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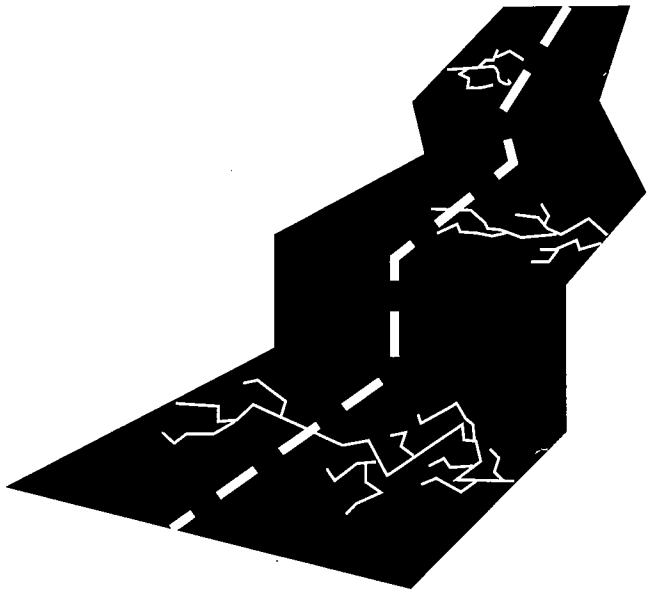
Crack Sealing Bituminous Pavements in Minnesota



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One of the most common maintenance activities performed on bituminous pavements by local governmental agencies relates to crack treatment. Crack treatments include crack sealing, crack filling, and crack repair. Crack sealing is the method of placing material in a crack to create a water tight barrier, while crack filling involves coating the sides or edges of a crack in an attempt to reduce the rate of deterioration. Crack repair is more extensive than both sealing or filling and can involve fine mix patching, tight blading, mill and repair, and overlays. Generally, rubberized materials, due to their ductile properties are considered to be crack sealants while asphalt based materials are considered fillers.

This report discusses the most commonly used materials and practices used by local engineers in Minnesota to seal and fill cracks on bituminous pavements. The report is based on the results of a survey conducted by the authors in 1991. The report presents the results in several ways and summarizes the findings.

17. Document Analysis a.Descriptors

crack sealing	hot air blown asphalt	Mn/DOT Spec 3719
crack filling	asphalt emulsion	Mn/DOT Spec 3723
crack repair	cold pour silicone	Mn/DOT Spec 3720
crumb rubber	hot-pour elastic sealer	heat lance
AC-3	low modulus sealer	routing
MC Oil	extra-low modulus sealer	

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FOREWORD

The purpose of this report is to give an overview of the practices of Minnesota city and county agencies with respect to sealing cracks on bituminous pavements. The report summarizes the results of a survey conducted on this subject by the authors during 1991. Guidelines are also given based on information available from other sources around the country.

The authors wish to acknowledge the contributions of the Minnesota city and county engineers and street/highway superintendents for their cooperation in completing the survey which comprises a large portion of this report. Individuals who also helped greatly in the preparation of this report are Roger Olson and Curt Turgeon of the Mn/DOT Physical Research Section, Office of Materials and Research, and Anne Mackereth and Sheila Hatchell of the Mn/DOT Information Services Center.

ABSTRACT

One of the most common maintenance activities performed on bituminous pavements by local governmental agencies is crack treatment. Crack treatments include crack sealing, crack filling and crack repair. Crack sealing is defined as placing material in a crack to create a water tight barrier (1). Crack filling involves coating the sides or edges of a crack in an attempt to reduce the rate of deterioration. Crack repair is more extensive than sealing or filling and can involve fine mix patching, tight blading, mill and repair, and overlays (1). It is apparent from a recent survey that these terms are often used interchangeably. Generally, rubberized materials, due to their ductile properties are considered to be crack sealants while asphalt based materials are considered fillers. Procedures that involve sand or fine aggregate are considered to be crack repairs.

The goal of crack sealing is to prevent water and incompressible material from entering the pavement system. Water intrusion through cracks leads to softening of the underlying subgrade soil. This situation may result in a weak pavement which can be damaged by heavy loads. For many pavements with extensive cracking, water enters the pavement system from the surface at a much higher rate than from below or laterally.

Crack filling is done to reduce the effects oxidation has on the asphalt. When asphalt pavements begin to oxidize, they become brittle and cannot withstand the bending imposed by passing vehicles as well as when they were flexible. The application of fresh asphaltic material along the sides of an existing crack slows the rate of oxidation and thus the rate of deterioration.

In Minnesota, most cities and counties seal cracks on a periodic basis in an attempt to combat the deterioration of city streets and county highways within their jurisdiction. However, there are many different reasons, materials, equipment and techniques for crack sealing.

It is for this reason that this report was written. It is the goal of the authors to assist local engineers and street/highway superintendents, in determining what their peers are doing in the area of crack sealing/filling. A secondary goal is to present guidelines used by other agencies outside Minnesota which may be applicable.

BACKGROUND

Frequently, the first types of distress visible on a new bituminous pavement are transverse cracks. A transverse crack, as the name implies, typically extends across a road perpendicular, or transverse, to the centerline (2). They are sometimes referred to as temperature cracks. These cracks are caused by the expansion and contraction of the asphalt material as the temperature changes. A bituminous pavement can undergo extreme amounts of expansion in hot weather and contraction in cold weather. Generally, the colder the temperature, the wider the crack opening will be. Also, the more freeze-thaw cycles a pavement is subjected to, the more likely it is to experience transverse cracking. As a result, for nearly all bituminous pavements built in Minnesota, transverse cracking will develop within a relatively short time after construction.

The frequency and time until transverse cracks occur is largely dependent on the mix design. A softer asphalt (one with a higher penetration) is usually more ductile and can stretch more without cracking. One way to reduce the frequency of transverse cracking as well as delay the time it takes for them to appear is by building a road with a softer asphalt in the mix. A softer asphalt, in addition to being more flexible, is also more prone to rutting however. As a result, roadways with heavily loaded trucks or high volumes of traffic are not good candidates for paving with a softer mix. Another strategy in mix design used to lessen the effects of oxidation on the asphalt mix is to increase the asphalt content. By doing so, the air void content of the mix will be less, and thus the mix will be less affected by oxidation. Compaction, or more precisely, lack of it, can also have an impact on the rate a pavement oxidizes. Poor compaction will result in higher air voids in the mix and result in a mix much more prone to the effects of oxidation.

Another common type of cracking that develops on bituminous pavements is known as block cracking. Block cracking, as the name implies, consists of cracks that divide the pavement into blocks. This type of cracking, caused by highly temperature sensitive mixes, is accelerated by the aging of the asphalt material. When asphalt material ages, it oxidizes and becomes more brittle. In time, if the pavement becomes too brittle, it will begin to deteriorate.

Longitudinal cracks, cracks which extend parallel to the centerline of the pavement, are also very common in Minnesota. This type of cracking can have several causes. The main causes, however, are related to cold joints, lack of subgrade support (settlement) and load. When the longitudinal cracks are found in the wheel path, they are generally load related and indicate the early stages of alligator cracking.

Reflective cracks are cracks and joints in an underlying pavement which reflect through the surface layer. The more deteriorated or brittle the underlying pavement, the more severe the reflection cracking will be (7). These cracks are formed when the surface layer attempts to conform to the profile of the stiffer base layer (7). This type of cracking can be found on bituminous overlays of bituminous pavements as well as bituminous overlays of concrete pavements. The latter case is a special case caused either by the upward movement of the slab (faulting/pumping) encouraged by moisture penetrating the subbase, or the expansion and contraction of the underlying concrete slab due to temperature change.

Since cracking of the nature described above is difficult if not impossible to prevent, the most common way to deal with it is to seal or fill the cracks after they have developed. Not all types of cracks lend themselves to be sealed or filled. Alligator cracking, for example, is a load related distress caused by fatigue failure in the pavement materials. Sealing this type of cracking may slow down the water intrusion temporarily, but if the problem of overloading is not dealt with, the

expected life of the sealant is very low.

Normally, the best types of cracks to seal as part of a bituminous crack sealing program are transverse, longitudinal and reflective cracks. Block cracking, due to its extensive coverage of a pavement surface, may require so much material that it is not cost effective to crack seal. A seal coat or thin overlay may be more appropriate as a temporary measure. When sealing longitudinal cracks, it is important to determine if the cracks are in the wheel path, and thus load related, or not. Load related longitudinal cracks indicate the pavement is failing structurally and that another rehabilitation may be more cost effective and address the cause of the distress more directly (7).

Alligator cracking should never be treated by crack sealing or filling (7). When longitudinal cracking in the wheel path has progressed to the point that an alligator skin type pattern has developed, crack sealing provides little benefit.

COMMON CRACK SEALING/FILLING MATERIALS

The materials for which information was gathered are those materials identified by Mn/DOT as the most common or which have Mn/DOT specifications (1). The materials identified in the survey are as follows:

- Crumb Rubber Crack Sealer
- Hot-Pour, Elastic Type Crack Sealer
- Hot-Pour, Low Modulus Elastic Type Crack Sealer
- Hot-Pour, Extra Low Modulus Elastic Type Sealant
- AC-3, Heated Air Blown Asphalt
- MC Oil & Sand
- Asphalt Emulsion
- Cold Pour Silicone
- Other Miscellaneous Materials

Generally, the elastic sealers are defined as crack sealants, AC-3 and Asphalt Emulsion as fillers and MC Oil and Sand as crack repair materials. Sealers are generally used on newer pavement or on those where the cracks have not deteriorated significantly. Fillers are generally used on pavement where the cracks have deteriorated to the point that sealer is no longer a viable material (1). Mn/DOT reports that agencies seem to be using more crack sealants and less crack fillers than in past years.

Table 1 shows the various material types, applicable specifications they meet and any brand names commonly used which fall under the same category.

Table 1. List of Commonly Used Crack Sealing Materials

Material Type	Applicable Specifications	Brand Names
Crumb Rubber (crack sealant)	Mn/DOT 3719	Crafco AR-1 Koch 9000
Hot-Pour Elastic Type Sealer (crack sealant)	Mn/DOT 3723 ASTM D 3405	Crafco Road Saver 221 Koch 9005 W.R. Meadows Hi-Spec
Hot-Pour, Low Modulus Elastic Type Sealer (crack sealant)	Mn/DOT 3720 ASTM D 3405 Mod.	Crafco Road Saver 231 W.R. Meadows Sof-Seal
Hot-Pour, Extra Low Modulus Elastic Type Sealer (crack sealant)		W.R. Meadows XLM
AC-3, Hot Air Blown Asphalt (crack filler)		
MC Oil & Sand (crack filler)		
Asphalt Emulsion (crack filler)		
Cold Pour Silicone (crack sealant)		Dow Corning 890 SL
Other Materials (sealants & fillers)		Crafco Mn Blend 34506 Koch Flex-A-Fill

The materials listed above are similar to those in LRRB report 89-19, "Evaluation of Materials and Methods for Bituminous Pavement Crack Sealing and Filling" (1). This report, written by Mr. Curt Turgeon with the Mn/DOT Office of Materials and Research, is an excellent resource for local agencies interested in crack sealing and filling. The report discusses procedures and materials and includes recommendations and sample provisions that could be incorporated into a specification.

LOCAL ROAD RESEARCH BOARD SURVEY

A survey was sent to over 200 Minnesota cities and counties in 1991 inquiring about their current bituminous pavement crack sealing practices. The survey asked each agency to identify up to two different crack sealing materials they typically use. For each material identified, the following 12 questions were asked:

- What time of year is the work done ?
- What percent of the work is done in-house versus contracted out ?
- Do you saw or route the cracks prior to sealing ?
- How long does the crack sealing/filling technique keep the cracks sealed/filled ?
- Have you ever had any failures ?
- If this is a hot pour sealant, how is the material kept hot ?
- What equipment do you use to place the sealant material ?
- How many people are normally used on crack sealing crew ?
- What is the approximate cost, including labor, to seal cracks with this material ?
- Do you seal cracks prior to a seal coat ?
- Do you seal cracks prior to an overlay ?

A copy of the survey can be found in Appendix C.

OVERALL RESULTS OF LRRB CRACK SEALING SURVEY

CRACK SEALING PROGRAMS

The results of the survey indicate that 81% of the survey respondents have a crack sealing program. For the county agencies, 84% (56 agencies) of the responding agencies indicate they have a crack sealing/filling program. For cities, 78% (47 agencies) of the responding agencies have a crack sealing/filling program.

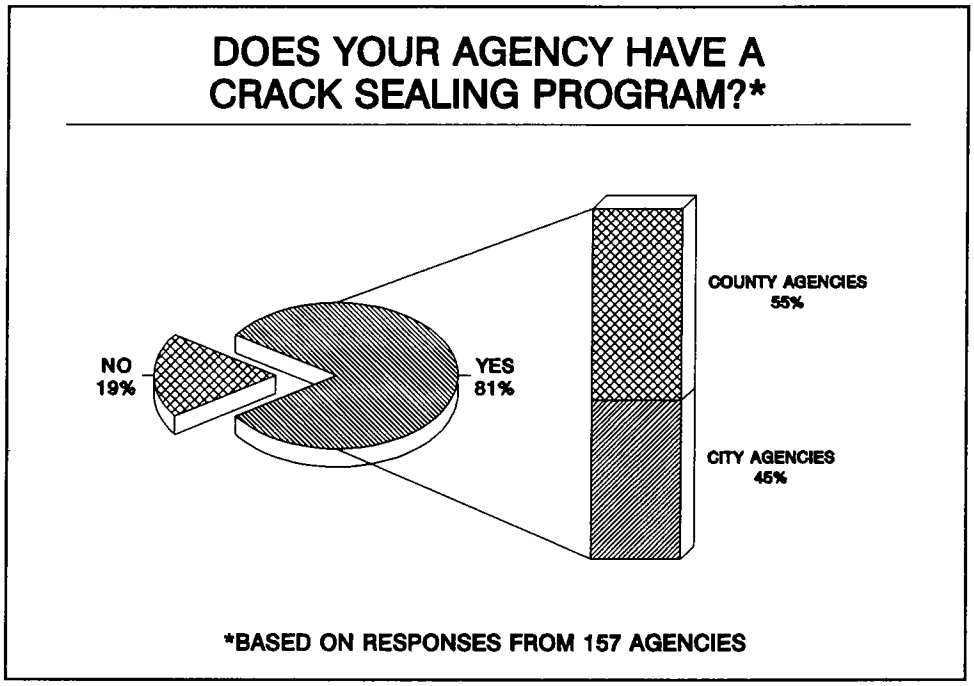

Figure 1
PERCENT OF AGENCIES THAT HAVE A CRACK SEALING PROGRAM

The survey indicates that the counties crack seal more often than do cities. On average, the counties seal cracks every three years while the cities seal cracks every four years. The survey also asked if the agency sealed cracks on an as-needed basis or on a set schedule. The results indicate that over 77% of the counties crack seal on an as-needed basis versus 23% that seal cracks on a set schedule. For the cities, 57% seal cracks on an as-needed basis, 43% on a set schedule.

MATERIAL USAGE

Two materials stand out as being the most commonly used; Mn/DOT Spec 3723, an elastic type sealer, was the most common followed by AC-3 which is a hot, air refined asphalt crack filler. With the exception of AC-3, there was little or no difference between county and city agencies when it came to using a particular material. A large difference occurred however, when using AC-3. Of the 36 agencies reporting usage of AC-3, 92% were county agencies. The reason for this large difference is unclear. Surprisingly, all three cities that use AC-3 are located in northern Minnesota.

The number and percent of agencies indicating they use a particular material type is shown below:

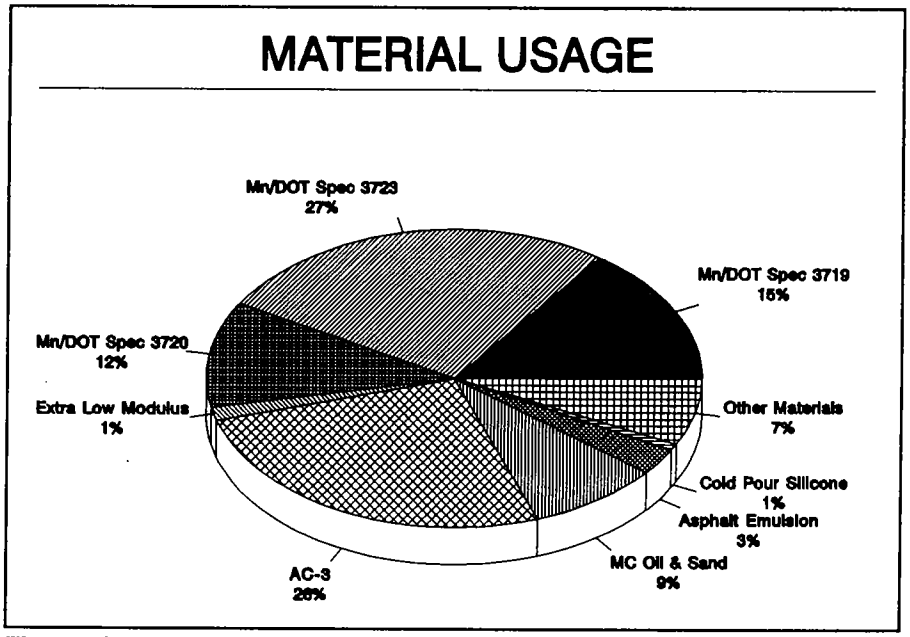

Figure 2. PERCENT SEALANT IS USED

The figure below shows the number of agencies reporting use of the various materials. The figure also shows the distribution of use by agency type.

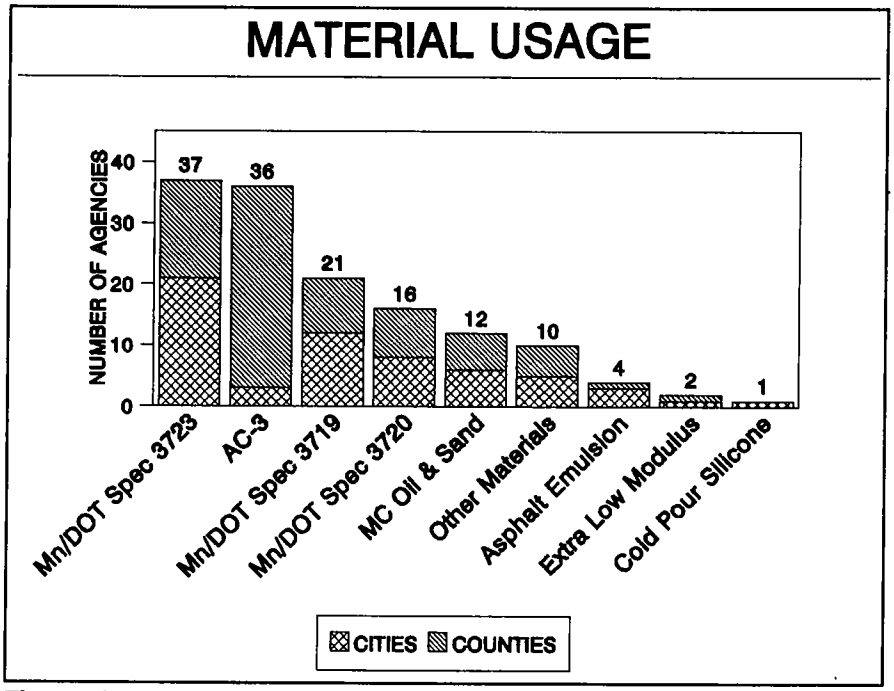

Figure 3. NUMBER OF AGENCIES USING EACH SEALANT

WHEN MATERIAL IS PLACED

The most common time of year to seal cracks, by a wide margin, was in the spring. The winter was the time of year least given by the survey respondents. Many of the agencies indicate that they seal cracks in more than one time of year, many seal them year round.

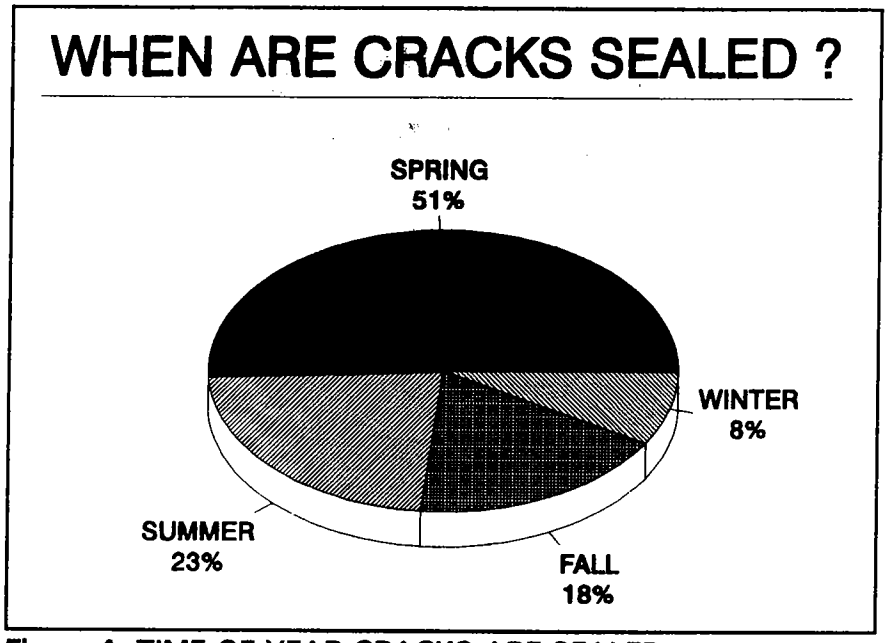

Figure 4. TIME OF YEAR CRACKS ARE SEALED

IN-HOUSE VERSUS CONTRACTED WORK

The survey shows that most crack sealing is done with the agency's own labor force and equipment. Nearly 80% of the crack sealing is done in-house as opposed to contracting out. The vast majority of agencies do all crack sealing in-house. Only 21% of the agencies ever contract out for crack sealing services. It appears that most agencies either do all of the work in-house or all of it by contract.

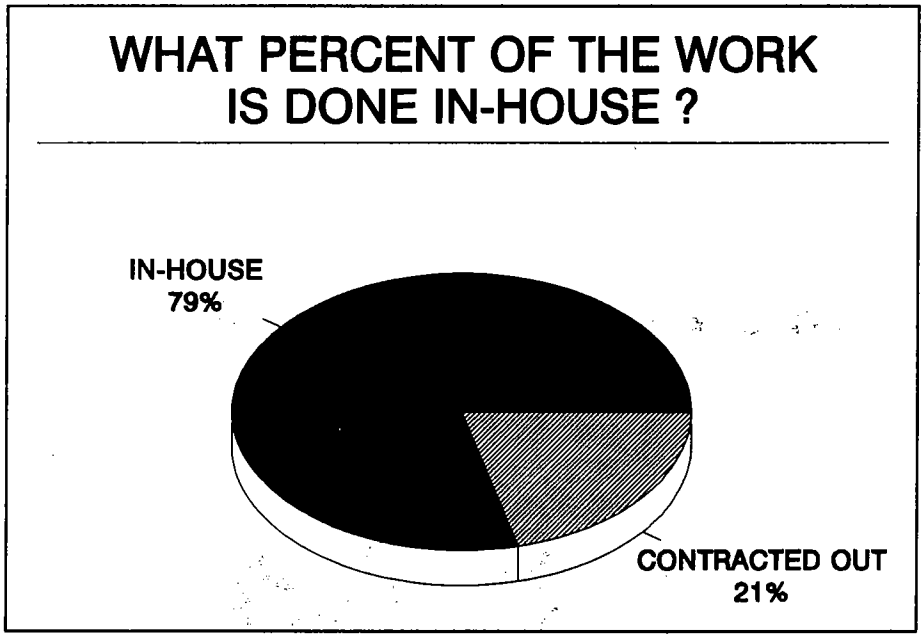

Figure 5. IN-HOUSE VERSUS CONTRACTED WORK

There were definite differences depending on what type of material was being used. All of the AC-3, MC Oil & Sand and Cold Pour Silicone users did crack sealing in-house. Mn/DOT Spec 3720 was the only material which resulted in the majority of the work being done on a contract basis. Over 55% of the agencies contract out for crack sealing when using this material.

SAWING OR ROUTING CRACKS PRIOR TO SEALING

Whether or not the cracks are sawed or routed prior to sealing depends primarily on the type of material being used. The survey indicates that sawing or routing is done 45% of the time. Of those agencies that responded to the survey, 36% ***always*** saw or route prior to crack sealing, 9% ***sometimes*** saw or route and 55% ***never*** saw or route prior to crack sealing. The statistics change depending on what material is being used. For example, none of the users of MC Oil & Sand, Asphalt Emulsion or Cold Pour Silicone and only 3% of AC-3 users ever saw or route prior to crack sealing. On the other hand, over 50% of the Mn/DOT Spec 3719, 3723 and 3720 users ***always*** saw or route prior to sealing and approximately 75% of these users saw or route at least some of the time.

Only seven agencies that saw or rout cracks have ever used a bond breaker to prevent the crack sealing material from bonding to the bottom of the reservoir. If the crack seal material bonds to the bottom of the reservoir, it may pull away from the sides of the crack as the crack begins to open. In some cases, the bonding of the material with the bottom of the reservoir may cause the sealant to fail. Types of bond breakers include grease and other liquids, masking tape and foam backer rod. Mn/DOT does not recommend either liquids or masking tape when sealing random cracks (1). Backer rod is effective in preventing a bond from forming to the bottom of the reservoir in wide, deep cracks. Mn/DOT does not have enough experience in the use of bond breakers to make a recommendation on their use (1). The state of South Dakota is an advocate of using a backer rod (paper rope) in routed cracks prior to sealing (7).

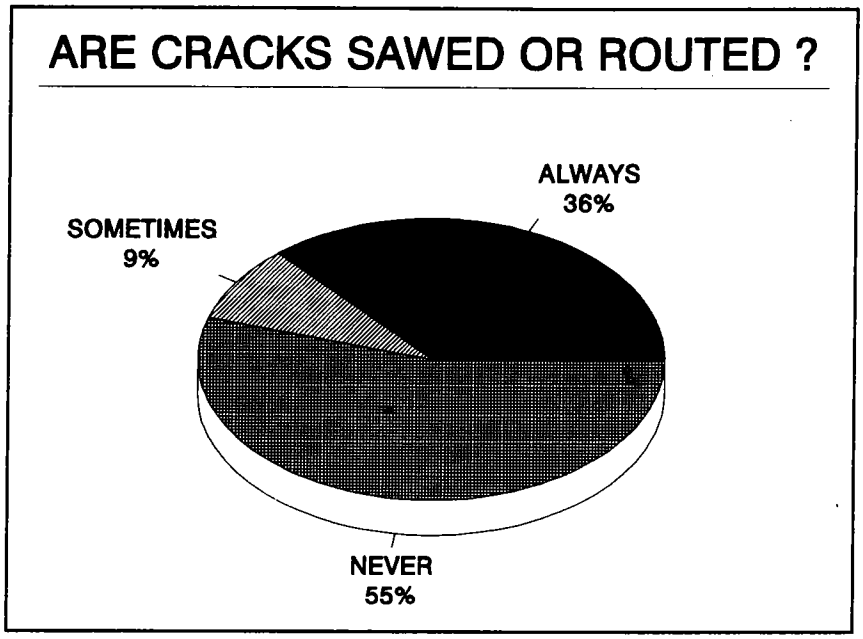

Figure 6. SAWING OR ROUTING PRIOR TO CRACK SEALING

Of those agencies that saw or route the cracks at least sometimes, the average size of the cut is approximately 3/4 inch wide by 7/8 inch deep. There was little variation in the dimensions of the reservoir between agencies. The most common size of reservoir reported was 3/4 inch wide by 3/4 inch deep.

MATERIAL FAILURES

The agencies were asked if they have ever experienced any failures using the material they were providing information on. Not surprisingly, at least 50% of the agencies said yes. The survey did not attempt to qualify what each agency considered a failure. Previous attempts to do so have resulted in a myriad of definitions. The materials in the "Other" category (see page 73 for a description of these materials) had the highest level of reported failures at 70%. The materials having the lowest level of failures experienced are the Extra Low Modulus Sealer and Asphalt Emulsion. Keep in mind that there were only two users of the Extra Low Modulus material responding to the survey. One indicated they had failures, the other indicated they did not.

Perhaps of more interest was the number of agencies indicating they have never had any failures with a certain material. Mn/DOT 3719, Crumb Rubber, had the most agencies indicating they have never had a failure with the material.