EVALUATION OF MATERIALS AND METHODS FOR BITUMINOUS PAVEMENT CRACK SEALING AND FILLING

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in cooperation with
The Local Road Research Board
FOREWORD

The intent of this report is to review the options available for treating cracks before more extensive repairs are needed. Recommendations are made where appropriate.

The author wishes to acknowledge the contributions of the Area Maintenance Engineers' Task Force on Transverse Cracks in Asphalt Cement Pavements whose members include; Andrew Sotebeer (Chair), Kenneth Wasnie, Robert Lackmann, Dennis Luoto, Harlan Van Heel, Roger Olson, Gerald Tieg, John Sampson and the author. Groups which also made significant contributions toward this report include Mn/DOT Aeronautics Section, Albany Industries Inc., Con/Spec Inc. and Construction Materials Inc. as well as Mn/DOT District Maintenance and Wright County Maintenance traffic control personnel.

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented. The contents do not necessarily reflect the official views of Mn/DOT or the LRRB. This report does not constitute a standard, specification or regulation.
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1. BACKGROUND

The most common form of asphalt pavement distress is cracking and the subsequent destruction from the intrusion of water.

Some crack patterns such as alligatoring and longitudinal cracks in the wheel paths suggest structural deficiency and require at least partial reconstruction to rehabilitate the pavement adequately. This type of crack can be eliminated through proper pavement design and base drainage. Thermal transverse cracks, reflective cracks, and block cracking are, as yet, unavoidable facts of life for an AC pavement. If left untreated, the intrusion of water, coupled with climate and traffic, can lead to multiple cracking, lipping, spalling and/or cupping due to stripping of the underlying material. Proper and timely treatment can limit these problems and greatly extend the life of an AC pavement.

Crack treatment strategies include sealing and filling. A crack which has reached advanced stages of deterioration requires a repair scheme. Crack repair options presently employed in Minnesota include fine mix patching, tight blading, transverse mill and repair, and overlays. Other areas have used asphalt slurry overbanding and sulfur slurry overbanding crack repair techniques. Due to the wide variety of repair types, this report will emphasize filling and sealing as a means to delay the need for repairs.

Test sections employing various sealing and filling materials and techniques were constructed on T.H. 242 in Coon Rapids and T.H. 212 west of Chaska in 1982 and on Wright Co. CSAH 75 in Monticello on 1988. Experience from these and other sites (including airport runways) and information from the National Value Engineering Study of the Repair of Transverse Cracks on Asphalt Pavement, 1988, and the parallel Mn/DOT Area Maintenance Engineers Task Force Report on Transverse Crack Maintenance Strategies for AC Pavements, December 21, 1988 formed the basis of this report.

As was previously mentioned, bituminous airport runways were examined to gather information for this report. The methods and materials discussed in this report have direct applications for runways. However, runways may exhibit transverse crack spacing of 100 feet plus. The amount of movement at each of these cracks may be beyond the abilities of these materials. Sawing and sealing relief joints (See NOTE) between widely spaced cracks has been somewhat effective in reducing the movements in the individual cracks and joints, thus allowing the sealers to perform effectively. It is more effective to cut the relief joints in a new pavement before a crack pattern is established. This point aside, the information presented in this report has direct applications for all bituminous pavements including airport runways, parking lots and highways.

NOTE: Sawing and sealing relief joints in bituminous over portland cement concrete overlays, bituminous over bituminous overlays and in new full depth bituminous construction is being investigated by the Physical Research Unit under a separate study.

2. SEALING

Sealing is defined as placing material in a crack to create a water tight barrier. It differs from filling in that filling only coats the edges of the crack and allows water to flow through the crack. Prohibiting or minimizing water intrusion is a high priority since it leads to stripping, pumping and freeze/thaw decay. The intrusion of incompressibles is also eliminated. The earlier the detrimental effects of water and incompressibles can be prevented, the better the chance of extending a pavement's life. Thus, sealing should occur as soon after the crack develops as possible.

To limit sealant failures due to seasonal crack opening and closing, it is preferred to seal cracks during the moderate temperatures of spring and fall when the cracks are open an average amount. Material manufacturers suggested limitations include minimum ambient temperatures of 40 to 50 degrees F and prohibiting application if the pavement is damp.
The goal of all crack preparation methods is to provide favorable conditions for proper bonding of the sealer. The available methods include creating a reservoir by sawing or routing, cleaning and drying the crack, and providing a bond break at the bottom of the seal.

IS A RESERVOIR NECESSARY?

Getting sealant material into the crack, with or without a reservoir, greatly increases the performance of a seal as opposed to creating a membrane over the crack.

A reservoir is created by either sawing or routing a recess into the crack. The intent is to furnish room for ample material to be applied, create a desirable seal shape, provide uniform surfaces for the sealant to adhere and allow the sealant to be applied slightly recessed thus avoiding tracking and possible damage to the seal by traffic or plows. Creating these features is needed when one is sealing closed narrow cracks (less than 1/2’’). Wider cracks already possess most of these traits.

Opponents to sawing/routing feel that sealing at the proper time of year when the crack is at its average size and applying a squeegee overband addresses the same concerns with less time, equipment, and manpower. Some feel the process actually damages the pavement due to the equipment’s inability to follow the crack at all times and by possibly creating secondary cracking.

Creating a reservoir is beneficial, however it is time consuming. Even though the equipment is relatively inexpensive ($4000—$5,000), more than one machine may be required to facilitate acceptable sealing productivity. Since much contract work is performed during the mid summer when cracks are tightest, requiring sawing or routing should be included in the specifications.

WITH RESERVOIR

If creating a reservoir is deemed necessary, the choice between sawing or routing must be made. A saw uses a single blade to cut a smooth walled reservoir, a router applies multiple percussion type blades which produces rougher edges. The more square notch and uniform sidewalls made by the saw are preferred, however the multiple blade design of the router may make it slightly more maneuverable. Sawing can be done either wet or dry. Dry sawing is preferred since wet sawing creates a sticky latency which must be removed from the crack before the sealant is applied. Routing in bituminous is a dry process. Due to the trade-offs involved and the continuous updates being made in both technologies, no definite recommendation can be made at this time on the selection of sawing vs. routing.

When purchasing equipment, speed, accuracy, maintenance (blade replacement) and equipment cost must be gauged before choosing between routing or sawing. Since the two processes are comparable, a contract specification should concentrate on the size/shape of reservoir and not on the method employed. Sand blasting should be required when wet sawing is used.

Shape factor is the term which describes the reservoir dimensions. A reservoir which is wider than it is deep will lessen the stress on the sealer during joint expansion. See Figure 1 on following page. When backer rod bond breaker is used a deeper cut is required to provide room for its placement.
Two basic concepts are offered for placing the sealer in a reservoir. The first is to apply a slight overband (see Figure 2a below). The overband limits cohesive failures and reinforces the edges of the reservoir. The second is to apply the material slightly recessed as in Figure 2b. This should be done when the edges of the reservoir are sound and when a soft material, which may be susceptible to plow damage or tracking in hot weather, is used.
WITHOUT RESERVOIR

If it is determined that a reservoir is not necessary, an over band type application method is suggested. Sealant should be poured into the crack and a strike off or squeegee should be used to create the desired cross-section. An example of a good overbanded crack cross-section is shown below in Figure 3.

![Diagram of crack cross-section](image)

**FIGURE 3**

Traffic must not be allowed on the surface until the material is properly cured or tracking will occur. Under body plows or motor graders may damage the overband. Some agencies have found that overband crack sealing is especially effective when done prior to a chip seal coat.

CLEANING AND DRYING

Several methods of cleaning and drying are available. Cleaning and drying is a high priority since even the best sealant will not bond in a dirty or moist crack. If a proper bond between sealant and pavement is not created, the activity has failed at the outset. The methods available include brushing or sweeping, blowing with compressed air, sand blasting and heat lancing.

--- Brushing and Sweeping

Brushing or sweeping the crack is the simplest and most available method. It will remove the large material but much of the fine dust will remain. No drying can be expected. This is the least effective cleaning method and is best used as a first step followed by blowing, sand blasting and/or heat lancing.

--- Compressed Air

Blowing with compressed air is effective at removing both large particles and dust. Some drying might be expected, however blowing may actually force the compressed air's humidity into the crack. It is essential that the compressor, air lines and all other equipment used to blow out cracks be oil free. The compressor and hoses used during some of the sealing on the TH 212 test sections had been previously used with a jack hammer. The residual oil in the system materialized in the crack and precluded any hope of achieving an adequate bond. Many states recommend or specify a minimum air blast of 100 psi. Using compressed air is both an effective and readily available method for crack cleaning.

Back pack or “leaf blowers” have been used for some of the test section placements. This equipment is very mobile since the operator carries the entire unit. Their cleaning capability appeared to be a step up...
from sweeping, however due to the relatively weak air blast created, they are not as effective at removing residue as using compressed.

— Sand cleaning/blasting

Sand cleaning not only removes dirt and dust but also strips away any loose particles. Routing and dry sawing may leave loose particles and wet sawing creates a wet sticky material. Sand cleaning helps to alleviate all of these problems. Although very effective, sand cleaning is not recommended for widespread use due to the specialized equipment and material required. It should be required when wet sawing is used, and considered for use on specialized pavements such as airport runways.

— Heat Lance

The newest cleaning/drying technique is the use of a heat lance. A heat lance is a high temperature air blast created by heating compressed air with a propane source. Temperatures can reach 3000 degrees F. The crack can be cleaned and dried simultaneously. However, excessive heating may scorch the asphalt and weaken the bituminous pavement. To avoid this problem, the crack should be swept and/or blown clean prior to use of the lance. This will limit the required application time for the heat lance to perform its function. Safety is of the utmost concern when dealing with such high temperatures and combustible materials.

The use of a heat lance is highly recommended and is particularly effective for night work, early morning work or other damp (but not wet) conditions.

**BOND BREAKER**

The purpose of bond breaker is to prevent the sealant from adhering to the bottom of the crack. Sealant adhering at the bottom of the crack, where the crack faces touch, may tear when the crack opens. This is primarily a concern when a reservoir is used.

Types of bond breakers include grease or other liquids, masking tape and foam backer rod. Liquids are difficult to handle and may destroy the bond completely if not properly applied. Masking tape is simpler, yet application is also worker intensive. Backer rod, a foamed rubber dowel, is the easiest to place and the most expensive. Backer rod may be utilized in wide deep cracks to create an artificial bottom to limit the amount of sealant required.

Due to the application difficulties, liquid and masking tape bond breakers are not recommended for use in random cracks. Backer rod is effective as a bond breaker in saw cut or routed random cracks and as an artificial bottom in wide deep cracks. The theory for using a bond breaker is sound, yet Mn/DOT does not have adequate field experience to make a recommendation on their use.

**2.B SEAL MATERIALS**

The requirements for a proper seal seem simple; stop water from entering the crack. To do this the sealant must adhere to the pavement, resist ripping, remain pliable during extreme cold and not liquify at high temperatures. Many materials exist which meet each of these criterion to some degree. A analysis of data from the crack sealing operation performed in Mn/DOT District 5 found that the cost of materials to be 24 percent of the total sealing cost. The majority of the cost is labor and traffic control. Therefore, if you are going to devote worker hours to crack sealing do not balk at relatively expensive materials.

Materials can be categorized by specification and/or by their composition. The inherent problem with many construction materials is matching lab performance and field performance. This is very true of crack sealing materials.
The following Mn/DOT specifications apply to hot poured crack sealants:

— Spec 3719 Crumb Rubber

This is a recipe specification with no lab performance requirements. The addition of lab performance requirements is recommended. The cold temperature performance of this type of material is considerably poorer (te stiffer, high modulus) than the polymer modified materials. However, the presence of crumb rubber is thought to improve the adherence properties of the product, particularly under adverse application/weather conditions. Its application should be limited to close transverse crack spacing, wide (3/4 to 1 inch) sawn or routed reservoirs (high shape factor), or other areas where the stretching stresses will be low.

A report produced by the Utah Department of Transportation suggests using polymer modified materials when a heat lance is available and using crumb rubber products when one is not. This suggestion is attributed to the purported better adhesion characteristics of crumb rubber asphalts. Due to their relatively higher stiffness in the colder climate of Minnesota, crumb rubber asphalts have, in general, demonstrated poorer crack sealing performance than the polymer modified asphalts.

Proprietary products, such as Crafco 516, have been developed which combines crumb rubber and polymer modifiers. This product is a step up from the plain crumb rubber but does not meet the requirements of Spec 3723 (ASTM 3405). Mn/DOT District 5 Maintenance has applied this material in an overband configuration and, after one winter, is pleased with the results. The one winter old test sections on CSAH 75 in Monticello showed this material placed in a 3/4" square routed reservoir performed better than a low modulus material (Spec 3720) placed as an overband, but not as well as a Spec 372* material (Meadows XLM) placed in a 1/2" square saw cut reservoir.

— Spec 3723 (ASTM D 3405) Hot-poured elastic type crack sealer

This is a performance specification for polymer modified asphalt. This is a widely used material nationally. The cold temperature performance is much better than 3719, i.e. it remains softer at low temperatures.

— Spec 3720 (ASTM D 3405 modified) Hot-poured, low modulus, elastic type sealer

This is a performance specification for polymer modified asphalt and is presently the best Mn/DOT low temperature performing material specification.

Polymer modified materials, “rubberized asphalt”, have been consistently the best performing materials on our and other agencies test sections. More attention to crack preparation to insure proper bond is suggested when using polymer modified materials.

— Spec 372* New specification under consideration

Presently, manufacturers produce hot poured materials which exceed some or all of the requirements of Spec. 3720. Also, a variety of new tests have been developed attempting to more closely imitate field performance, many of which the Mn/DOT Lab is not equipped to run. Consideration is being given to developing a new specification for the lower modulus materials possibly using some of the new tests.

Cold Pour Materials

Cold pour sealants have been developed and are readily available for Portland cement concrete. In fact, cold pour silicone is presently the only nonpreformed material allowed by Mn/DOT’s Pavement Engineering Section’s Concrete Unit for sealing of transverse joints in PCC.

A single component, self levelling cold pour silicone has recently been developed for asphalt pavements, Dow Corning 890 SL. A test section of this material has been placed and is under evaluation. Although it
is significantly more costly per pound, the pump for the material is much less expensive than a heat transfer kettle and the crew lag time created by the melter start up is eliminated. Although it shows promise, this is an experimental material whose performance and life-span have yet to be determined.

2.C EQUIPMENT

MELTER/APPLICATORS

All of the hot poured sealers described require a heat transfer type melting kettle. As the name implies, the heat is applied to a transfer oil which is circulated around the sealant in a double boiler or similar fashion. This system, when coupled with an adjustable thermostat, provides precise temperature control. This is essential for the sealers to react properly to insure no over heating occurs. The melters also employ agitation to provide uniform heating. The heat source is often a propane system, with diesel fired equipment also available.

A wide variety of propane fueled melters which offer quick start up time are presently available. Safety concerns existing from experience with earlier propane fueled equipment led to the development of less volatile diesel fueled systems. By using a fuel which is often readily available at a truck station, diesel fueled systems eliminate the need to store and handle the bulky propane canisters.

Some features that should be addressed when considering acquiring a melting kettle include:

- Heating Capacity, both tank volume and gals. per hour
- Start Up Time
- Wand vs. Pour Pots: Pour pots may allow the material to cool before application. The use of a wand is recommended. Provisions for the material to be circulated through the wand when it is not in use should be required. This will decrease the chance of clogging.
- Material Loading Features
- Temperature Control and Monitoring Accuracy

Also, most hot pour materials are not intended to be reheated. It may be possible to “get by” with reheating a material the following day. But standard practice should be to only heat as much material as can be placed in the time available. This should enter in when considering kettle size.

2.D CONTRACTOR vs. IN-HOUSE

To perform a quality job, a standard crack sealing operation may include an indirect heat kettle with wand applicator, a heat lance, an air compressor capable of maintaining pressure through the heat lance and a plain air wand, at least one saw or router should be available, at least one truck, approximately 4 to 8 workers, and traffic control equipment and personnel. A possible breakdown of the workers by job follows:

1-2 workers
1 worker
1 worker
1 worker
1 worker
1 worker

Plus Traffic Control
Procuring a crew and equipment can either be done by contracting out or made available in-house. The first stumbling block in performing the work in-house is the availability of equipment. Equipment can either be purchased or rented. Since this work cannot be performed during the winter, utilizing permanent and seasonal personnel may or may not be difficult during the busy spring, summer and fall months. A complete review of budget and manpower resources and informal price quotes from local crack sealing contractors will aid in making the decision between contractor or in-house. An example specification for crack sealing can be found in Appendix C.

3. FILLING

Crack filling has been defined as “a procedure to coat crack surfaces and fill pavement voids to protect and reinforce the adjacent pavement.” Filling is performed by applying a liquid asphalt product to the crack and adjoining surface. Although it may seal the crack for a short time, the long term benefits of sealing are not expected. Filling should be performed on cracks which have deteriorated to a point that sealing is no longer viable and more involved repair strategies are not needed.

There seems to be few seasonal or weather limitations on crack filling unless the product used is difficult to handle at temperature extremes, such as emulsions. To insure adequate bonding, filling should not be performed during extreme cold or on a damp pavement.

3.A PREPARATION FOR FILLING

No special crack preparation methods are required for filling. Most agencies feel that the crack should be broomed or blown free of sand and dirt. Due to the limited expectations of this activity, employing specialized equipment and procedures does not appear to be cost effective.

3.B FILLER MATERIALS

The primary crack filler used at this time is heated air blown asphalt (AC-3). Air blown asphalt refers to a refining process which hardens the asphalt. Other products such as emulsions and cutbacks are also utilized to a limited extent. Additives for the air blown asphalt include crumb rubber (see sealer materials 3719) and polyester fibers. If a crack seal material is improperly applied or does not perform as expected, it may function as a crack filler.

Results from the test sections on TH 212 and TH 242 indicate that emulsions and cutbacks tend to fade away in one year or less. Plain AC-3 is slightly more resilient to wear and weather. While the stiffness of asphalt crumb rubber blends, limits their cold temperature sealing performance, they do appear to work well as fillers. As yet, Mn/DOT has not placed any test sections using the polyester fiber additives in crack filler.

3.C FILLING EQUIPMENT

A minimum of a direct heating kettle is required to heat and apply plain AC-3. An indirect heating kettle is required for most asphalts containing additives and can be used for plain asphalt. Either pour pots or a wand system can be utilized to apply the material. Emulsions and cutbacks can be applied with standard asphalt distributors.

3.D FILLING, CONTRACTOR vs. IN-HOUSE

Due to the availability of equipment, and since the work can be performed during the winter when crews are available, filling has and probably will continue to be done in-house.
RECOMMENDATIONS

1. GENERAL

As is the recommendation in the Mn/DOT Task Force Report on Transverse Crack Maintenance Strategies for AC Pavements, “Crack sealing should be considered the primary crack treatment unless deterioration has progressed to the point where the sealant cannot perform their intended function.” Sealing can be performed on most cracks which do not exhibit excessive spalling or multiple cracking. Filling should be performed on cracks which display these signs of deterioration but do not require more advanced repair techniques. When cupping, lipping, multiple cracking and spalling are allowed to progress, the more costly and complicated repair techniques (slurry fills, tight blading, patching, and remove/replace methods) are needed. An example of an overall crack maintenance strategy is given in Appendix A.

2. SEALING

Sealing is carried out extensively by neighboring states and provinces. These and other agencies are pleased with their results and are continuing or expanding their programs.

Results will be heightened by catching the cracks early in the pavement’s life, by using advanced crack preparation techniques and by employing a properly specified and applied material.

2.A PREPARATION FOR SEALING

— Reservoir vs. No Reservoir

A reservoir should be sawed or routed into the crack on an as needed basis. If the cracks are not open enough to allow material to be placed or squeegeed directly into the cracks, a reservoir is recommended. A slight overhand is also helpful in protecting reservoir edges.

— Saw vs. Router

A saw makes a more desirable square cut with more uniform surfaces, routers may be more maneuverable and thus yield higher production rates. When wet sawing is employed, sand cleaning/blasting should be required.

— Reservoir Size/Dimensions

The reservoir should be wider than it is deep. Seal material and crack spacing should also be considered. Stiffer materials require wider reservoirs, a long spacing between cracks will also require a wider reservoir. Wider reservoirs reduce the amount the sealer is required to stretch. See Figure 1.

— No Reservoir Needed

Place an overband as shown in Figure 3. Concentrate on getting material into the crack versus covering it with a membrane. Squeegee the material to the recommended dimensions to lessen the chances of plow damage.

— Crack Cleaning and Drying

At a minimum the cracks should be blown clean with compressed air. The most effective and highly recommended system would include sweeping or blowing clean followed by cleaning and drying with a heat lance. The application time of the heat lance should be limited to avoid scorching the asphalt. Material application should take place as soon as possible after the cleaning and drying is performed to limit contamination and profit from the surface heating.
— Bond breaker

Although the need and effectiveness to eliminate bottom-up seal tears has not been documented, foam backer rod can easily be placed in a deep reservoir or in wide deep cracks to form a false bottom. Liquid and masking tape bond breakers are difficult to place and should not be used in random cracks.

2.B SEALER MATERIALS

The primary material requirement in Minnesota is an ability to remain pliable during extreme cold temperatures. The materials which are highly recommended because they satisfy this requirement best are the polymer modified asphalts that meet or exceed Mn/DOT Standard Specification 3720. Attention to weather, surface conditions and crack preparation is advised when using these materials to insure sufficient adhesion.

If an asphalt crumb rubber product is to be specified, lab performance criterion should be added to the specification. An example of such a specification is given in appendix B.

2.C SEALING EQUIPMENT

A wide variety of double jacketed melter/applicators are available. Consideration should be given to each of the before mentioned characteristics and how they apply to your intended use. Reliability of temperature control and thermometer accuracy are of foremost concern. A pressure wand, not pour pots, should be used to place the sealer.

2.D SEALING, CONTRACTOR vs. IN-HOUSE

This must be determined by local official based upon complexity of preparation desired and available equipment and resources.

3. FILLING

Filling should be performed on cracks which have deteriorated to a point that sealing is no longer viable and more involved repair strategies are not needed.

3.A FILLING PREPARATION

No specialized crack preparation techniques are required. Cracks should be broomed or blown free of sand and dirt to provide clean surfaces for the material to bond.

3.B FILLER MATERIALS

The most widely used and resilient filler material is AC-3. Inexpensive crumb rubber asphalts have performed well as short term seals and long term fillers.

3.C FILLER EQUIPMENT

Either a direct heat kettle or indirect/double boiler kettle may be used to heat the materials. They can be effectively placed using pour pots or wand systems. The material should be squeegeed off to provide a uniform band and limit plow and traffic damage.

3.D FILLING, CONTRACT vs. IN-HOUSE

Most, if not all, filling has been performed in-house. Since no major changes in the filling operation are foreseen, it appears in–house forces will continue to perform filling when necessary.
References


APPENDIX A
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>AGE</th>
<th>MATERIAL</th>
<th>PERFORMED BY</th>
<th>TIME OF YEAR</th>
<th>EXPECTED PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW</td>
<td>ONE MONTH</td>
<td>SAN &amp; SEAL</td>
<td>CONTRACTOR, AS PART OF CONSTRUCTION AGREEMENT</td>
<td>Cool temp. preferred</td>
<td>REGULATE CRACKING, PROHIBIT INTRUSION OF MOISTURE &amp; INCOMPRESSIBLES</td>
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<tr>
<td></td>
<td></td>
<td>Bit. over concrete</td>
<td>or approved low modulus material</td>
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<tr>
<td>A. REGULAR SPACED TRANSVERSE CRACKS</td>
<td>0 - 2 YRS</td>
<td>SEAL</td>
<td>CONTRACTOR/MAINTENANCE</td>
<td>SPRING AND FALL PREFERRED</td>
<td>PROHIBIT INTRUSION OF MOISTURE &amp; INCOMPRESSIBLES</td>
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<tr>
<td></td>
<td></td>
<td>Same as above</td>
<td>Depends on equipment and manpower availability</td>
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<tr>
<td>B. INTERMEDIATE &quot;MIDPANEL&quot; TRANSVERSE CRACKS DEVELOP</td>
<td>2 - 4 YRS</td>
<td>SEAL</td>
<td>Same as above or CRUMB RUBBER</td>
<td>Same as above</td>
<td>PROHIBIT INTRUSION OF MOISTURE &amp; INCOMPRESSIBLES</td>
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<td>Same as above</td>
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<td></td>
<td></td>
<td>FILL</td>
<td>AC-3, MC 250 CSS-1 \ MAINTENANCE</td>
<td>YEAR ROUND</td>
<td>COAT EDGES OF CRACK TO LIMIT SPALLING &amp; STRIPPING</td>
</tr>
<tr>
<td></td>
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<tr>
<td>C. SPALLING AND STRIPPING</td>
<td>4 - 8 YRS</td>
<td>REPAIR : \ SLURRY FILL \ OR \ SKIN PATCHING \ OR \ PATCHING \ NOT OR COLD MIX</td>
<td>IOWA SLURRY MIX \ DEPENDS UPON EQUIPMENT AVAILABILITY \ FINE HOT MIX \ MAINTENANCE \ MAINTENANCE</td>
<td>CONSTRUCTION SEASON \ MAINTENANCE YEAR ROUND</td>
<td>RE-ESTABLISH RIDE BY FILLING DEPRESSION AT CRACK</td>
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<tr>
<td>D. MULTIPLE CRACKING, 8 PLUS YRS CUPPING, LIPPING</td>
<td>MAJOR REPAIR : \ NOT MIX \ MAINTENANCE IF AVAILABLE</td>
<td>CONSTRUCTION SEASON</td>
<td>REHABILITATE STRUCTURE AT CRACK</td>
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<tr>
<td></td>
<td></td>
<td>REMOVE FAILED AREAS &amp; REPLACE BASE \ Aggregate preparation may be required.</td>
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</tbody>
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APPENDIX B
Recommended additional (lab performance) requirements specifying crumb rubber asphalt crack sealers.

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<tr>
<th>TEST</th>
<th>REQUIREMENT</th>
<th>TEST METHOD</th>
</tr>
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<tbody>
<tr>
<td>Penetration, 77 F, 150 g. 5 sec.</td>
<td>90 max.</td>
<td>ASTM D3407</td>
</tr>
<tr>
<td>Softening point</td>
<td>140 min.</td>
<td>ASTM D36</td>
</tr>
<tr>
<td>Resilience, 77F</td>
<td>20% min.</td>
<td>ASTM D3407</td>
</tr>
<tr>
<td>Ductility 39.2F 1 cm/minute.</td>
<td>10 cm min</td>
<td>ASTM D113</td>
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</table>
APPENDIX C
SPECIAL PROVISIONS

ASPHALT PAVEMENT CRACK SEALING

DESCRIPTION

This work shall consist of sawing or routing, cleaning and sealing cracks in the existing bituminous pavement.

MATERIALS

The Contractor shall provide certification that the sealant meets the requirements of Mn/DOT standard specification 3720.

The crack sealant compound shall be packaged in sealed containers. Each container shall be clearly marked with the name of the manufacturer, the trade name of the sealant, the manufacturer’s batch and lot number, the pouring temperature, and the safe heating temperature.

A copy of the manufacturer’s recommendations pertaining to the heating and application of the joint sealant material shall be submitted to the Engineer prior to the commencement of work. These recommendations shall be adhered to and followed by the contractor. The temperature of the sealer in the field application equipment shall never exceed the safe heating temperature recommended by the manufacturer. Any given quantity of material shall not be heated at the pouring temperature for more than six hours and shall never be reheated. Sealing shall not proceed if the temperature of the material has not reached or has fallen below the manufacturer’s recommended minimum application temperature.

Mixing of different manufacturer’s brands or different types of sealant shall be prohibited.

WEATHER LIMITATIONS

Sealant materials may be placed during a period of rising temperature after the air temperature in the shade and away from artificial heat has reached 40 degrees F and indications are for a continued rise in temperature. During a period of falling temperature, the placement of sealant material shall be suspended when the air temperature, in the shade and away from artificial heat, reaches 40 degrees F. Sealant shall not be placed when in the opinion of the Engineer, the weather or roadbed conditions are unfavorable.

Routing and sealing will be permitted only during daylight hours between May 1 and October 15.

CONSTRUCTION DETAILS

General The Engineer shall mark the cracks to be sawn/routed, cleaned and sealed. The sawing/routing, cleaning and sealing shall extend the full width of the surface, including shoulders where necessary.

The contractor shall conduct his operation so that sawing/routing, cleaning and sealing is a continuous operation. Traffic shall not be allowed to kneed together or damage the reservoir once it has been created. Sawn/routed cracks not sealed before traffic is allowed on the surface shall be re-sawn/routed at no additional cost to the state.
The sawing or routing equipment shall be mechanical and power drive, capable of following and cutting the cracks to the required dimensions without deviation from the crack or creating excessive spalling. Equipment designed to "plow" the cracks to dimension will not be permitted. Wet sawing will not be allowed.

Immediately prior to sealing, the crack and surface area six (6) inches on both side shall be cleaned of foreign matter and loosened particles with a broom or oil-free compressed air. The crack and surface area six (6) inches on both sides will then be cleaned and dried with a hot compressed air heat lance. The heat lance shall meet the following requirements: temperature of heated air at exit of orifice minimum of 2,800 degrees F. Velocity of exiting heated air minimum of 2,800 fps. The application time and final results of the cleaning are subject to the Engineer's approval.

The sealant shall be placed evenly and slightly recessed of the pavements surface. However, if the routing/sawing process results in spalled or rough edges the Engineer may require the material to be poured flush and squeegeed to fill in the rough edges. See diagram. The applicator wands shall be returned to the machine and the joint sealant material recirculated immediately upon completion of each crack. Pour pots or similar devices shall not be used to apply the sealer.

Sealant material picked up or pulled out during construction shall be replaced at contractor expense.

**METHOD OF MEASUREMENT**

This work will be measured by the number of lineal feet of cracks properly sawn/routed, cleaned and sealed. OR by the pounds of sealant installed as specified.

**BASIS OF PAYMENT**

The unit price bid per lineal foot, OR pound, shall include the cost of all labor, equipment, and materials necessary to complete the work as specified.

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Sealing in Bituminous Pavement</td>
<td>Lineal Foot or Pound *</td>
</tr>
</tbody>
</table>

* In some cases a unit of lineal foot will be easier to measure, this does require an exacting specification on how the reservoir is filled and more attentive inspections during placement. If the pay unit is in pounds, it is felt the contractor is more likely to apply ample material to the crack which may result in a better seal; this may also lead the contractor to go over on quantity.

Requiring a guarantee has been included in some agencies specifications. With this clause in the specification the contractor is required to “touch up” any failed areas for a specified period of time after placement (usually 3 yrs.). However, it is difficult to ascertain the exact effect on bid prices by requiring such a guarantee.