Report No. CDOT-DTD-R-2004-17
Final Report

DEVELOPMENT OF A PAVEMENT PREVENTIVE MAINTENANCE PROGRAM FOR THE COLORADO DEPARTMENT OF TRANSPORTATION

August 2004

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CDOT-DTD-R-2004-17		

4. Title and Subtitle	5. Report Date
DEVELOPMENT OF A PAVEMENT PREVENTIVE MAINTENANCE PROGRAM FOR THE COLORADO DEPARTMENT OF TRANSPORTATION	August 2004
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Larry Galehouse	CDOT-DTD-R-2004-17
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
National Center for Pavement Preservation 2857 Jolly Road Okemos, MI 48864	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Colorado Department of Transportation 4201 E. Arkansas Ave. Denver, CO 80222	14. Sponsoring Agency Code

15. Supplementary Notes

Also includes Preventive Maintenance Program Guidelines and a Distress Manual for HMA and PCC Pavements

16. Abstract

NCPP was contracted to review CDOT's preventive maintenance program. Each region was visited to discuss various preventive maintenance treatments and examine current maintenance practices. Areas requiring further action before implementing a successful preventive maintenance program were identified.

Implementation - Immediate:

- Define, document, and distribute common terms throughout CDOT to assure a consistent vocabulary for understanding, describing, and communicating concepts. Define preventive maintenance.
- Start modestly in implementing preventive maintenance, assembling the program methodically, and building on success.
- Identify a champion to lead the integration of preventive maintenance.
- Develop a statewide preventive maintenance manual containing guidelines, specifications, forms, estimating criteria, policy directives and best practices.
- Develop and use statewide preventive maintenance specifications for every treatment type to establish uniformity.
- Provide training addressing preventive maintenance and pavement management concepts, pavement and treatment selection, materials, application techniques, inspection, and quality control.
- Establish a new policy providing clear direction for preventive maintenance. Parameters should be defined to clearly define boundaries between preventive maintenance, rehabilitation, and reconstruction.
- State purchasing rules make it difficult sometimes in remote locations. Consider implementing a pilot project to determine benefits to warrant a possible rule change.
- Regions should synchronize engineering and maintenance activities. Recommend a program coordinator in each region to oversee potential conflicts and to increase coordination and communication.
- Perform an annual assessment of the preventive maintenance program and report findings to senior leadership in CDOT.
- Recommend expanding the preventive maintenance treatment menu of items to increase competition.
- Consolidate similar work into bigger contracts for new treatments to attract quality contractors and increase competition.

Implementation - Five Years:

- CDOT should keep comprehensive records on all aspects of the preventive maintenance program. After five years, CDOT should prepare a detailed report describing the benefits and costs of preventive maintenance and justifying continuation.
- After five years, the guidelines for treatment selection should be reviewed and adjust the guidelines as necessary.
- Recommend CDOT include the preventive maintenance program in the Surface Treatment Program funding to implement the strategy of a mix of fixes.
- Recommend that CDOT establish a goal to attain long-term network sustainability. Based on CDOT network, annual funding of $40-$50 million should be designated for preventive maintenance. Further increases should be considered when a higher condition level of the network is desired.

17. Keywords	18. Distribution Statement
pavement management	No restrictions. This document is available to the public through the National Technical Information Service Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	99	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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EXECUTIVE SUMMARY

The Colorado Department of Transportation (CDOT) is actively committed to the implementation of a pavement preventive maintenance program. Preventive maintenance will cost-effectively extend pavement life and improve the condition level of the highway network. Over time, the Department will be able to better satisfy user needs at a lower unit cost per lane mile. City and county agencies throughout Colorado will invariably recognize CDOT's proactive role and seek to establish collaborative relationships to improve the current state of the practice.

We visited each CDOT region to discuss various preventive maintenance treatments and gain insight into current maintenance practices. We met with the region materials engineers, pavement design / management engineers, maintenance superintendents, and maintenance supervisors, to develop an understanding of pavement maintenance best practices employed by CDOT. These meetings established excellent dialog and proved very beneficial in identifying areas requiring further action before implementing a successful preventive maintenance program.

CDOT's employees seem to enthusiastically embrace the concept of preventive maintenance and appear ready to put a new program into practice. The CDOT community is committed to maintaining the highway network in the best possible condition with the least disruption to the motoring public. With CDOT's positive attitude and commitment, executing a proactive maintenance program will ultimately provide substantial long-term cost savings, greater customer satisfaction, and improved statewide pavement conditions. CDOT is ready to begin the process of implementing a preventive maintenance program.

Findings and Recommendations

We have summarized below our findings and their associated recommendations with proposed implementation timeframes. We based the recommendations on information we gained from regional meetings, central office meetings, and field observations of current practices at CDOT.

Immediate Implementation

- **Finding**

  The region meetings gave us valuable opportunities for technical discussions on the meaning of such concepts as preventive maintenance with CDOT personnel. Through these discussions we became aware that the meanings of commonly used terms varied with the employee's understanding of the subject. For example, crack filling was confused with crack sealing, pavement life extension was misunderstood as service life, and aggregate descriptive terms such as gradation top size and nominal top size were used inconsistently. Effective communication within the Department is hindered by the use of conflicting terminology.

Recommendation (#1)

Terminology: An important requirement of effective communication within CDOT is the accurate understanding and use of consistent terminology. We recommend that CDOT define, document, and distribute common terms throughout the Department to assure a consistent vocabulary for understanding, describing, and communicating concepts. One of the most important definitions is that of "Preventive Maintenance" and we recommend that CDOT adopt a consistent definition such as

> "*Preventive Maintenance: Work undertaken that preserves the existing pavement, retards future deterioration, and improves the functional life without substantially increasing the structural capacity*."

Use of a consistent and accurate terminology will yield clear benefits such as improved communication between employees and a better understanding of both the operational processes and the pavement management system.

- **Finding**

  Most employees of CDOT appear to earnestly accept the overall concept of proactive maintenance and seem eager to implement a new program. Given their positive attitude, executing a preventive maintenance program to extend highway life and improve pavement performance will be well received.

Recommendation (#2)

Commitment: Establishing a solid preventive maintenance program takes time and requires a long-term commitment from CDOT leadership. The program benefits are not short-term, but rather accrue over time with improved pavement conditions with significant cost savings. As the most important step in implementing preventive maintenance, we recommend starting modestly, assembling the program methodically, and building on success.

- **Finding**

  Large complex organizations often experience varying degrees of turf protection, where particular groups operate independently. Fortunately, we did not find this behavior at CDOT. The most successful preventive maintenance programs are viewed as Department owned, involving significant contributions by planning, finance, design, materials, construction, maintenance, and research. Each entity makes continuous contributions to the program, thereby achieving synergy and ensuring success.

Recommendation (#3)

Champion: As with any new effort, establishing a preventive maintenance program will need a champion to lead the endeavor. Without a champion to promote the importance and coordinate the program, the new effort with likely fail. Several state transportation agencies, including Michigan, Minnesota, and North Carolina, have each established a position to lead their preventive

maintenance programs. We do not believe that CDOT needs to create a new position to coordinate the statewide program as the Pavement Management Program Manager and the Maintenance Design Engineer would be ideal candidates.

- **Finding**

  In some instances, we found that pavement maintenance practices were implemented differently from region to region and in different ways between engineering and maintenance personnel. Examples of dissimilarities include pre-treating distress prior to applying a surface treatment in one region while post-treating distress after the treatment has been placed in another region. Engineering and Maintenance viewed material specifications for surface treatments differently. Often, materials which should have been rejected for failure to meet CDOT specifications were accepted by Department personnel for various reasons. Occasionally, this practice has produced poorly performing surface treatments.

Recommendation (#4)

Program Manual: Uniformity of statewide practice is an important requirement to effectively measure the overall performance of preventive maintenance treatments. Treatment predictability should be an objective for the program. We recommend that CDOT develop a statewide preventive maintenance manual which would greatly assist the regions in applying the right treatment on the right road. The preventive maintenance manual should contain program guidelines already developed for CDOT, specifications, field documentation forms, project estimating criteria, and applicable policy directives. In addition, a condensed pocket guide would be beneficial as a reference during field reviews of potential future projects by staff. The pocket guide could be printed on durable media, contain treatment guidelines and a separate distress matrix for each treatment.

- **Finding**

  We found inter-regional variations in surface treatment specifications and the manner that they were implemented. These variations usually involved a departure from the accepted standard for material verification and quality control. For example, materials such as emulsions vary between a High Float Rapid Setting (HFRS) and High Float Medium Setting (HFMS), aggregate gradations vary widely, and crack sealants vary between suppliers. The time of the year that treatments are placed depends largely on the experience of the region maintenance superintendent. Placement equipment, which can affect the final performance of the product, generally depends on the region's equipment inventory. Although these issues can be problematic, the regions generally do a good job.

Recommendation (#5)

Specifications: A key ingredient for program success is the employment of uniform statewide preventive maintenance practices. Predictability of treatment

performance can only be achieved if all regions follow the same specifications and procedures. This involves consistency of materials, application and workmanship. We recommend that CDOT develop and use statewide preventive maintenance specifications for every anticipated treatment in Colorado.

- **Finding**

  Many regions voiced concern at the number of experienced personnel retiring from CDOT and the resulting loss of core competencies critical to ongoing operations. We found that maintenance personnel have a keen awareness of their limitations in certain areas such as placing surface treatments, while engineering staff have diminished confidence levels overseeing or inspecting some preventive maintenance treatment operations. Due to staff limitations, engineering has not done this type of work. Each group expressed a compelling need for training in preventive maintenance activities including treatment selection, application, materials, and learning best practices.

  Recommendation (#6)

  Training: Preventive maintenance programs are widely acclaimed as making good business sense. However, failure can result if the correct treatment is not used. For a new program, a single failure can overshadow hundreds of successes. The only way to minimize the potential of failure is through staff training. We recommend that CDOT establish a training program to incorporate modules addressing preventive maintenance and pavement management concepts, pavement and treatment selection, materials, application techniques, inspection, and quality control. Other state agencies often open their training sessions to contractors likely to bid on future work and we recommend that CDOT consider allowing prospective contractors to attend training sessions. These sessions offer an excellent setting for both employees and contractors to become thoroughly familiar with and discuss new preventive maintenance specifications.

- **Finding**

  We found in a few regions, confusion about the applicability of long-standing CDOT directives and policy statements. For example, information released more than 10 years ago, states that only cracks ¼ inch or larger should be treated prior to placing a surface treatment. While some regions continue to adhere to these statements, other regions see them as being obsolete.

  Recommendation (#7)

  New policy: We recommend that CDOT establish a new policy giving clear program direction and alignment for preventive maintenance. Parameters should be defined to clearly define the boundaries between programs (preventive maintenance, rehabilitation, etc) which perform similar types of work. Program work constraints are necessary to assure that correct funding sources are used. For example, while several programs may use full depth concrete repairs, the

quantity of work should determine the appropriate funding source. The following table illustrates the concept.

Work Quantity (Full Depth Repairs per Lane-Mile)	**Program**
≤ 19	Preventive Maintenance
20 – 60	Rehabilitation
≥ 61	Reconstruction

Placing boundaries on the amount of work is essential for the credibility of the program. Leadership will have better control of how scarce funding dollars are allocated, and CDOT personnel can better forecast future investment needs.

- **Finding**

  We found that maintenance personnel in a few regions were intimidated by the existing purchasing rules. In the more remote areas, finding a vendor / supplier able or willing to meet material specifications can be difficult or nearly impossible. In cases where a limited quantity of material is needed, the only option usually available is to contract with a vendor / supplier outside the immediate area and pay excessively high costs. Maintenance personnel requested more flexible purchasing rules with mechanisms to allow bulk purchases and stockpiling of materials, and pre-established price agreements with vendors / suppliers, etc.

Recommendation (#8)

Pilot Project: The funding requirements and regulations established by the State sometimes make it difficult for CDOT Regions to efficiently operate in remote areas of Colorado. We recommend that CDOT consider implementing a pilot project to determine whether the benefits are sufficient to warrant a possible rule change.

- **Finding**

  Several regions voiced a need for better communication and coordination between engineering and maintenance activities. A common concern was constructing new surface treatments over newly painted pavement markings. Another example was not allowing adequate lead time for the engineering staff to assemble M-Projects. These projects must be designed and bid early enough to be constructed within the same fiscal year.

Recommendation (#9)

Coordination: We recommend that each region synchronize all aspects of the CDOT operation, including engineering and maintenance. It is understandably difficult to avoid overlapping efforts and competing priorities. However, by designating a program coordinator in every region to oversee program needs, potential conflicts can be avoided or significantly reduced.

- **Finding**

  Accurate and timely record keeping is vital to maintaining a robust database in the pavement management system. Our discussions with both region and materials & geotechnical personnel revealed that updating the database was a problem. When a highway surface is improved by a specific maintenance treatment, the updated information needs to be forwarded to the appropriate person for entry into the database. This information is critical for pavement condition analysis and the meaningful determination of the cost-effectiveness of the maintenance treatments.

  Recommendation (#10)

  Reporting: An annual performance assessment is critical to program success. Each year the successes and failures of the preventive maintenance program should be documented by the Pavement Management Program Manager and the Maintenance Design Manager. The report should demonstrate and validate whether funds being expended are consistent with preventive maintenance policies and guidelines. All findings should be reported to senior leadership of CDOT.

- **Finding**

  At present, some regions are not using lower cost treatments, but rather opting for more costly treatments because of personal familiarity with the products being used. We see a need for more treatment options to build a set of best practices for statewide implementation.

  Recommendation (#11)

  Adding treatments: An early goal for the preventive maintenance program should be to annually treat the greatest number of miles possible. This means employing the most cost-effective treatment wherever possible. Succinctly stated, the best approach would be to "apply the right treatment on the right road at the right time." We recommend that CDOT consider expanding the preventive maintenance "tool box" with more treatment options to achieve better price competition and allowing more road miles to be addressed each year.

- **Finding**

  We see a need to generate sufficient work at the multi-regional / network level to entice competent, efficient contractors to bid on Colorado contracts.

  Recommendation (#12)

  Consolidating work: We recommend that during the first few years of program implementation, CDOT should consider consolidating similar types of work from several regions into a single contract. New treatments, previously not used in Colorado could be introduced to attract quality, conscientious contractors with reasonable bid prices. This approach has been successful in other states when new treatments were being introduced for the first time.

Five Year Implementation

- **Finding**

  CDOT's existing pavement management system does not account for the benefits derived from preventive maintenance treatments. The life extending benefits of maintenance activities, for either individual projects or at the network level, cannot be calculated and included in the analysis unless major modifications are made to the existing software. The personnel involved with the pavement management system are making improvements to resolve this issue.

Recommendation (#13)

Justification: The merits of preventive maintenance are wide-ranging, from improving network pavement conditions to reducing future budget needs. We recommend that during the first five years of the program, the Department should keep comprehensive records on all aspects of the preventive maintenance program. After the first five years of program experience, CDOT should prepare a detailed report describing the benefits and costs of preventive maintenance and justifying continuation of the program.

Recommendation (#14)

Adjust guidelines: The new preventive maintenance guidelines contain critical threshold values to assist the Department staff with candidate selection. The threshold values include remaining service life (RSL), Longitudinal and Transverse Crack Indices, International Roughness Index (IRI), and rutting / faulting measures. Each value is based on objective measures used in the pavement management system to report statewide pavement conditions. The guidelines also contain the expected life extension (in years) of each treatment. Both threshold values and life extensions are different for each treatment, and should be viewed as a starting point for the preventive maintenance program. We recommend that after approximately five years of pavement management data collection, CDOT should review and adjust the numbers as necessary to reflect Colorado's actual experience.

Recommendation (#15)

Integrate program: We recommend that CDOT include the preventive maintenance program in the STP funding allocation to support the Department's effort to implement a strategy employing a mix of fixes. This strategy should combine preventive maintenance, rehabilitation, and reconstruction to cost-effectively address statewide needs and avoid having to use a "worst first" approach.

Ten Year Implementation and Beyond

Recommendation (#16)

Network sustainability: Preventive maintenance will substantially extend pavement life at a comparatively low cost. We recommend that CDOT establish a goal to attain long term network sustainability though the optimal use of resources. The Department could achieve the goal by increasing preservation funding each year until an established minimum condition level could be met at any time. Based on the CDOT network, annual funding of $40-$50 million should be designated for pavement preventive maintenance. Further increases in funding should be considered when a higher condition level of the network is desired.

FIELD REPORT

The Colorado DOT is dedicated to gathering Region feedback before implementing a new pavement preventive maintenance program. Meetings were scheduled with the materials engineers, pavement management coordinators, maintenance personnel and other interested staff for the purpose of gaining consensus about program direction. The meetings were enthusiastically positive and personnel were eager to become involved in discussion.

Every meeting began with a general overview of the preventive maintenance program, presented by Jay Goldbaum. Copies of the program definition and draft program guidelines were distributed for review and comment. A number of topics were selected for discussion by the meeting participants and a summary of pertinent feedback is encapsulated below.

Region #1 – Aurora

Date: May 26, 2004

Participants:

- Robert LaForce, Region Materials Engineer
- Ken Wissel, Deputy Maintenance Superintendent
- Janet Minter, Pavement Management Engineer
- Jay Goldbaum, Pavement Management & Design Engineer
- Mike Keleman, Pavement Management Engineer
- Larry Galehouse, NCPP

Feedback:

- The use of magnesium chloride as a roadway snow and ice melter will leave residue in pavement cracks. Early season crack treatments will likely result in poor adhesion and major failures. The sealant cannot adhere to the crack sidewalls and most material is lost. Ken Wissel recommended that no crack filling should be scheduled until spring, after at least two rainfall events.

- The Region has a clear separation of responsibilities according to functional work. Strong communication and coordination of pavement maintenance activities is continually needed to avoid potential problems from arising.

- Seasonal limitation should be developed for all emulsion based products. The following placement times were discussed.

Location	Start	Stop
Above 10,000’	July 4	August 1
8,000’ to 10,000’	June 15	August 15
6,000’ to 8,000’	June 1	September 1
4,000’ to 6,000’	May 15	September 1
Below 4,000’	May 1	September 1

- Ken Wissel restricts chip seal usage to 1,200 annual average daily traffic (AADT) in his Region. This usage restriction is not consistent from Region to Region.

- Ken Wissel prefers to post-treat cracks rather than pre-treating them when using surface treatments, such as chip seals. Admittedly, this practice is not consistent Region to Region.

- The term crack sealing is used synonymous with crack filling possibly indicating a need to standardize Department terminology.

Region #2 – Pueblo

Date: June 1, 2004

Participants:

- Richard Zamora, Region Materials Engineer
- Frank Walters, Materials Unit Engineer
- Lowell Lester, Professional Engineer
- Charles Bennett, Maintenance Management System Coordinator
- Keith Flowerdew, Pueblo - Maintenance Superintendent
- Rudy Marquez, Lamar - Maintenance Supervisor
- Greg Wingard, Pueblo - Maintenance
- Jerry Lutz, Pueblo - Maintenance
- Jay Goldbaum, Pavement Management & Design Engineer
- Mike Keleman, Pavement Management Engineer
- Larry Galehouse, NCPP

- Use of magnesium chloride to melt roadway snow and ice causes problems when filling pavement cracks with sealant. The sealant will not stick in the crack. Although the Region is sensitive to this problem, crack filling, which is scheduled and performed routinely, is considered an effective maintenance activity.

- The Region requests some clarification for similar types of work done through different program funding sources (maintenance funds and resurfacing funds). Full depth concrete repairs, overlays, chip seals currently may have different funding sources and having clear concise guidelines for a preventive maintenance program is important.

- Low volume roads represent a problem to the Region once they fall into poor condition. Funding is difficult to obtain for reconstructing roads with low AADT because of higher system priorities. In many cases, these roads can be addressed with thin overlays, chip seals, or other surface treatments with good results, giving the pavement longer life. The guidelines should reflect different performance criteria for low volume roads versus higher volume roads.

- A copy of a chip sieve analysis was presented for a project performed April 6, 2004, on SH 50. Tests results display a Type 2 aggregate that did not comply with specifications. Admittedly maintenance operations customarily are forced to use materials falling outside specifications. Maintenance personnel understand that poor quality material often denote poor performing projects.

- Crack filling operations are generally limited to crack widths of ¼ inch or greater in size. This is a standard practice by the Region based on past experience. Maintenance personnel have no knowledge of a statewide policy that addresses crack filling and sealing applications.

- Seasonal limitations for emulsion based products were reviewed by the Region and considered acceptable without modification. The maintenance personnel have confirmed that emulsions need cure time after placement for good long-lasting chip seal performance.

- Maintenance personnel see benefit in fog sealing over chip seal projects. This practice is proven very effective, particularly on I-25. The general belief of experienced maintenance superintendents is that chip seals can be used on high volume roads having up to 10,000 AADT.

- Trigger values are needed for good preventive maintenance treatment applications. Currently, candidate pavements are selected primarily on age rather than condition.

Region #3 - Grand Junction

Date: June 3, 2004

Participants

- David Eller, Region Materials Engineer
- Bob Heidelmeier, Region Pavement Engineer
- Jim Pitkin, Grand Junction - Maintenance
- John David, Grand Junction – Maintenance
- Jeff Snyder, Craig - Maintenance Supervisor
- Kandace Lukow, Craig - Transportation Superintendent
- Weldon Allen, Grand Junction, Maintenance Superintendent
- Mike DeLong, Craig – Maintenance
- Sue Winpegler, Craig - Maintenance
- Jay Goldbaum, Pavement Management & Design Engineer
- Larry Galehouse, NCPP

- There is confusion about the following terms: routine maintenance, reactive maintenance, corrective maintenance and preventive maintenance. The maintenance personnel voiced interest in having a better understanding of terminology used by CDOT and elsewhere.

- During the maintenance superintendent's meeting held in Cripple Creek, the superintendents agreed that any pavement having less than 5 years remaining service life (RSL) will not be a preventive maintenance candidate. Unless a policy directive is written that provides guidance to the contrary, the superintendents will likely adhere to their agreement.

- The maintenance personnel raised a concern about funding constraints on M-projects. With recent material price escalations there is substantial interest in adjusting the M-project limit annually to keep pace with inflation and market increases.

- The Region uses two different sealants, ASTM D-3405 or D-5108, to treat cracks. Both materials can sometimes be problematic. A potential cause of the problem could be that crew production outpaces the ability of the melter to bring the sealant material to the recommended placement temperature. The melter equipment owned by the Department has a 450-gallon capacity. The smaller size melter may possibly limit the ability to maintain uniform temperatures when surcharged with new material.

- Weldon Allen stated that a maintenance goal is to crack fill approximately ten percent (10%) of Region mileage each year. Crack filling is proven to be a beneficial treatment to preserve the pavement surface.

- Fog seals are used on the majority of chip seals placed in the Region. The application rate is 0.10 gal/sq yd at 50% dilution. A HFMS-2P is generally used for fog sealing. The application time for a fog seal is from within 2 days to 10 days of chip seal placement.

- There are no prescribed guidelines on when to use the different CDOT Seal Coat Aggregate Gradations. Type 1 (3/8"), Type 2 (1/2") and Type 3 (3/4") are generally left to the discretion of the contractor. A need exists to standardize the aggregate size of chip seal depending on the specific location. For example, Region personnel propose the following criteria.
  Type 1 High Volume Roads
  Type 2 Low Volume Roads
  Type 3 Bottom Course of a Double Chip Seal
  Additional work is needed to standardize materials and specifications for preventive maintenance applications.

- The use of a chip seal treatment should not be regulated by traffic volume. Although the traffic volume may influence the life extension of the treatment, maintenance personnel believe a greater influence for the use of chip seals is the length of traffic queue. Using chip seals in areas requiring longer queue times with higher traffic volumes should be discouraged. Eagle County is an example where traffic queue times become excessively long.

- Maintenance personnel expressed apprehension with the existing purchasing rules. In more isolated areas of the Region, such as Craig, finding a vendor/supplier that meets material specifications can be difficult and often nearly impossible. Usually only a limited quantity of material is needed. Contacting a vendor/supplier outside the immediate area often means paying excessively high costs for delivery of smaller quantities. Maintenance personnel request more flexible purchasing rules having mechanisms to allow bulk purchases, stockpiling and pre-established price agreements with vendors/suppliers.

- A small number of maintenance personnel commented that problems sometimes exist obtaining environmental reviews of M-projects in a timely manner. These delays appear to be caused by the individual reviewer rather than any fault of the review process.

- An overwhelming concern is the loss of experienced personnel retiring from CDOT. It takes years for new employees to acquire the core competencies critical to ongoing operations. Most employees are keenly aware of their limitations in certain areas such as placing surface treatments or inspecting surface treatment operations. Every person articulated an unquestionable need for preventive maintenance training. Subject areas should include pavement selection, treatment selection, materials selection, quality control methods, and best application practices and techniques. Training should be offered to both maintenance employees and engineering personnel.

- Many Region people have interest in learning more about particular CDOT research projects. Often the final conclusions or findings are not well distributed among Department personnel. Improving the information distribution from research projects could potentially have greater benefit to CDOT operations.

Region #4 – Greeley

Date: January 28, 2004

Participants

- Gary DeWitt, Region Materials Engineer
- Rose McDonald, Pavement Management Engineer
- Joe Intermill, Evans - Maintenance
- Rick Chapman, Professional Engineer
- Jay Goldbaum, Pavement Management & Design Engineer
- Mike Keleman, Pavement Management Engineer
- Larry Galehouse, NCPP
-

- There is a need to develop a better organizational understanding of common terminology. For example, terms such as rehabilitation, preventive maintenance, routine maintenance, etc. have different meanings to different people in CDOT. Terminology such as design life, life extension, service life, etc. should be defined to provide a better understanding of the pavement management system.

- It is the opinion of most personnel that new "statewide" specifications should be developed for every preventive maintenance treatment. The new specifications can assure statewide uniformity, better price competition, and more predictable treatment performance. The current habit of many Regions using different practices and materials should be discontinued.

- The Region staff support training as the best way to insure a successful preventive maintenance program and minimize any potential problems from occurring. It was recommended that a training program should incorporate subject matter from preventive maintenance as well as pavement management.

Region #5 – Durango

Date: June 2, 2004

Participants

- Edward Archuleta, Region Materials Engineer
- Greg Roth, Maintenance Superintendent
- Jay Goldbaum, Pavement Management & Design Engineer
- Larry Galehouse, NCPP

- The placement of a chip seal treatment should not be determined by traffic volume. Based on Region experience, traffic volume is not an issue for chip seal use.

- The Region prefers to use HFMS-2P, a medium setting emulsion, on chip seal projects. According to Greg Roth, the Region chip seal crew lacks the experience to apply faster setting (breaking) emulsions. The medium set emulsion will be used until the crew acquires more knowledge and experience about chip sealing.

- Experienced personnel retiring from CDOT have critically impacted ongoing operations. Many maintenance personnel lack both knowledge and experience about pavement maintenance practices. There is a genuine need for employee training on chip sealing, crack filling, micro-surfacing, etc. in the Region.

- Confusion exists about the applicability of memoranda and directives issued many years ago. For example, a memo written more than 10-years ago, states that only cracks ¼ inch or larger should be treated prior to placing a surface treatment. Reissuing new statewide directives will be helpful to the Region to insure proper procedures are followed.

- More emphasis is needed on material testing in the Region. Often materials not meeting the CDOT specification are accepted by Region personnel for expediency, rather than rejecting the material and delaying the work. This practice has produced several poor performing chip seals. Ed Archuleta recommended a strong training program as the best way to remedy the situation.

- The environmental review and approval of an M-project is seldom achieved in a timely manner. Region personnel have reservations about whether the current business process is sufficient to meet their needs.

Region #6 – Denver

Date: June 4, 2004

Participants

- Reza Akhavan, Region Materials Engineer
- Kevin Ryburn, Pavement Design/Management Engineer
- Jay Goldbaum, Pavement Management & Design Engineer

- Mike Keleman, Pavement Management Engineer
- Larry Galehouse, NCPP
-

- A concern was voiced by Reza Akhavan about a change to the CDOT Standard Specifications. Earlier standard specifications had an introductory statement instructing maintenance work to follow same requirements as construction work. The new standard specifications book has omitted this statement. The Region engineering staff is concerned that preventive maintenance projects may not follow similar requirements as construction work.

- There is a need for better communication and coordination of pavement maintenance activities. Often the engineering staff is not given sufficient lead time to properly assemble M-Projects. These projects must be designed and bid early enough to be constructed within the fiscal year.

- The Region personnel consider formal training vital in retaining core competencies in the workforce. Maintenance employees need training in placing surface treatments, while engineering staff need training for inspecting surface treatment operations. Training in preventive maintenance activities should commence as soon as possible.

National Center for Pavement Preservation

Establishment

The National Center for Pavement Preservation (NCPP) was established by Michigan State University (MSU) and the Foundation for Pavement Preservation to lead collaborative efforts among government, industry, and academia in the advancement of pavement preservation.

Founded July 11, 2003 , the Center is the realization of a collective national vision of pavement practitioners, policy-makers and industry. Its purpose is to advance and improve pavement preservation practices through education, research and outreach.

Background

NCPP began as a collective vision of nationally recognized practitioners, policymakers and the beneficiaries of sound pavement management practices. With the completion of the interstate system and the states' major road networks, a common desire arose among American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA) and the Foundation for Pavement Preservation to advance the knowledge, technology and practices of cost effectively preserving pavement networks in good condition.

Most governmental agencies recognize the importance of preserving the enormous investment ($1.75 trillion) to construct the nation's highways. NCPP was established to foster and sustain a national advocacy for pavement preservation at the state and local levels. A national focus will better assure essential federal and state funding is available for this effort, the costs of which are estimated to be very high. In September 2002, AASHTO published a report which assessed the funding needs for the nation's highways from 2004 to 2009. The report stated that the annual cost over that five year period will be $92 billion to just maintain the status quo, while $125 billion will be required to achieve significant improvement. Between 1999 and 2000, the combined highway expenditures for all purposes at all levels of government, increased a remarkable 71% from $75 billion to $128 billion. But, of the $128 billion, $64.6 billion was for capital improvement, leaving a considerable shortfall for preservation needs.

Past national funding legislation, contained in the Intermodal Surface Transportation Efficiency Act (ISTEA) and the Transportation Efficiency Act - 21st century (TEA-21), permitted a major policy change by allowing the use of federal-aid for preservation through preventive maintenance treatments. This authorization has provided the financial inducement for several states to initiate proactive approaches to preservation by treating

pavements in good and fair condition to prolong their lives and defer the need for expensive major rehabilitation or reconstruction.

Pavement preservation is the application of engineering and fiscal management using cost-effective treatments and existing funds to control the future condition of pavement networks. Pavement preservation concepts stretch the period of life a pavement remains in serviceable condition for the traveling public. The benefit is an improved and stable condition level at a lower unit cost per lane mile.

NCPP's Objectives

Mission

Lead a collaborative national effort among government, industry and academia participants to advance and improve pavement preservation practices through education, outreach and research.

Vision

Use pavement preservation techniques to achieve sustainable network condition levels that satisfy user needs cost effectively.

Goals

- Become the primary resource for pavement preservation practices and activities.
- Promulgate the benefits of pavement preservation in partnership with the Foundation for Pavement Preservation (FP2) and MSU.
- Exploit the synergistic advantages of using the academic resources and programs of MSU and other academic partners to advance the knowledge and practice of pavement preservation.
- Enhance pavement preservation knowledge from experience and fundamental and applied research.
- Be a multi-service organization for establishing new pavement preservation programs or improving existing ones.

Staff Resources

NCPP Staff

NCPP has a director and seven staff specialists with skills in highway planning, design, construction, maintenance, and operations research.

Extended Staff

The Center's academic links allow it to draw upon the support of MSU and other major research-oriented institutions. As assignments require, the Center is able to assemble multi-disciplinary teams at short notice to perform research, outreach services, and training for clients responsible for managing and operating highway networks at the federal, state, and local levels in addition to private sector organizations. The faculty and staff skills required are drawn from areas such as engineering, operations research, and economics.

The Center presently has working relationships with four MSU faculty members, each of whom has a strong background in pavement technology.

Governance

NCPP has an Advisory Board, Technical Resource Group, Director, and seven project specialists. The Advisory Board represents federal and state governmental agencies, academia, and private industry and meets twice each year to provide policy guidance for the Center.

The Director oversees the Center's daily activities and makes periodic reports to the Advisory Board and the Chair of MSU's Department of Civil and Environmental Engineering.

Services

NCPP is the first formal organization to offer a unique national focus on pavement preservation needs. The Center provides nationwide guidance and assistance by offering primary services in

- Training
- Outreach
- Research Management

Training

Training is an integral part of any Pavement Preservation Program. Preservation practices are constantly evolving as new techniques and products are developed. The NCPP is able to:

- Offer Continuing Education Units in cooperation with MSU.
- Develop undergraduate and graduate courses in cooperation with MSU.
- Provide clients with custom-designed training needs conducted on-site or at an alternate location.
- Develop technical briefings.
- Host web-related, pavement preservation information.

Outreach

Technological advances are constantly providing new and improved tools to assist the pavement practitioner in developing more cost effective pavement preservation strategies.

These tools can improve decision making for pavement preservation that will help improve surface durability and reduce the need for frequent, routine or reactive pavement maintenance repairs.

The Center is available to assist pavement practitioners in adopting new pavement preservation strategies and processes and is able to:

- Integrate pavement preservation activities with pavement management systems.
- Administer functions for the Midwestern Pavement Preservation Partnership (MPPP) for pool-funded efforts.

- Provide assistance for pavement cost-effectiveness studies.
- Promote and promulgate pavement preservation principles at conferences, trade shows, etc.
- Provide and maintain a technical resource library.

Research Management

For more than fifty years, the highway industry has emphasized new construction. Research efforts have supported this activity by concentrating on improving pavement structure design, materials and construction processes. To date, hundreds of millions of dollars have been devoted to these research efforts. Inadvertently, maintenance and preservation studies were neglected as a means of improving performance.

Today there is an urgent need to adapt our existing roadways to carry ever increasing traffic volumes safely and efficiently without incurring the massive expenditures required to expand and rebuild our facilities. This need is forcing a major change in focus toward pavement preservation and away from new construction and major rehabilitation. Research is playing a key role in this change. The Center is ready to:

- Facilitate applied research projects in partnership with academia and the private sector.
- Oversee pool-funded studies.
- Participate as a "researcher" in national research studies.

Appendix A

Preventive Maintenance Program

Guidelines

1 – ASPHALT CRACK SEALING

Description: Crack sealing is the placement of specialized materials into working cracks by the cut and seal method. This method consists of cutting the desired reservoir shape at the working crack in the existing asphalt surface, cleaning the cut surfaces and placing the specified materials into the cavity. The cutting is performed with either a random crack saw or a crack router.

This treatment is usually performed on working cracks and sometimes done in conjunction with an Asphalt Crack Filling treatment for non-working cracks.

Purpose: Sealing cracks and open construction joints in the flexible pavement surface is done to prevent water from entering the pavement structure.

Existing Pavement Condition: The existing pavement should be relatively new with a good base and cross section. On a flexible base, the HMA surface should be two to four years old and on a composite pavement (with underlying concrete), one to two years old. The visible surface distress may include: fairly straight open longitudinal and transverse cracks with slight secondary cracking and slight raveling at the crack face, and no patching or very few patches in excellent condition.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
10	80	80	90	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 8.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: None.

Timing: The use of magnesium chloride as a roadway snow and ice melter may leave residue in pavement cracks. Early season crack treatment applications could likely result in poor adhesion and a high loss of the sealant material. To assure a successful crack sealing operation, work should be scheduled in the early fall once daytime temperatures begin to cool. Application should be scheduled only when dry and air temperatures are 35ºF or greater.

Performance: Crack sealing introduces materials that adhere to the crack walls, are flexible and elastomeric in nature. This allows significant strain to be absorbed by the material without fracture. Much of this strain will be recoverable and the crack may open and close with thermal stresses or traffic loading and remain sealed. The effectiveness of the seal will depend greatly upon the width of crack being sealed and the movement of the pavement structure at the crack.

This treatment addresses cracks ⅛" or larger, and should be followed in later years by further crack sealing or crack filling when additional cracks develop.

Surface treatment applications should not be scheduled until the crack sealant has sufficiently cured, usually from 3 to 12 months.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Flexible	Up to 4 [4]	Up to 3	Up to 2

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

2 – ASPHALT CRACK FILLING

Description: Crack filling is the placement of materials into non-working cracks by the overband crack fill method. This method consists of cleaning the crack in the asphalt pavement surface with compressed air and placing the specified materials into and above the crack.

This treatment is usually performed on non-working cracks and sometimes done with an Asphalt Crack Sealing treatment for working cracks.

Purpose: The purpose of overband crack filling in the surface of the asphalt pavement is to prevent water from entering the pavement structure.

This treatment is commonly used as a surface preparation for the Micro-Surface and Chip Seal treatments.

Existing Pavement Condition: The existing pavement should be relatively new with a good base and cross section. On a flexible base, the HMA surface should be two to four years old and on a composite pavement (with underlying concrete), one to two years old. The visible surface distress may include: fairly straight open longitudinal and transverse cracks with slight secondary cracking and slight raveling at the crack face, and no patching or very few patches in excellent condition.

Minimum PMS Values
FOR STAND ALONE APPLICATION

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	9	80	80	85	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 7.
(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.
Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Timing: The use of magnesium chloride as a roadway snow and ice melter may leave residue in pavement cracks. Early season crack treatment applications could likely result in poor adhesion and a high loss of the sealant material. To assure a successful crack filling operation, work should be scheduled in the early fall once daytime temperatures begin to cool. Application should be scheduled only when dry and air temperatures are 35ºF or greater.

Performance: When used as a pre-treatment, crack filling will help extend the service life of its subsequent surface treatment. A stand-alone overband crack filling will also extend the life of the pavement structure.

If crack filling is to be used as a stand-alone treatment, it should be used with due caution on pavements with large numbers of working cracks.

This treatment addresses most size cracks and should be followed in later years by further crack filling when additional cracks develop.

Surface treatment applications should not be scheduled until the crack sealant has sufficiently cured, usually from 3 to 12 months.

Expected Life Extension [(3)]

Commercial Traffic/Pavement Type	***(Trucks)/(Years)***		
AADT-T	***< 400***	***400 - 6000***	***> 6000***
Flexible	*Up to 4* [(4)]	*Up to 2*	*Up to 2*

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

3 – SAND SEALS

Description: A sand seal is an application of asphalt binder (normally an emulsion) covered with a fine aggregate.

Purpose: A sand seal is used to retard the oxidation of an existing pavement surface, improve skid resistance and to seal the pavement surface on low volume roadways.

Existing Pavement Condition: The existing pavement should have a good cross section and a good base. Visible surface distress may include moderate longitudinal and transverse cracking (with a minor amount of secondary cracking), slight raveling along the crack face, slight to moderate polishing, and/or an occasional patch in good condition.

Minimum PMS Values

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	9	80	80	85	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 7.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: All visible cracks should be filled by the overband crack filling method.

Timing:

Recommended Placement Times

Location	Start	Stop
Above 10,000'	July 4	August 1
8,000' to 10,000'	June 15	August 15
6,000' to 8,000'	June 1	September 1
4,000' to 6,000'	May 15	September 1
Below 4,000'	May 1	September 1

Performance: Sand seals are used only on low volume roads and on asphalt surfaced shoulders. Sand seals may appear to be moderately or severely raveled within 3 months of application. Despite appearances, the binder used to seal cracks is intact and should last up to 2 - 3 years.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	***(Trucks)/(Years)***		
AADT-T	***< 400***	***400 - 6000***	***> 6000***
Flexible	*Up to 3* [4]	*Not Advised*	*Not Advised*

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

Sand seals are a high risk treatment if applied to higher volume roads. They should not be placed in cool weather. The asphalt emulsion will require about one month of warm weather following construction to properly cure.

4 - CHIP SEALS

Description: A chip seal is a surface treatment in which the pavement is sprayed with asphalt (generally emulsified) and then immediately covered with aggregate and rolled. Chip seals may be applied in single or double applications.

Purpose: Chip seals will retard the oxidation of an existing pavement surface, improve skid resistance, seal surface cracks thus reducing the intrusion of water into the pavement structure, and retard the raveling of aggregate from a weathered pavement surface.

Existing Pavement Condition: The existing pavement should have a good cross section and a good base. Visible surface distress may include slight raveling, moderate longitudinal and transverse cracking (with a minor amount of secondary cracking), slight raveling along the crack face, slight to moderate polishing, and/or an occasional patch in good condition.

A chip seal should not be placed on a pavement with moderate or high fatigue cracking.

Minimum PMS Values

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	8	70	70	80	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 6.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: For single and double chip seals, all visible cracks and construction joints should be sealed by the overband crack fill method.

Timing:

Recommended Placement Times

Location	Start	Stop
Above 10,000’	July 4	August 1
8,000’ to 10,000’	June 15	August 15
6,000’ to 8,000’	June 1	September 1
4,000’ to 6,000’	May 15	September 1
Below 4,000’	May 1	September 1

Performance: Chip seals perform best on flexible pavement structures in rural areas with low traffic volumes.

Chip seals may perform poorly under moderate to heavy commercial traffic because of aggregate loss and flushing. As chip seals should not be placed in cool weather, the construction season for this work may be relatively short. The asphalt emulsion will require about one month of warm weather following construction to properly cure and gain adhesion. Application during periods of high temperatures and humidity may slow curing and lead to excessive flushing. Loose aggregate not embedded in the asphalt membrane may become airborne and damage the windshields of vehicles using the road. Chip seals can also be used on HMA surfaced shoulders.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	**(Trucks)/(Years)**		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Flexible	6 to 9 [4]	3 to 6	2 to 3

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

5 - MICRO-SURFACING

Description: Micro-surfacing is a mixture of polymer modified asphalt emulsion, fine aggregate, mineral filler, water, and other additives, properly proportioned, mixed, and spread on a paved surface.

Purpose: A single course micro-surfacing will retard oxidation and improve the pavement's skid resistance. A multiple-course micro-surfacing application will correct certain pavement surface deficiencies including rutting, minor surface profile irregularities, polished aggregate or low skid resistance and light to moderate raveling.

Existing Pavement Condition: The existing pavement should have a uniform cross section and a good base. Visible surface distress may include moderate longitudinal and transverse cracking, rutting, minor surface irregularities, flushed or polished surface and / or moderate raveling.

Minimum PMS Values

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	8 (multiple)	70	70	80	65
	12 (single)	70	70	75	65

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 6.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: Surface preparation typically includes crack filling, bump removal (if necessary), removal or protection of raised pavement markers, seal patching for large voids and potholes, and protection of utility structures.

Timing:

Recommended Placement Times

Location	Start	Stop
Above 10,000'	July 4	August 1
8,000' to 10,000'	June 15	August 15
6,000' to 8,000'	June 1	September 1
4,000' to 6,000'	May 15	September 1
Below 4,000'	May 1	September 1

Performance: Micro-surfacing corrects several surface deficiencies related to wet weather traffic accidents. A Micro-surface application performs under all traffic volumes to correct the pavement surface conditions described above.

The brittle nature of a standard micro-surfacing formulation makes it a poor crack sealer. Micro-surfacing mixes are very aggregate-specific because of the chemically triggered, quick reaction characteristics of the mixture. Late season night time micro-surfacing applications should be undertaken with caution due to their curing requirement of warm to moderate temperatures.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	**(Trucks)/(Years)**		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Flexible: Single Course	6 to 9 [4]	3 to 5	2 to 3
Flexible: Multiple Course	8 to 9 [4]	4 to 6	2 to 4

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

6 – Thin Bonded Wearing Course

Description: Thin Bonded Wearing Course is a layer of heavily polymerized emulsion followed by a thin (less than 1 inch) polymer modified hot mix overlay system placed on a structurally sound base.

Purpose: Thin Bonded Wearing Course is meant to provide a durable, open-graded, drainable, high-friction wearing surface on an existing flexible pavement.

Existing Pavement Condition: For flexible and composite pavements, longitudinal and transverse cracking should not exceed a moderate severity level. Block, edge, and reflective cracking at joints should not exceed a moderate severity level. Patches and potholes should not exceed a moderate level and should be properly repaired. Rutting should not exceed 0.5 inch. Bleeding should not exceed a moderate severity. Polished aggregate may be prevalent. Raveling may be severe.

Minimum PMS Values

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	8	70	70	80	65

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 6.
(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.
Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: The following items should be performed before paving operations.

1. Cover all utility structures such as manhole covers, etc.
2. Remove thermoplastic traffic markings.
3. Clean and fill pavement cracks greater than 0.25 inch wide.
4. Fill surface irregularities greater than 1 inch deep.
5. Mill or fill ruts greater than 0.5 inch.

Performance: Thin Bonded Wearing Course is not designed to bridge weak spots or to cover underlying pavement deficiencies. It will not add strength to the pavement structure.

Expected Life Extension (3)

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Flexible or Composite	Up to 9 (4)	Up to 7 (4)	Up to 5

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.
(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

7- HMA THIN OVERLAY (Less than 1½")

Description: A dense-graded hot-mix asphalt (HMA) applied at a maximum rate of 170 lb / square yard over an existing bituminous surface.

Purpose: A non-structural HMA overlay will provide protection to the pavement structure, slow the rate of pavement deterioration, correct many pavement surface deficiencies (e.g. raveling, oxidation, minor cracking), improve the ride quality and add strength to the existing pavement structure.

Existing Pavement Condition: The existing pavement should have a uniform cross-section and a substantially sound base with limited minor base failures and depressions. Visible surface distress may include moderate raveling, moderate longitudinal and transverse cracking, moderate severity fatigue cracking, and moderate severity block cracking.

Minimum PMS Values

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	6	70	70	60	65

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 4.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: The existing pavement should be prepared by repairing minor base failures and depressions, filling voids in the pavement surface, removing patched areas with poor adhesion or a very high asphalt contents that may bleed up through the new HMA surface, correcting severely tented joints, and correcting deficient super-elevations.

Performance: This treatment performs best on flexible pavement structures, but is also applicable to composite pavements depending on the extent of any reflective cracking.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Flexible	10 – 11 [4]	5 – 9 [4]	3 - 5

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

8 - SURFACE MILLING WITH NON-STRUCTURAL HMA OVERLAY (Less than 1½")

Description: The removal of an existing asphalt surface by the cold milling method and the placement of a dense-graded hot-mix asphalt (HMA) limited to a 170 lb / square yard application rate.

Purpose: This treatment will correct several existing surface deficiencies, improve the shape of the existing cross section, and may produce a more economical project compared with the non-structural HMA overlay treatment. The dense graded hot-mix asphalt will protect the pavement structure and improve the ride quality.

Existing Pavement Condition: The existing pavement should have a good base. Visible surface distress may include: severe surface raveling, multiple longitudinal and transverse cracking with slight raveling, a small amount of block cracking, patching in fair condition, de-bonding surface and slight to moderate rutting.

The cold milling operation is used to correct rutting in the existing asphalt surface layer where the rutting is not caused by a weak base and when the condition of the existing pavement has deteriorated to a point where it is not practical to correct the rutting problem by a more economical treatment. The cold milling operation is also used to remove an existing asphalt course that is de-bonding.

Existing pavement crown and superelevation sections that have been identified as having a relationship to accidents can be modified by cold milling. Often, only a single lane of the existing cross section needs a preventive maintenance treatment. In these cases, it is more economical to remove the existing HMA surface in that lane by cold milling and do nothing or do a less expensive fix on the less deteriorated portions of the cross section. In a curb and gutter section, cold milling can be used to remove a portion of the existing asphalt surface to retain the existing curb face. Cold milling can also be used in those areas where the existing pavement grade cannot be raised.

Minimum PMS Values

Pavement	Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)	Rut_Index
Flexible	6	70	70	50	50

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 4.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: None.

Performance: This is the highest type of preventive maintenance treatment available.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Flexible	10 -11[4]	5 - 10	3 - 5

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

(4) After application of the treatment, the pavement service life should be limited to a maximum RSL of 15 years due to anticipated environmental effects.

9 - DIAMOND GRINDING

Description: Diamond grinding is a process that uses a series of diamond-tipped saw blades (ranging from 50-60) mounted on a shaft or arbor to shave off the upper surface of a rigid pavement.

Purpose: Diamond grinding is used to improve the surface longitudinal profile and crown of a concrete pavement. Benefits from diamond grinding include: improved ride quality, the removal of joint and crack faults, the removal of wheel ruts caused by studded tires, the restoration of transverse drainage, and the improvement of skid resistance.

Existing Pavement Condition: The existing pavement should have a uniform cross section and a good base. Visible surface distress may include joint and crack faults not exceeding 0.25 inch, rut depths less than 0.25 inch, moderate to severe polishing, or not over twenty five percent scaling of the surface area.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)
8	70	70	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 9.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: Diamond grinding should not be used as a one step treatment for concrete pavement surface deficiencies. Frequently, other repairs should be performed prior to diamond grinding.

Performance: The reduced impact loading following diamond grinding should significantly extend the pavement's service life. Following diamond grinding, several years of traffic may cause joint faulting and cracking and return the pavement to its condition prior to diamond grinding. The extent of deterioration will depend on several factors, including the joint efficiency of the pavement and the amount and quality of concurrent concrete pavement treatment work. The improved skid resistance due to diamond grinding depends on the final micro-texture and macro-texture and the hardness and polishing characteristics of the aggregates. The improved skid values will decline until they reach the skid levels of the original surface at which point the values will generally remain steady. Diamond grinding should not be used as a one step treatment for concrete pavement deficiencies.

All concrete joints and major cracks must be resealed after diamond grinding.

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Expected Life Extension [3]

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Rigid	6	3	2 - 3

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

10 – CONCRETE CRACK SEALING

Description: Crack sealing involves sawing or routing, cleaning and sealing of cracks in the concrete pavement that are longer than 3 feet and wider than 0.125 inch. If the crack is wider than 0.4 inch, a backer rod must be used.

Purpose: Cracks are sealed in concrete pavements to inhibit water and incompressible materials from penetrating the pavement structure, thereby slowing the pavement's deterioration rate.

Existing pavement condition: Slowly deteriorating concrete pavements should have a high priority for crack sealing. For a stand-alone Concrete Crack Sealing treatment, the concrete pavement should have a low severity level of longitudinal and transverse cracks. No other pavement deficiencies should be present.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)
10	70	70	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 7.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Timing: The use of magnesium chloride as a roadway snow and ice melter may leave residue in pavement cracks. Early season crack treatment applications could likely result in poor adhesion and a high loss of the sealant material. To assure a successful crack sealing operation, work should be scheduled in the early fall once daytime temperatures begin to cool.

Performance: To help slow the deterioration of concrete pavements, crack sealing is best used with other rigid pavement treatments such as joint resealing, minor spall repair, and /or full depth concrete joint repair. Proper crack preparation and cleaning is essential for a successful performance.

Subsequent preventive maintenance crack sealing projects should follow every five years or until the condition of the pavement requires work that is beyond the scope of preventive maintenance.

Expected Life Extension (3)

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Rigid	Up to 6	Up to 3	Up to 2

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

11 - CONCRETE JOINT RESEALING

Description: This treatment includes the removal of the existing joint seals, and resealing the transverse and longitudinal joints with preformed neoprene, silicones, or low-modulus hot-poured rubber.

Purpose: Concrete pavement joints are sealed to prevent water and incompressible materials from entering the pavement structure, thereby slowing the rate of deterioration of the concrete pavement.

Existing Pavement Condition: Resealing with neoprene can be done when the concrete pavement is fairly new and is typically used where pourable sealants have failed. Joint faces must be in good condition with very little or no spalling. Joints should not be open more than 1 inch at any temperature throughout the year. Joint widths should not vary by more than 0.125 inch.

Resealing with silicones is typically done on older concrete pavements (more than 10 years old). Self-leveling silicone can be used in joints where spalls are less than 1 inch deep and less than 1.5 inch wide (measured from the joint face). Non-sag silicone can be used in joints where spalls are less than 1.5 inch wide (measured from the joint face). If spalls exceed these limits, joint spalls must be repaired before using silicones. Caution should be used when using silicones on pavement containing carbonate or slag aggregates.

Low-modulus hot-poured rubber is an option for resealing concrete pavements containing carbonates and slag aggregate. Its movement capabilities are lower than silicone so cutting the joints wider may be necessary. Low-modulus hot-poured rubber should be used when resealing longitudinal joints.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)
10	70	70	90

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 7.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Performance: A properly placed concrete pavement seal should preserve the service life by slowing the concrete pavement's deterioration. Proper joint preparation and cleaning is essential for a successful performance.

Expected Life Extension [3]

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Rigid	4 - 6	3 - 5	2 - 3

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000'elevation should be reduced up to 50% from the values shown in the table.

12 – PARTIAL DEPTH REPAIR

Description: Partial depth repair is used to repair localized areas of surface deterioration within the upper one-third of the slab depth.

Purpose: To improve the ride quality and assist in sealing the pavement surface.

Existing Pavement Condition: The concrete pavement should be in relatively good condition with only localized areas needing repair.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)
10	70	70	90

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 7.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Existing Pavement Surface Preparation: Remove the concrete pavement and reinforcing steel in the area within the upper one-third of the slab depth.

Performance: The performance of this treatment is dependent upon the type of material placed in the repair area.

Concrete repairs are better suited to multi-lane highways due to traffic restrictions during the curing of the concrete. There should be a minimum of 3 days between casting the concrete and opening the repair to traffic. If an accelerator is used for faster strength gain, the anticipated longevity of the repair will be reduced.

The repair areas will usually induce a variation in tire noise from a difference in surface texture between the repair and the existing pavement.

Expected Life Extension (3)

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Rigid	4 - 6	2 - 3	Up to 3

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

13 - DOWEL BAR RETROFIT

Description: Dowel bar retrofit is the placing of dowel bars across joints and / or cracks that exhibit poor load transfer.

The work consists of five operations: cutting the slots across the joint and / or crack; preparing the slots; placing the dowel bars; backfilling the slots with grout; and opening the pavement to traffic.

Purpose: A dowel bar retrofit treatment restores the effective load transfer at joints and cracks, significantly reduces the occurrence of severe faulting, and increases the structural capacity of the pavement.

Existing Pavement Condition: Dowel bar retrofits should only be used to rehabilitate existing jointed concrete pavements in good to fair condition without serious deterioration. There should be very little to no spalling along the joint or crack. Crack widths should be less than 0.25 inch and faulting less than 0.125 inch.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)
10	70	70	80

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 7.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Performance: This treatment should generally be used with other rigid pavement treatments including diamond grinding, joint re-sealing, and crack sealing.

Expected Life Extension (3)

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Rigid	4 - 6	2 - 3	Up to 3

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

14 - FULL DEPTH CONCRETE PAVEMENT REPAIR

Description: This treatment consists of the removal and replacement of the concrete pavement at the deteriorated joint or open crack. The concrete repair includes load transfer, pavement reinforcement, and contraction and / or expansion joints with joint seals.

Purpose: A full depth concrete repair will restore the pavement's structural integrity and should at least maintain its existing ride quality. Secondary benefits include less water entering the pavement structure and a slower rate of future distress.

Existing Pavement Condition: The concrete pavement should be in good condition and deteriorating slowly. Transverse joints and cracks to be repaired should show at least 3 feet of severe spalling over their length within the lane. Other transverse joints and cracks with openings wider than 0.25 inch or faulting more than 0.125 inch are appropriate for full depth repairs.

Minimum PMS Values

Min RSL (1)	Long_Index	Tran_Index	Ride_Index (2)
7	70	70	50

(1) For low commercial traffic roadways (AADT-T < 400), the minimum RSL = 4.

(2) These are initial starting points that should be fine-tuned over time based upon experience in using this treatment option.

Note: Contact the Region Pavement Manager for the Index Values of specific highways.

Performance: The full depth concrete pavement repair is limited to 30 new patches per lane mile. Concrete repairs will usually induce a variation in tire noise from a difference in surface texture between the repair and the existing pavement. This treatment is better suited to multi-lane highways due to traffic restrictions during the curing of the concrete. There should be a minimum of 3 days between casting the concrete and opening the repair to traffic.

If an accelerator is used for faster strength gain, the anticipated longevity of the repair will be reduced.

Expected Life Extension (3)

Commercial Traffic/Pavement Type	(Trucks)/(Years)		
AADT-T	**< 400**	**400 - 6000**	**> 6000**
Rigid	6 -11	3 - 10	Up to 5

(3) The time range is the expected life-extending benefit given to the pavement, not the anticipated longevity of the treatment. The life-extending value for pavements above 8,000' elevation should be reduced up to 50% from the values shown in the table.

Appendix B

Colorado DOT Distress Manual for HMA and PCC Pavements

…Pavement Preservation

The National Center for Pavement Preservation
Michigan State University
2857 Jolly Road
Okemos, MI 48864
(517) 432-8220

TABLE OF CONTENTS

I Distresses in Hot Mix Asphalt (HMA) Pavements

1. Fatigue Cracking – [HMA Pavement Distress]

Description:
Fatigue cracking (Figure 1) occurs in areas subjected to repeated traffic loadings. In the early stages, this distress can be a series of interconnected cracks, later developing into many-sided, sharp-angled pieces, usually less than 2 feet on the longest side, with the characteristic alligator pattern or chicken wire appearance. (Figure 2) Cracking begins at the bottom of the HMA layer or the stabilized base and propagates to the surface. This alligator cracking is a major structural distress and normally occurs with rutting.

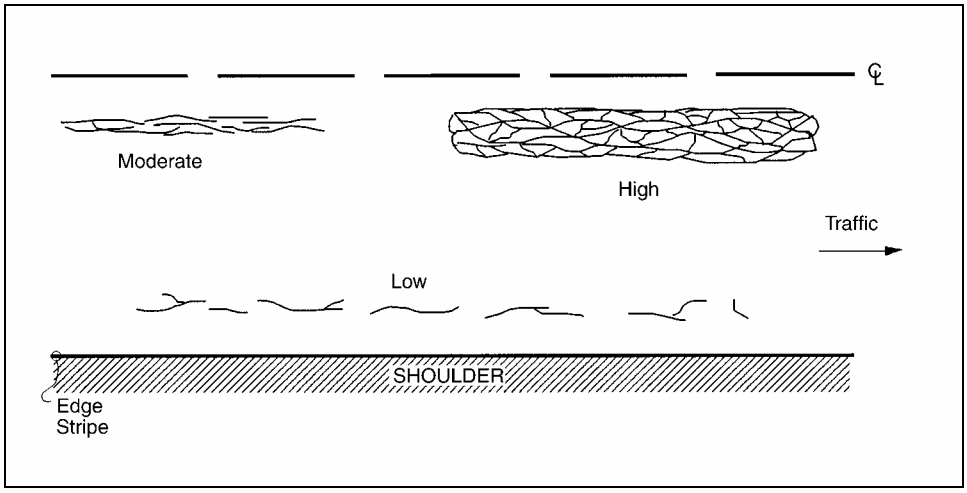

Figure 1 – Fatigue Cracking

Figure 2 – Chicken Wire/Alligator Pattern Cracking

Fatigue Cracking (Continued)

Severity Levels:

Low: An area with fine, longitudinal, parallel, hairline cracking with few connecting cracks. The cracks are not spalled or sealed and pumping is not evident. (Figure 3)

Figure 3 - Low Severity Fatigue Cracking

Moderate: An area of interconnected cracks forming a complete pattern or network. The cracks may be lightly spalled or sealed and pumping is not evident. (Figure 4)

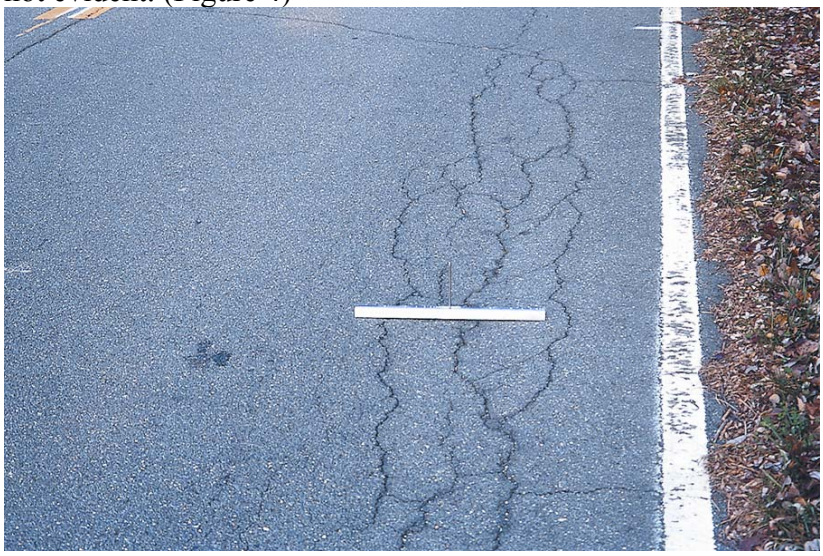

Figure 4 - Moderate Severity Fatigue Cracking

High: An area of moderately or severely spalled interconnected cracks forming a complete pattern. The pieces may move under traffic, the cracks may be sealed, and pumping may be evident. (Figure 5)

Fatigue Cracking (Continued)

Figure 5 - High Severity Fatigue Cracking with Spalled Interconnected Cracks

Treatments:

Low: This is a candidate for either - crack filling, sand seal, or chip seal treatment.

Moderate: Treatments for a moderate severity level could be either - Nova Chip, HMA Overlay or a Surface Milling with a HMA Overlay.

High: The high severity level condition is beyond a preservation treatment. Do nothing under the Pavement Preservation Program; handle under either as a rehab or reconstruction project.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

2. Block Cracking – [HMA Pavement Distress]

Description:
Block cracking is a pattern of cracks dividing the pavement surface into approximately rectangular pieces. (Figure 6) The rectangular blocks range in size from 1 square foot to 100 square feet. This distress is caused primarily by shrinkage of the asphalt and daily temperature cycling and is not load related. Block cracking usually occurs over a large portion of the pavement surface, but may occur only in non-traffic areas. The smaller the blocks, the more advanced the hardening of the asphalt. This distress may also occur with fatigue cracking in the wheel paths. (Figure 7)

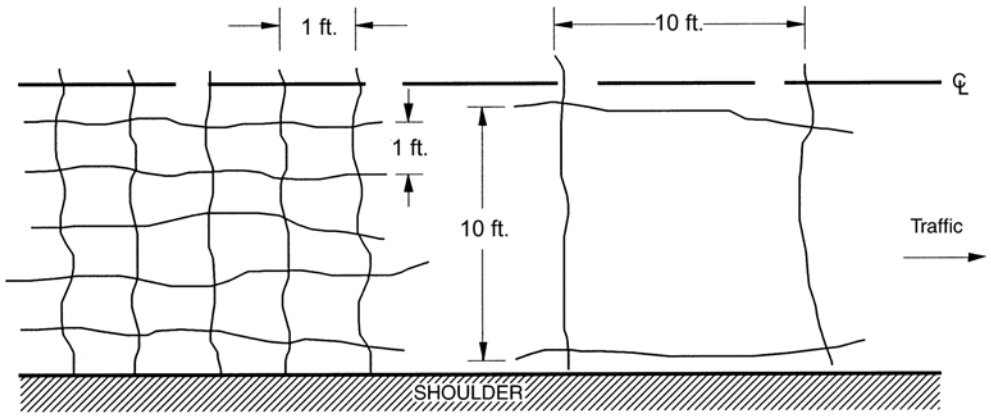

Figure 6 - Block Cracking

Figure 7 - Block Cracking

Block Cracking (Continued)

Severity Levels:

Low: Crack widths are less than 0.25 inch or sealed cracks of undetermined width have sealant in good condition.

Moderate: Crack widths that range from 0.25 inch to 0.75 inch or any crack width up to 0.75 inch and adjacent low severity random cracking.

High: Any crack with average width more than 0.75 inch or any crack width up to 0.75 inch and adjacent moderate to severe random cracking. (Figure 8)

Figure 8 - Block Cracking

Treatments:

Low Severity: This is a candidate for a crack filling treatment.

Moderate Severity: A recommended treatment can be a chip seal, Nova Chip, or HMA Overlay.

High Severity: The preferred treatment is a Surface Milling with a HMA Overlay.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

3. Edge Cracking – [HMA Pavement Distress]

Description:
Edge cracking generally applies to pavements with unpaved shoulders. However, edge cracking can also occur adjacent to paved shoulder joints or curb and gutter sections, due to poor compaction or water infiltration. The cracks run parallel to and usually within 24 inches of the outer edge of the pavement. Edge cracking is accelerated by traffic loading and can be caused by a frost-weakened base or sub-grade near the pavement edge. The area between the cracking and the pavement edge is termed "raveled" if it breaks up, sometimes with pieces removed. (Figure 9)

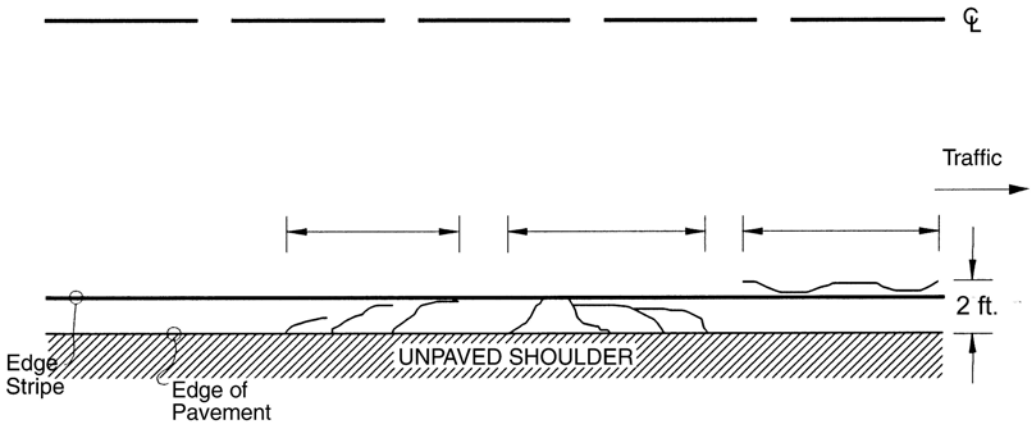

Figure 9 - Edge Cracking

Severity Levels:

Low: Low or medium cracking with no breakup or raveling. (Figure 10)

Moderate: Medium cracking with some breakup and raveling occurring up to 10 percent of the length of affected pavement.

High: Considerable break up or raveling of more than 10 percent the length of the affected pavement.

Edge Cracking (Continued)

Figure 10 - Edge Cracking

Treatments:

Low: No treatment necessary.

Moderate: Consider a crack filling treatment.

High: Saw cut full depth along the edge of pavement removing raveled and broken sections. Inspect the base material and stabilize or repair if necessary. Replace removed sections with full depth compacted HMA patching material. Consider adding a paved HMA shoulder (minimum depth of 3 inches) as part of the repair if traffic has been driving on the edge of the pavement.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

4. Longitudinal Cracking – [HMA Pavement Distress]

Description:
Longitudinal cracks (Figure 11) run parallel to the centerline (may be either in the wheel paths or outside). These types of cracks are caused by poor construction of the paving lane joint, shrinkage of the pavement surface as a result of low temperatures, or asphalt hardening and /or daily temperature cycling.

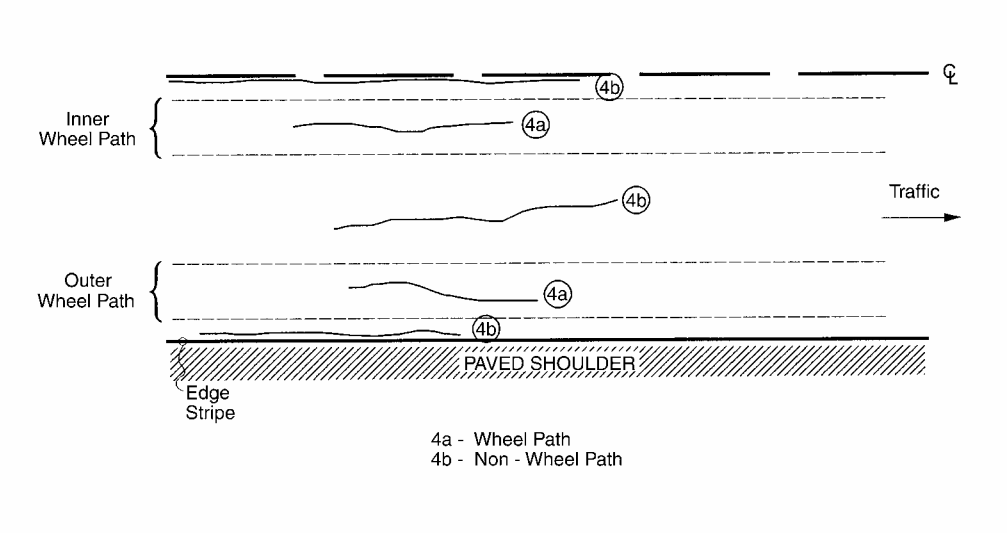

Figure 11 - Longitudinal Cracking

Severity Levels:

Low: Crack widths averaging less than 0.25 inch or filled cracks of any width in good condition.

Moderate: Cracks averaging between 0.25 inch and 0.75 inch or any crack width up to 0.75 inch plus adjacent low severity random cracking. (Figure 12)

Longitudinal Cracking (Continued)

Figure 12 - Moderate Severity Longitudinal Cracking in the Wheel Path

High: Cracks averaging over 0.75 inch or any crack with average width or less than 0.75 inch plus adjacent moderate to high severity random cracking. (Figure 13)

Figure 13 - High Severity Longitudinal Cracking not in Wheel Path

Longitudinal Cracking (Continued)

Treatments:

Low: This is a candidate for a crack fill treatment.

Moderate: Consider the crack fill treatment or crack fill followed by a chip seal, sand seal or Nova Chip.

High: The treatments that can be considered include HMA Overlay, or a surface milling with a HMA Overlay.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

5. Reflective Cracking – [HMA Pavement Distress]

Description: This distress (Figure 14) occurs on asphalt surfaced pavements which have been laid over a Portland Cement Concrete (PCC) base or an old asphalt pavement and is not load-related. However, traffic loading may cause breakdown of the asphalt near the crack. When the pavement is fragmented along a crack, the crack is said to be "spalled".

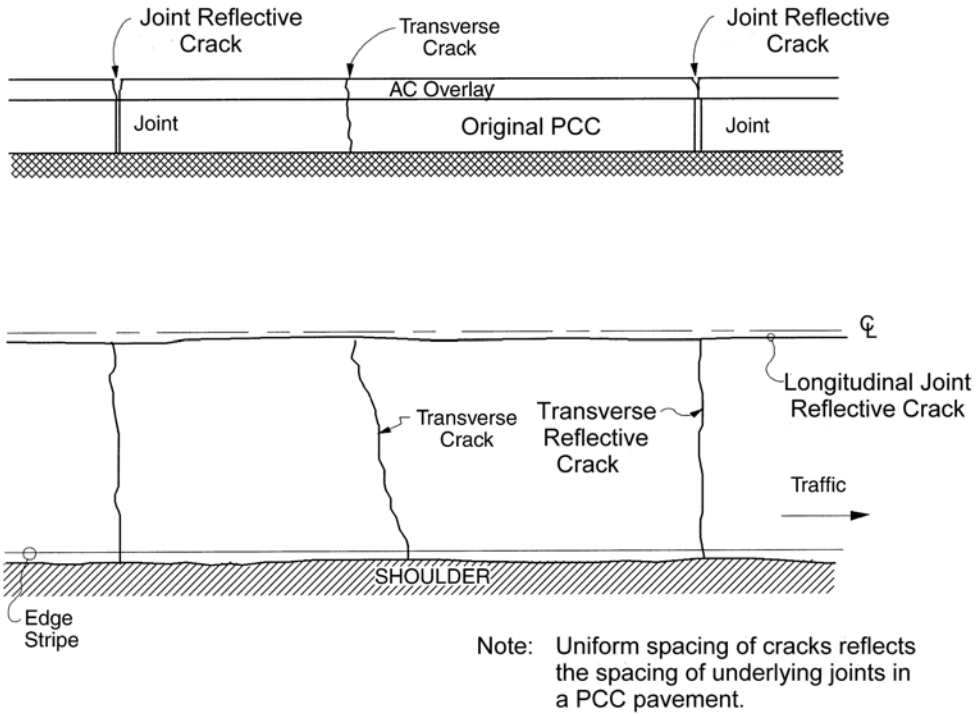

Figure 14 - Reflective Cracking

Severity Levels:

Low: Any unfilled crack width averaging less than 0.25 inch or any sealed crack with sealant material in good condition and a width that can not be determined.

Moderate: Any crack width averaging between 0.25 inch and 0.75 inch or any crack averaging less than 0.75 inch plus adjacent low severity random cracking.

High: Any crack width averaging more than 0.75 inch or any crack less than 0.75 inch plus adjacent moderate to high severity random cracking. (Figure 15)

Reflective Cracking (Continued)

Figure 15 - High Severity Reflection Cracking at Joints

Treatments:

Low: Apply a crack fill treatment.

Moderate: Apply a crack fill or a crack sealing treatment.

High: Mill and Fill treatment.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

6. Transverse Cracking – [HMA Pavement Distress]

Description: Cracks which are predominately perpendicular to the pavement centerline (Figure 16).

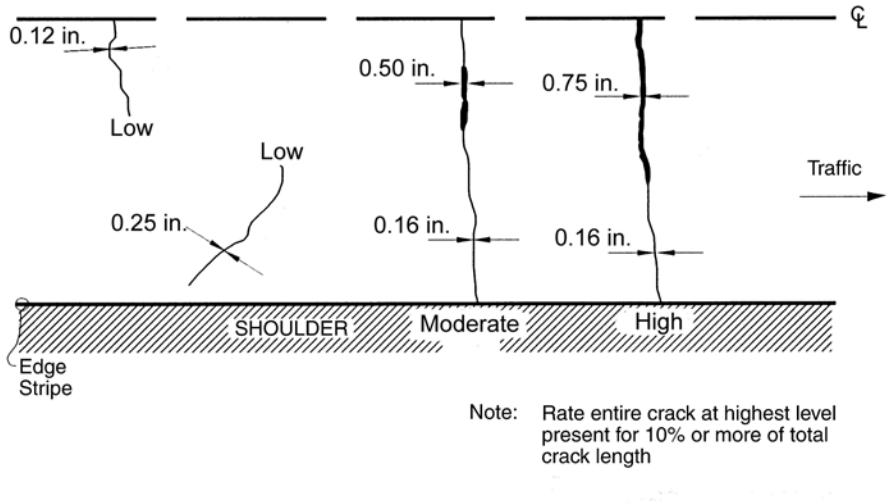

Figure 16 - Transverse Cracking

Severity Levels:

Low: Any unsealed crack with a mean width up to 0.25 inch or a crack with good condition sealant plus an undetermined width. (Figure 17)

Figure 17 - Low Severity Transverse Cracking

Transverse Cracking (Continued)

Moderate: Any crack width averaging between 0.25 inch and 0.75 inch or any crack up to 0.75 inch and adjacent low severity random cracking. (Figure 18)

Figure 18 - Moderate Severity Transverse Cracking

High: Any crack width greater than 0.75 inch or any crack averaging less than 0.75 inch plus adjacent moderate to high severity random cracking. (Figure 19)

Figure 19 - High Severity Transverse Cracking

Transverse Cracking (Continued)

Treatments:

Low: This is crack fill or crack seal candidate.

Moderate: Consider the crack fill, crack seal, sand seal, chip seal or Nova Chip treatments.

High: This should be candidate for HMA Overlay, or a surface milling with a HMA Overlay.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

7. Rutting – [HMA Pavement Distress]

Description: Rutting (Figures 20 and 21) is a longitudinal surface depression in the wheel path that may not be noticeable until after rain (Figure 22) fills the ruts. Rutting is a lateral material deformation in any of the pavement layers or sub-grade caused by traffic loading. This type of distress can lead to a major structural failure.

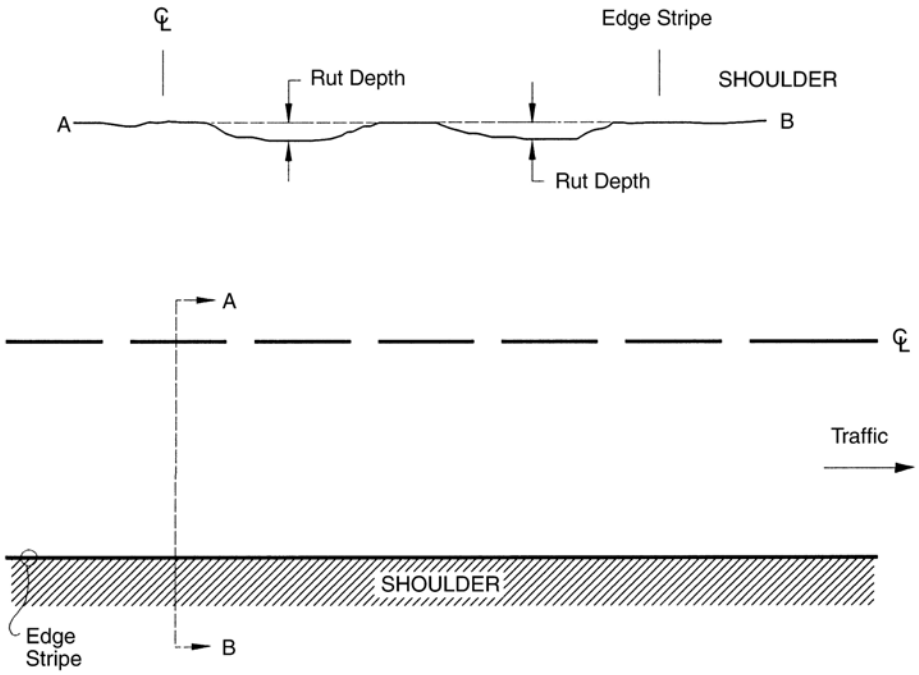

Figure 20 - Rutting

Figure 21 – Rutting

Rutting (Continued)

Figure 22 - Standing Water in Ruts

Severity Levels: Severity levels may be categorized by rut depth.

Low: Rutting depth ranges from 0.25 inch to 0.5 inch.

Moderate: Rutting depth ranges from 0.5 inch to 1 inch.

High: Rutting depth exceeds 1 inch.

Treatments:

Low: No repair required or micro-surface if rutting is approaching 0.5 inch.

Moderate: Consider micro-surfacing or surface milling and a HMA Overlay.

High: The preferred treatment for a rut depth less than 1.5 inches is a surface milling and a HMA Overlay.

8. Shoving – [HMA Pavement Distress]

Description: Shoving is a longitudinal displacement of a localized area of pavement surface, sometimes associated with vertical displacement. This distress is generally caused by braking or accelerating vehicles and is usually located on hills, curves or at intersections. (Figures 23 and 24)

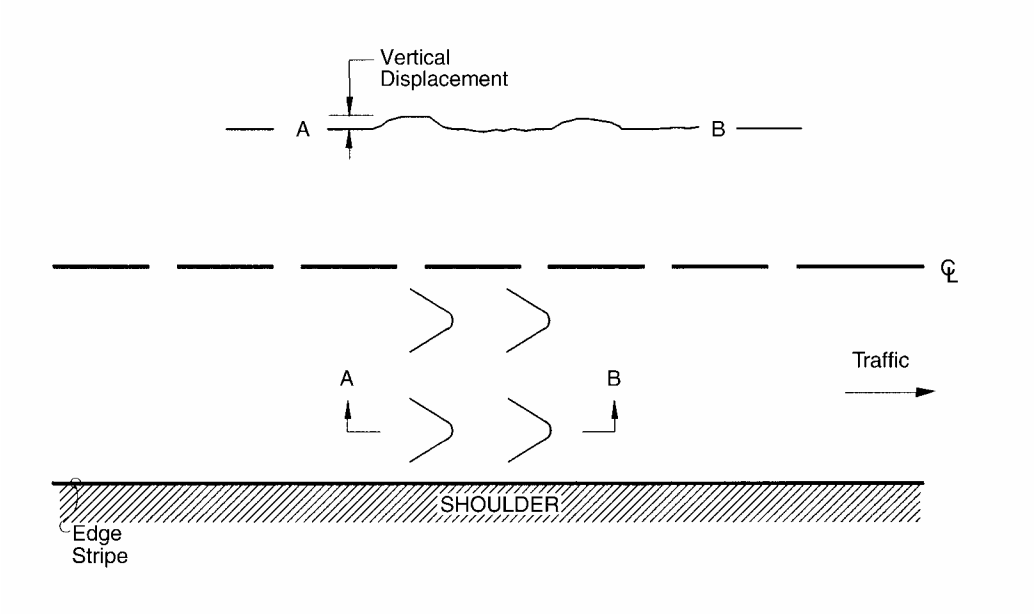

Figure 23 - Shoving

Figure 24 - Shoving in Pavement surface

Severity Levels: The three severity levels may be defined by the relative effect of shoving on ride quality values.

Shoving (Continued)

Treatments:

Low: Nothing is required.

Moderate: Surface milling and a HMA Overlay is the preferred treatment.

High: Surface milling and a HMA Overlay is the preferred treatment.

9. Bleeding – [HMA Pavement Distress]

Description: Bleeding, which usually occurs in wheel paths, is excess bituminous binder material which has leaked to the surface, making a glass-like, tacky, reflective surface hiding the aggregate particles. This distress condition is caused by excess asphalt cement in the mix, excess sealant and / or low air void content during hot weather. As this process is not reversible in cold weather, tar will continue to accumulate on the surface over time. (Figures 25, 26, and 27)

Figure 25 – Discoloration

Figure 26 - Loss of Texture

Bleeding (Continued)

Figure 27 - Aggregate Obscured

Severity Levels: The presence of bleeding indicates a potential mixture formulation problem and its extent should be monitored.

Low: Bleeding is noticeable only a few days of the year and does not stick to shoes or tires.

Moderate: Asphalt sticks to shoes and /or tires during a few days of the year.

High: Bleeding occurs extensively and sticks to shoes and tires during several days of the year.

Treatments:

Low: Although no repairs are required, the condition should be monitored for future correction.

Moderate: Consider a chip seal or sand seal.

High: The treatments that can be considered include a HMA Overlay or a surface milling with a HMA Overlay.

10. Polished Aggregate – [HMA Pavement Distress]

Description: Traffic has worn the surface binder away to expose the coarse aggregate particles. Once the aggregate particles become worn smooth, the surface friction may be reduced to unsafe levels.

Severity Levels: Although severity levels have not been identified, the degree of polishing should be significant on at least 70% of the exposed aggregate. (Figure 28)

Figure 28 - Polished Aggregate

Treatments: Roadways and intersections requiring a reasonable coefficient of friction should be given a chip seal, sand seal, or micro-surfacing treatment to increase vehicular tire adhesion when braking or stopping.

11. Raveling – [HMA Pavement Distress]

Description: Raveling is the wearing away of the pavement surface caused by dislodging of aggregate particles and the loss of asphalt binder. This distress ranges from loss of fine aggregate (Figure 29) to loss of fine and some coarse aggregate (Figure 30) and ultimately to a very rough and pitted surface (Figure 31). This can be caused by hardened binder, a poor quality mix or softened surface due to oil spillage.

Figure29 - Loss of Fine Aggregate

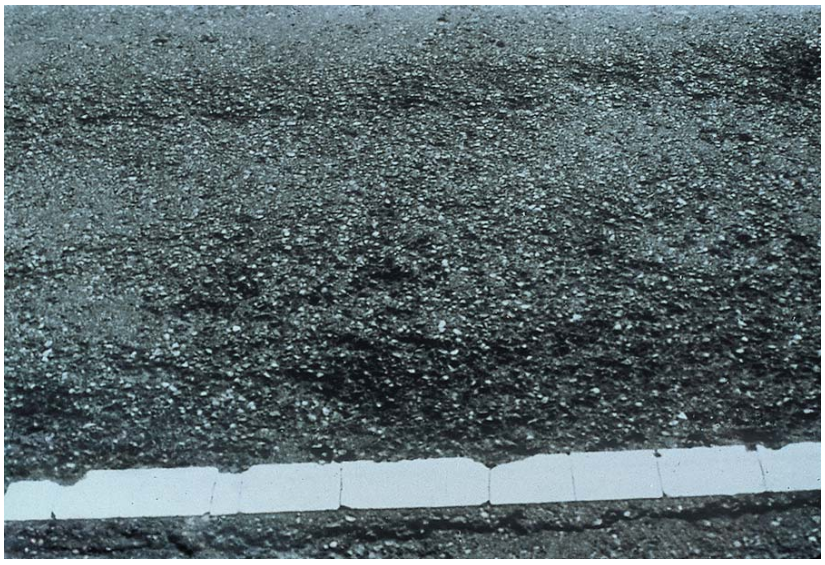

Figure 30 - Loss of Fine and Some Course Aggregate

Polished Aggregate (Continued)

Figure 31 - Loss of Course Aggregate

Severity Levels: Raveling indicates potential mix problems and should be monitored.

Low: Aggregate or binder has started to wear away with some pitting. If oil spillage has occurred, the stain is visible but the pavement surface may not be deformed.

Moderate: Aggregate and / or binder has worn away with a moderately rough and pitted surface. If there oil spillage has occurred, the surface is soft and can be deformed.

High: Aggregate and / or binder has considerable wear and is very rough and severely pitted. Pitted areas larger than 4 inches in diameter and more than 0.5 inch deep are considered potholes.

Treatments:

Low: This is a good candidate for a chip seal or sand seal treatment.

Moderate: Apply a micro-surfacing treatment.

High (Small Areas): Consider applying a surface milling and fill with a HMA mixture.

High (Large Areas): Remove loose material and clean existing surface, apply tack coat, and overlay with 1.5 inch of HMA asphalt overlay or a Nova Chip.

II Distresses in Portland Cement Concrete (PCC) Pavements

1. Corner Breaks – [Rigid Pavement Distress]

Description: A Corner Break is a slab fracture along a line intersecting the adjacent transverse and longitudinal joints at approximately 45 degrees. The lengths of the fractured sides range from 12 inches to one half the slab width. (Figure 32)

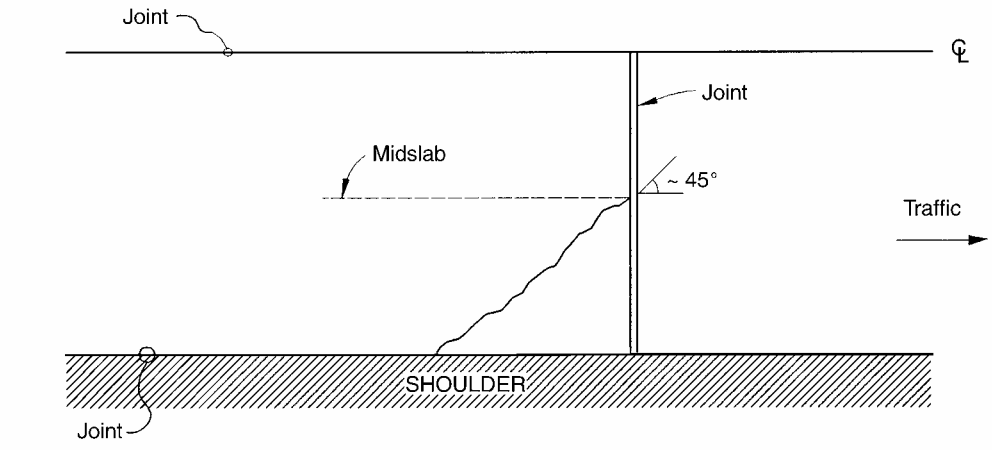

Figure 32 - Corner Breaks

Severity Levels:

Low: The crack is not spalled for more than 10% of the crack length, there is no faulting, the corner piece is not broken into two or more parts and there is no loss of material or patching. (Figure 33)

Corner Breaks (Continued)

Figure 33 - Low Severity Corner Break

Moderate: Crack shows low-severity spalling for more than 10% of its total length or faulting of the crack or joint is less than 0.5 inch or the corner piece has not broken into two or more parts. (Figure 34)

Figure 34 - Moderate Severity Corner Break

High: Crack shows moderate to high severity spalling over 10% of its total length or faulting of the crack or joint is at least 0.5 inch or the corner piece has broken into two or more parts or patching material is present.

Corner Breaks (Continued)

Treatments:

Low & Medium: These are good candidates for the concrete crack sealing treatment. After cleaning out the crack, seal any crack over 0.125 inch wide with crack sealant.

High: The preferred treatment is the Full Depth Concrete Pavement Repair treatment. Saw cut the slab full depth into a rectangular section and remove old pavement. After inspection of base material, stabilize or repair as required. Pour new concrete section with dowelled expansion joint and construction joint and cure according to local conditions.

2. Durability Cracking ("D" Cracking) – [Rigid Pavement Distress]

Description: "D" Cracking is a distress caused by freeze/thaw expansion of the coarse aggregate which breaks down the concrete slab over time. Dark color staining due to saturation near joints and closely spaced fine crescent shaped cracks may lead to eventual disintegration of the entire slab. (Figure 35)

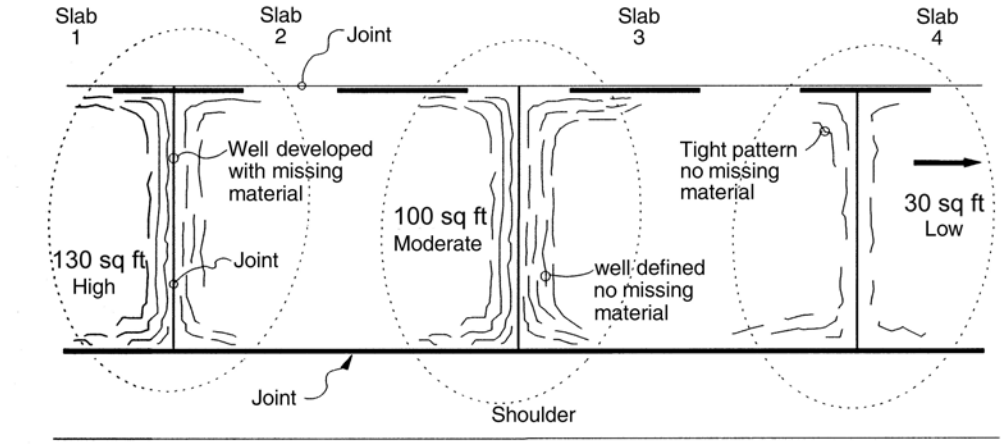

Figure 35 - Durability Cracking

Severity Levels:

Low: The "D" cracks are tight with no missing or loose pieces or patching from previous repairs.

Moderate: The "D" cracks are well-defined and some pieces are loose or missing. (Figure 36)

Figure 36 - Moderate Severity "D" Cracking with Well Defined Pattern

High: The "D" cracking has progressed to a well-developed pattern with a significant amount of loose material. Displaced pieces up to 1 square foot in size may have been patched. (Figure 37)

Figure 37 - High Severity "D" Cracking with Loose and Missing Material

Durability Cracking (Continued)

Treatments:

Low & Moderate: Monitor for future repair.

High: This may be a candidate for the Full Depth Concrete Pavement Repair treatment.

Note: The extent of major "D" cracking may determine that major rehabilitation or reconstruction is required.

3. Longitudinal Cracking – [Rigid Pavement Distress]

Description: Cracks that are predominantly parallel to the pavement centerline caused by a combination of repeated traffic loading, thermal gradient curling, and repeated moisture loading. (Figure 38)

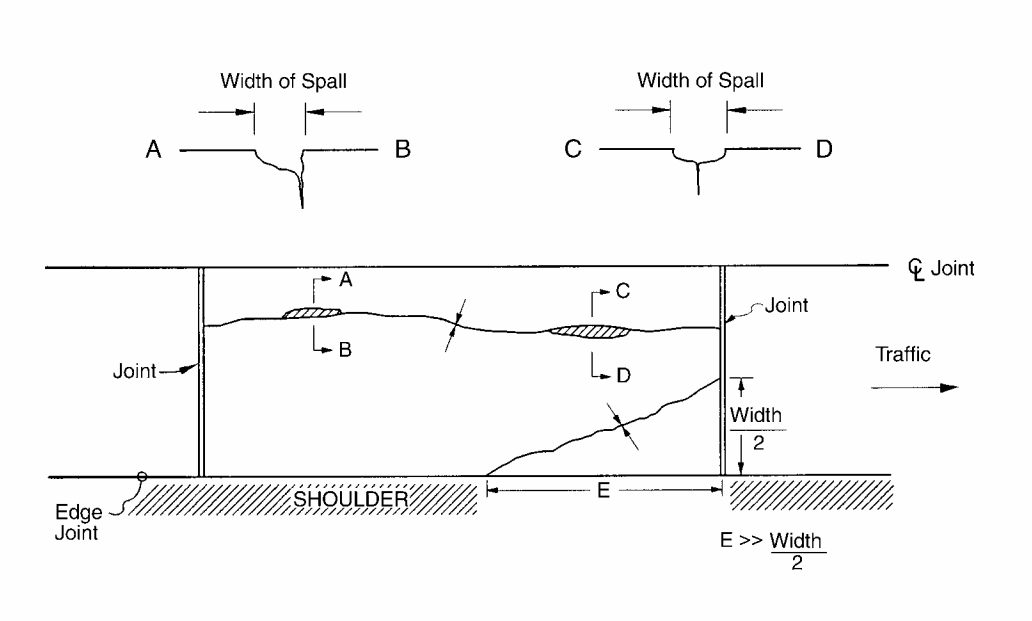

Figure 38 - Longitudinal Cracking

Severity Levels:

Low: Crack widths less than 0.1 inch, no spalling and no measurable faulting; or well sealed cracks having widths that cannot be measured (Figure 39).

Figure 39 - Low Severity Longitudinal Cracking

Longitudinal Cracking (Continued)

Moderate: Crack widths at least 0.1 inch up to 0.5 inch; or with spalling less than 3 inches; or faulting up to 0.5 inch (Figure 40).

Figure 40 - Moderate Severity Longitudinal Cracking

High: Crack widths at least 0.5 inch; or with spalling at least 3 inches; or faulting at least 0.5 inch (Figure 41).

Figure 41 - High Severity Longitudinal Cracking

Longitudinal Cracking (Continued)

Treatments:

Low: This is a candidate for the concrete crack sealing treatment.

Moderate & High: The recommended treatments for this severity level are Concrete crack sealing with partial depth repair and diamond grinding to remove the faulting in the high severity areas.

4. Transverse Cracking – [Rigid Pavement Distress]

Description: Cracks that are predominantly perpendicular to the pavement centerline caused by a combination of repeated traffic loading, thermal gradient curling, and repeated moisture loading. (Figure 42)

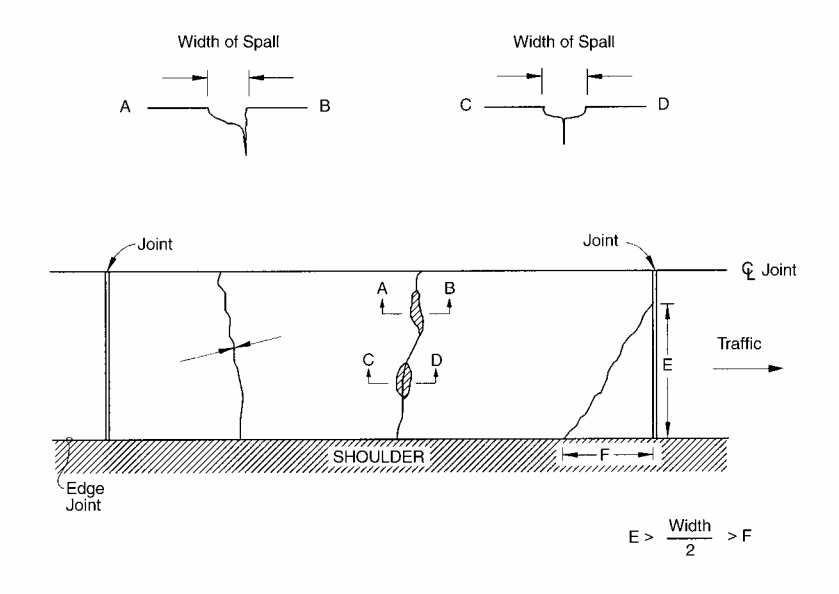

Figure 42 - Transverse Cracking

Severity Levels:

Low: Crack widths less than 0.1 inch, no spalling, and no measurable faulting; or well sealed cracks having widths that cannot be measured.

Moderate: Crack widths at least 0.1 inch up to 0.2 inch; or with spalling less than 3 inch; or faulting up to 0.2 inch (Figure 43).

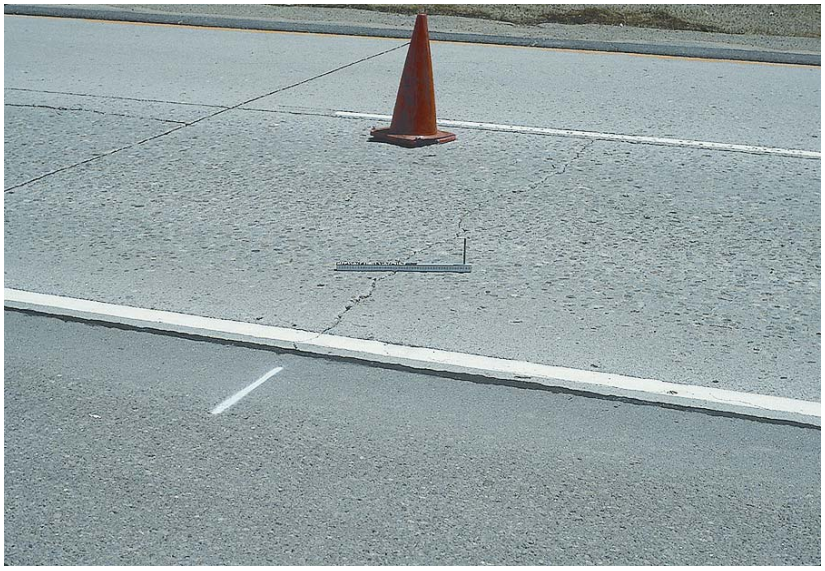

Figure 43 - Moderate Severity Transverse Cracking

Transverse Cracking (Continued)

High: Crack widths at least 0.2 inch; or with spalling at least 3 inch; or faulting at least 0.2 inch (Figure 44).

Figure 44 - High Severity Transverse Cracking

Treatments:

Low: This is a candidate for Concrete Crack Sealing.

Moderate: The Concrete Crack Sealing treatment with the Partial Depth Repair treatment to repair the spall areas.

High: In addition to the treatments for the moderate severity level, the Diamond Grinding treatment should be used to fix the faulting.

* Spalling may be addressed by partial depth repair - requires reforming and sealing cracks.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

5. Joint Seal Damage (Longitudinal and Transverse) – [Rigid Pavement Distress]

Description: Joint seal damage is any condition which enables incompressible materials or water to infiltrate the joint from the surface.

Severity Levels: Severity levels do not apply to longitudinal joint seals. Severity levels for transverse joint seals are as follows:

Low: Joint seal damage extends over 10% of the joint. (Figure 45)

Figure 45 - Low Severity Joint Seal Damage

Moderate: Joint seal damage extends over 10% - 50% of the joint.

High: Joint seal damage extends over 50% of the joint.

Treatments:

Low: Monitor for future repair.

Moderate & High: Concrete Joint Resealing.

Note: Surface cracks having heavy vegetation growth must be treated with herbicide 7 to 21 days prior to pavement work. A glyphosate herbicide, such as Roundup®, is recommended with 41% minimum active ingredient. After spraying vegetation, wait 5 – 7 days before cleaning the cracks. Debris should be thoroughly removed from the cracks, but never to a depth exceeding 4 inches.

6. Longitudinal Joint Spalling – [Rigid Pavement Distress]

Description: Cracking, breaking, or chipping of concrete slab edges within 12 inches of the face of the longitudinal joint. (Figure 46)

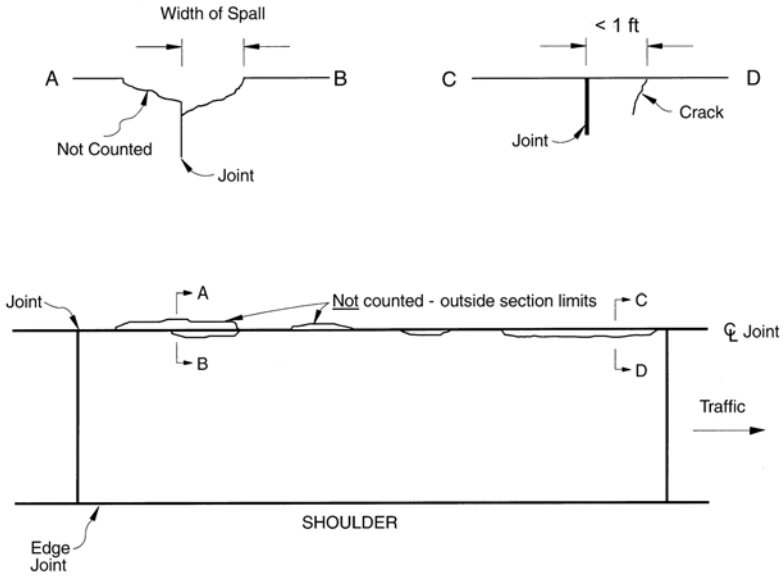

Figure 46 - Spalling of Longitudinal Joints

Severity Levels:

Low: Spalls up to 3 inches wide, measured to the face of the joint, with loss of material, or spalls with no loss of material and no patching (Figure 47).

Figure 47 - Low Severity Spalling of Longitudinal Joint

Longitudinal Joint Spalling (Continued)

Moderate: Spalls 3 inches to 6 inches wide, measured to the face of the joint, with loss of material.

High: Spalls greater than 6 inches wide, measured to the face of the joint, with loss of material or broken into two or more pieces or containing patching material from a previous repair (Figure 48).

Figure 48 - High Severity Spalling of Longitudinal Joint

Treatments:

Low: This is a candidate for the Concrete Joint Resealing treatment.

Moderate & High: The Concrete Joint Resealing and Partial Depth Repair treatments are the recommended treatments..

7. Transverse Joint Spalling – [Rigid Pavement Distress]

Description: Cracking, breaking, or chipping of concrete slab edges within 12 inches of the face of the transverse joint. (Figure 49)

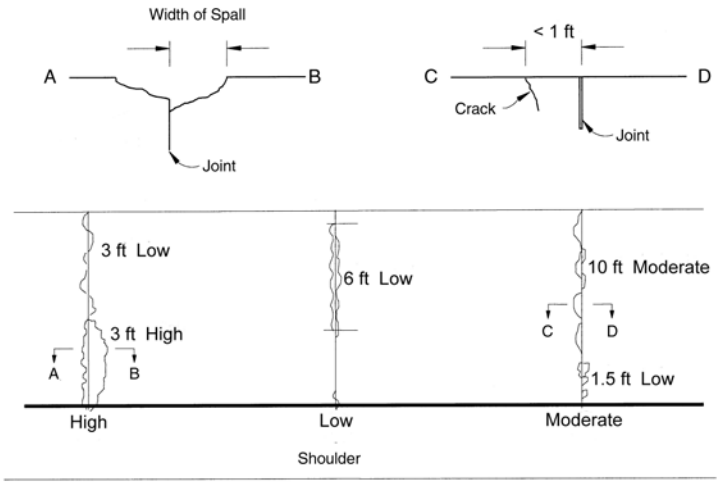

Figure 49 - Spalling of Transverse Joints

Severity Levels:

Low: Spalls up to 3 inches wide, measured to the face of the joint, with loss of material, or spalls with no loss of material and no patching.

Moderate: Spalls 3 inches to 6 inches wide, measured to the face of the joint, with loss of material. (Figures 50 and 51)

Figure 50 - Moderate Severity Spalling of Transverse Joint, Far View

Transverse Joint Spalling (Continued)

Figure 51 - Moderate Severity Spalling of Transverse Joint, Close-up View

High: Spalls greater than 6 inches wide, measured to the face of the joint, with loss of material or broken into two or more pieces or containing patching material from a previous repair.

Treatments:

Low & Moderate: The recommended treatments are the Concrete Joint Resealing and Partial Depth Repair.

High: The Concrete Joint Resealing and Partial Depth Repair treatments are recommended for the less severe spalls. If the transverse width of spalled area approaches 2 ft., consider Full Depth Concrete Pavement Repair.

8. Map Cracking and Scaling – [Rigid Pavement Distress]

Description: Map Cracking (Figure 52) is a series of hairline cracks that extend only into the upper surface of the slab. These cracks, which tend to intersect at angles of 120 degrees, are caused by over-finishing of the concrete and may lead to scaling to a depth of 0.125 inch to 0.5 inch. Scaling (Figures 53 and 54) is also caused by deicing salts, improper construction, freeze/thaw cycles and poor quality coarse aggregate.

Figure 52 - Map Cracking

Figure 53 – Scaling

Map Cracking and Scaling (Continued)

Figure 54 - Scaling, Close-up View

Severity Levels:

Low: Map cracking exists over most of the slab area and the surface is in good condition with only minor scaling present.

Moderate: The slab shows less than 15% scaling of the surface.

High: More than 15% of the surface is scaled.

Treatments:

Low: Do nothing except monitor for future deterioration.

Moderate: Partial depth repair treatment in isolated areas is recommended.

High: This severity level is probably beyond pavement preservation options and should be handled as a rehabilitation or reconstruction project.

9. Polished Aggregate – [Rigid Pavement Distress]

Description: Surface mortar and texturing has worn away to expose the coarse aggregate particles. (Figure 55)

Figure 55 - Polished Aggregate

Severity Levels: The degree of polishing may be reflected in a reduction of surface friction resulting in less safe driving conditions.

Treatments: Diamond grind the pavement surface to increase friction and tire traction.