate Location (Eastbound)</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Station 2220 to 2250 (Place on top of 1 inch tight blade leveling)</td>
<td>24 Foot Total (Mainline). (12' Lt. to 12' Rt.)</td>
</tr>
</tbody>
</table>

B. Surface Preparation

The pavement surface upon which the fabric shall be placed shall be free of dirt, water or foreign material. The pavement surface shall be broomed clean where necessary. A tack coat composed of AC-1, 120/150 penetration grade asphalt applied to the inplace surface at a uniform rate of 0.15 to 0.30 gallons per square yard. Application of the asphalt cement tack coat shall be by an approved distributor whenever possible, with hand spraying kept to a minimum. Hand spraying shall be allowed only where distributor truck cannot be used.

The temperature of the asphalt cement at the time of application shall be between 280° and 325° F. Application of the asphalt cement shall be conducted only during the daylight hours, when the pavement and air temperatures are 60° F. or higher, when the relative humidity is less than 75 percent and when the road surface is dry. Application of the bituminous material shall be suspended when the weather or road conditions are unfavorable.

The asphalt cement shall be applied to an area two to four inches wider than the width of the fabric being placed, but restricted to the area of immediate fabric laydown. Hand applied asphalt cement may be permitted to ensure complete fabric saturation in isolated areas as determined by the Engineer.

C. Fabric Laydown

After application of the asphalt cement tack coat, the fabric shall be placed into the fresh asphalt cement. Fabric shall be machine placed but shall be placed within appropriate limits of the application of asphalt cement at all times.

The fabric shall be placed essentially wrinkle-free without air bubbles and be in complete contact with the road surface. Wrinkles large enough to cause folds shall not be allowed. Brooming or rolling (pneumatic roller) may be required to ensure there are no air bubbles and contact with the road surface is present. Hand brooming shall be from the center outward, moving in the direction of laydown.

The fabric shall overlap adjacent fabric panels from four to six inches. Additional asphalt cement shall be applied uniformly to make the joints at a uniform applied rate of 0.1 gallon per square yard. This can be applied by the distributor in the case of longitudinal joints of adjacent panels. For transverse joints, the asphalt cement shall be applied by hand operation. The joints shall be shingled to facilitate runoff in the event of rain prior to paving. Transverse joints shall be shingled in the direction of paving in order to prevent edge pickup by the paver.

D. Fabric Overlay

Hot mix paving operations shall follow membrane placement as soon as the membrane has cured (approximately 30 minutes).

Turning of the paver and other vehicles shall be gradual and kept to a minimum to avoid damage to the membrane. If equipment tires tend to stick to the membrane during paving, a small quantity of sand, hot-mix or other material may be broadcast ahead of the vehicles to relieve this problem. The material used as a blister aggregate shall be approved and spread as directed by the Engineer. Any tearing of the fabric inplace shall be corrected to the Engineer's satisfaction at the expense of the contractor.
The hot plant mix to be placed on the fabric shall meet the requirements of Mn/DOT Specification 2331 except as modified below:

1. No tack coat is required on the surface of the fabric interlayer prior to placement of the next lift of bituminous hot plant mix.

2. The temperature of the hot-mix to be placed directly on the fabric shall have a laydown temperature between 230°F and 300°F.

E. Equipment

1. Asphalt Distributor

The distributor shall be capable of spraying the asphalt cement at the prescribed temperature and application rate. It shall be adjustable to give a uniform spray pattern over the entire width of application. A hydrostatic type distributor is preferred. No drilling or skipping shall be permitted. The Engineer shall require preliminary test applications at an off-site area to ensure proper distributor performance.

The distributor shall be equipped with a hand spray with only one nozzle. The hand spray shall be easily controlled and have a positive shut-off valve.

2. Fabric Handling

A length of A.S.A. standard one inch pipe to handle the roll width being used shall be on hand for proper roll handling. Special laydown equipment has been developed by the fabric supplier to expedite the operation. Machine laydown of the fabric is required, but is subject to a performance basis as approved by the Engineer.

3. Miscellaneous Equipment

Stiff bristle brooms to smooth the fabric and scissors for cutting the fabric shall be provided. Buckets and squeegees can be used for applying the asphalt cement to fabric laps and joints.

Under extremely windy conditions, when the asphalt cement may not be sufficiently tacky to hold the fabric in place, roofing nails and tabs may be used.

A pneumatic roller meeting the requirements of Mn/DOT 2331.3C2c(2) may be used to smooth fabric into the asphalt cement.

331.4 METHOD OF MEASUREMENT

A. Bituminous Material

Bituminous material applied on the road will be measured by volume in gallons at 60°F.

B. Fabric Treatment

The non-woven polypropylene fabric (Petromat) will be measured by the square yard and shall include all work completed and accepted prior to covering with hot bituminous mixture as specified, including blotter material.

331.5 BASIS OF PAYMENT

Payment for the accepted quantities of bituminous material (asphalt cement) and the fabric treatment at the appropriate contract prices shall be compensation in full for all costs and work necessary to complete construction of the fabric treatment as specified.

Payment will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>331.505</td>
<td>Bituminous Material – Fabric Treatment</td>
<td>Gallon</td>
</tr>
<tr>
<td>331.507</td>
<td>Petromat Fabric</td>
<td>Square Yard</td>
</tr>
</tbody>
</table>
357.1 DESCRIPTION

This work shall consist of preparing and treating the inplace concrete, the top of the first one inch lift of leveling and the top three (3) inches of leveling with a hot rubber - asphalt interlayer treatment. Work shall be performed in accordance with the specification herein described.

357.2 MATERIALS

A. Bituminous Material

The bituminous material for the hot rubber - asphalt interlayer treatments shall be AC-1, 85/100, 120/150 or 200/300 penetration grade asphalt conforming to the requirements of Mn/DOT 3151.

At least 21 days prior to the beginning of the hot rubber - asphalt interlayer treatment, the Contractor shall submit to the Engineer representative samples of the asphalt cement. The asphalt cement sample shall be from the same source (refinery) as intended for use in the hot rubber - asphalt interlayer treatment and preferably from the plant asphalt storage or working tank.

B. Granulated Crumb Rubber

The granulated crumb rubber (100 percent vulcanized) shall meet the following requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number 8</td>
<td>100</td>
</tr>
<tr>
<td>Number 10</td>
<td>98-100</td>
</tr>
<tr>
<td>Number 40</td>
<td>0-10</td>
</tr>
</tbody>
</table>

The granulated crumb rubber shall be accepted for mixing into the asphalt cement if accompanied by a certificate of compliance from the supplier stating that the material has been tested during the grinding process and meets the gradation as specified above.

The specific gravity of the granulated crumb rubber shall be $1.15 \pm 0.02$ and shall be free of fabric, wire or other contaminating materials, except that up to four percent of calcium carbonate may be included to prevent the particles from sticking together.

C. Cover Aggregate

The cover aggregate material may be obtained from any source provided that the material is 100 percent passing the 1/2-inch sieve, zero to twenty-five percent passing the Number 8 sieve and zero to two percent passing the Number 200 sieve and has a Los Angeles Rattler Loss of less than 15 percent for the crushed quarry rock portion of the aggregate. The aggregate shall be relatively free from clay balls, clay coating, organic matter or foreign substances.
357.3 CONSTRUCTION REQUIREMENTS

A. General

The following construction requirements provide for the placement of the hot rubber-asphalt interlayer treatment. The areas to be treated shall be as designated by the Engineer but shall be approximately as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Approximate Location (Eastbound)</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Station 1790 to 1840 (On top of inplace concrete)</td>
<td>26 Feet Total (24 Feet Mainline plus 1 Foot onto each Shoulder).</td>
</tr>
<tr>
<td>2</td>
<td>Station 1840 to 1890 (On top of one inch of blade laid leveling).</td>
<td>26 Feet Total (24 Feet Mainline plus 1 Foot onto each Shoulder).</td>
</tr>
<tr>
<td>3</td>
<td>Station 1890 to 1940 (On top of 3 inches of leveling).</td>
<td>35 Feet Total (Mainline plus Shoulder). (15' Lt. to 20' Rt.)</td>
</tr>
</tbody>
</table>

B. Restrictions

The rubber-asphalt interlayer operations shall meet the requirements as specified in Mn/DOT Specification 2356.3A.

At least 21 days prior to the application of the cover aggregate material, the Contractor shall submit to the Engineer a representative sample (approximately 100 pounds) for testing.

C. Equipment

The equipment used shall include a power broom for cleaning the pavement surface and three pneumatic tired rollers meeting the requirements of Mn/DOT 2331.3C2c(2), aggregate spreading equipment that can be so adjusted as to spread accurately the given amounts per square yard, a self-powered pressure distributor equipped with a separate power unit, distributing pump capable of pumping the specified material at the specified rate through the distributor tips, and equipment for heating the bituminous material. The distribution bar on the distributor shall be fully circulating with nipples and valves so constructed that they are bathed in the circulating asphalt to the extent that the nipples will not become partially plugged with congealing asphalt upon standing, thereby causing preliminary streaked or irregular distribution of the asphalt. Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices and a thermometer for reading temperature of tank contents. The spray bars on the distributor shall be controlled by a boatman riding at the rear of the distributor in such a position that operation of all sprays is in full view and accessible to him for controlling spread widths.

The distributor shall be equipped with an internal mixing device capable of maintaining a completely homogenous blend of the ingredients.

The method and equipment for combining the rubber and asphalt shall be so designed and accessible that the Engineer can readily determine the percentages, by weight, of each of the two materials being incorporated into the mixture.

The cover aggregate shall be applied with an approved mechanical-type spreader as specified in Mn/DOT 2356.382 - Aggregate Spreader.
D. Construction Details

2. Mixing

The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semifluid material. The temperature of the asphalt shall be between 350°F and 450°F. The Engineer shall judge when the material has reached application consistency. After reaching the proper consistency, application shall proceed immediately and in no case shall the mixture be held at temperatures over 350°F, for more than one hour after reaching that point.

The proportions of the two materials, by weight, shall be 75 percent ± 2 percent asphalt and 25 percent ± 2 percent rubber. After the full reaction described above has occurred, the mix may be diluted with kerosene. The amount of kerosene used shall be 0 percent to 7 1/2 percent, by volume, of the hot rubber - asphalt composition as required for adjusting the viscosity for spraying or better "wetting" of the cover aggregate. The kerosene shall have a boiling point of not less than 350°F, and the temperature of the hot composition shall not exceed this temperature at the time of adding the kerosene.

2. Spreading

Prior to the hot rubber - asphalt treatment, the surface to be sealed shall be cleaned and treated with a cationic emulsion asphalt tack meeting the requirements of Mn/DOT 2357. The application rate shall not exceed 0.04 gallon per square yard residual bitumen. The hot rubber - asphalt mixture shall be applied after the tack has broke and at a uniform rate of application of 0.60 ± 0.06 percent of a gallon per square yard based on 7 1/2 pounds per hot gallon. No traffic shall be permitted on uncovered hot rubber - asphalt material.

3. Application of Cover Aggregate

The application rate of the cover aggregate shall be as designated by the Engineer, within the range of 20 to 35 pounds per square yard. At the time of spreading, the cover aggregate shall not contain more than two percent (by weight) of free surface moisture.

Sufficient rollers shall be furnished to cover the width of the spread with one pass. The first pass shall be made immediately behind the aggregate spreader and if the spreading is stopped for any reason, the spreader shall be moved ahead so that all cover material spread may be immediately rolled. The rolling shall continue until four complete coverages within two (2) hours after the application of the cover material. Traffic shall not be permitted on the sealed surface until all rolling has been completed.

All edges shall be swept clean of overlapping cover material prior to the adjacent application of rubber - asphalt material.

All reasonable precautions shall be taken to avoid "skips" and "overlays" at joints and to protect the surfaces of adjacent structures from being spattered or marred. Correction of any such defects will be required at the Contractor's expense. All transverse joints shall be made by placing building paper over the ends of the previous applications and the joining application shall start on the building paper. The paper shall be removed and disposed of to the satisfaction of the Engineer.

E. Traffic Control

Except for times when it is necessary that hauling equipment and/or pilot vehicles (if used) must travel on the newly applied membrane (rubber - asphalt and cover aggregate), traffic of all types shall be kept off the membrane until it has
had time to set properly. The speed of all hauling equipment and pilot vehicles (if used) shall not exceed 25 miles per hour. The minimum traffic free period shall not be less than three hours. Advisory signing shall be provided for a period of 24 hours after membrane operations are completed to maintain vehicle speeds under 25 miles per hour, if the bituminous surface course is not placed the same day on the membrane.

F. Removing Loose Cover Material

The power broom used in removing loose cover material shall be a rotary metal bristle sweeper type.

On the morning following each day of seal coat operations, the Contractor shall sweep off the surplus cover aggregate from the previous day's seal coat construction, if exposed. This operation shall be conducted while the road surface is still cool and care shall be exercised that the aggregate which has set is not disturbed.

G. Interlayer Overlay

The placement of the hot-mix bituminous surface mixture shall be completed within 48 hours after the application of the rubber - asphalt interlayer treatment; except that, at the Contractor's/Engineer's mutual agreement, this period may be extended to a maximum of five (5) calendar days; and provided the Contractor accepts responsibility for maintaining the integrity of the membranes during the additional time. Any blotting, flushing with water; patching with rubber - asphalt, additional sweeping or other means necessary and approved by the Engineer, after the first 24 hours, will be at the Contractor's expense. During the initial 48 hour period, such work required by the Engineer will be paid for in accordance with the items herein specified.

Turning of the paver and other vehicles shall be gradual and kept to a minimum to avoid damage to the interlayer treatment. Any tearing and/or damage of the inplace interlayer treatment shall be corrected to the Engineer's satisfaction at the expense of the Contractor.

The bituminous surface course to be placed on the interlayer treatment shall meet the requirements of Mn/DOT 2331 except as modified or supplemented as follows:

1. No tack coat is required on the surface of the rubber - asphalt interlayer prior to placement of the next lift of bituminous hot plant mix.

357.4 METHOD OF MEASUREMENT

A. Bituminous Material

The asphalt vulcanized rubber will be measured and paid for per ton of the mixture applied on the roadway, which includes asphalt cement, granulated rubber and kerosene (based on 7 1/2 pounds per hot gallon).

B. Cover Aggregate

The cover aggregate will be measured by weight of material deposited on the road which includes aggregate and rolling.

357.5 BASIS OF PAYMENT

Payment for the accepted quantities of bituminous material (including required additions) and cover aggregate (including aggregate and rolling) at the appropriate contract prices shall be compensation in full for all costs of constructing the rubber - asphalt interlayer treatment as specified.
Payment for the rubber - asphalt interlayer treatment will be made on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>357.601</td>
<td>Rubber - Asphalt - Interlayer Treatment</td>
<td>Ton</td>
</tr>
<tr>
<td>357.601</td>
<td>Cover Aggregate - Interlayer Treatment</td>
<td>Ton</td>
</tr>
</tbody>
</table>