Cold climate condition survey of Asphalt-Rubber membranes

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COLD CLIMATE CONDITION SURVEY OF ASPHALT-RUBBER MEMBRANES

ABSTRACT

An evaluation of the application of Asphalt-Rubber in cold climates was undertaken to dispel the misconception that Asphalt-Rubber only works in hot, dry climates.

This survey was conducted on Stress Absorbent Membranes (SAMs) and Stress Absorbent Membrane Interlayers (SAMIs).

Climatic regions included in this study are dry cold, wet cold and frequent freeze thaw.

All Asphalt-Rubber projects were placed before 1983, the majority are more than 10 years old. Freeze index for these projects range from 500 to 4,500 degree days, with annual rainfall from 15 to 60 inches per-year.

The survey revealed early problems with the loss of cover aggregate, which improved as bar distribution, application rates and type of aggregates used, were modified.

In spite of aggregate loss, Asphalt-Rubber sealed and stopped crack reflection of alligator or block type cracks.

Without crack preparation with Asphalt-Rubber or other methods, Asphalt-Rubber as a membrane alone in SAMs and SAMIs have not been effective in stopping transverse cracking in cold climates. However, neither have other materials or methods. This study has revealed that large cracks must be pre-prepared.

Projects where transverse cracks were pre-prepared, did not reflect through the surface. Secondary cracking and spalling have been reduced even in the membranes.

Asphalt-Rubber in cold climates has the same improved properties in durability, flexibility and temperature susceptibility as it does in warm climates compared to standard asphalt under the same conditions. The survey indicates Asphalt-Rubber does last at least twice as long as standard asphalts, and in many cases, three and four times as long.

The mix and application procedures for Asphalt-Rubber in the late 1970’s are not the same today. Many problems are attributable to the learning process in the development of Asphalt-Rubber.

There is also a tendency to forget the original pavement condition and make a critical evaluation of Asphalt-Rubber applications by the condition of the pavement today.
INTRODUCTION

Since the introduction of Asphalt-Rubber to Roads and Streets in the late 1960's, several thousands of miles of Asphalt-Rubber have been applied. Documented reports have been published on its historical use. The greatest amount of this documented work has come from the Southwestern portion of the United States. As a result of the success of Asphalt-Rubber primarily in Phoenix, Arizona, where it was conceived and developed, a misconception has evolved that Asphalt-Rubber performs only in hot, dry deserts and should not be considered in other climates.

Asphalt-Rubber has been used in every climatic condition in North America. The results are similar.

This report is on the performance of Asphalt-Rubber in cold climates. Four regions using Asphalt-Rubber placed prior to 1983 were inspected for this study. All climates are considered cold, although not all have the same moisture conditions. The index of degree days is more than 500. The study areas are as follows:

1. **Saskatchewan, Canada**
   - Temperature Range — -40°F to 99°F.
   - Freeze index - 3,500 to 4,500 degree days.
   - Rainfall - 15" to 60".

2. **Sterling, Massachusetts**
   - 1979 Construction.
   - Freeze index - 500 degree days.
   - Temperature range — -30°F to 95°F.
   - Rainfall - 60".

3. **Minnesota**
   - More than 30 miles of Asphalt-Rubber has been placed in Minnesota since 1978. In 1978 and 1980 these applications were part of a test series of SAM and SAMI compared to thicker overlays, soft asphalt cements, fabrics, carbon black and sulfur extended asphalts. (8) A Stress Absorbent Membrane Interlayer, (SAMI), with changing overlay thickness and levels of Asphalt-Rubber layers, was placed in 1983. (8, 9 & 10). The freeze index for Minnesota is from 1,500 to 2,500 degree days for the four projects. Rainfall is 30 to 40 inches with temperature ranges of — -30°F to 100°F.

4. **Arizona**
   - Arizona's Department of Transportation has placed more than 287 miles of Asphalt-Rubber as a SAM or SAMI since 1972. Approximately 17 miles were placed 7,000 feet or higher, and 36 miles were placed at 6,000 feet or higher. The freeze index at 7,000 feet in Arizona is 900 and the index at 6,000 is 800. Both high elevation areas where Asphalt-Rubber was applied, receive 14 to 20 inches of annual precipitation. All high elevation projects in Arizona have some of the greatest freeze-thaw cycles in the country.

HISTORICAL BACKGROUND

**Saskatchewan**

From 1978 through 1983, 701.2 kilometers of Asphalt-Rubber Stress Absorbent membrane were placed.

Saskatchewan officials became interested in Asphalt-Rubber in the 1970's. The potential for stopping reflective cracking and the resilient properties were considered very beneficial. The first trial was in 1971 and was reported in the 1984 Canadian Technical Asphalt proceedings by J. L. M. Scott. (6).

In 1978, about 33 Km over eight projects had been placed on existing asphalt pavements, oil treatments, aggregate base, and on subgrades.

The next year, 1979, 182 Km were placed on subgrades and sealed subgrades, based on a preliminary assessment that Asphalt-Rubber would perform equal to oil treatment. There were problems in obtaining a satisfactory ride. Data on this application can be found in the 1979 Proceedings of the Canadian Technical Asphalt Association. (2).
In 1980, 143 Km were placed on granular pavements. The 1981, 1982 and 1983 work demonstrated that fatigue cracking can be sealed. Saskatchewan Highway Engineers said, “this is the first project that has not had reflective cracking show through”. It has replaced or at least delayed the need for an overlay for several years.

Pavement conditions before the Asphalt-Rubber seal was placed include fatigue block cracking, some pot holes, wet subgrades, compaction planes and wet shoulders.

A 1982 report by Mr. G. H. Heiman, (1), indicated the Saskatchewan performance of the Asphalt-Rubber was as follows:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Poor</td>
<td>7%</td>
</tr>
<tr>
<td>Poor</td>
<td>5%</td>
</tr>
<tr>
<td>Fair</td>
<td>21%</td>
</tr>
<tr>
<td>Good</td>
<td>22%</td>
</tr>
<tr>
<td>Very Good</td>
<td>45%</td>
</tr>
</tbody>
</table>

The subgrade and poor weather conditions at the time of application caused the very poor performance.

A visual inspection was made by the author in the summer of 1987. Comments and observations are included here.

Climatic conditions on the Saskatchewan projects vary from a cold dry condition in the Southwest to a cold wet condition in the Northeast. Thermal conditions cause very large transverse cracks at intervals of 20 to 30 feet. Asphalt-Rubber membranes alone cannot stop this force, nor can it bridge it. The Freeze index is 3,500 to 4,500 degree days.

Average daily traffic is from 350 to 6,300 with an over-all average of 1,650 ADT.

Sterling, Massachusetts

On Highway 12 off Interstate 190 in Worcester County, Massachusetts, a series of six test sections were placed in 1980. Some sections are on a portland cement concrete pavement placed in 1950. The P.C.C.P. slabs are 57’ x 10’, three slabs wide or 30 feet with added shoulders of 3 to 6 feet for a total width of 40’+. Average rainfall is 65” with temperatures from —30°F to 90°F.

The six test sections in this project were compared to a pavement design section on the Interstate and a railroad bridge approach, all constructed in 1980. These are considered standard designs for pavement in Massachusetts. Sections are shown below:

<table>
<thead>
<tr>
<th>Section</th>
<th>Existing Pavement</th>
<th>Test Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Asphalt Concrete</td>
<td>2 1/4” of AC overlay directly on P.C.C.P. Saw cut directly over existing P.C.C.P. joints and filled with Asphalt-Rubber.</td>
</tr>
<tr>
<td>B</td>
<td>Asphalt Concrete</td>
<td>Crack sealed, Asphalt-Rubber Stress Absorbent Membrane Interlayer, 2 1/2” of AC overlay.</td>
</tr>
<tr>
<td>C</td>
<td>P.C.C.P.</td>
<td>Crack preparation with “Band-Aid” Asphalt-Rubber strips. Asphalt-Rubber Stress Absorbent Membrane Interlayer, 2 1/2” AC overlay.</td>
</tr>
<tr>
<td>D</td>
<td>P.C.C.P.</td>
<td>2 1/4” AC overlay for control section. No crack preparation.</td>
</tr>
<tr>
<td>E</td>
<td>Asphalt Concrete</td>
<td>Crack preparation with “Band-Aid” Asphalt-Rubber Strips, 2 1/4” AC overlay. Saw cuts over existing P.C.C.P. joints and fill cut.</td>
</tr>
<tr>
<td>F</td>
<td>Prepared Native Soil</td>
<td>9” of AC</td>
</tr>
</tbody>
</table>

Average daily traffic is 5,000 to 10,000.
A "Band-Aid" is the application of a polymerized sealant covered with a 12" fiberglass strip and again covered with a sealant.

The Stress Absorbent Membrane Interlayer is Asphalt-Rubber applied at 0.6 gallon-per-square-yard followed by 35 pounds per-square-yard of 3/8 precoated cover aggregate.

Sawed joints were cut directly over the constructed joints in the portland cement concrete pavement.

**Minnesota**

Four projects utilizing Asphalt-Rubber as a SAM and SAMI were applied by the Office of Research and Development, Minnesota Department of Transportation, in cooperation with the Federal Highway Administration. These studies were to evaluate the ability of several methods to prevent reflective cracking of a bituminous overlay on portland cement concrete pavements and asphalt concrete pavements.

Asphalt-Rubber was included as a SAM and SAMI in four of the 10 methods. A detailed description is in the 1987 survey portion of this report.

Minnesota climate is similar to its neighbor to the north, Saskatchewan, with freeze indexes of 1,500 to 3,000 degree days and precipitation of 30 to 40 inches per-year. Thermal cracking is a major problem and cracks appear at intervals of 20 to 40 feet. The original concept was to eliminate thermal cracks with interlayers using Asphalt-Rubber, fabrics, deep lift overlays, and breaking and setting the existing pavement, followed by the overlay.

Their results indicated thermal cracks cannot be eliminated using a membrane alone, which is similar to the Canadian experience. Rubber in combination with thick lifts appeared to give the best surface with the least amount of reflective cracking.

The SAM gave a good performance, however, cracking was a block or alligator type elimination rather than thermal.

**Arizona**

Arizona is not normally considered a cold weather area as compared to Canada, Massachusetts or Minnesota. Nonetheless, Asphalt-Rubber was applied in elevations of 6,000 to 7,200 feet in freeze indexes of 800 to 900 degree days, with annual precipitation of 14 to 20 inches. The freeze-thaw cycles are in excess of 500 per year.

In 1976 and 1977 some 18 miles of Asphalt-Rubber was applied as a SAM to U.S. 180, Northwest of Flagstaff. See Photo 1.

1. SAM showing transverse cracks after nine years, Flagstaff, Arizona.
This area has a freeze index of 900, and 20 inches of annual precipitation. The pavement section in 1976 was 3.5 inches of asphalt. There were no crack evaluations made in 1976, however, the pre-existing surface did have an excess of 50% cracks.

In 1980, the ADOT Pavement Management System began its evaluation of U.S. 180. The percentage of cracks has remained the same.

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>2%</td>
</tr>
<tr>
<td>1981</td>
<td>2%</td>
</tr>
<tr>
<td>1982</td>
<td>2%</td>
</tr>
<tr>
<td>1983</td>
<td>3%</td>
</tr>
<tr>
<td>1984</td>
<td>2%</td>
</tr>
<tr>
<td>1985</td>
<td>3%</td>
</tr>
<tr>
<td>1986</td>
<td>4%</td>
</tr>
</tbody>
</table>

The as-built structural number has remained at 1.85 average since 1980. There has been some maintenance since 1976, however this data is not available. Based on the original condition, the Asphalt-Rubber has performed well for 11 years. ADOT is planning a major reconstruction or resurfacing because of the high summer traffic to the Grand Canyon and to the ski area in the winter.

In 1976, seven miles of Asphalt-Rubber was placed as a SAMI followed by three inches of asphalt concrete on U.S. 666. The elevation is 5,725 feet with a freeze index of 750 and 14 inches of annual precipitation.

Performance has been good, and nothing has been done to the pavement since 1976.

In 1979, several sections of Asphalt-Rubber as a SAM and a SAMI were compared with fabric and recycling, including heater scarification, for U.S. 60 at Springerville. This work is being evaluated by ADOT and a report will be forthcoming. Freeze index for the Springerville area is 800 to 900, and it receives about 14 inches of rain per-year. The rubber application has performed equal to any other test section as of January 1988.

Arizona has more than 280 miles of Asphalt-Rubber as a SAM or SAMI on its highway system, with 36 miles of it in cold climate areas. Several reports have been published by ADOT, and others will be issued on Asphalt-Rubber in the future.

**Method of Evaluation**

The evaluation consisted of a visual inspection of the project in each region, recording the amount and degree of alligator or block, transverse and longitudinal shrinkage cracking and raveling. Comparisons are made with the standards of that region.

**SURVEY OF CONDITION 1987**

**Saskatchewan**

Inspection reports of the 300 Km surveyed in 1987 are too voluminous for this report, however they are available on request.

The 1978 application of Asphalt-Rubber indicated stone retention was satisfactory with some snow plow damage. Bar distribution appeared to be a problem on the outside spray tips as indicated by Photo 2.

Projects placed in 1980 were on granular subgrades and existing pavements. Most of these pavements have been overlayed since 1982. Maintenance personnel described performance prior to the overlay as very good to fair.

The 1981 Asphalt-Rubber seal application was primarily for pavement rehabilitation. It revealed that fatigue cracking could be sealed.

Worst climatic conditions were found in Nipawin with -50 F. and 60 inches of annual moisture, mostly snow. Asphalt-Rubber sealing placed on Highway 35 in 1981 is in very good condition as shown in Photo 3.
2. Loss of aggregate cover at outside bar tips, Saskatchewan.

Crack reflection appears to be minimized, however it has not stopped. Transverse cracks are very prominent. Evaluation of the 1978 seals ranged from fair to very good.

In 1979, applications were placed directly on an untreated subgrade or a subgrade that had been oiled. There were some problems in obtaining a satisfactory ride. Chip loss was considerable and continued each year. Shoulders broke down causing maintenance problems. Most of the 1979 project has been overlayed or reconstructed.

3. Highway 35, Saskatchewan.
Asphalt-Rubber was placed on cold mix and granular base pavements, standard seals and granular bases. All of these applications have replaced or at least delayed the need for an overlay for several years. Very positive comments were expressed by District personnel to the author. Overall performance was rated fair to excellent. A 1981 application in the dry, West half of the Province did have 20-40% chip loss with rapid raveling and roping evident, some areas were re-sealed. Transverse cracks have been repaired in some areas, however they are pronounced. See Photo 4.

4. SAM, 1979 application showing typical transverse cracks.

Application of Asphalt-Rubber in 1982, on Highway 12 out of Saskatoon had chip loss from 5 to 25%. Cracks have not reflected through except for transverse cracking. Some of the areas have excellent surfaces with no cracks, while others indicate some crack reflection.

Highway 7 at McGee had an excellent surface with only transverse cracking. See Photo 5.

5. Typical SAM application on a treated base after nine years, Highway 7, McGee, Saskatchewan.
Saskatchewan’s Department of Transportation discovered a major distribution difference across the spray bar application of the Asphalt-Rubber. This was very obvious in the 1981 and 1982 work. Center and outside edges of the pavements lost 75% of aggregate cover. The problem existed prior to 1981, based on observations.

Applications of Asphalt-Rubber in 1983, were applied to pavements with more than 3,000 ADT, such as the Trans-Canada highway. These surfaces are in good condition with some raveling. However, even with the high percentage of chip loss, the remaining Asphalt-Rubber appears to be stopping crack reflection. See Photos 6 & 7.


7. Water coming through a crack that stops at the SAM, Saskatchewan.
The first year of the 1983 application did have variable chip loss. These surfaces were fog sealed with an emulsified asphalt. Fogging did stop the flying rocks however, the Ministry of Transportation decided to stop this work.

An inspection revealed the Asphalt-Rubber was doing what was intended, keeping fatigue blocking substantially sealed for at least four years. In some cases it has been nine years. See Photo 8.

8. Typical alligator and block cracking with a SAM. Note the SAM has stopped this distress.

Sterling, Massachusetts

This Asphalt-Rubber application was inspected in April of 1987, and with some work done in Rhode Island in 1979. Also reference is made herein to the Report by Dr. Charles E. Dougan, Director of Research and Materials, State of Connecticut, Department of Transportation.

Sterling's project is now eight years old. The standard section off of the Interstate was 9 inches of asphalt concrete, constructed in 1980, after the experimental sections. See Photos 9 and 10 for cracking conditions. Inspection in 1987 revealed more than 3,300 feet of cracks.

9. Control section showing typical transverse cracking in full-depth asphalt concrete design, Sterling, Massachusetts.
The saw cut section with the "Band-Aid" joint preparation is performing well. There are 150 feet of random cracking between saw cuts. The joint filler is not bonding to the asphalt, causing water penetration. See Photo 11.

Secondary cracking has also developed at the saw cut joints. See Photo 11 & 12.
12. Saw cut over existing P.C.C.P. joints, Sterling, Massachusetts.

There are more than 3,380 feet of cracks in the control section, as shown in Photos 9 and 10. The saw cut section with no Band-Aid or Asphalt-Rubber SAMI has 3,363 feet of cracks. Pot holes have developed at the saw cut joints.

On the Asphalt-Rubber section (SAMI) there are 95 feet of cracks. Forty feet is at the beginning of the test section where it is believed the application rate was less than specified. See Photo 13.


Sterling test sections show the Asphalt-Rubber is preventing crack reflection by 97% of the control section or the saw cut section with no Asphalt-Rubber or “Band-Aids”. Asphalt-Rubber in the saw cut
section with a SAMI and the “Band-Aid” has twice the cracks than the SAMI with no “Band-Aid” and no saw cuts.

In the State of Connecticut, the project is a portion of Route 79, and was constructed in 1980. It consists of a 898-foot section compared to the standard of Connecticut overlays by the maintenance improvement program. From 1983 through 1985 there was a marked increase in cracking in the standard section from 4.8 to 39 feet per 100 feet. The Asphalt-Rubber showed very little change, 3.0 feet per 100 feet. A 1986 survey showed the cracking at 9.2 feet per 100 feet and the control section at 82 feet per 100 feet. A report by C. E. Dougen (7) concluded, “After six years of service, the Asphalt-Rubber concrete (Modified Connecticut DOT Class 2) mix on Route 79, in Madison, has performed better than the Standard Class 2 Control Mix.”

Rhode Island’s Asphalt-Rubber application inspected in 1987, was a Stress Absorbent Membrane (SAM) with 1/2-inch maximum size aggregate cover. This project is on the Narragansett South Pier Road placed in 1979. The surface is very good. Some cracks are evident, however they seem to heal every summer. More than 60 inches of annual precipitation is received in this area, and temperatures range from 0°F to 90°F.

Arizona

Arizona’s Department of Transportation Research Center at Arizona State University, has evaluated Asphalt-Rubber applications. A report will be published in 1988. Cold climate applications will be included in this report.

High elevation, cold climate applications were surveyed by the author in December 1987. Evaluations were made in the same manner as other climate applications in this report.

The Springerville application on U.S. 60, above 7,000 feet, was placed in 1972-74, as a SAM. There are seven sections on U.S. 60, six have received additional treatment after six years. None of the other SAMs placed on U.S. highways in Arizona have been retreated, and all are still performing after 10 to 13 years.

In Flagstaff, the application was on U.S. 180 at 7,200 feet, and was placed in 1977, as a SAM. This same route also received a SAMI and 2.5 inches of asphalt concrete overlay in 1976.

Pavement management crack data indicated 20-30-percent of the pavement cracked in the first five years, and then only increased by 0-to-3-percent for the next seven years. Cracks surveyed in 1987, are mostly transverse cracks as reported in the Saskatchewan and Minnesota evaluations. See Photo 1.

ADOT’s report in summary states “The SAM and SAMI sections show very little cracking after several years of service.” Asphalt-Rubber layers are effective in preventing reflection cracking. Transverse cracking is ongoing, and should be handled as a separate problem.

Minnesota

The first project to use Asphalt-Rubber was in 1978 when the Minnesota Department of Transportation placed 16.8 miles of a specified leveling course. They used four methods to reduce pavement failure as a result of reflective cracking. They are:

1. Asphalt-Rubber Seal Coat, Stress Absorbing Membrane (SAM)
2. Asphalt-Rubber, Stress Absorbing Interlayer (SAMI)
3. Full Width Fabric Treatment
4. Asphalt Additives (Carbon Black and Sulfur)

These were further compared with control sections using 85/100, 120/150 and 200/300 pen grade asphalt cement.

A 1987 Minnesota Department of Transportation report by Tom Ravn, Ron Cassellius and Roger Olson, advises that none of the methods used in the study were totally effective. There was a consistent crack pattern of transverse temperature cracks at about 40 feet in all test sections. This is consistent with the other region results.

Its conclusions reveal Asphalt-Rubber interlayers (SAMI) were somewhat effective in reducing reflective cracking. Overlays with 1 1/2 inches as opposed to 3/4” in thickness were more effective.
The Asphalt-Rubber Seal Coat (SAM) is performing effectively when compared to the controlled wearing course.

Average daily traffic is from 8,600 to 1,000 on Highway 63 in the Southeast section of Minnesota with 30 inches of rain and a freeze index of 1,500 degree days.

A second project is on Highway 10 in the Northwestern section, a 1957 and 1958, 8-inch concrete pavement with 6,500 ADT. Freeze index is 2,250 degree days. It was placed to develop a method to prevent reflective cracking, as was the first project, except on P.C.C.P. This was overlayed in 1980.

Four methods were used to prevent reflective cracking as follows:
1. Saw cut the P.C.C.P. to reduce panel size.

Twelve research sections were included in the construction of this project. Specified 5 1/4 inches of bituminous overlay was held constant over the length of the 24-mile project.

Three Asphalt-Rubber stress absorbing membrane interlayers were constructed at three different depths in the overlay. An Asphalt-Rubber interlayer was placed on top of the existing P.C.C.P. (bottom of overlay), at one-inch above the P.C.C.P. and at three inches above the P.C.C.P.

A 1985 report by Harvey S. Allen indicated none of the materials or methods were totally successful in preventing reflective cracking in the overlay. The Asphalt-Rubber interlayer was more effective when placed on the existing P.C.C.P. Of the methods and materials evaluated, saw-cutting of the panels and the Asphalt-Rubber interlayer were the most successful in reducing reflective cracking.

A third (1983) project in the Southwestern portion of the State is on Highway 19. It included four research sections using Asphalt-Rubber interlayers, (SAMls), prior to variable thicknesses of asphalt concrete overlays on P.C.C.P. See Photo 14.

14. Test section, Highway 19, Minnesota, SAMI.

Four sections test are:
1. Control Section, four-inch overlay, no SAMI.
2. Three-inch overlay, no joint repair, SAMI
3. Four-inch overlay, Asphalt-Rubber joint sealant, SAMI.
4. Four-inch overlay, no joint repair, SAMI.

Existing P.C.C.P. was cracked, prior to the SAMIs and overlays, every four feet by a mechanical pavement breaker.

A Minnesota Department of Transportation report by Harvey Allen and Karl Keel in 1985 (10) contains the following observations:
None of the methods totally stopped reflective cracking. The four-inch overlay had significantly reduced reflective cracking. Observations are for a short period of time and it is reasonable to expect that the final findings could change.

**Comments**

It is obvious that Asphalt-Rubber as a membrane or an interlayer has been successful in the cold climates. Past publications issued have usually dealt with warm dry climates. There are other projects in the cold climate areas that have not been included here.

Saskatchewan projects were designed to stop reflective cracking from fatigue blocks. It did that for more than five years and up to 10 years. Several trials on many types of pavements and bases were attempted with limited success. However, they all have out performed anything else that has been attempted.

Asphalt-Rubber still has its limitations just as any asphalt has, however, the addition of rubber has improved the product to perform under wider conditions.

A major concern in cold climates is transverse cracking. Thermal forces that exist in the pavement and the loss of flexibility due to temperature reduction has caused large active cracks. Asphalt-Rubber as a membrane has not been able to bridge this. It appears that no other method has been able to solve this problem. Research by Dr. McCleod and others have made some inroads into temperature susceptibility.

Many of the problems in Saskatchewan were due to the learning process as indicated by the Highway Engineers. Corrective actions were taken. These include improving the construction techniques. Keeping the construction train very close. Adjusting fall or spring application for conditions. Poor bar distribution created raveling at the outside tips. This was corrected along with improvements in the aggregate. Flush coats stopped raveling in 1983 very well.

Minnesota's applications of SAMIs did not stop reflective cracking, nor did any other method. Reflective crack prevention methods in Minnesota are still being evaluated. Continued study may bring out new and different solutions.

Cold weather conditions did not reduce the Asphalt-Rubber properties any more than the standard asphalt when compared to themselves. Asphalt-Rubber had a greater resistance to temperature susceptibility to the cold climatic conditions than did any other material.

**Conclusions**

Saskatchewan projects suffered chip loss that concerned the Transportation Department in the first-year. Several corrective measures were applied, which improved the reduction of the chip loss. About the time chip loss was controlled the process was stopped by Transportation officials.

Asphalt-Rubber did what was intended in Saskatchewan and that was keeping fatigue blocking substantially sealed for at least four years.

The Asphalt-Rubber has lasted two to three times longer than any other seal in Saskatchewan, even in the areas where severe chip loss took place the first-year. Application of the Asphalt-Rubber sealed the pavement and retarded reflective cracking. Asphalt-Rubber on treated bases has performed very well in areas of 4,500 degree day freeze index. In Saskatchewan, Asphalt-Rubber has sealed and reduced maintenance for more than nine years.

Asphalt-Rubber membranes alone have not stopped transverse cracking, however this condition may be retarded using Asphalt-Rubber as a crack filler. This is a major problem in cold climates. Sterling, Massachusetts, Rhode Island, and the Connecticut projects in the Northeastern portion of the United States indicate a strong advantage in using Asphalt-Rubber. After eight years, Asphalt-Rubber applications have out performed the standards used by various agencies. Follow-up reports have documented performance of the Asphalt-Rubber applications.

Use of Asphalt-Rubber as a SAMI in cold climates based upon Minnesota research is still being investigated. Although none of the methods used prevented reflective cracking, the Asphalt-Rubber appeared to perform the best. Perhaps a combination of methods and materials should be considered, such as Asphalt-Rubber interlayer with an Asphalt-Rubber concrete followed by a SAM.

In cold climates, the problem of transverse cracking has not been solved. Asphalt-Rubber membranes alone have not stopped these crack reflections, but the inspection survey indicates the crack is retarding water infiltration from the surface. Further, the membrane has retarded secondary cracking and spalling. Transverse cracks need to be pre-prepared prior to a membrane by filling with a material
capable of tolerating the force that caused them. Asphalt-Rubber has shown to be good in the mild and warm climates of the world as a crack filler.

There is a tendency to forget the original pavement condition and make a critical evaluation of Asphalt-Rubber application by the condition of the pavement today. Asphalt-Rubber is not capable of solving all problems, nor would an engineer expect it. Proper engineering and practical economics need to be included for the evaluation and design.

END

REFERENCES


