U.S. Department of Transportation
Federal Highway Administration

**SD2019-01-F**

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**Department of Transportation**

# Pavement Preservation Guide Update for SDDOT and Local Agencies SD2019-01
# Final Report

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## ACKNOWLEDGEMENTS

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# TECHNICAL REPORT STANDARD TITLE PAGE

| | | | |
|---|---|---|---|
| 1. Report No.<br>SD2019-01-F | 2. Government Accession No. | 3. Recipient's Catalog No. | |
| 4. Title and Subtitle<br>Pavement Preservation Guide Update for SDDOT and Local Agencies | | 5. Report Date<br>03/26/2021 | |
| | | 6. Performing Organization Code | |
| 7. Author(s)<br>Gonzalo R. Rada, R. Gary Hicks and James Bryce | | 8. Performing Organization Report No. | |
| 9. Performing Organization Name and Address<br>Wood Environment & Infrastructure Solutions, Inc.<br>12000 Indian Creek Court, Suite F<br>Beltsville MD, 20705 | | 10. Work Unit No. | |
| | | 11. Contract or Grant No.<br>SD2019-01 | |
| 12. Sponsoring Agency Name and Address<br>South Dakota Department of Transportation<br>Office of Research Room 164<br>700 East Broadway Avenue<br>Pierre, SD 57501-2586 | | 13. Type of Report and Period Covered<br>Draft Final Report<br>December 2019 – March 2021 | |
| | | 14. Sponsoring Agency Code | |
| 15. Supplementary Notes<br>An executive summary is published separately as SD2019-01-X. | | | |

16. Abstract

Pavement preservation is a strategy of maintaining a pavement's functional condition at relatively low cost. By extending pavement life and enhancing pavement performance, preservation practices provide and maintain serviceable roadways in a cost-effective manner. To help with the pavement preservation decision-making process, the South Dakota Department of Transportation (SDDOT) has a well-developed pavement preservation program with guidelines that have served as a template for other DOTs. Those guidelines, however, were last updated in 2010, and many advances in pavement preservation practices had been made in the interim. Accordingly, the overarching objective of the research detailed in this report was to update SDDOT's pavement preservation guidelines to reflect changes in preservation practices, as well as to develop a simple cost-benefit analysis method that could be considered at the state or local level. To accomplish the stated objective, fourteen tasks were carried out, beginning with a project kick-off meeting, and concluding with a presentation to the SDDOT Research Review Board. The approaches to completing each task, along with details related to the conduct of each of the tasks, are provided in this report, along with the major findings and conclusions. The report also details the three most significant recommendations resulting from the project, which are: (1) implement and evaluate the newly developed pavement preservation guidelines, (2) implement and evaluate the cost benefit tool developed for local agencies, and (3) provide training to state and local agencies on pavement preservation to assist with the implementation of the guidelines. The final chapter of the report details the benefits that are expected from the conduct and implementation of this research.

| | | | |
|---|---|---|---|
| 17. Keywords<br>Pavement preservation, preservation treatments, pavement management, cost-benefit analysis | | 18. Distribution Statement<br>No restrictions. This document is available to the public from the sponsoring agency. | |
| 19. Security Classification (of this report)<br>Unclassified | 20. Security Classification (of this page)<br>Unclassified | 21. No. of Pages<br>137 | 22. Price |

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## LIST OF ABBREVIATIONS

| Acronym | Definition |
|---|---|
| AASHTO | American Association of State Highway Transportation Officials |
| ACPA | American Concrete Paving Association |
| ARRA | Asphalt Recycling and Reclaiming Association |
| AADT | Annual average daily traffic |
| CBA | Cost benefit analysis |
| CIR | Cold in-place recycling |
| CRC | Continuously reinforced concrete |
| DBR | Dowel bar retrofit |
| DOT | Department of Transportation |
| EUAC | Equivalent uniform annual costs |
| FHWA | Federal Highway Administration |
| HMA | Hot-mix asphalt |
| HIR | Hot in-place recycling |
| IRI | International roughness index |
| LCC | Life-cycle cost |
| LCCA | Life-cycle cost analysis |
| LTPP | Long-Term Pavement Performance |
| MDT | Montana Department of Transportation |
| MnDOT | Minnesota Department of Transportation |
| NCHRP | National Cooperative Highway Research Program |
| NDDOT | North Dakota Department of Transportation |
| NHI | National Highway Institute |
| NHS | National Highway System |
| OPI | Overall pavement index |
| PCC | Portland cement concrete |
| PMS | Pavement management system |
| PPE | Personal protection equipment |
| PPRA | Pavement Preservation Recycling Alliance |
| SDDOT | South Dakota Department of Transportation |
| SDLTAP | South Dakota Local Technical Assistance Program |
| SPS | Specific Pavement Studies |
| TRB | Transportation Research Board |
| TRIP | TRB Research in Progress |
| TRIS | TRB Research Information Services |
| TSP | Technical Services Program |
| UTW | Ultra-Thin Whitetopping |

# 1.0 EXECUTIVE SUMMARY

The research detailed in this report was conducted to update the pavement preservation guidelines of the South Dakota Department of Transportation (SDDOT) and to develop a simple cost-benefit analysis method that could be considered at the state or local level. The cost-benefit analysis method was implemented into a tool that can be used to analyze the cost of preservation treatments and to assist with pavement preservation decision-making. SDDOT has a well-developed pavement preservation program with guidelines that served as a template for many other DOT preservation guidelines, but those guidelines were last updated in 2010 and many advances have been made in the interim. This research focused on updating the 2010 SDDOT guidelines using preservation information developed over the past ten years by the SDDOT and other DOTs with similar climate and practices.

## 1.1 Fundamentals of Pavement Preservation

Pavement preservation is a combination of activities that help to provide and maintain serviceable roadways in a cost-effective way by extending pavement life and enhancing pavement performance. Preservation activities involve the application of preventative treatments that slow deterioration or correct isolated defects, deferring costly pavement rehabilitation or reconstruction. Preventive maintenance is a primary component of pavement preservation and refers to a planned strategy of cost-effective treatments to an existing roadway system. It is primarily used to maintain or improve the functional condition of the system without increasing the structural capacity.

The research detailed in this report focused on updating the guidelines used by SDDOT and local agencies in South Dakota to select and install preventive maintenance treatments (hereafter referred to as preservation treatments). A simple cost-benefit analysis tool was also developed. The next sections of this summary detail the problem statement, objectives and work tasks that were conducted as part of this project. Finally, the resulting recommendations and research benefits are presented. For ease of reference, each of the subsequent sections in this summary share the title and number of specific chapters throughout the main report.

## 1.2 Problem Description

The SDDOT's Pavement Preservation Guide was nine years old when the research presented in this report commenced. The guide needed to be reviewed and updated to include the most recent techniques and materials available for pavement preservation. In addition, the guide needed to be a useful document to all individuals involved in pavement management and preservation, from lead workers to program managers. Following a review of the current state of the practice in South Dakota, this study identified opportunities for improvement in SDDOT's current pavement preservation guidelines. Those improvements served as the basis of the research objectives and tasks.

Besides the guidelines, there was also a need for a cost-benefit analysis tool that could be easily applied for decision-making, especially by local agencies. In addition, since training is an important component of an effective preservation system, there was a need to review the existing

SDDOT's training programs and other technology transfer opportunities and to provide recommended changes. These activities also served as the basis of multiple research tasks.

## 1.3 Research Objectives

The overarching objectives of this project were to update SDDOT's pavement preservation guidelines to reflect changes in preservation practices and to develop a simple cost-benefit analysis method for state or local government users. The overarching objective was important to keep at the forefront—SDDOT is working towards improvement of pavement preservation practices. More specifically, the stated objectives of this project were to:

1. Review SDDOT's and other agencies' pavement preservation practices, including the SDDOT Pavement Preservation and Field Guides, and identify opportunities for application of new materials and techniques.

   This objective was met through an extensive literature review, multiple interviews with stakeholders in South Dakota and extensive discussion with experts in other State DOTs.

2. Develop a basic cost-benefit technique to support decision-making by local street and highway departments.

   This objective was me by first developing a methodology, along with written detailed guidance based on modern practice, and then building that methodology into a simple Microsoft Excel® based tool.

3. Create updated Pavement Preservation and Field Guidelines.

   This objective was met by implementing the recommendations developed while meeting objective 1 into the existing Pavement Preservation and Field Guidelines.

4. Review SDDOT's existing pavement preservation training course and recommend changes to be consistent with the revised Pavement Preservation and Field Guidelines.

   This objective was met by evaluating the content of the existing training material compared to existing practice and lessons learned while meeting each of the prior objectives. Existing training material was deemed to be very well done, but many gaps in topics existed.

Each of the four objectives formed the tasks that were conducted in this research and are discussed in more detail later in the report.

## 1.4 Task Descriptions

The objectives of the research were met through the conduct of the following fourteen tasks:

1. Technical panel kick-off meeting
2. Pavement preservation literature review

3. SDDOT pavement preservation guide review
4. Survey of SDDOT pavement preservation guide usage
5. Information to pursue via interviews
6. Tasks 2 – 5 technical memorandum
7. Interviews of SDDOT and local government personnel
8. Cost-benefit analysis method
9. Draft of updated guidelines
10. Review of SDDOT training material
11. Task 7 – 11 technical memorandum
12. Updated pavement preservation guidelines
13. Final project report
14. SDDOT Research Review Board presentation

The approaches to completing the tasks, along with details related to the conduct of each of the tasks is provided in Chapter 4 of the full report. The Task 1 kickoff meeting was held virtually with a detailed discussion of the tasks, responsibilities, and other pertinent items related to the conduct of this project. Tasks 2 was completed by reviewing and synthesizing the most recent literature on pavement preservation with a focus on US based practices. Similarly, Task 3 was completed by carefully comparing the existing content of SDDOT's guide to modern preservation practices and recommending revisions. Task 4 was completed via an online survey and directly informed the interview material developed in Task 5 and the groups interviewed in Task 7, which was completed virtually. Task 6 was completed by the research team by incorporating the information learned in Tasks 1 through 5 into a written memorandum.

Task 8 was focused on the Cost-benefit analysis method, which was originally conceived and designed as a Python based tool incorporating fuzzy logic. However, upon request from SDDOT, the original approach was abandoned and a simple excel based tool was designed along with written guidance. Task 9 was completed by incorporating the materials identified in Task 3 into the guide, while also ensuring that the lessons learned in subsequent tasks were also addressed. The results from Tasks 8 and 9 were submitted to SDDOT for review.

The review of the training material in Task 10 was conducted by evaluating gaps in the existing material and developing recommendations. Task 11 was completed by the research team by incorporating the information learned in Tasks 7 through 10 into a written memorandum. After receiving feedback from SDDOT on the Task 9 updated guidelines, Task 12 was completed by addressing the SDDOT comments. Finally, Task 13 was completed, the work of which is represented in this report, and Task 14 was scheduled to be completed virtually.

## 1.5 Findings and Conclusions

Completion of the tasks listed above led to several findings and conclusions pertinent to pavement preservation practices in the SDDOT. These findings and conclusions, summarized next, are broken into five sections that broadly correspond to the task structure.

### *1.5.1 Literature Review*

The completion of the literature review led to five primary findings:

1. The overall structure and content of many preservation guidelines was similar across agencies. This is explicitly stated in several locations, such as in the 2019 Minnesota DOT Preservation guidelines that directly cite the SDDOT guidelines as a primary source of material.
2. Many recent publications that would contribute to updates to the SDDOT guidelines were found. For example, the Federal Highway Administration (FHWA) published a series of pavement preservation checklists in 2019 that are valuable reference materials.
3. Cost-benefit analysis was not detailed in many of the state DOT guidelines reviewed, although many guidelines contained information about costs and information about treatment life.
4. No state DOT guidelines that were reviewed contained detailed information about the preservation of unpaved roads, though many alluded to the need to preserve those routes.
5. The literature review showed that many improvements have been made with respect to estimating the effects of pavement preservation on pavement condition and performance.

### *1.5.2 SDDOT Guidelines Review*

The review of the existing SDDOT pavement preservation guidelines produced many findings directly relevant to the project, as well as recommendations for updating the existing guidelines. First, the organization of the current guidelines was found appropriate for SDDOT's purposes, and consistent with that of many other recent guidelines. However, many parts were found that required updates to reflect changes and advances in the state of the practice since the 2010 pavement preservation guidelines were published. This consisted of edits to update introductory material, changes to the matrices in the 2010 guide, new treatments added for asphalt pavements and updates to other treatments, and the inclusion of a cost-benefit method for asphalt pavements.

### *1.5.3 Online Survey*

A total of 30 responses to the online survey were received, which is a 56% response rate. The responses came from a variety of respondents including SDDOT personnel, City, County and regional practitioners, the South Dakota Local Technical Assistance Program (SDLTAP), and a consultant. The majority of respondents were familiar with and had made use of the guidelines for at least the past 3 years. Furthermore, a majority of those surveyed indicated that the existing structure of the guidelines was adequate as is and simply needed an update. A question about the structure of the cost-benefit analysis indicated that many respondents were interested in a written procedure with examples, while fewer were interested in a stand-alone tool. Many additional comments were received via the survey, each of which are detailed in the report and each of which were considered during the conduct of the research.

### *1.5.4 Interviews*

Interviews were conducted with the various stakeholders in South Dakota that will potentially benefit from the update to the pavement preservation guidelines. One of the most significant results from the interviews was the identification of three distinct pavement preservation audiences: SDDOT, larger counties and cities, and smaller counties and cities. It was also concluded from the interviews that while the updated pavement preservation guidelines are intended to serve all three audiences, the simple, user-friendly cost-benefit analysis tool should be geared towards smaller counties and cities. Other findings from the interviews included distress types and treatments that interviewees believed should be added or removed from the guidelines, construction information that should be updated, information on costs and distress data, and recommendations for associated training materials.

### *1.5.5 SDDOT Training Material Review*

In addition to the preservation guidelines and information already available for this research, the project team was provided with two sets of training materials. The first set only contained a course outline, so it was not possible to assess the adequacy of the content for training purposes. The second set was from the SDLTAP, which was very well presented, but did not include instructors' notes and was only for a portion of the preservation treatments in the guidelines. The project team then identified and described many additional sources of training materials.

## 1.6 Recommendations

Following completion of the tasks detailed previously, the project team identified three key recommendations, each stated concisely below.

### *1.6.1 Pavement Preservation Guidelines*

*Implement and evaluate the newly developed 2021 pavement preservation guidelines.*

The 2021 pavement preservation guidelines should be adopted by state and local agencies. To date, they have only been reviewed by the technical panel set up by SDDOT and now need to be distributed to state and local agencies for their use. The guide includes new distress types, decision matrices, and treatments, all of which need field verification by agencies in the state.

### *1.6.2 Cost-Benefit Analysis Tool for Local Agencies*

*Implement and evaluate the cost benefit tool developed for local agencies*

The 2021 pavement preservation guidelines include a new cost benefit analysis and tool developed for use by state and local agencies. To date, they have only been reviewed by SDDOT's project technical panel and now need to be distributed to local agencies for their use. The tool currently includes default costs and life extensions which may have to be adjusted to suit local conditions within the state.

### *1.6.3 Pavement Preservation Training Needs*

*Provide training to state and local agencies on pavement preservation to assist with the implementation of the guides.*

Based on the review of SDDOT's preservation training materials, the research team recommends the creation of a two- to four-hour pavement preservation introductory module addressing the topic areas covered by the updated guidelines. The training would be accomplished via PowerPoint presentation, starting from the SDLTAP introductory presentation, but augmented based on the updated guidelines as well as through the incorporation of examples illustrating the distress-treatment selection matrices and the cost-benefit analysis tool. This introductory module (like the updated guidelines) would consist of the following:

- Introduction to Pavement Preservation
- Treatment Selection Guidelines
- Review of Preservation Treatments
- List of References

In addition to the introductory module, it is recommended that SDDOT create a training library of treatments. This library would contain information for each treatment under consideration by SDDOT but would not be limited to South Dakota information only. Development of the introductory module should rely on the work done by the SDLTAP coupled with the information contained in the updated guidelines as well as other relevant references noted earlier. The library of treatments would also make use of the material already prepared by the SDLTAP, but they should be significantly augmented by information from other sources, as discussed in greater detail in Chapter 5 of this report.

## 1.7 Research Benefits

Several benefits are expected from the conduct and implementation of this research. As stated previously, the products recommended for implementation include the 2021 pavement preservation guidelines, the cost benefit analysis tool, and the proposed training material to assist state and local agencies in better understanding the design and construction of pavement preservation projects in South Dakota. The potential benefits from implementation of the pavement preservation guidelines include improved construction quality, fewer short-term failures, and better long-term performance. Similarly, the potential benefits from implementation of the cost-benefit analysis tool include improved project selection and use of more cost-effective treatments. Potential benefits associated with implementation of the training recommendations include improved construction quality for preservation treatments (because both contactors and agency inspectors would be better prepared), improved short- and long-term performance because of better qualified personnel, and improved safety in traffic zones (fewer collisions and fatalities).

These benefits are discussed in more detail in the full report, and an approach for measuring and assessing the benefits was recommended. The approach is based on developing a baseline estimate of several factors, such as costs and treatment lives, and then monitoring the field

performance of preservation treatments over time. Monitoring and assessing field performance over time will allow SDDOT to estimate improvements in the effects of preservation – i.e., increased service life and decreased costs over time for the pavement network.

# 2.0 PROBLEM DESCRIPTION

The research presented in this report was conducted to update and improve pavement preservation guidelines and practices throughout the State of South Dakota. This included multiple objectives, which are detailed in the next chapter of this report. This chapter includes the motivation for the study, such as the need to update and improve the existing SDDOT pavement preservation guidelines, as well as to incorporate advances in the state-of-the-practice of pavement preservation through improved tools and training recommendations.

Pavement preservation is a strategy of maintaining a pavement's functional condition at relatively low cost. Preventive maintenance is the primary part of a pavement preservation strategy, and it comprises relatively low-cost treatments applied to an existing roadway system and its appurtenances. Preventive maintenance is a tool for pavement preservation not directly associated with a specific treatment; rather it is associated with the condition of the pavement when the treatment is applied. When a preventive treatment is applied in a timely and proper manner, it is expected to affect pavement performance in one of the following ways (Applied Pavement Technology, 2015):

- Preventing or slowing down infiltration of moisture and incompressible material (e.g., rocks and stones that get caught up in cracks and seals and ice during freeze thaw cycles) by applying treatments such as crack or joint seals, membrane seals, and certain patches. This also has an effect of reducing the ingress of deicing salts, reducing the rate of degradation of the reinforcing steel.
- Providing protection against aging and oxidation of existing asphalt surfaces by applying treatments such as flexible surface treatments.
- Restoring surface integrity by applying preservation treatments for flexible pavements and partial or full depth slab repairs for concrete pavements.
- Improving surface texture for both flexible and concrete pavements by applying surface seals, thin AC overlays, and diamond grinding.
- Reducing pavement roughness by applying treatments such as thin AC overlays and diamond grinding.

The fundamental objective of pavement preservation is to reduce the long-term costs of managing pavement networks by extending the life of pavements through application of relatively low-cost treatments to pavement segments. Rada *et al*. (2018) and Bryce *et al*. (2018) both describe how pavement preservation practices and data have continued to evolve over time and how the effects of preservation treatments on pavement performance continue to be better understood through comprehensive analyses. A review of current literature reveals that the state of practice for pavement preservation continues to evolve over time, which means that the guidance and tools implemented by DOTs must also evolve to maintain best practices.
A detailed review of the 2010 SDDOT pavement preservation guidelines also revealed many improvements that could be implemented. Those improvements formed the basis of tasks detailed in Chapter 4 of this report.

# 3.0 RESEARCH OBJECTIVES

The overarching objective of this project was to update SDDOT's pavement preservation guidance to reflect changes in preservation practices, as well as to develop a simple cost-benefit analysis method that could be considered at the state or local level. This objective was important to keep at the forefront—SDDOT is continuously working towards improvement of pavement preservation practices. Within the stated overarching objective, four project specific objectives were identified, which are discussed throughout the remainder of this chapter. Emphasis is given to how the objectives were achieved through the conduct of the work detailed in this report.

## 3.1 Review SDDOT and Other Agency Practices and Guides

*Objective 1: Review SDDOT's and other agencies' pavement preservation practices, including the SDDOT Pavement Preservation and Field Guides, and identify opportunities for application of new materials and techniques.*

The goal of this objective was to thoroughly review SDDOT materials, review and compile current practices from other agencies, and then to identify specific updates to SDDOT's current practices. This objective was accomplished through a two-pronged approach:

1. A thorough review of current agency practices with particular emphasis on agencies in similar climates such as Illinois, Iowa, Minnesota, Montana, North Dakota, Wisconsin, Wyoming, etc. This review also included current literature that documents preservation effectiveness (e.g., Rada *et al*., 2018) and research reports by FHWA.
2. A thorough review of the current SDDOT pavement preservation guidelines and field guide to identify the key aspects that should be updated or expanded.

The two steps in the approach were conducted in parallel, and then brought together to form a set of recommendations specific to SDDOT. Important to meeting this objective was consistent communication with SDDOT and stakeholders that will also benefit from completion of this project, so multiple meetings with SDDOT and other agencies in South Dakota were held. Achieving this objective led to a comprehensive understanding of current practices and potential improvements to those practices.

## 3.2 Develop Basic Cost-Benefit Technique

*Objectives 2: Develop a basic cost-benefit technique to support decision-making by local street and highway departments.*

The goal of the second objective was to help support pavement preservation practices in local street and highway departments through development of a cost-benefit method. To meet this objective, a thorough review of current cost-benefit methods was conducted, and the data available to local street and highway departments was assessed. Following the review of practices and current data, a cost-benefit method was developed that incorporated the pavement distresses detailed in the SDDOT guidelines, life extension values for each treatment, and fully loaded treatment costs. The cost-benefit method was documented in detail and included in the

SDDOT Pavement Preservation Guidelines and was also implemented into a simple Microsoft Excel® based tool.

## 3.3 Develop Updated Pavement Preservation and Field Guidelines

*Objective 3: Create updated Pavement Preservation and Field Guidelines.*

The goal of this objective was to implement the information gained in the literature review, interviews, and cost-benefit method into an updated set of SDDOT pavement preservation and field guidelines. Completion of the first objective revealed that the content and structure of the 2010 SDDOT guidelines and existing field guide were consistent with best-practice, and therefore the structure of those documents were maintained in the updated versions. This objective was met by revising the 2010 guidelines to match the current state of practice, removing outdated content, incorporating guidance on the cost-benefit method, and including references to updated outside resources that can inform modern pavement preservation practices. The organization and format of the guidelines were also revised to facilitate understanding of the pavement preservation material.

## 3.4 Review Training Materials and Recommend Changes

*Objective 4: Review SDDOT's existing pavement preservation training course and recommend changes to be consistent with the revised Pavement Preservation and Field Guidelines.*

The final objective was to review the existing SDDOT training materials and recommend changes or updates commensurate with the results obtained from meeting the first three objectives. This objective was met by first gathering all existing training materials from the SDDOT, including presentations, workbooks, and schedules. Multiple resources were gathered from SDDOT and SDLTAP, and those were comprehensively reviewed. Although some shortcomings were identified (e.g., lack of speakers notes), much of the training materials were thorough and reflect modern practice. Several changes were recommended that primarily focused on augmenting the current training with additional topics and modules. An approach to making the updates to the materials was also developed and is discussed in the next chapter of this report.

# 4.0 TASK DESCRIPTIONS

Accomplishments of the objectives detailed in the previous chapter of this report required completion of the fourteen research tasks detailed in this chapter. These are the same tasks that were detailed in the solicitation that led to the project. They are also the same tasks included in the research team's proposal to SDDOT. In the description of the tasks that follow, several of the titles were revised (shortened or changed to reflect the work done). The research team's interpretation – including objective and approach – to accomplishing each task is discussed over the remainder of the chapter.

## 4.1 Technical Panel Kick-Off Meeting

*Task 1: Meet with technical panel to review project scope and work plan.*

The first task of the project was to schedule and hold a virtual kick-off meeting with the SDDOT technical panel. This meeting was the first step in a collaborative process between SDDOT staff and the research team. In this meeting, the team laid out a plan for working hand-in-hand with SDDOT to build consensus on project objectives and deliverables.

The meeting was originally scheduled for December 30, 2019, but due to a severe winter storm affecting South Dakota, the meeting was rescheduled for January 22, 2020 from 2:30 to 4:45 pm. Prior to meeting, the research team developed a draft meeting agenda as well as a work plan for performing the project, which listed each task, assigned responsibility, and identified target due dates. Both documents were provided to the SDDOT prior to the meeting, and they were revised based on SDDOT input.

In accordance with the agenda, the specific topics covered during the meeting included:

- Part 1: Project Management
  1. Introductions
  2. SDDOT expectations
  3. SDDOT selection panel comments to consider
  4. Wood research team organization
  5. SDDOT project team organization
  6. Communications
  7. Issue resolution.
- Part 2: Work Plan
  1. Discussion of overall scope
  2. Specific work plan task discussions
  3. SDDOT involvement
  4. Potential challenges/strategies to mitigate
  5. Schedule

On January 26, 2020, four days after the kick-off meeting was held, the research team submitted to the SDDOT the meeting minutes, which documented the major discussion points, resolutions, and action items.

## 4.2 Pavement Preservation Literature Review

*Task 2: Review and summarize literature regarding pavement preservation practices in states with climatic conditions like South Dakota's (e.g., Minnesota, Iowa, North Dakota, and Montana).*

The objective of the literature review task was to gather relevant information relating to the pavement preservation guidance. Although the research team had identified in the proposal many of the important references as part of previous research efforts, the results of this task supplemented the information already available to the research team. More specifically, the objective of the literature review was to identify recent developments in pavement preservation treatments, which included:

- Building on literature reviews and surveys recently conducted by the research team on the focus subject area, with specific emphasis on venues where practitioners are encouraged to present, such as the regional American Association of State Highway and Transportation Officials (AASHTO) Technical Services Program-2 (TSP-2) pavement preservation partnerships and industry meetings.
- A search utilizing the Transportation Research Board (TRB) Research in Progress (TRIP) database, TRIS Research Information Service database, FHWA information resources, online libraries (plus online searches using key words), state and regional transportation agencies, industry organizations, academic institutions, military departments, and other related information sources.

Specific attention was paid to the various topics in literature related to pavement preservation and how those topics could contribute to the SDDOT's pavement preservation practices. For example, much literature on pavement preservation related to the assessment of the performance of preservation treatments, which was valuable to the development of the Task 8 cost-benefit methodology. Another common literature focus was the implementation of pavement preservation in strategic agency programs.

Ultimately, the information resulting from this task provided an important foundation for the update of the SDDOT pavement preservation guidelines, as well as the development of the cost-benefit analysis tool. The results of the literature review are presented in Appendix A.

## 4.3 SDDOT Pavement Preservation Guide Review

*Task 3: Review the current SDDOT Pavement Preservation Guide and Field Guide.*

The objective of this task was to thoroughly review the SDDOT pavement preservation guidelines and field guide to assess where improvements or updates could be made. Considerable research on preservation treatments had been conducted since SDDOT's preservation guidelines were published in 2010, and this research proved to be useful in the updating of the guides.

As detailed later in this report, the existing SDDOT guidelines were found to be very detailed, including treatment selection guidelines, information about the possible range of preservation

treatments, and treatment construction considerations. However, several areas of potential improvement were identified. These improvements are presented in Appendix B of this report.

Completion of this task produced a preliminary list of potential improvements, including but not limited to the revision of the treatment feasibility tables, and consideration of additional treatments, construction considerations, and quality assurance practices. This list of improvements was revised during the tasks that followed, but it provided the research team with a working list of items to investigate.

## 4.4 Survey of SDDOT Pavement Preservation Guide Usage

*Task 4: Develop and administer an online survey of SDDOT personnel and local government officials who deal with pavement preservation to determine their use of the current Pavement Preservation Guide and to solicit suggestions for the update.*

In addition to the traditional literature search, the research team also conducted an online survey of stakeholders that use the SDDOT guidelines in an effort to:

- Assess the extent of usage of the guidelines in selecting or implementing pavement preservation treatments, and
- Identify shortcomings or improvements that may be necessary from the perspective of the users of the guidelines. For example, it was important to know if the users of the guidelines would benefit from additional details, examples or case studies, or whether the users believe the structure of the guidelines were adequate and simply needed an update.

The research team worked with the SDDOT in the development and administration of the online survey, which included the identification of additional information to pursue via interviews in a later project task. The online survey was finalized (see Appendix C) and distributed on March 6, 2020 to a list of 54 people provided by the SDDOT; responses were accepted until March 27, 2020. In all, a total of 30 responses to the online survey were received, a 56% response rate (30 of 54), which was considered acceptable for the intended survey purposes.

## 4.5 Information to Pursue via Interviews

*Task 5: Review the results from the Task 4 survey and identify any additional information that may be obtained through additional interviews of selected personnel.*

The objective of this task was to assess the information gathered from the survey to develop a list of needed information to pursue via interviews. The interviews were planned to be conducted via phone or webinar to maximize the number of people that could be contacted while minimizing project costs; approval for this delivery mechanism was solicited and received from the SDDOT. The most important aspect of this task was to identify the right questions to ask the right people to maximize potential benefits to SDDOT and local agencies. The list of questions and people that were contacted for interviews are addressed in the next chapter.

## 4.6 Tasks 2 through 5 Technical Memorandum

*Task 6: Prepare and present to the technical panel a technical memorandum communicating the results of Tasks 2 through 5.*

Following the successful completion of the previous tasks, the research team developed a technical memorandum that was delivered to the SDDOT on April 15, 2020. The objective of the memorandum was to document the research, findings, and conclusions resulting from the effort in Task 2 through Task 5. The memorandum focused on three key elements:

- Results from the literature review,
- Assessment of the current SDDOT guides, and
- Findings from the online survey and proposed topics to address in the Task 7 interviews.

In addition, the memorandum linked each of the above elements to present a clear path forward for the project.

On completion of the memorandum, the research team worked with SDDOT staff to schedule the second technical panel meeting. As with the Task 1 kick-off meeting, this virtual meeting was another important step in the collaborative process associated with updating the guidelines.

The meeting took place from 9:00 am to 10:05 am CST on April 28, 2020, and addressed the following topics:

- Introductions
- Project Overview
- Task 2. Literature Review
- Task 3. Review of the Guides
- Tasks 4 and 5. Online Survey
- Task 7. Interviews
- Task 8. Cost Benefit Method
- Wrap up

Draft minutes of the meeting were submitted to the SDDOT on April 29, 2020; revisions to the minutes were not required. In addition, the original memorandum was revised based on input provided by the SDDOT during and immediately after the meeting. The final version of the memorandum was submitted to the SDDOT on May 6, 2020.

## 4.7 Interviews of SDDOT and Local Government Personnel

*Task 7: Interview SDDOT and local government officials identified by the Technical Panel to acquire additional information needed to update the Pavement Preservation Guide.*

Following the review of the Task 6 memorandum, the interviews were scheduled with key stakeholders that use the SDDOT pavement preservation guidelines – i.e., 20 SDDOT, county, city, SDLTAP and consultant personnel. The purpose of the interviews was to capture additional

insights on pavement preservation treatments and data availability issues which had not yet been documented in the literature.

The interviews took place during the period of May 27 to June 2, 2020. In all, four separate interviews were conducted involving SDDOT, Counties, Cities, and SDLTAP personnel, respectively. The interviews were carried out via virtual meetings and they involved anywhere from 7 to 19 participants. Attempts were made to set up an interview with the consultant SDDOT identified during the Task 4 online survey, but no reply was received from the individual in response to our original and follow-up requests. The interview results are discussed in detail in the next chapter.

## 4.8 Cost-Benefit Analysis Method

*Task 8: Develop a simple cost/benefit analysis method that could support decision-making by local street and highway departments.*

The objective of this task was to develop a simple, user friendly cost-benefit analysis tool to support the pavement preservation decision making process within the State of South Dakota. The effort commenced with a virtual interview meeting to confirm the research team's understanding of the pertinent details related to the development of the simple, user-friendly cost-benefit analysis tool. Seven SDDOT, SDLTAP, and project staff members participated in the meeting, which was held on June 17, 2020. The decision of developing the tool for smaller counties and cities was confirmed at the meeting. In addition, the proposed cost-benefit analysis approach was presented and discussed during the meeting.

Based on the Task 7 Interviews and the June 17, 2020 meeting, the research team developed an approach for creating a simplified and user-friendly cost-benefit analysis tool. Although the user experience was designed to be simplified, the approach used in the tool was more complex and based on *Fuzzy Logic*, which is a technique that allows for ambiguous inputs to be translated into logically consistent outputs.

Based on the meetings and interviews, the development of the cost-benefit tool was predicated on the following:

- Primary audience of the tool is smaller counties and cities that do not have a formal pavement management system—those that do have a formal system will use that for preservation treatment recommendations,
- Users of the tool may not have detailed information on the condition of their pavements in terms of specific distress-severity combinations, and
- Tool should not be overly burdensome to learn nor the results be ambiguous.

The research team engaged a team of computer scientists to assist with the development and deployment of the tool to ensure that the user experience met the requirements listed above. Development of the tool continued with feedback from SDDOT, including a July 24, 2020 meeting between the research team and SDDOT. During that meeting, more detail on the Information Technology aspects of the tool were requested. A team of computer scientists

developed options for the SDDOT to communicate with their Information Technology experts; they were submitted to SDDOT on July 27, 2020.

On July 31, 2020, SDDOT indicated that simplicity and maintenance of the tool was paramount and requested that the tool be completed entirely in Microsoft Excel®. This necessitated a complete change in approach—the *Fuzzy Logic* based approach cannot be implemented simply and efficiently in Microsoft Excel®. Therefore, the research team, in consultation with SDDOT, developed a new approach for the cost-benefit tool.

The cost-benefit tool based completely in Microsoft Excel® was based on the treatment feasibility matrices in the guidelines, which—as detailed in the next task—underwent significant revisions. Fundamentally, the tool was designed based on the following five steps:

1. **Evaluate/Input Pavement Distress and Severity Combination.**
   The tool includes the severity and extent categories that are presented in these guidelines, and the user must select (via dropdown menu) the combination of distress-severities and distress-extents that match the condition of their given pavement segment.

2. **Identify Feasible Treatment**s.
   This is performed automatically in the tool using the feasibility matrix in the guidelines.

3. **Quantify Costs.**
   The recommendations in the tool are to include fully loaded costs, which represent the sum of all costs associated with placing the treatment—placing a preservation treatment can require multiple activities and costs. Users can update costs via a separate sheet in the tool.

4. **Quantify Benefits.**
   The tool uses the life extension values associated with each treatment to quantify the benefits. Furthermore, since life extension values are generally presented as a range in literature, users can also input the maximum and minimum values.

5. **Calculate the equivalent uniform annual costs (EAUC).**
   The costs and benefits are combined in the Cost-Benefit Analysis (CBA) tool using the equivalent uniform annual cost—the larger the life extension or the lower the cost, the lower the equivalent uniform annual cost.

The output of the tool is the minimum, maximum, and expected equivalent uniform annual cost values for each of the feasible treatments. The treatments that are not feasible for any single distress-severity-extent combination that exists on the pavement are not shown as feasible in the tool and their costs are not displayed.

In addition to the tool, guidance on cost-benefit analysis and on how the tool works was developed. Per request from SDDOT in a July 31, 2020 email message, the guidance also discusses how the North Dakota Local Technical Assistance Program (NDLTAP) assessment tool and the Pavement Preservation Recycling Alliance (PPRA) website can be used to enhance

pavement preservation decision making. The guidance is included as an appendix to the updated SDDOT pavement preservation guidelines.

The tool and guidance were delivered to SDDOT along with the draft of the updated pavement preservation guidelines on October 15, 2020. The resulting tool was discussed with the SDDOT during the November 6, 2020 Task 11 technical panel meeting. In addition, minor comments on the tool were provided in writing by the SDDOT on November 20, 2020. The final version of the tool was submitted to the SDDOT on February 1, 2021.

## 4.9 Draft of Updated Guidelines

*Task 9: Prepare a draft of updated SDDOT Pavement Preservation and Field Guides.*

The objective of this task was to use the lessons learned throughout the first eight tasks of the project to develop an updated draft of the SDDOT pavement preservation guidelines. A critical element in the development of the updated SDDOT guidelines was the Task 7 interviews, which yielded recommendations on the distress types and preservation treatments that should be added to or deleted from the existing SDDOT guidelines, construction information to include in the updated guidelines, and how to address pavement preservation costs in the written guidelines and cost-benefit analysis tool.

Using the existing guidelines and the Task 7 interview results as a starting point, the research team began working on the updated guidelines in early July 2020. The existing treatments were reviewed, and new ones were added as needed. The decision was made that no preservation treatments would be deleted, since those under consideration for deletion were still used occasionally. Recommendations were also made to SDDOT to change the format and to add a table of contents, list of figures, and list of tables. During the same period, SDDOT provided a list of appendices to include in the guide; three of which were provided by SDDOT:

- Preservation Project Eligibility (FHWA memorandum dated February 26, 2019),
- Rumble Strip/Strip Guidance (SDDOT memorandum dated August 28, 2009), and
- SDDOT Pavement Preservation Technical Appraisal (FHWA memorandum dated June 2009)

A fourth appendix, containing instructions and details about the cost-benefit analysis tool, was added by the research team.

The marked-up guidelines were sent on July 26, 2020 for review by the SDDOT project manager and technical panel. New photos for several of the treatments and performance standards for each treatment were requested. All photos were to include proper safety gear and not include logos of construction companies.

The recommended format changes were approved by SDDOT on August 5, 2020. In addition, on August 25, 2020, the research team received the marked-up guidelines with SDDOT's responses to most of the comments from the research team as well as comments from SDDOT. Included

with these marked-up guidelines was a memorandum containing comments and suggested edits to the guide. These changes and suggested edits included:

- Formatting matters,
- Issues related to photos,
- Appendices,
- FHWA guidance update,
- SDDOT Pavement Management System synopsis,
- Evaluating pavement data,
- Combination of sections within the guidelines,
- SDDOT distress manual link,
- Surface treatment frequency table,
- Treatment table in Section 1-4,
- Treatment summaries and performance standards,
- Additional treatment suggestions, and
- Additional distress type.

During September 2020, most of the above comments were addressed. The updated guidelines were submitted to SDDOT on September 23, 2020 to address the remaining unresolved comments and to accept changes to the guidelines considered acceptable by SDDOT. The research team also requested additional photos for use in the guidelines; only a few photos were received. The guidelines were also reformatted following the FHWA format, which SDDOT found to be acceptable.

As the next version of the guidelines was being prepared, the issue of pavement distress-preservation treatment matrices was reconsidered. The research team originally recommended the use of pavement distress type and severity as the basis for identifying feasible and recommended preservation treatments. This is the approach taken by the Minnesota DOT as well as the approach described in the SDDOT pocket guide. The matrices originally prepared by the research team were reviewed by the SDDOT technical panel, and their feedback included:

- The consensus of the technical panel was that the revised matrices (on two pages) were more concise and easier to read than those matrices (on 14 pages) contained in the existing guidelines guide. At the meeting, the technical panel agreed that the new matrices were suitable for use in the updated guidelines and in the development of the associated cost-benefit tool.
- Patching does not qualify as a preservation treatment as stated in the FHWA project eligibility guidelines. The panel recommended patching not be added as a stand-alone treatment for this reason. If patching serves as a prerequisite to other preservation-eligible treatments, perhaps it could be included it in the guidelines, with the caveat that it is not eligible for federal pavement preservation funding.

Despite the positive comments, SDDOT then expressed concerns about the simplified matrices. They concluded upon further consideration that they wanted the identification of feasible and recommended treatment to be a function of not only distress type and severity, but also a function of distress extent. In addition, SDDOT wanted the format of the matrices to match the

example (transverse cracking) they had prepared for illustrative purposes. Moreover, SDDOT wanted the matrices on as few as pages as possible—a maximum of one page (back and front) for the asphalt matrices and one page for the concrete matrices.

In response to the changes stipulated by SDDOT, the research team proceeded with the development of new matrices. Once completed, they were sent to SDDOT for review and were to be included in the draft version of the guidelines, which was formally submitted under separate cover to SDDOT on October 15, 2020. The guidelines are 150 pages long, and consequently have not been included with this report. The draft guidelines were discussed with the SDDOT technical panel as part of the Task 11 panel meeting, and they were revised and finalized by the research team based on the SDDOT input received. It was hoped by the research team that part of the input would include new or better photographs (e.g., proper personal protective equipment [PPE] being used, contractor's names not shown, etc.), but no photographs were received.

## 4.10 Review SDDOT Training Material

*Task 10: Review SDDOT's existing training pavement preservation course and other related presentations and recommend changes or updates. Changes should be consistent with the updated Pavement Preservation and Field Guides.*

The objective of this task was to review the existing South Dakota pavement preservation training materials and provide recommended updates. Following the completion of Tasks 1 through 9, the research team had a thorough understanding of SDDOT's pavement preservation practices. Using the lessons learned from the prior tasks, the research team reviewed the existing training materials and recommended updates.

The following information was provided by the SDDOT to the research team for review:

- South Dakota DOT's Pavement Preservation Guidelines (2010 edition)
- South Dakota DOT's Maintenance Pavement Preservation Decision Guide
- South Dakota DOT's Pavement Distress Manual (2020)
- South Dakota DOT's Enhanced Pavement Management – System Synopsis (2020)
- South Dakota DOT's Pavement Preservation Course AFE 7205 Outline (2017)
- SDLTAP (South Dakota State University) Pavement Preservation PowerPoint presentations (2018 to 2020)

The first four items are SDDOT pavement preservation reference documents, while the last two are training course material. The information on the South Dakota DOT's Pavement Preservation Course (AFE 7205) consisted of an outline that was used to deliver a two-day training course on March 22–23, 2017. The outline consisted of the following nine modules:

- Introduction
- Pavement Management System
- Traffic Control and Safety
- Preservation of Asphalt Pavements

- Preservation of Concrete Pavements
- Preservation of Shoulders
- Drainage Preservation
- Bridge Preservation
- Closing

The SDLTAP (South Dakota State University) training material included the following five PowerPoint presentations prepared between 2018 and 2020:

- Introduction (27 slides)
- Chip Seals (82 slides)
- Crack Sealing (49 slides)
- Asphalt Patching (136 slides)
- Chip and Shot Rate (34 slides)

The findings and recommendations from the review of the above referenced training materials are detailed in the next chapter and were also discussed during the Task 11 SDDOT technical panel meeting.

### 4.11 Tasks 7 through 10 Technical Memorandum

*Task 11: Prepare and present to the technical panel a technical memorandum communicating the results of Tasks 7 through 10.*

Following the completion of Task 10, the research team prepared a technical memorandum documenting the research, findings, and conclusions of Tasks 7 through 10. The memorandum was submitted to the SDDOT on October 19, 2020; revisions to the memorandum were not required.

After completion of the memorandum, the research team worked with SDDOT staff to schedule and hold the third and final SDDOT technical panel meeting. As with the Task 1 kick-off meeting and the Task 6 technical panel meeting, this meeting represented an important step in the collaborative process associated with updating the existing SDDOT pavement preservation guidelines.

The meeting was held virtually from 11:00 am to 12:30 pm CDST on November 6, 2020. Prior to the meeting, the research team worked with SDDOT staff to prepare the meeting agenda, which included the following major elements:

1. Introductions,
2. Project Objectives
3. Task 7. Interviews
4. Task 8. Simple Cost-Benefit Method
5. Task 9. Draft of Updated SDDOT Pavement Preservation Guidelines
6. Task 10. Review of SDDOT Existing Training Material
7. Path forward

Minutes of the meeting were submitted to the SDDOT on November 8, 2020; revisions to the minutes were not required.

## 4.12 Updated Pavement Preservation Guidelines

*Task 12: Based on feedback from the technical panel, revise the Pavement Preservation and Field Guides as needed and submit them for approval of the technical panel.*

Following the Task 11 meeting and additional input received from the SDDOT on November 20, 2020, the research team developed a revised version of the SDDOT pavement preservation guidelines. This version of the guidelines was provided to SDDOT on December 7, 2020, and comments on that version were received from SDDOT on January 11, 2021. Another revised version of the guidelines was prepared by the project team based on SDDOT's latest round of comments, but three comments required further SDDOT clarification. Accordingly, the latest version of the guidelines with the three comments requiring clarification were submitted to SDDOT on January 22, 2021. Clarification of the three comments was received from SDDOT on February 5 and 7, 2021, and based on that input, the project team revised and finalized the guidelines. The final version of the guidelines was submitted to SDDOT on March 26, 2021.

During the Task 11 meeting, the technical panel recommended the removal of two appendices from the guidelines: Pavement Preservation Technical Appraisal (SDDOT June 2009) and Rumble Strip/STRIPE Installation (SDDOT August 2009). They were removed as suggested; however, recognizing the documents' value to the SDDOT pavement preservation operations, they were recommended for inclusion as appendices to this report. Accordingly, they are contained in Appendices D and E, respectively.

## 4.13 Final Project Report

*Task 13: In conformance with Guidelines for Performing Research for the South Dakota Department of Transportation, prepare a final report summarizing the research methodology, finding, conclusions and recommendations, including changes to any specifications and Approved Products procedure.*

The objective of this task was to produce a report documenting the entire research effort (Tasks 1 through 14) – the report is contained within this document. A draft version of the final project report was submitted to the SDOT on December 8, 2020. Comments on the draft report were received from the SDDOT on January 20, 2021. In turn, the research team revised the draft report based on the SSDDOT input and submitted the final version of the report on March 26, 2021.

The research team recognized the final project report as an important resource for current and future practices and took care to produce a thorough and useful final report. The report provides enough detail so that the results can be replicated, while using terminology and approaches that are familiar to SDDOT and local agencies.

## 4.14 SDDOT Research Review Board Presentation

*Task 14: Make an executive presentation to the South Dakota Department of Transportation Research Review Board at the conclusion of the project.*

The final task in the project was to prepare and deliver a presentation that summarized the research results and detailed the recommendations developed as part of the project. In putting the presentation together, the research team fully recognized the importance of conveying the project results in a manner that was understandable by a general audience of engineers, but which included enough detail for the project's technical quality to be evaluated.

Prior to the meeting, the research team coordinated meeting arrangements with SDDOT. The research team also developed a presentation for the meeting and provided it to the SDDOT on January 17, 2021 for review and comment prior to the meeting. Revisions to the presentation were made based on input from the SDDOT, and they were finalized on February 12, 2021.

The actual meeting with the SDDOT Research Review Board took place on February 16, 2021. In making the final preparations for the meeting, the research team recognized that the meeting objectives for this final task were to communicate the critical findings, revisions to the state-of-the-practice, and other important information to SDDOT. Like the Tasks 1, 6 and 11 meetings, the Task 14 presentation to the SDDOT Research Review Board was done via a virtual meeting. It was originally envisioned that a member of the research team would attend the meeting in person to deliver the presentation, but this was not possible due to the Covid-19 pandemic.

# 5.0 FINDINGS AND CONCLUSIONS

Numerous findings and conclusions were made throughout the project, starting with the confirmation that the existing SDDOT pavement preservation guidelines were sound. The guidelines needed organizational and format changes, updates to reflect ten years of technical advances, and the addition of a simple cost-benefit methodology to aid pavement preservation decision-making.

For ease of understanding, major findings and conclusions have been organized into the following categories, which closely align with the project objectives:

- Literature review,
- SDDOT guidelines review,
- Online survey,
- Interviews, and
- SDDOT training materials review.

The research team's approach to the tasks leading to these findings and conclusions was detailed in the previous chapter.

## 5.1 Literature Review

The literature review detailed in Appendix A resulted in many findings directly relevant to the project, as well as multiple recommendations for updating the SDDOT pavement preservation guidelines. The first finding from the literature review was that the overall structure and content of many preservation guidelines was similar across agencies. This was explicitly stated in several locations, such as in the 2019 Minnesota DOT Preservation guidelines that directly cite the SDDOT guidelines as a primary source of material. This finding motivated the following conclusions:

- The structure and layout of the SDDOT guidelines, which is common across many states, is presented in a logical and concise manner. Although the material differs throughout the guidelines for different DOTs, the existing SDDOT structure provides a logical and acceptable framework for the updated pavement preservation guidelines.
- Updates to the SDDOT guidelines should not rely primarily on studying other DOT guidance but should also come significantly from recent research. For example, the National Cooperative Highway Research Program (NCHRP) has published many reports (e.g., Rada *et al.* 2018) that advance the state of the practice. The NCHRP research reports detail items such as how to assess the effectiveness of preservation treatments and how to conduct cost-benefit analyses. Similarly, NCHRP Report 14-37 provides construction guidelines for emulsion chip seals, micro surfacing, fog seals, and hot applied chip seals (Shuler *et al*. 2018). Another NCHRP effort, Project 14-44, which began in September 2020, is tasked with developing the same type of guidance for slurry seals, scrub seals, and tack coats; this will be valuable for future reference.

Secondly, the FHWA published a series of pavement preservation checklists in 2019 that are valuable reference materials. The FHWA checklists include considerations related to construction, quality assurance, traffic control, pavement markings, and much more – https://www.fhwa.dot.gov/pavement/preservation/ppcl00.cfm. The updated SDDOT guidelines make use of these concise checklists, which are written for both flexible and rigid pavement treatments

Third, cost-benefit analysis is not detailed in many of the state DOT guidelines reviewed, although many guidelines contained information about costs (both relative costs and actual cost estimates) and information about treatment life. Many research reports (e.g., Bryce *et al*. 2018 and Van Dam *et al*. 2019) detail cost-benefit analysis methods related to pavement preservation. Some guidelines (e.g., Michigan DOT) contain information about lifecycle cost models including preservation treatments.

Fourth, no state DOT guidelines that were reviewed contained detailed information about the preservation of unpaved roads, though many states alluded to the need to preserve those routes. Research reports that can inform guidelines on the preservation of unpaved roads, however, were documented in the literature review. The best resource was found to be a 2015 FHWA report (https://www.fhwa.dot.gov/construction/pubs/ots15002.pdf).

Finally, the literature review showed that many improvements have been made with respect to estimating the effects of pavement preservation on pavement condition and performance. These updated models and methods proved valuable when revising the current guidelines and developing new information for inclusion (e.g., cost-benefit guidance). The literature showed that pavement preservation is an active research area with significant potential to help DOTs manage pavements.

After completion of the literature review, the research team continued to monitor recent reports that could potentially be relevant to the update of the SDDOT pavement preservation guidelines.

## 5.2 SDDOT Guidelines Review

Like the literature review, a review of the existing SDDOT pavement preservation guidelines produced many findings and recommended updates to the guidelines, which are detailed in Appendix B and summarized below:

- Organization
  - The existing organization of the guidelines seemed to work well for the SDDOT, and it was consistent with many of the current DOT guidelines, though it could be improved through addition of a cost-benefit analysis method.
- Content
  - In Section 1.1, the FHWA Pavement Preservation Definitions needed to be updated by adding a page or two of definitions at the beginning to include reference to the updated FHWA guidance.
  - In Section 1.2, the introduction on pavement preservation needed to be updated to reflect changes in practice since 2010.

- In Section 1.3, the treatment selection guides needed updates – e.g., add new treatment selection guides for new distress types, modify existing ones if needed, and delete ones that are not widely used. Overall, the process seemed to be simple and easily understood by the potential users of the guidelines. In addition, the surface treatment frequency chart on page 22 needed updates to consider the findings in the literature review. Furthermore, this section needed to be updated to include the cost-benefit method developed as part of the project, which was intended to support, as needed, SDDOT and local agency personnel with the treatment selection process.
- In Section 1.4, the treatments for flexible pavements seemed to be appropriate for SDDOT. Minnesota DOT uses ultra-thin bonded wearing courses, which could be added if contractors are available in the area. For rigid pavements, some of the treatments are no longer used or not widely used, such as dowel bar retrofit (DBR), pavement sub-sealing, and pavement jacking. While SDDOT considers these treatments obsolete, they were included in the guidelines for local agencies that may still use them.
- In Section 1-4.01, special considerations needed to be updated to reflect current practice for both flexible and rigid pavement preservation treatments. These special considerations were obtained from the FHWA checklists detailed in the literature review, along with other sources.
- In Sections 1-4.02 and 1-4.03, the treatment summaries needed to be updated to reflect current practice. New and improved photos were to be substituted if required for each of the treatments.
- In Section 1-4.04, the section on drainage preservation needed to be updated to reflect changes in practice over the past 10 years.
- In Section 1-4.05, the section on blading and graveling of roadways needed to be updated to reflect changes in practice over the past 10 years. The FHWA publication Gravel Roads Construction and Maintenance Guide published in 2015 was the main resource used to update this section.

- Appendices needed to be updated to include new information from FHWA as well as other pertinent information, including the cost-benefit information.

## 5.3 Online Survey

As indicated in the previous chapter, a total of 30 responses to the online survey were received, a 56% response rate (30 of 54), which was considered adequate for the intended survey purposes. The breakdown of respondents by agency is provided in Figure 1. As shown, 21 (or 70.0%) of the responses came from South Dakota DOT (SDDOT) personnel, another 7 (or 23.4%) from City, County or Regional Highways, 1 (or 3.3%) from the SDLTAP, and 1 (or 3.3%) from a Consultant.

Similarly, the breakdown of respondents according to their involvement in the pavement preservation process is summarized in Figure 2. As shown, 13 (or 43%) of responses came from SDDOT managers/decision-makers, 9 (or 30%) from local agency managers/decision-makers, 2 (or 7%) from SDDOT pavement management engineers, 1 (or 3%) from SDLTAP center training staff, and 5 (or 17%) other.

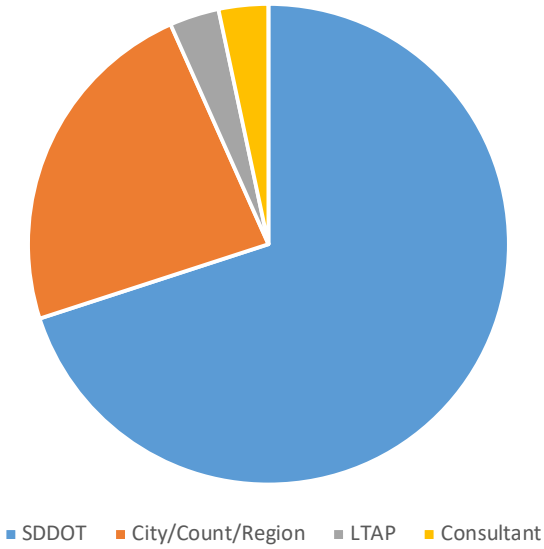


**Figure 1. Breakdown of Online Survey Respondents by Agency.**

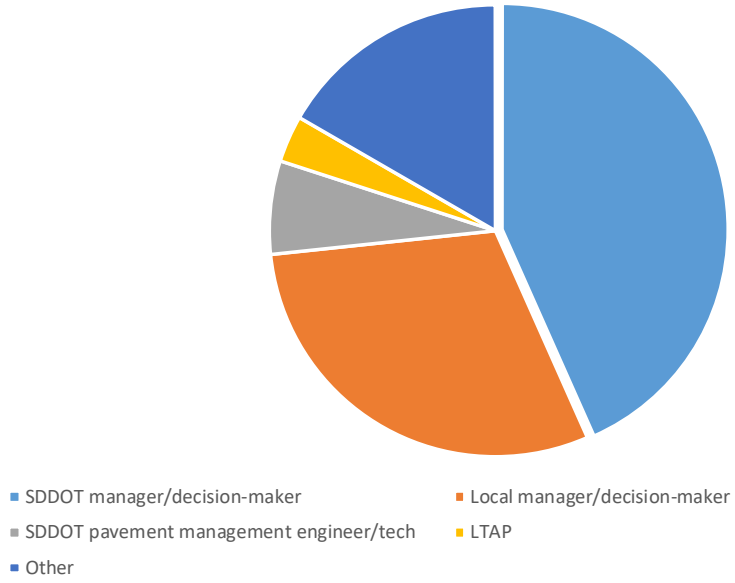


**Figure 2. Breakdown of Online Survey Respondents by Role.**

After defining the agency and role within the agency's pavement preservation process, the survey then explored the usage of the existing SDDOT pavement preservation guidelines by those respondents. The first question looked at the usage of the guidelines over time, while the second question addressed the frequency of usage on an annual basis. Rather than looking at the survey results for each question individually, Table 1 presents a usage-frequency matrix that simultaneously looks at both sets of responses. As shown, almost half of the respondents (14 of 30 or 47%) have been using the guidelines for more than 5 years, and they use them 5 to 10 times per year. The table also shows that 22 (or 74%) of the respondents are familiar with and have made use of the guidelines for at least the past 3 years—i.e., in general the respondents appeared to be highly familiar with the existing guidelines.

**Table 1. SDDOT Pavement Preservation Guidelines: Usage and Frequency.**

| Frequency/Time Usage | Frequently/Routinely (10 or more times per year) | Occasionally/Sometimes (5 to 10 times per year) | Rarely/Never (less than 5 times per year) |
|---|---|---|---|
| No Response | 1 (3.3%) | | |
| Not used or < 1 year | 0 (0.0%) | 0 (0.0%) | 3 (10.0%) |
| Past 1 to < 3 years | 1 (3.3%) | 3 (10.0%) | 0 (0.0%) |
| Past 3 to < 5 years | 0 (0.0%) | 1 (3.3%) | 1 (3.3%) |
| More than 5 years | 3 (10.0%) | 14 (46.7%) | 3 (10.0%) |

The fact that the respondents were generally familiar with the existing SDDOT pavement preservation guidelines added context to the next survey question, which sought an opinion on the nature of the changes required to the existing guidelines. An overwhelming majority (25 or 84%) of the respondents indicated that the existing structure of the guidelines was adequate as is and simply needed an update (which was consistent with findings from the Task 3 review of the existing SDDOT pavement preservation guidelines). Another 4 (or 13%) respondents disagreed, as they felt it was important to add information on a cost-benefit approach and examples, distresses in treatment selection, pavement preservation references and training resources, and pavement preservation standards specifications and quality assurance information. However, the research team believed these additions could be incorporated into the structure of the existing guidelines; in other words, they were part of the required updates. The remaining respondent (1 or 3%) did not provide an answer to this question.

The next two questions in the survey addressed the incorporation of a simple cost-benefit analysis method into the existing SDDOT pavement preservation guidelines that would allow engineers, as well as maintenance supervisors and workers, to compare preservation treatment options for given road segments. The first question asked if the respondent anticipated using this simple cost-benefit method, and 23 (or 77%) of the respondents indicated that they would, while another 3 (or 10%) indicated no and the remaining 4 (or 13%) did not respond. For the 23 (or 77%) that responded yes, 14 of 23 (or 61%) indicated they would prefer a written procedure with examples incorporated into the SDDOT's pavement preservation guides, while the remaining 9 of 23 (or 39%) indicated that they would prefer a standalone tool in MS Excel. The breakdown of the preferred cost-benefit method approach is summarized in Table 2. As shown, both SDDOT and other respondents tended to favor the written procedure, but there was clear interest in the standalone tool.

**Table 2. Cost-Benefit Method Approach Breakdown.**

| Agency | Written procedure with examples | Standalone tool in MS Excel |
|---|---|---|
| SDDOT | 7 | 4 |
| Other | 7 | 5 |

The last survey question allowed respondents to provide additional comments or suggestions not addressed by the survey that the research team should consider as part of the SDDOT pavement preservation guidelines update. Some of the more significant comments or suggestions provided are listed below:

- Keep it simple to allow for easy transition as new County Highway Superintendents take on their role,
- Recommended application rates are not always listed,
- Cost estimates for the last two years would be beneficial,
- Hot links to specifications and other industry info would be helpful,
- A discussion on profile milling is missing,
- Guidance on rumbles and when to re-establish if missing for the lighter surface treatment types,
- A discussion on cold in-place recycling for minor and major rehabs is missing.
- A discussion on engineered emulsions should be included, and
- The Department is using more RAP, and some projects have used very high RAP content. Does this require different pavement preservation procedures?

In summary, the online survey results provided valuable information that ultimately contributed to the successful accomplishment of the project. In general, the outcomes were consistent with those from the Task 2 literature review and the Task 3 review of the existing SDDOT guidelines. For example, it became very clear that the existing structure of the SDDOT guidelines was adequate as is, and it simply needed an update. Similarly, it was also very clear that the incorporation of a simple cost-benefit analysis method was important.

There were, however, cases where clarification was required before proceeding with other activities. For example, in the case of the simple cost-benefit method, respondents tended to favor the written procedure, but there was interest in the standalone tool. Accordingly, deciding which approach to pursue was an important and urgent decision. Similarly, a number of excellent suggestions were provided by the respondents, some of which could be easily implemented, while others required further discussion and clarification.

Considering the above and as envisioned by the solicitation, it became clear that there was a need to pursue interviews with a number of the survey respondents to more clearly define the path forward. Based on the responses to the survey and taking into account other factors such as agency and role in the pavement preservation process, 20 people from the SDDOT, counties, cities and SDLTAP were recommended for interview. Moreover, it was decided that the interviews be carried out, as suggested earlier, in groups as follows:

- SDDOT personnel (7)
- County personnel (6)
- City personnel (5)

In addition, individual interviews would be carried out with SDLTAP (1) and a consultant (1).

Finally, a set of questions was formulated based on the online survey results and in support of the SDDOT pavement preservation guidelines update. They included:

- What distress types if any should be eliminated or added to the decision matrixes?
- What treatments should be added and deleted from the existing guides?
- What sort of information on construction and quality assurance should be added to the manual?
- Is cost information available in support of the cost-benefit method? Also, for each treatment, would actual treatment cost or relative treatment costs be more beneficial?
- What sort of training material is desired and what topics should be covered?

## 5.4 Interviews

One of the most significant results from the Task 7 interviews was the identification of three distinct pavement preservation audiences: SDDOT, larger counties and cities, and smaller counties and cities. It was also concluded from the interviews that while the updated pavement preservation guidelines are intended to serve all three audiences, the simple, user-friendly cost-benefit analysis tool developed under Task 8 should be geared towards smaller counties and cities. Other findings and conclusions from the interviews included:

- List of distress types that should be added to or deleted from the existing SDDOT guidelines:
  - For asphalt pavements, the consensus recommendation was to keep the existing distress types but add amount of depression and depth of transverse cracking and longitudinal cracking (mid-lane, edge, rumble strips).
  - For concrete pavements, the consensus recommendation was to keep the existing distress types but add transverse cracking for non-reinforced concrete.
- List of preservation treatments that should be added to or deleted from the existing SDDOT guidelines:
  - For asphalt pavements, the consensus recommendation was to keep the existing preservation treatments and add bonded wearing courses, which are expected to be in frequent use within the next 10 years. The addition of cold-in-place recycling was also discussed, but the consensus at the time was that this is not considered preservation and therefore should not be added. (Ultimately, however, cold-in-place recycling was included in the updated guidelines, as interest on the treatment was expressed by SDDOT personnel following the interviews.)
  - For concrete pavements, the consensus recommendation was to keep the existing preservation treatments but eliminate (1) dowel-bar retrofit (DBR) and (2) pavement sub-sealing/slab (foam) jacking as these treatments have become increasingly uncommon. Meeting participants did not express strong opinions about deletion of these two treatments.

    - For gravel roads, the consensus was to use the information provided in the FHWA preservation of gravel roads report, which was prepared by SDLTAP staff members.
- List of construction information (e.g., QA guidelines) that should be included in the updated guidelines:
    - The consensus was that new information to be added to the guidelines should be the SDDOT specifications and the FHWA checklists for each preservation treatment.
    - There was also consensus that new photos would be useful.
- Definition of how pavement preservation costs should be addressed in the updated guidelines and cost-benefit analysis tool:
    - The consensus was that the tool will run based on actual costs, but the guidelines should be based on relative costs.
    - Costs are expected to vary considerably across the state, and some agencies may not have fully loaded cost information.
- Definition of need to verify pavement management system (PMS) distress data prior to application of preservation treatments:
    - While sophistication of PMS may vary, in most cases a field visit is used to confirm the reasonableness and appropriateness of the recommended preservation treatment.
- Recommendations on training material needed as well as the list of topics to be covered:
    - Discussions on training were limited in large part because the project does not entail the development of training material, but rather the review of existing training material and training practices. Training modules exist for some preservation treatments such as chip seals, gravel roads, etc., and most of the training is done in person (face-to-face).

## 5.5 SDDOT Training Material Review

The training material provided to the research team on pavement preservation in South Dakota included:

- SDDOT's Pavement Preservation Guidelines (2010),
- SDDOT's Maintenance Pavement Preservation Decision Guide,
- SDDOT's Pavement Distress Manual (2020),
- SDDOT's Enhanced Pavement Management – System Synopsis (2020),
- SDDOT's Pavement Preservation Course AFE 7205 Outline (2017), and
- SDLTAP (South Dakota State University) Pavement Preservation PowerPoint presentations (2018 to 2020).

The first four listed references should be used extensively in the update of any existing pavement preservation training material or in the development of new material. Every person involved in South Dakota's pavement preservation program should be aware of and familiar with these four documents and their contents.

The research team reviewed an outline of SDDOT's Pavement Preservation Course AFE 7205 outline. The course modules appear reasonable, but the training goes beyond just pavement preservation. Since only an outline was provided, it was not possible to assess the adequacy of the content of the material for training purposes.

As for the SDLTAP training material, the team found the presentations were very nicely done, but there were little to no instructor notes, which could lead to lack of consistency from one instructor to another. In addition, the first presentation (Introduction; 27 slides) will require revisions to reflect those changes made as part of the updated SDDOT pavement preservation guidelines, and the presentations must be significantly expanded to cover all treatments included in the newly developed guidelines.

Based on the above findings, the research team concluded there is a need for the creation of a two- to four-hour pavement preservation introductory module covering the topic in the updated guidelines. Development of the introductory module would rely on existing SDLTAP materials, the updated guidelines, and other relevant references noted earlier. The library of treatments would also make use of the material already prepared by the SDLTAP, but they should be significantly augmented by information from other sources, including:

- FHWA pavement preservation: https://www.fhwa.dot.gov/pavement/preservation/
- FHWA Local Aid Programs: https://www.fhwa.dot.gov/innovativeprograms/centers/local_aid/events.aspx
- National Highway Institute training on concrete preservation: https://www.nhi.fhwa.dot.gov/course-search?sf=0&course_no=131126
- National Highway Institute training on asphalt and concrete preservation: https://www.nhi.fhwa.dot.gov/course-search?tab=0&key=Pavement+Preservation&res=1
- National Center for Pavement Preservation: https://www.pavementpreservation.org/classes
- Pavement Preservation and Recycling Alliance: https://roadresource.org/
- International Slurry Surfacing Association: https://www.slurry.org/page/education
- Western Regional Association for Pavement Preservation: http://wrapp.org/
- AASHTO TSP2 website: https://tsp2pavement.pavementpreservation.org/
- AASHTO Just In Time Training: http://shrp2.transportation.org/Pages/Just-In-Time-Training.aspx
- OSHA course on safety: https://www.oshatrain.org/courses/mods/612e.html
- Asphalt Institute: http://www.asphaltinstitute.org/training/
- International Grooving and Grinding Association: http://www.igga.net/resources/technical-information
- National Asphalt Pavement Association: http://store.asphaltpavement.org/index.php?categoryID=131
- Foundation for Pavement Preservation: https://fp2.org/webinars/

In addition to the above sources, one of the best training opportunities is the FHWA and PPRA webinars on asphalt preservation treatments. The webinars began in 2020 and have been offered once per month. To date, they have included sessions on crack sealing, slurry surfacing, chip seals, cold in-place recycling, and more. Additional information about these webinar training opportunities can be found at https://roadresource.org/webinars.

Similarly, the FHWA National Highway Institute (NHI) launched a new five-course series in 2020 titled "Constructing PCC Pavement Preservation Treatments." This series focuses on construction methods and offers tips targeted at construction and maintenance workers; visual

aids, graphics, videos, and more are provided. Additional information may be found at https://content.govdelivery.com/accounts/USDOTNHI/bulletins/277cbe1.

# 6.0 RECOMMENDATIONS

This chapter explicitly defines the research team's recommendations to the South Dakota Department of Transportation on the application or implementation of research findings. The recommendations in this chapter are the only ones that should be considered by SDDOT. Recommendations are numbered sequentially, and they are concisely summarized, followed by more extensive explanation and elaboration.

To the extent possible, each recommendation is sufficiently defined to allow later determination as to whether it has been followed and accomplished. The basis for each recommendation was established in prior sections of the report.

## 6.1 2021 Pavement Preservation Guidelines

*Recommendation 1: Implement and evaluate the newly developed 2021 pavement preservation guidelines.*

The 2021 pavement preservation guidelines should be implemented by state and local agencies. To date, they have only been reviewed by the technical panel set up by SDDOT and now need to be distributed to state and local agencies for their use. The guide includes new distress types, decision matrices, and treatments, all of which need field verification by agencies in the state.

It is envisioned that the implementation process would require the following three tasks:

- Establish a steering committee—led by the SDDOT/SDLTAP—to help guide and direct the development of the implementation and evaluation plan.
- Conduct a survey of potential users within South Dakota to ensure all aspects of the 2021 guidelines are adequately addressed. If there are comments, they should be sent to the steering committee for consideration.
- Needed changes to the guidelines (distress types, decision matrices, and treatments) should be made as the need arises. For example, it may be necessary to make changes to the decision matrices or add new treatments and photos as required.

## 6.2 Cost-Benefit Analysis Tool for Local Agencies

*Recommendation 2: Implement and evaluate the cost benefit tool developed for local agencies.*

The 2021 pavement preservation guidelines include a new cost-benefit analysis tool developed for use by local agencies. To date, the tool has only been reviewed by the technical panel set up by SDDOT and now it needs to be distributed to local agencies for their use. The tool currently includes default costs and life extensions that may have to be adjusted to suit local conditions within the state.

It is envisioned that the implementation and evaluation process would require the following three tasks:

- Establish a steering committee—led by SDLTAP and local agencies—to help develop and oversee the implementation and evaluation plan.
- Conduct survey of potential users within South Dakota to ensure all aspects of the cost-benefit analysis tool are adequately addressed. If there are comments, they should be sent to the steering committee for consideration.
- Needed changes to the tool should be made as the need arises. For example, it may be necessary to change default costs, default life extensions or distress-treatment selection matrices as the need arises. To make these changes, editable matrices and a video on how to change the tool were provided to SDDOT with the final project deliverables.

## 6.3 Pavement Preservation Training Needs

*Recommendation 3: Provide training to state and local agencies on pavement preservation to assist with the implementation of the guides.*

Based on the findings presented in chapter 5, the research team recommends the creation of a two- to four-hour pavement preservation introductory module addressing the topic areas covered by the updated guidelines. The training would be accomplished via PowerPoint presentation, starting from the SDLTAP introductory presentation, but augmented based on the 2021 updated guidelines and the incorporation of examples illustrating the distress-treatment selection matrices and the cost-benefit analysis tool. The contents of this introductory module (like the updated guidelines) would consist of the following:

- Introduction to Pavement Preservation
  - Definitions
  - Basics
- Treatment Selection Guidelines
  - Gather Pavement Information
  - Assess and Evaluate Pavement Condition
  - Identify Recommended and Feasible Preservation Treatments (Distress-Treatment Matrices)
  - Select Most Appropriate Preservation Treatment
  - Examples
- Review of Preservation Treatments
  - Special Considerations
  - Treatments for Asphalt Pavements
  - Treatments for Concrete Pavements
  - Treatments for Gravel Roads
  - Drainage Treatments
- List of References

In addition to the introductory module, it is recommended that SDDOT create a training library of treatments. This library would contain information for each treatment under consideration by SDDOT but would not be limited to South Dakota information only. It is envisioned that development of the introductory module and the library of treatments would require the following five tasks:

- Establish a steering committee—led by the SDLTAP—to help guide the development of the proposed training material.
- Conduct a survey of potential users within South Dakota to ensure all training aspects and requirements are adequately addressed.
- Prepare a detailed curriculum outline, led by the steering committee but with the review and approval of key SDDOT staff involved in the pavement preservation process.
- Identify sources of information for creation of training library of treatments. In addition to the information available to SDDOT, a wealth of training information (webinars, presentations, articles, libraries, etc.) is available that can be tapped to create the proposed library of treatments without expending additional resources.
- Develop a curriculum following the outline prepared under Task 3. This would be accomplished by SDDOT staff assigned by the steering committee.

Development of the introductory module should rely on the work done by the SDLTAP, the information contained in the updated guidelines, and other relevant references noted earlier. The library of treatments would also make use of existing SDLTAP material, but it should be significantly augmented by information from other sources as discussed in Chapter 5 of this report.

# 7.0 RESEARCH BENEFITS

This chapter identifies the nature of the benefits realized through the completed research and implementation of research results. This section also identities an approach for assessing benefits of implementation, such as savings of time or cost, improved safety, quality improvement, etc. Based on reasonable assumptions established by the research team and the project's technical panel, the potential financial value of the benefits could be estimated for both short term and long-term benefits.

## 7.1 Nature of Benefits

As stated in the prior chapter, the products recommended for implementation include the 2021 pavement preservation guidelines, the cost benefit analysis tool, and the proposed training material to assist state and local agencies in better understanding the design and construction of pavement preservation treatments in South Dakota. The potential benefits from implementation of the pavement preservation guidelines include improved construction quality that should result in better preservation treatments, better preservation treatments that should result in fewer short-term pavement failures and improved long-term pavement performance. The potential benefits associated with the cost-benefit analysis tool include improved treatment selection that should result in improved performance and fewer failures, and use of more cost-effective treatments that should result in savings by placing the right treatment, on the right pavement, at the right time. Similarly, the potential benefits to be realized by implementing the training recommendations include improved construction quality associated with both contactors and agency inspectors better prepared to deliver quality treatments, improved training on pavement preservation resulting in improved short- and long-term performance because of more qualified personnel, and improved safety in traffic zones resulting in fewer accidents and fatalities. These benefits would apply to both State and local agencies.

## 7.2 Approach for Assessing Benefits

Figure 3 illustrates the general approach for monitoring both the short- and long-term benefits of the products developed as a part of this project. SDDOT can use this approach either statewide or at the region level. Since the materials, climate and costs for preservation treatments do vary through the state, it would be recommended the benefits be assessed by region. For local agencies, it may be necessary for each City or County to follow the general approach in Figure 3 in order to assess the benefits of this study.

It is recommended that the benefits be evaluated over the short term (less than 2 years) and over the long term (5 to 10 years or more), depending on the expected life of the various pavement preservation treatments. For agencies with pavement management systems, tracking the performance of preservation treatments over time should be a simple operation. Performance tracking may be more difficult for local agencies without pavement management systems, so long-term monitoring of the pavements using a simple pavement evaluation process would be necessary.

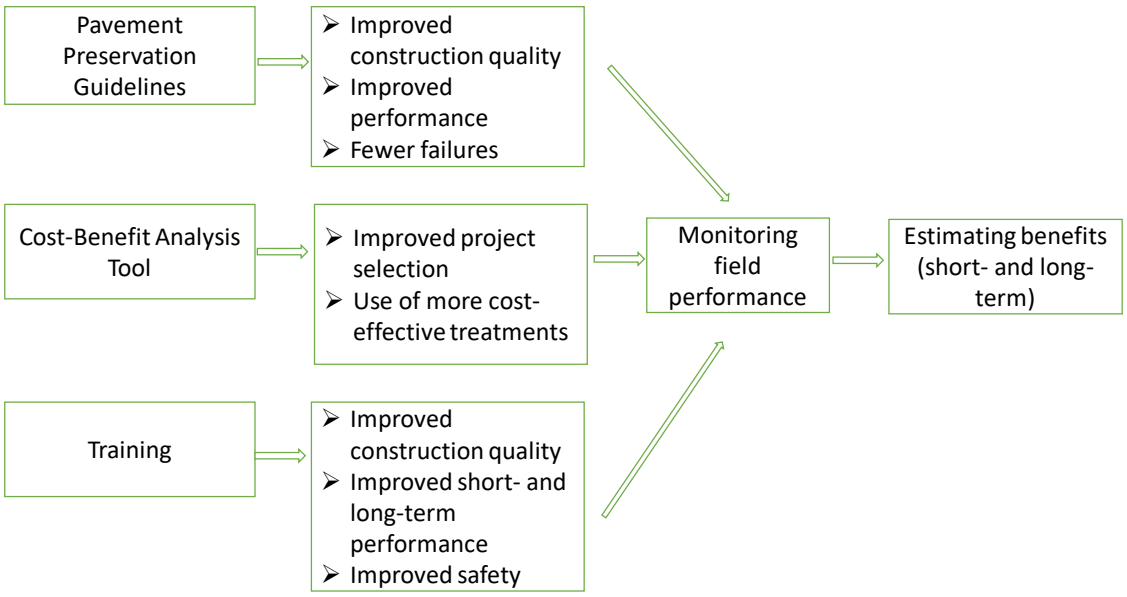


**Figure 3. Flow Chart for Assessing Benefits.**

## 7.3 Potential Financial Value of Benefits

The potential value of the benefits identified earlier could be substantial. SDDOT would have to establish a baseline against which to assess the impact of the new guidelines. For example, if the performance of the treatments increases by 10-25% because of improved quality control, this would mean treatments would be placed less frequently resulting in fewer interruptions to traffic, time savings, improved performance, and safety. Cost savings will be difficult to establish unless the proposed monitoring system is implemented.

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# APPENDIX A: LITERATURE REVIW SYNTHESIS

Pavement preservation defines a set of activities that are aimed at maintaining and improving the functional condition of an existing pavement without significantly affecting the structural capacity of the pavement (Rada et al. 2018). Pavement preservation activities typically involve the application of preventative and responsive treatments that slow deterioration or correct isolated defects and defer rehabilitation or reconstruction. The Federal Highway Administration (FHWA) defines preservation treatment as:

> …work that is planned and performed to improve or sustain the condition of the transportation facility in a state of good repair. Preservation activities generally do not add capacity or structural value but do restore the overall condition of the transportation facility (Waidelich 2016).

This literature review details findings from an evaluation of state department of transportation (DOT) pavement preservation reference documents—specifically focused on states with similar climates to South Dakota—as well as from nationally relevant research.

## State Agency Preservation Guidelines

References and guidelines from the Minnesota, Montana, Michigan, and Illinois were reviewed in detail as part of this literature review. These DOTs were selected because of similar geographic location to South Dakota and, just as importantly, because they have published reference documents. The main findings are detailed in the next sections.

### *Minnesota DOT*

The Minnesota DOT recently completed and published a pavement preservation manual that reflects similar characteristics to the current SDDOT guide. (Minnesota DOT 2019) It is important to note that many sections in the Minnesota DOT Preservation Guide match those in the SDDOT Guide verbatim, which is documented on page 1 of the guide. The following sections detail the preservation treatment types and other relevant information from the Minnesota DOT guide. Table 3 shows the treatments, cost information, and other notes about the treatments considered in the Minnesota DOT preservation guidelines.
The following are the considerations for use of each treatment:

- Crack Filling
  - Effective at reducing or delaying moisture damage, further crack deterioration, and roughness. Crack filling is typically used for non-working cracks.
- Rout and Seal Cracks
  - Effective at reducing or delaying moisture damage, further crack deterioration, and roughness.

**Table 3. Preservation Treatments in the Minnesota DOT Guide.**

| Treatment | Cost Information[a] | Other Information |
|---|---|---|
| Crack Filling | $3,400 per lane mile | Estimated Performance Period: 1 to 3 years. Recommendations for treatment are addressed in the guide along with construction and other considerations (e.g., ranges for acceptable condition, etc.). |
| Rout and Seal Cracks | $3,700 per lane mile | Estimated Performance Period: 2 to 4 years. Recommendations for treatment are addressed in the guide along with construction and other considerations. |
| Micro Surfacing[b] | $19,400 – $25,000 per lane mile | Estimated Performance Period: 5 to 7 years. Production Rate: 7–10 centerline miles per day for both scratch and surface course. Recommended if traffic is greater than 10,000 annual average daily traffic (AADT), and other condition-based metrics (e.g., acceptable when rutting measured in less than 10% of mile section is 0.5 inches or less in the left wheel path, etc.) are met. |
| Seal Coat[b] | $13,000 per lane mile | Estimated Performance Period: 5 to 7 years. Production Rate: 10–12 centerline miles per day. Recommended if traffic is less than 10,000 AADT, and other condition-based metrics are met. |
| Thin Overlay or Thin Lift Mill and Overlay[b] | Mill depth of 1.0 – 1.5" = $6,125 per lane mile 1.5" Bituminous Overlay $23,000 – $42,000 per lane mile | Estimated Performance Period: 8 to 10 years. Recommended if there are less than 30 total transverse cracks, any severity, in 500 feet; or crack spacing of more than 17 feet, and other condition-based metrics are met. |
| Ultra-Thin Bonded Wear Course[b] | $35,200 per lane mile | Estimated Performance Period: 7 to 12 years. Usually placed on top of a new mill and overlay or a micro milled surface. Occasionally it is placed directly on existing asphalt or concrete surfaces if the overall ride of the existing pavement is in good condition. Recommended to address light distresses, and can withstand high traffic volumes. |
| Micro Milling[b] | $5,280 – $10,560 per lane mile | Not in the decision tree and has no defined performance period. Micro Milling is a potential alternative to thin mill and overlay when used with a Chip Seal, Micro Surface, Thin Overlay, or Ultra-Thin Bonded Wear Course. |
| Fog Seal | $915 – $4,225 per lane mile | Estimated Performance Period: 2 to 4 years. Not currently in the decision tree for their PMS, and is intended primarily to address raveling/weathering, moisture infiltration, and low-severity cracking. |
| Mastic for Crack and Pothole Repair | $2.00 – $3.00 per pound | Estimated Performance Period: 2 to 8 years. Not currently in the decision tree for their PMS, and is intended primarily to fill voids. |

*a.* not including mobilization, traffic control, and striping
*b.* Compliance with the Americans with Disabilities Act is required

- Micro Surfacing
  - Effective at correcting or inhibiting raveling and oxidation of the pavement surface, improving surface friction, sealing the pavement surface, and filling minor surface irregularities and wheel ruts.
- Seal Coat
  - Effective at improving poor friction, inhibiting raveling, correcting minor roughness and bleeding, and sealing the pavement surface.
- Thin Overlay or Thin Lift Mill and Overlay
  - Viable option for improving ride, surface friction, surface characteristics, and improving the profile, crown, and cross slope.
- Ultra-Thin Bonded Wear Course
  - Effectively addresses minor surface distresses and increases surface friction.
- Micro Milling
  - Removes a thin layer of the existing pavement surface and restores pavement smoothness.
- Fog Seal
  - Can be applied to seal bituminous shoulders, rumble strips, parking lots, recreational trails, or chip seals.
- Mastic for Crack and Pothole Repair
  - A flowable, load-bearing material that can be used to fill voids in the road surface.

### *Minnesota DOT Special Case: Longitudinal Joints*

The Minnesota DOT guide includes a section of treatments and actions specific to longitudinal joint repair, and those treatments are described next.

#### *Crack Filling*

The Minnesota DOT implements a crack-filling program to reduce infiltration of moisture to the base and sub-grade through cracks occurring at longitudinal joints. Table 4 shows the costs for crack filling at longitudinal joints, Table 5 describes the pavement-related criteria for a good candidate, and Table 6 shows the criteria for a poor candidate for this treatment. This treatment is applicable if the severity of cracking is low and the extent of cracking is little. Placement should take place during moderate dry weather. Application during spring and fall weather enables the filler content to expand and contract while cracks are at a reasonable depth, but application should be avoided when there is moisture on the roadbed. To achieve good bonding between the sealant and the crack walls, proper crack cleaning and drying are essential. On the other hand, Rout and Seal is an alternative of Crack Filling.

**Table 4. Cost Data for Crack Filling.**

| Cost per Road Station (RDST) | Cost per Lane Mile | Cost per Lane Mile Year | Extended life |
|---|---|---|---|
| $130 | $3,400 | $1,130-$3,400 | 1 to 3 years |
| Note: Mobilization, traffic control and striping are not included. | | | |

**Table 5. Good Crack Fill Candidate.**

| Criteria | Notes |
|---|---|
| Age since last rehab >5 but ≤8 and | |
| Moderate transverse cracking ≤50% and | Less than 25 mod. severity transverse cracks in 500' (or crack spacing of more than 20 ft). |
| | No high-severity longitudinal cracking and |
| | No high-severity transverse cracking and |
| Low-severity transverse cracking >=13% and | More than 6.5 low-severity transverse cracks in 500' (or a crack spacing of less than 75 ft). |
| Total transverse cracking <40% and | Less than 20 transverse cracks, any severity, in 500' (or a crack spacing of more than 25 ft). |
| | Last maintenance activity not a crack seal and not a crack fill. |

**Table 6. Not a Good Crack Fill Candidate.**

| Criteria | Notes |
|---|---|
| Age since last rehab ≤5 or >8 or | |
| Moderate transverse cracking >50% or | More than 25 mod. severity transverse cracks in 500' (or crack spacing of more than 20 ft). |
| | Any high-severity longitudinal cracking or Any high-severity transverse cracking or |
| Low-severity transverse cracking <13% or | Less than 6.5 low-severity transverse cracks in 500' (or a crack spacing of less than 75 ft). |
| Total transverse cracking ≥40% or | More than 20 transverse cracks, any severity, in 500' (or a crack spacing of more than 25 ft). |
| | Last maintenance activity a crack seal or a crack fill. |

*Rout and Seal Crack*

This method does not provide a structural advantage, but rather decreases absorption of moisture by cracks. In addition, this treatment is only considered a candidate if the severity of cracking is minor and if little to no structural cracking is present. Placement should occur during moderate, dry weather. Application during spring and fall weather allows the sealant material to expand and contract when cracks are at moderate widths. When there is moisture on the roadbed, application should be avoided. Proper crack cleaning and drying are essential for a good bonding between the sealant and the walls of the reservoir.

*Hot Pour Crack Sealant*

If there is low severity cracking of a longitudinal joint, the best option is to use a hot pour crack sealant as detailed in Chapter 4 of the Minnesota DOT guide. Hot pour sealant may be used to treat longitudinal joint cracking of medium severity, provided the joint does not have potholes or excessive raveling. MnDOT does not specify routing and sealing for longitudinal cracks; only clean and seal (Crack Filling) is specified for longitudinal cracks. As with any crack treatment method, it is important to ensure the crack is clean and dry before sealant is applied.

*Mastic*

This would involve applying mastic to a deteriorated joint. This treatment is often utilized with longitudinal joint deterioration of medium to high severity. Until treatment, the milling out of highly spalled areas should be performed to produce the best results. This treatment produces relatively low production and requires a closure of at least one lane, and causes a need to re-stripe the lane markings as well as re-cutting of rumble strips where applicable.

*Micro Surfacing*

Micro surfacing includes in some cases using a modified micro-surfacing rut box to separate the longitudinal joint and fill any voids and cracks, thus creating a uniform appearance along the joint. This procedure can be used against longitudinal joint degradation of medium to high intensity. MnDOT usually does not mill before this treatment is applied, but if significant spalling is present, milling may yield better long-term performance. This process has a higher production rate than patching, but it involves two lane closures, as the micro-surfacing machine must straddle the joint. Because this treatment applies to the whole of the longitudinal joint, re-striping is always necessary.

*Bituminous Hand Patching*

This is a very labor-intensive type of bituminous patching in which workers shovel hot mix asphalt or cold mix patching material along the longitudinal joint into potholes. Often the mix is tamped with a shovel to compress the material into place, but better compaction can be accomplished by driving with a repair truck over the patch mix or using a steel drum roller. Often affected areas are milled before the mix is applied, but in many instances the mix is applied directly to the potholes without milling. It can be used to control rolling traffic. Typically, the final appearance is not uniform, since only isolated areas are treated. Quality varies according to methods of installation and planning, but this is typically used as a short-term fix until a more extensive procedure can be implemented.

*Blow Patching*

The next bituminous patching method involves the use of a blow-patch vehicle. This is a specialized piece of equipment that combines emulsion and fine aggregate into a slurry, and blows the resulting mixture through cracks, potholes, and other vacuums without the need for a workers team. All patching is performed using controls inside the blow patch vehicle. The

operator will take care in applying the appropriate aggregate and emulsion combination. Too rich a mixture may lead to patches of bleeding which may need to be re-patched. Blow patching is typically slower than hand patching, but is often safer, as traffic is not exposed to laborers. Traffic control is required during patch installation to protect the vehicle and the operator from the blow patch.

*Milling and Patching*

Usually the longitudinal milling and patching are the most robust type of bituminous patching. This includes milling into the longitudinal joint several inches, spreading hot mix asphalt into the milled area, and compacting with a steel drum roller. This type of patching gives a homogeneous appearance and restores a badly deteriorated joint structure. It should be noted that, with low production, this method requires two lanes to be closed and is labor intensive. This treatment requires the affected lane markings to be re-stripped. They will also need to be re-cut if rumble strips are needed.

### *Treatment Selection Matrix*

Preservation treatments are assessed based on the combination of a pavement's current condition with the forms of distress present. In some cases, it is necessary to combine preservation strategies to correct the combination of distress present on the pavement. The selection process for combining preservative treatments (like in the SDDOT 2010 guidelines) includes the following general steps:

- Gather pavement information.
- Assess pavement condition.
- Evaluate pavement data.
- Identify feasible preservation treatments.
- Select preservation treatment.

Currently, pavement management has decision trees that are integrated into their pavement management system (PMS) software to help choose pavement preservation strategies to maintain pavement condition. Selecting preservation strategies involves collecting pavement information such as pavement construction history, pavement performance data, pavement design life, condition data, traffic data, and information about the pavement's structural design. Some of this information is included in the PMS software, which is a good tool to collect preliminary information about sections of the project. The type of pavement dictates the treatment choice, since different techniques are best for different types of surfaces. Besides the type of pavement, the pavement's age and design life can provide insight into how the pavement has performed over time, and how it can be expected to perform in the future. If the pavement is near the end of its design life, preservation may be an indication that it will be less cost-effective. Data regarding traffic density, specifically the number of heavy trucks, is a critical detail in deciding which treatments to use.

To determine if a pavement section is a good candidate for pavement preservation treatments, the Minnesota DOT (like the South Dakota DOT), considers the following:

- Are there excessive distresses (large quantities and/or severe levels of distress) on the pavement section or are the distresses a warning sign of an underlying structural problem?
- Has the time for applying a pavement preservation treatment while it is in "good" condition passed?
- Are there other known problems (e.g., material problems, utility issues, drainage issues, or signs of construction problems)?
- Is there a history of pavement problems in this location?

If the answer to most of these questions is "no," then the portion of pavement would likely be a good candidate for pavement preservation techniques. If the answer is "yes" to most of those questions, preservation techniques should not be considered. Instead, more research is needed to identify other options for rehabilitation.

### *Identifying Feasible Preservation Treatments*

The treatment strategy identified as candidates for pavement preservation for those pavement sections can be determined by looking at the type and severity of pavement distress present on the pavement. The Minnesota DOT provides guidelines for determining recommended and feasible treatments. Treatment selection advice is based on factors such as levels of distress, nature of the ride surface noise, traffic levels, and relative costs. Treatment feasibility is based primarily on a relationship between a single treatment and one particular distress. When there are multiple distresses, the treatment to address each type of distress should be examined, and the recommended treatments should be used in combination with engineering judgement to make final decisions on treatment. It should be noted that regional pricing, the availability of qualified contractors, and material availability could also play a role in treatment selection.

### *Cost and Benefit Analysis*

Of the preservation treatments that are feasible, the best treatment is one that can provide the highest cost to benefit ratio while achieving the project's objectives. There are several approaches to determine the treatment for the associated cost with the most benefit. For many pavement management systems, this analysis is done internally. Ideally, optimization (maximizing benefits for given constraints) governs the selection of the right treatment at the correct time. However, treatment selection can be accomplished by a manual evaluation of the benefits versus the projected cost of the treatment. In addition to the benefits and costs of the feasible treatments, preservation treatment selection also includes consideration of the variety of project constraints affecting the selection of treatments. Similar to the SDDOT approach, project constraints to be considered when choosing preservative treatments include:

- Availability of qualified contractors,
- Availability of quality materials,
- Agency practice or local preference,
- Time (of year) of construction,
- Initial costs,
- User preferences,
- Pavement noise,

- Facility downtime, and
- Surface friction.

The results of these restraints can differ from project to project and should be considered when choosing the final treatments for inclusion in a pavement preservation program.

***Montana DOT***

The Montana DOT published an asset management plan in 2018 that provides details regarding strategic goals and business practices, including pavement preservation. (Montana DOT 2018) The Montana DOT has a strategic goal to preserve highway pavement conditions at existing or higher levels and describes how preservation treatments contribute to that goal. The Montana DOT uses decision trees, age, condition indexes, and district input to determine what type of preservation work, if any, will be performed on a route. Ride quality determines the need for overlays, which are triggered by International Roughness Index (IRI) values greater than 112 in/mi. Rutting at 0.3 inches or higher triggers mill and fill, overlay, or micro surfacing, and cracking indices in the mid-fair to mid-good range triggers crack sealing if pavement age is less than 6 years or chip seals if pavement age is between 6 and 12 years.

The Montana DOT asset management plan notes that crack sealing and chip seals, which are two preventive maintenance activities, are applied at specific intervals or as needed. Crack sealing is generally applied between three and six years from when a project is completed. Chip seals are applied to pavements immediately following a pavement resurfacing project, and then applied between six and twelve years after the first chip seal. The Montana DOT also notes that it implemented an aggressive preventive maintenance program following an analysis of various strategies and evaluating the lowest lifecycle cost strategies. The following treatment types are considered:

- Crack Seal/joint seal
- Fog Seal
- Seal and Cover
- Sand Seal
- Scrub Seal
- Concrete panel repair/replacement
- Dowel bar retrofit
- Diamond grinding
- Cape seal
- Mill/fill
- Hot in-place recycling (HIR)
- Cold in-place recycling (CIR)
- White topping

The Montana DOT (MDT) asset management plan includes cost-effectiveness based on the annual cost for each treatment and extended life of the pavement within that treatment, as shown in Table 7. MDT engineers use the series of decision trees recommended by their PMS to optimize the pavement lifecycle cost. For cost analysis, they look at multiple alternatives and the

estimated costs of future treatments over a design life of 40 years or more. The reason behind this process is to decide the efficient design alternative that leads to the lowest lifecycle cost.

**Table 7. Pavement Treatment Cost Effectiveness.**

| Scope | Treatment | Cost per lane mile | Years gained per lane mile | Annual cost per lane mile |
|---|---|---|---|---|
| Light Preservation | Crack Seal | $4,600 | 3 | $1,500 |
| Light Preservation | Chip Seal | $21,000 | 7 | $3,000 |
| Resurfacing | Micro surfacing | $56,300 | 7 | $8,000 |
| Resurfacing | Overlay | $116,700 | 12 | $9,700 |
| Resurfacing | Minor Rehabilitation | $140,300 | 12 | $11,700 |
| Structural/ Capacity/ Geometric | Major Rehabilitation | $291,600 | 15 | $19,400 |
| Structural/ Capacity/ Geometric | Reconstruction | $631,800 | 20 | $31,600 |

### *Michigan DOT*

The Michigan DOT published information for their Capital Preventive Maintenance program in 2010. (Michigan DOT 2010) The following sections provide information related to the pavement preservation treatments used in Michigan. The guidance for placing specific preservation treatments is based on the minimum estimated remaining service life (RSL), distress index (DI), ride quality index (RQI), IRI, and rutting.

#### *Non-Structural HMA Overlay*

This treatment can be applied when the pavement only has some minor base failure and depressions. The moderate raveling, longitudinal and transverse crack, and block cracking (smaller scale) may be considered in visible surface distress, but should not be extensive. A non-structural HMA overlay should not be placed on the following existing pavement conditions: severely distressed composite pavement, severely raveling or rutted bituminous pavement, pavement with a weak base, or a bituminous surface that is debonding. In addition, a pavement with excessive amounts of crack sealing may not be a good candidate for a non-structural HMA overlay. Table 8 shows the condition thresholds for a non-structural HMA overlay.

**Table 8. Required Condition for Non-Structural HMA Overlay.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|
| Flexible | 3 | <40 | <70 | <163 | <1/2” | 5 to 10 |
| Composite | 3 | <25 | <70 | <163 | <1/2” | 4 to 9 |

#### *Surface Milling with Non-Structural HMA Overlay*

For surface milling treatment, the distress of the pavement may include surface raveling, multiple longitudinal and transverse cracking (including minor raveling), block cracking (minor), and minor to reasonable rutting. If a weak base is not a reason for rutting and if more economical

treatments are not practical to solve the rutting problem, then cold milling operation helps to fix rutting in the existing bituminous surface layer. The specific condition thresholds are shown in Table 9.

**Table 9. Required Pavement for Surface Milling with Non-Structural HMA Overlay.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|
| Flexible | 3 | <40 | <80 | <212 | <1” | 5 to 10 |
| Composite | 3 | <30 | <80 | <212 | <1” | 4 to 9 |

*Chip Seals*

For single chip seals, the over band crack fill treatment can be used for all visible cracks and construction joints. If the cracks and construction joints are more than 12 inches in length and greater than ¼ of an inch in width, they should be filled by double chip seals. Table 10 shows the condition thresholds for a chip seal.

**Table 10. Required Condition for Chip seals.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|
| Flexible | 5 (double)<br>6 (single) | <30 (double)<br><25 (single) | <54 | <107 | <1/8” | 3 to 6<br>4 to 7 |
| Composite | 5 (double) | <15 | <54 | <107 | <1/8” | 3 to 6 |

*Cape Seal (Micro Surface/Chip Seal Combinations)*

A combination of chip seal followed by micro surfacing is called a Cape seal. It is recommended when the distress level, cracking, and raveling are higher than those for a chip seal. Before chip sealing, micro surfacing can be used to fill ruts.

*Micro Surfacing*

Micro surfacing treatments can be recommended when pavement surface has minor cracking, rutting, irregularities, and moderate raveling. If a pavement has moderate to major surface cracks, then micro surfacing cannot be used because of its poor crack sealing and brittle nature. Micro surfacing is chemically triggered, very specific to aggregate treatment, and has a quick reaction behavior. To cure micro surfacing mixes, warm weather is required. Table 11 shows the condition thresholds for a Micro Surfacing treatment.

**Table 11. Required Condition for Micro Surfacing.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|
| Flexible | 5 (multiple or heavy single)<br>10 (regular single) | <30 (multiple or heavy single)<br><15 (regular single) | <54 | <107 | <1” | 3 to 5<br>4 to 6 |
| Composite | 5 (double) | <15 | <54 | <107 | <1” | - |

*Crack Treatment*

If the longitudinal and transverse cracking are fairly open with slight secondary cracking and raveling at the crack face, and no patching or few patches in excellent condition, then crack treatment should be applied. There should be some attention given to the result of the crack treatment if it is observed that the previous treatment was a surface seal (i.e., micro- or chip seal). It is possible that the treatment is excessive if it is required to protect the underlying pavement, because there was probably an over-banding operation performed before applying the surface seal.

Usually all the perpendicular cracks in the lanes traveled should be sealed by the cut and seal method. On the other hand, all the other cracks in the shoulder areas and traveled lanes can be filled by the over band crack fill method. Individual seals should not be used in transverse cracks that have excessive cracking around the main crack. A more thorough pavement surface treatment could be needed if there is a presence of this type of transverse crack. However, it is important to note that this operation requires maintenance, and is not a one-time operation. To maintain the sealed pavement surface, there should be a routine maintenance crack sealing or crack filling operation if and when additional cracks develop. Table 12 shows the condition thresholds for considering this treatment.

**Table 12. Required Condition for Crack Treatment.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|
| Flexible | 10 | <15 | <54 | <107 | <1/8” | Up to 3 |
| Composite | 10 | <5 | <54 | <107 | <1/8” | Up to 3 |

*Over-Band Crack Filling*

All non-working cracks should be filled with over band crack filling treatment, and Table 13 shows the condition thresholds for this treatment.

**Table 13. Required Condition for Over-Band Crack Filling.**

| Pavement | Minimum RSL (Years) | D.I. | | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|---|
| Flexible | 7 | <20 | | <54 | <107 | <1/8” | Up to 2 |
| Composite | 7 | <20 | | <54 | <107 | <1/8” | Up to 2 |

*Ultra-Thin Overlay*

This treatment can be applied when raveling and surface irregularities are minor and cross sections are free of ruts and distortions. If the pavement exhibits light distress and is free of ruts and distortions, then Ultra-Thin HMA overlay treatment could be applied. It should not be applied on a milled surface. Table 14 shows the condition thresholds for considering this treatment.

**Table 14. Required Condition for Ultra-Thin HMA Overlay.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Rut | Gained Years |
|---|---|---|---|---|---|---|
| Flexible | 7 | <30 | <54 | <107 | <1/8” | 3 to 6** |
| Composite | 7 | <20 | <54 | <107 | <1/8” | 3 to 6** |
| | | | | | | ** This is an estimation; statistical data were not used to develop these. |

*Full Depth Concrete Pavement Repair*

If the deterioration rate of the pavement is slow and if the cracks and transverse joints have at least 3 feet of moderate to severe spalling over their length, then a full depth concrete pavement treatment should be applied. In addition, if the crack width is beyond 1/4” or faulting in excess of 1/8” that exhibited by other transverse cracking, then full depth repair is appropriate. Table 15 shows the condition thresholds for this treatment.

It should be noted that the tire noise changes are usually caused by a change of surface texture from the repair pavement to the existing one. When an accelerator for calcium chloride is used to increase its strength faster, the expected repair lifespan will then be reduced by about 50 percent. The repair’s lifespan would usually be decreased if the strength gain by using grade P1 concrete is accelerated at normal rates.

**Table 15. Required Condition for Full Depth Concrete Pavement.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Gained Years |
|---|---|---|---|---|---|
| Rigid | 7 | <20 | <54 | <107 | 3 to 10 |

*The full depth concrete pavement repair is limited to 30 patches per lane mile.
**Higher R.Q.I. /I.R.I. numbers should consider Concrete Pavement Restoration.

*Concrete Joint Resealing*

If the existing sealant of the pavement has failed, then concrete joint resealing is appropriate treatment. Table 16 shows the condition thresholds for this treatment.

**Table 16. Required Condition for Concrete Joint Resealing.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Gained Years |
|---|---|---|---|---|---|
| Rigid | 10 | <15 | <54 | <107 | 3 to 5 |

*Concrete Crack Sealing*

Concrete pavements with low rates of cracking growth should be prioritized as candidates for crack sealing. This treatment should be applied every five years or until extensive work beyond

the Capital Preventive Maintenance Program is required to comply with the pavement condition. Table 17 shows the condition thresholds for this treatment.

**Table 17. Required Condition for Concrete Crack Sealing.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Gained Years |
|---|---|---|---|---|---|
| Rigid | 10 | <15 | <54 | <107 | Up to 3 |

*Diamond Grinding*

This is a good candidate for the case of a pavement with a good base, containing joint and crack failures no greater than 1/4 inch, a rut depth less than 1/4 inch, moderate to severe polishing, or no more than 25 percent scaling of the surface area with visible surface distress. Diamond grinding of concrete pavements will usually not be used where the fault is wider than 1/4 inch. The unit cost of grinding diamonds will be increased by greater fault depths. As already stated, diamond grinding should not be used as a one-step remedy for the treatment of the concrete pavement deficiencies. Table 18 shows the condition thresholds for this treatment.

**Table 18. Required Condition for Diamond Grinding.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Gained Years |
|---|---|---|---|---|---|
| Rigid | 12 | <10 | <54 | <107 | 3 to 5 |

*Dowel Bar Retrofit*

This procedure will be undertaken to maintain original joints in good condition. Very little or no split in the joint or crack should be there. Crack widths should be under 1/4 inch and failure below 1/8 inch. If there is a significant fault with the current cracks and joints in the concrete pavement, this should not be used as stand-alone remedy. Table 19 shows the condition thresholds for this treatment.

**Table 19. Required Condition for Dowel Bar Retrofit.**

| Pavement | Minimum RSL (Years) | D.I. | R.Q.I. | IRI | Gained Years |
|---|---|---|---|---|---|
| Rigid | 10 | <15 | <54 | <107 | 2 to 3 |

*Open-Graded Underdrain Outlet Cleaning and Repair*

Cleaning and repairing of open-graded undrain outlets should start on a rigid pavement which is about ten years old. Subsequent preventive maintenance projects should be cleaned and repaired every ten years or until the pavement condition requires extensive work beyond the Capital Preventive Maintenance Program.

Since this work will be done by contract, defining the work to be done in the contract and providing a relatively accurate quantity of the plan is necessary. Requiring the contractor to explore the open-graded underdrain outlets shall not be included in the Projects for Preventive

Maintenance, as such work cannot be accurately identified and quantified. The repair work for the underwater outlet will be limited to work perpendicular to the roadway.

The Michigan DOT also published updated guidance on pavement selection that includes detailed descriptions of including pavement preservation in lifecycle cost models. (Michigan DOT 2019) This guidance provides detailed information based on measured field data and average costs. Table 20 through Table 23 show the detailed lifecycle cost plans for different pavement types.

**Table 20. Pavement Preservation Strategy for HMA Pavement (New Construction).**

**Fix Type: New/Reconstruction HMA Pavement**

| Activity | Approx. Age | Distress Index (before) | Distress Index (after) | RSL (yrs.) (before fix) | Extended Life (yrs.) | RSL (yrs.) (After fix) | Cost per Lane-mile | Time to fix 1 mile (Days) |
|---|---|---|---|---|---|---|---|---|
| Initial Construction | 0 | | 0 | | | 14 | Computed | |
| Preservation | 8 | 12 | 3 | 6 | 5 | 11 | $27,085 | 0.48 |
| Preservation | 12 | 9 | 4 | 7 | 3 | 10 | $38,975 | 0.62 |
| Preservation | 16 | 12 | 1 | 6 | 6 | 12 | $49,374 | 0.90 |
| Preservation | 20 | 7 | 1 | 8 | 5 | 13 | $29,000 | 0.65 |
| Rehabilitation or Reconstruction | 33 | | | | | | | |

**Table 21. Pavement Preservation Strategy for Concrete Pavement (New Construction).**

| Activity | Approx. Age | Distress Index (before) | Distress Index (after) | RSL (yrs.) (before fix) | Extended Life (yrs.) | RSL (yrs.) (After fix) | Cost per Lane-mile | Time to fix 1 mile (Days) |
|---|---|---|---|---|---|---|---|---|
| Initial Construction | 0 | | 0 | | | 26 | Computed | |
| Preservation | 12 | 8 | 4 | 14 | 3 | 17 | $38,455 | 1.34 |
| Preservation | 16 | 9 | 5 | 13 | 3 | 16 | $41,056 | 1.48 |
| Preservation | 21 | 14 | 9 | 11 | 2 | 13 | $66,723 | 1.76 |
| Rehabilitation or Reconstruction | 34 | | | | | | | |

**Table 22. Pavement Preservation Strategy for Concrete Pavement (Rehabilitation).**

| Activity | Approx. Age | Distress Index (before) | Distress Index (after) | RSL (yrs.) (before fix) | Extended Life (yrs.) | RSL (yrs.) (After fix) | Cost per Lane-mile | Time to fix 1 mile (Days) |
|---|---|---|---|---|---|---|---|---|
| Initial Construction | 0 | | 0 | | | 21 | Computed | |
| Preservation | 10 | 2 | 1 | 11 | 2 | 13 | $22,789 | 1.05 |
| Preservation | 13 | 3 | 2 | 10 | 2 | 12 | $37,776 | 1.33 |
| Rehabilitation or Reconstruction | 25 | | | | | | | |

**Table 23. Pavement Preservation Strategy for HMA Pavement (Rehabilitation).**

| Activity | Approx. Age | Distress Index (before) | Distress Index (after) | RSL (yrs.) (before fix) | Extended Life (yrs.) | RSL (yrs.) (After fix) | Cost per Lane-mile | Time to fix 1 mile (Days) |
|---|---|---|---|---|---|---|---|---|
| Initial Construction | 0 | | 0 | | | 14 | Computed | |
| Preservation | 7 | 9 | 3 | 7 | 3 | 10 | $20,266 | 0.38 |
| Preservation | 10 | 9 | 3 | 7 | 3 | 10 | $48,354 | 0.65 |
| Preservation | 13 | 9 | 3 | 7 | 3 | 10 | $29,304 | 0.53 |
| Preservation | 16 | 9 | 3 | 7 | 3 | 10 | $47,789 | 0.71 |
| Rehabilitation or Reconstruction | 26 | | | | | | | |

### *Illinois DOT Bureau of Local Roads and Streets*

Another valuable reference is the Bureau of Local Roads and Streets Manual published by the Illinois DOT. (Illinois DOT Bureau of Local Roads 2012) The document outlines the basics of a good pavement preservation program, and links it directly to pavement management practices and PMS implementation. The list of treatments detailed in this manual is extensive, and includes the following:

**Flexible Pavements**
Crack Filling
Crack Sealing
Fog Seals
Sand Seals
Scrub Seals
Rejuvenators
Slurry Seals
Micro Surfacing
Chip Seals
Cape Seals
Cold In-place Recycling (CIR)
Hot In-Place Recycling (HIR)
Thin Asphalt Concrete Overlay

**Rigid Pavement**
Crack Sealing
Joint Resealing
Diamond Grinding
Diamond Grooving
Full-Depth Repairs
Partial-Depth Repairs
Load Transfer Restoration (LTR)
Cross Stitching
Pavement Subsealing/Undersealing

Ultra-Thin Bonded Wearing Course
Ultra-Thin Whitetopping (UTW)
Cold Milling

The manual details a five-step process (similar to the SDDOT approach) for selecting the right preservation treatment:

1. Gather pavement information.
   - This step includes gathering data other than pavement condition that is important to the analysis. For example, traffic, pavement age and design life, pavement type, cross-section, and materials are critical for making the proper pavement preservation decision.
2. Assess pavement condition.
   - The manual recommends collecting information about the severity types and extents, which can then be used directly with the treatment selection matrix.
3. Evaluate pavement data.
   - The guide recommends answering the following questions, noting that the answer to each should be "no" for considering preservation:
     - Is there excessive distress (large quantities and/or severe levels of distress) on the pavement section?
     - Is there evidence of structural problems?
     - Has the time for applying a pavement preservation treatment to the pavement (while it is in good condition) passed?
     - Are there other known pavement problems (e.g., material problems or signs of construction problems) on the pavement section?
     - Is there a history of pavement problems in this location?
4. Identify feasible preservation treatments.
   - The manual provides a comprehensive set of treatment selection matrices, which are not reproduced here given their size. The selection guidelines include distress information in the same format as the South Dakota manual, but also include traffic levels and friction considerations.
5. Select most appropriate preservation treatment.
   - The previous step will frequently result in more than one feasible treatment, so the manual recommends selecting the most appropriate treatment based on the following considerations:
     - Availability of qualified contractors.
     - Availability of quality materials.
     - Agency practice or local preference.
     - Time (of year) of construction to account for climactic considerations for specific treatments.
     - Initial costs.
     - User preferences.
     - Pavement noise.
     - Facility downtime.
     - Surface friction.

The manual also includes detailed information about each treatment in the same format as the Minnesota DOT guide detailed previously in this literature review. However, instead of estimate costs in absolute dollars, the cost information is presented relative to each treatment. Additionally, it lists a set of broad considerations for preservation, including:

- Raised Pavement Markers – which may need to be removed and may also necessitate a pavement repair to address the surface after marker removal.
- Pavement Preparation – all bumps greater than 0.5 inches should be ground (unless the preservation treatment includes grinding). Also, the surface should be cleaned and, if crack sealing is necessary, it should be performed at least three months prior to preservation treatment application.
- Pavement Markings – a minimum of seven days of dry weather should occur after preservation treatment placement before pavement markings are placed.
- Traffic Control – this is necessary on all treatments, and the contractors should be aware to not open the pavement to traffic before the material is ready for traffic.
- Treatment Sequencing – this is a consideration for rigid pavements. An appropriate example of a sequence is: full- or partial-depth repairs, load transfer restoration, diamond grinding, and joint resealing.

**Broader Literature Review**

FHWA has recently published a series of preservation checklists, each of which are available within their pavement preservation website[1]. The checklists include extensive information related to construction requirements, traffic control, quality assurance, and many other topics. The checklists do not detail treatment selection considerations, but provide information assuming the treatment is appropriate for the pavement. The following treatments are identified (with their FHWA report designation in parentheses):

- Crack Treatment (FHWA-HIF-19-028)
- Chip Seal (FHWA-HIF-19-029)
- Thin Hot Mix Asphalt Overlay (FHWA-HIF-19-030)
- Fog Seal (FHWA-HIF-19-032)
- Micro Surfacing Application (FHWA-HIF-19-031)
- Hot In-Place Asphalt Recycling Application (FHWA-HIF-19-034)
- Cold In-Place Asphalt Recycling Application (FHWA-HIF-19-035)
- Slurry Seal Application (FHWA-HIF-19-036)
- Fabric Interlayer Application (FHWA-HIF-19-037)
- Full Depth Reclamation Construction (FHWA-HIF-19-038)
- Asphalt Emulsion Based Tack Coat (FHWA-HIF-19-039)
- Scrub Seal (FHWA-HIF-19-040)
- HMA Asphalt Patching (FHWA-HIF-19-041)
- High Friction Surface Treatments (FHWA-HIF-19-042)

[1] https://www.fhwa.dot.gov/pavement/preservation/ppcl00.cfm

- Cape Seals (FHWA-HIF-19-043)
- Ultrathin Bonded Wearing Course (FHWA-HIF-19-044)
- Joint and Crack Sealing (FHWA-HIF-19-045)
- Diamond Grinding (FHWA-HIF-19-046)
- Dowel Bar Retrofit (FHWA-HIF-19-047)
- Partial Depth Repair (FHWA-HIF-19-048)
- Full Depth Repair of Portland Cement Concrete Pavements (FHWA-HIF-19-049)
- Cross-Stitching for Portland Cement Concrete Pavements (FHWA-HIF-19-050)
- Longitudinal Diamond Grooving of Portland Cement Concrete Pavements (FHWA-HIF-19-051)

FHWA also recently published a document outlining strategies for pavement preservation in 2019. (Van Dam 2019) The guide covers many concepts specific to concrete pavement preservation, including proposing a definition of preservation specific to concrete pavements as "A strategy of extending concrete pavement service life for as long as possible by arresting, greatly diminishing, or avoiding pavement deterioration processes." (pg. 2) The authors note that the preservation strategy can be achieved in any of the following ways:

- Designing and constructing a durable long-lasting pavement that is relatively distress-free throughout its life.
- Using overlays (asphalt or concrete) to maintain the structural adequacy and serviceability of the pavement.
- Maintaining serviceability through pavement restoration treatments.

The report then provides details about each of the three methods for pavement preservation, including information about the condition rating, treatment selection, and special considerations. Finally, the report details lifecycle cost and lifecycle management techniques that can be used to evaluate the efficacy of the preservation treatments.

Buss et al. (2019) evaluated pavement preservation treatment effectiveness using data from the Iowa DOT. The analysis was performed for both asphalt treatments (micro surfacing, slurry seal, patching, and crack sealing) and concrete treatments (dowel bar retrofitting/diamond grinding, grinding and grooving, crack sealing/joint filling, and patching). Data were gathered from many preservation projects around the state of Iowa, and the data were evaluated to estimate a life extension based on four condition index values (pavement condition index, cracking index, ride quality index, and rutting index). The report also included an evaluation of which treatments are expected to affect certain distresses, though many of the conclusions are drawn from very small sample sizes and anecdotal information.

Jones (2019) published a paper detailing pavement preservation practices applied to unpaved roads. The paper evaluated chemical treatments to decrease the long-term degradation in ride quality, increase the blading interval, decrease gravel loss, and decrease the amount of dust generated by a vehicle driving on the road. The paper also included cost-benefit analyses of the treatments and other information valuable to this effort. This paper makes reference to an FHWA report on the topic of unpaved road preservation, which can provide valuable information to the SDDOT preservation guide update. (Jones et al. 2013, FHWA 2015)

Bryce et al. (2018) conducted an analysis of the effects of flexible pavement preservation treatments on many distresses using data from the Long-Term Pavement Performance (LTPP) database and 10 state DOTs. Models were developed to evaluate both the immediate change in condition and the long-term change in performance for specific pavement condition measures resulting from the application of preservation treatments. It is expected that the results presented in Bryce et al. (2018) will be valuable for informing the cost-benefit analyses, as well as the treatment selection matrix.

Rada et al. (2018) synthesized findings from a literature review and analysis of State DOT and LTPP data, and found the following effects of preservation treatments:

- Thin AC overlays (specific to AC pavements):
  - An immediate change in IRI, rutting and cracking is exhibited.
  - A change in performance was demonstrated for IRI, rutting, and at least one cracking type in at least one source of data. Not all data sources or literature demonstrated a change in performance for IRI and cracking.
- Chip seals (AC pavements):
  - No immediate change in IRI or rutting is expected, but an immediate change in cracking is exhibited.
  - A change in performance for IRI and at least one cracking type was exhibited in at least one source of data.
- Micro surfacing (AC pavements):
  - No change in IRI is expected, but a change in cracking is exhibited. Adequate data for evaluating rutting was not available.
  - Adequate data were not available for assessing the changes in performance following micro surfacing for the performance measures.
- Diamond grinding with and without dowel bar retrofit (portland cement concrete [PCC] pavements):
  - An immediate change in IRI and faulting is expected, and no immediate change in cracking is expected.
  - Adequate data were not available for assessing the changes in performance following diamond grinding with and without dowel bar retrofit for the performance measures.

Izeppi et al. (2015) developed a district-level preservation treatment selection tool using data in the State of Virginia for flexible pavements. The treatments considered included chip seal, slurry seal, micro surfacing, and thin overlays. Although the work presented in Izeppi et al. (2015) is focused on selecting the best treatment, and not necessarily the timing, the methods used to select the treatment are applicable to preservation timing. In this case, performance was defined as the area beneath the predicted condition curve as a function of time and only treatment costs were considered. Cost-effectiveness for treatments was defined using the cost-benefit ratio, where the benefit is defined as the improvement in performance resulting from the application of preservation. In addition, Izeppi et al. (2015) developed a tool for engineers to use when selecting specific treatments, and the tool uses marginal cost-effectiveness to prioritize the treatments. The approach to treatment selection developed by Izeppi et al. (2015) is shown in Figure 4, and it is expected that this approach can inform the cost-benefit analysis.

Mahoney et al. (2014) assessed chip seals for the Washington Department of Transportation (DOT) in an effort to develop a set of best practices, including developing a set of recommendations for timing based on the year that chip sealing results in the maximum service life extension. The recommendations for timing in Mahoney et al. (2014) are based on a review of available literature, interviews with 35 State DOTs, and meetings with stakeholders in the State of Washington. The results developed by Mahoney et al. (2014) recommended applying a chip seal between overlays (though specific timing is not recommended) for pavements with traffic levels less than 20,000 vehicles per day.

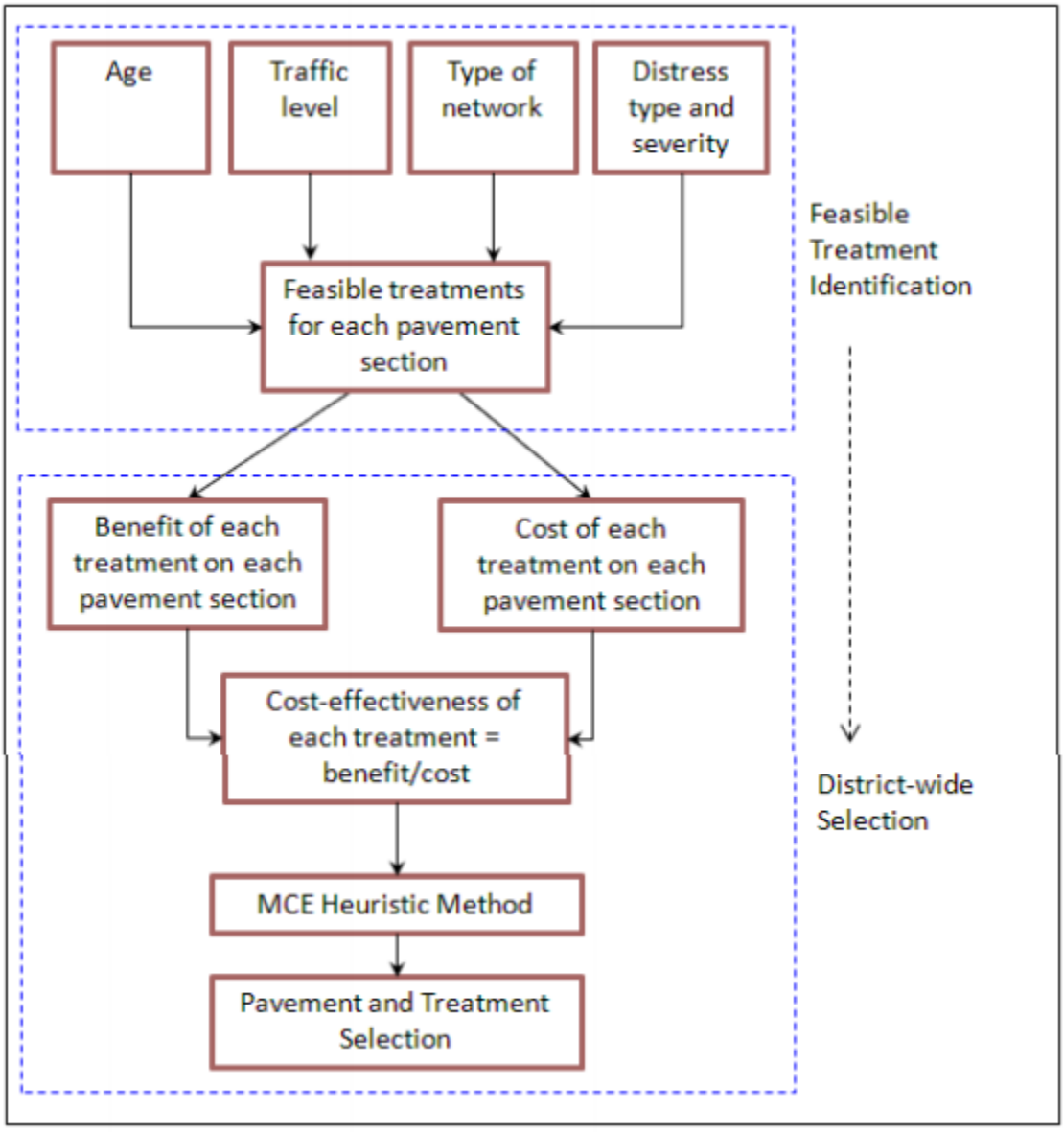


**Figure 4. Overview of Preservation Treatment Selection Process. (Izeppi et al. 2015)**

Anderson et al. (2012) evaluated the timing of preservation for addressing environmental aging for flexible pavements in the State of Minnesota. The approach used by Anderson et al. (2012) was to conduct rheological tests on pavements that received a chip seal to evaluate changes in the

asphalt properties of the original pavement over time. It was hypothesized that the application of the chip seal would slow the rate of oxidation of the underlying pavement. The results were based on the evaluation of a pavement test section specifically designed for the research that was divided into several segments, one of which was a control (no preservation), and the rest of which received a chip seal at different time intervals. The results of the research indicated no discernable trends that relate the timing of the placement of the preservation to changes in the rheological properties of the asphalt. Furthermore, the researchers noted that waiting more than two years after initial construction of the pavement to place a chip seal may result in the asphalt having the same rheological properties as if no chip seal is placed.

Zhi et al. (2012) assessed the proper timing for applying slurry seals based on pavement condition data collected in China. The condition indicators used in the study were crack ratio, rut depth, IRI, and sideway force coefficient (friction). For each indicator, performance curves were developed for do-nothing and post-slurry seal application scenarios. The post-slurry seal application performance curve was found to be dependent on the existing pavement condition at the time of treatment. Hajj et al. (2012) used pavement condition data collected by three local agencies in the State of Nevada to develop performance prediction models for the do-nothing condition and for two sequential applications of slurry seals at different times. The study evaluated both new pavement construction and overlay sections. Cost-benefit ratios were used to assess the timing for two sequential slurry seal applications, where the benefit was defined as the area under the curve for the treatment condition up to a terminal condition, similar to the definition of performance in Zhi et al. (2012). Instead of timing in terms of years, Hajj et al. (2012) recommended the application of slurry seals at specific condition rating values.

Dosa (2012) assessed the effectiveness of chip seals in four climatic zones in the United States, using life extension and relative benefit as indicators. Life extension was defined as the time difference between the untreated deterioration model and the treatment deterioration model to reach a threshold or target condition value. The relative benefit was defined the same way as in Zhi et al. (2012). Benefit-cost ratios were calculated for all initial pavement conditions in all climatic regions (dry freeze, dry non-freeze, wet freeze, and wet non-freeze). Costs included only agency costs and were expressed as dollars per lane-mile. It was found that the measures of effectiveness were higher for sections whose initial condition was smooth at the time of the treatment. No significant variations in benefit were observed among climatic conditions.

The Pennsylvania DOT developed guidelines regarding the condition of the pavement when a specific preservation treatment should be applied. To develop the guidelines, Morian (2011) developed pavement performance curves for three specific treatments (seal coat, micro surfacing, and a thin bonded wearing course) based on the Pennsylvania DOT's overall pavement index (OPI). The condition data for each treatment were further subdivided into four categories based on traffic levels and functional class:

- Average Annual Daily Traffic (AADT) less than 2000
- AADT greater than 2000
- National Highway System (NHS)
- Interstate Highways

The approach taken by Morian (2011) was to first calculate a life extension associated with the three preservation treatments, and then to conduct an analysis to assess when the benefit to cost

ratio was maximized. The pavement life extension was defined as the number of additional years given to reach the terminal serviceability value as a result of the treatment. Terminal serviceability indices were defined for each of the traffic categories, and can be interpreted as the pavement condition level at which the treatment is considered to be failed or extensive repair or replacement is required.

A relationship between pavement life extension and pavement condition level at the time of treatment was developed for all treatments within each traffic category at the good/fair OPI values and at the terminal OPI. It was found that the pavement life extension for a specific treatment can be computed for any condition level using a second-order polynomial function. To determine the most cost-effective OPI scenario, an LCC analysis (LCCA) was conducted considering different initial pavement conditions.

Haider and Dwaikat (2011) used data from Long-term Pavement Performance (LTPP) Specific Pavement Studies Experiment 3 (SPS-3) to develop mathematical models to estimate the optimum timing based on different treatment effectiveness evaluation criteria. Pavement performance was measured in terms of roughness (IRI); however, the authors note that the same approach can be used for other distress types. (Haider and Dwaikat 2011)

## APPENDIX B: REVIEW OF EXISTING SDDOT GUIDELINES

The objective of the effort detailed in this appendix was to thoroughly review the SDDOT Pavement Preservation and Field Guidelines in order to assess where improvements or updates can be made. The result of this task was a preliminary list of potential improvements to the guides. Simplicity is the key to the guides, as is the need to make a connection to the PMS used by the state and local agencies.

SDDOT expectations are to make the process simplified and connect with the DOT PMS. The DOT uses automated equipment while most of the local agencies collect pavement data manually. Sioux Falls reportedly is the only local agency that uses an automated van. [2]

### Organization

The 2010 guidelines are very detailed, including sections on:

- Pavement preservation definitions
- Introduction to pavement preservation
- Treatment selection guides
- Treatments
- Information on a variety of preservation treatments
  - Construction
  - Relative cost and expected life
- References
- Appendices

The guidelines may be enhanced in many ways, including:

- Enhance treatment selection guides by including other distress types.
- Include quality assurance for treatments done by contract or in-house.
- Add the connection to the PMS used by state and local agencies.
- Add cost-benefit analysis for both state and local agencies.
- Include information about what treatments require compliance with the Americans with Disabilities Act (ADA).

### Review of Content

The following includes a brief review of the content of the guidelines along with recommendations on items in need to be updated:

Pavement Preservation Definitions. This section will need to be updated to reflect recent changes FHWA definitions outlined in the following link: https://www.fhwa.dot.gov/preservation/memos/160225.cfm. The appendices should provide more detail on the FHWA current program as well as information on the cost-benefit approach to be developed as part of this guideline.

[2] https://www.dakotanewsnow.com/content/news/Automated-system-to-survey-the-citys-streets-560705241.html

Introduction to Pavement Preservation. Similarly, the field of preservation has made significant progress over the past 10 years which needs to be reflected in the introduction to pavement preservation.

Treatment selection guides. These are provided for both flexible and rigid pavements as a function of distress type. The section includes discussions on the following:

- *Gather pavement information*. This includes pavement type, pavement age and design life, traffic, and pavement cross section and materials. This information should be housed in the state and local agencies' pavement management system to make an informed selection of the right treatment, at the right time, on the right road
- *Assess pavement information*. The current pavement condition must also be assessed to determine feasible pavement preservation treatments. This includes details on the type, severity, and extent of all distress present on the pavement. Information on the SDDOT pavement management system is available, but very little is included on the pavement management systems used by local agencies.
- *Evaluate pavement data*. This section provides some guidance to determine whether pavement preservation or rehab might be the most appropriate treatments. It appears to provide good information and may not need to be updated.
- *Identify feasible pavement preservation treatments*. The appropriate treatment strategy for pavement sections identified as candidates for pavement preservation are discussed in this section by looking at the type and severity of the pavement distresses on the pavement. Guidance is given for both flexible and rigid pavements where the matrices are based on a relationship between a single treatment for a given distress. When multiple distresses exist, the appropriate treatment to address each distress type is examined, and the recommended treatments must be used in combination with engineering judgement to make the final treatment decisions. These matrices may be updated to reflect current practice. Another alternative is to use the treatment selection procedure included in www.roadreseource.com for flexible pavements; these alternatives will be evaluated in the coming phases of the project.
- *Select the most appropriate pavement preservation treatment*. Of the feasible preservation treatments, the most appropriate is one that provides the best cost-benefit ratio while meeting the constraints of the project. There are several ways to identify the treatment with the most benefit for the associated cost. It can be done internally within many pavement management systems. Other approaches include a simple cost-benefit model using Microsoft Excel or the procedure included in www.roadresource.com for flexible pavements. The new cost-benefit method would be introduced here, with examples included in an appendix.

Other factors that are considered for selecting preservation treatments in the 2010 guidelines include:

- Availability of quality contractors,
- Availability of quality materials,
- Agency practice or local preference,
- Time of year for construction,
- Initial costs,

- User preferences,
- Pavement noise,
- Facility downtime, and
- Surface friction.

During the kickoff meeting on January 22, 2020, the need to include more on transverse cracks in flexible pavements was discussed, including the depression in the crack and how much leveling is needed prior to treating the cracks. Also, longitudinal cracks should be considered, since the SDDOT mentioned they have problems with early cracking in rumble strips at the centerline and the edges of the pavement. The other treatments considered in the existing guides for flexible pavements could probably remain as is. Transverse cracks should also be considered in the rigid pavement treatments selection for non-reinforced rigid pavements. For the rigid pavements, DBR and sub-sealing and pavement jacking are not widely used. Consideration should be given to eliminating these treatments from the new guide. However, we need to also be aware that the local agencies may use some of these, so we will need to investigate this to understand what (if any) should be removed from the guide.

Treatments. The treatments currently included in the guides for flexible and rigid pavements are shown in Table 24. They include both preventive and minor rehabilitation techniques. There are also sections dealing with drainage preservation and gravel roads.

**Table 24. Treatments Considered in 2010 Pavement Preservation Guidelines.**

| Treatments for Flexible Pavements | Treatments for Rigid Pavements |
|---|---|
| Crack Treating<br>Crack Leveling<br>Rout and Seal Cracks<br>Fog Seals<br>Sand Seals<br>Scrub Seals<br>Rejuvenators<br>Slurry Seals<br>Micro surfacing<br>Chip Seals<br>Thin Asphalt Concrete Overlay – Less than 1.5”<br>Rut Filling<br>Spray Patching | Crack Sealing<br>Joint Resealing<br>Diamond Grinding<br>Diamond Grooving<br>Full-Depth Repairs<br>Partial-Depth Repairs<br>Dowel Bar Retrofit (DBR)<br>Cross Stitching<br>Pavement Sub- sealing/ Under sealing<br>Pavement Jacking / Mud Jacking |
| **Drainage Preservation and Gravel Road Maintenance** | |

Prior to the presentation of each treatment type, there is a special considerations section that provides details that are applicable to many of the treatments, including;

- Pavement surface preparation,
- Pavement markings,
- Traffic control,
- Treatments sequencing, and
- Rumble strips/stripes.

The prior sections will have to be updated to reflect current practices by SDDOT and local agencies.

One-page treatment summaries along with photos are included for each of the treatments listed in Table 24. They include the following:

- Treatment description,
- Pavement conditions addressed,
- Application limitations,
- Construction considerations,
- Traffic considerations,
- Special considerations,
- Performance period or expected life, and
- Relative cost.

Based on the results of the kickoff meeting, the SDDOT would like to use the same format, but may want to include QA in some of the treatments and typical costs for the treatments so they could be used in the cost-benefit analysis. The Wood team will also review the standard specs for the treatments to ensure they include QA for in-house work.

Drainage and gravel road treatments should remain and may be expanded to include new materials developed over the past 10 years. FHWA has a new manual on gravel road construction and maintenance that was published in 2015 and included at the following link https://docplayer.net/11245662-Gravel-roads-construction-maintenance-guide.html. Both the state and local agencies manage gravel roads since a small portion of the state network and the majority of the county networks are gravel.

References. These will need to be updated to include the findings of the literature review in Task 2.

Appendices. These will need to be updated and will include FHWA definitions and other new materials such as the cost-benefit method and examples of its use.

**References**

FHWA Report, Gravel Roads Construction and Maintenance Guide, August 2015 https://docplayer.net/11245662-Gravel-roads-construction-maintenance-guide.html.

Maryland SHA, Pavement Preservation Guide for Pavement Preservation, 2011 https://www.pavementpreservation.org/wp-content/uploads/2012/12/2012_MDSHA_Pavement_Preservation_Guide.pdf

Minnesota DOT Pavement Preservation Manual, 2019
https://www.dot.state.mn.us/materials/pavementpreservation/manualsandguides/documents/MnDOT_Pavement_Preservation_Manual_2019_signed.pdf
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National Concrete Pavement Technology Center, Concrete Pavement Preservation Guide, 2014,
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South Dakota DOT, Pavement Preservation Guidelines, February 2010,
https://dot.sd.gov/media/documents/PavementPreservationGuidelines1112011.pdf
South Dakota DOT, Standard Specifications, 2015 https://dot.sd.gov/doing-business/contractors/standard-specifications/2015-standard-specifications
South Dakota DOT, Pavement Distress manual, 2017,
https://dot.sd.gov/media/documents/DistressManual.pdf

## APPENDIX C: ONLINE SURVEY

### Project SD019-01
### Pavement Preservation Guidelines Update for SDDOT and Local Agencies

The objective of the referenced project is to update the South Dakota DOT's (SDDOT's) 2010 pavement preservation guidelines to reflect changes in preservation practices, as well as to develop a simple cost-benefit analysis method that can be implemented at the State and local level. In support of the stated objective, this online survey is being conducted to:

- Assess the extent of usage of the guidelines in selecting or implementing pavement preservation treatments.
- Identify shortcomings or improvements that may be necessary from the perspective of the users of the guidelines. For example, it is important to know if the users of the guidelines would benefit from additional details, examples, or case studies, or whether the users believe the structure of the guidelines is adequate and simply needs an update.

We would greatly appreciate if you could complete this online survey in support of the project. It should not take more than 5 to 10 minutes to complete.

Responder's name: _____
Responder's agency: _____
Responder's e-mail: _____
Responder's phone: _____

1. What role best describes your pavement preservation involvement (please check most appropriate option):
   - SDDOT manager/decision-maker _____
   - Local agency manager/decision-maker _____
   - SDDOT pavement management engineer/technician _____
   - Local agency pavement management engineer/technician _____
   - SDDOT pavement data collection engineer/technician _____
   - Local agency pavement data collection engineer/technician _____
   - SDLTAP center training staff _____
   - Other (please specify) _____

2. How long have you been using the SDDOT pavement preservation guidelines?
   - Have not used before or < 1 year _____
   - Past 1 to < 3 years _____
   - Past 3 to < 5 years _____
   - More than 5 years _____

3. How frequently do you use the material presented in the SDDOT pavement preservation guidelines?
   - Frequently/Routinely (10 or more times per year) _____
   - Occasionally/Sometimes (5 to 10 times per year) _____
   - Rarely/Never (less than (less than 5 times per year) _____

4. The current version of the SDDOT pavement preservation guidelines consists of the following five sections:
    - Pavement preservation definitions
    - Introduction to pavement preservation
    - Treatment selection guides
    - Treatments
    - References

    These sections require various levels of updating.

    a. Do you believe the structure of the guide is adequate as is and simply needs an update? (Y for Yes or N for No) _____

    b. If no, which of the following items would you recommend (please check all that apply:

        Addition of cost-benefit method and examples: _____

        Addition / deletion (please circle one) of distress(es)
        in treatment selection _____

        If so, please list (use A for addition or D for deletion in front of each of each distress):

        _____
        _____
        _____
        _____
        _____
        _____
        _____
        _____
        _____

        Addition / deletion (please circle one) of pavement
        preservation treatment(s) _____

        If so, please list (use A for addition or D for deletion in front of each of treatment):

        _____
        _____
        _____
        _____
        _____
        _____
        _____
        _____
        _____

Addition of pavement preservation references and training resources: _____

Addition of pavement preservation standards specifications and quality assurance information: _____

Addition of other pavement preservation guidance elements not listed above: _____

If so, please list below:

_____
_____
_____
_____
_____
_____
_____
_____
_____

5. An outcome of the project will be a simple cost-benefit analysis method that will allow engineers as well as maintenance supervisors and workers to compare preservation treatment options for given road segments.
    a. Do you anticipate using such a method? (Y for Yes or N for No) _____
    b. If yes, do you prefer a (please check one):
        i. Written procedure with examples incorporated into the SDDOT's pavement preservation guides, or _____
        ii. Standalone tool in MS Excel _____

6. Additional comments/suggestions not addressed so far that you would like us to consider as part of the SDDOT pavement preservation guidelines update are welcomed and appreciated. Please use space provided below:

_____
_____
_____
_____
_____

We greatly appreciate the time you have taken to complete this online questionnaire. Your input will greatly contribute to the successful completion of the project.

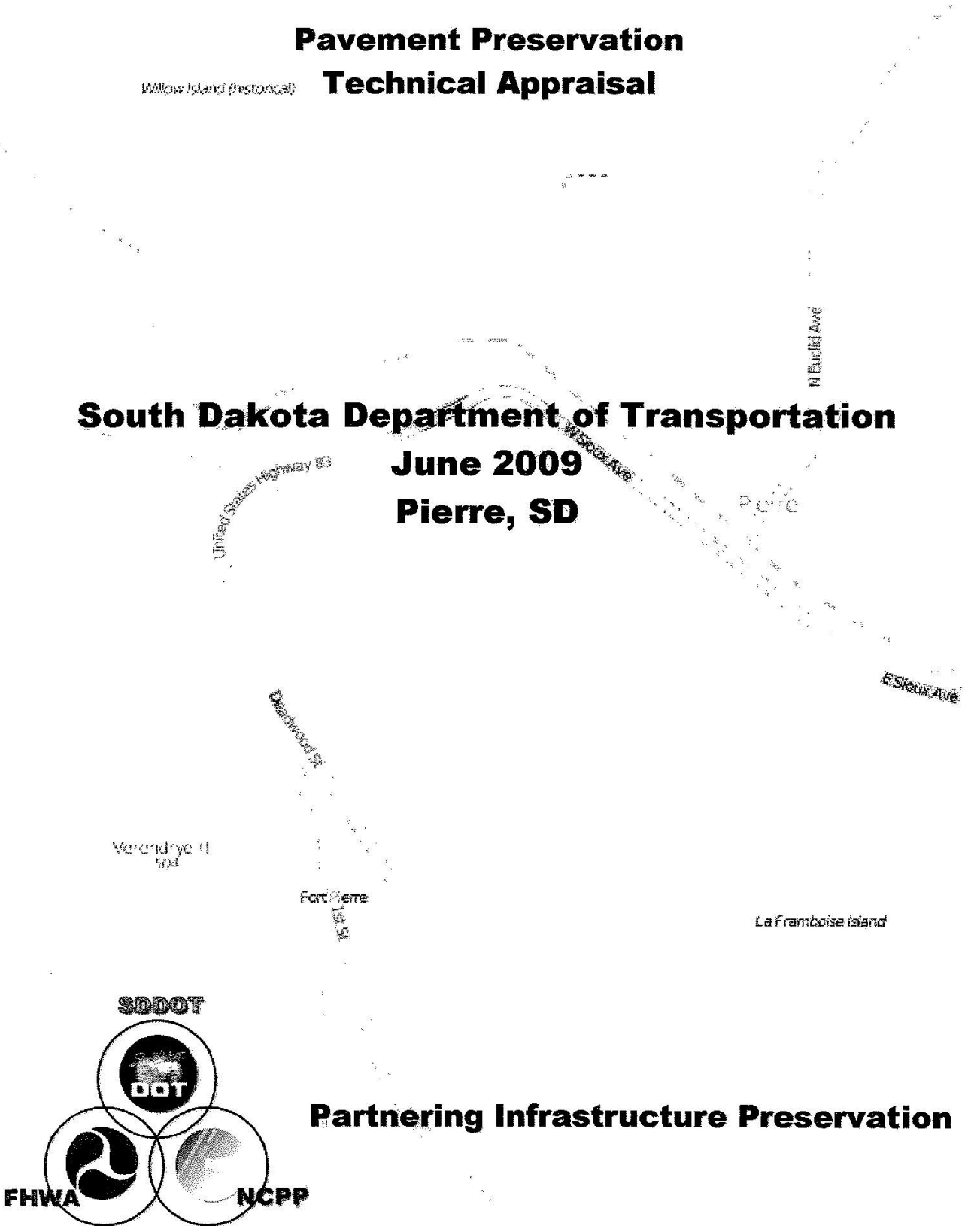
Thank you,
**The SD019-01 Project Team**

## APPENDIX D: PAVEMENT PRESERVATION TECHNCIAL APPRAISAL

(SDDOT JUNE 2009)

# Pavement Preservation
# Technical Appraisal

## South Dakota Department of Transportation
## June 2009
## Pierre, SD




SDDOT
DOT
FHWA
NCPP

## Partnering Infrastructure Preservation

# PAVEMENT PRESERVATION TECHNICAL APPRAISAL SOUTH DAKOTA EXECUTIVE SUMMARY

# DRAFT

The Federal Highway Administration (FHWA) and the National Center for Pavement Preservation (NCPP) would like to thank the South Dakota Department of Transportation (SD DOT) for their cooperation and assistance in producing this report. Interviews with SD DOT headquarters and region staff were conducted during the week of 23 March 2009, by a team consisting of: Craig Smith, Area Engineer, South Dakota DOT; Brett Hestdalen, Pavement and Materials Engineer, FHWA South Dakota Division Office; Bob Orthmeyer, Senior Pavement Engineer, FHWA Resource Center-Olympia Fields; Brian Pfeifer, Pavement Engineer, FHWA Illinois Division Office; and, Larry Galehouse, Director, National Center for Pavement Preservation. (A complete list of participants is included in Appendix A).

We conducted technical interviews with Headquarters staff in Pierre, and staff from the Pierre and Mitchell Regions to gain insight into current preservation practices. We met with managers, engineers, administrators, technicians, and maintenance supervisors, to develop an understanding of best practices employed by SD DOT. These meetings established excellent dialog and proved very beneficial in identifying areas where further actions could improve an existing pavement preservation program.

It is imperative that DOTs use the principles of transportation asset management (TAM), including pavement preservation, to help address the issues of an aging transportation infrastructure facing the nation today and to manage and allocate resources to improve our nation's transportation system performance. TAM is a strategic approach that strives to provide the best return for each dollar invested by maximizing system performance, improving customer satisfaction, and minimizing life-cycle costs. We hope that the discussions conducted during this program appraisal have been constructive in helping to apply TAM principles to improve pavement performance in South Dakota.

## Observations and Recommendations

We have summarized below our observations and their associated recommendations. These are based on information we gained from headquarters meetings and region meetings about current practices at SD DOT. We also made other observations which did not prompt recommendations. These supplemental observations are contained in Appendix I.

## Major Recommendations

### 1. Training

We found a need and desire for training in the regions and at the Central Office and at all levels from policy / decision-makers to field employees. Training is necessary to understand pavement condition, treatment selection, and proper timing, i.e., using the "right treatment on the right road at the right time." We have the following observations and recommendations:

**Observation 1.1**

- Many DOT field offices are staffed by new employees with limited experience in pavement preservation. The agency faces a challenge to retain well trained employees and is often used as a training ground. According to staff response, the agency's most immediate pavement preservation training needs are to instruct region and area personnel in the principles of pavement preservation. Staff also believe a guideline document is needed. The following employee disciplines being proposed for training include:
    - Region engineers,
    - Field engineers,
    - Area engineers,
    - Region materials engineers,
    - Region design staff,
    - Technicians,
    - Inspectors,
    - Maintenance supervisors,
    - Maintenance workers,
    - Consultants, and
    - Contractors.

  Region staff told us that the Department's most immediate pavement preservation training needs were:
    - Pavement Management Systems,
    - Understanding the various preservation treatments and their expected performance,
    - Specific "hands-on" training course on how to apply chip seals, i.e., equipment calibration, spreading, rolling, and brooming,
    - Inspector training for preservation treatments, such as chip seals, slurry seals, micro-surfacing, etc (for consultants and "in-house" staff),
    - Project selection and understanding treatment timing,
    - Developing long-term pavement preservation strategies, and
    - Emulsion training for engineers.

***Recommendation 1.1***

- *We recommend that pavement preservation training be given to selected field and office employees in the following areas:*
    - *Pavement Management Systems - This type of training is essential if the Department expects to use the PMS to do strategic planning and assist with project selection[1]. Training should be provided for all users of pavement management information.*
    - *Basic Pavement Preservation Concepts – This should include basic concepts, terminology, procedures, etc. and would be suitable for all employees.*
    - *Pavement Preservation for Maintenance & Construction Personnel – As the name implies, this training should be directed at maintenance*

[1] Staff subsequently told us that the Department used its PMS to do strategic planning and project selection. A high percentage of all pavement projects are selected from recommendations based upon the PMS.

*and construction personnel, in addition to consultants and contractors, and would focus on project selection and related field aspects of pavement preservation.*

- *Treatments – This training should cover the technical aspects of various pavement preservation treatments such as micro-surfacing, slurry seals, chip seals, crack sealing, fog seals, etc. As with all treatments, the training should be project-related and aimed at guiding the choice of appropriate techniques in specific instances. Staff benefiting from this training includes designers, maintenance and construction engineers, materials and laboratory staff, highway maintenance supervisors, managers, and consultants.*
- *Inspector Training – This training should be for field employees having to inspect treatments, e.g. chip seals, crack sealing, etc.*
- *Preservation Strategy Development – This training should instruct headquarters and district decision-makers in network and project level strategic analysis and strategy development. Training should be made available to Region engineers, planners, and leadership positions.*

*We further recommend that contractors be instructed on the importance of the Department's "designed" chip seals and the need for quality to achieve the agency's expectation of long-term pavement performance.*

*(Appendix B contains a list of available training courses.)*

*The National Center for Pavement Preservation will be available to assist the South Dakota Department of Transportation with training options and developing a framework for a future pavement preservation program.*

## 2. Pavement Management System (PMS)

The DOT uses Deighton's dTIMS CT Pavement Management System upgraded from version 7 to version 8. The dTIMS stands for Deighton Total Infrastructure Management System and CT means concurrent transformation, which allows the system to compare various assets and different locations.

South Dakota had been collecting hard copy sufficiency information since 1979. The data (which were not analyzed), described pavement dimensions, structure, ADTs, etc. In 1984, the agency began to collect ride quality information using a single sensor, and in 1986, it began to collect rutting data. In 1995, the agency began using Deighton software to collect distress information.

We make the following observations and recommendations.

**Observation 2.1**

- The pavement management system does not account for pavement preservation strategies in terms of extended pavement life. The system does not use separate deterioration curves, e.g., chip seals[2].

  The system assumes that standard maintenance practices will be applied to pavement segments throughout their useful lives.

***Recommendation 2.1***

- *Take advantage of the improved PMS' capabilities to:*
  - *Track deterioration rates for all segments and use the PMS to derive "Deterioration versus Time" relationships that are location / treatment specific. Each derived relationship would be based on the performance of aggregations of similar segments.*
  - *Determine extended pavement life for various preservation strategies.*
  - *Forecast pavement conditions.*

  *Knowing extended life will also allow the calculation of cost effectiveness.*

**Observation 2.2**

- Staff told us that the pavement preservation program had enabled the agency to maintain a good condition on the overall network. The agency's goals are expressed as follows by an index ranging from 0 to 5, with 5 being the best:
  - Interstate Highways 3.9 to 4.2
  - Major Arterials 3.7 to 4.0
  - Minor Arterials 3.4 to 3.8
  - State Secondary 3.0 to 3.6
  - State Urban 3.6 to 4.0
  - State Municipal 3.6 to 3.9

***Recommendation 2.2***

- *Introduce and use the Remaining Service Life (RSL) concept to cover all road segments. RSL is an easily understood concept and is ideal for use in communicating with the public and legislators. RSLs would also effectively allow the Department to establish a realistic foundation for its analysis of alternative long-term network strategies[3] based on the life extensions that could reasonably be expected from the application of each pavement preservation treatment.*

  *(Staff subsequently told us that unless there was a national definition and all states were required to use it, they considered RSL at the national level to be moot. At the state level, RSL was merely an alternative to the Department's present practice, i.e., the use of condition levels. The agency already had a realistic foundation for its analysis of alternative long-term network strategies based upon condition and deterioration curves.)*

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[2] Staff subsequently told us that chip seal performance was accounted for in the performance curves as the agency anticipates the need for and actually performs crack sealing and chip sealing on all of its asphalt pavements.

[3] FHWA's NHI Course # 131104A, "*Integrating Pavement Preservation and Pavement Management*" is available to address this more fully.

*Accurate pavement condition forecasting, which is essential for developing long-term strategies, can only be accomplished if rates of pavement deterioration can be accurately determined. To do this, the Department will need to measure and track over time, the deterioration of individual parameters such as ride, rutting, etc. for individual segments. This leads to the calculation of RSLs, which in turn, allows alternative long-term strategies to be evaluated.*

*(Staff subsequently told us that the Department already had accurate long-term pavement condition forecasting in the PMS and that the use of RSL was an unnecessary alternative to their present practice.*

*All distresses collected by the Department are tracked over time on individual segments. The Department also adds treatments to the PMS as they are developed and used. Currently, the PMS contains all treatments used by the agency.)*

*Perform an assessment of South Dakota's highway network to quantitatively verify the extent to which present programs / practices are improving the network's overall performance. The concepts involved in such an assessment are described in detail in Appendix C. Eventually, when additional treatments have been added to the PMS, the Department will be able to develop optimal strategies (consistent with quantified statewide goals) whose costs will dictate the required size of the preservation program.*

*(Staff subsequently told us that the agency's PMS derived optimal strategies using benefit-cost analyses based on pavement condition, performance curves, and available budgets.)*

## 3. Project Selection

**Observation 3.1**

- The Department is in the process of developing a guideline document to direct project selection. The PMS will provide candidate documents and selection will be driven by benefit-cost analysis. The agency has a PMS synopsis, which is updated each year. The Department has dedicated $20M for pavement preservation and short written guidelines would foster a better understanding of pavement preservation project selection principles.

***Recommendation 3.1***

- *Continue to develop a unified, comprehensive set of project selection guidelines that can be objectively applied throughout the network[4]. Without*

[4] Model program guidelines and technical information from 8 states have been collected and are available on a CD entitled "Pavement Preservation 2: State of the Practice". This CD is available from the Federal Highway Administration, Office of Asset Management, 400 7th Street, SW, Room 3211, Washington, DC 20590, Telephone 202-366-1557.

*these guidelines, projects will be selected by the individual regions, each with its own ideas of what constitutes appropriate treatment in particular situations. The guidelines will enable region engineering and planning staff to establish the essential linkages between choosing appropriate treatments for specific pavement conditions and knowing what life extensions to expect from those treatments. Of comparable importance are the notions of network uniformity and objectivity which are necessary for accurately projecting future pavement condition and performance. The guidelines should also link appropriate PMS measures to potential treatments.*

*(Staff subsequently told us that project selection guidelines were in fact being followed through the network analysis of pavement preservation projects.)*

**Observation 3.2**

- Most surface treatment projects are programmed and placed within 12 months, although the agency is starting to plan some projects for chip seal and crack seal 24 months in advance. For other treatments, the time lags between project selection and treatment application are as follows:
  - Thin overlays (1½") 3 years,
  - Dowel bar replacement 3 years,
  - Minor concrete joints 1 to 3 years,
  - Surface Treatments
    - Chip seal 1 year, and
    - Crack sealing 1 year.

In a subsequent observation, staff questioned the 1-year time lag for chip seals and crack seals. They believed the time lag was closer to 3 years for chip seals and 1-2 years for crack seals.

Staff also told us that they required sufficient time to facilitate the overall statewide planning and budgeting process. 3R projects often required safety and ADA issues to be addressed, thereby lengthening the design process. In addition, the PMS analysis was based upon projected condition using the performance curves.

***Recommendation 3.2***

- *Continue to make sure that planned pavement preservation projects are appropriate for the pavement condition at the time of application. With a good PMS and an accurate database, this may be done by planning a preservation treatment for a projected condition..*

## 4. Terminology

We make the following observation and recommendation:

**Observation 4.1**

- Region staff said there are minor terminology variations between regions, e.g., sand seals versus chip seals, flush seals versus fog seals. Many alternative terms refer to the same treatments.

***Recommendation 4.1***

- *The use of a consistent and accurate terminology will yield clear benefits such as improved communication between employees, other state DOTs, and a better understanding of both operational processes and the Pavement Management System (PMS). The Department should use the commonly accepted definitions as a framework upon which to re-classify its existing processes. Incorporate the revised definitions into the Department's new guidelines. One of the most important definitions is that of "Pavement Preservation" and we recommend that the Department adopt a definition consistent with that used by AASHTO and FHWA. (Further information is contained in Appendices D and E.) Both the FHWA and the AASHTO Subcommittee on Maintenance also stand ready to assist the agency in achieving consistency in this area.*

## 5. Champion

**Observation 5.1**

- In their Pre-Appraisal questionnaire, staff reported that the role of championing the pavement preservation concept and program was shared between Operations, Pavement Management, and Materials and Surfacing.

***Recommendation 5.1***

- *We believe that the SD DOT would gain considerable advantages by formally designating a high level person to facilitate the establishment and growth of its pavement preservation program. Several other state transportation agencies, including California, Louisiana, Michigan, Minnesota and North Carolina have established full time positions to lead their pavement preservation programs. The position would need to be able to function at both a policy level as an advocate and at the operational level as a facilitator. We do not believe that the South Dakota DOT needs to look far to find a Champion to coordinate their statewide program as ideal candidates could potentially be drawn from existing positions*[5].

## 6. Performance Monitoring

We made the following observation and recommendation:

**Observation 6.1**

- While the agency does not specifically track the performance of pavement preservation projects, the PMS assumes that preservation techniques are being implemented throughout the life of the pavement.

[5] Some states have designated their State Maintenance Engineer in recognition of the need to consider both new capital improvements and maintenance capital improvements.

***Recommendation 6.1***

- *Begin to formally track long-term performance of reconstruction, rehabilitation and preservation projects and begin to measure the life-extending benefits of pavement preservation treatments. Make sure that actual South Dakota experience is routinely entered into the PMS. As the Department builds and refines the database, it will be able to replace initial assumptions (based on historical pavement performance) with actual data. (The existing PMS should be capable of effectively measuring this information.)*

  *(Staff subsequently told us that the agency had performance curves for all pavement types and major treatments that indicated long-term performance. They felt that their existing database could provide performance information for pavement preservation treatments.)*

# General Observations and Recommendations

## 7. Business Process

**Observation 7.1**

- Staff told us that the Department funds PE which it estimates to be no more than 2.5 %, although some of the PE could be overhead.

***Recommendation 7.1***

- *If not already doing so, track PE and CE costs by project. It is necessary to know these costs when the Department's PMS calculates the cost-effectiveness of using particular preservation treatments and uses this information to perform network strategy analysis.*

  *(Staff subsequently told us that PE and CE percentages were already contained in the PMS and were included in the benefit-cost analysis used to derive optimal strategies.)*

## 8. Quality Control and Quality Assurance

**Observation 8.1**

- Maintenance forces use the same HMA mixes as the rest of the agency, but they do not necessarily follow the same density tests. However, all HMA mix parameters are sampled and tested.

  The testing procedures and inspections, with crack sealing and filling are not always followed by maintenance, although occasionally maintenance submits some samples for testing.

**Recommendation 8.1**

- *We recommend that to the extent practicable, maintenance forces follow the same QC / QA standards as the rest of the Department. (We realize that some*

*maintenance activities such as the application of intermittent, short-term pavement patches located at extended distances from hot mix plants makes it impractical to rigidly follow the same QC / QA specifications as for more traditional construction.)*

## 9. Public / Political Relations

**Observation 9.1**

- Implementation of a pavement preservation program has been well received in South Dakota and staff estimated that about 80% of people favored it. The Department regularly surveys customer satisfaction. The Governor and Legislature also favor pavement preservation.

***Recommendation 9.1***

- *We commend South Dakota for its efforts and success in conveying the importance of pavement preservation to the public, Governor, and Legislature, and we recommend that these efforts continue. The preservation message may be further strengthened by placing even more emphasis on timely preservation as the most effective means of reducing the frequency of costly reconstruction. Explain the transitional need to prevent good roads from deteriorating while appearing to neglect roads needing major rehabilitation or reconstruction. As more good roads are saved from premature deterioration by the application of preservation treatments, the number of deteriorated roads needing major rehabilitation or reconstruction will diminish.*

**Observation 9.2**

- South Dakota's news media have been "kind" to the DOT, although they have not really promoted the pavement preservation concept. The media tends to be receptive to road construction information. The news concentrates on reporting about the worst roads.

***Recommendation 9.2***

- *Use the media proactively to disseminate the "preservation message" to the public. It is vitally important that the public understand the value of being proactive and that a policy of "worst first" will eventually end in failure to raise the quality of the system without a massive increase in resources. (Suggested news release formats are shown in Appendix F.)*

## 10. Program Implementation

**Observation 10.1**

- Staff told us that the South Dakota FWHA Division Office and the South Dakota DOT had jointly developed guidance on pavement preservation activities that are eligible for federal funding. The guidance was posted on the Department's Intranet and an E-mail notice was sent to agency personnel on December 23, 2008. The Department regards safety as a systems process and it reviews all safety requirements, but it is concerned about the use of 2-lift

overlays[6] and their effect on safety upgrade requirements. Staff also told us that most pavement preservation projects receive an environmental categorical exclusion.

***Recommendation 10.1***

- *We commend the South Dakota Department of Transportation for working with the FHWA Division and we recommend negotiating a formal agreement with FHWA that would grant the Department safety and environmental categorical exclusions for its pavement preservation projects.*

  *(Staff subsequently told us that the process was identified through the Stewardship agreement.)*

**Observation 10.2**

- Staff told us that their pavement preservation program did not have any ADA issues.

***Recommendation 10.2***

- *Although South Dakota's pavement preservation program may not have ADA issues at present, this may not always be the case. Review the FHWA's memoranda (Appendices G and H) clarifying the agency's role in accessibility and be prepared to use their legal interpretations to simplify and reduce ADA requirements as they may apply to future preservation projects.*

  *(Staff subsequently told us that based on their analysis of the Department of Justice's (DOJ's) guidance and Kinney versus Yerusalim, South Dakota's definition of pavement preservation techniques do not require ADA upgrades.)*

**Observation 10.3**

- Staff told us that the development of specifications was a continual process. Presently, they were attempting to develop a statewide specification for chip seals. Some regions also have their own specifications.

***Recommendation 10.3***

- *Wherever possible, establish and use standard specifications that can be applied statewide for the various preservation treatments. Occasionally, special circumstances in the regions may require the use of special provisions, but the use of different specifications for the same treatment should be discouraged. (In the case of failing chip seals, it may be preferable to provide specific training to contractor personnel.)*

## 11. Preservation Treatments[7]

[6] Usually, 80% of overlays involve one lift (1.5" to 2.0") and 20% involve two lifts.

[7] The Department should consider the long-term prices, availability, and quality of oil and asphalt products. As long-term oil prices continue to rise, the price advantage of HMA will continue to erode. With this reality, the agency should be looking at more cost-effective preservation treatments that can extend pavement life and postpone the need for more costly reconstruction and heavy rehabilitation.

**Observation 11.1**

- Central and northwest South Dakota have relatively poor aggregate. Mitchell Region staff told us that they had difficulty obtaining a good single size cubical aggregate. Obtaining this aggregate from the plant at Sioux Falls involves a haul of about 100 miles. The aggregate costs $35 per ton when hauled for long distances and $20 to $25 per ton when hauled for short distances.

  Staff also told us that Mitchell was getting good aggregate, but the local supplier had not been willing to further improve his process. In this case, the additional cost of importing better aggregate would not have been cost effective.

***Recommendation 11.1***

- *We commend South Dakota DOT for obtaining good quality aggregate. Good materials are essential to the longevity and success of pavement preservation treatments, especially surface treatments such as chip seals, micro-surfacing and thin overlays, and the use of marginal materials may diminish performance. We have observed that when states are faced with lower quality local aggregates, alternative sources of durable high quality offer much better overall results. When evaluated on a life-cycle basis, the use of such aggregates (including added transportation costs) will be more cost-effective and produce longer lasting and predictable treatments. The cost-effectiveness will vary according to the circumstances, particularly the treatment's expected longevity and transportation costs. NCHRP Synthesis 342[8] (Page 26) reports that Australian and New Zealand road agencies are willing to transport high quality aggregate up to 500 miles to ensure performance and longevity of their chip seals. The economics would tend to favor this practice where preservation treatment longevities were high, say 10 to 12 years instead of 5 to 7 years currently expected for chip seals. Longevity and predictability are essential elements of long-term network strategies.*

**Observation 11.2**

- The Pierre Region has experienced problems in obtaining good micro-surfacing contractors and the Mitchell Region staff told us that South Dakota lacked sufficient good quality chip seal contractors to accommodate the state's needs.

***Recommendation 11.2***

- *We recommend that more agency employees and contractors doing work for the South Dakota DOT be required to attend future training classes in micro-surfacing and chip seals. (This would require additional certification and a thoroughly developed curriculum.) Often the preservation contractor's*

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It would also be useful to revisit South Dakota's February 1989 report, ***"Evaluation of Various Surface Sealing Techniques for the Preventive Maintenance of Flexible Pavements"***.

[8] NCHRP Synthesis 342, "Chip Seal Best Practices"

*workforce has not received formal training to improve their understanding of the product they provide. This approach of bringing key crew members in for training has been successful in other states when treatment quality needs improvement.*

## 12. Research and Development

**Observation 12.1**

- Staff told us that their most immediate research needs in pavement preservation were to develop:
  - A "Guideline Document" for pavement preservation, and
  - A pavement preservation training courses to be given to region personnel.

**Recommendation 12.1**

- *We recommend that the SD DOT develop a comprehensive "Guideline Document" for pavement preservation which reflects preservation principles, but is specifically tailored to the state's circumstances and needs.*

  *We also recommend that rather than "reinventing the wheel"; the Department take advantage of the many pavement preservation courses that already exist. This training is available from the NHI and other organizations, including the NCPP. Further information is contained in Appendix B.*

## 13. Pavement Preservation Assistance

**Observation 13.1**

- The FHWA's Division Office reported that federal funds had been used extensively to perform research to enhance the SD DOT's pavement management system and pavement preservation programs. The Division's office employees had served on the agency's technical panels and working groups and had assisted in updating many of the components of the pavement preservation program. For example, assistance was provided in the development of SD DOT's QC/QA specifications, material testing, inspector certification programs, and construction specifications. The Division office had also served on the technical panels that developed the design procedure for chip seals and enhanced the pavement management system. AASHTO specifications, National Research findings, FHWA technical memoranda, and guidance had all been utilized as appropriate to develop the state's preservation program.

  With the limited amount of state dollars available, federal funding plays a vital role in South Dakota's pavement preservation program. The Division Office has worked with the SD DOT to develop guidance on pavement treatments eligible for federal funding.

***Recommendation 13.1***

- *We commend the FHWA's Division Office for continuing its proactive approach and "value added" involvement with the SD DOT by providing policy and technical information. The Division's role in encouraging and helping the SD DOT to take advantage of opportunities for improving its pavement preservation program has been important and we recommend that the Division continue to provide this critical assistance.*

## 14. Materials

**Observation 14.1**

- When faced with inferior local materials the Department chooses high quality materials and pays the additional transportation costs. As a result, South Dakota does not appear to have any recent materials problems.

**Recommendation 14.1**

- *We commend the Department for its willingness to transport high quality materials (i.e., aggregate) when faced with inferior local materials. The Department has found that good quality materials are essential to the success and longevity of pavement preservation treatments, especially surface treatments such as chip seals, micro-surfacing and thin overlays.*

# Appendix A – List of Participants

| Name | | Affiliation |
|---|---|---|
| Aalberg | Greg | Sioux Falls Area, Engineering Supervisor |
| Behm | Mike | Assistant Director P & E |
| Bjorneberg | Tim | Project Development |
| Brandner | Loren | Mobridge Materials Supervisor |
| Feller | Joe | Chief Materials Engineer |
| Forman | John | Pierre Region Engineer |
| Galehouse | Larry | NCPP, Director |
| Gall | Rod | Yankton, Engineering Supervisor |
| Goldammer | Charles | Highway Maintenance Supervisor |
| Gordon | Rick | Pierre Area Engineer Supervisor |
| Gustafson | Jeff | Operations Engineer |
| Hansen | Jerry | Yankton, Highway Maintenance Supervisor |
| Hestdalen | Brett | FHWA SD Division, Pavement & Materials Engineer |
| Hodges | Darin | Concrete Engineer |
| Huffman | Tim | Maintenance Supervisor |
| Humphrey | Jason | Construction/Maintenance Engineer |
| Hyde | Jim | Pierre Area Engineer |
| Jorgensen | Todd | FHWA SD Division, Assistant Division Administrator |
| Jundt | Joel | Director of Planning and Engineering |
| Kirschenmen | Larry | Yankton, Highway Maintenance Supervisor |
| Lunde | Blair | Pavement Management Engineer |
| McMahon | Ron | FHWA SD Division, Operations Team Leader |
| Norrid | Brad | Winner Engineer Supervisor |
| Orthmeyer | Bob | FHWA RC, Senior Pavement Engineer |
| Peterson | Ron | Yankton, Area Engineer |
| Pfeifer | Brian | FHWA, Illinois Division |
| Prunty | Eric | Mitchell Area Engineering Supervisor |
| Rieger | Mark | Mobridge Area Project Engineer |
| Rohlf | John | FHWA SD Division, Division Administrator |
| Rowen | Rick | Bituminous Engineer |
| Sestak | Joe | Yankton, Project Engineer |
| Sherman | Doug | Winner Area Engineer |
| Smith | Craig | Sioux Falls Area Engineer |
| Stroeder | Eric | Mobridge Area Engineering Supervisor |
| Tveidt | Kevin | Deputy Secretary |
| Van Dam | Brian | SF Area, Transportation Specialist I |
| Vetter | Chris | Mobridge Construction Tech. |
| Villbrandt | John | Mobridge Area Engineer |
| Voegeli | Keith | Highway Maintenance Supervisor |
| Week | Tom | Mitchell Region Engineer |
| Williams | Tammy | Mitchell Area Engineer |

| Geographic Regions | | | |
|---|---|---|---|
| **Region** | **Location** | **Region** | **Location** |
| Aberdeen | Northeast | Pierre | Central |
| Mitchell | Southeast | Rapid City | West |

# Appendix B – List of Training Courses

## National Center for Pavement Preservation (NCPP)

**Pavement Preservation: Applied Asset Management**

This is a 2-day course for policy-level administrators, planners, and economists focusing on pavements viewed as a system; and also for engineers and technicians interested in applying preservation techniques at the project level. The course presents cost-effective strategies for planning and managing highway and street networks and is useful for budget planning and resource allocation. At the project level, participants will gain a practical understanding of pavement distresses and the appropriateness of various preservation techniques used to treat those distresses. The second day features a "hands-on" network simulation exercise where the participant develops an integrated long-term pavement strategy.

**Understanding Chip Seals: Theory and Practice**

This is a 1-day course for highway agency field managers, engineers, technicians, and industry representatives. The course traces the evolution of the art of chip sealing and includes the latest technological advances. Participants are introduced to the concepts and taught how to design chip seals. The course then covers contracting, materials selection, equipment and construction practices, and chip seal performance measures.

**Pavement Preservation: Slurry Seal and Micro-Surfacing**

This one-day course is intended to provide participants with a comprehensive understanding of slurry seal and micro-surfacing systems. The principal focus is to offer pavement practitioners the essential skills for selecting good candidate pavements, designing and estimating projects, and gaining awareness of good construction practices. Upon the conclusion of the course the participants will possess the necessary knowledge to achieve excellent success with slurry seals and micro-surfacing projects.

## National Highway Institute (NHI)

**131054A Pavement Preservation: The Preventive Maintenance Concept**

This is a 2-day introductory course for highway agency upper management and policy makers. The course provides a conceptual introduction to pavement preventive maintenance and a description of current preventive maintenance treatments and technology. It also presents information needed to develop or improve a preventive maintenance program by illustrating the experiences of 5 states which have established preventive maintenance programs.

**131058A Pavement Preservation: Selecting Pavements for Preventive Maintenance**

This is a 2-day, project-level technical course for highway agency field managers / practitioners and industry representatives. The course focuses on selecting

## List of Training Courses (continued)

appropriate preservation treatments for pavements based on actual field conditions. The subject matter includes detailed illustrations of pavement evaluation, project selection, and materials considerations for various preventive maintenance applications.

**131103A Pavement Preservation: Design and Construction of Quality Preventive Maintenance Treatments**

This is a 3-day technical course for construction foremen and agency construction inspectors. The course contains modules covering all generally used preventive maintenance treatments and focuses on the best design and construction practices for those treatments. It also addresses troubleshooting construction practices to enable participants to identify the results of poor construction practices.

**131104A Pavement Preservation: Integrating Pavement Preservation and Pavement Management**

This is a 2-day continuation course for pavement management engineers, region / district maintenance engineers, local agency engineers, maintenance management engineers, and planning and programming personnel. The course presents several ways in which pavement management tools can support a pavement preservation program at the project, network, and strategic analysis levels. It also presents reasons why agencies should integrate pavement preservation into their pavement management activities and advice on how to recognize and overcome obstacles to successful integration.

**131116 Pavement Management Systems: Characteristics of an Effective Program (1 Day)**

**131116A Pavement Management Systems: Characteristics of an Effective Program (1½ Days)**

This course was designed to help improve the effectiveness of an existing pavement management program. In addition to introducing the basic components of an effective pavement management program, the course materials illustrate the effective use of pavement management information and provide opportunities for participants to identify strategies that will help enhance their existing capabilities. The focus of the class is broad enough to include data collection activities, condition assessment, program development, investment analysis, and other uses of pavement management information to support an agency's decision processes to improve pavement performance. The role of pavement management in supporting an agency's transportation asset management program at the strategic, network, and project levels is also introduced.

# Appendix C – Network Pavement Preservation

In network-level analysis, it is essential to know whether present and / or planned program actions (preservation, resurfacing, rehabilitation, reconstruction) will produce net improvements in the aggregate condition of the network as measured by average remaining service life (RSL). Consider the network whose current condition is shown in Figure 1.

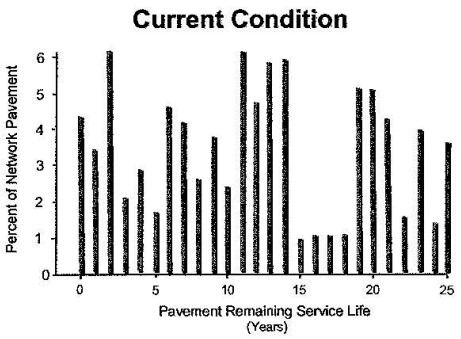


**Figure 1 – Current Condition**

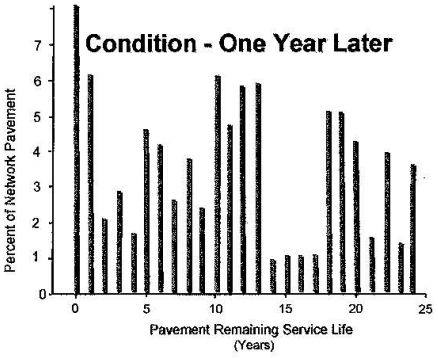


**Figure 2 – Condition 1 Year Later**

If no improvements are made for one year, the entire network will age one year to the condition shown in Figure 2.

The deterioration can be thought of as the total lane-miles multiplied by 1 year, or one *lane-mile-year*. To offset deterioration over the entire network, the agency would need to annually perform a quantity of work equal to the total number of system-wide lane-mile-years just to maintain the status quo. Performing less work would result in a net decline of the network, while more work would result in a net improvement of the network.

Consider a small quantitative example. Suppose your agency's highway network consisted of 38,500 lane-miles. Figure 3 declares that without intervention, it will lose 38,500 lane-mile-years per year.

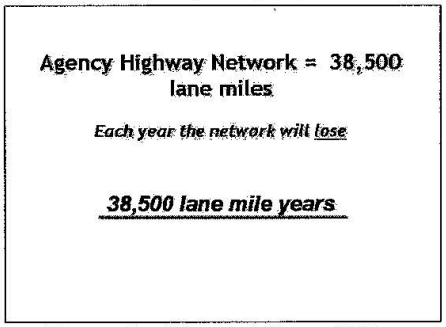


**Figure 3 – Network Lane-Miles**

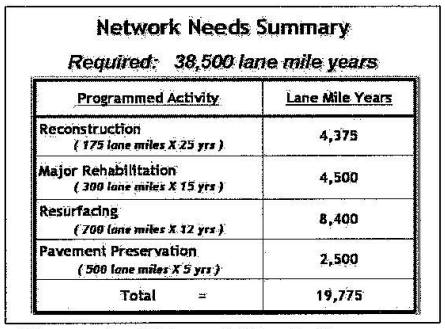


**Figure 4 – Network Needs Summary**

Figure 4 displays the agency's programmed activities of reconstruction, rehabilitation, resurfacing, and preservation that would restore only 19,775 lane-mile-years to the network in that year. This quantity of added life consists of 4,375 lane-mile-years which come from reconstruction; 4,500 lane-mile-years from rehabilitation; 8,400 lane-mile-years from resurfacing; and 2,500 lane-mile-years from pavement preservation. These programmed activities fall short of the required 38,500 lane-mile-years to maintain the status quo, and hence would contribute to a net one year loss in network pavement condition of 18,725 lane-mile-years.

This exercise can be performed for any pavement network to benchmark the current trend.

# Appendix D – Pavement Preservation Definitions

U.S. Department of Transportation
**Federal Highway Administration**

# Memorandum

Subject: **ACTION**: Pavement Preservation Definitions Date: September 12, 2005

*(Original Signed by David R. Geiger, P.E.)*
From: David R. Geiger, P.E. Reply to
Director, Office of Asset Management Attn. of: HIAM-20

To: Associate Administrators
Directors of Field Services
Resource Center Director and Operations Manager
Division Administrators
Federal Lands Highway Division Engineers

As a follow-up to our Preventive Maintenance memorandum of October 8, 2004, it has come to our attention that there are differences about how pavement preservation terminology is being interpreted among local and State transportation agencies (STAs). This can cause inconsistency relating to how the preservation programs are applied and their effectiveness measured. Based on those questions and a review of literature, we are issuing this guidance to provide clarification to pavement preservation definitions.

Pavement preservation represents a proactive approach in maintaining our existing highways. It enables STAs to reduce costly, time consuming rehabilitation and reconstruction projects and the associated traffic disruptions. With timely preservation we can provide the traveling public with improved safety and mobility, reduced congestion, and smoother, longer lasting pavements. This is the true goal of pavement preservation, a goal in which the FHWA, through its partnership with States, local agencies, industry organizations, and other interested stakeholders, is committed to achieve.

A Pavement Preservation program consists primarily of three components: preventive maintenance, minor rehabilitation (non structural), and some routine maintenance activities as seen in figure 1.


*Figure 1: Components of Pavement Preservation*

An effective pavement preservation program can benefit STAs by preserving investment on the NHS and other Federal-aid roadways, enhancing pavement performance, ensuring cost-effectiveness, extending pavement life, reducing user delays, and providing improved safety and mobility.

It is FHWA's goal to support the development and conduct of effective pavement preservation programs. As indicated above, pavement preservation is a combination of different strategies which, when taken together, achieve a single goal. It is useful to clarify the distinctions between the various types of maintenance activities, especially in the sense of why they would or would not be considered preservation.

For a treatment to be considered pavement preservation, one must consider its intended purpose. As shown in Table 1 below, the distinctive characteristics of pavement preservation activities are that they restore the function of the existing system and extend its service life, not increase its capacity or strength.

**Pavement Preservation Guidelines**

| | Type of Activity | Increase Capacity | Increase Strength | Reduce Aging | Restore Serviceability |
|---|---|---|---|---|---|
| Pavement Preservation | New Construction | X | X | X | X |
| | Reconstruction | X | X | X | X |
| | Major (Heavy) Rehabilitation | | X | X | X |
| | Structural Overlay | | X | X | X |
| | Minor (Light) Rehabilitation | | | X | X |
| | Preventive Maintenance | | | X | X |
| | Routine Maintenance | | | | X |
| | Corrective (Reactive) Maintenance | | | | X |
| | Catastrophic Maintenance | | | | X |

***Table 1-*** *Pavement Preservation Guidelines*

## Definitions for Pavement Maintenance Terminology

**Pavement Preservation** is "a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations."
*Source: FHWA Pavement Preservation Expert Task Group*

An effective pavement preservation program will address pavements while they are still in good condition and before the onset of serious damage. By applying a cost-effective treatment at the right time, the pavement is restored almost to its original condition. The cumulative effect of systematic, successive preservation treatments is to postpone costly rehabilitation and reconstruction. During the life of a pavement, the cumulative discount value of the series of pavement preservation treatments is substantially less than the discounted value of the more extensive, higher cost of reconstruction and generally more economical than the cost of major rehabilitation. Additionally, performing a series of successive pavement preservation treatments during the life of a pavement is less disruptive to uniform traffic flow than the long closures normally associated with reconstruction projects.

**Preventive Maintenance** is "a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity)." *Source: AASHTO Standing Committee on Highways, 1997*

Preventive maintenance is typically applied to pavements in good condition having significant remaining service life. As a major component of pavement preservation, preventive maintenance is a strategy of extending the service life by applying cost-effective treatments to the surface or near-surface of structurally sound pavements. Examples of preventive treatments include asphalt crack sealing, chip sealing, slurry or micro-surfacing, thin and ultra-thin hot-mix asphalt overlay, concrete joint sealing, diamond grinding, dowel-bar retrofit, and isolated, partial and/or full-depth concrete repairs to restore functionality of the slab; e.g., edge spalls, or corner breaks.

**Pavement Rehabilitation** consists of "structural enhancements that extend the service life of an existing pavement and/or improve its load carrying capacity. Rehabilitation techniques include restoration treatments and structural overlays." *Source: AASHTO Highway Subcommittee on Maintenance*

Rehabilitation projects extend the life of existing pavement structures either by restoring existing structural capacity through the elimination of age-related, environmental cracking of embrittled pavement surface or by increasing pavement thickness to strengthen existing pavement sections to accommodate existing or projected traffic loading conditions. Two sub-categories result from these distinctions, which are directly related to the restoration or increase of structural capacity.

*Minor rehabilitation* consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develop in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation.

*Major rehabilitation* "consists of structural enhancements that both extend the service life of an existing pavement and/or improve its load-carrying capability." *Source: AASHTO Highway Subcommittee on Maintenance Definition*

**Routine Maintenance** "consists of work that is planned and performed on a routine basis to maintain and preserve the condition of the highway system or to respond to specific conditions

and events that restore the highway system to an adequate level of service." *Source: AASHTO Highway Subcommittee on Maintenance*

Routine maintenance consists of day-to-day activities that are scheduled by maintenance personnel to maintain and preserve the condition of the highway system at a satisfactory level of service. Examples of pavement-related routine maintenance activities include cleaning of roadside ditches and structures, maintenance of pavement markings and crack filling, pothole patching and isolated overlays. Crack filling is another routine maintenance activity which consists of placing a generally, bituminous material into "non-working" cracks to substantially reduce water infiltration and reinforce adjacent top-down cracks. Depending on the timing of application, the nature of the distress, and the type of activity, certain routine maintenance activities may be classified as preservation. Routine Maintenance activities are often "in-house" or agency-performed and are not normally eligible for Federal-aid funding.

Other activities in pavement repair are an important aspect of a STA's construction and maintenance program, although they are outside the realm of pavement preservation:

**Corrective Maintenance** activities are performed in response to the development of a deficiency or deficiencies that negatively impact the safe, efficient operations of the facility and future integrity of the pavement section. Corrective maintenance activities are generally reactive, not proactive, and performed to restore a pavement to an acceptable level of service due to unforeseen conditions. Activities such as pothole repair, patching of localized pavement deterioration, e.g. edge failures and/or grade separations along the shoulders, are considered examples of corrective maintenance of flexible pavements. Examples for rigid pavements might consist of joint replacement or full width and depth slab replacement at isolated locations.

**Catastrophic Maintenance** describes work activities generally necessary to return a roadway facility back to a minimum level of service while a permanent restoration is being designed and scheduled. Examples of situations requiring catastrophic pavement maintenance activities include concrete pavement blow-ups, road washouts, avalanches, or rockslides.

**Pavement Reconstruction** is the replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure. Reconstruction usually requires the complete removal and replacement of the existing pavement structure. Reconstruction may utilize either new or recycled materials incorporated into the materials used for the reconstruction of the complete pavement section. Reconstruction is required when a pavement has either failed or has become functionally obsolete.

If you need technical support or further guidance in the pavement preservation area, please contact Christopher Newman in the FHWA Office of Asset Management at (202) 366-2023 or via e-mail at Christopher.Newman@fhwa.dot.gov.

# Appendix E – Suggested Pavement Management Terms

**Threshold Distress Index**
A pavement condition indicator when a rehabilitation or reconstruction should be considered. The threshold distress index is arbitrarily set to some value, e.g. 50.

**Remaining Service Life, RSL (Distress)**
The estimated number of years, from a specified date, until a pavement section reaches the threshold distress index. RSL is a function of the distress level and rate of deterioration.

**Ride Index, International Ride Index (IRI)**
An index created that quantifies the user's perception of pavement ride quality. IRI is usually reported in inches per mile and increases as ride quality deteriorates.

**Threshold Ride Quality Index**
An index that establishes the beginning of poor ride quality on pavements; e.g. 120.

**Fix Life**
The anticipated life provided by the pavement fix, excluding any future pavement treatments.

**Design Life**
The number of years anticipated for a pavement section at the time of initial construction. Design life does not include any additional life estimates provided by anticipated future preventive maintenance.

**Service Life (Analysis Period)**
The anticipated life of a rehabilitation or new/reconstruction, including additional pavement life provided by anticipated future preventive maintenance. This term is used to describe the number of years from the initial new construction, reconstruction or rehabilitation of a pavement to a subsequent rehabilitation or reconstruction. A service life or analysis period equals the sum of the original design/fix life plus any additional pavement life provided by future anticipated preventive maintenance. Analysis period is the term typically used to describe the time used in a life cycle cost analysis.

# Appendix F – Press Release Formats

Suggested press releases could be patterned after the following examples.

**Example 1**

The Department of Transportation today announced it will be investing $80.0 million in 260 projects statewide next year through its Preventive Preservation Program.

The Program is designed to reduce normal wear and tear on the roads, and extend its service life by several years. In 2003, the DOT will be using the program to maintain 1,100 miles of roadway. "This is akin to taking care of your car – from changing the oil to rotating the tires," said State Transportation Director Tom Smith. "Everyone knows your vehicle will last much longer with a little routine maintenance. Roads and bridges are no different."

Research shows that for every $1 spent on pavement preservation, the state can save at least $6 in road rehabilitation and reconstruction. DOT's goal is to have 90 percent of state roads in good condition by 2010. Achieving this goal would not be possible without the Pavement Preservation Program. "Pavement preservation helps keep good roads in good condition," Smith said. "You can't continually make improvements without taking care of the investments you have already made. To do so would be a waste of time and money – and both are precious commodities."

**Example 2**

Pavement Preservation project extends life of roadway. The Department of Transportation (DOT) will begin resurfacing more than 11 miles of southbound US-26 from Normandy Road to Johnston Street starting July 5, 2006.

Southbound US-26 will have one lane of traffic maintained at all times. Northbound traffic will be unaffected. "Pavement preservation projects allow us to come in and fix a roadway before it falls into poor condition. The fixes that we do now may prevent the need to come in sooner to do a complete reconstruction of the roadway," said State Transportation Director Tom Smith.

The project entails the resurfacing of 11.1 miles of roadway and is scheduled for completion in late August 2005. "Our goal is to preserve the existing roadway while also preserving the ability of motorists to get through. It's a tough but necessary balancing act," said DOT's District Engineer Angus McTaggert.

More than $1 million project is being funded through the passage of Governor Brooks' Build Main Roads II plan and TEA-21. It will preserve this section of roadway for approximately five years.

**Example 3**

July 31, 2006--The Department of Transportation today announced more than 13 miles of US-121 near Wildwood will be resurfaced beginning Wednesday, Aug. 2.

"This project will continue to preserve our existing system by improving the ride quality of US-121 and extending the service life of the pavement for years to come," said Fred Niemeyer,

manager of the DOT's local field office in Junction City. "All work will be performed using single lane closures, leaving one lane open to traffic throughout the project limits."

Crews will place a thin one-course overlay of asphalt on north- and southbound US-121 from the southern McClain county line to 47 Mile Road.

"Work will be done around-the-clock in an effort to expedite the project, allowing completion by early-October," Niemeyer said. "The contractor has agreed to pave at night, which will reduce the impact on motorists."

This $2.2 million project continues Gov. Dallas Brooks' commitment to preserving and improving the state's transportation network.

Protect our families: Please slow down in work zones. - A message from the DOT and the Bring 'em Home Alive safety coalition.

# Appendix G – Informational Memorandum for ADA

# Memorandum

U.S. Department of Transportation

**Federal Highway Administration**

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**Subject:** **INFORMATION:** Clarification of FHWA's Oversight Role in Accessibility

**Date:** 9-12-06

**From:** J. Richard Capka
Administrator

**Reply to Attn of:** HCR-1
HIF-1

**To:** Associate Administrators
Chief Counsel
Chief Financial Officer
Directors of Field Services
Resource Center Director and Operations Managers
Division Administrators
Federal Lands Highway Division Engineers

The Federal Highway Administration (FHWA) announces consolidating guidance to clarify and address ongoing issues concerning FHWA's oversight of States' and localities' compliance with the Americans with Disabilities Act (ADA) and Section 504 of the Rehabilitation Act (Section 504). Based on the work of an ADA and Section 504 working group, the Associate Administrators for Civil Rights and Infrastructure present the attached clarification Memo to FHWA offices to explain how the FHWA is to oversee States' and localities' efforts to meet ADA and Section 504 obligations. In detailed Questions and Answers, FHWA provides further details on FHWA oversight and the actions required by the States and localities to meet ADA and Section 504 requirements. The Memo and the Questions and Answers will be posted on the Civil Rights Web site. Both of these documents clarify existing FHWA policies on issues including FHWA ADA and Section 504 oversight responsibilities, and appropriate actions by States and localities to meet the requirements of ADA and Section 504. Through the actions detailed above, the FHWA continues to work with States and localities to ensure that persons with disabilities may access the public right of way without discrimination.
Attachment


# Appendix H – Action Memorandum for ADA

# Memorandum

U.S. Department of Transportation

**Federal Highway Administration**

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**Subject:** **ACTION:** Clarification of FHWA's Oversight Role in Accessibility

**Date:** 9-12-06

**From:** Frederick D. Isler
Associate Administrator for Civil Rights
King W. Gee
Associate Administrator for Infrastructure

**Reply to Attn of:** HCR-1
HIF-1

**To:** Associate Administrators
Chief Counsel
Chief Financial Officer
Directors of Field Services
Resource Center Director and Operations Managers
Division Administrators
Federal Lands Highway Division Engineers

The Federal Highway Administration (FHWA) recognizes the need for the transportation system to be accessible to all users. The purpose of this memorandum is to clarify FHWA's role and responsibility to oversee compliance on pedestrian access required by the Americans with Disabilities Act of 1990 (ADA) and Section 504 of the Rehabilitation Act of 1973 (Section 504). Since 1978, FHWA has promoted accessible transportation systems through technical assistance and guidance on ADA and Section 504. In addition, accessibility improvements are eligible for Federal-aid funding.
The FHWA is responsible for implementation of pedestrian access requirements from the ADA and Section 504. This is accomplished through stewardship and oversight over all Federal, State, and local governmental agencies ("public agencies") that build and maintain highways and roadways, whether or not they use Federal funds on a particular project.

## *Policy*

In February 2000, the FHWA issued a policy providing technical guidance to integrate facilities for pedestrians, including persons with disabilities, into the transportation infrastructure. The guidance can be found at www.fhwa.dot.gov/environment/bikeped/design.htm#d4.
The ADA and Section 504 do not require public agencies to provide pedestrian facilities. However, where pedestrian facilities exist they must be accessible. Furthermore, when public agencies construct improvements providing access for pedestrians, the completed project also must meet accessibility requirements for persons with disabilities to the maximum extent feasible.

## *Planning*

Title 23 requires that long-range transportation plans and transportation improvement programs, in both statewide and metropolitan planning processes, provide for the development and integrated management and operation of accessible transportation systems and facilities.
Additionally, State DOTs and Metropolitan Planning Organizations (MPOs) must certify (at least

biennially for State DOTs and annually for MPOs) that the transportation planning process is being carried out or conducted in accordance with all FHWA, Federal Transit Administration and other applicable Federal statutory and regulatory requirements [see 23 CFR 450.220 and 23 CFR 450.334, respectively]. Further, 23 CFR 450.316(b)(3) requires the metropolitan planning process to identify actions necessary to comply with the ADA and Section 504.

## *Transition Plans*

The ADA and Section 504 require State and local governments with 50 or more employees to perform a self-evaluation of their current services, policies, and practices that do not or may not meet ADA requirements. The public agency must develop a Transition Plan addressing these deficiencies. This plan assesses the needs of persons with disabilities, and then schedules the required pedestrian accessibility upgrades. The Transition Plan is to be updated periodically, with its needs reflected in the processes utilized by State DOTs, MPOs, and transit agencies to develop the Statewide Transportation Improvement Programs and metropolitan Transportation Improvement Programs.

## *Projects*

Public agencies should work to meet accessibility requirements throughout the project delivery process. Issues surrounding pedestrian accessibility should be addressed at the earliest stage possible to reduce or prevent conflicts with other right-of-way, planning, environmental, and design considerations. This could include the acquisition of right-of-way and use of special plan details for specific locations to remove barriers. Projects requiring pedestrian accessibility include projects for new construction and projects altering existing street and highway facilities.

## *New Construction*

All projects for new construction that provide pedestrian facilities must incorporate accessible pedestrian features to the extent technically feasible, without regard to cost. The development process should ensure accessibility requirements are incorporated in the project.

## *Alterations*

Alterations shall incorporate accessibility improvements to existing pedestrian facilities to the extent that those improvements are in the scope of the project and are technically feasible, without regard to cost. Projects altering the usability of the roadway must incorporate accessible pedestrian improvements at the same time as the alterations to the roadway occur. See **Kinney v. Yerusalim**, 9 F.3d 1067 (3d Cir. 1993), cert. denied, 511 U.S.C. 1033 (1994). Alterations are changes to a facility in the public right-of-way that affect or could affect access, circulation, or use by persons with disabilities. The FHWA has determined that alterations are projects that could affect the structure, grade, function, and use of the roadway. Alteration projects include reconstruction, major rehabilitation, structural resurfacing, widening, signal installation, pedestrian signal installation, and projects of similar scale and effect.

## Maintenance

Maintenance activities are not considered alterations. Therefore, maintenance projects do not require simultaneous improvements to pedestrian accessibility under the ADA and Section 504. The U.S. Department of Justice (DOJ) and the courts consider maintenance activities to include filling potholes. The FHWA has determined that maintenance activities include actions that are intended to preserve the system, retard future deterioration, and maintain the functional condition of the roadway without increasing the structural capacity. Maintenance activities include, but are not limited to, thin surface overlays (nonstructural), joint repair, pavement patching (filling potholes), shoulder repair, signing, striping, minor signal upgrades, and repairs to drainage systems.

As part of maintenance operations, public agencies' standards and practices must ensure that the day-to-day operations keep the path of travel open and usable for persons with disabilities, throughout the year. This includes snow and debris removal, maintenance of pedestrian traffic in work zones, and

correction of other disruptions. Identified accessibility needs should be noted and incorporated into the transition plan.

## *Accessibility Design Criteria for Sidewalks, Street Crossings, and Trails*

### Sidewalks and Street Crossings

Where sidewalks are provided, public agencies shall provide pedestrian access features such as continuous, unobstructed sidewalks, and curb cuts with detectable warnings at highway and street crossings. 28 CFR 35.151(c), referencing 28 CFR Part 36, App. A, ADA Accessibility Guidelines (ADAAG). The FHWA encourages the use of ADAAG standards. If pedestrian signals are provided, they must have a reasonable and consistent plan to be accessible to persons with visual disabilities. Sidewalks and street crossings generally should use the guidelines the Access Board is proposing for public rights-of-way. The FHWA distributed an information memorandum on November 20, 2001, stating that ***Designing Sidewalks and Trails, Part II, Best Practices Design Guide*** can be used to design and construct accessible pedestrian facilities. This report provides information on how to implement the requirements of Title II of the ADA. *Designing Sidewalks and Trails for Access* is the most comprehensive report available for designing sidewalks and street crossings and contains compatible information on providing accessibility with information published by the Access Board in the ADAAG. This report can be found at www.fhwa.dot.gov/environment/sidewalk2.
When the Access Board completes guidelines for public rights-of-way and they are adopted by the United States Department of Transportation and DOJ as standards under the ADA and Section 504, they will supersede the currently used standards and criteria.
When Federal-aid highway program funds are used for parking facilities, or buildings such as transit facilities, rest areas, information centers, transportation museums, historic preservation projects, or other projects where pedestrians are expected, the project must meet the current applicable accessibility standards, whether or not the project is within the public right-of-way. The ADAAG includes special provisions for building alterations and for historic preservation projects.

### Shared Use Paths and Trails

The design standards for shared use paths and trails are specific to the function of the path or trail:

- Shared use paths and pedestrian trails that function as sidewalks shall meet the same requirements as sidewalks. Where shared use paths and pedestrian trails cross highways or streets, the crossing also shall meet the same requirements as street crossings, including the provision of detectable warnings.
- Shared use paths and pedestrian trails that function as trails should meet the accessibility guidelines proposed in the Access Board's *Regulatory Negotiation Committee on Accessibility for Outdoor Developed Areas Final Report* found at www.access-board.gov/outdoor/outdoor-rec-rpt.htm. This report also has guidelines for Outdoor Recreation Access Routes (routes connecting accessible elements within a picnic area, camping area, or a designated trailhead).
- Recreational trails primarily designed and constructed for use by equestrians, mountain bicyclists, snowmobile users, or off-highway vehicle users, are exempt from accessibility requirements even though they have occasional pedestrian use.

Most trailside and trailhead structural facilities (parking areas, restrooms) must meet the ADAAG standards.

## *Technical Feasibility and Cost*

When constructing a new transportation facility or altering an existing transportation facility, a public agency should consider what is included within the scope of the project. For elements that are within

the scope of the project, the ADAAG provides that "Any features of a...facility that are being altered and can be made accessible shall be made accessible [i.e., made to conform with ADAAG] within the scope of the alteration." ADAAG 4.1.6(j). The only exception to this rule is where conformity with ADAAG is "technically infeasible," meaning that "existing structural conditions would require removing or altering a load-bearing member which is an essential part of the structural frame [e.g., in the case of a highway project, a bridge support]; or because other existing physical or site constraints prohibit modification of addition of elements, spaces, or features which are in full and strict compliance with the minimum requirements for new construction and which are necessary to provide accessibility." ADAAG 4.1.6(j).

Where making an alteration that meets accessibility requirements is technically infeasible, the public agency must ensure that the alteration provides accessibility to the "maximum extent feasible." If a public agency believes that full ADAAG compliance is technically infeasible, the public agency should document that the proposed solution to the problem meets the "maximum extent feasible" test. With respect to any element of an alteration that is within the scope of the project and is not technically infeasible, DOJ guidance provides that under ADAAG standards "cost is not a factor." DOJ Technical Assistance Manual for Title II of the ADA, II-6.3100(4). Consequently, if the accessibility improvement is technically feasible, the public agency must bear the cost of fully meeting ADAAG standards. However, cost may be a factor in determining whether to undertake a stand-alone accessibility improvement identified in a Transition Plan. For example, if an existing highway, not scheduled for an alteration, is listed in the public agency's Transition Plan as needing curb cuts, the public agency may consider costs that are "unduly burdensome." The test for being unduly burdensome is the proportion of the cost for accessibility improvements compared to the agency's overall budget, not simply the project cost.

If the project alters any aspect of the pedestrian route, it must be replaced with accessible facilities. Additional work outside of the scope and limits of the project altering a facility is at the discretion of the agency. However, any features not conforming to ADA requirements outside the project scope should be added to the Transition Plan.

## *FHWA Responsibilities*

The FHWA is responsible for ensuring public agencies meet the requirements of the ADA and Section 504 for pedestrian access for persons with disabilities. Under DOJ regulations, FHWA divisions must work with their State DOTs, MPOs, and local public agencies to ensure ADA and Section 504 requirements are incorporated in all program activities for all projects within the public right-of-way regardless of funding source. Program activities include project planning, design, construction, and maintenance. Furthermore, FHWA is responsible for ensuring accessibility requirements for projects that are not within public right-of-way, but use funding through FHWA. This includes parking areas, information centers, buildings, shared use paths, and trails. Divisions have a legal responsibility to work with State agencies or other recipients to ensure ADA and Section 504 requirements are incorporated into all projects using funding through FHWA.

For all projects that use Federal funds as part of the financing arrangements, the division offices need to periodically:

- Review those projects, where they have oversight responsibilities, for accommodation of pedestrians. The divisions shall not approve Federal funding for projects that do not adequately provide pedestrian access for persons with disabilities where the project scope and limits include pedestrian facilities in the public right-of-way.
- Review the Stewardship Agreement to ensure pedestrian accessibility requirements are included, as appropriate.
- Review the State DOT, MPO, and/or local jurisdiction processes, procedures, guidelines, and/or policies that address ADA in transportation planning and programming processes and how accessibility commitments are addressed in transportation investment decisions.
- Assist transportation agencies in updating their Transition Plans. The United States Department of Transportation Section 504 regulation requires FHWA to monitor the compliance of the self-evaluation and Transition Plan of Federal-aid recipients (49 CFR

27.11). The ADA deadline for completing the accessibility improvements within the Transition Plan was in 1995. For those State and local governments that have not performed the self-evaluation and prepared a plan, it is critical that they complete the process.

- Encourage and facilitate training for FHWA personnel on accessible pedestrian features.
- Ensure pedestrian accessibility compliance through periodic program reviews of recipients' highway planning, design, and construction activities.
- In addition, the Federal Lands Highway Divisions should ensure that each direct Federal construction project fulfills both policy guidance on pedestrian access and meets the minimum ADA and Section 504 accessibility requirements.

For all highway, street and trail facilities, regardless of whether Federal funds are involved, the division offices need to:

- Perform onsite review of complaints about accessibility and report the findings of the review to HCR-1.
- Make presentations and offer training on pedestrian accessibility at meetings, conferences, etc.
- In contacts with State and local officials, encourage them to develop procedures for incorporating pedestrian accessibility into their projects.

## *Additional Information and Resources*

A Web site with questions and answers concerning recurring issues, training opportunities, and background legal information on FHWA's responsibilities under the ADA and Section 504 is located at http://www.fhwa.dot.gov/civilrights/index.htm. This memorandum has been reviewed and approved by the U.S. Department of Transportation General Counsel as consistent with applicable disability law. Questions concerning these obligations may be directed to:

- For Accessibility Policy: Candace Groudine, Bob Cosgrove, Office of Civil Rights
- For Design Standards: William A. Prosser, Office of Program Administration
- For Trails: Christopher Douwes, Office of Natural and Human Environment
- For Construction and Maintenance: Christopher Newman, Office of Asset Management
- For Legal: Lisa MacPhee, Office of the Chief Counsel


# Appendix I - Supplemental Observations

## 1. Training

- Pavement preservation is not a regular part of training and there are no specific training classes for pavement preservation. Training is most needed in crack sealing, fog seals, and preservation treatments in general.
- Designers are required to design projects with which they are not familiar, e.g., dowel bar retrofits (DBRs). Staff told us that contractors would probably resist training, particularly contractors in most need of the training.
- SD Pierre Region – Staff told us that a free, on-line pavement preservation training course was being offered in the spring of 2009. Prior to that, almost no training had been offered since the Bureau of Personnel had taken over the training responsibilities about 6 years ago.
- SD Pierre Region – Training is needed by:
    - Field engineers, technicians, designers for field staff (50 persons per region),
    - Maintenance supervisors and lead workers (20 persons per region), and
    - Regular maintenance workers (80 persons per region).
- SD Pierre Region – Staff told us that their most immediate pavement preservation training needs were:
    - Emulsion training,
    - Inspector training for different types of treatments,
    - Treatment application timing, and
    - Treatment tools available.
- SD Mitchell Region – Staff told us that within the preceding 1 or 2 years, a chip seal video conference had been offered, but there had been no training in asphalt treatments. The only training that staff could remember was limited to chip seals.
- SD Mitchell Region – Training is needed by:
    - Area engineers,
    - Maintenance supervisors,
    - Region engineers,
    - Engineering staff, and
    - Regular maintenance workers.
- SD Mitchell Region – Staff told us that their most immediate pavement preservation training needs were:
    - Pavement Management System and departmental operations,
    - Preservation guidelines to assist with treatment choice and application timing, and
    - Details of preservation treatments and their applicability.
- The state's universities are not involved with pavement preservation training.
- South Dakota's LTAP Center at the South Dakota State University in Brookings, SD is not involved with pavement preservation training, but would be willing to assist agencies with their needs.
- According to staff in the Mitchell Region, the LTAP had not provided any training in pavement preservation.
- Staff mentioned the following LTAP personnel as potential resources:

  - Ken Skorseth, Program Manager,
  - Larry Weiss, Technical Assistance Provider, and
  - Ronald Marshall (formerly with FHWA), Technical Assistance Provider.
- No training on the PMS is currently being offered, although this type of training is essential if the Department expects to use the PMS to do strategic planning and assist with project selection.
- The Department's training responsibility is now located in the Bureau of Personnel.
- South Dakota requires 30 Continuing Education Units (CEUs) each two years to maintain engineering registration (PE license).

## 2. Pavement Management System

- Asphalt and concrete distress data are collected and stored in the PMS. In addition, the PMS contains construction history and some types of material history.
- Asphalt distress data include transverse cracking, fatigue cracking, block cracking, patch deterioration, roughness, and rutting (using a Road Profiler).
- Concrete distress data include D-cracking, Alkali Silica Reaction (ASR), corner cracking, joint spalling, joint seal condition, faulting, roughness, and punch outs (on continuous reinforced concrete (CRC)).
- Each year, pavement information is collected from almost[9] all of the system. Visual distress is observed for both lanes in one direction. The Road Profiler collects information in both directions.
- Pavement information is collected by observing visual distress over 100% of the system (windshield survey at 10 to 15 mph along the shoulder) and the use of a Road Profiler (Pathways Van) to collect ride and rutting information.
- The pavement information is collected by two crews of college students each summer after a 2-week training course. The collection exercise includes running a quality control element for speed and quick checks. Distress information is entered via a touch-screen computer with drop down menus. Distress type, severity, and extent are collected.
- Pavement data are recorded for 0.25 mile segments. The profiler is able to record information from any length of segment, but restricts segment length to 0.10 mile.
- The pavement information data are available to anyone within the agency, either in the published "needs book" or via the on-line Intranet for state employees.
- The agency's referencing system uses Mileage Reference Markers (MRMs). Mileages begin at zero in the south and west and posted in the field and at the "high ends" of bridges. Locations are shown in the MRM log guide.
- Staff believe the pavement condition rating is very accurate and changes or errors are infrequent, but may happen occasionally. The ratings are checked for accuracy.
- The pavement management system contains chip seals, micro-surfacing, rout and seal, overlays, and mill and overlay.
- SD Pierre Region – Generally, the pavement condition rating (PCR) is considered by staff to be good. The regions can request a change in the PCR if the pavement's condition appears inconsistent with the recorded PCR. The regions have the

[9] Reduced from 100% due to ongoing construction.

flexibility to address needs that may appear in short order to avoid major problems. Maintenance personnel see these needs and potential problems.

- Pierre Region staff generally accepts pavement preservation, but have certain frustrations. The PMS may recommend different timeframes than originally predicted. Some regions experience a reduction in the project size to accommodate another region's big job and so, they miss the window of opportunity. The predictability relationships (curves) are not always accurate. There is a formal / informal feedback loop in the Region's ride around. The number of problems has diminished in recent years.
- SD Mitchell Region – Generally, the pavement condition rating (PCR) is considered by staff to be good. Occasionally, when some ratings are slightly inaccurate, the Region can make adjustments. The PCR is used as a tool.
- SD Mitchell Region – The Falling Weight Deflectometer (FWD) is beginning to be used to test certain project candidates.
- The rate of pavement deterioration is considered within the pavement management system and the system uses individual distress indices rather than a composite index, although the latter is reported.
- The pavement management system can review plots of all conditions and forecast pavement condition.
- Preservation strategies do include a "mix of fixes".
- The PMS provides a means of budgeting, based on needs, to achieve a certain goal. The DOT is also considering a complete Asset Management approach.

## 3. Project Selection

- Within the agency, project selection is ultimately the responsibility of the Project Development Section, but the process involves consensus building by a team from regional offices comprised of representatives from PMS, Materials, and field staff. Region and Area Engineers and a FHWA representative are included on the teams and others may attend as needed. Initially, reviews were conducted separately for Interstate and non-Interstate highways, but the separate reviews have since been combined.
- The DOT has a strong proactive approach to pavement preservation.
- Staff told us that they are incorporating more detailed guidance into the new guidelines. They are also trying to distribute funding somewhat uniformly to meet the state's needs, but sometimes project priorities are strongly influenced by traffic and PMS considerations.
- Pavement surface conditions are treated by the following preservation treatments:

| | |
|---|---|
| o Crack seals | Transverse cracking |
| o Chip seals | Block cracking |
| o Micro-surfacing | Rutting |
| o Spall repair | Deteriorated joints |
| o Diamond grinding | Faulting |

- Pavement preservation treatments used on all functional road classifications.
- Pavement preservation projects (1 year out) are included in the STIP as a group line item. Programmed projects (3+ years out) are referenced individually in the STIP.

- In the past, traffic volumes influenced the selection of certain pavement preservation treatments. The agency is reducing its use of chip seals on Interstate highways.
- The monetary value of avoided traffic delays associated with reduced work zone requirements for preservation projects is not considered when evaluating the cost effectiveness of pavement preservation treatments. Staff told us that very few areas have major traffic concerns and they felt that the additional analytical effort would not be worth the effort.
- Pierre Region staff told us that chip seals were no longer applied to the Interstate highways stemming from problems encountered with loose chips and windshield damage in the Mitchell and Watertown areas. Chip seals appear to work well on roadways carrying 2,000 ADT up to 4,000 or 5,000 ADT.
- Mitchell Region – Project selection begins when the Planning and Programming (P&P) staff meet with the Region staff to discuss their priorities. The P&P staff refine the project list and meet as a large group in April / May to develop the 5-year STIP. Chip seals are treated as a stand-alone treatment and are not debated. The process is continuing to improve.
- Mitchell Region staff believe guidelines are a good idea and would help make pavement preservation treatment selections more uniform and consistent.
- With the exception of chip seals on Interstate highways, traffic volumes in the Mitchell Region have not influenced the selection of certain pavement preservation treatments.
- Mitchell Region's staff strongly support pavement preservation. However, they support a 2-lift overlay rather than a single lift. Often, funding decides what the agency can do. The negatives are those pavement projects that fail early.

## 4. Terminology

- According to staff, the FHWA's eligibility requirements define the terminology.

## 5. Champion

- No further comments

## 6. Performance Monitoring

- The Department believes that a 20-year design asphalt pavement will last for its design life of 20 years. South Dakota, which consistently applies preservation treatments to its pavements, is considerably ahead of many other agencies.
- Pierre Region – Staff told us that a 20-year design left without maintenance would last about 7 to 8 years. Other Pierre Region staff felt the design would last about 10 years.
- Mitchell Region – Staff told us that a 20-year design left without maintenance would last about 12 to 15 years.

## 7. Business Process

- Staff told us that the Department estimates CE at 8 %, although this number may be higher than the actual.

- Past reviews show that the amounts designated for PE and CE usually have been sufficient to cover these costs.
- When soliciting bids for pavement preservation projects, the agency uses standard bid items, except for asphalt binders which are costed separately.
- Most projects normally are prepared for bidding on 11" x 17" plan sheets, with some 8½" x 11" sheets being used. All bidding is done electronically and plans contain typical sections, standard traffic control, etc.
- The typical advertising lead time for bidders of pavement preservation projects is usually 3½ weeks with the standard being 3 weeks. Bids are due by the first and third Wednesday of each month, except in December.
- Pavement preservation plans are formally reviewed prior to posting. Currently, there are insufficient reviewers due to a staff shortage.
- The Department requires all contractors to be pre-qualified based on financial ability, equipment, work experience, and ability to do the work.
- All projects are let through Headquarters and plans are checked for consistency.
- Staff told us that the only warranty project (design-build) that the Department had done did not go well. The warranty period varied from 3 to 5 years depending on the particular item being warranted.
- Mitchell Region staff told us that for a past project, a 5-year warranty was difficult to enforce.

## 8. Quality Control & Quality Assurance

- Staff told us that the way they assure the placement of a good product varied by type of project For example,
    - HMA: In 1995, the Department launched a QC / QA program and provided training and seminars across the state during 1995 and 1996.
    - Concrete: The Department requires American Concrete Institute (ACI) certification for testing and all technicians are certified to conduct inspections.
    - Thin treatments: Training has been provided by Mr. Tom Wood using video-conferencing.
    - Crack sealing and crack filling: Training is provided by on-the-job experience.
    - Micro-surfacing: The Department uses a standard specification and attempts to work with contractors, e.g., Monarch Oil Company, Ballou Construction Company.
- Project contractor submit mix designs, chip seal compatibility test reports, aggregate source documentation, and load tickets.
- Pierre Region – Project contractors submit mix designs for approval, aggregates and emulsions are sampled and tested, and transport deliveries are certified.
- Mitchell Region – the Region assures the placement of a good product by testing the materials and inspecting the work.
- To insure that materials used on preservation projects meet specifications, the Department uses tested stock and an approved product list (still makes one test per lot). Although asphalt binders and emulsions are not certified, every load is sampled and tested.

## 9. Public / Political Relations

- The Department has undertaken an extensive 2-year program to educate the Legislature, especially with respect to funding. There have also been public meetings, such as STIP hearings at which preservation and the proactive use of public funds have been discussed. The agency has also prepared special pavement preservation presentations for discussions with public groups.
- Staff told us that about 95% of the agency's management supported the preservation concept. Occasionally, there has been opposition from persons who have had to cut (construction) projects.
- Acceptance of the preservation concept has taken time and required a change in the organization's culture. Preservation's eligibility for federal funding has also helped to promote the change, and staff estimated a 75% to 80% acceptance of the preservation concept by rank and file employees.
- Staff also told us that the Spring Engineering Meeting was used to pass information between regions.
- The South Dakota public is largely comfortable with the concept of pavement preservation, although a few communities are pushing for economic development.
- In response to the few public and political inquiries about working on good roads when roads in poor condition do not receive similar priority, the Department urges its employees to use analogies. The Department also participates in the development of the STIP and reviews of state pavements.
- Pierre Region – The management is strongly committed to pavement preservation.
- Mitchell Region – Staff told us that often, a lack of funds can explain why roads are not reconstructed. Staff probably hear more about the problem from their employees than from the public.
- Pierre Region staff told us that the public tended to look at the "worst first".
- In the Mitchell Region, staff felt that the public did not understand the pavement preservation concept.
- The Department places road information on the Internet. In the Mitchell Region, the media are more interested in reporting what is being done that will impact traffic. News releases come from Headquarters in Pierre.

## 10. Program Implementation

- South Dakota DOT plans its pavement preservation strategy about 3 years ahead. Chip seals and crack seals are planned about a year ahead. Each year, a team visits the regions to assist with programming projects into the STIP.
- Pavement preservation is integrated into a comprehensive network strategy that includes major rehabilitation and reconstruction.
- South Dakota DOT's PMS proposes candidate preservation projects which are then checked by field team to verify their suitability. The PMS does not always show current rutting information. The raw data are available to field personnel.
- The agency's pavement preservation program of $20M / year is integrated with the PMS and all treatments are included.

- Staff told us that the life-extending benefits of pavement preservation treatments are estimated from 145 performance relationships (curves) stored in the PMS. The performance relationships are based on data collected since about 1993.
- The agency tracks the performance of pavement preservation treatments by annual observations to verify the accuracy of the data contained in the PMS.
- Preservation treatment costs are obtained from an annual report produced in December or January each year.
- Although spot sealing is done by maintenance forces, staff told us that less than 10% (by cost) of pavement preservation is done using agency forces.
- Staff told us that usually, there was good competition for surface treatments by up to 8 or 9 contractors.
- Although the agency does not make formal cost effectiveness calculations, staff told us that they intuitively know that pavement preservation is very cost effective.
- Often, a second round of crack sealing are done by state forces, although this amounts to less than 20% of this type of work.
- Mitchell Region staff told us that they did not see a problem with safety criteria as there were reduced standards for preservation projects. Staff also felt that there were no undue environmental requirements for preservation projects.

## 11. Preservation Treatments

- South Dakota's preservation "toolbox" contains the following 15 treatments[10]:
  - Concrete joint repair or panel replacement,
  - Thin overlays,
  - Restoration of pavement drainage system,
  - Dowel bar retrofit,
  - Partial and / or full depth concrete repairs,
  - Concrete spall repair,
  - Under-sealing and / or pavement jacking concrete pavement,
  - Chip seals,
  - Rout and seal cracks in asphalt pavements,
  - Shoulder repair,
  - Micro-surfacing,
  - Macro-surfacing,
  - Rut filling,
  - Diamond grinding, and
  - Re-sealing joints and random cracks in concrete pavement.
- Staff told us that all treatments will work if used on the right road at the right time, while other staff told us that they had had less success with chip seals. Chip seals applied late in the season had experienced more problems.
- Decisions on when to place pavement preservation treatments are based on PMS trigger values which are revised to reflect past and present experience.
- Industry influence on the selection of pavement preservation treatments has not been a problem. Some influence may be exerted on the pavement selection of large projects, but the influence has been limited.

[10] "Preservation Project Eligibility Guidance", 15 December 2008.

- The Department's annual expenditures for chip seals and crack seals average $20M. The total Pavement Preservation 3-year budget ranges from $160M to $180M.
- The duration of a treatment's effectiveness may be based on experience, historical data, or performance relationships (curves).
- Some new contractors have had problems due to lack of experience. Sometimes problems are caused by the use of poor materials. The Department would be interested in considering a certification requirement for contractors.
- The public tend to dislike chip seals because of the loose stones. As a way of minimizing loose stones, the Regions will apply a fog seal using a 50% solution of CSS-1h after the final brooming of a chip seal. The Region's fog seals have the following benefits: 1) pavement markings applied to the fog seals are more readily visible, and 2) a fog seal's color stays black for periods ranging from several months to 2 years.
- A 26-foot wide fog seal costs about $1,000 per mile and traffic can be put on a fog seal after 1 to 1½ hours and sometimes after as little as 45 minutes.
- Pierre Region – Staff told us that they were uncertain of the potential benefits of rout and seal treatments.
- Pierre Region – The Region has experienced success with micro-surfacing which appears to have great potential due to its ability to correct certain rutting, although some of the contractors have produced mixed results. Chip seals have also performed well.
- Pierre Region – Staff told us that chip seals can use local aggregate sources, which keeps prices down. Microsurfacing also has good rut-filling potential which can avoid the necessity of an overlay.
- Lacking a formal process for determining the duration of a treatment's effectiveness, the Pierre Region relies on its experience and judgment.
- Pierre Region – Staff did not see industry influence as a big issue. Some HMA contractors are doing chip seals.
- Mitchell Region – Most overlays consist of a single lift. Less than 5% of overlays consist of 2 lifts.
- Mitchell Region – The Region has had success with chip seals, sometimes with an asphalt scratch coat.
- Mitchell Region – Staff told us that the preservation treatments eliminated surface water "ponding" in ruts, restored ride, and improved friction.
- Mitchell Region – Staff told us that they had had less success with concrete spall repairs.
- Mitchell Region – The concrete spall repairs had experienced problems with materials and freezing and thawing.
- The Mitchell Region determines the duration of a treatment's effectiveness by visual inspection based on past experience. Staff makes annual inspections with the maintenance crews.
- Mitchell Region – Staff did not experience any pressure from contractors.

## 12. Research and Development

- The Office of Research administers and performs research conducted by the South Dakota Department of Transportation (SDDOT), under the direction of the Department's Research Review Board[11]. Each year, the Office of Research solicits research problems from the Department's central and field offices. In meetings with individual offices or in Department-wide need assessment meetings, Department personnel are asked to suggest research pertinent to their needs. The Office of Research also invites suggestions from the academic and consultant communities.
- When the research suggestions have been received, the Office of Research prepares a list and ballot for the Board's selection and prioritization at its August meeting each year. The Department has a formal process for preparing and distributing requests for proposals (RFPs), accepting proposals and bids, awarding contracts, and developing work plans. RFPs are typically for open bids from across the country.
- The Department may obtain research services from the South Dakota School of Mines and Technology, or the South Dakota State University at overhead rates of 40% to 42 %. Research may be sole-sourced to the state's universities if and when needed.

## 13. Pavement Preservation Assistance

- The DOT's pavement management system and preventive maintenance program have been in existence for a long time and the DOT does a very good job of running the programs. Because the programs are so advanced, the Division Office's role has been somewhat limited. Within the Division Office, pavement management and pavement preservation are two of the collateral duties of the Pavement and Materials Engineer. The Division Office's main avenue for providing assistance to the DOT has been through the sharing of best practices, and serving on various DOT technical panels. Part of the Pavement and Materials Engineer duties include approval of the DOT specifications, which provides an opportunity to assist in developing pavement preservation specifications. For several years, the FHWA Engineers had accompanied the DOT personnel on van trips conducted in the various Regions to

[11] The Board's membership is broad and includes SDDOT and local government representatives:

- Secretary of Transportation
- Deputy Secretary of Transportation
- Director, Division of Planning / Engineering
- Director, Division of Operations
- Director, Division Fiscal & Local Assistance
- Chief Highway Engineer
- Materials & Surfacing Engineer
- Research Engineer & Research Staff Engineer
- Field Operations Representative
- City Government Representative
- County Government Representative
- Federal Highway Administration Research Coordinator
- South Dakota Board of Regents System Vice President for Research

The Director of the Division of Planning/Engineering chairs the Board, and the Research Engineer is its secretary. The City, County, and Field Operations representatives serve two-year terms, beginning on the first of January of even numbered years. The other representatives serve as long as they hold their respective positions.

program construction projects. With the advanced state of DOT pavement preservation program, the FHWA has not been invited or attended the van trips the last couple of years.

## 14. Materials

- South Dakota has available the following types of aggregate:
  - Limestone (good quality) on the west side of the state,
  - Granite on the east side and in the Black Hills,
  - Quartz on the east side of the state,
  - River gravel (poor quality) along the Missouri River, and
  - Natural sand on the east and south sides of the state.
- Quartz and limestone are preferred; granite is more isolated. The agency is prepared to haul good quality aggregate up to 200 miles for a project.
- Staff told us that South Dakota's proportions of concrete and asphalt pavements have remained relatively stable over time.
- The Department has experienced problems with reactive aggregates which it addressed with the use of fly ash. Some sands and river gravels are no longer used. The Department screens aggregates using ASTM C1260-07, "Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)".
- In the past, the Department had a problem with asphalt stripping and required lime to be added to HMA mixes. Some stripping problems were experienced on I-90, but most of the bad sources are gone. The agency uses the ASTM[12]-4867 stripping test.
- In its asphalt binders, the Department routinely uses polymers (SBS or SBR). Binders include:
  - PG 58-28 (with recycled asphalt pavement (RAP)),
  - PG 64-28 choice),
  - PG 64-34, and
  - PG 64-22 (some lesser quantities).
- The agency uses the AASHTO specification and / or the South Dakota specification to specify the residual asphalt percentage in the emulsions it uses.
- The Department uses the following emulsions:
  - Chip seals AE-150S, CRS-2P
  - Tack coats CSS-1h
  - Fog seals CSS-1h
- Maintenance forces routinely use the same binders and emulsions as construction forces, except that maintenance uses AE-150S rather than CRS-2P. AE-150S is used when improved stability at high and low temperatures is required. The Department does use polymers in its emulsions and CRS-2P is its emulsion of choice rather than the AE-150S, except for use with dirty aggregates.
- The agency obtains emulsions from Jebro, Inc., Flint Hills Resources, and Senec (western South Dakota).
- Pierre Region staff told us that in 2008, they had difficulty obtaining emulsions.
- Mitchell Region – Most aggregate in the Mitchell Region is quartzite.

[12] ASTM = American Society for the Testing of Materials.

- Mitchell Region – In the past, the Region did experience asphalt stripping problems, but these have been successfully addressed with the use of lime.
- Mitchell Region – Some aggregates have caused alkali silica reactions (ASRs).
- Mitchell Region – Although the Region generally uses PG 64-34, they use PG 58-28 for recycled asphalt pavement (RAP[13]).
- Mitchell Region – The Mitchell Region uses the following emulsions:
  - CRS-2P Current emulsion,
  - AE-150S Used in the past, and
  - CSS-1h Used for shoulder flushes and tack coats.
- Mitchell Region – Staff told us that maintenance forces did not routinely use the same materials as construction forces for rut filling. This is significant because high-polymer mixes tend to be difficult to work.

[13] RAP usage is up to 20%.

## APPENDIX E: RUMBLE STRIP/STRIPE INSTALLATION

(August 28, 2009 SDDOT Memorandum)

**Department of Transportation**
**Division of Planning & Engineering**
**Office of the Director**
700 E Broadway Av, Pierre, SD 57501-2586
Phone: 605 773-3174 Fax: 605 773-3921

MEMORANDUM

DATE: August 28, 2009

TO: Division of Planning & Engineer & Division of Operations

FROM: Mike Behm, State Highway Engineer
Division of Planning & Engineering

RE: Rumble Strip/STRIPE installation

The purpose of this document is to provide engineers additional guidance on the installation of rumble strips/STRIPES. Rumble strips/STRIPES should be considered on all projects. The installation of rumble strips/STRIPES will be decided on a case by case basis after analyzing all pertinent data and utilizing engineering judgment.

Recent research as identified in NCHRP 17-32, Guidance for the Design and Application of Shoulder and Centerline Rumble Strips, recognizes the safety benefits and subsequent reduction of single-vehicle run-off-the-road crashes through the installation of shoulder Rumble Strips. Shoulder Rumble Strips have been installed on South Dakota roads for over a decade. This guidance is intended to supplement current rumble strip guidance.

**Project Types Defined**

Stand Alone Rumble Strip/STRIPE Projects – Grouped projects where the primary purpose is to accommodate rumble strip installation. The projects may include grinding, asphalt surfacing, and shoulder modification.

Coordination Project – Installation of Rumble Strips/STRIPES during resurfacing, concrete paving, new and reconstruction, or rehabilitation of the roadway section.

**Asphalt Mainline Surface**

| Functional Classification | Shoulder Width | Mainline Width | Strip Width | Rumble Type | Continuous Or Intermittent |
|---|---|---|---|---|---|
| Interstate | 4' inside<br>10' outside | 28' | 12" | Rumble Strip | Continuous |
| Non-Interstate | 4' | 24'+shld | 8" | Rumble STRIPE | Intermittent |
| | >4' | 28' | 12" | Rumble Strip | Intermittent |

**Use**

Rumble strips/STRIPES should be considered on rural sections with posted speed limits 50 mph or greater. Typical crash types that have the potential to be reduced by shoulder rumble strips/STRIPES include roll-over on roadway, roll-over off roadway, and fixed object off roadway. The adjacent land use and road functionality should also be a consideration in determining whether to install rumble strips/ STRIPES.

The use of rumble STRIPES has been proven to enhance the visibility of pavement markings not only during night time conditions but also during wet weather. The use of rumble STRIPES should be coordinated with the region traffic engineer.

**Shoulders >4'**

Shoulder type may be asphalt, concrete, or gravel. A 28' mainline top for asphalt paving should be constructed to accommodate the use of rumble strips on the mainline pavement. The use of 12" rumble STRIPES can be considered as an effort to increase visibility of pavement markings upon recommendation from the region traffic engineer.

**4' Shoulders**

For sections of roadway with 4' shoulders, the engineer should use 8" rumble STRIPES in lieu of rumble strips in order to provide adequate lateral clearance for bicycle use. The engineer should also consider the inslope rate, location of fixed objects as compared to the edge of traveled way, horizontal/vertical alignment and other design elements.

**Shoulders < 4'**

The use of rumble Strips/STRIPES on sections with shoulders less than 4' should be reviewed with the region traffic engineer and the department's traffic and safety engineer after an analysis of historical crash data, inslope, fixed objects, horizontal/vertical alignment, current and future bicycle use, and other design elements.

**Bicycle Use**

The engineer should take into consideration the amount of bicycle use on a facility and its relation to shoulder width and lateral clearance. A minimum of 4' shoulder is required to accommodate bicycle use. If rumble strips/STRIPES are recommended on sections with less than 4' shoulders, a thorough analysis of bicycle use should be completed. Information pertaining to bicycle use can be obtained by contacting local bicycle shops and user groups.

**Centerline Rumble Strips/STRIPES**

The purpose of centerline rumble strips/STRIPES is to reduce the number of head on collisions. Centerline rumble strips/STRIPES can be considered on undivided rural sections of highways where crash history indicates a potential for increased head on collisions. Recommendations to install centerline rumble strips/STRIPES should be coordinated with department's traffic and safety engineer.

**PCCP Rumble Strips**

The installation of formed-in rumble strips on new PCCP pavement shall be spaced consistent with two times the joint spacing or a 40' maximum spacing. If for example, joint spacing is 15', the rumble strip should be placed 30' center to center and shall not coincide with any transverse contraction joint. If the proposed lane width is 14', the rumble strip should be installed on the PCCP.

For the installation of rumble strips on existing 14' wide PCCP lane(s), every effort should be made to grind rumble strips on a basis consistent with Asphalt Pavement Rumble Strip design, on the existing concrete pavement.

For existing PCCP two lane rural highways with 12' wide lanes, the Rumble Strip should be installed a maximum of 2' from the edge of concrete lane on the shoulder.

For divided highways, if the existing outside lane PCCP is 12', the Rumble Strip should be installed a maximum of 2' from the edge of concrete lane on the outside shoulder. Rumble Strips should be placed a maximum of 12" from the edge of concrete lane on the inside shoulder.

**Reference Material**:
South Dakota Department of Transportation Bicycle & Pedestrian info:
http://www.sddot.com/pe/projdev/planning_bp.asp

South Dakota Game Fish & Parks State Park Bicycle Tours:
http://www.sdgfp.info/Publications/Parks/BicycleTours.pdf

Federal Highway Technical Advisory for Roadway Shoulder Rumble Strips:
http://www.fhwa.dot.gov/legsregs/directives/techadvs/t504035.htm

South Dakota Department of Transportation Standard Plates:
SDDOT / Road Design / Standard Plates