MANUAL NUMBER
2000-04

PB2000-103311

Best Practices Handbook

T²/LTAP PROGRAM
CENTER FOR TRANSPORTATION STUDIES
UNIVERSITY OF MINNESOTA

MINNESOTA DEPARTMENT
OF TRANSPORTATION
(MN/DOT)

MINNESOTA LOCAL ROAD
RESEARCH BOARD
(LRRB)

REPRODUCED BY: NTIS
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161

PROTECTED UNDER INTERNATIONAL COPYRIGHT
ALL RIGHTS RESERVED.
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE

Reproduced from
best available copy.

FUNDING ACKNOWLEDGEMENT

This project was conducted with funding provided by the Minnesota Local Road Research Board (LRRB). The LRRB's purpose is to develop and manage a program of research for county and municipal state aid road improvements. Funding for LRRB research projects comes from a designated fund equivalent to 1/2 of one percent of the annual state aid for county and city roads.

Technical Report Documentation Page

1. Report No. MN/RC - 2000-04	2.	3. Recipient's Accession No.
4. Title and Subtitle BEST PRACTICES HANDBOOK ON ASPHALT PAVEMENT MAINTENANCE		5. Report Date February 2000 6.
7. Author(s) Ann M. Johnson, P.E.		8. Performing Organization Report No.
9. Performing Organization Name and Address Professional Engineering Services, Ltd. 213 Townes Lane Wayzata, Minnesota 55391		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No.
12. Sponsoring Organization Name and Address University of Minnesota Center for Transportation Studies 200 Transportation & Safety Bldg. 511 Washington Avenue, S.E. Minneapolis, Minnesota 55455-0220		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract (Limit: 200 words)

The purpose of this handbook is to provide background information about the importance of pavement preservation and preventive maintenance, as well as present maintenance techniques for a variety of distresses and conditions. The major focus of this handbook is on preventative maintenance activities, which are performed while the roadway is still in good condition with only minimal distress, before the pavement falls into a condition where structural overlays, major milling or reclaiming, or replacement is necessary.

The most common flexible pavement distresses are cracking, roughness, weathering, raveling, rutting and bleeding. If the distresses identified in a pavement are related to structural deficiencies, the pavement section is most likely not a candidate for preventive maintenance treatment, and should be scheduled for rehabilitation or reconstruction. Maintenance treatments covered in this handbook include: Crack repair w/sealing, including clean and seal, saw and seal, and rout and seal; crack filling, full depth crack repair, fog seal, seal coat, double chip seal, slurry seal, microsurfacing, thin hot mix overlays, and potholes and pavement patching.

Tables are outlined giving the most common flexible pavement distresses, along with the best practices for rehabilitation for each. Also given are recommended applications for crack sealers and fillers, surface treatments, and pothole patching. Specifications, technical memoranda and special provisions are included for all treatment methods recommended in the handbook.

17. Document Analysis/Descriptors Asphalt pavement maintenance Preventive maintenance Crack repair Crack sealing Fog seal Seal coat Potholes Patching Microsurfacing Slurry Seal		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 50	22. Price

Best Practices Handbook
on

ASPHALT PAVEMENT MAINTENANCE

February 2000

PUBLISHED BY
Minnesota Technology Transfer (T^2) Center / LTAP Program
Center for Transportation Studies
University of Minnesota
511 Washington Avenue S.E.
Minneapolis, MN 55455-0375

Prepared by
Ann Johnson, P.E., Professional Engineering Services, Ltd.
Edited by
Pamela J. Snopl, Managing Editor, T^2/CTS

PRINTED BY
Minnesota Department of Transportation
Office of Research and Strategic Services
395 John Ireland Blvd.
St. Paul, MN 55155
Phone: 651-282-2274
E-mail: ora.research@dot.state.mn.us.

The University of Minnesota is an equal opportunity educator and employer.
This publication is available in alternative formats upon request.
Printed with 30 percent postconsumer waste.

Acknowledgments

We wish to thank the Minnesota Local Road Research Board (LRRB) for the financial support to make this important resource possible. The Technical Advisory Panel that steered this project was extremely helpful in identifying key issues and concerns of those responsible for maintaining our asphalt pavements. They also were very generous with their time to review this document and contribute to its technical accuracy and application within Minnesota.

We appreciate the assistance of the following people who served on the Technical Advisory Panel for this resource document:

Gary Bergeson, Minnesota Department of Transportation
Gary Bruggeman, Minnesota Department of Transportation
Maria Hagen, University of Minnesota, Center for Transportation Studies
Jerry Geib, Minnesota Department of Transportation
Paul Keranen, Minnesota Department of Transportation
Steve Lund, Minnesota Department of Transportation
Mike Marti, Koch Pavement Solutions
Roger Olson, Minnesota Department of Transportation
Kevin Pieper, Hennepin County
Duane Schwartz, City of Roseville
Doug Weiszhaar, Minnesota Department of Transportation
Tom Wood, Minnesota Department of Transportation

Project consultation provided by Ann Johnson, Professional Engineering Services, Ltd.

Contents

Part I: Pavement Maintenance and Preservation 1

Chapter 1: Types of Maintenance 1
Preventive Maintenance and Pavement Preservation 4
Corrective Maintenance 7
Emergency Maintenance 8

Chapter 2: A Systems Approach to Pavement Maintenance 9
Pavement Management Systems 9
Mn/DOT's Pavement Maintenance Program 10
Traffic Control and Safety 11

Chapter 3: Treatment Selection 13
Determining a Treatment's Cost-Effectiveness 13
Selection Factors 14
Types of Maintenance Treatments 15

Part II: Recommended Treatment Practices 21

Chapter 4: Crack Treatments 23
Crack Repair with Sealing: Clean and Seal 26
Crack Repair with Sealing: Saw and Seal 28
Crack Repair with Sealing: Rout and Seal 30
Crack Filling 32
Full- and Partial-Depth Crack Repair 34

Chapter 5: Surface Treatments 37
Fog Seal 38
Seal Coat 40
Double Chip Seal 43
Slurry Seal 45
Microsurfacing 47
Thin Hot-Mix Overlays 49

Chapter 6: Pothole Patching and Repair 51
Cold-Mix Asphalt 54
Spray Injection Patching 55
Hot-Mix Asphalt 57
Patching with Slurry or Microsurfacing Material 58

Bibliography 61

Appendix A: Distress Identification and Severity 63
Bleeding 64
Cracking, Alligator or Fatigue 64
Cracking, Block 64
Cracking, Edge 65
Cracking, Longitudinal 65
Cracking at Joints, Reflection 65
Cracking, Transverse 66
Lane-To-Shoulder Drop-Off 66
Patch/Patch Deterioration 66
Polished Aggregate 67
Potholes 67
Raveling and Weathering 67
Rutting 67
Shoving 68

Appendix B: Mn/DOT Specifications and Provisions 69
Specification 2381: Bituminous Stockpile Patching Mixture 70
Specification 3719: Joint and Crack Sealer (Hot-Poured, Crumb Rubber Type) 74
Specification 3720: Joint and Crack Sealer (Hot-Poured, Low-Modulus, Elastic) 76
Specification 3723: Joint and Crack Sealer (Hot-Poured Elastic Type) 78
Specification 3725: Joint and Crack Sealer (Hot-Poured, Extra Low Modulus, Elastic Type) 80
Special Provision for Asphalt Concrete Crack Sealing 82
Special Provision for Bituminous Fog Sealing 85
Special Provisions for Bituminous Seal Coat 87
Special Provision for Micosurfacing 93
Special Provision for Microsurfacing Warranty 103
Engineering Services Division Technical Memorandum No. 99-05-MRR-02 107
Draft Special Provisions for Bituminous Seal Coat Double Seal 108

Figures

Figure 1-1. Maintenance Categories 4
Figure 1-2. Performance of Preventive Maintenance Treatments 6
Figure 4-1. Reservoir Dimensions 28

Tables

Table 3-1. Asphalt Maintenance Techniques 17
Table 3-2. Crack Treatments 18
Table 3-3. Treatments for Surface Defects 19
Table 4-1. Recommended Applications for Crack Sealant and Fillers 24
Table 4-2. Effective Crack Sealing Tips 25
Table 5-1. Recommended Applications for Surface Treatments 37
Table 6-1. Recommended Applications for Patching 53
Table 6-2. Effective Patching Tips 53

Introduction

How to Use This Handbook

This handbook is divided into two parts. Part I provides background information about asphalt pavement maintenance and preservation. Chapter 1 covers types of maintenance; Chapter 2, a systems approach for pavement management; and Chapter 3, treatment selection.

Part II presents maintenance techniques for a variety of distresses and conditions. Chapter 4 covers crack treatments; Chapter 5, surface treatments; and Chapter 6, pothole patching and repair.

Appendices provide additional information. Appendix A gives distress identification and severity, and Appendix B lists relevant specifications.

The major focus of the handbook is on preventive maintenance activities, which are performed while the roadway is still in good condition with only minimal distress, before the pavement falls into a condition where structural overlay, major milling or reclaiming, or replacement is necessary.

Additional Resources

The Minnesota Local Road Research Board (LRRB) developed a set of pavement distress manuals, one for use with concrete and the other for use with asphalt pavement. Small and spiral bound, the manuals are designed for easy use in the field. They identify low-, medium-, and high-severity levels of each pavement distress with photos. Distresses are categorized by their cause: environmental, traffic, or construction. The complete set (including a third, larger manual covering both concrete and asphalt, meant for office use) was developed with input from city, county, and state engineers, and customized to include those issues and distresses most found in Minnesota. Information from the manuals was used to develop Tables 3-1 through 3-3 in Chapter 3. The manuals and companion report (numbered 89-01) are available through Mn/DOT's Office of Research and Strategic Services (ORSS), phone 651-282-2274, e-mail ora.research@dot.state.mn.us.

The American Public Works Association pavement distress manual is also available through the Mn/DOT Library.

Part I:
Pavement Maintenance and Preservation

Chapter 1: Types of Maintenance

Today's increasing budget constraints require that state and local agencies perform more work with less money. Historically, the emphasis of local highway departments has been on building new roads, but the new focus is on maintaining and preserving existing pavement surfaces. This shift has resulted in three types of pavement maintenance operations:

Preventive Maintenance: Performed to improve or extend the functional life of a pavement. It is a strategy of surface treatments and operations intended to retard progressive failures and reduce the need for routine maintenance and service activities.

Corrective Maintenance: Performed after a deficiency occurs in the pavement, such as loss of friction, moderate to severe rutting, or extensive cracking. May also be referred to as "reactive" maintenance.

Emergency Maintenance: Performed during an emergency situation, such as a blowout or severe pothole that needs repair immediately. This also describes temporary treatments designed to hold the surface together until more permanent repairs can be performed.

All types of maintenance are needed in a comprehensive pavement maintenance program. However, emphasizing preventive maintenance may prevent a pavement from requiring corrective maintenance. Preventive maintenance is *completing the right repair on the right road at the right time.*

Many pavement treatments can be used for preventive, corrective, or emergency maintenance. Figure 1-1 illustrates the differences among these three types of maintenance. As indicated on the graph, the main difference is the condition of the pavement when the treatment is applied. There are no clear boundaries between when a treatment is preventive versus corrective, or corrective versus emergency.

Although all three types of maintenance are important, this handbook focuses on preventive maintenance activities because these are the most cost-effective and offer the best means for prolonging pavement service life. The remainder of this chapter describes the three maintenance types.

Preceding Page Blank

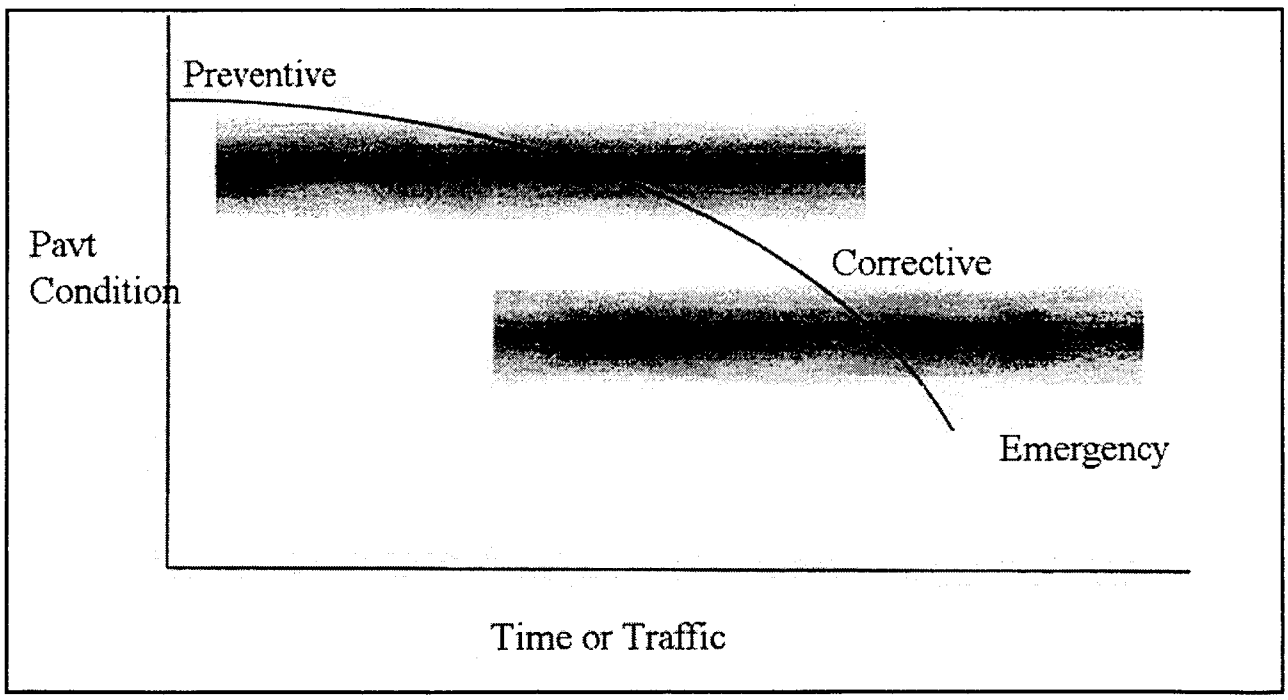

Figure 1-1. Maintenance Categories

Preventive Maintenance and Pavement Preservation

A preventive maintenance program is a systematic approach to using a series of preventive maintenance treatments over time. One treatment will improve the quality of the pavement surface and extend the pavement life, but the true benefits of pavement maintenance are realized when there is a consistent schedule for performing the preventive maintenance.

An effective pavement preservation program integrates many preventive maintenance strategies and rehabilitation treatments. The goal of such a program is to extend pavement life and enhance system-wide performance in a cost-effective and efficient way. Studies show that preventive maintenance is six to ten times more cost-effective than a "do nothing" maintenance strategy.

Benefits of pavement preservation include improved customer service and substantial life cycle cost savings; treatments are especially cost-effective when applied early in the life of a pavement. In addition, by extending the life of a pavement section until it can be rehabilitated, preventive maintenance allows an agency to even out its maintenance budget from year to year, which otherwise can vary greatly. For example, the Michigan Department of Transportation has used preventive maintenance to balance out its construction program. They report that their program enables them to optimize the network condition with a given preservation budget, resulting in more stable funding needs.

Critical elements of a successful pavement preservation program are:

1. selecting the roadway
2. determining the cause of the problem
3. identifying and applying the correct treatment(s)
4. determining the correct time to do the needed work
5. observing performance

The program can then be adjusted according to the results.

Preventive maintenance activities can include conventional treatments such as crack sealing, chip sealing, fog sealing, rut filling, and thin overlays. They can also include emerging technologies such as ultra-thin wearing courses, very thin overlays, and microsurfacing applications. Aside from crack treatments, all of these treatments leave the pavement with a new wearing surface. A fog seal provides a new wearing surface, although it generally has a lower friction number than the original surface.

When to Apply Preventive Maintenance Treatments

Waiting until after a failure occurs is not cost-effective or preventive maintenance. The effectiveness of a preventive maintenance treatment is directly related to the condition of the pavement. Conducting preventive maintenance activities on a sound pavement in good condition will be very effective in prolonging that pavement's service life. Conducting an inappropriate repair (either method or timing) can actually accelerate the rate of distress development.

Preventive maintenance is generally planned and cyclical in nature. Its intent is to repair early pavement deterioration, delay pavement failures, and reduce the need for corrective maintenance and service activities. Although this type of maintenance is not performed to improve the load-carrying capacity of a pavement, it extends the pavement useful life and level of service. Figure 1-2 shows the relationship between pavement condition and time (or traffic).

Often, preventive maintenance methods are designed to repair damage caused by the environment. Periodic renewal of the pavement surface can provide several benefits, including sealing the pavement surface (which prevents water from penetrating into the pavement structure), and controlling the effects of oxidation, raveling, and surface cracking. Environmental conditions remain fairly consistent over time, so the maximum time between preventive maintenance treatments should be based on time, rather than the amount of traffic on a roadway section.

To help choose the correct time to apply a treatment, a condition survey and non-destructive testing can be used. This provides a more rational approach to determining which pavements need treatment and when the treatment should be done. Using the output of the pavement condition survey, threshold limits can be developed to define when a treatment type should be implemented.

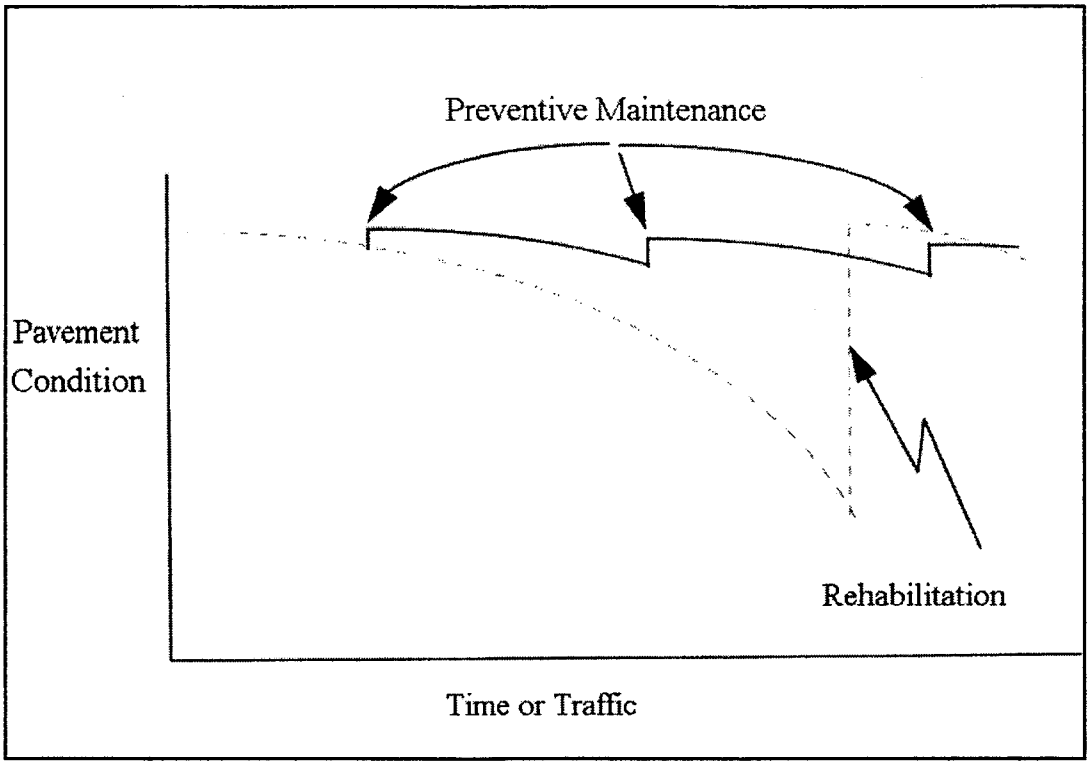

Figure 1-2. Performance of Preventive Maintenance Treatments

Why Wasn't Preventive Maintenance Used in the Past?

Preventive maintenance has been around for a long time but was not used as much in the past for several reasons:

- Many of the available preventive maintenance treatments were considered unsuitable for high-volume roadways.
- Lack of federal aid for maintenance encouraged agencies to allow pavements to deteriorate sufficiently to qualify for rehabilitation that was funded by federal aid.
- Information was lacking about the performance and cost-effectiveness of preventive maintenance practices.
- Highway agencies wished to minimize driver exposure to roadway operations and lane closures. This prevailing philosophy is reactive rather than proactive or preventive.

Some highway agencies are also reluctant to program treatments on pavements in good condition when there is a large backlog of pavements in poor condition within the system. It is common for preventive maintenance to be forgotten when potholes and other maintenance problems demanding immediate attention consume much of a limited maintenance budget. The

public expects that problems such as potholes get fixed first, causing preventive maintenance work to be neglected.

Another reason preventive maintenance funding may be limited is because pavement maintenance and winter maintenance (snow and ice removal) operate from the same budget. Because of its direct effect on driver safety, winter maintenance is usually given a higher priority, and any money that remains when winter is over funds pavement maintenance. This leftover amount may not be sufficient to fund an adequate maintenance program.

Keys to a Successful Program

Education: To implement a pavement preservation program effectively, elected officials, top management, and maintenance staff should be educated about pavement preventive maintenance, why it is needed, and why it should be a priority. This education should stress that it is more economical to preserve pavements in good condition than it is to replace them when they wear out. Highway agency professionals need to develop a better understanding of the benefits of a program and the differences among preventive, corrective, and emergency maintenance.

The general public also should be educated about pavement preservation. An uninformed public can contribute to the reluctance to adopt pavement preservation strategies. For example, motorists often misunderstand the purpose of preventive maintenance and will complain when they see work crews fixing a road that seems to be in fine shape. The public may perceive that the agency is not using funds appropriately by taking care of pavements in need of repair.

Philosophy: Developing a preventive maintenance program requires a shift in thinking, from rehabilitation and reconstruction to preservation.

Timing: Treatments must be applied in time to preserve the structure of the pavement. Distressed pavements may not be suitable candidates for preventive maintenance.

Funding: An effective preventive maintenance program requires adequate funding. Criteria need to be established for the selection of pavements that qualify for preventive maintenance, and this policy must be enforced.

Corrective Maintenance

Corrective maintenance differs from preventive maintenance primarily in cost and timing. While preventive maintenance is performed when the pavement is still in good condition, corrective maintenance is performed when the pavement is in need of repair, and is therefore more costly.

Corrective maintenance is much more reactive than preventive maintenance, and is performed to correct a specific pavement or area of distress.

Delays in maintenance increase pavement defects and their severity so that, when corrected, the cost is much greater. Consequently, the life cycle costs of the pavement will be considerably increased when corrective maintenance is performed.

Corrective maintenance activities include structural overlays, mill and overlays, pothole repair, patching, and crack repair.

Emergency Maintenance

This maintenance activity may be performed during an emergency situation, such as when a blowout or severe pothole must be repaired immediately, generally for safety reasons, or to allow for traffic to use the roadway. Emergency maintenance also describes those treatments that hold the surface together until a more extensive rehabilitation or reconstruction treatment can be accomplished.

When emergency maintenance is needed, some of the typical considerations for choosing a treatment method are no longer important. Cost may be the least important consideration, after safety and time of application are considered. Materials that may not be acceptable when used in preventive or corrective maintenance activities, for cost or long-term performance reasons, may be highly acceptable when used in an emergency situation.

Chapter 2: A Systems Approach to Pavement Maintenance

Pavement Management Systems

A Pavement Management System (PMS) is the name given to a tool or method that assists in optimizing strategies for providing and maintaining pavements in a serviceable condition over a given period of time. One of the primary benefits of a pavement management system is that it helps users select cost-effective alternatives for pavement maintenance and rehabilitation.

Mn/DOT has been involved in pavement management for over 20 years. A Pavement Management section was created in 1982 and is currently part of the Office of Construction and Materials Engineering.

Mn/DOT's major pavement management component is its computerized PMS. The PMS has been operational for several years, and the results are sent to the districts for use in program development. The PMS data files are part of the Transportation Information System (TIS).

Many local agencies do not have a formal pavement management system, but use an informal method for determining which pavements receive a specific maintenance treatment at any time. The large variation in system size and pavement type across the state results in many types of pavement management systems in use, many of which are very effective regardless of their size or format.

Pavement Rating Systems

One of the key components of any pavement management system is the pavement rating system. These systems involve calculating a numerical score or index based on the visible pavement distress (cracks, patches, rutting, etc.), which allows users to make an unbiased comparison between roadway segments based on their condition.

The U.S. Army Corps of Engineers developed PAVER, one of the most popular pavement rating systems. This computer system calculates a numerical index between 0 and 100 called the Pavement Condition Index (PCI). A pavement with a score of 100 would have no distress of any kind. Pavements in worse condition would have ratings lower than 100.

Other systems are available that have been developed by private industry. Mn/DOT can assist in identifying and selecting an appropriate management

system for an agency. Call the Mn/DOT Office of Materials and Research at 651-779-5592 for more information.

Mn/DOT's PMS Survey

The Mn/DOT Pavement Management System survey uses three indices:

PSR: The Present Serviceability Rating is a measure of the roughness of the pavement, measured with a profilometer. The results of the profiler test are, through use of a correlation equation, converted into the PSR. The PSR ranges from 0 (very poor) to 5 (perfect).

SR: The Surface Rating is a survey of the surface distresses (cracking, rutting, faulting, etc.) over a 500-foot sample of the pavement. It is gathered using an automated van, which allows the survey to be conducted in the office from video. The various distresses have different weightings, which are deducted from a perfect score of 4.0. The range of possible values is 0 (severely distressed) to 4 (no distresses).

PQI: The Pavement Quality Index is simply the square root of the product of the PSR and the SR. The PQI ranges from a low of 0 to a high of 4.5 (square root of 20). Once the PQI drops below 2.8, the pavement is generally considered to need corrective maintenance or rehabilitation such as a structural overlay, mill and overlay, or total replacement.

Mn/DOT's Pavement Maintenance Program

Mn/DOT is working to develop a pavement preservation program. Recently, a task force was formed to evaluate Mn/DOT's effectiveness in administering a pavement preservation program for roadways and bridges. The task force concluded that the following components are needed for program implementation.

Planned Spending Account: The pavement preservation program by its very nature is not normally seen as a high priority, primarily because pavement preservation requires the use of limited resources to fix roads in generally good condition. This becomes even more difficult when a large portion of the system is in poor condition. Dedicated funding could eliminate the need to make this decision and ensure that pavement preservation work is completed. Dedicated funding does work, and it is highly recommended by several states and the Federal Highway Administration (FHWA). These agencies feel that this is the best way to start a pavement preservation program and gives them the best opportunity for success.

Improved Planning: The plan for developing a pavement preservation program is based on needs calculated by Mn/DOT's Pavement Management System. The process is as follows:

1. Mn/DOT's Pavement Management Unit identifies pavement sections benefiting from preventive maintenance activities.
2. The Pavement Management Unit provides recommended fixes and sends them to the District/Division.
3. Annual targets are set by the District/Division using a portion of that list, based on life of fixes and overall system optimization. The District/Division selects projects from the list of potential candidates developed by Mn/DOT's Pavement Management Unit. The list, with any subsequent changes, will be based on established criteria, essentially the three primary pavement preservation criteria listed here:
   - The Right Road—The road section must have some distress but must also be "good enough" for pavement preservation to be fully successful.
   - The Right Time—Expected life curves and section history should be examined to ensure a successful fix.
   - The Right Fix—Existing distress and section type will dictate which treatment(s) are appropriate.
4. Districts develop a pavement preservation plan using the above information.

Training: Training will be a major challenge to the overall success of this program. The development of accurate, easy-to-use design and construction standards is critical to the success of the program. Technical guidelines will be developed and include the following sections:

Project Selection:	How to make the proper selection
Specifications:	Detailed instructions on how to build it right
Materials:	What are the correct materials for each fix
Design:	Typical details for each fix
Construction Methods:	The best methods to build it right
Construction Administration:	To select an appropriate method
Training:	Include development of a best practices manual, technical short courses, on-site instruction and assistance

Program Evaluation: Performance measures are a necessary part of the pavement preservation program.

Traffic Control and Safety

A primary consideration of all pavement maintenance operations is safety. Whether maintenance operations must be completed under traffic or with lane closures, traffic control and safety on site must be considered when planning the work. The Mn/DOT *Temporary Traffic Control Zone Layouts*

Field Manual should be used as a resource for planning traffic control for all situations, including moving, mobile, short-term stationary, intermediate, and miscellaneous layouts. Other topics included in the manual include height and lateral sign locations, mounting signs, channeling devices, portable changeable message signs, and flagging information.

The typical layouts of temporary traffic control zones contained in the *Temporary Traffic Control Zone Layouts Field Manual* do not cover all situations. Because each situation is different, engineering judgement is required to ensure proper traffic control. This manual is available from Mn/DOT's Office of Manual and Sales at 651-296-2216.

Chapter 3: Treatment Selection

Pavement distresses contribute to pavement failure in different ways. The most common flexible pavement distresses are cracking, roughness, weathering, raveling, rutting, and bleeding. *(See Appendix A for definitions of pavement distresses and severity levels.)*

If the distresses identified in a pavement are related to structural deficiencies, the pavement section is most likely not a candidate for preventive maintenance treatment, and should instead be scheduled for rehabilitation or reconstruction.

Other distresses can be corrected with preventive, corrective, or emergency treatments. To be effective, an engineering approach should be taken to select and construct the treatment. It is critical that the proper maintenance treatment be done at the right time for the pavement to function as designed and for the maintenance program to be effective.

Determining a Treatment's Cost-Effectiveness

Many factors should be considered when determining the value of any pavement maintenance treatment. The decision process should include the following three questions, asked and answered in the following order:

1. Does the treatment enhance pavement performance?
   Enhanced performance can be measured in several ways, including comfort, convenience, safety, or life cycle costs. If there are no improvements in any of these customer-related issues, then there is no reason to use the treatment. If one or more of the areas can be enhanced, then you should ask the second question.

2. Is the treatment cost-beneficial?
   Measuring the benefit of a treatment should include an assessment of the pavement's performance, and not necessarily the performance of the treatment itself. For example, if a seal coat is placed on a pavement, the cost-benefit analysis should compare the life of that pavement (after receiving the seal coat) with that of a similar pavement that did not receive the seal coat. The seal coat itself may only last five years, but it may have extended the life of the treated pavement by ten years. Likewise, if sealing the cracks in a pavement extends its life an additional number of years, then the value of extending the pavement life should be considered when determining cost-effectiveness.

The error often made when comparing maintenance costs is to compare the cost and life of the treatment with the cost and life of the pavement. This comparison is not valid.

3. What is the best treatment method to use?
   Once a treatment has been determined to be cost-effective, then select the best materials and construction methods.

Selection Factors

By removing normal bias, politics, and other subjective factors, pavement management systems enable users to determine the most cost-effective treatment. The selection is generally based on factors including:

- existing pavement type
- crack condition
- type and extent of distress
- roadway use and level of traffic
- climate and environmental factors
- traffic loading
- cost of treatment
- expected life
- availability of qualified staff and contractors
- availability of quality materials
- time of year of placement
- facility downtime
- pavement noise
- surface friction

One of the factors listed above—crack condition—provides a good example for understanding how the treatment selection process works. The correct type of maintenance for distressed pavements often depends on the density and general condition of the cracks. If cracks are frequent but do not have a high degree of edge deterioration, they may be best treated with a surface treatment. If they are low to moderate in frequency but have typically progressed to a point of high edge deterioration, then crack strategies or patching may be needed. If cracks are moderate in density and have some or little deterioration, they may be treated effectively through sealing or filling.

In general, many cracks that are severely deteriorated indicate a pavement in an advanced state of decay. In this situation, crack sealing or filling is both uneconomical and technically unsound, as it does little to delay the need for more extensive corrective actions.

A policy that specifies the type and timing of maintenance to perform on cracked pavements is helpful. These policies are often based on an assessment of the overall pavement condition or specific crack characteristics.

Cracks may also contain other deficiencies, such as additional cupping or faulting, and may move vertically under traffic loads. Such deficiencies can add significantly to the overall pavement roughness and often worsen rapidly with time. Normally, patching or milling and overlay are appropriate for correcting these distresses. However, if the vertical deflection and distress severity are not too high, a temporary fix with crack repair may be adequate.

Types of Maintenance Treatments

Crack repair w/sealing. A localized treatment method used to prevent water and debris from entering a crack, which might include routing to clean the entire crack and to create a reservoir to hold the sealant. It is only effective for a few years and must be repeated. However, this treatment is very effective at prolonging the pavement life. Includes the following three crack repair methods:

Clean and seal: Used on all types of cracks, it involves using a hot air lance or compressed air to blow out the debris in the crack, then filling with a sealant.

Saw and seal: Involves using a pavement saw to create transverse joints at regular intervals along a newly placed pavement, then filling with a sealant.

Rout and seal: Used on transverse and longitudinal cracks. Involves using a pavement saw or router to create a reservoir centered over existing cracks, then filling with a sealant.

Crack filling: Differs from crack sealing mainly in the preparation given to the crack prior to treatment and the type of sealant used. Crack filling is most often reserved for more worn pavements with wider, more random cracking.

Full-depth crack repair: A localized treatment method to repair cracks that are too deteriorated to benefit from sealing. Secondary cracking requires the reestablishment of the underlying base materials.

Fog seal: An application of diluted emulsion (typically at a rate of 1:1) to enrich the pavement surface and delay raveling and oxidation. Considered a temporary treatment.

Seal coat: Used to waterproof the surface, seal small cracks, reduce oxidation of the pavement surface, and improve friction.

Double chip seal: An application of two single seal coats. The second coat is placed immediately after the first. This treatment waterproofs the surface, seals small cracks, reduces oxidation of the pavement surface, and improves friction.

Slurry seal: A mixture of fine aggregate, asphalt emulsion, water, and mineral filler, used when the primary problem is excessive oxidation and hardening of the existing surface. Slurry seals are used to retard surface raveling, seal minor cracks, and improve surface friction.

Microsurfacing: Commonly referred to as a polymer-modified slurry seal; however, the major difference is that the curing process for microsurfacing is a chemically controlled process, versus the thermal process used by slurry seals and chip seals. Also may be used to fill ruts.

Thin hot-mix overlays: Includes dense, open, and gap-graded mixes that improve ride quality, reduce oxidation of the pavement surface, provide surface drainage and friction, and correct surface irregularities.

Pothole patching: Includes using cold- and hot-asphalt mixture, spray injection methods, as well as slurry and microsurfacing materials, to repair distress and improve ride quality.

Table 3-1 lists each type of maintenance technique along with reasons for using each one. Average treatment life and costs are also summarized. Note that these values will vary depending on the project location and environmental conditions. Each agency could prepare a similar table to assist in selecting a specific treatment. The table can be prepared using expertise within an agency and supplemented with information from material suppliers, contractors, consultants, and association representatives. Once prepared, a treatment method can be identified given specific project conditions.

Table 3-2 further breaks down recommended treatments for crack repairs, and Table 3-3 outlines treatments for surface defects and potholes.

Table 3-1. Asphalt Maintenance Techniques

Use these techniques only on structurally sound pavements.
Appendix A defines low-, medium-, and high-severity cracking.

Technique	Reasons for Use							Average Treatment Life (years)	Average Unit Cost	Reference Page
	Friction	Raveling	Rutting	Potholes	Cracking					
					Low	Med	High			
Crack treatments										
Crack repair with sealing										
Clean and seal					X	X		3	$0.20/lf	26
Saw and seal								7-10	$1.70/lf	28
Rout and seal					X	X		3	$0.70/lf	30
Crack filling						X	X	2-3	$0.25/lf	32
Full-depth crack repair							X	5	$5.00/lf	34
Surface treatments										
Fog seal		X						1-2	$0.15/sy	38
Seal coat	X	X						3-6	$0.55/sy	40
Double chip seal	X	X						7-10	$1.50/sy	43
Slurry seal	X	X						3-5	$1.50/sy	45
Microsurfacing	X	X	X					5-8	$1.75/sy	47
Thin hot-mix overlay		X	X					5-8	$25/ton	49
Pothole and Patching Repair										
Cold-mix asphalt				X				1	$55/ton[a]	54
Spray injection patching				X				1-3	Not Available[b]	55
Hot-mix asphalt				X			X	3-6	$25/ton[a]	57
Patching w/slurry or microsurfacing material				X			X	1-3	0.85/sy[a]	58

[a] Cost for materials only.
[b] Price varies with conditions.
lf=lineal foot
sy=square yard

Table 3-2. Crack Treatments

Use these techniques only on structurally sound pavements.
Appendix A defines low-, medium-, and high-severity cracking.

Type of Crack	Treatment							
	Full-depth crack repair	Crack Repair w/sealing			Crack filling	Patching	Chip seal or seal coat	Thin hot-mix overlay
		Clean and Seal	Saw and seal	Rout and seal				
Alligator								
Low severity							X	
Medium severity						X		
High severity						X		
Transverse								
Low severity		X		X			X	
Medium severity		X		X	X		X	
High severity	X				X	X	X	
Longitudinal								
Low severity		X		X	X			
Medium severity	X	X		X	X			
High severity	X				X	X		
Block								
Low severity		X		X			X	
Medium severity							X	X
High severity					X	X		X
Reflection								
Low severity		X		X				
Medium severity		X		X	X			
High severity		X			X	X		X

Table 3-3. Treatments for Surface Defects

Type of Distress	Treatment						
	Patching	Fog seal	Seal coat	Double chip seal	Slurry seal	Micro-surfacing	Thin hot-mix overlay
Potholes							
Low severity	X						
Medium severity	X						
High severity	X						
Patch deterioration							
Low severity							
Medium severity	X						
High severity	X						
Surface Defects							
Rutting							
Low severity	X				X	X	
Medium severity	X				X	X	X
High severity	X					X	X
Shoving							
Low severity							
Medium severity	X						
High severity	X						
Bleeding							
Low severity			X	X	X	X	
Medium severity			X	X	X	X	
High severity			X	X	X	X	X
Polished aggregate							
Low severity			X	X	X	X	
Medium severity			X	X	X	X	X
High severity			X	X	X	X	X
Raveling							
Low severity		X					
Medium severity		X	X				
High severity	X		X	X	X	X	X

Part II:

Recommended Treatment Practices

Preceding Page Blank

Chapter 4: Crack Treatments

This chapter presents guidelines for crack repair and sealing operations, sealant specifications, and recommended practices. It covers three types of crack treatments:

Crack sealing: A localized treatment method used to prevent water and debris from entering a crack. Crack sealing involves blowing out the debris in the crack or using a saw or router to create a reservoir, then filling with a sealant. Cracks that are sealed are typically less than 3/4-inch wide. Three approaches fall into this category: clean and seal, saw and seal, and rout and seal.

Many local highway agencies in Minnesota include crack sealing as part of their preventive maintenance program. Sealing cracks in asphalt-surfaced roads helps prevent moisture from infiltrating the pavement structure. This moisture weakens the structural subsurface layers and is a primary cause of pavement deterioration. Although the benefits of crack sealing may not be obvious immediately, they will be evident several years later when a sealed pavement shows fewer signs of deterioration than an unsealed pavement.

Crack filling: Differs from crack sealing mainly in the preparation given to the crack prior to treatment and the type of sealant used. Crack filling is most often reserved for more worn pavements with wider, more random cracking. Cracks are typically wider than 3/4 inch.

Full-depth crack repair: A localized treatment method to repair cracks that are too deteriorated to benefit from sealing.

To Seal or Fill?

The width and spacing of the targeted crack type is the principal basis for determining whether to seal or fill. Normally, cracks less than 3/4-inch wide, which are spaced uniformly along the pavement and have limited edge deterioration, should be sealed. To effectively seal the cracks, the router or saw width must touch both sides of the crack. Cracks that are greater than 3/4-inch wide and are very numerous are not practical to seal, both because the router or saw will not touch both sides of the crack and because of the number of cracks present.

The practice of crack treatments has evolved from crack filling with asphalt cements to sealing pavements with specially engineered sealant materials.

Sealant or Filler?

Many types of crack treatment materials are available. Table 4-1 gives the principal material families and types. Table 4-2 gives tips for effective sealing.

Asphalt cement and liquid asphalt possess little flexibility and are very temperature susceptible, so they are limited to use as fillers in non-working cracks. Additives such as mineral fillers and fibers provide minimal elasticity to asphalt and do not significantly affect temperature susceptibility. Mineral-filled and fiberized asphalt are most appropriate for use in crack-filling operations.

Table 4-1. Recommended Applications for Crack Sealant and Fillers

Material	Mn/DOT Spec	Recommended Application
Low-modulus rubberized asphalt	3720 3725	**Crack sealer**—During the evolution of the rout-and-seal method, the use of a lower modulus sealant with a 3/4-inch x 3/4-inch reservoir size and less overband has shown to be very effective. Initially, material meeting the specifications of Mn/DOT 3720 was the product of choice for this system. Mn/DOT specification 3725, which has slightly higher resiliency properties, is now the recommended sealant for rout and seal. It is also the recommended sealant for saw and seal.
Rubberized asphalt	3723	**Crack filler/crack sealer**—Material meeting the specifications of Mn/DOT 3723 has been the common sealer for rout and seal until recently. This product exhibits good adhesion qualities. This material can be used for rout and seal in situations where wider reservoir widths are needed. This product can also be used for the clean-and-seal (formerly known as blow-and-go) method.
Crumb rubber	3719	**Crack filler**—Crumb rubber is very effective in the clean-and-seal method. This process works best in the early spring or late fall when the cracks are open. Although crumb rubber will crack in the winter, it will re-heal during warmer weather. A double jacket melter is needed to maintain proper temperature of the product during application.
Asphalt emulsion	CSS-1 CSS-1H CRS-2P HFMS-2	**Crack filler**—Asphalt emulsion can be used as a crack filler. The primary purpose would be to coat the edges of the crack and fill some of the crack. Since emulsions are 33 percent water, the quantities will shrink with curing. Emulsions are safe and easy to use but are limited to use in warmer seasons.
Asphalt cement	AC-3	**Crack filler**—AC-3 is an air-blown asphalt that can be used to coat the edges and fill cracks. This product will get quite brittle in the winter and may track in warmer weather.
Cutback asphalt	RC MC SC	**Crack filler**—Cutback asphalt, like emulsions, can be used primarily to coat the edges of cracks. Cutbacks are not as readily available and are not as safe as emulsions, but can be used in the winter months.

Table 4-2. Effective Crack Sealing Tips

Technique	Tip
Clean and seal (formerly "blow and go")	Make sure that cracks are clean and dry before placing sealant. Perform in late fall or early spring when cracks are open. Take care to not burn pavement with hot air lance. Follow manufacturer's recommendations for sealant application temperatures.
Saw and seal	Place the sealant flush to the pavement surface. The strike-off will create a "slight overband" that provides better adhesion of the sealant to the pavement surface/reservoir edge corner. See the *Seal Coat Handbook* (Mn/DOT document no. 1999-07) for more information.
Rout and seal	The total width of the overband should be about 2-1/2 inch (3/4-inch route plus 3/4-inch overband on each side of the route.) The overband thickness should be as thin as possible.
Crack filling	The preparation is fairly minimal, generally consisting of blowing the loose debris from the crack with compressed air. In some cases, you can use a hot air lance to **clean and dry the crack** before applying the filler material. Material that meets Mn/DOT specification 3719, Crumb Rubber, is recommended. The use of AC-3 as a crack filler is discouraged.
Full-depth crack repair	Milling depth varies from 1/2 inch for cracks in good condition, to full depth for pavements with severe deterioration in the crack vicinity. The mill width varies from 10 to 12 inches for shallow milling, to 3 to 4 inches for deep milling. When choosing the configuration of the area to be milled, the trench should be wide enough to ensure good compaction. It is difficult to achieve good compaction in a deep and narrow trench.
Crack sealing and overlays	Crack sealing is recommended 6 to 12 months prior to an overlay. To eliminate bumps in overlays caused by too much sealant or roller slippage, use proper sealant application procedures and roller techniques.

Crack Repair with Sealing:
Clean and Seal

Description
This crack seal treatment is used on all types of cracks. It involves using a hot air lance or compressed air to blow out the debris in the crack, then filling with a sealant.

Do not confuse crack sealing with crack filling. Crack filling, typically done with asphalt emulsion or AC-3, does not seal the cracks from water infiltration. Instead, it reduces the amount of water and incompressible material entering the pavement system. Because the filler material hardens quickly, most crack-filling operations must be repeated annually to be effective.

Timing
Use while cracks are still narrow to be economical.

Purpose
Reduces or prevents water and incompressible material from entering the pavement structure, which can weaken the base material and prevent the pavement from expanding and contracting freely.

Existing Pavement Condition
Needs a new or recently rehabilitated surface on a sound base with a good cross section and good lateral support. Visible surface distresses may include longitudinal or transverse cracks with little or no secondary cracking or raveling at the crack face.

Maintenance Methods
Clean and dry all cracks with compressed air before treating.

Seasonal Limitations
Best applied when temperatures are moderately cool, as in spring and fall.

Traffic Control
Reroute traffic until the sealant material cures. If the pavement must be opened immediately after sealing, protect the sealant against pick-up by tires by lightly covering the sealant material with fine sand or toilet paper.

Anticipated Performance and Service Life
If you perform this technique at the right time, it can be expected to perform for three years before substantial amounts of the sealant begin to pull off the side(s) of the crack. While the sealant may no longer be preventing water and

incompressible material from entering the pavement structure, it may still be reducing infiltration substantially and prolonging pavement life.

Limitations

To maintain the sealed pavement surface, repeat this treatment throughout the life of the pavement. Excessive amounts of sealant on the surface can lead to reduced pavement friction.

Precautions

Moisture will inhibit bonding of the crack sealer to the walls of the crack.

Materials

See Table 4-1 (page 24). Material meeting Mn/DOT Specification 3719 is preferred.

Construction Specifications that Apply

Special Provision for Asphalt Concrete Crack Sealing (see Appendix B).

Unit Cost for Estimating

Unit price costs for clean and seal typically range between $0.10 and $0.30 per lineal foot, depending on the size of the project.

Crack Repair with Sealing:
Saw and Seal

Description
This method uses a pavement saw to create transverse joints at regular intervals along a newly placed pavement, then filling with a sealant.

Timing
Perform on newly placed asphalt pavement, at least 48 hours after paving.

Purpose
Controls shrinkage cracks due to thermal changes. Sealing the cracks reduces or prevents water and incompressible material from entering the pavement structure, which can weaken the base material and prevent the pavement from expanding and contracting freely.

Existing Pavement Condition
Newly paved asphalt pavement should be free of cracks.

Maintenance Methods
Use one single pass of a saw to create the reservoir. The dimensions of the reservoir are classified by shape factor, which is the ratio of the reservoir width to depth. The higher the shape factor, the less stress the sealant is subjected to as the pavement expands and contracts. In Minnesota, there is no standard reservoir shape. The most common shapes are nearly rectangular, such as 3/4-inch by 3/4-inch or 1-inch by 1-inch (a shape factor of 1). Mn/DOT's standard specification calls for a 5/8-inch by 1/2-inch reservoir, but the size may be adjusted depending on the sealant properties.

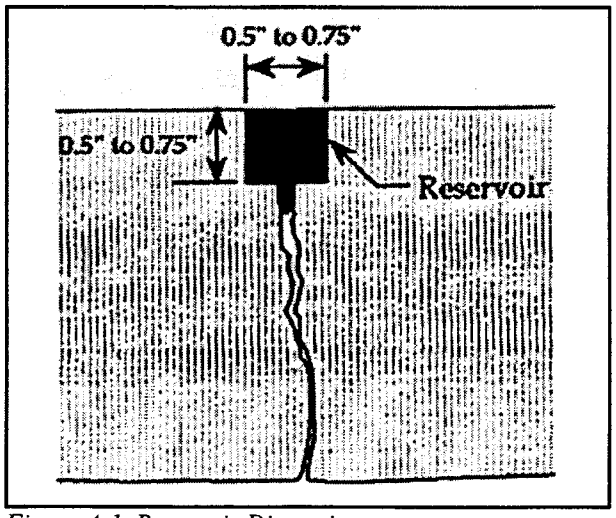

Figure 4-1. Reservoir Dimensions

Place the sealant flush with the pavement surface. The strike-off will create a slight overband that provides better adhesion of the sealant to the pavement surface/reservoir edge corner.

Mn/DOT recommends a spacing of 40 feet, depending on the type of subgrade. Pavements on granular soils may benefit from having the joints spaced at 30 feet.

Placement with an overband is acceptable; however, consider motorcycle traffic. When longitudinal cracks are sealed, especially on curves, tires may slip when traveling over the overband material. This can be very dangerous and should be considered when sealing longitudinal cracks on curves.

Traffic Control Concerns

Reroute traffic until the sealant material cures. If the pavement must be opened immediately after sealing, protect the sealant against pick-up by tires by lightly covering the sealant material with fine sand or toilet paper.

Anticipated Performance and Service Life

Studies indicate that sealing on a new asphalt surface will last seven to ten years and significantly reduce the amount of random cracking in newly placed asphalt pavements.

Limitations

To maintain the sealed pavement surface, repeat this treatment throughout the life of the pavement. Excessive amounts of sealant on the surface can lead to reduced pavement friction.

Precautions

Moisture will inhibit bonding of the crack sealer to the walls of the crack.

Materials

See Table 4-1 (page 24). Material meeting Mn/DOT Specification 3725 is recommended.

Unit Cost for Estimating

Unit price costs for saw and seal are typically about $1.70 per lineal foot, depending on the size of the project.

Crack Repair with Sealing:
Rout and Seal

Description
Use this method on transverse and longitudinal cracks. It involves using a pavement saw or router to create a reservoir centered over existing cracks, then filling with a sealant. This procedure reduces or prevents water and incompressible material from entering the pavement structure, which can weaken the base material and prevent the pavement from expanding and contracting freely.

Timing
Perform rout and seal early in the pavement's life to be successful. If the cracks are too badly deteriorated or too wide, do not seal them. Instead, consider crack filling, slurry crack filling, or crack mill and fill as a maintenance alternative.

Purpose
Reduces or prevents water and incompressible material from entering the pavement structure, which can weaken the base material and prevent the pavement from expanding and contracting freely.

Existing Pavement Condition
Needs a new or recently rehabilitated surface on a sound base with a good cross section and good lateral support. Visible surface distresses may include longitudinal or transverse cracks with little or no secondary cracking or raveling at the crack face.

Maintenance Methods
Mn/DOT recommends a 3/4-inch by 3/4-inch reservoir, but you may adjust the size depending on the sealant. Level the sealant with a 3/4-inch overband. Make a second pass with additional sealant.

To require an overband is acceptable; however, give consideration for motorcycle traffic. When longitudinal cracks are sealed, especially on curves, tires may slip when traveling over the overband material. This can be very dangerous and should be considered when sealing longitudinal cracks on curves. (See Figure 4-1 on page 28.)

Seasonal Limitations
Best applied when temperatures are moderately cool, as in spring and fall.

Traffic Control

Reroute traffic until the sealant material cures. If the pavement must be opened immediately after sealing, protect the sealant against pick-up by tires by lightly covering the sealant material with fine sand or toilet paper.

Anticipated Performance and Service Life

If you apply rout and seal at the right time, it can be expected to perform for three years before substantial amounts of the sealant begin to pull off the side(s) of the reservoir. While the sealant may no longer be preventing water and incompressible material from entering the pavement structure, it may still be reducing infiltration substantially and prolonging pavement life. Work in Ontario has shown that routing and sealing cracks adds a minimum of two years of life to a pavement, with an average of five years.

A new or recently rehabilitated surface on a sound base with a good cross section and good lateral support is needed. Visible surface distresses may include longitudinal or transverse cracks with little or no secondary cracking or raveling at the crack face.

Limitations

To maintain the sealed pavement surface, repeat this treatment throughout the life of the pavement. Excessive amounts of sealant on the surface can lead to reduced pavement friction.

Precautions

Moisture will inhibit bonding of the crack sealer to the walls of the crack.

Materials

See Table 4-1 (page 24). Materials meeting the specifications of Mn/DOT 3720 and 3725 should be considered when sealing cracks in the northern part of the state.

Construction Specifications that Apply

Special Provision for Asphalt Concrete Crack Sealing (see Appendix B).

Unit Cost for Estimating

Unit price costs for rout and seal typically range between $.50 and $.85 per lineal foot, depending on the size of the project.

Crack Filling

Description

Crack filling differs from crack sealing mainly in the preparation given to the crack prior to treatment and the type of sealant used. While crack sealing is primarily done on newer pavements containing fairly narrow cracks, crack filling is most often reserved for more worn pavements with wider, more random cracks.

Timing

Primarily done on older pavements with wider cracks.

Purpose

Crack fillers do not prevent water and incompressibles from entering the crack the way that crack sealers do. Instead, they reduce the amount of water and incompressibles entering the crack and also coat crack edges, reducing the rate of oxidation.

Existing Pavement Condition

Older with more severe cracking.

Maintenance Methods

The preparation is fairly minimal, generally consisting of blowing the loose debris from the crack with compressed air. In some cases, use a hot air lance to clean and dry the crack before applying the filler material.

Seasonal Limitations

May be done all year. Often occurs during cool weather (35-55°F), when cracks are almost fully open.

Traffic Control

Cracks can be filled under traffic, given appropriate safety considerations for workers. Allow traffic over the repaired areas as soon as maintenance workers and equipment are clear.

Anticipated Performance and Service Life

Expected life of crack fillers such as AC-3 and asphalt emulsion ranges from a few months to up to one year. The rubberized fillers typically last much longer, with an expected life of two to three years. Cracks may also be filled with microsurfacing material. Those crack treatments can be expected to last two to three years as well.

Limitations

Crack fillers do not prevent water from infiltrating the pavement, but coat the edges of existing cracks to prevent oxidation.

Materials

The sealants used in crack filling are generally less expensive than those used in crack sealing. You may use sealants containing crumb rubber, asphalt emulsion, or AC-3, although the use of AC-3 as a crack filler is discouraged. One recommendation is a product that meets Mn/DOT Standard Specification 3719, Crumb Rubber. You may also fill cracks with microsurfacing material or slurry.

Crack sealing, in contrast, uses more expensive polymer-modified sealants. The main reason for this is performance. High-end, polymer-modified sealants must have a very clean, dry surface in order to adhere to the joint sidewalls. Since crack filling requires very little reservoir preparation and leaves the reservoir edges rough, these sealants do not perform. Sealants containing crumb rubber are very sticky and less sensitive to the cleanliness of the crack. They tend to adhere much better to the sidewalls of the cracks. However, they are also more brittle than the polymer sealants in cold weather and do not have the ability to stretch as far when the pavement is contracting. As a result, crack filling does not last as long as crack sealing but is a better choice for older, more worn pavements with wider, more deteriorated cracks.

Unit Cost for Estimating

Crack filling normally costs approximately $0.25 per lineal foot depending on the amount of preparation, the type of filler used, and the size of the project.

Full- and Partial-Depth Crack Repair

Description

Involves milling a trench centered over an existing crack, placing hot-mix asphalt (HMA) into the reservoir in one or more lifts, and compacting to achieve density.

Timing

Cracks containing secondary cracking may show up at any time after construction. Perform this repair as soon as secondary cracking is present; prolonging repairs will lead to additional loss of support from the underlying base materials and additional secondary cracking.

Purpose

Uses full-depth and partial crack repair to repair cracks that contain secondary cracking. The full-depth repair is required to reestablish the underlying base or pavement material.

Existing Pavement Condition

Consider the wide and shallow (partial-depth) option for pavements with cracks that are deteriorated at the surface but fairly sound just below the surface. Reserve the narrow and deep option for pavements with severe deterioration or those with stripping of the asphalt at the cracks and/or those with problems that extend to the bottom of the bituminous layer.

Maintenance Methods

Milling depth varies from 1-1/2 inches for cracks in good condition to full depth for pavements with severe deterioration in the crack vicinity. The most common mill width used for this purpose is 14-1/2 inches. When choosing the configuration of the area to be milled, make sure the trench is wide enough to ensure good compaction. It is difficult to achieve good compaction in a deep and narrow trench.

While this procedure requires few materials—asphalt emulsion for tack and hot-mix asphalt—it requires much equipment. A milling machine, vacuum, skid loader, truck(s) with mix, rollers, and trucks with trailers for the equipment are all required. In addition, this procedure requires more labor than most other techniques and as a result tends to be very time consuming and costly. However, if the cracks are in extremely poor condition, mill and fill may be the only viable crack treatment option.

Sequence:

1. Mill out the crack.
2. If needed, use a skid loader to remove millings from the roadway.
3. Vacuum out the reservoir.
4. Tack the reservoir with asphalt emulsion.

5. Place hot mix into the reservoir.
6. Compact the reservoir with roller.

Seasonal Limitations
Same limitations as those for hot-mix asphalt paving.

Traffic Control Concerns
Release traffic after mixture has been compacted.

Anticipated Performance and Service Life
Expected life of cracks repaired with the mill-and-fill technique is largely dependent on the density achieved. Lack of density will result in shoving from traffic and a short patch life. Poor mix design and wet pavement can also lead to poor patch life. If done correctly, mill and fill can last up to five years.

Limitations
Trench width limits compaction. Remove an adequate section for compaction of underlying base and asphalt hot-mix layers with a roller.

Precautions
Properly drain cracks that have been milled and had pavement removed if they are allowed to stand before placing a new asphalt course.

Materials
Aggregate base (if needed), hot-mix asphalt base, and wearing course materials.

Construction Specifications that Apply
Milling, asphalt wearing course.

Unit Cost for Estimating
Mill-and-fill costs are based on the width and depth of the trench to be filled. Typical costs are $4.00 to $6.00 per lineal foot for a trench that is 4 inches deep and 14-1/2 inches wide.

Chapter 5: Surface Treatments

Surface treatments include sealing the existing asphalt pavement surface with asphalt, and in some cases, following that application with an aggregate if additional friction is desired. The asphalt may be a cutback or emulsion, but emulsions are recommended based on the added safety and reduced environmental ramifications.

The treatments outlined in this chapter include fog seal, seal coat, double chip seal, slurry seal, microsurfacing, and thin hot-mix asphalt overlays. The seal treatments differ only in the amount and type of aggregate that is placed over the asphalt emulsion that seals the pavement surface. Sand sealing is not included in this manual and is not recommended because quantities are difficult to control, resulting in bleeding or excess sand on the pavement surface.

Table 5-1. Recommended Applications for Surface Treatments

Material	Mn/DOT Spec	Recommended Application
Fog seal	2355	CSS-1 or CSS-1h diluted with 50 percent water usually applied at 0.05 to 0.15 gal/sy, depending on the pavement texture, weather conditions, and traffic. A spraying temperature of 125°F to 160°F and surface temperature of at least 50°F are recommended.
Seal coat	2356	See the *Seal Coat Handbook* (Mn/DOT document number 1999-07) for design methodology and application rates.
Double chip seal	None	Use the design application rates. Pavement should be dry and clean, and all necessary repairs or reconditioning work should be completed prior to placement of the double chip seal. Do not place chip seals in cool weather or on days with high humidity. Also do not place them when there is a chance of rain.
Slurry seal	None	Pavement should be dry and clean, and all necessary repairs or reconditioning work should be completed prior to placement of the slurry seal. Place when the air and pavement temperature are both at least 50°F and there is no chance of freezing within 24 hours after placement. Do not place during rain.
Microsurfacing	Special Provision	Follow mix design carefully. Ideal for high-volume roads. Pavement should be clean, and all necessary repairs or reconditioning work completed prior to placement of the microsurfacing.
Thin hot-mix overlay	2350 LV Type 5	It is important to use a quality designed mix. Density is vital to performance. Non-designed sand mixes are not recommended. Place with paver, not blade.

Preceding Page Blank

Fog Seal

Description

A fog seal is an application of diluted asphalt emulsion without a cover aggregate, used to seal and enrich the asphalt pavement surface, seal minor cracks, prevent raveling, and provide shoulder delineation. An asphalt distributor is normally used to apply the fog seal.

Fog seals are used on both low- and high-volume roads. Its primary use on high-volume roads has been to prevent raveling of open-graded friction courses and to delineate between the mainline and the shoulder. Its wider use on heavily trafficked roads is restricted because the pavement friction may be reduced until traffic wears some of the asphalt from the surface.

Timing

As light to moderate raveling and/or oxidation and weather develop. Generally, the coarser the surface and thinner the initial asphalt film thickness in the existing asphalt mixture, the sooner treatment is required.

Purpose

Use this method to seal and enrich the asphalt pavement surface, seal minor cracks, prevent raveling, and delineate shoulders.

Existing Pavement Condition

Only use fog seals where the existing pavement is sufficiently porous to absorb a substantial amount of the emulsion.

Maintenance Methods

Before placing the fog seal, make sure the pavement is dry and clean, and complete all necessary repairs or reconditioning work. Then apply sealer with an asphalt distributor. The application rate is the key element.

Seasonal Limitations

Best applied when temperatures are warm or hot. Cool temperatures require longer curing times prior to opening the roadway to traffic.

Traffic Control Concerns

Keep traffic off the emulsion until it has cured significantly. Under favorable conditions, two to three hours may be sufficient. Require reduced speeds until traffic wears some of the asphalt off the surface. Emulsion rates usually range from 0.1 to 0.15 gallon per square yard, depending on the pavement texture, weather conditions, and traffic. The application rate is kept low to prevent splashing and decreased skid resistance. A spraying temperature of 125°F to 160°F and surface temperature of at least 50°F and rising are recommended. You may also use sand cover to improve the surface friction.

Anticipated Performance and Service Life

Expected life depends on the properties of the underlying pavement and its exposure to sunlight. The performance life of this type of treatment is fairly short, ranging from one to two years.

Limitations

Under adverse weather conditions it may be several hours before the road can be opened to traffic. For these reasons, fog seals are most often used on shoulders and in parking lots where the potential for reduced pavement friction is not a concern.

Precautions

Use only where the existing surface is sufficiently porous to absorb substantial amounts of the emulsion. Do not use in areas with cracks larger than hairline. Use with caution on high-volume roadways.

Materials

Asphalt emulsion diluted mix with 50 percent water (such as CSS-1, CSS-1H) or proprietary rejuvenators meeting Mn/DOT Specification 3151.

Construction Specifications that Apply

Special Provision for Bituminous Fog Sealing (see Appendix B).

Unit Cost for Estimating

Fog sealing is very inexpensive. Price is normally about $0.10 to $0.20 per square yard depending on the type of binder, the application rate, and the size of the project.

Seal Coat

Description

A seal coat is an application of asphalt followed immediately with an aggregate cover. Applications with two layers are referred to as a double chip seal. Rapid-setting asphalt emulsions are normally used when placing a seal coat. Seal coats can waterproof the surface, provide low-severity crack sealing, and restore surface friction.

Timing

You can seal coat at any time in a pavement's life.

Purpose

The primary reason to seal coat an asphalt pavement is to protect the pavement from the deteriorating effects of sun and water. When an asphalt pavement is exposed to sun, wind, and water, the asphalt hardens, or oxidizes. This causes the pavement to become brittle, cracking the pavement. A seal coat provides a waterproof membrane that not only slows down the oxidation process but also helps the pavement shed water, preventing it from entering the base material.

A secondary benefit is an increase in the surface friction, which happens when the cover aggregate adds additional texture to the pavement. A seal coat can increase surface texture on a raveled pavement.

Existing Pavement Condition

Pavements that are dry and raveled are good candidates for seal coating. Some agencies also choose to seal coat pavements in good condition as a preventive maintenance technique.

Maintenance Methods

The Seal Coat Handbook (Mn/DOT document number 1999-07) provides very detailed information about seal coat placement and design.

One of the most important factors when considering a seal coat is the design procedure used to determine the quantities of asphalt binder and cover aggregate. The goal is to have the aggregate particles approximately 70 percent embedded into the asphalt layer. You must make adjustments to account for the traffic volume on the roadway; the absorption of the asphalt binder into the existing pavement; the absorption of the asphalt binder into the cover aggregate; the texture of the existing pavement; and the size, shape, and gradation of the cover aggregate. The correct application rate will result in a single layer of chips embedded approximately 70 percent into the binder with little or no excess chips to remove.

To ensure that the application rates are correct, calibrate the equipment used in chip sealing. You can place a series of rubber mats on the pavement to calibrate the chip spreader. Calibration procedures also exist for determining the application rate of asphalt distributors. On the distributor, adjust the nozzle angle in relation to the spray bar so that the spray fans will not interfere with each other. The recommended angle is between 15 and 30 degrees. The nozzle size, spacing, and angle will determine the spray bar height.

Sequence:

1. Sweep the existing surface to clean and remove loose debris.
2. Apply the asphalt binder with a distributor.
3. Apply cover aggregate using a chip self-propelled spreader.
4. Roll the chip-sealed surface with pneumatic-tired rollers. Five to six passes should be the goal.
5. Sweep excess chips as soon as possible without damaging the sealed surface. You can normally do this the next day, sooner if modified binders are used.

Seasonal Limitations

Seal coats are affected greatly by weather conditions, especially during construction. A warm, sunny day with low humidity is the ideal condition. Humidity and cool weather will delay the curing time and keep the seal coat tender for a longer period of time, making it more susceptible to damage by traffic. Rain can cause major problems when seal coating. If the asphalt binder has not cured, it can become diluted and rise above the top of the cover aggregate. After the water evaporates, asphalt may cover the entire surface, causing tires to pick up aggregate or track the binder across the surface. Never seal coat when showers are threatening.

Conduct seal coating operations (including traffic restrictions on the freshly constructed seal coat) after May 15 and before August 31, only during daylight hours, when the pavement and air temperature are 60°F or higher, and when the relative humidity is less than 75 percent. In addition, do not conduct seal coat operations in foggy or rainy weather.

Traffic Control Concerns

Do not permit traffic on the sealed road surface until after all rolling has been completed and the bituminous material has set and will not pick up on vehicle tires.

Anticipated Performance and Service Life

Expected life of a seal coat is approximately three to six years.

Limitations

Loose chips not embedded in the asphalt membrane will become airborne and possibly damage vehicle windshields. Excessive binders or wet aggregates could cause flushing. Traffic noise will also increase after application of a chip seal.

Precautions

Although seal coats provide effective sealing and friction, the possibility of loose chips and broken windshields along with excessive noise has prompted some states to restrict use of chip seals to low-volume roads.

Materials

Bituminous material meeting the specifications of Mn/DOT 3151. Seal coat aggregate meeting the specifications as outlined in the appendix.

Construction Specifications that Apply

Special Provisions for Bituminous Seal Coat (see Appendix B)

Unit Cost for Estimating

Placing a seal coat varies widely depending on the type of binder, type of aggregate, and the size of the project. Using conventional emulsions results in a range between $0.40 and $0.70 per square yard. Using a latex-modified binder adds an additional $0.04 to $0.08 per square yard.

Double Chip Seal

Description

This treatment involves the application of two single seal coats. The second coat is placed immediately after and directly over the first. Sixty percent of the total asphalt binder required is placed in the first pass, with larger aggregate. The remaining forty percent is placed in the second pass, with aggregates half as large as those placed first.

Timing

Generally later in a pavement's service life than for crack sealing or fog sealing.

Purpose

Waterproofs the surface, seals small- to medium-sized cracks, and improves surface friction. This treatment reinforces the benefits of a single chip seal. As the top layer of aggregate wears off, the bottom remains. It offers better aggregate retention overall, as the bottom layer is more deeply embedded. A double chip seal results in a quieter, smoother surface than a single chip seal, and is a good alternative for pavements in poor condition.

Existing Pavement Condition

A stable pavement on a sound base with a good cross section and good lateral support. Visible surface distresses may include moderate raveling, surface wear, longitudinal cracks, and transverse thermal cracks with some secondary cracking and some deterioration along crack faces. A minor amount of patching in good condition is acceptable. Surface may show signs of slight to moderate block cracking, moderate to severe oxidation, and/or slight to moderate flushing or polishing.

Maintenance Methods

Before placing the double chip seal, make sure pavement is dry and clean and complete all necessary repairs or reconditioning work.

Seasonal Limitations

Conduct seal coating operations (including traffic restrictions on the freshly constructed seal coat) after May 15 and before August 31, only during daylight hours, when the pavement and air temperature are 60°F or higher, and when the relative humidity is less than 75 percent. In addition, do not perform seal coat operations in foggy or rainy weather.

Traffic Control Concerns

Do not permit traffic on the sealed road surface until after all rolling has been completed and the bituminous material has set and will not pick up on vehicle tires.

Anticipated Performance and Service Life

Life extension depends on the type and amount of traffic and the roadway geometry. Heavy commercial traffic and frequent stopping and turning movement reduce the life of this application and cause local deterioration.

Limitations

Loose chips not embedded in the asphalt membrane will become airborne and possibly damage vehicle windshields. Excessive binders or wet aggregates could cause flushing. Traffic noise will also increase after application of a chip seal.

Other limitations include a limited life or premature failure if the chip seal is not properly designed or constructed, and prolonged traffic disruption during construction and curing.

Precautions

Do not place chip seals in cool weather or on days with high humidity. Also do not place them when there is a chance of rain.

Materials

The bituminous material for seal coat will be one of the following kinds and grades conforming to Mn/DOT Specification 3151:

> When the Contract quantity exceeds 2000 gallons, and unless the Plans or Special Provisions permit other options, the kind to be used will be Emulsified Asphalt, Cationic grades. In all cases the grade to be used will be as designated by the Engineer. It is strongly recommended that a polymer-modified emulsion be used on double seal to increase early retention of aggregate.
>
> Aggregate for bituminous double seal coat shall conform to the requirements in the specification for grading and quality. The size of the first seal aggregates should be twice as big as the final seal aggregate.

Construction Specifications that Apply

Draft Special Provisions for Bituminous Seal Coat Double Seal (see Appendix B).

Unit Cost for Estimating

Unit costs for a double chip seal are about $1.50 per square yard depending on the type of binder, the application rate, and the size of the project.

Slurry Seal

Description

A slurry seal is a mixture of fine aggregate, asphalt emulsion, water, and mineral filler. The mineral filler most often used is Portland cement.

Slurry seals are used to seal the existing asphalt pavement surface, slow surface raveling, seal small cracks, and improve surface friction. Slurry seals are similar to chip seals in that they use a thermal break process, requiring heat from the sun and pavement. This process takes anywhere from two to eight hours depending on the heat and humidity.

Timing

As minor surface cracking first develops, or to treat light to moderate raveling and/or oxidation.

Purpose

Slurry seals are effective where the primary problem is excessive oxidation and hardening of the existing surface. Use slurry seals to retard surface raveling, seal minor cracks, and improve surface friction. Slurry seals will not perform well if the underlying pavement contains extensive cracks.

Existing Pavement Condition

Excessive oxidation and hardening of the pavement surface.

Maintenance Methods

Make sure the pavement is dry and clean, and complete all necessary repairs or reconditioning work prior to placing the slurry seal. Apply a thin film of water to control premature breaking and improve bond with the existing pavement. Then apply slurry over pavement surface.

Seasonal Limitations

Place slurry seals when the air and pavement temperature are both at least 50°F and there is no chance of freezing within 24 hours after placement. Do not place slurry seals during rain, and do not apply them if rain is expected before the slurry is set.

Traffic Control Concerns

A curing period is necessary before allowing traffic on the treated surface. Therefore, use of a slurry seal may not be appropriate where traffic must be allowed very soon after application. In warm weather, slurry seals require at least two hours to cure, depending on the ambient air temperature, humidity, and type of emulsion. Adjusting the mineral filler will help reduce the set time of the slurry mixture but may hamper workability.

Anticipated Performance and Service Life

Expected life of a slurry seal is three to five years. Factors affecting performance include traffic loading, environmental conditions, existing pavement condition, material quality and mix design, and construction quality.

Limitations

Do not use on high-volume roads since friction initially may be reduced until traffic wears some of the asphalt from the surface.

Precautions

Slurry seal will not perform well if the underlying pavement is cracked. Use only where the existing surface is stable with low-severity cracking.

Materials

Slurry seals are generally produced and placed using a truck-mounted slurry machine. Aggregate, water, filler, and emulsion are proportioned and mixed together in a mixer and applied immediately to the pavement surface with a spreader box.

Aggregates for slurry mixes may consist of most hard crushed aggregates such as granite, limestone, trap rock, slag, and taconite tailings. They conform to one of three gradations: Type 1, Type 2, and Type 3. The maximum size for slurry aggregates is 2.36 mm (#8 sieve) for Type 1, and 9.5 mm (3/8-inch sieve) for Types 2 and 3. Type 3 has a coarser gradation than Type 2. All slurry gradations have between 5 and 15 percent passing the 75-micron sieve (#200). The slurry is applied basically one aggregate layer thick.

A tack coat is not necessary unless the pavement to be sealed is extremely dry and raveled or the slurry is being placed on a concrete surface.

Unit Cost for Estimating

Costs are approximately $1.50 per square yard depending on the size of the project, materials used, and the rate of application.

Microsurfacing

Description

Microsurfacing is sometimes incorrectly referred to as a polymer-modified slurry seal. The major difference is that the curing process for microsurfacing is chemically controlled, whereas slurry seals and chip seals use the thermal process. Microsurfacing was designed for use as a rut-filling material in Europe in the 1970s and introduced to the United States in 1980. Since then, many states have used this treatment for both surfacing and rut filling on roads with moderate- to heavy-volume traffic.

Timing

Use when ruts exceed 3/4 inch or friction drops to unacceptable levels. You may also use it as a preventive maintenance technique to prolong pavement life when oxidation becomes moderate to severe on pavements with minor cracking.

Purpose

As a preventive maintenance or surface treatment for an existing AC pavement, microsurfacing provides a skid-resistant surface and reduces the amount of water that enters the pavement layers through the pavement surface. Microsurfacing restores the transverse cross-section profile and may also be used to fill ruts.

Existing Pavement Condition

Excessive oxidation and hardening of the pavement surface.

Maintenance Methods

Make sure the pavement is clean, and complete all necessary repairs or reconditioning work prior to microsurfacing.

Seasonal Limitations

Avoid late season application.

Traffic Control Concerns

Re-route traffic until the treatment cures. Microsurfacing cures and develops strength faster than conventional slurry seals and can be opened to rolling traffic in about an hour.

Anticipated Performance and Service Life

Service life is about seven or more years for high traffic and considerably longer for low to moderate traffic. The service life is dependent on the condition of the pavement at the time of microsurfacing placement.

Factors affecting performance include traffic loading, environmental conditions, existing pavement condition, material quality and mix design, and construction quality.

Limitations

Do not use on pavements with moderate to heavy cracking.

Precautions

Materials used in microsurfacing must be designed to work together.

Materials

Microsurfacing is a mix of polymer-modified emulsion, well-graded crushed mineral aggregate, mineral filler (normally Portland cement), water, and chemical additives that control the break time. The aggregate, mineral filler, emulsion, and water are mixed in a truck-mounted traveling plant, which is deposited into a spreader box. No compaction is needed and, under normal environmental conditions, traffic may be allowed over the application within an hour after placement.

Because this is a chemical curing process, material selection and the mix design are crucial. The mix design normally sets the amount of polymer-modified emulsion and filler as a function of the amount of mineral aggregate. You can adjust the amount of water, mineral filler, and additives in the field to control the time at which the emulsion breaks and the time at which traffic can be allowed. It can also be changed due to change in temperature, humidity and texture of the existing surface.

Construction Specifications that Apply

See Appendix B.

Unit Cost for Estimating

Microsurfacing normally ranges between $1.50 and $2.00 per square yard depending on the materials used and the size of the project.

Thin Hot-Mix Overlays

Description

Thin hot-mix asphalt (HMA) overlays are blends of aggregate and asphalt cement. Three types of HMAs (dense-graded, open-graded friction courses, and gap-graded) have been used in the United States to improve the functional (non-structural) condition of the pavement. Thicknesses typically range from 3/4 to 1-1/2 inch. These mixes are often modified with polymers to meet high performance expectations.

Timing

Prior to the onset of fatigue-related pavement distress.

Purpose

Thin hot-mix asphalt overlays are used on all types of roadways for functional improvements. Functional improvements are those improvements that enhance the smoothness, friction, and/or profile of the roadway while adding little or no additional load-carrying capacity. These are particularly suitable for high-volume roads in urban areas where longer life and relatively low-noise surfaces are desired. These applications are used in all climatic conditions.

Existing Pavement Condition

A stable pavement with a sound base with a fair cross section and good lateral support. Visible surface distresses may include moderate to extreme raveling and longitudinal and transverse cracks with some secondary cracking. A moderate amount of patching in good condition is acceptable. Milling prior to overlay is recommended when severe surface distress is present.

Maintenance Methods

Milling or a leveling course should precede thin HMAs where pavements need cross-section improvements. In addition, seal all cracks prior to application. Use tack coats when using thin HMAs.

Seasonal Limitations

Place mixes in warm weather (55°F minimum) and roll immediately. Due to their low mass, they lose heat to the atmosphere very quickly. As a result, achieving density is only possible if they are compacted very quickly while they are still hot.

Traffic Control

Traffic control requirements for thin HMAs are minimal.

Anticipated Performance and Service Life

Expected life of thin HMA overlays has varied but is expected to average five to eight years. Some states report as low as two to four years; others report as many as ten years.

Limitations

Thin HMA overlays add little structure to the existing pavement and should not be used on pavements showing structural distress or deterioration, unless the distress is corrected first. Deteriorated cracks and localized pavement failures will quickly reflect through the new surface.

Precautions

The principal problems with thin HMAs are similar to those of other thin overlay techniques. A recent AASHTO survey reported problems such as delamination, reflective cracking, poor friction, low durability, excessive permeability, and maintenance problems.

Materials

Mix 2350 LV type 5 is recommended and should be placed with a paver. Compaction is important to performance. Non-designed "sand mixes" are not recommended.

Construction Specifications that Apply

Mn/DOT 2350 and 2360.

Unit Cost for Estimating

The cost of thin HMA overlays depends largely on the layer thickness and the size of the project. In Minnesota, thin HMA overlays using Specification 2350 usually range from $18 to $30 per ton of mix.

Chapter 6: Pothole Patching and Repair

Many studies have compared patching procedures. Variables include material type, installation technique, equipment, weather, and emergency repair needs. Ideally, life cycle cost analysis is conducted to evaluate the cost-effectiveness of specific repair techniques.

Patches are appropriate for repairing alligator cracking, potholes, failed patches or utility cuts, corrugations, washboarding, shoving, depressions, slippage cracks, and rutting.

The three types of pothole patches are:

Permanent: Used on pavement that is in good condition and has a relatively long life expectancy, and when agency resources are available to do the work.

Semi-permanent: Used as a proactive measure to keep a small pothole from turning into a major failure. The procedure for semi-permanent patching is similar to permanent patching, but the pavement is not cut and the resulting patched area is not rectangular.

Temporary: Used when there is a pothole that could damage vehicles that needs to be patched immediately, but it is not realistic to close the roadway. Temporary patching can also be used on a road that is in generally poor condition or is scheduled for an overlay or reconstruction soon.

Maintenance staff should consider pavement condition, pavement life expectancy, and overall resource availability when determining the type of pothole patch to place. In addition, the three most important elements for proper pothole patching are:

- Use high-quality patching materials, which are cost-effective compared with less expensive products. Lower cost materials end up costing more because they don't last.
- Compact every patch, even if you compact the patch by driving over it with a truck.
- Place—do not throw—material in the patch area.

Construction Methods

Full-depth permanent patching removes the material in the failed area and replaces it with fresh asphalt mixture. The recommended procedure for good permanent repair is:

1. Mark the area to be patched, extending outside the distressed area. The outline should be rectangular with two sides at right angles to the direction of traffic. Cut the outline of the patch with a saw, milling machine, or jackhammer.

2. Excavate as much pavement as necessary, including granular base and subgrade, to reach firm support. For the patch to be an integral part of the pavement, its foundation must be at least as strong as the original pavement. Appropriate excavation equipment includes milling machines, backhoes, and front-end loaders. For a distress such as slippage cracking, milling of the asphalt surface layer may be the only excavation necessary. For alligator cracking and potholes, remove weak granular base and subgrade materials prior to replacement of the asphalt surface course.

   The faces of the excavation should be straight, vertical, and solid. Trim and compact the granular base or subgrade to establish a firm foundation. Apply tack to the vertical edges of the excavation, and a prime or tack coat to the base of the excavation.

3. Backfill the excavation with asphalt mixture. Shovel the patching mixture directly from the truck, and place the mix against the edges first. Spread the mix carefully to avoid segregation. Avoid pulling material from the center of the patch to the edges. If more material is needed at the edge, deposit it there and rake away any excess. Use enough material to ensure that, after compaction, the patch surface is flush with the adjacent pavement, not humped or depressed.

   The maximum lift thickness depends upon the type of asphalt mix and the available compaction equipment. Place hot-asphalt mixes in lifts as thick as practical, to increase heat retention and facilitate compaction. Compact each lift of the patch thoroughly. After compaction, the surface of the patch should be at the same grade as the surrounding pavement.

You may use several materials for pothole patching. They are discussed in the rest of this chapter. Table 6-1 gives recommended applications, and Table 6-2 gives effective patching tips.

Table 6-1. Recommended Applications for Patching

Material	Mn/DOT Spec	Recommended Application
Cold mix	2381	Cold mix is normally used during winter months. Important to use high-quality material and compact properly. Compaction is essential for every patch, even if you drive over the patch with a truck to do it.
Spray injection	None	This process is best suited for transverse crack repair and pothole filling. Fairly high production, but operator dependent. Requires special equipment. Can be leased, purchased, or done by contract.
Hot mix	2350 LV Type 5	Clean reservoir. Use in good weather. A roller is required for densification, as compaction is critical. Place material in the patch area, do not throw it in.
Slurry and Microsurfacing material	None	Based on availability of equipment to be used for transverse crack leveling. This process is a high-production operation that should create a level surface. Microsurfacing gives a more durable patch but is more sensitive to placement activities. Because of the required cure period, slurry should not be used to fill deep cracks or cracks that have developed large potholes.

Table 6-2. Effective Patching Tips

Technique	Tip
All	Quality control, density are very important to obtaining good performance. Use high-quality patching material, which is cost-effective compared with less expensive products. Lower cost materials end up costing more because they don't last.
Cold mix	When using cold mix in heated hoppers, watch temperatures. Do not heat materials over 100°. When heated to higher temperatures, binder will harden.

Cold-Mix Asphalt

Description
Cold-mix asphalt is a mixture of mineral aggregate and emulsified or cutback asphalt and additives.

Timing
As needed.

Purpose
To repair fatigued pavement and potholes when hot mix is not available. Also use for temporary patches.

Existing Pavement Condition
Cold-mix patches are appropriate for repairing potholes, failed patches, or utility cuts.

Maintenance Methods
See above for temporary or permanent patching.

Seasonal Limitations
Cold mix is normally used in poor climate conditions but it can be used any time.

Anticipated Performance and Service Life
Expected life of asphalt cold mixes is one year.

Materials
See the specification in Appendix B.

Construction Specifications that Apply
Specification 2381, Bituminous Stockpile Patching Mixture (see Appendix B).

Unit Cost for Estimating
Material costs for cold-mix asphalt are about $55 per ton, depending on the size of the project and materials used. Additional costs are added for labor and incidentals.

Spray Injection Patching

Description

Spray injection patching, also referred to as blow patching, involves using air pressure to apply asphalt emulsion and aggregate into large cracks and potholes. This procedure received very high marks from recent Strategic Highway Research Program (SHRP) studies.

Timing

As needed.

Purpose

To repair fatigued pavement and potholes.

Existing Pavement Condition

Patches are appropriate for repairing alligator cracking, potholes, failed patches or utility cuts, corrugations, washboarding, shoving, depressions, slippage cracks, and rutting.

Maintenance Methods

The spray injection procedure consists of the following steps:

1. Blow water and debris from the pothole
2. Spray a tack coat on the sides and bottom of the pothole.
3. Blow asphalt and aggregate into the pothole.
4. Cover the patched area with a layer of aggregate.

Seasonal Limitations

Best when used in spring.

Traffic Control

Allow traffic over the repaired areas as soon as maintenance workers and equipment are clear.

Anticipated Performance and Service Life

Expected life of cracks repaired with the injection patching technique depends on the density achieved. Lack of density will result in traffic shoving the mix and short patch life. In addition, poor mix design and wet pavement can also lead to poor patch life. If done correctly, spray injection patches can last upwards of five years.

Limitations

The machinery requires frequent maintenance because the crushed aggregate and emulsified asphalt cement tend to clog. Clogging is less frequent if machinery is used daily.

Precautions

One of the primary causes of poor patch life is insufficient density. This procedure uses air pressure to obtain density and drive the aggregate and emulsion into cavities and small areas that would be very difficult to do with HMA. In addition, the air pressure dries and removes excess water in the crack. Since asphalt emulsion is compatible with water, the crack does not need to be perfectly dry to obtain long patch life.

There are currently two types of spray injection units: the trailer-mounted unit where the operator works from behind using a boom extension, and the self-contained unit where the single operator works from inside the cab of the truck and controls the boom by remote control. The performance of both procedures is operator-dependent. It is critical to obtain the correct proportions of asphalt emulsion and aggregate or the patch will be too dry, leading to raveling, or over-asphalted, leading to tracking and bleeding.

Materials

Asphalt emulsion and aggregate.

Unit Cost for Estimating

Unit costs for spray injection patching vary greatly, with the size of patch, amount of work to be done for preparation, and other factors.

Hot-Mix Asphalt

Description
Hot-mix asphalt is a heated mixture of mineral aggregate and asphalt cement produced in a hot-mix plant.

Timing
As needed.

Purpose
To repair fatigued pavement and potholes.

Existing Pavement Condition
Patches are appropriate for repairing isolated areas of alligator cracking, potholes, failed patches, or utility cuts.

Maintenance Methods
See above for temporary or permanent patching.

Seasonal Limitations
Material may not be available at all times of the year.

Traffic Control
Allow traffic over the repaired areas as soon as the patch has cooled sufficiently so that it is not displaced by weight of vehicles.

Anticipated Performance and Service Life
Hot-mix asphalt patches typically last from three to six years. If done correctly with proper preparation, hot-mix patches can last 15 years or more.

Limitations
This work is limited by the availability of hot-mix asphalt to complete the patching.

Materials
Asphalt materials and aggregates as per Mn/DOT 2350.

Construction Specifications that Apply
Mn/DOT Standard Specification for Hot-Mix Asphalt Mixture 2350.

Unit Cost for Estimating
Hot-mix patch material typically costs approximately $25 per ton. Placement costs vary according to conditions.

Patching with Slurry or Microsurfacing Material

Description

Slurry crack filling involves placing slurry, which is a mixture of aggregate, asphalt emulsion and a mineral filler, such as Portland cement, into a wide crack and striking it off with a squeegee. Slurry-filling cracks is good for use in roadways with severe transverse cracks and/or depressed transverse cracks. A 3-foot wide squeegee, with sideboards, is typically used to feather the material into the depressed areas.

Timing

As needed.

Purpose

To repair fatigued pavement or potholes.

Existing Pavement Condition

Patching with slurry or microsurfacing material is appropriate for repairing alligator cracking, potholes, failed patches or utility cuts, corrugations, washboarding, shoving, depressions, slippage cracks, and rutting.

Maintenance Methods

Crack preparation can include milling and blowing loose material from the cracks, or nothing at all. In most instances, no crack preparation is done. This material flows down into any cavities, bonds any loose pieces together, and sets up very hard when cured. The cure rate ranges from 30 minutes to 1 hour, depending on the air temperature, humidity, and materials used.

Because of the required cure period, do not use slurry to fill deep cracks or cracks that have developed large potholes.

Rut filling is only successful if the rut was caused by mechanical compaction of the pavement. Filling ruts caused by an unstable pavement layer or structurally deficient pavement will not last.

Guidelines for use of microsurfacing to fill ruts include:

- Ruts up to 3/4-inch deep: Use full-width scratch coat application to level the surface before placing the final surface.
- Ruts greater than 3/4-inch: Use a rut-filling spreader box to fill the ruts before placing the final surface.
- Ruts greater than 1-1/2 inch: Fill ruts in multiple placements using the rut-filling spreader box.

The maximum thickness applied in a single lift should be less than 1-1/2 inch. Ruts deeper than 1-1/2-inch deep require multiple passes with a special rut-filling spreader box to restore the original cross section.

The construction sequence is:

1. Mill and blow out existing depressions, if desired.
2. Position slurry unit over the crack or depression to be filled.
3. Deposit sufficient amount of slurry material at the transverse center of the crack.
4. Strike off the material with a squeegee or lute rake to fill depressions.

Seasonal Limitations

Avoid late season application.

Traffic Control Concerns

Allow material to harden before permitting traffic back on the roadway.

Anticipated Performance and Service Life

Since slurry is a fairly new procedure in Minnesota there is not much long-term performance data. However, most agencies indicate that cracks filled with slurry will stay filled for three to five years depending on traffic, climate, and pavement conditions.

Limitations

Do not use on pavements with moderate to heavy cracking. Due to its brittle nature, microsurfacing is a poor crack sealer.

Precautions

Because it sets up very hard, a crack usually develops in the filled area after one year. However, this is normally only a hairline crack and can be treated with the rout-and-seal procedure if desired. In addition, filling cracks with slurry prior to placement of an overlay will improve the smoothness of the pavement in the crack vicinity.

Materials

Materials used for filling patches with slurry and microsurfacing are the same as those described under surface treatments. Smaller gradations are used for patching.

Unit Cost for Estimating

Filling cracks with slurry typically costs $0.85 per square yard.

Bibliography

Asphalt Institute. *A Basic Asphalt Emulsion Manual*, Asphalt Institute Manual Series No. 19, third edition.

Asphalt Institute. *Alternatives in Pavement Maintenance, Rehabilitation, and Reconstruction*, Asphalt Institute Information Series No. 178 (IS-178), second edition.

Asphalt Institute. *Asphalt Cold-Mix Manual*, Asphalt Institute Manual Series No. 14 (MS-14), February 1977.

Asphalt Institute. *Asphalt in Pavement Maintenance Manual,* Asphalt Institute Manual Series No. 16, third edition.

Center for Transportation Studies. "Q & A: LRRB Pothole Repair Video," *Technology Exchange*, Center for Transportation Studies, January-March 1999, Volume 7, No. 1.

Federal Highway Administration. Notes from "Pavement Preservation: A Road Map for the Future," presented by the Federal Highway Administration in Kansas City, Missouri, October 26, 1998.

Hicks, R.G., J.S. Moulthrop, and J. Daleiden. *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Transportation Research Board (TRB) 1999, November 123, 1998.

Huston, P., and D. Nybakken. *Runway Crack Repair Research Project (Silver Bay Municipal Airport)*, April 1, 1996.

Janisch, D. *Minnesota Seal Coat Handbook*, Mn/DOT Report No. 1999-07, December 1998.

Janisch, D. *Seal Coat Procedures and Problems,* March 1, 1992.

Janisch, D., and J. Sexton. *Crack Sealing Bituminous Pavements in Minnesota*, January 1, 1992.

Janisch, D. and C. Turgeon. *Sawing and Sealing Joints in Bituminous Pavements to Control Cracking,* Minnesota Department of Transportation (Mn/DOT) Report No. MN/PR- 96/27, March 1996.

Lukanen, E. *An Evaluation of Aggregate and Chip Seal Surfaced Roads at Mn/ROAD,* Mn/DOT Report No. 1998-24, January 1997.

Minnesota Local Road Research Board. *Flexible Pavement Distress Manual*, 1989.

Minnesota Department of Transportation et al. *Asphalt Pavement Maintenance Workshop Manual*, Mn/DOT, LRRB, FHWA and CTS, 1997.

Preceding Page Blank

Smith, R.E., and C.K. Beatty. *Microsurfacing Usage Guidelines,* TRB 1999, November 20, 1998.

State of Ohio. *Research Protocols for Pavement Preservation: Lead States' Work Plan,* October 16, 1998.

Strategic Highway Research Program. *Asphalt Pavement Repair Manuals of Practice,* Strategic Highway Research Program Document SHRP-H-348, October 1994.

Strategic Highway Research Program. *Innovative Materials Development and Testing, Volume 1: Project Overview,* Strategic Highway Research Program Report No. SHRP-H-352.

Turgeon, C. *Evaluation of Materials and Methods for Bituminous Pavement Crack Sealing and Fillings*, December 1, 1989.

Wegman, D. *Design and Construction of Seal Coats,* February 1, 1991.

Yves, B. *Very Thin and Ultra-Thin Wearing Courses Using Hot-Mixed Bituminous Materials: A Review of Use and Performance,* Transportation Research Board (TRB) 1999.

Zaniewski, J.P., and M.S. Mamlouk. *Pavement Maintenance Effectiveness: Preventive Maintenance Treatments (Participant's Handbook),* FHWA Report No. FHWA-SA-96-027, February 1996.

Recommended Web sites:
www.lrrb.gen.mn.us
www.mnroad.dot.state.mn.us

Appendix A: Distress Identification and Severity

Bleeding

Description

Excess bituminous binder occurring on the pavement surface. May create a shiny, glass-like, reflective surface that may be tacky to the touch. Usually found in the wheel paths.

Severity

Low: An area of pavement surface discolored relative to the remainder of the pavement by excess asphalt.

Moderate: An area of pavement surface that is losing surface texture due to excess asphalt.

High: Excess asphalt gives the pavement surface a shiny appearance. The aggregate may be obscured by excess asphalt, and tire marks may be evident in warm weather.

Cracking, Alligator or Fatigue

Description

Occurs in areas subjected to repeated traffic loadings (wheel paths). Can be a series of interconnected cracks in early stages of development. Develops into many-sided, sharp-angled pieces, usually less than 1 foot on the longest side, characteristically with a chicken wire/alligator pattern in later stages.

Severity

Low: An area of cracks with no or only a few connecting cracks; cracks are not spalled or sealed; pumping is not evident.

Moderate: An area of interconnecting cracks forming a complete pattern; cracks may be slightly spalled; cracks may be sealed; pumping is not evident.

High: An area of moderately or severely spalled interconnecting cracks forming a complete pattern; pieces may move when subjected to traffic; cracks may be sealed; pumping may be evident.

Cracking, Block

Description

A pattern of cracks that divides the pavement into approximately rectangular pieces. Rectangular blocks range in size from approximately 1 to 100 square feet.

Severity

Low: Cracks with a 1/4-inch mean width, or sealed cracks with sealant material in good condition and a width that cannot be determined.

Moderate: Cracks with a mean width between 1/4 inch and 3/4 inch, or any crack with a 3/4-inch mean width and adjacent low-severity random cracking.

High: Cracks with a mean width greater than 3/4 inch, or any crack with a 3/4-inch mean width and adjacent to high-severity random cracking.

Cracking, Edge

Description

Applies only to pavements with unpaved shoulders. Crescent-shaped cracks or fairly continuous cracks that intersect the pavement edge and are located within 2 feet of the pavement edge, adjacent to the shoulder. This includes longitudinal cracks outside the wheel path and within 2 feet of the pavement edge.

Severity

Low: Cracks with no breakup or loss of material.

Moderate: Cracks with some breakup and loss of material for up to 10 percent of the length of the affected portion of the pavement.

High: Cracks with considerable breakup and loss of material for more than 10 percent of the length of the affected portion of the pavement.

Cracking, Longitudinal

Description

Cracks predominantly parallel to the pavement centerline. The location within the lane (wheel path versus non-wheel path) is significant.

Severity

Low: Cracks with a 1/4-inch mean width, or sealed cracks with sealant material in good condition and a width that cannot be determined.

Moderate: Cracks with a mean width between 1/4 inch and 3/4 inch, or any crack with a 3/4-inch mean width and adjacent low-severity random cracking.

High: Cracks with a mean width greater than 3/4 inch, or any crack with a 3/4-inch mean width and adjacent to high-severity random cracking.

Cracking at Joints, Reflection

Description

Cracks in asphalt concrete overlay surfaces that occur over joints in concrete pavements. Knowing the slab dimensions beneath the asphalt surface helps to identify reflection cracks at joints.

Severity

Low: An unsealed crack with a 1/4-inch mean width, or a sealed crack with sealant material in good condition and a width that cannot be determined.

Moderate: Any crack with a mean width between 1/4 inch and 3/4 inch, or any crack with a 3/4-inch mean width and adjacent low-severity random cracking.

High: Any crack with a 3/4-inch mean width, or any crack with a 3/4-inch mean width and adjacent to high-severity random cracking.

Cracking, Transverse

Description

Cracks that are predominantly perpendicular to the pavement centerline and are not located over joints in underlying concrete pavements.

Severity

Low: Cracks with a 1/4-inch mean width, or sealed cracks with sealant material in good condition and a width that cannot be determined.

Moderate: Cracks with a mean width between 1/4 inch and 3/4 inch, or any crack with a 3/4-inch mean width and adjacent low-severity random cracking.

High: Cracks with a mean width greater than 3/4 inch, or any crack with a mean width of 3/4 inch and adjacent to high-severity random cracking.

Lane-To-Shoulder Drop-Off

Description

Difference in elevation between the traveled surface and the outside shoulder. Typically occurs when the outside shoulder settles as a result of pavement layer material differences.

Severity

No severity levels are assigned. They could be defined by categorizing the measurements taken. A record of the measurements taken is much more desirable, however, because it is more accurate and repeatable than are severity levels.

Patch/Patch Deterioration

Description

Portion of the pavement surface, greater than 1 square foot, that has been removed and replaced or additional material applied to the pavement surface after the original construction.

Severity

Low: Patch has at most low-severity distress of any type.

Moderate: Patch has moderate-severity distress of any type.

High: Patch has high-severity distress of any type.

Polished Aggregate

Description

Surface binder worn away to expose coarse aggregate.

Severity

No severity levels are assigned. However, the degree of polishing may be reflected in a reduction of surface friction.

Potholes

Description

Bowl-shaped holes of various sizes in the pavement surface. Minimum plan dimension is 6 inch.

Severity

Low: Less than 1 inch deep.

Moderate: 1 to 2 inches deep.

High: More than 2 inches deep.

Raveling and Weathering

Description

Wearing away of the pavement surface in high-quality hot-mix asphalt concrete. Caused by the dislodging of aggregate particles and loss of asphalt binder.

Severity

Low: The aggregate or binder has begun to wear away but not progressed significantly. Some loss of fine aggregate is visible.

Moderate: Aggregate and/or binder has worn away and the surface texture is becoming rough and pitted. Loose particles exist and loss of fine aggregate and some loss of coarse aggregate.

High: Aggregate and binder has worn away and the surface texture is very rough and pitted due to the loss of coarse aggregate.

Rutting

Description

A rut is a longitudinal surface depression on the wheel path. It may have associated transverse displacement.

Severity

No severity levels are defined for this distress. They could be defined by categorizing the measurements taken. A record of the measurements taken is much more desirable, however, because it is more accurate and repeatable than are severity levels.

Shoving

Description

Shoving is a longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles and is usually located on hills, curves, or at intersections. It also may have associated vertical displacement.

Severity

No severity levels are defined. However, they can be defined by the relative effect of shoving on ride quality.

Appendix B: Mn/DOT Specifications and Provisions

Specification 2381: Bituminous Stockpile Patching Mixture

2381.1 Description

This specification covers production of plant-mixed bituminous stockpile patching mixture.

2381.2 Materials

A. Mineral Aggregate

A1. Composition

The aggregate shall be composed of 100 percent crushed material and shall conform to one of the classifications described in Specification 3141.2B; except that for Class B, only limestone and dolomite will be permitted.

The aggregate shall be free from loosely bonded aggregations, clayey lumps, and other objectionable matter.

A2. Washing

Washing of the aggregate will not be required except as may be necessary for removal of adherent clay coatings.

A3. Gradation

	Mixture Type	
Sieve Size	A Percent Passing	B Percent Passing
3/4 inch	100	100
3/8 inch	95-100	95-100
No. 4	75-100	50-85
No. 8 *	15-45	30-55
No. 10	10-35	25-50
No. 16 *	0-10	15-40
No. 40	0-8	5-25
No. 200	0-3	0-3

* For information only—these are not specification sieves.

A4. Quality

The shale content by weight of total sample shall not exceed five percent.

A5. Aggregate Additives

Hydrated Lime.....3106

If hydrated lime is required to be incorporated into the mixture, the Plans or Special Provisions will so indicate and this addition will be considered incidental and no direct compensation will be made. The furnishing and incorporation of this additive at the Engineer's direction will be compensated for as Extra Work in the absence of Contract

Unit price therefor. No direct compensation will be made for any such additive incorporated at the Contractor's option.

B. BITUMINOUS MATERIAL.....3151

The bituminous material for mixture shall conform to the requirements for one of the following grades, subject to any limitations imposed by the Plans and/or Special Provisions. The grade to be used shall be subject to the approval of the Engineer.

M.C. Liquid Asphalt.....MC-250, MC-800

C. ANTI-STRIPPING ADDITIVES

The furnishing and incorporation of anti-stripping additives, at the Engineer's direction, will be compensated for as Extra Work, unless otherwise provided for in the Special Provisions. No direct compensation will be made for any additive(s) incorporated at the Contractor's option.

In the event that the Contractor elects to incorporate any anti-stripping additives into the mixture, the type and amount must be approved by the Engineer prior to incorporating into the mixture.

2381.3 Mixture Production Requirements

A. EQUIPMENT REQUIREMENTS

Bituminous mixing plants shall meet the requirements of Specification 2331.C1.

B. MIXTURE COMPOSITION AND ACCEPTANCE REQUIREMENTS

B1. Aggregate Samples and Job-Mix Formula

At least 15 days prior to the start of the mixture production, the Contractor shall submit to the Department's Bituminous Engineer (or his designee) representative aggregate samples of each of the respective materials that he proposes to use in the mix production. The submittal shall consist of at least 100 pounds of aggregate material. If it is proposed to use multiple aggregate sources/types, the samples may be proportioned to reflect the proposed blend.

At the time of the aggregate(s) submittal, it is recommended that the Contractor also submit aggregate stockpile gradations for each of the different types of material intended for use. The Contractor shall also indicate the proposed proportions of the aggregate materials to be incorporated into the mixture.

The Engineer, using the representative aggregate samples submitted by the Contractor and the proposed mixture proportions and gradations, will evaluate the acceptability of the proposed blend and (composite) gradation and will establish the Job-Mix Formula (JMF) to be used in production of the mixture.

The Job-Mix working range for the mixture shall be established within the specified gradation limits by applying the following tolerances (plus or minus) to the JMF:

Aggregate Tolerances		
	Mixture Type	
Sieve Size	A Percent Passing	B Percent Passing
No. 10 or larger	± 8	± 8
No. 40	*	± 6
No. 200	*	*

* The working range for these sieves shall be the specification limits indicated in Section 2381.2A3.

B2. Bituminous Material Content

The quantity of bituminous material incorporated into the mix shall be such that Mixture A and B contains a minimum of 4.7 and 5.1 percent residual asphalt, by total weight of mixture, respectively. (Mixture A and B will require approximately 6.0 and 6.5 percent bituminous material, by total weight of mixture, respectively.)

The Engineer may make adjustments to the percentage of bituminous material incorporated into the mixture (either increase or decrease) as conditions dictate based on aggregate and mixture characteristics.

B3. Mixture Acceptance Criteria

a) Aggregate gradations shall be within the job-mix working range established in 2381.3B1. Gradation tests will be performed either at the time of mixture production or after mixture production. After mixture production, tests will be performed on the aggregate after the extraction of the bituminous material from the mixture and acceptance will be based on the average results of a sample of three increments of mixture taken from the stockpile.

b) The percentage of bituminous material, by weight, in the mixture shall be within plus or minus 0.3 percentage points of the amount designated by the Engineer. The determination of bitumen content of the mixture will be made by the spot-check method described in the Department's Bituminous Manual.

If the spot check method is not used, extraction tests will be performed in accordance with Method E of AASHTO T-164-80 (Standard Method of Tests for Quantitative Extraction of Bitumen from Bituminous Paving Mixture) to determine the residual asphalt content of the mixture. Acceptance of the mixture will be based on the average results of three extraction tests, without retention factor. The average residual asphalt content shall not exceed plus or minus 0.4 percent of that indicated in Section 2381.3B2.

C. Preparation of Mixture

All mineral aggregates and bituminous material shall be proportional by weight. The mixture shall be such that it may be stockpiled, handled, placed, and finished without stripping of the bituminous material from the aggregate.

The mineral aggregate shall be clean and surface dry before mixing.

Mixing period shall be of a sufficient length of time to produce a uniform mixture in which all aggregate particles are thoroughly coated.

The mixture temperature, at time of discharge from the pugmill or drum mixer, shall not exceed 170°F.

2381.4 Method of Measurement

The accepted quantities of Bituminous Patching Mixture will be measured by weight of material.

2381.5 Basis of Payment

The bituminous stockpile patching mixture will be paid for at the contract unit price per ton of mixture produced. This price shall be compensation in full for all the costs associated with furnishing materials, producing the mixture, and loading it on board the Department's truck at the mixing plant and/or stockpiling the mixture at sites designated in the plans or other contractual documents.

Item No.	Item Unit
2381.501	Bituminous Stockpile Patching MixtureTon

Specification 3719: Joint and Crack Sealer (Hot-Poured, Crumb Rubber Type)
February 1997

3719.1 Scope
This specification covers joint and crack sealant of the hot-poured, crumb rubber type for sealing cracks in concrete and bituminous pavements and miscellaneous structures.

3719.2 Requirements

A. General Requirements
The sealant material shall consist of asphalt and crumb rubber blended together by the manufacturer to produce a homogeneous mixture. Only material from certified sources is allowed for use.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B. Physical Requirements
The sealant shall conform to the following physical property requirements:
1. Recycled rubber, mass, % of asphaltic components, minimum 18
2. Cone Penetration, 77° F, dmm (ASTM D5329), maximum 90
3. Bond Test, 50% extension, @- 0° F Pass 5 cycles
4. Flow, 140° F, mm, maximum 5
5. Resilience, 77° F, minimum 40
6. Softening Point, deg F, minimum 180

The sealant shall meet the above requirements after one cycle of heating to application temperature, cooling and reheating to the recommended application temperature.

C. Packaging and Marking
The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 50 lb. weight, clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, and pouring temperature recommended by the manufacturer.

3719.3 Sampling And Testing

A. Sampling
Samples shall be furnished for testing in such size and number as directed by the Engineer.

B. METHODS OF TEST

Testing shall be according to the appropriate test methods reference on ASTM D 1190 except that the bond test shall be performed using mortar blocks prepared according to the Mn/DOT Method.

B1. Softening Point ASTM D 36

B2. Cement Mortar Blocks (Mn/DOT Method)

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens). After curing one day in moist air and six days in water at 74F ± 3 F, the blocks shall be cut into 1- by 2- by 3-inch test blocks using a diamond saw blade. Discard the 1-inch strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime-saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth of blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 0.50 ± 0.01 inch apart enclosing a reservoir of 2 by 2 by 0.50 inch.

Specification 3720: Joint and Crack Sealer (Hot-Poured, Low-Modulus, Elastic)

February 1997

Scope

This specification covers joint and crack sealer of the hot-poured, low modulus, elastic type, for sealing joints and cracks in concrete and bituminous pavements, bridges, and other structures.

3720.2 Requirements

A. General Requirements

The sealant shall be composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound. Only materials from certified sources allowed for use.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B. Physical Requirements

The sealant shall conform to ASTM D 3405 except for the following modifications:

(1)	Cone Penetration, 77° F, dmm (ASTM D5329), maximum	90 - 150
(2)	Bond at -20° F, 3 cycles, 200% extension	Passes
(3)	Resilience at 77° F, minimum, %	60
(4)	The sealant material shall weigh not less than 9.01 nor more than 9.35 lb/gal.	

The sealant material may be subjected to any or all of the above tests after prolonged heating of the material for six hours with constant mixing in a laboratory melter at the manufacturer's recommended pouring temperature. After such heating, the material shall meet the above specified requirements.

C. Packaging and Marking

The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 50 lb. weight, clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, and pouring temperature recommended by the manufacturer.

3720.3 Sampling and Testing

Samples shall be furnished for testing in such size and number as directed by the Engineer.

B. METHODS OF TEST

B1. Testing shall be according the ASTM D 3402 except the bond test will be run using sawed cement mortar blocks prepared by the Mn/DOT method.

B2. Cement Mortar Block (Mn/DOT Method)
Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens). After curing one day in moist air and six days in water at 74F ± 3F, the blocks shall be cut into 1- by 2- by 3-inch test blocks using a diamond saw blade. Discard the 1-inch strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime-saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth or blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 0.50 ± 0.01 inch apart enclosing a reservoir of 2 by 2 by 0.50 inch.

Specification 3723: Joint and Crack Sealer (Hot-Poured Elastic Type)
February 1997

3723.1 Scope

This specification covers joint and crack sealer of the hot-poured elastic type, for sealing joints and cracks in concrete and bituminous pavements, bridges, and other structures. On concrete structures requiring less than 50 lb. of material, the contractor may substitute an approved silicone or polyurethane sealer.

3723.2 Requirements

A. General Requirements

The sealant shall be composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound. Only material from certified sources is allowed for use.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B. Physical Requirements

The sealant shall conform to ASTM D 3405 except for the following modifications:

1. Cone Penetration, 77°F, dmm (ASTM D5329), maximum 60 - 90
2. Bond at -20F, 3 cycles, 100% extension Passes
3. Mandrel bend test at -29F, 1-inch mandrel, No Cracking
4. Resilience at 77F, minimum, % 40

C. Packaging and Marking

The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 50 lb. weight, clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, and pouring temperature recommended by the manufacturer.

3723.3 Sampling And Testing

A. Sampling

Samples shall be furnished for testing in such size and number as directed by the Engineer.

B. Methods of Test

B1. Testing shall be according to ASTM D 3405 except the bond test will be run using sawed cement mortar blocks prepared by the Mn/DOT method.

B2. Mandrel Bend Test ASTM D 522 Method B
Test at -29F using 1-inch mandrel, 180 degree bend over five seconds. Test specimen prepared according to ASTM D3405, Flow Test, and conditioned at -29F for a minimum of four hours.

B3. Cement Mortar Blocks (Mn/DOT Method)
Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens). After curing one day in moist air and six days in water at 74F ± 3 F, the blocks shall be cut into 1- by 2- by 3-inch test blocks using a diamond saw blade. Discard the 1-inch strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime-saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth or blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 0.50 ± 0.01 inch apart enclosing a reservoir of 2 by 2 by 0.50 inch.

Specification 3725: Joint and Crack Sealer (Hot-Poured, Extra Low Modulus, Elastic Type)
December 1998

Scope
This specification covers joint and crack sealer of the hot-poured, extra low modulus, elastic type, for sealing joints and cracks in concrete and bituminous pavements, bridges, and other structures.

Requirements

A. General Requirements
The sealant shall be composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound. Only material from certified sources is allowed for use.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B. Physical Requirements
The sealant shall conform to the following properties when heated in accordance with ASTM D5167:
1. Cone penetration, 77F, dmm (ASTM D5329) 100 - 150
2. Cone penetration, -0F, dmm (ASTM D5329 modified) 25 min.
3. Flow, 140F, 5h (ASTM D5329) 10 mm max.
4. Resilience (ASTM D5329) 30 - 60 %
5. Bond, -20F, 200% extension (ASTM D5329) Pass 3 cycles
6. Asphalt Compatibility (ASTM D5329) Pass

The sealant material may be subjected to any or all of the above tests after prolonged heating of the material for six hours with constant mixing in a laboratory melter at the manufacturer's recommended pouring temperature. After such heating, the material shall meet the above specified requirements.

C. Packaging and Marking
The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 50 lb. weight, clearly marked with the name of the material, the name of the manufacturer, brand name, mass, batch number, and pouring temperature recommended by the manufacturer.

Sampling and Testing

A. SAMPLING

Samples shall be furnished for testing in such size and number as directed by the Engineer.

B. METHODS OF TEST

B1. Testing shall be according to ASTM D5329 except the bond test will be run using sawed cement mortar blocks prepared by the Mn/DOT method.

B2. Cement Mortar Blocks (Mn/DOT Method)

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens). After curing one day in moist air and six days in water at 74F ± 3 F, the blocks shall be cut into 1- by 2- by 3-inch test blocks using a diamond saw blade. Discard the 1-inch strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime-saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water.

Blot the washed blocks with absorbent lint-free cloth or blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 0.50 ± 0.10 inch apart enclosing a reservoir of 2 by 2 by 0.50 inch.

Special Provision for Asphalt Concrete Crack Sealing
January 1998

Description

This work shall consist of routing, cleaning and sealing all random, longitudinal and transverse cracks in bituminous concrete pavement and/or overlays, in accordance with the plans, specifications and as ordered by the Engineer.

Materials

CRACK SEALANT

The Contractor shall provide certification that the sealant meets the requirements of Mn/DOT Standard Specification 3720 (Hot-Poured, Low-Modulus, Elastic Type Sealant). Only those products that meet the requirements of 3720 and have performed satisfactorily based on Department analysis, may be used. A listing of acceptable products may be obtained by contacting the Chemical Lab at the Mn/DOT Maplewood Materials Laboratory.

The crack sealant compounds 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 the 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. Materials shall not be placed if the material's temperature is below the manufacturer's recommended minimum application temperature.

Mixing of different manufacture's brands or different types of sealants shall be prohibited.

BASIS OF ACCEPTANCE

Acceptance of the sealant material is based on certification by the manufacturer that sealant meets the requirements listed under MATERIALS. The Department reserves the right to conduct supplementary sampling and testing.

EQUIPMENT REQUIREMENTS

The melting kettle shall be double jacketed boiler type, equipped with both agitation and recirculation systems capable of melting and applying the sealant through a pressure-fed hose and wand. A 45-mm diameter "Shoe" or dish-style wand tip shall be used to ensure uniformity to overband type application of sealant material. The melter applicator shall be capable of starting at ambient temperature and bring the sealant material up to application temperature in one hour or less, while continuously agitating and recirculating the sealant. The melter shall be equipped with automatic thermostatic controls and temperature gauges to monitor the sealant temperature in the applicator lines and temperature of heat transfer oil in the kettle jacket.

The pavement cutter shall have carbide -tipped cutters radially mounted around a flywheel, held in place on hardened steel pins. The cutters shall be adjustable by rearrangement of the holding spacers such that the cutter is capable of achieving a maximum width of 2 inches and a minimum depth of cut of 3/8 inch. The pavement cutter shall be capable of cutting the countersunk design configuration into the pavement, expeditiously, with ease and in one single pass. An engine capable of achieving a minimum of 15 kW shall power the pavement cutter.

The air compressor shall be a minimum of 935 gpm and capable of emitting air through the nozzle within the range of 520 to 1040 kPA. The air compressor shall be equipped with traps capable of removing moisture and oil from the air.

The hot air lance shall operate with propane and compressed air in combination and be capable of achieving a temperature of heated air at the exit orifice of 1800° F and a discharge velocity of 3000 fps.

CONSTRUCTION DETAILS

Crack Preparation

All random, transverse and longitudinal cracks measuring less than or equal to 3/4 inch in width shall be routed to a width and depth of 3/4 inch. The pavement cutter shall at all times exhibit the capability of expeditiously cutting the design reservoir in one easy pass. The Contractor shall change cutters when it is evident from inspection that the reservoir configuration specified is not being achieved in an easy and expeditious manner in conformance with design. The Contractor shall demonstrate the cutter's capability of following meandering cracks and maintaining centering of the reservoir over the crack, ±3/4. The resulting reservoir shall have vertical side walls and a uniform horizontal profile.

All random, transverse and longitudinal cracks measuring more than 3/4-inch width will not require routing, but shall be cleaned of foreign matter to a depth equal to the width of the crack.

Prior to commencement of crack sealing, the debris left on the pavement surface as the result of the routing and/or crack cleaning operations shall be removed by sweeping or blowing with compressed air, in a manner not hazardous to the motoring public.

Crack Sealing

The sealant shall not be incorporated when the pavement is wet or the ambient or pavement temperature falls below 40°F. Immediately prior to the placement of the crack sealing in either the routed configuration or the cleaned-out crack, the surface areas of both as well as the surface areas of the pavement 1 inch on either side of their sidewalls, shall be cleaned and dried with hot compressed air from a hot air lance. This treatment shall continue until the affected areas are darkened.

The crack sealant shall be placed within two minutes from the time the hot air lance has passed over the crack reservoir and its adjacent pavement side surfaces. This time is critical; the shorter the better.

At no time shall the sealant remain in the discharge hoses and applicator wand in an uncirculated condition for a period of time exceeding 15 seconds. The applicator wand

shall be returned to the kettle holding tank and the material recirculated immediately upon completion of sealing each crack.

The sealant temperature, as discharged into the crack reservoir, shall be 46°F below the safe heating temperature ±5°F. No crack sealing shall commence until the Engineer has determined that the specified pouring temperature has been achieved. During incorporation of sealant into the crack reservoir a leveling of the sealant shall be achieved through the use of a banding wand tip attachment. A sealant overband 1-1/4-inch wide and a maximum of 1/16-inch convex high shall be achieved.

The temperature of material in the tank, as well as at the point of discharge, shall be recorded at one-hour intervals and kept available for inspection by the Engineer.

The Engineer may permit the contractor to apply toilet paper or a light coating of sand or other dust to the surface of the newly placed sealant if traffic results in tracking of the crack sealing material.

At the end of the work day and at such times as required by the Engineer, the Contractor shall clean and remove all debris generated in the area of work by his operations. The Contractor's operations shall at all times be conducted in a manner not deleterious to the public at large or the Engineering and Labor Forces involved on the project.

METHOD OF MEASUREMENT

This work will be measured by the number of kilograms of sealant properly placed in accordance with the requirements put forth in these specifications.

Basis of Payment

The unit price bid per pound of sealant shall include the cost of furnishing all labor, equipment and materials necessary to complete the work as specified or as ordered by the Engineer.

Special Provision for Bituminous Fog Sealing

Description

This work shall consist of treating an existing bituminous pavement to seal the surface in accordance with the plans, specification 2355 and as ordered by the Engineer.

Materials

BITUMINOUS MATERIAL

The Contractor shall provide bituminous for fog seal that meets the requirements of Mn/DOT Standard Specification 3151. Asphalt emulsion shall be diluted with water, 50 percent by volume, to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Construction Details

RESTRICTION

Fog seal operations shall be conducted in a manner that will offer the least inconvenience to traffic. The fog seal shall not be applied until the road surface and weather conditions are acceptable to the Engineer. Emulsions shall not be used at temperature less than 4°C (39°F).

EQUIPMENT

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

ROAD CONSTRUCTION METHODS

At the time of applying bituminous material, the road surface shall be dry and clean. All objectionable foreign matter on the road surface shall be removed and disposed of by Contractor as approved by the Engineer.

APPLICATION OF BITUMINOUS MATERIAL

The bituminous material shall be applied at a uniform rate of 0.23 to 0.70 L per square meter (0.05 to 0.15 G per square yard) for diluted asphalt emulsion. Care shall be taken to adjust application rate to take into account changes in current surface condition. At no time should the bituminous material be applied at a rate that causes run off or pooling. Sand shall be spread on the newly fogged surface at pedestrian crossing unless otherwise directed by the Engineer.

Measurement And Payment

BITUMINOUS MATERIAL

Bituminous material used for fog seal will be measured by volume undiluted at 15°C (59°F).

Basis Of Payment

Payment for the accepted quantity of bituminous material used for fog seal at the Contract price per unit of measure will be compensation in full cost of furnishing and applying the material as specified by the specified or as ordered by the Engineer.

Item No.	Item Unit
2355.502	Bituminous Material for Fog Seal liter

Special Provisions for Bituminous Seal Coat

Description

This work will consist of an application of bituminous material followed by an application of cover aggregate on designated areas of an existing pavement.

Materials

A. Bituminous Material

The bituminous material for seal coat will be one of the following kinds and grades conforming to Mn/DOT standard specification 3151. When the Contract quantity exceeds 2000 gallon (7.570 L), and unless other option are permitted by the Plans or Special Provisions, the kind to be used will be Emulsified Asphalt, Cationic grades. In all cases the grade to be used will be as designed by the Engineer.

B. Seal Coat Aggregate

Aggregate for bituminous seal coat shall conform to the requirements in the table below for grading and quality. The particular type or grading to be used shall be as shown in the Plans. All percentages are by weight.

The material shall meet the requirements for grading and quality when placed in hauling vehicles for delivery to the roadway, or during manufacture and placement into a temporary stockpile.

B1. Composition

The aggregate shall consist of sound, durable particles of sand, gravel or crushed stone, or combination thereof. It shall be clean, uniform in quality and free from wood, bark, roots and other deleterious materials. All aggregate to be used for bituminous seal coat shall conform to Class A, B, C or D as described in Mn/DOT standard specification 3137.2B.

B2. Gradation and Quality

	Total Percent Passing				
Sieve Size	**FA-1**	**FA-2**	**FA-3**	**FA-4**	**FA-5**
1-inch square	100	100	100	100	100
3/4-inch square	100	100	100	100	90-100
1/2-inch square	100	100	100	90-100	20-55
3/8-inch square	100	100	90-100	40-70	0-15
1/4-inch square	100	100	40-70	0-15	0-5
U.S. No. 4	95-100	85-100	0-15	0-5	---
U.S. No. 8	---	10-40	0-5	---	---
U.S. No. 16	45-80	0-10	---	---	---
U.S. No. 50	10-30	0-5	---	---	---
U.S. No. 100	2-10	---	---	---	---
U.S. No. 200	0-1	0-1	0-1	0-1	0-1

% Shale, Max by weight	5	5	3	2	2
Static Stripping Test	Pass	Pass	Pass	Pass	Pass
Flakiness index, Max.	N/A	30	30	30	30
Los Angeles Rattler, % Max. on Plus No. 4 fraction			30	30	30

B3. Sampling and Testing

A Sampling, Sieve Analysis, and Shale Test.....Department's Bituminous Manual
B Static Stripping Test.....AASHTO T 182
C Flakiness Index .....FLH T508
D Los Angeles Rattler Loss.....AASHTO T 96

C. WATER

All water will be potable and compatible with the chip seal. The Contractor must ensure compatibility.

D. MIX DESIGN

The chip seal coat will be designed in accordance with the Asphalt Institute design method found in their Manual Series No. 19, 1979 Edition. The chip seal design will be prepared by qualified personnel experienced in asphalt surface treatment design.

The surface design will be based on the traffic volume(s) and pavement conditions contained in the plans. The final application rates for the asphalt binder and cover aggregates will be determined after the source of the material is known and field adjustments are made.

The design will include the following information:
(1) Aggregate gradation
Bulk specific gravity of the aggregate
Loose unit weight of the aggregate
Asphalt type and rate of application
Aggregate rate of application

In addition to the above data, the Contractor will submit with the design of the seal coat a sample of the aggregates and emulsions for use by the Engineer for verifying the test results. The Department may verify the design.

After the mix design has been established, the mixture supplied to the project will conform to the following tolerances:
Passing U.S. No. 4 and larger sieves: ± 7%
Passing U.S. No. 8 to U.S. No. 100 sieves: ± 4%
Passing U.S. No. 200 sieve: ± 2%
Residual Asphalt (by extraction): ± 0.4%

Construction Requirements

A. Weather Limitations

Seal coating operations (including traffic restrictions on the freshly constructed seal coat) will be conducted:

Not before May 15 nor after August 31;
Only during daylight hours;
When the pavement and air temperature are 60°F or higher;
When the relative humidity is less than 75 percent; and
When the road surface is dry and clean.

In addition, seal coat operations will not be done in foggy or rainy weather. The seal coating operations will not be started, and will be suspended, when any of the above conditions cannot be met.

B. Equipment

B1. Distributor

The bituminous material will be applied with a distributor meeting the requirements of Mn/DOT standard specification 2321.3C1.

B2. Aggregate Spreader

The cover aggregate will be applied with an approved mechanical type aggregate spreader that is capable of distributing the aggregate uniformly to the required width and at the designated rate, with the application being sharply defined at the edges. The aggregate spreader will be a self-spreader type mounted on pneumatic-tired wheels that are so located as to operate on the freshly applied aggregate.

Prior to construction, the aggregate spreader will be calibrated in accordance with ASTM D5624-95 in the presence of the Engineer. The allowable deviation in the amount of aggregate spread on each of the rubber mats will not be more than ± 1 lb./sq.yd. in the transverse direction or deviate more than ± 1 lb./sq.yd. from the design application rate in the longitudinal direction.

B3. Pneumatic-Tired Roller

A sufficient number of self-propelled pneumatic-tired rollers will be used for rolling aggregates after spreading such that the entire width of the treatment area is covered in one pass of the rollers. In most cases this will require a minimum of three rollers. Each pneumatic-tired roller will have a total compacting width of not less than 60 inches and will have a minimum ground contact pressure of 80 pounds per square inch.

B4. Brooms

Brooms shall be motorized with a positive means of controlling vertical pressure and capable of cleaning the road surface prior to spraying bituminous material and removing loose particles after treatment as required.

C. Road Surface Preparations

All roadway surfaces to be sealed will be cleaned by the Contractor. The Contractor will sweep the pavement with a motorized broom to remove all loose material. All depressions not reached by the power broom will be cleaned by the Contractor using

hand brooming. The Contractor will ensure that the outer edges of the pavement to be sealed including 1-foot of the shoulder width, if applicable, are thoroughly cleaned. Work will not continue until the Engineer approves the surface.

All iron (manholes, gate valves, catch basins, etc.) shall be covered to prevent adherence of the asphalt binder. Suitable covering includes plywood disks, sand, kraft paper, roofing felt or other approved methods. The Contractor shall remove the protective coverings within two (2) hours after the seal coating operation and dispose of properly.

When specified in the Contract or ordered by the Engineer, a tack coat will be applied to the prepared road surface in accordance with Mn/DOT standard specification 2357.

D. Traffic Control Plan

The Contractor shall submit a detailed traffic control plan to the Engineer for approval prior to beginning construction. The traffic control plan shall include the type and locations of all signs, barricades, temporary lane markers, flag persons and pilot vehicles, as necessary. All barricades and signs shall meet the requirements of the *Minnesota Manual on Uniform Traffic Control Devices.*

E. Application of Bituminous Seal Material

Emulsified asphalt will not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing. Application of the bituminous material will be made only when the surface is dry as determined by the Engineer.

The beginning rate of application for the bituminous material will be at the rate determined by the surface treatment design. A short test strip (50-100 feet long) shall be constructed to ensure the binder application rate is adequate. After applying the binder to this test strip, the chip spreader will place the cover aggregate at the design application rate. The aggregate in the wheel paths of the chip spreader should be inspected for proper embedment. The Engineer will make adjustments to the rate of application if necessary. Application of the bituminous material will be made uniformly at this rate with the pressure distributor, one full lane width at a time (including shoulder). Further adjustments in the rate of application will be made by the Engineer, if needed, during the course of the work.

The temperature of the bituminous material at the time of application will be as approved by the Engineer, within the limits specified below:

Binder Type	Temperature Range (Deg. F)	Temperature Range (Deg. C)
CRS-1, CRS-2, CRS-2P	125-185	52-85
RS-1	70-140	21-60
RS-2, HFMS-2	125-185	52-85
RC-250	165-220	74-105
RC-800	200-225	93-107
RC-3000	230-290	110-145

F. Application of Cover Aggregate

Immediately after the emulsified asphalt has been sprayed evenly over the roadway surface, aggregates of the type specified will be evenly applied to the roadway surface by self-propelled spreader equipment. The aggregate will be distributed uniformly by a

spreader within one minute of the emulsified asphalt application. The speed of the spreader will be such that stones are not rolling over.

All aggregate will be moistened prior to placement to provide aggregates that are uniformly damp at the time of placement on the roadway.

The aggregate will be spread in one operation in such a manner that an 8-inch strip of emulsified asphalt is left exposed along the longitudinal center to form a lap for succeeding applications of emulsion. If necessary, thin or bare spots in the spread of aggregates will be corrected by hand spreading or other methods subject to approval of the Engineer.

G. Rolling Operations

The aggregate will be rolled following spreading. A maximum time of three minutes will be allowed between the spreading of the aggregate and completion of the initial rolling of the aggregate. The rollers will proceed in a longitudinal direction at a speed less than or equal to 5 miles per hour. The rollers will make three complete coverages of the aggregate with the final pass being in the direction of traffic. The Engineer may require more rollers to ensure the rolling is being done quickly enough to embed the aggregate before the binder breaks.

I. Protection of the Surface

No traffic will be permitted on the sealed road surface until after all rolling has been completed and the bituminous material has set to a degree satisfactory to the Engineer and will not pick up on vehicle tires.

In addition to other barricades and warning signs required by the Contract, the Contractor will furnish and deliver to the Project such other barricades and warning signs as the Engineer deems necessary for use in conjunction with seal coat construction. The Contractor will erect and maintain those barricades and signs at locations directed by the Engineer.

When the road under construction is open to traffic during daylight hours, the Contractor will furnish a minimum of two flag persons and a pilot vehicle to direct and guide traffic through the construction zone. One flagger will be stationed in advance of the seal coat operations and another at the rear barricade at the beginning of the uncovered bituminous material. It will be the duty of the flagger to stop all traffic and to acquaint the traveling public with the nature of the work underway, the limitations on the road surface available for traffic use, and the reason for reduced driving speed. All traffic, including construction traffic, will be held to speeds not exceeding 25 miles per hour. Advisory signing will be provided for a period of 24 hours after seal coat operations are completed to maintain vehicle speed to 25 mph.

On the morning following each day of seal coat operations, the Contractor will sweep off the surplus aggregate from the previous day's seal coat construction. This operation will be conducted while the road surface is still cool, and care will be exercised that the aggregate which has set is not disturbed. Where sealing is done in municipalities, the Contractor will dispose of the surplus aggregate in a manner satisfactory to the Engineer.

Method Of Measurement

A. Bituminous Material

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

B. Seal Coat Aggregate

Seal coat aggregate will be measured as indicated in the Proposal, by weight or by volume (vehicular measure) of material deposited on the road.

Basis Of Payment

Payment for the accepted quantities of bituminous material (including any required additives) and seal coat aggregate at the appropriate Contract prices will be compensated in full for all costs of constructing the seal coat as specified.

Payment for the bituminous seal coat will be made on the basis of the following schedule:

Item No.	Item Unit
	Bituminous Material for Seal Coat Gallon
2356.507	Seal Coat Aggregate Ton

Special Provision for Microsurfacing

1. Description

Microsurfacing shall consist of a quick-traffic mixture of polymerized asphalt emulsion, crushed aggregate, Portland cement or hydrated lime, water and other additives properly proportioned, mixed and applied on a prepared surface. This work shall be performed in accordance with the applicable Mn/DOT Standard Specifications and the following:

2. Materials

A. Portland Cement or Hydrated Lime

Portland cement mineral filler shall conform to Mn/DOT standard specification 3101 for Type I cement. Hydrated lime mineral filler shall be free of lumps.

B. Asphalt Emulsion

The emulsion shall be a polymer modified asphalt emulsion conforming to the requirements of AASHTO M208 for CSS-1h, plus the following:

Tests on Emulsion	Requirement:
Residue after Distillation†	AASHTO T59 62 percent, min

Tests on Distillation Residue:	Requirement:
Softening Point	AASHTO T53 135°F, min
Penetration at 77°F	AASHTO T49 40 – 90
Absolute Viscosity at 140°F	ASTM D 2171 800 Pa·s, min

†The temperature for the distillation procedure shall be held at 355±10°F for 20 minutes. The entire distillation procedure shall be completed within 60 minutes from the first application of heat. The cement mixing test shall be waived.

C. Aggregate

All aggregate to be used for microsurfacing shall conform to Mn/DOT standard specification 3139 for Class A, B, and Taconite Tailings, or blend thereof, subject to the following:

Sieve Size Range:	Requirement:
Mn/DOT Type 2,	
Mn/DOT Type 2 Special	Passing 3/8 inch, retained on #16, or
Mn/DOT Type 3:	Passing 3/8 inch, Not less than 90 percent retained on #8 Class A and/or Taconite Tailings, by weight

Tests on Aggregate:	Requirement:
Sand Equivalent	AASHTO T176 60 percent, min
Abrasion Resistance	AASHTO T96 30 percent, max
Soundness (using $MgSO_4$)	AASHTO T104 15 percent, max

The Abrasion Resistance test shall be done on the parent materials of the Class A, B, and Taconite Tailings components of the aggregate, if applicable. The Soundness test shall be done on the parent material of the Class B aggregate component of the blend, if

applicable. The Abrasion Resistance and Soundness test values shall be the weighted average of tests done on the following sieve sizes:
Passing _ inch, retained on _ inch
Passing _ inch, retained on @ inch
Passing @ inch, retained on #4 sieve

Sieve Size Range:

Grading Requirements For Microsurfacing
Total Percent Passing

Sieve Size	Mn/DOT Type 1	Mn/DOT Type 2 **	Mn/DOT Type 2 Special	Mn/DOT Type 3 ***
_ (50mm)	100	100	100	100
@ (9.5mm)	100	100	100	100
# 4 (4.75mm)	100	90 – 100	86 – 94	70 – 90
# 8 (2.38mm)	85-100	65 – 90	45 – 65	45 – 70
# 16 (1.18mm)	72-92	45 –70	25 – 46	28 – 50
# 30 (600μ m)	50-75	30 – 50	15 – 35	19 – 34
#50 (300 μ m)	35-55	18 – 30	10 – 25	12 – 25
#100 (150 μ m)	15-35	10 – 21	9 – 19	7 – 18
#200 (75 μ m)	5-15	5 – 15	5 – 15	5 – 15

** Is same as ISSA Type II
*** Is same as ISSA Type III

D. WATER

The water shall conform to Mn/DOT standard specification 3906.

E. MIXTURE REQUIREMENTS

E1. Mix Design

The Contractor shall submit to the Engineer a complete mix design, prepared by a qualified laboratory experienced in microsurfacing technology, ten working days prior to the start of production. The source of all materials used for the mix design shall be listed. A job-mix-formula (JMF) shall be provided to the Engineer at the pre-construction meeting and will show that the individual proportions of each of the materials when combined will meet the following mix design criteria:

Test Description	Specification
ISSA TB-114	Wet Stripping 90 percent, min
ISSA TB-100	Wet Track Abrasion Loss
	- One Hour Soak 538 g/m^2 max
	- Six Day Soak 807 g/m^2 max
ISSA TB-144	Saturated Abrasion Compatibility 3 g loss, max
ISSA TB-113	Mix Time at 77°F Controllable to 120 sec., min

Mix Time at 100°F Controllable to 35 sec., min

The JMF shall be within the following limits:

Asphalt Binder Content (Residual):	5.5 – 10.5 percent, by dry weight of aggregate.
Mineral Filler:	0.25 - 3.0 percent, by dry weight, of aggregate.

A change in aggregate, aggregate blend, or asphalt emulsion source will require a new mix design.

E2. Quality Control

The Contractor shall produce a mixture that will be in compliance with the JMF and the quality control tolerances. The methods described in this section shall be used by the Contractor to measure compliance. The Contractor shall sample and test the material in the stockpile to assure the correct passing material is provided prior to starting microsurfacing production. Contractor shall perform all tests according to referenced standards and maintain all quality control documentation and make available to the Engineer upon request or at completion of work.

a. Aggregate

The Contractor shall sample from the microsurfacing machine at a rate of 1 per 500 tons of aggregate used, or a minimum of 1 per day of mixture production. Aggregate gradation shall be determined according to AASHTO T11 and AASHTO T27. The gradation testing must be completed at the stockpile site. Results of gradation testing must be made available to engineer the same day as sample is taken. Companion samples at the request of the Engineer will be provided to the Engineer. The quality control tolerances for the JMF are listed in below.

Quality Control Tolerances
Percent Tolerances in JMF for Each Sieve Size

Sieve Size	Stockpile Tolerance
@ inch	±5
#4	±5
#8	±5
#16	±5
#30	±5
#50	±4
#100	±3
#200	±2

Schedule of Price Reduction for Microsurfacing Construction

Price reduction for aggregate failing gradations required by Specifications as determined by daily quality testing.

Payment for microsurfacing aggregate by the ton for failing gradation are based on a 2 percent price reduction for each 1 percent passing outside of stockpile tolerance requirements for all sieves. This Schedule of Price Reduction for Microsurfacing Construction only applies to non warranty work.

b. Sand Equivalent Test
The Contractor shall determine the Sand Equivalent (AASHTO T176) with each aggregate gradation. Quality control tolerance is ±7 percent of target value as established in mix design. The sand equivalent test must be completed at the stockpile site. Results of sand equivalent testing must be made available to engineer the same day as sample is taken.

c. Asphalt Content
The Contractor shall calculate the percent asphalt content of the mixture from the equipment counter readings randomly, a minimum of three times a day. The Contractor shall keep a written record of spot checks of asphalt content checks. The Contractor shall use an approved form for recording spot checks. Contractor may use his own forms as long as approved by the project Engineer.

The quality control single test tolerance is ±0.5 percent and the average daily asphalt content is ±0.2 percent from the JMF.

d . Application Rate
The design application rate shall be the total amount of microsurfacing material placed to meet the requirements for cross section, and surfacing. This amount will be the combination of all courses placed.

e. Documentation
The Contractor shall provide a daily report to the Engineer within one working day with the following information:
- Control Section, Job Number, Route, Engineer, Date, Air Temperature, Control Settings, Calibration Values, Unit Weight of Emulsion (LB/gal)
- Percent Residue in Emulsion, Beginning and Ending Intervals, Counter Readings (and Beginning, and Ending, and Total)
- Length, Width, Total Area (y_), pounds of aggregate, gallons of emulsion
- Percent of Each Material, Percent of Asphalt Cement, Application Rate, Combined Application Rate (LB/y_)
- Daily asphalt spot check reports.
- JMF (Percent Portland Cement, Percent Emulsion, Gradations, Percent Asphalt Cement)
- Contractor's Authorized Signature
- Calibration Forms
- Aggregate Certification or Shipment of Tested Stock Report
- Asphalt Emulsion Bill of Lading

E3. Mix Design Format
The final mix design shall contain prescribed information in the format identified below.
- Source of each individual material.
- Aggregate:
  Gradation
  Sand Equivalent
  Abrasion Resistance
  Soundness
- Field Simulation Tests:
  Wet Stripping Test
  Wet Track Abrasion Loss
  Saturated Abrasion Compatibility

Trial Mix Time @ (77°F) and (100°F).

- Interpretation of Results and the Determination of a Job Mix Formula (JMF):
  Percentage of Mineral Filler (minimum and maximum)
  Percentage of Water, including aggregate moisture (minimum and maximum)
  Percentage of Mix Set Additive (if required)
  Percentage of Modified Emulsion
  Residual Content of Modified Emulsion
  Percentage of Residual
  Signature and Date

E4. Mn/DOT Sampling

a. Aggregate
The Contractor shall sample from the microsurfacing machine at a rate of 1 per 1500 tons of aggregate used, or minimum of 1 sample for project, whichever is greater. The sample shall be provided to the Engineer.

b. Asphalt Emulsion
The Contractor shall sample from the microsurfacing machine at a rate of 1 per 1500 tons of aggregate used, or a minimum of 1 per project, which ever is greater. The sample shall be provided to the Engineer.

3. Construction

A. EQUIPMENT

Equipment shall be safe, environmentally acceptable and capable of producing the specified product.

A1. Mixing Machine
The Contractor shall use a continuous microsurfacing laydown machine. The mixing machine shall be equipped with a positive connection conveyer belt aggregate delivery system and an interconnected positive displacement, water-jacketed gear pump to accurately proportion aggregate and asphalt emulsion. The mineral filler feed must be located so the proper amount of mineral filler is dropped on the aggregate before discharging into the pugmill. The pugmill must be a continuous flow twin shaft multi-blade type and a minimum of 4-feet long. The blade size and side clearance must meet the equipment manufacturer's recommendations. The asphalt emulsion shall be introduced within the first one-third of the mixer length to ensure proper mixing of all materials prior to exit from the pugmill.

Rate indicators for proportioning each material to be mixed, shall be provided. The rate indicators shall be readily accessible and positioned so the amount of each material used can be determined at any time. Each material's rate indicator shall be calibrated and tested to ensure proper operation prior to production.

The mixing machine will be equipped with a water pressure system and nozzle type spray bar to provide water spray ahead of and outside the spreader box when required. Water will be applied at a rate to dampen the surface, but not to create free flowing water ahead of the spreader box.

A continuous machine shall be self propelled, front feed and continuous loading. It shall be equipped with opposite side driving stations on the front to optimize longitudinal alignment during placement. The machine shall be equipped with a remote forward speed control at the back mixing platform so that the back operator can control forward speed and level of mixture in the spreader box. Sufficient transport units shall be used to help assure a continuous operation during mix production and application.

The mixing machines shall be calibrated prior to use. The Contractor will maintain documentation showing individual calibrations of each material at various settings, which relate to the machine's metering devices. The Contractor shall supply all materials and equipment, including scales and containers necessary for calibration.

A change in aggregate or asphalt emulsion source will require recalibration.

A2. Spreader Box

The mixture shall be spread uniformly by a mechanical type spreader box, attached to the mixer and equipped with spiral augers mounted on adjustable shafts to continually agitate and distribute the mixture. The equipment will provide sufficient agitation to the mixture to prevent stagnation, excessive build-up, or lumps. The spreader box shall be equipped with front and rear flexible seals to achieve direct contact with the road. The final pass or surface pass shall use a secondary strike-off attached to the spreader box to provide a finished smooth surface texture. A drag shall produce a uniform finish. A drag having excessive mixture build-up shall be replaced.

A3. Rut Box

The Microsurface Rutfilling application will be achieved with a steel V-configuration screed rut box specifically commercially designed and manufactured to fill ruts. The rut box shall achieve a mixture spread width of 5 to 6 feet and have a strike-off to control crown.

A4. Weighting Equipment

Use of portable scales to weight material must be certified according to Mn/DOT standard specification 1901.8 and modified as follows. The scale must be re-certified after any change in location of scale. The scale will be randomly spot checked at the rate of one per week or one per project, whichever is greater.

A5. Miscellaneous Equipment

Hand squeegees, shovels and other equipment shall be provided as necessary to perform the work. Cleaning equipment such as power brooms, air compressors, water flushing equipment, and hand brooms shall be adequate for surface preparation. Power brooms, distributors and truck-mount spreaders shall be equipped with at least one approved, flashing, rotating or oscillating amber light that is visible in all directions. Continuous units shall be equipped with one such light on each side.

B. Pre-Construction Meeting

A pre-construction meeting between the Contractor and Engineer will be held on-site prior to beginning work. The agenda for this meeting will include:

- Review of the Contractor's detailed work schedule
- Review of the Contractor's traffic control plan
- Calibration of equipment
- Review of the Job Mix Formula

- Inspection of the condition and adequacy of equipment, including transport units and materials
- Test strip(s) to demonstrate the materials and placement procedures
- Job Mix Formula (JMF).

C. SURFACE PREPARATION

The Contractor is responsible for preparing and maintaining a clean surface up to, and immediately prior to, placement of the microsurfacing. The surface shall be cleared of all loose material, vegetation, plastic markings, and other objectionable material.
Tack coat shall be applied to the prepared road surface on all Portland cement concrete surfaces. Tack Coat for asphalt surface shall be as specified in the plan or directed by the Engineer. The tack coat shall consist of one part emulsion to two parts water. Rate of application shall be (.05 - .15 g/y_). The emulsion used shall be CSS-1, or CSS-1H meeting Mn/DOT standard specification 3151. The equipment used in placing the tack coat shall be capable of uniformly placing the material without excessive runoff meeting Mn/DOT standard specification 2357.

Drainage structures, monument boxes, water shutoffs, etc., shall be protected during application of material.

D. TEST STRIP

The Contractor shall construct a 1000-foot-long, one-lane width test strip to be evaluated by the Engineer. The test strip shall be constructed after dark, no sooner than one hour after sunset and no later than one hour before sunrise. When multiple machines are used, each machine shall be required to lay a test strip which will be compared to the other machines for variances in surface texture and appearance.

The microsurface test strip shall be capable of carrying normal traffic within one hour after application without any damage occurring. The Engineer will inspect the completed test strip after 12 hours of traffic to determine if the mix design is acceptable. Full production may begin after the Engineer accepts a test strip. The location of the test strip shall be approved by the Engineer.

The temperature of the emulsion shall not exceed 125°F. If the emulsion is above the temperature limit the construction of the test strip must be postponed until emulsion temperature is under 125°F.

The contractor will be required to run a new test strip when the system used in job mix changes or there is field evidence that the system is out of control. The system includes the following:
- Emulsion
- Aggregate supplier
- Type of mineral filler
- Laydown machine

In place of construction of a test strip, a contractor may submit evidence of a successful construction of a test strip on another State project using the same mix designs. The project must have been constructed the same construction season. The system used for the test strip must be identical to all parts of the proposed system.

E. APPLICATION

Microsurface mixtures shall be applied in a manner to fill ruts, when specified, and minor cracks and leave a uniform surface with straight edges, straight longitudinal and transverse joints.

Drainage structures, monument boxes, water shutoffs, etc., shall be protected during application of material.

E1. Rutfilling

Microsurface Rutfilling shall be done on pavement segments greater than 1000 feet in length, with an average rut depth that exceeds 1/2 inch. The Contractor shall use a microsurface mix with Mn/*DOT's* Type 2 Special, or Type 3 aggregate as specified, applied with an approved rut box for each designated wheel track. A clean overlap and straight edges shall be required between wheel tracks. Each rutted wheel track shall be overcrowned to allow for proper consolidation by traffic.

E2. Scratch Course

Microsurface Scratch Course shall be applied full lane width in one course. The primary screed on the laydown box shall be rigid steel screed. All Microsurface Scratch Course shall be made with Mn/DOT's Type 2, Type 2 Special, or Type 3 aggregate as specified. There shall be no excess buildup or uncovered areas.

E3. Surface Course

Microsurfacing Surface Course shall be applied full lane width in one course. All Micro-Surface Surface Course shall be made with Mn/DOT's Type 2, or Type 2 Special aggregate as specified. There shall be no excess buildup or uncovered areas.

F. SURFACE QUALITY

The finished surface shall be free from excessive scratch marks, tears, rippling, and other surface irregularities. The surface area shall not contain transverse ripples or streaks greater than _ inch in depth as measured by a 10-foot straight edge. The surface shall not exhibit tear marks greater than _ inch wide and 4 inch long, or a mark greater than 1 inch wide and 1 inch long. If, during the course of microsurfacing placement, surface defects develop, the job will be stopped until the Contractor proves to the Engineer that the problem has been corrected.

G. JOINTS AND LINES

Longitudinal construction joints and lane edges shall coincide with the proposed painted lane lines. Longitudinal joints shall be constructed with less than 3-inch overlap on adjacent passes and no more than _ inch overlap thickness as measured with a 10-foot straight edge. If applicable, place overlapping passes on the uphill side to prevent any ponding of water.

The Contractor shall construct neat and uniform transverse joints with no more than 1/8 inch difference in elevation across the joint as measured with a 10-foot straight edge. The Contractor shall ensure straight lines along curbs and shoulders. No runoff in these areas will be permitted. All edge lines shall be neat and uniform with no more than 2 inches of horizontal variance in any 100 feet.

If, during the course of microsurfacing placement, these requirements are not being met, then the job will be stopped until the Contractor proves to the Engineer that the problem has been corrected.

H. Restored Cross Section

The restored cross section of the pavement section between any edge line, lane line or center line as measured using a 10-foot straight edge transversely across the pavement shall not exceed 3/8 inch, or 3/16 inch when measured with a 6-foot straight edge. The preceding shall not apply to any area within 12 inches of the edge line, lane line or center line.

I. Traffic Control

Traffic shall not be allowed on the mixture until it has cured sufficiently to prevent pickup by vehicle tires. The Contractor shall protect the new surface from potential damage at intersections and driveways. Any damage by traffic to the mixture shall be repaired by, and at the Contractor's expense.

The contractor shall submit a detailed traffic control plan to the Engineer for approval prior to beginning construction. The traffic control plan shall include the type and locations of all signs, barricades, temporary lane markers, flag persons, and pilot vehicles, as necessary. All barricades and signs shall meet the requirements of the *Minnesota Manual on Uniform Traffic Control Devices.*

The new surface shall be capable of carrying normal traffic within one hour after application without any damage occurring to the microsurfacing. If the new surface is not capable of meeting this requirement, the job will be stopped until the Contractor proves to the Engineer that the problem has been corrected. Before beginning production after a shutdown the Contractor shall construct a test strip in accordance with section 3. D. of this special provision.

J. Weather Limitations

The mixture can be placed only when the air and pavement surface temperature are 50°F or above and rising. Placement is not permitted if it is raining, temperatures are forecasted to be below 32°F within 24 hours.

4. Measurement and Payment

Payment for **Microsurface Rutfilling** as specified includes materials, equipment, and labor for removal of the existing pavement markings, cleaning existing pavement, temporary pavement markings, stationing, traffic control, and the placement of mix to each wheel rut creating full lane coverage.

Payment for **Microsurfacing Scratch Course** as specified includes materials, equipment, and labor for removal of the existing pavement markings, cleaning existing pavement, temporary pavement markings, stationing, traffic control, and the placement of one course of mixture for full lane coverage.

Payment for **Microsurfacing Surface Course** as specified includes materials, equipment, and labor for removal of the existing pavement markings, cleaning existing pavement, temporary pavement markings, stationing, traffic control, and the placement of one course of mixture for full lane coverage.

Payment for Tack Coat as specified includes materials, equipment, and for removal of the existing pavement markings, cleaning existing pavement, temporary pavement markings, stationing, traffic control and placement of tack for full lane coverage.

Item	**Unit**
Microsurface Rutfilling	gallon@ and ton†
Microsurface ~~Standard~~ *Scratch Course*	gallon@ and ton†
Microsurface Surface Course	gallon@ and ton†
Tack coat	gallon@

†Based on the dry weight quantity of aggregate placed *and gallons of emulsion used.*
@ Gallons of emulsion undiluted at 60°F.

Special Provision for Microsurfacing Warranty
(Preventive Maintenance)

1. Description

The warranty for a Microsurfacing shall consist of the warranty form, initial acceptance, warranty bond, warranty performance criteria, and the rights and responsibilities of the Department and Contractor.

2. Definitions

Acceptance Date of Construction - The date when the Microsurfacing is completely constructed, is continuously open to traffic, and the Microsurfacing has been determined to be in compliance with the contract and project specifications by the Department by the issuance of the initial acceptance. This date will constitute the start date for the warranty period.

Warranty Bond - This is a bond that guarantees the Microsurfacing installed under the contract, against defects in materials and/or workmanship which may develop after the Acceptance Date of Construction for the specified warranty period.

Conflict Resolution Team (CRT) - This team is responsible for resolving disputes between the Department and the Contractor regarding any non-compliance of the warranty performance criteria. Shall be made up of five members appointed as follows: two by the Contractor, two by the State, and one jointly.

Paving Pass - The section of pavement consisting of a typical lane width delineated by the edge of shoulder, edge of metal, lane line or center line.

Segment - A portion of roadway, 660 feet in length and width as identified by the paving pass. The beginning point of a segment will start at the beginning of any individual distress type.

Surface deficiencies that will be evaluated in the Microsurfacing warranty performance are defined as follows:

- Flushing - Excess asphalt binder that occurs on the Microsurfacing that creates a shiny, reflective condition that becomes tacky to the touch at higher temperatures.
- Delamination - A physical separation of the Microsurfacing with the pervious pavement surface.
- Weathering and Raveling - Wearing away of the Microsurfacing, from the previous pavement surface course, caused by the dislodging of aggregate particles (raveling) and loss of asphalt binder (weathering).

3. Initial Microsurfacing Acceptance

At the construction completion of the Microsurfacing, or a portion as determined by the Department, the Department and Contractor shall review the Microsurfacing for compliance with the contract and the project specifications. If the Microsurfacing is determined by the Department to not be in compliance, then the Contractor shall repair and make good at its own expense any and all defects in materials and/or workmanship. The Department and the Contractor shall document and execute the initial acceptance on a form furnished by the department when the Microsurfacing is determined by the Department to be in compliance. This date is then the Acceptance Date of Construction.

A copy of initial acceptance shall be sent to the Contractor 's Warranty Bond surety agent by the Department.

The Department may accept the Microsurfacing and begin the warranty period, excluding any area needing corrective work, due to seasonal limitations.

4. Warranty Bond

The Contractor shall furnish a warranty bond, as required in Section 7.0 of this Special Provision, in an amount equal to 100 percent of the contract total. The warranty period shall be for two (2) years. The effective starting date of the warranty bond shall be the Acceptance Date of Construction.

5. Warranty Performance Criteria

Surface deficiencies of the microsurfacing that will be measured during the warranty shall not exceed the following threshold values. The threshold values for each parameter will be determined separately. If either threshold value is exceeded during the warranty period, the Microsurfacing will be considered in non-compliance with the warranty performance provision.

- Flushing - no more than 5 percent per segment.
- Delamination - no more than 2 percent per segment.
- Weathering and Raveling - no more than 5 percent per segment.
- Requirements for corrective action - the following minimum parameters shall be exceeded before any corrective action is required:
  4 segments - Surface Deficiencies (one or more types).
  Any single surface deficiency in excess of 10 percent per segment shall require corrective action.

Corrective work is limited to only those segments that exceed the specified threshold levels and shall be performed prior to conclusion of the warranty period or within such other time frame as agreed to by the Department and the Contractor, unless safety concerns dictate otherwise.

6. Rights And Responsibilities Of The Department

The Department:

a. is responsible for monitoring the Microsurfacing during the warranty period and will provide the Contractor all written reports of the surface treatment's condition related to the warranty performance criteria.
b. is responsible for notifying the Contractor, in writing, of any required warranty work.
c. reserves the right to approve the date(s) requested by the Contractor to perform warranty work.
d. reserves the right to approve all materials and methods used in warranty work.
e. reserves the right to determine if warranty work performed by the Contractor meets the contract and project specifications.
f. reserves the right to perform, or have performed, routine maintenance during the warranty period, which routine maintenance will not relieve the Contractor from meeting the warranty requirement of this Special Provision.
g. reserves the right to require the Contractor to make immediate emergency repairs to the Microsurfacing to prevent an unsafe road condition as determined by the Department. Should the Contractor fail to comply with this requirement, to the

Department's satisfaction and within the time frame required by the Department, the Department has the right to perform or have performed, at the Contractor's sole expense, any emergency repairs deemed necessary by the Department. Any such emergency repairs undertaken will not relieve the contractor from meeting the warranty requirements of this Special Provision.

h. shall document the condition of the Microsurfacing prior to emergency repairs.

7. Rights And Responsibilities Of The Contractor

The Contractor:

a. shall unconditionally warrant to the Department that the Microsurfacing shall be free of defects in materials and workmanship as defined by the warranty performance criteria as set forth above, for a period of two (2) years from the Acceptance Date of Construction of the Microsurfacing. This warranty and the Warranty Bond, shall be on forms furnished by the Department. These completed forms shall be submitted to the Department prior to award of contract.

b. is responsible for performing all warranty work, including, but not limited to, traffic control and restoring all associated pavement features at no additional cost to the Department.

c. is responsible for replacing all temporary repairs, resulting from the Microsurfacing being in non-compliance with the warranty performance criteria, with Department approved materials and methods.

d. shall notify the Department and shall submit a written course of action proposing appropriate corrective measures for the needed warranty work 5 calendar days prior to commencement of any warranty work, unless the warranty work requires immediate emergency repairs as determined by the Department.

e. shall follow all maintaining traffic requirements of the contract when any warranty work is performed.

f. shall complete all warranty work in a neat and uniform manner and shall meet the requirements specified in the contract.

g. is required to supply to the Department original documentation pursuant to subsection 107.10 of the 1996 Standard Specifications for Construction that all insurance required by the contract is in effect during the period(s) that any warranty work is being performed.

h. shall furnish to the Department, in addition to the regular performance and lien bond for the contract, supplemental performance and lien bonds covering any warranty work being performed. These supplemental bonds shall be furnished to the Engineer, using Department approved forms, prior to beginning any warranty work in the amount required by the Department to cover said warranty work and be in all respects satisfactory and acceptable to the Department.

i. shall make repairs to the Microsurfacing prior to conclusion of the warranty period or within such other time frame as agreed to by the Department and the Contractor after receiving notification from the Department that required warranty work is necessary, unless the Department notifies the Contractor that immediate emergency repairs are necessary to the Microsurfacing to prevent an unsafe road condition, in which event the Contractor shall make said emergency repairs within a time frame required by the Department.

is responsible for all costs of all emergency repairs to the Microsurfacing deemed necessary by the Department to prevent an unsafe road condition.

shall be liable during the warranty period in the same manner as contractors currently are liable for their construction-related activities with the Department pursuant to the Department's 1996 Standard Specifications for Construction, including, but not

limited to subsections 103.06, 107.10 and 107.11 of said Standard Specifications. This liability shall arise and continue only during the period when the Contractor is performing warranty work. This liability is in addition to the Contractor performing and/or paying for any required warranty work, and shall include liability for injuries and/ or damages and any expenses resulting therefrom which are not attributable to normal wear and tear of traffic and weather, but are due to defective materials, faulty workmanship, and to the operations of the Contractor as set forth more fully in subsections 103.06, 107.10 and 107.11 of the 1996 Standard Specifications for Construction.

9. Non-Extension of Contract

This Special Provision shall not be construed as extending or otherwise affecting the claim process and statute of limitation applicable to the Contract.

10. Measurement and Payment

All Contractor costs associated with the performance of this provision, including but not limited to, maintaining traffic, corrective treatments with associated work, materials, and engineering will not be paid for separately. All costs will be considered as included in the Contractors prices included in the contract.

MEASUREMENT AND PAYMENT

Measurement will be made by the weight and gallon of materials needed to cover an area with microsurfacing – special performed as specified. Payment will be made under *Pay Items* (Microsurfacing) at the Contract bid price per weight and gallon of materials used, which shall be compensation in full for mobilization and all materials, equipment, and labor for removal of the existing pavement markings, cleaning existing pavement, temporary pavement markings, stationing, traffic control, ~~application if a tack coat if required~~ and the placement of one course of mixture for full lane coverage.

Item	Unit
Microsurface Rutfilling	gallon & ton†
Microsurface ~~Standard~~ *Scratch Course*	gallon & *ton†*
Microsurface ~~Standard~~ *Surface Course*	gallon & *ton†*
Tack coat	gallon@

† Based on the dry weight quantity of aggregate placed and gallons of emulsion used.
@ Gallons of emulsion un- diluted at 60°F.

Engineering Services Division Technical Memorandum No. 99-05-MRR-02
January 21, 1999

Expiration

This Technical Memorandum supercedes Technical Memorandum 98-05-MRR-02 and shall continue to be in force until January 1, 2003 or until superceded or specifications are revised.

Specification 3725 has been added as an alternative to Specification 3720. This product has similar properties to 3720 but has lower resiliency. Specifications 3719, 3720 & 3723 shall remain in effect as originally stated in Technical Memorandum 98-05-MRR-02. All joint and crack sealer specifications are attached to this document.

Inspection and Sampling

Each respective specification contains the required inspection and sampling of Hot-Poured Joint and Crack Sealer under the Mn/DOT Schedule for Materials Control.

Only material from certified sources is allowed for use. A list of certified sources authorized are on file at the Chemical Laboratory.

Recommended Usage

Specification 3719 is a crumb rubber type product recommended for use in more severely cracked asphalt pavements applied following compressed air cleaning.

Specification 3723 is used for situations similar to 3719 and some rout-and-seal projects that require more durable and less resilient material.

Specification 3720 is recommended for:

- most rout and seal
- most saw and seal
- all PC pavement sealing that requires a hot-pour type sealant

Specification 3725 is used as an alternate to Specification 3720 for rout and seal and saw and seal.

Any technical questions on the contents of this Technical Memorandum should be addressed to James McGraw at 651-779-5548.

Any questions regarding the publication or distribution of Technical Memorandum should be addressed to Andrew Halverson, Acting Design Standards Engineer at 651-296-3023, or to Helen Blair, Administrative Assistant, at 651-296-2381.

Draft Special Provisions for Bituminous Seal Coat Double Seal
March 1999

Description

A double seal application of two single seal coats immediately after the first seal on designated areas of an existing pavement.

Materials

A. Bituminous Material

The bituminous material for seal coat will be one of the following kinds and grades conforming to Mn/DOT standard specification 3151. When the Contract quantity exceeds 2000 gallons, and unless the Plans or Special Provisions permit other options, the kind to be used will be Emulsified Asphalt, Cationic grades. In all cases the grade to be used will be as designated by the Engineer. It is strongly recommend to use a polymer-modified emulsion on double seal to increase early retention of aggregate.

B. Seal Coat Aggregate

Aggregate for bituminous double seal coat shall conform to the requirements in the table below for grading and quality. The particular type or grading to be used shall be as shown in the Plans. The size of the first seal aggregates should be twice as big as the final seal aggregate. To determine the if the aggregate is proper size, use the average size as determined by graphing the gradation of the aggregates. All percentages are by weight. The material shall meet the requirements for grading and quality when placed in hauling vehicles for delivery to the roadway, or during manufacture and placement into a temporary stockpile.

B1. Composition

The aggregate shall consist of sound, durable particles of sand, gravel or crushed stone, or combination thereof. It shall be clean, uniform in quality and free from wood, bark, roots and other deleterious materials. All aggregate to be used for bituminous seal coat shall conform to Class A, B, C or D as described in Mn/DOT standard specification 3137.2B.

B2. Gradation and Quality

	Total Percent Passing				
Sieve Size	**FA-1**	**FA-2**	**FA-3**	**FA-4**	**FA-5**
1 inch square	100	100	100	100	100
3/4 inch square	100	100	100	100	90-100
1/2 inch square	100	100	100	90-100	20-55
3/8 inch square	100	100	90-100	40-70	0-15
1/4 inch square	100	100	40-70	0-15	0-5
U.S. No. 4	95-100	85-100	0-15	0-5	---
U.S. No. 8	---	10-40	0-5	---	---
U.S. No. 16	45-80	0-10	---	---	---

U.S. No. 50	10-30	0-5	---	---	---
U.S. No. 100	2-10	---	---	---	---
U.S. No. 200	0-1	0-1	0-1	0-1	0-1
% Shale, Max. by weight	5	5	3	2	2
Static Stripping Test	Pass	Pass	Pass	Pass	Pass
Flakiness Index, Max.	N/A	25	25	25	25
Los Angeles Rattler, % Max. on Plus No. 4 fraction	30	30	30		

B3. Sampling and Testing

A Sampling, Sieve Analysis, and Shale Test .....Department's Bituminous Manual
B Static Stripping Test .....AASHTO T 182
C Flakiness Index .....FLH T508
D Los Angeles Rattler Loss ..... AASHTO T 96

C. WATER

All water will be potable and compatible with the chip seal. The Contractor must ensure compatibility.

D. MIX DESIGN

The double chip seal coat will be designed in accordance with the Asphalt Institute design method found in their Manual Series No. 19, 1979 Edition. The double chip seal design will be prepared by qualified personnel experienced in asphalt surface treatment design.

The surface design will be based on the traffic volume(s) and pavement conditions contained in the plans. The final application rates for the asphalt binder and cover aggregates will be determined after the source of the material is known and field adjustments are made.

The design will include the following information:
(1) Aggregate gradation
Bulk specific gravity of the aggregate
Loose unit weight of the aggregate
Asphalt type and rate of application
Aggregate rate of application

In addition to the above data, the Contractor will submit with the design of the seal coat a sample of the aggregates and emulsions for use by the Engineer for verifying the test results. The Department may verify the design.

After the mix design has been established, the mixture supplied to the project will conform to the following tolerances:

Passing U.S. No. 4 and larger sieves: ± 7%
Passing U.S. No. 8 to U.S. No. 100 sieves: ± 4%
Passing U.S. No. 200 sieve: ± 2%
Residual Asphalt (by extraction): ± 0.4%

Construction Requirements

A. Weather Limitations

Seal coating operations (including traffic restrictions on the freshly constructed seal coat) will be conducted:

Not before May 15 nor after August 31;
Only during daylight hours;
When the pavement and air temperature is 60°F or higher;
When the relative humidity is less than 75 percent; and
When the road surface is dry and clean.

In addition, seal coat operations will not be done in foggy or rainy weather. The seal coating operations will not be started, and will be suspended, when any of the above conditions cannot be met.

B. Equipment

B1. Distributor

The bituminous material will be applied with a distributor meeting the requirements of Mn/DOT standard specification 2321.3C1.

B2. Aggregate Spreader

The cover aggregate will be applied with an approved mechanical type aggregate spreader that is capable of distributing the aggregate uniformly to the required width and at the designated rate, with the application being sharply defined at the edges. The aggregate spreader will be a self-spreader type mounted on pneumatic-tired wheels that are so located as to operate on the freshly applied aggregate.

Prior to construction, the aggregate spreader will be calibrated in accordance with ASTM D5624-95 in the presence of the Engineer. The allowable deviation in the amount of aggregate spread on each of the rubber mats will not be more than 1 lb./sq.yd. in the transverse direction or deviate more than 1 lb./sq.yd. from the design application rate in the longitudinal direction.

B3. Pneumatic-Tired Roller

A sufficient number of self-propelled pneumatic-tired rollers will be used for rolling aggregates after spreading such that the entire width of the treatment area is covered in one pass of the rollers. In most cases this will require a minimum of three rollers. Each pneumatic-tired roller will have a total compacting width of not less than 60 inches and will have a minimum ground contact pressure of 80 pounds per square inch.

B4. Brooms

Brooms shall be motorized with a positive means of controlling vertical pressure and capable of cleaning the road surface prior to spraying bituminous material and removing loose particles after treatment as required.

C. Road Surface Preparations

All roadway surfaces to be sealed will be cleaned by the Contractor. The Contractor will sweep the pavement with a motorized broom to remove all loose material. All depressions not reached by the power broom will be cleaned by the Contractor using hand brooming. The Contractor will ensure that the outer edges of the pavement to be sealed, including 1 foot of the shoulder width, if applicable, are thoroughly cleaned. Work will not continue until the Engineer approves the surface.

ALL IRON (MANHOLES, GATE VALVES, CATCH BASINS, ETC.) SHALL BE COVERED TO PREVENT ADHERENCE of the asphalt binder. Suitable covering includes plywood disks, sand, kraft paper, roofing felt or other approved methods. The Contractor shall remove the protective coverings within two (2) hours after the seal coating operation and dispose of properly.

When specified in the Contract or ordered by the Engineer, a tack coat will be applied to the prepared road surface in accordance with Mn/DOT standard specification 2357.

D. Construction of Double Seal

Binder Application Rates

To determine the application rate of the first seal, add the total amount of binder need for each seal together. Then multiply the total amount by 60 percent to determine application rate for first seal. The remaining 40 percent is applied for the second seal.

Aggregate Application Rates

Care must be taken not to overapply the aggregate for the first seal. If any extra aggregate is present after compaction, sweep the roadway to remove it before construction starts on second seal.

E. Traffic Control Plan

The Contractor shall submit a detailed traffic control plan to the Engineer for approval prior to beginning construction. The traffic control plan shall include the type and locations of all sips, barricades, temporary lane markers, flag persons and pilot vehicles, as necessary. All barricades and sips shall meet the requirements of the *Minnesota Manual on Uniform Traffic Control Devices.*

F. Application of Bituminous Seal Material

Emulsified asphalt will not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing. Application of the bituminous material will be made only when the surface is dry as determined by the Engineer.

The beginning rate of application for the bituminous material will be at the rate determined by the surface treatment design. The Engineer will make adjustments to the rate of application if necessary. Application of the bituminous material will be made uniformly at this rate with the pressure distributor, one full lane width at a time (including shoulder). The Engineer will make further adjustments in the rate of application, if needed, during the course of the work.

The temperature of the bituminous material at the time of application will be as approved by the Engineer, within the limits specified below:

	Distributor Spraying Temperature, degrees F	
Asphalt Emulsions	Minimum	Maximum
CRS-1, CRS-2, CRS-2P	125	185

G. Application of Cover Aggregate

Immediately after the emulsified asphalt has been sprayed evenly over the roadway surface, aggregates of the type specified will be evenly applied to the roadway surface by self-propelled spreader equipment. The aggregate will be distributed uniformly by a spreader within one minute of the emulsified asphalt application. The speed of the spreader will be such that stones are not rolling over.

All aggregate will be moistened prior to placement to provide aggregates that are uniformly damp at the time of placement on the roadway.

The aggregate will be spread in one operation in such a manner that an 8-inch strip of emulsified asphalt is left exposed along the longitudinal center to form a lap for succeeding applications of emulsion. If necessary, thin or bare spots in the spread of aggregates will be corrected by hand spreading or other methods subject to approval of the Engineer.

H. Rolling Operations

The aggregate will be rolled following spreading. A maximum time of three minutes will be allowed between the spreading of the aggregate and completion of the initial rolling of the aggregate. The rollers will proceed in a longitudinal direction at a speed less than or equal to 5 miles per hour. The rollers will make three complete coverages of the aggregate with the final pass being in the direction of traffic. The Engineer may require more rollers to ensure the rolling is being done quickly enough to embed the aggregate before the binder breaks.

I. Protection of the Surface

No traffic will be permitted on the sealed road surface until after all rolling has been completed and the bituminous material has set to a degree satisfactory to the Engineer and will not pick up on vehicle tires.

In addition to other barricades and warning signs required by the Contract, the Contractor will furnish and deliver to the Project such other barricades and warning signs as the Engineer deems necessary for use in conjunction with seal coat construction. The Contractor will erect and maintain those barricades and signs at locations directed by the Engineer.

When the road under construction is open to traffic during daylight hours, the Contractor will furnish a minimum of two flag persons and a pilot vehicle to direct and guide traffic through the construction zone. One flagger will be stationed in advance of the seal coat operations and another at the rear barricade at the beginning of the uncovered bituminous material. It will be the duty of the flagger to stop all traffic and to acquaint the traveling public with the nature of the work underway, the limitations on the road surface available for traffic use, and the reason for reduced driving speed. All traffic, including construction traffic, will be held to speeds not exceeding 25 miles per hour. Advisory signing will be provided for a period of 24 hours after seal coat operations are completed to maintain vehicle speed to 25 mph.

On the morning following each day of seal coat operations, the Contractor will sweep off the surplus aggregate from the previous day's seal coat construction. This operation will be conducted while the road surface is still cool, and care will be exercised that the aggregate which has set is not disturbed. Where sealing is done in municipalities, the Contractor will dispose of the surplus aggregate in a manner satisfactory to the Engineer.

Method Of Measurement

A. Bituminous Material

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

B. Seal Coat Aggregate

Seal coat aggregate will be measured as indicated in the Proposal, by weight or by volume (vehicular measure) of material deposited on the road.

Basis Of Payment

Payment for the accepted quantities of bituminous material (including any required additives) and seal coat aggregate at the appropriate Contract prices will be compensated in full for all costs of constructing the seal coat as specified.

Payment for the bituminous seal coat will be made on the basis of the following schedule:

Item No.	Item Unit
	Bituminous Material for Seal Coat Gallon
2356.507	Seal Coat Aggregate Ton