Study of Crack Sealant Products (Routing and Sealing)

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Ted Harrison, Materials Engineer, Alberta Transportation

In 1994, the department established a large scale Rout and Seal crack seal evaluation program to assess the field performance of eight different sealant products. The products evaluated include the following: Beram 195, Elsro 1191, Bakor 590-13A, Koch 5030, Hydrotech 6160, Crafo 522, Husky 1611, and Superflex 100.

Evaluations of the various sealant products commenced in 1994/95 and were finalized in 2002.

Key Words: Distribution

Unlimited

Project Co-ordinator
Terry Willis, Director, Materials & Technical Services

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STUDY OF CRACK SEALANT PRODUCTS (Routing & Sealing)

1.0 INTRODUCTION

As asphalt pavements age and deteriorate, the need for corrective measures to restore safety and rideability increases. When a cracked pavement appears to be in need of some sort of maintenance, a quick assessment can be made to determine the appropriate action. Such an assessment requires an evaluation of existing pavement conditions and knowledge of future rehabilitation plans.

Routing and sealing cracks in asphaltic concrete pavement as part of a preventative maintenance program was implemented in 1994 as a full scale test program. Demonstration and test sites were set up across the province at the following locations:

- Highway 35:04, North of Grimshaw (km 0.30 to km 2.48)
- Highway 63:00, South of Newbrook (km 13.0 to km 18.0)
- Highway 56:12, South of Big Valley (km 6.5 to km 13.0)
- Highway 3:10, East of Lethbridge (km 0.0 to km 1.86)

2.0 OBJECTIVES

The objectives of the Routing and Sealing project were to:

- Determine the effectiveness of the eight different sealant products installed in 1994 using the Rout and Seal method of crack sealing.
- Monitor the durability and performance of the sealant products.
- Determine the effectiveness of the narrow profile vs. the wide profile configuration.
3.0 BACKGROUND

Improved sealant performance involves properly routing the existing pavement crack. Creation of a larger reservoir by routing allows the sealant to expand with less strain, provides a large bonding area and provides a clean surface for bonding. It also protects the sealant from traffic wear.

The most significant improvement to sealant properties has been the improved ability of the sealant to stay flexible at cold temperatures and retain cohesion and adhesion.

Sealant performance is affected by many factors such as: sealant properties, installation methods, workmanship, climate, pavement condition, winter maintenance and traffic. Close monitoring and detailed documentation related to these factors are required for a proper evaluation of methods and materials.

Suppliers of Hot Pour rubberized sealant materials were approached prior to installation of the products in 1994, to provide their most suitable product for effectively sealing cracks in Alberta. A total of eight products were installed for this evaluation project.

4.0 MATERIALS

The 1994 test program involved eight Crack Sealant Products from eight suppliers on four highway projects (see APPENDIX G for provincial map) as per the following table:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>HYDROTECH</th>
<th>HUSKY</th>
<th>ELSRO</th>
<th>KOCH</th>
<th>BAKOR</th>
<th>CRAFCO</th>
<th>BERMAC</th>
<th>BITUMAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
<td>I.W.S.</td>
<td>HUSKY</td>
<td>ELSRO</td>
<td>KOCH</td>
<td>BAKOR</td>
<td>Lafrentz</td>
<td>M'Asphalt</td>
<td>Ace</td>
</tr>
<tr>
<td>Grade</td>
<td>6160</td>
<td>1611</td>
<td>1191</td>
<td>9030</td>
<td>590-13A</td>
<td>522</td>
<td>Beram 195</td>
<td>Super-Flex 100</td>
</tr>
<tr>
<td>Test Site</td>
<td>Hwy. 56:12, 36:04, 63:00</td>
<td>Hwy. 3:10, 35:04, 63:00</td>
<td>Hwy. 3:10, 56:12, 63:00</td>
<td>Hwy. 53:12, 35:04, 63:00</td>
<td>Hwy. 3:10, 35:04, 63:00</td>
<td>Hwy. 3:10, 35:04, 63:00</td>
<td>Hwy. 56:12, 35:04, 63:00</td>
<td>Hwy. 63:00</td>
</tr>
</tbody>
</table>

* All test sites had transverse and longitudinal cracks treated using the narrow and wide profiles.

5.0 CONSTRUCTION HISTORY

The rout and seal work commenced on the first highway project on April 28, 1994 and was completed on May 27, 1994. The following shows a brief history and the working conditions of the highway sites:

**Highway 3:10**

Work commenced at the Highway 3:10 site on April 28, 1994. It was sunny with temperatures starting around freezing and rising during the day to highs near 15°C. Work at this site was completed on April 29, 1994.

This site is a four-lane divided highway running east from the City of Lethbridge to Coaldale. The sealant products originally proposed at this site were Beram
195, Crafco 522, Elsro 1191 and Koch 9030 (due to shipping problems the Beram and Koch products were replaced with the Bakor 590-13A and Husky 1611 sealants).

Highway 56:12

Work commenced at the highway 56:12 site on May 2, 1994. It was cloudy, 13°C when the contractor started working and it started to rain later that first day. Work commenced again on May 8 and was completed on May 9. The weather was sunny with temperatures around 15°C.

This site was a narrow, two-lane roadway running south from SH590 towards SH589. The sealant products used on this site were Elsro 1191, Hydrotech 6160, Beram 195 and Koch 9030.

Highway 63:00

Work commenced at the highway 63:00 site on May 10, 1994. The weather was mostly sunny with an average daytime temperature in the mid-teens. The work was completed on May 13, 1994.

All eight crack sealant products were used at this site; Hydrotech 6160, Husky 1611, Elsro 1191, Koch 9030, Bakor 590-13A, Crafco 522 and Beram 195. The eighth product used was the Super-Flex 100; this product was included in the evaluation at the request of Ace Asphalt Ltd.

Highway 35:04

Work commenced at the highway 35:04 site on May 25, 1994. The weather was overcast with temperatures of 20°C. The work was completed on May 27, 1994. Sealant products used on this site were Hydrotech 6160, Husky 1611, Koch 9030, Bakor 590-13A, Crafco 522 and Beram 195.

6.0 INITIAL MATERIAL PERFORMANCE

It was impossible initially to determine which materials would provide the best long-term performance. Initial observations concluded that there are some substantial differences in the materials, which will affect performance.

The viscosities of the materials differed dramatically which was important when it came to the amount of squeegeeing that was required to keep the material in the rout. As an example, at one end of the scale the Elsro 1191 product had relatively low viscosity and required multiple passes of the squeegee. The Hydrotech 6160 product, which had higher viscosity, usually stayed in place after only one pass of the squeegee.

The application temperature ranges differed with each product. Most of the products specified an application temperature in the range of 180°C – 200°C, while the Beram 195 specified a range of 120°C to 135°C.
There also appeared to be a difference in the application density of each product. It appeared that some of the sealant products provided more lineal metres per kilogram than others. This was based purely on visual observations.

7.0 INSTALLATION

Installation took place at many different locations under a variety of conditions. Selected test sections represent various climatic conditions, installation methods, pavement structures and pavement conditions. Three demonstration sites and one research site were selected for the 1994 Routing and Sealing test program:

- Highway 3:10 (demonstration site), Lethbridge East City Limits to West of Coaldale (kilometer 0.000 to kilometer 1.860).
- Highway 35:04 (demonstration site), North of Highway 2 to Junction of S.H. 686 (kilometer 0.000 to kilometer 2.480).
- Highway 63:00 (Research Site), North of Highway 28 to South of Newbrook (kilometer 13.000 to kilometer 18.000).

8.0 PAVEMENT CRACK CONDITION

The sealant products were placed on 7 year old through 11-year-old pavements in 1994. The following table illustrates the crack condition at these sites:

<table>
<thead>
<tr>
<th>Highway</th>
<th>Crack Condition</th>
<th>Pavement age at Installation in 1994</th>
<th>Year of Chip Seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway 3:10</td>
<td>Slight cupping, moderate secondary cracks and spalling</td>
<td>8 years</td>
<td>1989</td>
</tr>
<tr>
<td>Highway 56:12</td>
<td>Slight cupping, moderate secondary cracks and spalling</td>
<td>9 years</td>
<td>1999</td>
</tr>
<tr>
<td>Highway 63:00</td>
<td>Slight cupping, moderate secondary cracking and spalling</td>
<td>7 years</td>
<td>1990</td>
</tr>
<tr>
<td>Highway 35:04</td>
<td>Slight cupping, extreme secondary cracking and spalling</td>
<td>11 years</td>
<td>1986</td>
</tr>
</tbody>
</table>
9.0 HORIZONTAL CRACK MOVEMENT

One of the most significant factors affecting product performance is temperature related horizontal crack movement. Cracks open up in the winter, causing cohesion stress within the product, and adhesion stress between the product and the ACP interface. In order to provide a year round seal, sealant must possess excellent low temperature flexibility and adhesion properties.

In the 1995 Rout and Seal Crack Maintenance Product Performance Study, the sealant products installed in May 1994 were monitored for crack movement. The following is a summary of the 1995 findings:

Table 3

<table>
<thead>
<tr>
<th>Highway</th>
<th>Crack Type</th>
<th>Max. Crack Movement (Jan. 95) (mm)</th>
<th>Elongation % (estimate) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wide Profile (40mm X10mm)</td>
</tr>
<tr>
<td>35:04</td>
<td>Transverse</td>
<td>6.9</td>
<td>17</td>
</tr>
<tr>
<td>63:00</td>
<td>Transverse</td>
<td>10.5</td>
<td>26</td>
</tr>
<tr>
<td>3:10</td>
<td>Transverse</td>
<td>5.1</td>
<td>13</td>
</tr>
<tr>
<td>55:12</td>
<td>Transverse</td>
<td>6.6</td>
<td>17</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>7.3</td>
<td>18</td>
</tr>
<tr>
<td>35:04</td>
<td>Longitudinal</td>
<td>5.4</td>
<td>14</td>
</tr>
<tr>
<td>63:00</td>
<td>Longitudinal</td>
<td>1.6</td>
<td>4</td>
</tr>
<tr>
<td>3:10</td>
<td>Longitudinal</td>
<td>1.0</td>
<td>3</td>
</tr>
<tr>
<td>55:12</td>
<td>Longitudinal</td>
<td>0.6</td>
<td>2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>2.2</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 3 summarizes the crack movements and the corresponding percent elongation experienced at the various sites. As a result of the measurements, it was observed that sealants experience as much as 55% elongation in transverse cracks (10.5mm of crack opening) and as little as 2% elongation in longitudinal cracks (0.6mm of crack opening).

A guideline for determining if a crack is 'working' (requiring a crack treatment), is if the crack movement is 2.5mm or greater (reference from Smith and Romine, SHRP, 1993). Most of the cracks at these sites fall into this category except for longitudinal cracks at three of the sites. In table 3, it can be seen that most of these cracks are 'working', and the sealant undergoes a significant amount of elongation.

10.0 EVALUATION METHOD

Evaluations of sealant performance were based on visual assessments and regular inspections. Assessments were initially carried out in the summer of 1994 and in the winter of 1995 to evaluate year-round performance. Assessments
were also carried out in February 1996, February 1998, February 1999 and March/April 2002 to establish the long-term performance of each sealant. Signs of stress or loss were noted for approximate amounts, location, and severity, when required. Modes of stress or loss were noted in the following forms:

- Partial and full depth adhesion loss
- Partial and full depth cohesion loss
- Pull-outs
- Edge deterioration
- Plow abrasion
- Crazing (fine surface cracks)
- Overband wear (from traffic)
- Tracking (from traffic)
- Extrusion (when cracks close in warm weather)
- Weathering
- Patterning (traffic)

‘Crazing’ (fine surface cracks) is a term used to indicate the early stage of cohesion loss.

‘Loss’ is the term used for indicating partial or full depth failure. Loss indicates a failure to maintain adhesion and/or cohesion integrity.

‘Sag’ is the term used for the winter rating where the sealant is recessed in the rout. This term is used generically, as sag can be attributed to a number of causes:

1. Underfilling
2. Shrinkage of sealant due to cooling
3. Sealant flowing towards the shoulder
4. Sealant slumping into the crack
5. Tensile displacement (sealant stretches and becomes thinner and wider) due to crack movement.

11.0 SEALANT PERFORMANCE FIELD OBSERVATIONS

A correlation has been noted between the rout profile and the amount of sag. In general, there was a greater degree of sag in the Narrow Profile than in the Wide Profile. As well, there is a correlation between the rout profile and the damaging effects of traffic. In the majority of longitudinal wide profile routs in the wheelpaths, there is patterning and intermittent adhesion loss. The forward motion of traffic causes this type of effect.

No crazing could be seen in any of the sealants placed in longitudinal routed cracks. There is significantly less horizontal movement in longitudinal cracks.

Short term and long term sealant performance observations are included in Appendix A and B.
12.0 SUMMARY of OBSERVATIONS

Crack sealants were evaluated in a wide range of locations and conditions. The objective of this evaluation was to report on field performance of the various products. This evaluation focused on products installed in 1994. The following summarizes the initial sealant performance assessments for the 1994/95 inspections along with the longer-term assessments to 2002:

(a) Effects of application methods on performance

Sealants placed in wide profile routs have performed better than those in narrow profile routs for the following reasons:

1. Use of the wide rout (transverse routs) results in less crack following the edge of the rout, which contributes to adhesion loss. This is due to the installation difficulty when using the narrow profile configuration in keeping the edge of the rout away from the edge of the crack (Appendix 'F' rout profiles).

2. There is less observable cohesion stress with the sealant in the wide profile rout. This is due to less elongation experienced by the sealant:
   - Longitudinal wide profile rout sealant in wheelpaths has shown a significant amount of patterning and adhesion loss due to the effects of traffic. Of the total amount of rout under these conditions (excluding Super-Flex 100), 75% has shown this type of defect (352m out of 467m). Conversely, of the total amount of longitudinal narrow profile routs in wheelpaths (245m), none of it has shown this type of defect.
   - There has been no perceptible difference between sections where hot compressed air and cold compressed air was used at installation.
   - The only visible drawback to the use of an overband is the effects of a small amount of plow damage observed. In some areas, abrasion has led to a small amount of adhesion loss. Abrasion was evident only on the high areas of pavement (centerline, between the wheelpaths, and on the shoulder).

(b) Sealant Performance

Based on the initial performance assessment the sealant products are showing their ability to seal pavement cracks (Table 4 & Chart 1). As the function of a sealant is to adhere to the rout, while retaining cohesiveness, any stress or loss in these areas will impair its ability to perform. A rating system was initially developed to present the interim results of sealant performance. This rating was based on severity and amounts of stress and/or loss. Crazing was used as the indicator of cohesion stress; loss is
the indicator for partial to full depth failure. Code numbers were given for the worst performance (0) and the best performance (5).

As can be seen from the long-term performance of the sealants (Table 5 & Chart 2), the performance comparison of the products becomes clear. Even though conditions varied to a certain degree for each product, these numbers give a good picture of performance relative to other products and relative to overall performance.

**Initial Performance 1994/95**

<table>
<thead>
<tr>
<th>Highway</th>
<th>Beram 195</th>
<th>Elsro 1191</th>
<th>Bakor 590-13A</th>
<th>Koch 9030</th>
<th>Hydrotech 6180</th>
<th>Crafco 522</th>
<th>Husky 1611</th>
<th>*Super-Flex 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:10</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>56:12</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>35:04</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>63:00</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Avg.</td>
<td>5.0</td>
<td>2.0</td>
<td>4.7</td>
<td>3.3</td>
<td>1.0</td>
<td>4.0</td>
<td>3.7</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Super-Flex 100 replaced with Beram 195 in 1995.

**Longer Term Performance 2002**

<table>
<thead>
<tr>
<th>Highway</th>
<th>Beram 195</th>
<th>Elsro 1191</th>
<th>Bakor 590-13A</th>
<th>Koch 9030</th>
<th>Hydrotech 6180</th>
<th>Crafco 522</th>
<th>Husky 1611</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:10</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56:12</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>35:04</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>63:00</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Avg.</td>
<td>1.5</td>
<td>1.0</td>
<td>0.7</td>
<td>2.5</td>
<td>0.0</td>
<td>3.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

**Rating Description**

0 Full depth adhesion and/or cohesion loss and/or pullouts over most of the product
1 Partial to full depth adhesion and/or cohesion loss through most of the product
2 Partial depth adhesion and/or cohesion loss is apparent over much of the product
3 Significant amounts of stress showing, although has not yet led to partial depth loss
4 Greater amounts of cohesion and/or adhesion stress
5 None or small amounts of cohesion and/or adhesion stress
Chart 1 summarizes Table 4 results, by product and rating from worst (0) to best (5). It can be seen from Chart 1 that the first 5 products are rated significantly better than the last 3 for their initial performance (1994/95).

Chart 2 summarizes Table 5 results, by product and rating from worst (0) to best (5). The best performing sealants based on their long-term performance (7 years) are Husky 1611, Crafo 522 and Koch 9030. Of the remaining 5 products, 2 have failed (Hydrotech 6160, Super-Flex 100) and the remaining 3 (Elsro 1191, Bakor 590-13A, Beram 195) show major amounts of adhesion and cohesion loss of the sealant.
13.0 CONCLUSIONS

Cracks have opened significantly in the winter months, which in turn have caused the sealants to undergo extensive elongation. From our observations of the sealant products, the superior products continue to seal the crack from the ingress of moisture. The substandard products have shown their limitations by inferior performance.

A superior product is required year round to maintain adhesion and cohesive integrity with the pavement. The most significant variable indicating product performance was crack movement in the winter months. This variable revealed significant limitations of some sealant products.

An important factor in Routing and Sealing performance is that the rout be properly centered over the crack. It is evident that where the crack is along the edge of the rout, bond breaks occur along this edge. Moisture conditions remain the most detrimental factor in causing a bond problem and effecting the overall performance of the sealant.

Sealant performance is not necessarily tied to crack condition. There were areas where sealant performance was poor with cracks in good condition; conversely performance was fair with cracks in poor condition. However, significant crack deterioration can limit success. This is due to factors such as the ability to make proper rout and the chances of further edge deterioration.

It has been observed that crack sealant will not perform properly where there is evidence of segregation.

14.0 RECOMMENDATIONS

Time of year to perform work

Theoretically the best time to seal cracks is when they are still open in the spring. This would reduce stresses once cracks fully open in the winter. However, conditions may not always allow this type of effort.

Rout Profile

Based on the routing and sealing study and previous evidence and documentation continues to support the following rout profiles:

<table>
<thead>
<tr>
<th>Rout Type</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse Routs, Non-Sealed</td>
<td>40mm X 10mm</td>
</tr>
<tr>
<td>Transverse Routs, Chip Seal</td>
<td>40mm X 15mm</td>
</tr>
<tr>
<td>Longitudinal Routs</td>
<td>19mm X 19mm</td>
</tr>
</tbody>
</table>
If the rout profile width is reduced the amount of bond breaks (missed crack) would increase. This was a general observation for Alberta's experience with the various rout profiles used. Also observed was that the rout should be totally filled with a maximum under-fill of 5%.

Centered Rout

A very important factor in Routing and Sealing performance relates to having the rout properly centered over the crack. In many instances bond breaks have occurred where the crack is seen running along the edge of the rout. Routs should be sufficiently cleaned and cuttings should be blown away.

Moisture Presence

If moisture conditions are questionable, routing and sealing work should not proceed. Excessive moisture conditions will cause a bond problem. If the sub-surface becomes saturated, sealant bond can be inhibited unless sufficient drying and cleaning has occurred. Based on evidence from the department and industry, a hot air blast shortly after a heavy rain does not dry/clean cracks sufficiently to promote a good bond. A few days of hot windy weather is required for drying. A hot air blast can have negative consequences by bringing moisture to the surface, thereby inhibiting bond.

Successful Sealant Products

Based on the eight sealant products under evaluation from 1994 to 2002, the following products performed and are still performing adequately as a crack sealant:

- Husky 1611
- Crafo 522
- Koch 9030

These sealant products were recommended for inclusion in the Alberta Transportation and Utilities Rout and Seal program for 1995 based on the initial sealant study.

Recommendations as outlined in the Alberta Transportation “11.0 Crack Maintenance Guidelines”

1. Rout and Seal is recommended in the following conditions:

- Crack opening is between 3-12mm. Pavements with crack opening between 12-20mm shall be evaluated to determine whether or not routing is appropriate. Pavements with crack openings greater than 19mm shall be cleaned and filled without routing. Types of cracks considered for routing and sealing are:
- Longitudinal cracks (center line, mid-lane, wheel track single crack, and meandering cracks).
- Transverse cracks.
- Edge cracks.

2. **Rout and Seal is not recommended in the following conditions:**

   - Crack opening is less than 3mm.
   - Cracks are alligator (map) type.
   - Crack is severe in density. It is assumed that rout and seal would be ineffective in delaying further deterioration.
   - Pavement is being considered for rehabilitation.
References


Alberta Transportation and Utilities, “Rout and Seal Crack Maintenance Product Performance”. February 1995
Appendix ‘A’

Short Term Sealant Performance Observations
General Observations made in 1994/95

Highway 3:10 EBL

All sealant performance was excellent until the onset of winter (1994). Following is a summary:

Overall condition: Abrasion caused by snowplows is evident on most sealant products in the middle to outer edges of both shoulders; this has led to a small amount of partial depth adhesion loss. All wide profile rout sealant is flush with the ACP surface; narrow profile sealant is showing slight sag.

Elsro 1191

Inspection in December 1994 showed that most of the Elsro 1191 sealant has crazing. By January 1995 indications of stress had progressed to ‘crazing to partial depth cohesion loss over most of the sealant’. In the wide profile rout, this sign of stress was concentrated over the ACP crack. It was also evident in the wide profile rout that the sealant had slumped into the ACP crack more than the other products at this site. This product has a 'grainy' texture.

Bakor 590-13A

Low overall amount of crazing noticed in December 1994. By January 1995, crazing had progressed to moderate amounts of crazing in the narrow profile rout.

Crafco 522

Low amount of crazing on shoulders in December 1994. By January 1995, this had progressed to low amounts of crazing over the entire section, but was more noticeable in the narrow profile. Also noticed was a small amount of stone intrusion.

Husky 1611

Low amount of crazing on the shoulders in December 1994. By January 1995, this had progressed to low amount of crazing in wide profile routs and moderate amount of crazing in narrow profile routs.

Highway 56:12

Excellent performance of all products throughout the summer of 1994, except for sealant in longitudinal wheelpath wide profile routs. Most of the wide profile routs in this location (wheelpaths) showed 'patterning' and intermittent partial to full depth adhesion loss due to the effects of traffic. As ACP segregation was seen elsewhere on this project, it may have been a contributing factor in the adhesion loss.
Approximately 5 meters of sealant in the section where Koch 9030 was installed is failing due to edge deterioration. In this case, edge deterioration was caused by segregation in the ACP. Routing further damaged the already weak pavement in these segregated areas.

Sealant geometrics changed slightly at this site. In the wheelpaths, the sealant was generally flush with the ACP surface, whereas outside the wheelpaths, in the higher areas of the pavement, sealant had sagged in the rout.

Plow abrasion caused damage to some of the sealant, but only at the high areas of the pavement (centerline, between the wheelpaths, and on the shoulders). In some routs, this damage has led to adhesion loss.

**Beram 195**

Low amount of 'bubbling' throughout, which occurred shortly after installation. It is felt that this bubbling was due to moisture migrating up from below. There appears to be less plow damage with this product, possibly due to the fact that there is more sag, thereby having less material above the pavement surface. No crazing showing with this product.

**Elsro 1191**

High amounts of crazing to partial depth cohesion loss; more concentrated in the narrow profile rout. An interesting observation was that during a winter inspection, this product was very pliable, yet exhibited large amounts of cohesion loss, whereas Beram 195 was relatively firm, yet exhibited no signs of stress.

**Koch 9030**

Moderate amount of partial to full depth adhesion loss in the wide profile routs. One contributing factor could be segregation, as there was a noticeable amount in the area. Low amount of the same type of adhesion loss in the narrow profile routs, where the segregation is less noticeable. Product appearance changed from end to end, possibly due to a change in application temperatures.

**Hydrotech 6160**

Extreme amount of partial to full depth cohesion loss; it is more concentrated in the narrow profile rout.

**Highway 35:04**

By October 10, 1994 segments of approximately 0.5 meters each of full depth adhesion loss was showing towards the outer edge of the NBL, in the area where Koch 9030 was installed. This loss may be attributed to segregation, as it can be seen in the area.
Of the small amount of wide profile longitudinal routs in the wheelpaths, over half of it had intermittent full depth adhesion loss due to the effects of traffic.

By January 1995, plow abrasion was evident on most transverse cracks. Damage occurred towards the outer edge of the shoulder (where the product pooled at installation), and to a lesser degree, on centerline. This has led to a small amount of adhesion loss.

**Beram 195**

No signs of stress in either profile.

**Bakor 590-13A**

Low amount of crazing in wide profile and narrow profile routs.

**Koch 9030**

Moderate amount of crazing in the wide profile routs (no narrow profile routs with this product).

**Hydrotech 6160**

Moderate amount of partial to full depth cohesion loss, more noticeable in the narrow profile routs than in the wide profile routs.

**Crafco 522**

Low amount of crazing in the wide profile routs; high amount of crazing in the narrow profile routs. There appears to be more sag with this product, than with other products at this site.

**Husky 1611**

Moderate amount of crazing in the wide profile routs (no narrow profile routs with this product).

**Highway 63:00**

Patterning and intermittent full depth adhesion loss appeared shortly after installation in the wide profile longitudinal wheelpath routs. This is due to the effects of traffic. Of the 126 meters of wide profile routs in this location, 98 meters showed this behavior. This total amount excludes 22 meters of Super-Flex 100 sealant due to its significantly different properties (see Super-Flex 100 below).

Plow abrasion for approximately 0.4 meters on the transverse cracks in the middle to outer edge of the shoulders can be seen on most cracks. In some cases this has initiated adhesion loss.
Beram 195

Negligible amount of crazing was observed on this sealant.

Elsro 1191

Low to high amount of crazing to partial depth cohesion loss in the wide profile routs. Moderate to high amount of crazing to partial depth cohesion loss in the narrow profile routs.

Bakor 590-13A
Low amount of crazing in both rout profiles.

Koch 9030

Moderate amount of crazing in the narrow profile routs and low amounts of crazing in the wide profile rout. This product had a small amount of sand and stone intrusion.

Hydrotech 6160

High amount of partial to full depth cohesion loss (70% est.); low amount of adhesion loss (20% est.) in the wide profile routs. In the narrow profile routs, high amounts of partial to full depth cohesion loss (75% est.); low amount of adhesion loss (25% est.).

Crafco 522

Low amounts of crazing in both profiles; slightly more noticeable where there was more sag.

Husky 1611

None to low amounts of crazing in the wide profile routs; high amounts of crazing in narrow profile routs.

Super-Flex 100

Extreme amount of full depth adhesion loss on both sides of rout, leading to about one-third of it being picked out in chunks on both profiles. This material is extremely brittle in cold temperatures. Sealant in a small amount (22m) of longitudinal wide profile wheelpath rout has not shown signs of stress from traffic.
Appendix ‘B’

Longer Term Sealant Performance Observations
General Observations made in February 1996

Highway 3:10

The sealant products at this site are continuing to function as intended. However, there are two significant points worth noting:

1. Cohesion stress in the Elsro 1191 sealant has not increased significantly, but because of the high amount of partial depth cohesion loss, this product is still rated as unsatisfactory at this site, at this time.

2. 'Crack on edge of rout' has caused more full depth cohesion failures this year – in particular with the Bakor 590-13A and the Husky 1611 sealant. It is not known at this time if this is due to more on edge of rout in these areas.

Elsro 1191

This sealant is very flexible but has a major amount of crazing to partial depth cohesion loss. Small amount of failures due to crack on edge of rout.

Bakor 590-13A

Good performance. Quite flexible with only a small amount of crazing. However, there is approximately one quarter of the routes in bond failure due to 'crack on edge of rout'. More of the problem is at the west end in the narrow profile routes.

Crafco 522

Excellent performance with this product. It is the most flexible product at this sight. There is a slight amount of crazing and a small amount of 'crack on edge of rout'.

Husky 1611

Good performance. Slight amount of crazing to partial depth cohesion loss. This product is still flexible, but is the least flexible at this site. 'Crack on edge of rout' is causing about 15-20% bond failures.

Highway 56:12

Summary of sealant performance at this site:

1. Beram 195 continues to perform far better than the rest of the sealant products at this site.

2. Koch 9030 continues to perform poorly, although it is felt that these problems may be due to other factors such as segregation/poor workmanship/poor conditions at installation (moisture suspected).
3. Performance of the Elsro 1191 sealant is still questionable.

4. Hydrotech 6160 leaves no question as to its poor performance.

**Elsro 1191**

This product is quite flexible but has a major amount of crazing and sporadic full depth cohesion failure.

**Hydrotech 6160**

As last year, there is approximately 95% full depth cohesion failure.

**Koch 9030**

As last year, performance is poor with about a 50%-60% failure rate. Most of this is where the crack is on the edge of the rout. Most of the problem is loss of bond, with a small amount of loss due to cohesion stress.

**Beram 195**

Little change from last year. Excellent performance with only a slight amount of crazing and plow damage in the high areas of the pavement.

**Highway 63:00**

In general sealants on this project are showing more indications of stress this winter.

**Superflex 100**

This material was installed in the fall of 1994, but had failed by the following March. In the summer of 1995, the remaining material was pulled out and replaced by Beram 195. The re-sealed routes are showing good performance.

**Beram 195**

This sealant continues to perform very well. A small amount of material has broken out in chunks, possibly due to plows. There is a small amount of crazing in the NBL and a small amount of bond and partial depth cohesion breaks towards centerline on the SBL.

**Elsro 1191**

Cohesion stresses have progressed from last year at this time. There is also a major amount of partial to full depth cohesion loss.
Bakor 590-13A

Cohesion stresses have also progressed with this product. There is a significant amount of crazing and some sections have progressed to partial to full depth cohesion loss.

Koch 9030

This product continues to function well as a sealant. Crazing has progressed to a moderate amount of partial depth cohesion loss. Where some cracks have opened more than others have, cohesion loss is greater.

Hydrotech 6160

This product is not functioning as a sealant. Cohesion loss has progressed slightly from last winter, to almost total full depth cohesion loss.

Crafco 522

Very good performance overall. Slight amount of full depth cohesion loss with Moderate to major amounts of crazing.

Husky 1611

This product continues to function well as a sealant. Cohesion stresses have progressed since last winter. Major amounts of crazing with many cracks showing partial depth cohesion loss.

Highway 35:04

Overall performance of the sealants on this project range from excellent to fair.

Husky 1611

Excellent performance, most cracks are sealed.

Koch 9030

Excellent performance, small amounts of one-side bond failures.

Hydrotech 6160

Fair performance, evidence of cohesion failures.

Beram 195

Excellent performance.
Bakor 590-13A
Good performance, but with small amount of bond failures and cohesion stresses.

Crafco 522
Excellent performance.

General Observations made in February 1998

Highway 63:00
The Koch 9030, Crafco 522 and Husky 1611 products continue to perform far better than the rest of the products on this site.

Beram 195
This sealant has a total adhesion failure. Sealant is remaining in crack, which may be providing a plug once the cracks close during warm weather.

Elsro 1191
There is a major amount of partial to full depth cohesion loss and crazing.

Bakor 590-13A
Significant amount of crazing with partial to full depth cohesion loss.

Koch 9030
Slight to moderate crazing. This product continues to perform well as a crack sealer.

Hydrotech 6160
There is partial to full depth cohesion and adhesion failure.

Crafco 522
This product is performing very well. There is slight crazing in the under filled cracks.

Husky 1611
This product continues to perform well as a sealant. There is slight to moderate crazing of the product.
General Observations made in February 1999

Highway 63:00

From field observations the Koch 9030, Crafo 522 and Husky 1611 products are still performing well as a crack sealer. The Bakor 590-13A product has failed as many sections have broken out.

Beram 195

The Beram 195 sealant has adhesion failure and some sections have broken out in chunks in the wide profile. Material remaining in the crack may be providing a plug once the cracks close during warm weather.

Elsro 1191

There is a major amount of partial to full depth cohesion loss and some adhesion failure. However this material is still providing a seal when the cracks close during warm weather.

Bakor 590-13A

There is a significant amount of adhesion failure and partial to full depth adhesion loss. Many sections have broken out in chunks. One longitudinal crack was observed to be holding up.

Koch 9030

This product continues to function very well as a crack sealer. Some adhesion failure was observed, however the material is performing very well.

Hydrotech 6160

There is adhesion and full depth cohesion loss with this material. This material may still form a seal when cracks close during warm weather.

Crafo 522

This product is performing very well as a crack sealer.

Husky 1611

This product continues to function well as a seal. Some cracking of the sealant was observed but is performing very well overall.
Highway 56:12

Poor performance of all sealant products was observed cohesion/adhesion failures in all products. Elsro 1191 is marginally better than the other products on this site. Material still remains in cracks.

Highway 3:10

The overall performance of the sealant products on this site is good. There is some adhesion, cohesion failure that was observed, but no material loss.

General Observations made in March 2002

Highway 56:12 was seal coated in 1999; therefore no further observations were made after 1999.

Highway 63:00

The sealant products that are still performing well at this site are the Koch 9030, Crafo 522 and Husky 1611. The Bakor 590-13A product has failed with many broken out sections. The remaining sealant products may still be providing a plug but have shown various failure modes. Photographs of this site are available in Appendix ‘C’.

Beram 195

Sidewall adhesion failure, material remains in crack and may be providing a plug once the cracks close during warm weather.

Elsro 1191

There is a major amount of partial to full depth cohesion failure. There is no loss of material and it may be providing a plug once the cracks close during warm weather.

Bakor 590-13A

Significant amount of adhesion failure and partial depth adhesion loss was observed. Many sections of the crack sealant have broken out.

Koch 9030

Some sidewall adhesion failure, the sealant continues to perform well as a crack sealer.
Hydrotech 6160

Adhesion and full depth cohesion loss with this sealant was observed. There is no loss of material and it may be providing a plug once the cracks close during warm weather.

Crafco 522

Slight crazing, this product is performing very well as a crack sealer.

Husky 1611

This product continues to function well as a crack sealer. Some minor cracking of the sealant was observed.

General Observations made in April 2002

Highway 3:10

The Sealant products on this site are performing very well. The Bakor 590-13A product was noted to have sidewall adhesion failure. Some minor problems were observed with the other products at this site, however the sealant remains in the crack and is providing a seal. Photographs of this site are available in Appendix 'D'.

Bakor 590-13A

Sidewall adhesion failure, material remaining in crack, may be providing a plug once the cracks close during warm weather.

Husky 1611

Some minor crazing of the sealant product was noted along with minimal amounts of sidewall adhesion failure.

Elsro 1191

Isolated areas of sidewall adhesion failure were noted with this product.

Crafco 522

Some sidewall adhesion failure was observed with this sealant product.
General Observations made in June 2002

**Highway 35:04**

The performance of the sealant products on this site range from good to fair. The Bakor 590-13A and Hydrotech 6160 products are showing cohesion and adhesion failure. However, the sealant remains in the crack and is providing a seal. Photographs of this site are available in Appendix "E".

**Husky 1611**

This sealant looks very good; there is a minor amount of sidewall adhesion failure and slight crazing of the product.

**Koch 9030**

This sealant is performing well with moderate amounts of crazing. There are sections that have failed due to pavement failure.

**Hydrotech 6160**

There is adhesion and full depth cohesion loss with this product. This sealant remains in crack and may be providing a seal during warm weather.

**Beram 195**

The product is performing well with evidence of minor amounts of sidewall adhesion failure.

**Bakor 590-13A**

There is adhesion and full depth cohesion loss with this product. This sealant remains in crack and may be providing a seal during warm weather.

**Crafco 522**

This product is performing very well. Slight crazing of the sealant was observed. Some sections have failed due to pavement failure.

**Elson 1191**

This product has sidewall adhesion failure with moderate amount of crazing.
Appendix ‘C’

Highway 63:00, March 2002 Photographs
The original material placed in the fall of 1994 was “Superflex 100” which had 100% failure by March 1995. Beram 195 was installed in the summer of 1995. Observations on March 1, 2002: Sidewall adhesion failure, material remaining in crack, may be providing a plug once the cracks close during warm weather.

Beram 195 installed in 1994. Observations on March 1, 2002: Sidewall adhesion failure, material remaining in crack, may be providing a plug once the cracks close during warm weather.
Koch 9030 installed in 1994. Observations on March 1, 2002: This product continues to function very well as a crack sealer. Some adhesion failure was observed of the product. There was no materials loss noted.
Husky 1611 installed in 1994. Observations on March 1, 2002: This product continues to function well as a crack sealer. Some minor cracking of the sealant was noted, otherwise the sealant is performing very well.
Elsro 1191 installed in 1994. Observations on March 1, 2002: There is a major amount of partial to full depth cohesion failure. There is no loss of material and it may be providing a plug once the cracks close during warm weather.
Hydrotech 6160 installed in 1994. Observations on March 1, 2002: Adhesion and full depth cohesion loss with this material. There is no loss of material and it may be providing a plug once the cracks close during warm weather.
Crafco 522 installed in 1994. Observations on March 1, 2002: Noticed slight cohesion and sidewall failure; otherwise this product is performing very well as a crack sealant.
Appendix ‘D’

Highway 3:10, April 2002 Photographs
Bakor 590-13A installed in 1994. Observations on April 18, 2002: Sidewall adhesion failure, material remaining in crack, may be providing a plug once the cracks close during warm weather.

Husky 1611 installed in 1994. Observations made on April 18, 2002: This product is functioning very well as a crack sealer. Some minor crazing of the sealant was noted and minimal sidewall adhesion failure.
Elsro 1191 installed in 1994. Observations on April 18, 2002: This sealant is performing very well as a crack sealant. Isolated areas of sidewall adhesion failure were noted with this product.

Crafco 522 installed in 1994. Observations on April 18, 2002: Some sidewall adhesion failure was noticed with this product. This sealant is performing very well as a crack sealant.
Appendix ‘E’

Highway 35:04, June 2002 Photographs
Koch 9030: Pavement edge deterioration, which has created sidewall adhesion failure.
Crafco 522 installed in 1994. Observations on June 20, 2002: Slight crazing of the sealant was observed. Some sections have failed due to pavement failure.
Bakor 590-13A installed in 1994. Observations on June 20, 2002: This product has adhesion and full depth cohesion loss. The sealant remains in the crack and may be providing a seal during warm weather.
Hydrotech 6160 installed in 1994. Observations on June 20, 2002. This product has full depth adhesion and cohesion. The sealant remains in crack and may be providing a seal during warm weather.
Beram 195 installed in 1994. Observations on June 20, 2002: This sealant is performing well, there are minor amounts of sidewall adhesion failure.
Rout and Seal Profiles
DRAWING 1 - ROUT PROFILES

NARROW ROUT PROFILE

![Diagram of narrow rout profile with dimensions]

WIDE ROUT PROFILE

![Diagram of wide rout profile with dimensions]

Not to Scale
Appendix ‘G’

Provincial Map showing Rout and Seal locations