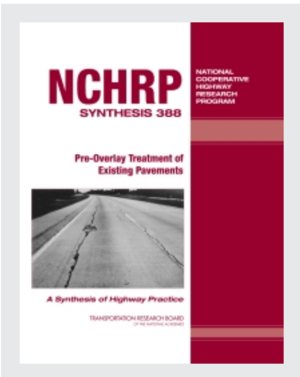


Pre-Overlay Treatment of Existing Pavements

DETAILS

143 pages | | PAPERBACK
ISBN 978-0-309-41889-8 | DOI 10.17226/23060

AUTHORS

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 388

Pre-Overlay Treatment of Existing Pavements

A Synthesis of Highway Practice

CONSULTANTS
JOHN H. TENISON
and
DOUGLAS I. HANSON
AMEC Earth and Environmental, Inc.

SUBJECT AREAS
Maintenance

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2009
www.TRB.org

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Academies was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NOTE: The Transportation Research Board of the National Academies, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

NCHRP SYNTHESIS 388

Project 20-5 (Topic 38-06)
ISSN 0547-5570
ISBN 978-0-309-09826-7
Library of Congress Control No. 2008910981

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration, U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at:
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academys p urposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

Cover figure: Longitudinal cracking, where cracks are predominantly parallel to the pavement centerline.

FOREWORD

By Staff
Transportation Research Board

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jon M. Williams
Program Director
Transportation Research Board

This report summarizes and discusses the current pre-overlay treatment practices of state departments of transportation (DOTs) for both hot-mix asphalt and portland cement concrete pavement structures. Information is provided to assist pavement management and pavement design groups in their selection of pre-overlay treatments.

Information was gathered through a literature review and a survey of all state DOTs. The survey was augmented by follow-up interviews with individuals.

John H. Tenison and Douglas I. Hanson of AMEC Earth and Environmental, Inc. collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

PRE-OVERLAY TREATMENT OF EXISTING PAVEMENTS

SUMMARY

This synthesis summarizes the current pre-overlay treatment practices of U.S. state departments of transportation (DOTs) for existing hot-mix asphalt (HMA) and portland cement concrete (PCC) pavement structures. This document is intended to assist pavement management and pavement design groups as they select a preferred pre-overlay treatment that would address the observed distresses in an existing pavement structure before placement of either an HMA or PCC overlay.

Research has shown that if the proper pre-overlay treatment is selected and used before construction of the actual structural overlay, the expected structural performance of either an HMA or PCC overlay may be enhanced. Likewise, if an incorrect pre-overlay treatment is selected and used before construction of either an HMA or PCC overlay, then the expected structural performance may be reduced. It is up to an agency's pavement design group to understand when a particular pre-overlay treatment (or treatments) should be considered for any given project and, once a particular pre-overlay treatment is selected, how the final constructed pavement structure may perform.

It is the state DOT's responsibility to ensure that all needed material and construction specifications address the methods and/or performance expectations of any pre-overlay treatment. This will allow for the consistent evaluation of each pre-overlay treatment strategy over time so that when it is needed, the strategy—based on its observed documented performance—can be properly used, modified, or disposed of as required to meet the future needs of that particular state DOT.

A survey questionnaire was distributed to all state DOTs in the United States, with 39 states responding to the survey. The purpose of the survey was to determine which pre-overlay treatments are presently being used to address given pavement distress and severity conditions. The survey questionnaire did not consider low-severity situations because it was assumed these would be addressed by the respective agencies' routine maintenance programs.

The survey data revealed a consensus among responding state DOTs about the most preferred pre-overlay treatments for some pavement distress types and severity conditions. However, there is also a divergence of opinion about the most preferred pre-overlay treatment. Therefore, this synthesis lists multiple primary and secondary preferred pre-overlay treatment strategies. It is not the purpose of this synthesis to offer definitive recommendations on or conclusions about the most effective pre-overlay treatment strategies in these situations. Many variables throughout the United States are considered when determining which pre-overlay treatment is truly the most effective on any given project. These variables include:

- Climate,
- Soil type,
- Traffic-loading conditions,
- Direct positive or negative experience with a particular pre-overlay strategy,
- Variations in how a particular pre-overlay strategy is specified for use,
- Actual construction procedures and equipment, and
- Materials allowed to be used while executing a particular pre-overlay strategy.

CHAPTER ONE

INTRODUCTION

REPORT BRIEF

Purpose of Synthesis

The purpose of this synthesis is to summarize current practices by state departments of transportation (DOTs) in preparing their existing pavement structures for either a hot-mix asphalt (HMA) or portland cement concrete (PCC) overlay. Although there have been some studies related to pre-overlay treatments of existing pavements, these findings have not been integrated into a single systematic report.

Synthesis Scope

The scope of this synthesis was to perform a comprehensive literature review, develop and then analyze the results of a related synthesis questionnaire, and conduct telephone interviews with personnel from selected state DOTs to clarify their survey responses. Questionnaire response summaries can be found in Appendix C, which can be found only in the web version of this report (http://trb.org/news/blurb_detail.asp?id=10051). The summary data presented indicates the initial responses provided by the various agencies.

Intended Audience

The information in this report is intended to assist state DOT's pavement design groups, which may not have had the full knowledge and experience of their predecessors, to select a pre-overlay treatment strategy before placement of an overlay on an existing HMA or PCC pavement.

State DOTs are shifting their emphasis away from new pavement construction and reconstruction and toward pavement rehabilitation. Additionally, state DOTs have been losing their knowledgeable pavement design personnel; personnel who have been responsible for making decisions to ensure that longer-lasting, lower future maintenance pavement structures are built and meet the monetary and performance expectations of that particular state DOT.

GENERAL BACKGROUND

To ensure the most effective use of limited state DOT agency funds for pavement rehabilitation, it is extremely important to properly evaluate the condition of existing pavements. The evaluations in this report are intended to assist agency pavement design groups in identifying which pre-overlay strategies can be considered to ensure the best overall performance of either an HMA or PCC overlay. These evaluations are also intended to help pavement design groups understand various existing distresses in pavement structures so that the performance impacts of those distresses on HMA or PCC overlays are either minimized or completely negated. A brief overview of types of distresses is provided in Appendix B, which can be found only in the web version of this report (http://trb.org/news/blurb_detail.asp?id=10051). These descriptions are provided as a guide only and should not be viewed as the only guidance available for distress-type severity description or identification.

GLOSSARY OF ACRONYMS AND TERMS

This section defines the various acronyms and terms used throughout this synthesis.

Agency—state-level governmental unit that has the primary responsibility for the planning, design, construction, and maintenance of a transportation network.

ACPA—American Concrete Pavement Association.

Composite pavement—pavement structure composed of an asphalt concrete wearing surface and PCC slab; "composite pavement" also refers to an asphalt concrete overlay on a PCC slab (*Mechanistic Empirical Pavement Design Guide* n.d., NCHRP, Project 1-40).

Continuously reinforced concrete pavement (CRCP)—PCC pavement with longitudinal reinforcement at or above mid-depth designed to hold shrinkage cracks tightly closed. Transverse joints exist only for construction purposes and on-grade structures. Transverse reinforcement may or may not exist. Longitudinal joints exist similar to those with other types of concrete pavements (*Mechanistic Empirical Pavement Design Guide* n.d.).

Flexible pavement—pavement structure that maintains intimate contact with and distributes loads to the subgrade, and that depends on aggregate interlock, particle friction, and cohesion for stability (*Mechanistic Empirical Pavement Design Guide* n.d.).

HMA—hot-mix asphalt.

IRI—International Roughness Index.

Jointed plain concrete pavement (JPCP)—jointed PCC pavement containing transverse joints spaced to accommodate temperature gradients and drying shrinkage stresses to avoid cracking. This pavement contains no distributed steel to control random cracking and may or may not contain joint load transfer devices (*Mechanistic Empirical Pavement Design Guide* n.d.).

PCC—portland cement concrete.

Rehabilitation—work undertaken to extend the service life of an existing pavement facility. Rehabilitation includes placement of additional surfacing material or other work necessary to return an existing roadway (including shoulders) to a condition of structural or functional adequacy. Rehabilitation could also include the partial removal and replacement of the pavement structure. It does not refer to normal periodic maintenance activities; "periodic maintenance" is interpreted to include such tasks as resurfacing activities of less than 1 in. thickness or of short lengths of roadway; patching; filling potholes; sealing cracks and joints, or other repairs of minor failures; undersealing of concrete slabs other than as an essential part of rehabilitation; and other activities primarily intended to preserve existing roadway. Pavement rehabilitation projects, on the other hand, should substantially increase the service life of a significant length of roadway (*AASHTO Guide for Design of Pavement Structures* 1993, p. I-45).

Rigid pavement—pavement structure that distributes loads to the subgrade, having as one course a PCC slab of relatively high-bending resistance (*Mechanistic Empirical Pavement Design Guide* n.d.)

GENERAL AGENCY ISSUES AND PROBLEMS

Every state DOT agency contains many competing private and public priorities, performance expectations, fluctuating funding issues, and various levels of pavement performance knowledge among its personnel, all of which may influence selections of pavement structures to be rehabilitated and to what extent. The decisions a state DOT makes may or may not be carried through by future state DOT agency administrations. As such, a pavement design group needs to be flexible in its recommendations in response to circumstances that could become, at times, very complex. The purpose of this section, therefore, is to help raise a pavement design group's awareness of these issues so that it can adopt a successful design that will be acceptable to most of those actually affected by that design.

Possibility of Multiple Solutions

Once a segment of roadway has been selected and scheduled for a rehabilitation project, there may be preexisting expectations within the state DOT agency about what activities will be performed during that project and what amount of funding is necessary to support those activities. These expectations and their associated perceived funding requirements, if they have been established well before the project has actually been evaluated and a final design recommendation prepared, may cause the pavement design group to consider multiple pre-overlay treatment and design solutions. These solutions, in turn, may or may not satisfy the agency's expectations, exceed the agency's funding constraints, or both. Therefore, the pavement design group should convey its knowledge of pre-overlay treatment performance to the decision maker for that specific rehabilitation project. This will allow a well-informed and balanced decision to be made on whether the state DOT's project expectations and/or funding are met and which alternative will ultimately be constructed.

Various Performance Expectations

The pavement design group may find that members of the design team have different performance expectations. These differences are the result of:

- Competing statewide and regional needs for the available funding,
- General knowledge of the design team's members concerning their individual perceptions of the performance afforded by various pre-overlay treatment strategies,
- Specific long-term performance models used by pavement management systems with various pre-overlay treatment strategies,
- Upper-level and executive management decisions and directives, and
- The needs of the public ultimately served by the roadway project.

The pavement design group will need to provide consistent information regarding the performance of pre-overlay strategies on pavement rehabilitation. During the design process, the design team will look for guidance from the pavement design group and its members' understanding of maintenance and construction procedures, agency material specifications, and pavement design theory, as well as their overall pavement design experience. Through research, the pavement design group will need to understand what strategies have and have not worked within a particular regional area. Members of the pavement design group will also need to constantly expand, and then share, their knowledge, including their experiences within their respective agencies' regions, in adjoining states, and both inside and outside the United States.

CHAPTER TWO

EVALUATION OF EXISTING PAVEMENT

INTRODUCTION

This chapter presents an overview of the pavement evaluation process, including a description of the various pavement evaluation activities that are commonly conducted. The overall objective of pavement rehabilitation design is to provide a cost-effective solution that addresses the deficiencies of the pavement and that meets all of the imposed constraints such as available funding, constructability, and lane closures. This objective cannot be achieved without first conducting a thorough pavement evaluation to determine the underlying causes and the extent of the pavement's deterioration. This requires a systematic data collection effort and an analysis of the structural and functional condition of the pavement as well as several other factors. The following is a compilation of a review of pavement design manuals from Alberta (Canada), California, Colorado, Florida, Illinois, Iowa, Kentucky, Minnesota, New York, Texas, Utah, Virginia, and Wisconsin. These manuals are available on the Internet and the reader is referred to them for more detailed information. The National Highway Institute course on pavement rehabilitation was also reviewed.

Reliable and cost-effective design for a pavement rehabilitation project requires the collection and detailed analysis of key data from the existing pavement. Such data are often categorized as follows:

- Traffic lane pavement condition (e.g., distress, smoothness, surface friction, and deflections);
- Shoulder pavement condition;
- Past maintenance activities;
- Pavement design features (e.g., layer thicknesses, shoulder type, joint spacing, and lane width);
- Geometric design features;
- Layer material and subgrade soil properties;
- Traffic volumes and loadings;
- Climate; and
- Miscellaneous factors (e.g., utilities and clearances).

Table 1 presents the steps that should be followed in the process of developing data for the design of an HMA or PCC overlay. The table is an adaptation of the guidance in the Minnesota Pavement Design Guide ("Pavement Design Guide, Part 2").

It can be seen from a review of Table 1 that the development of the necessary information upon which to base an overlay design will in most cases require nondestructive and in many cases destructive testing. The amount of sampling and testing required is dependent on the following:

- Observed pavement distress—The type, severity, extent, and variation of visible distress on a pavement greatly affect the locations and amount of field sampling and testing. If the distress is uniformly spread over the project, sampling is most likely conducted in an objective manner. Otherwise, sampling can be targeted in areas of high-distress concentrations.
- Variability—The variability along the project site will affect the amount of material and sampling required. Projects at sites with greater variability in material properties will require a greater amount of testing so that this variability can be properly characterized and accounted for in rehabilitation design.
- Traffic volume—The locations and number of allowable samples may be limited on higher-trafficked roadways owing to worker and driver safety concerns. Lane closure restrictions and safety-related issues are typically not issues on roadways with lower traffic volumes.
- Economics—Most agencies have a limited budget that determines the types and amount of sampling and testing that can be conducted for a given project. Engineering judgment must be used to determine a sampling and testing plan that minimizes the amount of testing required to adequately assess a pavement's condition, while staying within the provided budget constraints.

Nondestructive testing (NDT) is preferable to destructive testing because significantly more data can be collected at a relatively low cost. In general, a limited number of destructive tests will be required to verify the material properties of the pavement and to ensure that the proper inputs are used for the modeling of the pavement structure used when analyzing the NDT data. As an example, coring or a limited number of test pits may be required to verify the type and thickness of the surfacing layer and the thickness of the supporting layers.

DETAILED EVALUATION

Historic Data Collection

This step (step 1, Table 1) is primarily a review of records. It is recommended that the construction and maintenance files be reviewed along with pavement management information to

TABLE 1
FIELD DATA COLLECTION AND EVALUATION PLAN

Step	Title	Description
1	Historic data collection	This step involves the collection of information such as location of the project, year constructed, pavement management records, year and type of major maintenance, pavement design features, materials and soils properties, traffic, climate conditions, and any available performance data.
2	Initial field survey	This step involves conducting a windshield and detailed distress survey of sampled areas within the project to assess the pavement condition. Data required include distress information, drainage conditions, subjective smoothness, traffic control options, and safety considerations.
3	First data evaluation and the determination of additional data requirements	Determine critical levels of distress/smoothness and the causes of distress and smoothness loss using information collected during the first field survey. This list will aid in assessing preliminarily existing pavement condition and potential problems. Additional data needs will also be assessed during this step.
4	Nondestructive testing	This step involves conducting detailed measurements to include falling weight deflectometer testing, ground penetrating radar, and a limited amount of coring and sampling and measuring vertical clearances.
5	Destructive laboratory testing of samples	This step involves using the data collected as the result of the second field survey to develop a destructive sampling and laboratory testing program to determine properties such as material strength, resilient modulus, permeability, moisture content, drainage properties, composition, density, and gradations and to evaluate materials for expansion characteristics.
6	Second data collection and evaluation	This involves the determination of existing pavement condition and an overall problem definition. Condition will be assessed and the overall problem defined by assessing the structural, functional, and subsurface drainage adequacy of the existing pavement. Condition assessment and overall problem definition also involve determining material durability, shoulder condition, variability in pavement condition along the project, and potential constraints. Additional data requirements for designing rehabilitation alternatives will also be determined during this step.
7	Final field and office data compilation	Preparation of a final evaluation report.

determine the performance history of the pavement section. Previous pavement designs should be reviewed to determine the thicknesses of the pavement layers, as well as the strength of the subgrade layers that existed during the design of the original pavement to be overlaid. Particular attention should be paid to any unusual or special conditions that existed when the pavement was originally built (such as sections of the roadway that have either expansive or collapsible soils, or unusual traffic conditions owing to a quarry or manufacturing plant that is putting heavy loads on a section of a road).

Initial Field Survey

This is the most important step in the process (step 2, Table 1). The pavement designer needs to conduct a windshield survey or an initial surveillance of the roadway's surface, drainage features, and other related items. When the windshield survey is completed, the pavement designer will need to undertake a more detailed investigation of any unique features of the roadway that will affect pavement performance. The pavement designer should also contact the local maintenance superintendent to determine recurring maintenance problems that have required attention in the past.

First Data Evaluation

Using the information gathered in the first two steps, a preliminarily evaluation of overall pavement condition should be performed (step 3, Table 1). At this time, a listing of the possible pavement rehabilitation approaches should be undertaken. A testing plan should be created so that the necessary data are established to fill the gaps in the information needed to develop a pavement design. For example, it may be determined at this point that the existing pavement is in good condition and adequately designed for the traffic using the road; thus, the pavement may require only a surface treatment and additional testing is not required. However, it may be determined that the existing pavement is at an advanced stage of distress and that detailed testing is therefore required to develop an appropriate pavement design. This step is important because it may eliminate unnecessary in-field testing or the need to send a field crew back two or more times to obtain the necessary in-field data.

Nondestructive Testing

When performing a pavement evaluation, it is often necessary to conduct a detailed investigation of the in-place materials of a candidate pavement section (step 4, Table 1). This is a two-step process involving NDT and destructive testing. The destructive testing may not be needed; however, if it is needed, the NDT should be used to develop a plan for the destructive testing. The most common of NDT techniques are the use of the falling weight deflectometer (FWD) and ground penetrating radar (GPR). These NDT techniques are powerful tools for identifying weaknesses and defects in the existing pavement structure. By properly interpreting this NDT information, decisions that are more knowledgeable can be made regarding the most feasible rehabilitation alternatives to consider.

Falling Weight Deflectometer Testing

FWD equipment operates by applying a load to the pavement system and measuring the resulting maximum surface deflection or the surface deflection basin. The results are used to provide an estimate for

- HMA pavements
  - Elastic modulus of each of the structural layers (at nondistressed locations), and
  - Structural adequacy (at nondistressed locations).
- PCC pavements
  - Concrete elastic modulus and subgrade modulus of reaction (center of slab),
  - Load transfer across joints (across transverse joints in wheel path),
  - Void detection (at corners), and
  - Structural adequacy (at nondistressed locations).

The most commonly used equipment is the FWD, a trailer-mounted or truck bed-mounted device that delivers a transient force impulse to the existing pavement's surface (see Figure 1). The equipment uses a weight that is lifted to a given height on a guide system and is then dropped. The falling weight strikes a set of rubber buffers, mounted to a 12-in. circular foot plate, which transmits the force to the pavement. A thin-ribbed rubber pad is always mounted under the foot plate.

By varying the mass, the drop height, or both, the applied impulse load can be varied. This applied load may be varied between 2,500 lbs-force and 27,000 lbs-force for regular types of FWD. The goal is to load the pavement similar to that made by a passing dual truck tire set. Seven to nine deflection sensors measure the surface deflections caused by the applied impulse load. The first deflection sensor is always mounted in the center of the loading plate, whereas the rest are positioned at various radial distances up to 6 ft from the applied load center. From all deflections recorded, peak values are stored and displayed.

FWD testing is conducted at pavement temperatures between 40°F and 90°F. Testing at temperatures above 90°F is usually not recommended, because at such temperatures viscous properties of the HMA become predominant, whereas pavement structure modeling and analysis is based on linear-elastic properties. When deflection measurements are taken on a HMA pavement, the results should be corrected (standardized) to a particular type of loading system and normalized to an arbitrarily defined set of climatic conditions. In general, measured deflections are adjusted to a reference pavement temperature, usually 70°F, to account for the effect of temperature on asphalt-treated materials modulus.

For HMA pavements, the data collected are used as input data to backcalculate the elastic modulus of each layer. The deflection information along with pavement layer thicknesses (obtained from a limited number of cores) and the HMA pavement temperature at the time of testing, and the Poisson

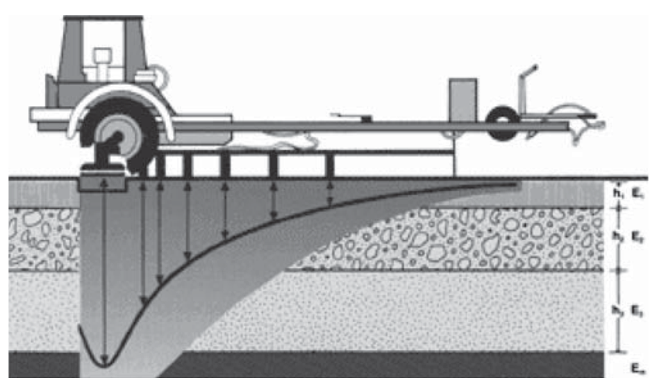


FIGURE 1 Falling weight deflectometer.

ratio is used as input (*Pavement Design Guide* 2006). The backcalculation process works on the assumption that the pavement structure can be modeled as an elastic layered system. Using the parameters previously discussed and a likely range of "probable" layer moduli provided by the pavement designer, a computer program is used to mathematically calculate a theoretical deflection basin. This theoretical basin is compared with the actual deflection basin. The computer program then adjusts the assumed elastic layer moduli used to make the calculation and calculates a new deflection basin. When a reasonable match is made, the elastic layer moduli that provided that match are reported as the individual layer elastic moduli.

The spacing of test points will vary depending on the length of the road and the level of investigation. For project-level evaluations, test spacing may vary from 100 ft (30 m) to 500 ft (150 m) for HMA pavements. On two-lane roads, the deflection measurements should be taken from the outer wheel path. It is suggested that the odd number readings be taken in one direction and the even number readings taken in the other direction. On multilane roads, it is important that the measurements be taken in the outer lane in each direction. On jointed plain concrete pavement (JPCP), the testing should occur at the mid-slab point, 5 ft from a crack or joint, and at the corner of the slab. The corner deflections are taken to determine the load transfer efficiency across the joints. Figure 2 is a schematic of testing locations on a JPCP pavement.

Rolling Dynamic Deflectometer

The rolling dynamic deflectometer (RDD) (Bay and Stokoe 1998) is a truck-mounted deflectometer that can be used to determine a continuous deflection profile for a pavement. It applies large cyclic loads to the pavement and measures the resulting deflections with up to four deflection sensors as it moves along the pavement. The testing is performed while the RDD vehicle travels at speeds of up to 1.5 mph.

Continuous deflection profiles can be used to:

- Assess the overall stiffness of a pavement;
- Differentiate the relative stiffness of different sections of the pavement;
- Detect cracks, joints, and weak regions;
- Assess the performance of cracked or jointed regions;
- Delineate the areas of the pavement influenced by joints and cracks; and
- Identify areas where additional discrete testing should be performed.

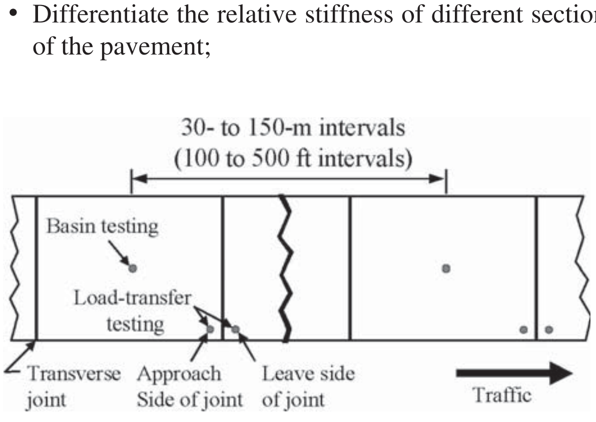


FIGURE 2 Testing locations for FWD testing for JPCP.

Seismic Pavement Analyzer

The seismic pavement analyzer (SPA) is a trailer-mounted device that looks similar to an FWD (*Pavement Design Guide* 2006). The equipment uses two impact hammers to load the pavement. Three geophones and five accelerometers measure the velocity of the shock wave that passes through the pavement. By knowing the speed of the shock wave, specialized software, developed by the University of Texas at El Paso, can be used to calculate the moduli of the pavement layers. This technology is similar to that used by geologists to determine the thickness and type of rock layers when doing oil and exploration studies.

Ground Penetrating Radar

GPR is used to characterize a pavement structure (Minnesota, "Pavement Design Guide, Part 2" 2006). Figure 3 shows the equipment. The radar system sends out pulses of electromagnetic (EM) energy and works by detecting the electrical echo caused when the pulse meets EM discontinuities, such as pipes, voids, or abrupt changes in material properties. As the radar moves across the surface of a pavement, the reflected waves are used to create an image of the profile of the layers within the pavement system. The measured output is a time profile of how long it takes the EM pulse to penetrate the pavement system and bounce back to the GPR receiver expressed as the two-way travel time (TWTT). TWTT is the time taken for the signal to leave the transmit antenna, bounce off the target, and finally be detected by the receive antenna. Radar data are collected over a time period or time window. The longer the time window over which the radar observes the returning

FIGURE 3 Ground penetrating radar equipment.

signal, the farther that signal will have traveled. This time profile can then compute the approximate layer depths.

Verification Testing

Despite the significant advancements in these NDT technologies, it is often necessary to validate the data generated with these devices. This is best accomplished by taking cores of the existing pavement structure at predetermined locations to compare with the results generated by NDT. Ideally, thickness cores would be taken at the location of each NDT deflection test; however, this is not practical from a time-based or economic standpoint. Therefore, each user agency has developed its own procedures for determining the appropriate number and location of cores for NDT thickness determination. As a general rule, the higher the variability of the NDT results, the more important coring is to verifying those results. Through proper interpretation of the NDT data, the most appropriate locations for taking cores can be determined. Coordinated in this fashion, both FWD and GPR are very complementary and can lead to extremely accurate characterization of the entire pavement section being considered for rehabilitation

Laboratory (Destructive) Testing

At the completion of the NDT, it may be necessary to conduct destructive sampling to obtain samples for laboratory testing (step 5, Table 1). The purpose of this testing is:

- To determine the thickness of the pavement layers (PCC, HMA, Base, etc.);
- To determine the cause of rutting or shoving problems in an HMA layer;
- To obtain a visual inspection of the paving materials to determine if stripping has occurred in the HMA layer;
- To obtain samples of the underlying layers to design a subdrainage system if needed;
- To evaluate the subgrade materials for their expansive characteristics; and
- To evaluate the properties of PCC pavements for D-cracking, alkali silica reactivity, or delamination.

The determination of the number and type of samples will depend on the observed pavement distress, the variability along the site (particularly as characterized by NDT), the traffic on the given roadway as it affects the safety of the sampling crew, and the cost of the testing.

First, the type, severity, extent, and variation of visible distress on a pavement greatly affect the locations and amount of field sampling and testing. Targeted coring is often required to investigate the specific distress mechanisms of areas where high-distress concentrations are observed. Conversely, a random (objective) coring plan may be more appropriate when observed distress appears to be somewhat uniform over the entire project. Engineering judgment plays a key role in determining what types of samples to take, where to take them, and the quantity needed to adequately assess the material characteristics of the existing pavement structure.

Overall project variability is the second factor in identifying sampling locations because of its effect on rehabilitation design and future pavement performance. The best indicators of project variability are deficiencies in pavement condition and NDT results. Accordingly, their variability should be considered in determining an appropriate number of samples as well as sampling locations. In general, more variability means more sampling.

The cost of sampling and testing is small in comparison with the total rehabilitation cost. Most agencies have a limited budget that determines the types and amount of sampling and testing that can be conducted on a given project. Therefore, it is paramount that engineering judgment be applied to achieve a balance between the amount of testing required to adequately assess a pavement's condition and the cost of the sampling program.

The testing program should be directed toward determining:

- How the existing materials compare with similar materials that would be used in a new pavement;
- How the materials may have changed since the pavement was constructed; and
- Whether or not the materials are functioning as expected.

The types of tests done will depend on the material types and the types of distress observed. A typical testing program might include strength tests for HMA and PCC cores, gradation tests to look for evidence of degradation and/or contamination of granular materials, and extraction tests to determine binder contents and gradations of HMA mixes. PCC cores exhibiting durability problems may be examined by a petrographer to identify the cause of the problem. There are various laboratory test methods that are used to measure material strength, stiffness, or its ability to resist deformation or bending. Some of the more common tests used in the assessment of HMA pavement paving materials include the following:

- California Bearing Ratio (CBR)
- *R*-value,
- Triaxial testing,
- Unconfined compressive strength (bound or stabilized materials and cohesive soils),
- Indirect tensile strength (bound or stabilized materials),
- Resilient modulus, and
- Dynamic or complex modulus.

Second Data Collection and Evaluation

In this step (step 6, Table 1), all of the data are assembled and an initial evaluation of the data is completed. Any data that are missing is identified and, if necessary, additional sampling is requested.

Preparation of Evaluation Report

In the last step (step 7, Table 1), the final report compiling and summarizing the data accumulated during the evaluation is prepared. This report will be used to prepare alternate options for the overlay and/or rehabilitation of the existing pavement. It is suggested that this report contain:

- A summary of the pavement distress,
- A review of the testing program conducted,
- A summary of the test results and recommendations for design values to be used by the pavement designer,
- A discussion of any unusual distress and the causes of that distress, and
- A description of any special problems that will need to be addressed during actual pavement design (such as a high-volume intersection or an area of very soft soils).

SAFETY

The evaluation of an existing pavement generally involves doing inspections and sampling on active, sometimes very-high-volume roadways. It is essential that whenever individuals are doing pavement evaluation work that they wear the proper safety equipment and establish the appropriate traffic control signing that conforms with that agency's safety policy.

Worker and driver safety concerns associated with lane closures on high-trafficked roadways can play a key role in determining the locations for sampling and the maximum number of samples that can be taken. For example, in urban areas with high traffic volumes, it may be nearly impossible (or prohibited) to close a lane. Even if lane closures are allowed, the agency may have to significantly reduce the number of traffic lane samples (owing to lane closure time constraints) or require that testing be completed at night. Even on low-volume roads, it is important that their locations be carefully selected. Proper signing and traffic control should be provided for any lane closures.

SUMMARY

When the pavement evaluation process is completed, the pavement designer will have a thorough understanding of the existing pavement problems to be rehabilitated. Once these problems are identified, the next task will be to develop pavement alternatives that can be used to return the roadway to a good condition.

CHAPTER THREE

HOT-MIX ASPHALT OVERLAY OVER EXISTING HOT-MIX ASPHALT PAVEMENT PRE-OVERLAY TREATMENTS

INTRODUCTION

A pavement designer can select the appropriate pre-overlay treatment(s), if needed, that may be used on a particular project provided they have a good understanding of:

- Existing in-field conditions of a pavement structure,
- Existing variations in structural section and subgrade strength,
- The expectations of their agency with regard to funding and performance,
- The current general construction capabilities of the highway supplier and contracting at-large community,
- The expected performance of the pre-overlay treatment materials that are being considered for use,
- Associated costs involved in recommending a particular pre-overlay treatment over another pre-overlay treatment, and
- The principals of structural pavement design.

An HMA pavement structure that exhibits very few low severity surface cracks versus a pavement structure that exhibits extensive high severity surface cracking should be handled in a completely different manner with regard to pre-overlay treatment before the placement of an HMA overlay. Does the pavement designer decide to do nothing in a given distressed area or do they designate areas to be locally removed and replaced? Are there areas in which the entire HMA surface will be partially or completely milled off or will either cold or hot in-place recycling be used for the pre-overlay treatment? Other decisions that may need to be made have to do with whether the surface should just be crack sealed, chip sealed, micro-surfaced, or slurry sealed. If rutting or shoving exists, will the top of the ruts and shoved areas be milled or bladed off or can they remain as is in-place? All of these types of decisions will come with an associated cost and will affect, in negative, neutral, or positive ways, the future performance of the constructed HMA overlay over the existing HMA pavement structure.

There are also some pre-overlay treatment decisions that need to be made a significant time before the actual construction of the HMA overlay. A case in point is when HMA crack sealing maintenance operations are be done relative to when the HMA overlay is placed. If performed too soon, many crack sealing materials will swell up within the confines of the sealed cracks during the placement of an HMA overlay and may cause a significant bump in the surface of the HMA overlay. To prevent this from occurring, the pavement designer needs to work with the respective agency maintenance organization to ensure that all maintenance crack sealing operations allow enough time for the crack sealant material to harden before the scheduled placement of the HMA overlay.

During the actual placement of the HMA overlay, the use of a properly applied asphalt tack coat between the top of the existing HMA surface and the bottom of the HMA overlay is recommended. The use of the tack coat will effectively bond both of these HMA layers together so that they will react as a single layer that resists the fatigue impacts owing to the applied traffic loadings. If this bond does not exist, the HMA overlay could act as an independent layer that may fail early as a result of the fatigue-related stresses that it endures.

It is also recommend that if the HMA overlay consists of differing lift thicknesses, the thicker HMA lifts should be placed first, with the thinner lifts placed last. Placing the thicker HMA lift(s) first can effectively bridge over any underlying weakened and/or uneven areas in the existing pavement and will ultimately provide for a smoother riding surface once the full HMA overlay has been placed and compacted. The performance impact of constructing a smoother pavement is that the pavement will last longer as a result of the lower dynamic-induced traffic loadings that are applied to the pavement structure.

The results from a Long-Term Pavement Performance (LTPP) program provide many findings that may be considered by a pavement designer when selecting a pre-overlay treatment:

- Overlay thickness and pre-overlay roughness level are the two factors that most influence the performance of asphalt overlays in the SPS-5 experiment with respect to roughness, rutting, and fatigue cracking (Hall et al. 2000).
- Overlay thickness does not appear to have a strong effect on the occurrence of longitudinal cracking in the wheel path and rutting (Von Quintas et al. 2000).
- Compared with thinner (2 in.) overlays, thicker (5 in.) overlays consistently have less longitudinal cracking outside the wheel path (Rauhut et al. 2000).
- Data consistently show fewer transverse cracks on milled surfaces when compared with unmilled surfaces before overlay placement (Rauhut et al. 2000).

- The amount of transverse cracking is dependent on the original pavement condition before overlay placement. The overlays placed on pavements classified in good condition exhibit less transverse cracking than on pavements classified in poor condition (Rauhut et al. 2000).
- Overlay designs that provide pavement structure consistent with traffic expectations can be expected to perform well for more than 10 years (Rauhut et al. 2000).

TECHNIQUES

The following is a brief summary description of the various treatment techniques that state DOT agencies are presently using for pre-overlay treatments.

Blading-Off

This is performed by a road grader's blade to remove existing rutting and shoving humps in the HMA's surface before the placement of an HMA overlay.

Chip Seal

This has been used for many years on lower volume roads (fewer than 2,000 vehicles per day) as the wearing surface on untreated granular roadbeds. The Asphalt Institute's *A Basic Asphalt Emulsion Manual* (2001) lists the following uses of chip seals:

- Provide a low-cost, all-weather surface for light to medium traffic.
- Provide a waterproof layer to prevent the intrusion of moisture into the underlying courses.
- Provide a skid-resistant surface for pavement that has become slippery because of bleeding or polishing of surface aggregates. These pavements may be treated with sharp, hard aggregate to restore skid resistance.
- Give new life to a dry, weathered surface. A pavement that has become weathered to the point where raveling might occur can be restored to useful service by application of a single-surface or multiple-surface treatment.
- Provide a temporary cover for a new base-course that is to be carried through a winter season or for planned stage construction. The surface treatment makes an excellent temporary surface until the final HMA course is placed.
- Salvage an old pavement that has deteriorated because of aging, shrinkage cracking, or stress cracking. Although the surface treatment has little or no structural strength, it can serve as an adequate stopgap measure until a more permanent upgrading can be funded and completed.
- Define shoulders so they will not be mistaken as traffic lanes.
- Provide rumble strips for safety.

Chip seals have also been used on higher volume roads [more than 10,000 ADT (average daily traffic)] because of their ability to waterproof the surface, provide low-severity crack sealing, and improve surface friction. The possibility of loose chips and traffic disruptions, however, has limited the use of chip seals on higher volume facilities. Using a stiffer binder and a greater initial embedment of the aggregate chips has been shown to overcome loose chip problems reported elsewhere (Grogg et al. 2001).

Cold Milling

This is done to remove by milling small or large areas of the existing top portion of the HMA structural layer. If small areas are removed within the project, new HMA material is typically placed and compacted to match the cold milled depth. If larger areas are cold milled, these areas may or may not be replaced with HMA before the placement of the final HMA overlay. Additionally, cold milling may be used to correct surface profile defects, which may include rutted areas, restoration of cross-slope, removal of an oxidized HMA surface, or to improve the longitudinal profile of the existing HMA surface.

Crack Sealing

This is performed to prevent incompressible materials from filling either nonworking or working cracks and/or to prevent surface water from entering the underlying pavement layers. When done, there are two methods employed to prepare the crack for sealant material. The first method does not clean out the crack, whereas the second method does clean out the crack of incompressible materials by use of a router and/or high-pressure air. The types of flexible crack sealant materials range from modified asphalt emulsions and binders to specialty crack filler products. It is recommended that if a long-term performance crack filler material is needed, that either an AASHTO or ASTM compliant material be considered for use.

Fog Seal

This is done to seal the surface of HMA pavements that have begun to ravel from the hardening of the asphalt cement near the pavement surface because of age and oxidation. In sealing the surface and reducing the rate of further hardening of the asphalt cement, fog seals have been shown to prolong the effective service life of these pavements several years. They have also been used to prevent raveling of chip seals and to seal pavements placed late in the fall or with excessively high-void content. On higher volume routes, fog seals have been used to prevent raveling of open-graded friction seals and to maintain shoulders (Grogg et al. 2001).

Full-Depth Pulverization

This is performed by completely removing the existing HMA layer by either ripping up the existing HMA layer and then further processing using a grid roller or by removing and transporting the scarified HMA material for processing at an aggregate crusher site. The processed HMA material is used for aggregate base material.

Full-Depth Reclamation

This is done by uniformly pulverizing the full thickness of the existing HMA material with a predetermined portion of the underlying materials (base, subbase, and/or subgrade) to provide an upgraded, homogeneous material.

Full-Depth Repair

This is performed to remove full-depth defects in the existing HMA layer. The existing distressed areas of the HMA layer are removed by grinding or ripping, the exposed base layer is then recompacted, a tack coat is applied to all exposed surfaces, and then an HMA inlay is placed and compacted to match the surrounding existing HMA surface elevations.

Interlayers

This is placed on top of the existing HMA layer to retard the propagation of existing HMA cracks through a newly constructed HMA overlay. An interlayer may be a geotextile- or fiberglass-type material that is impregnated with an asphalt binder material, a large stone HMA mix, or a stress adsorbing membrane (SAMI).

Micro-Seal

This is done to seal and provide an ultra-thin, gap-graded friction course that will improve the skid resistance of an existing HMA pavement's surface. It usually consists of an application of a polymer-modified emulsion tack coat on which a micro-seal material is placed.

Micro-Surfacing

An enhanced polymer-modified slurry sealing system that is used for much of the same purposes that slurry seals are used, but may provide larger aggregate size and, with more construction and curing control, be placed in a greater thickness. With these attributes, micro-surfacing is commonly used for rut filling, minor leveling, and restoration of skid resistant surfaces, as well as providing a slurry seal system that can be used on higher volume roadways (Grogg et al. 2001).

Partial-Depth Repair

This is performed to remove various surface defects and top-down cracking. The existing distressed areas of the HMA surface are milled off to a depth of from 2 to 4 in.; an HMA inlay is then placed and compacted to match the surrounding existing HMA surface elevation.

Patching

This is done to make a temporary or permanent repair to a particular area of severely distressed pavement and may actually extend the service life of the existing HMA structure. Depending on the type and the depth of the distress, either a partial-depth or full-depth patch is placed. Subgrade materials may need to be considered for removal and replacement if saturated or of poor quality. The types of products that may be used for patching operations are hot-, cold-, and proprietary mix bituminous materials.

Recycling

This is performed to address moderate-to-severe structural- and/or environmental-related distresses. The effectiveness of either hot- or cold-recycling techniques depends on the effective recycled depth of material relative to the actual depth of the distress. If the full depth of the particular distress is reached during the recycling operation, the performance impact related to that distress may be mitigated. If the full depth of the particular distress is not recycled, a part of the distress will remain in the existing HMA layer and may affect the future performance of the constructed HMA overlay. An example of this would be a severely longitudinal cracked existing HMA surface. If the full depth of the longitudinal crack is recycled, the chance for the longitudinal crack to reflect back through the recycled and new HMA overlay layers may have been mitigated. If the full depth of the longitudinal crack was not recycled, a part of the crack will remain and it may, in time, reflect back through both the recycled HMA as well as the constructed HMA overlay. The pavement designer needs to fully understand the capabilities of the selected type of in-place recycling equipment as well as have a good understanding of the existing HMA and base layer thickness variations to select the proper technique and depth for recycling.

If cold in-place recycling is selected for use and a paving fabric was used in the construction of the existing pavement structure, the depth to the paving fabric should be known to prevent unexpected recycling construction delays unless the paving fabric material easily degrades under the cold milling operation. If the paving fabric's depth is within 1 in. to 1.5 in. of the cold milling depth, unacceptable long strips of the paving fabric may peel up and clog the paving operation. If the paving fabric's depth is greater than 1.5 in. of the cold milling depth, problems with the paving fabric should be mitigated.

Sand Seal

Sand seal is used to fill an intermediate use between fog seals and full chip seals, which are often used where an HMA pavement has raveled to the extent that there is significant fine aggregate missing from the surface. A sand seal is used instead of a fog seal to fill in the lost fine aggregate. A sand seal is also used as a pavement preparation treatment to provide a uniform surface before constructing a chip seal and to seal low severity fatigue cracks before constructing an overlay (Grogg et al. 2001).

Scrub Seal

This is placed in situations very similar to that of sand or chip seals. Scrub seals can be applied when the distress level is greater than what would normally be used as a criterion for the application of a sand seal. The reason for this is that the mechanical action of the brush will force emulsion and aggregate into the pavement surface and cracks (Grogg et al. 2001).

Slurry Seal

Slurry seals are used most effectively on pavements where the primary problem is excessive oxidation and hardening of the existing asphalt. They are used for sealing minor surface cracks and voids and retarding surface raveling, particularly on city streets where there are special layer depth constraints in curb and gutter sections. They have also been used to improve surface friction characteristics and to delineate different pavement surface areas. Finally, they have been used to fill and stabilize open-graded mixes that are raveling excessively (Grogg et al. 2001).

Surface Leveling

Surface leveling is performed if uneven surface defects in the existing HMA surface are evident. These surface defects may include rut filling, restoration of cross-slope, or to improve the longitudinal profile of the existing HMA surface.

PRE-OVERLAY STRATEGIES

Following are the survey results from the state DOT questionnaire in the form of bar charts. These bar charts will summarize what strategies the various state DOTs are presently using to address medium and high severity distresses associated with existing HMA pavement structures before the placement of an HMA overlay. They present up to six of the most used strategies and are organized from the highest relative use strategy to the lowest relative use strategy. If more than six strategies are presently being used, then the additional strategies are only mentioned.

Fatigue Cracking

The primary strategy used for moderate severity fatigue cracking is to mill out 2 to 4 in. of the affected areas and replace with the HMA overlay before constructing an HMA inlay. The secondary strategy is to not undertake any pre-overlay treatment before placing the HMA overlay. If cold in-place recycling is used, the average depth ranges from 3 in. to 4 in. If hot in-place recycling is used, a 2 in. depth is used.

Other employed pre-treatment strategies not shown in Figure 4 are:

- Installing a reinforcing fabric before the overlay (4% relative use);
- Applying a strip seal (2% relative use);
- Full-depth reclamation (1% relative use);
- Mill out full-width (1% relative use); and
- Mill out, install a crack relief layer, and then inlay with HMA (1% relative use).

The literature review suggests that full-depth removal and patching may be a more effective pre-overlay treatment than the primary and secondary strategies (Grogg et al. 2001).

The primary strategy used for high severity fatigue cracking is to remove full-depth the existing HMA layer and replace

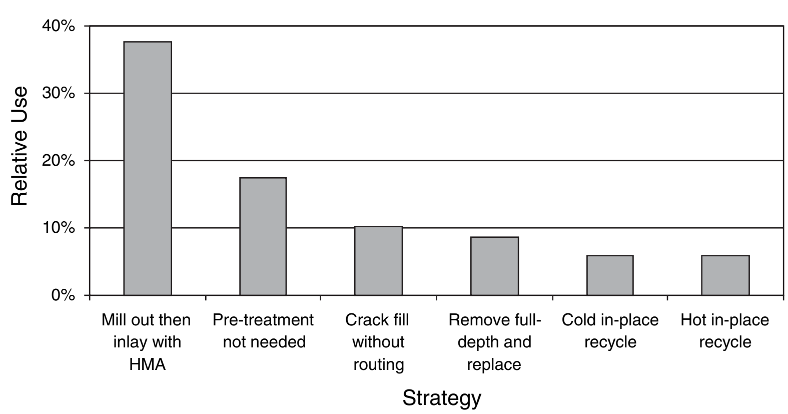


FIGURE 4 Fatigue cracking—Moderate severity (69 responses).

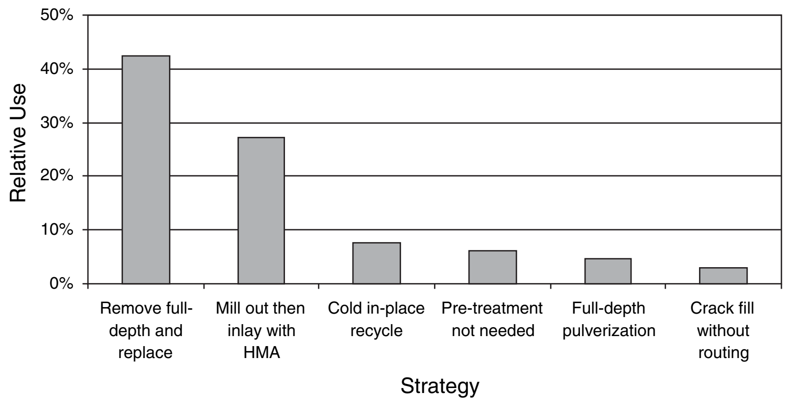


FIGURE 5 Fatigue cracking—High severity (66 responses).

with new HMA before the construction of the HMA overlay. The secondary strategy is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay. If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 5 are:

- Mill out, install a crack relief layer, and then inlay with HMA (4% relative use);
- Hot in-place recycle (3% relative use); and
- Mill out full-width (1% relative use).

The literature review suggests that full-depth removal and patching is the recommended strategy (Grogg et al. 2001).

Block Cracking

The primary strategy used for moderate severity block cracking is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay. The secondary strategy is to not do any pre-overlay treatment before placing the HMA overlay. If cold in-place recycling is used, the average depth ranges from 3 to 4 in. If hot in-place recycling is used, a 2 in. depth is used.

Other employed pre-treatment strategies not shown in Figure 6 are:

- Mill out, install a crack relief layer, and then inlay with HMA (4% relative use);
- Remove full-depth and replace (3% relative use);
- Full-depth pulverization (2% relative use); and
- Mill out full-depth (1% relative use).

The primary strategy used for high severity block cracking is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before construction of the HMA overlay. The secondary strategy is to remove full-depth the affected existing HMA layer and replace with new HMA before construction of the HMA overlay. If cold in-place recycling is used, the average depth ranges from 3 to 4 in. If hot in-place recycling is used, a 2 in. depth is used.

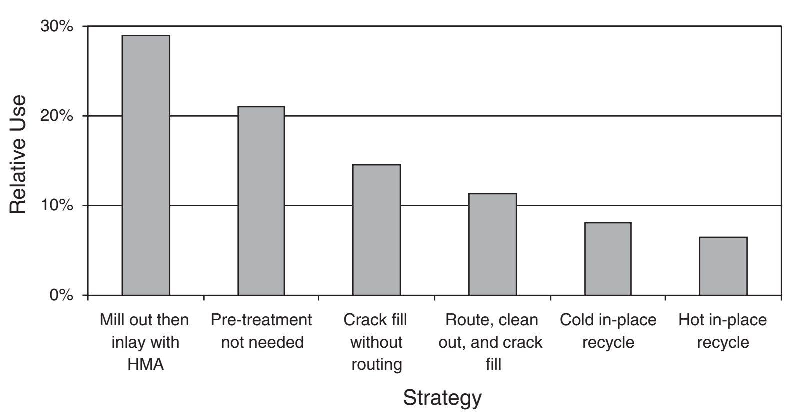


FIGURE 6 Block cracking—Moderate severity (62 responses).

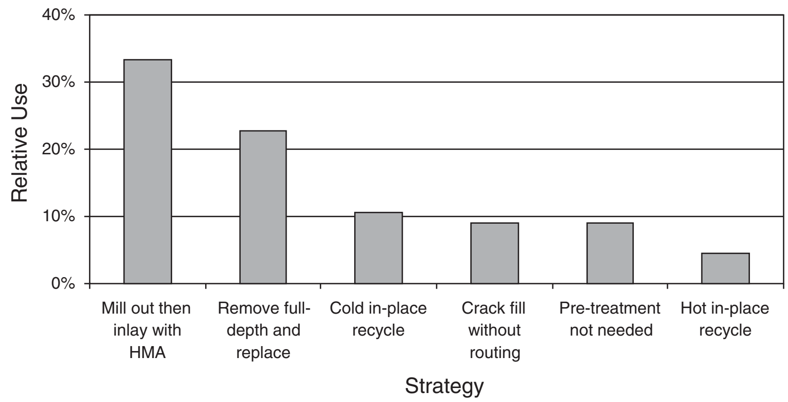


FIGURE 7 Block cracking—High severity (66 responses).

Other employed pre-treatment strategies not shown in Figure 7 are:

- Mill out, install a crack relief layer, and then inlay with HMA (4% relative use);
- Clean out cracks by routing then crack fill (3% relative use);
- Full-depth pulverization (2% relative use); and
- Mill out full-depth (2% relative use).

Edge Cracking

The primary strategy used for moderate severity edge cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy is to crack fill without the use of routing to clean out the crack.

Other employed pre-treatment strategies not shown in Figure 8 are:

- Mill out then inlay with HMA (4% relative use), and
- Remove and replace all damaged material then crack fill (4% relative use).

The primary strategy used for high severity edge cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies range from (see Figure 9):

- Removing full-depth a 2 ft width of the shoulder adjacent to the edge crack and replacing with HMA, and
- Removing and replacing the entire shoulder width with HMA.

Longitudinal Cracking

The primary strategy used for moderate severity longitudinal cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies range from:

- Crack fill without the use of routing to clean out the crack,
- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before construction of the HMA overlay, or
- Crack fill with the use of routing to clean out the crack.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in. If hot in-place recycling is used, a 2 in. depth is used.

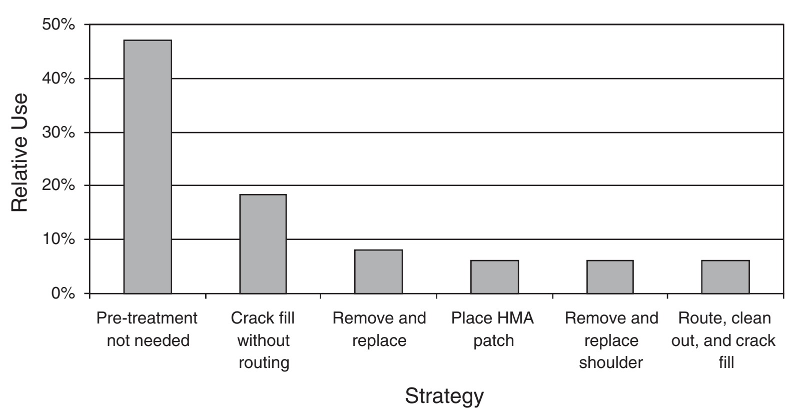


FIGURE 8 Edge cracking—Moderate severity (49 responses).

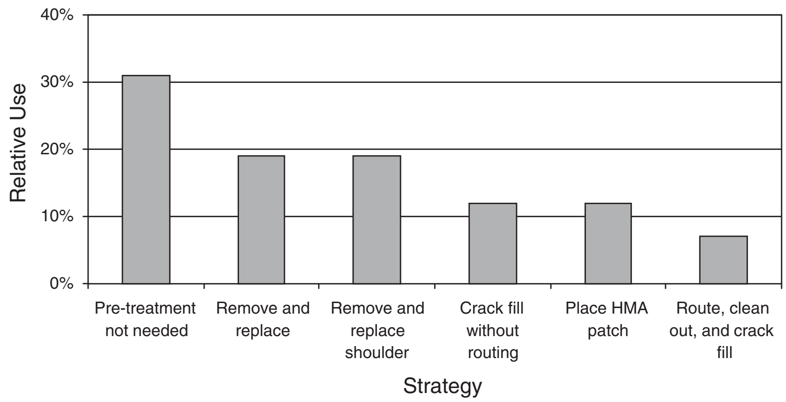


FIGURE 9 Edge cracking—High severity (42 responses).

Other employed pre-treatment strategies not shown in Figure 10 are:

- Mill out full-width (2% relative use);
- Mill out, install a crack relief layer, and then inlay with HMA (2% relative use);
- Apply a surface treatment (2% relative use); and
- Full-depth pulverization (2% relative use).

The primary strategy used for high severity longitudinal cracking is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before construction of the HMA overlay. The secondary strategies range from:

- Crack fill with the use of routing to clean out the crack;
- Crack fill without the use of routing to clean out the crack; or
- Not performing any pre-overlay treatment before placing the HMA overlay.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in. If hot in-place recycling is used, a 2 in. depth is used.

Other employed pre-treatment strategies not shown in Figure 11 are:

- Mill out full-width (3% relative use);
- Mill out, install a crack relief layer, and then inlay with HMA (3% relative use);
- Place an HMA patch (3% relative use);
- Remove full-depth and replace (3% relative use);
- Mill out then apply a surface treatment (1% relative use); and
- Full-depth pulverization (1% relative use).

The literature review for both moderate and high severities suggests that the following strategies have varying degrees of success (Grogg et al. 2001):

- Place geotextiles or fabrics before the overlay,
- Install stress-relieving or stress-absorbing membrane interlayers, and
- Install crack-arresting interlayers.

Transverse Cracking

The primary strategy used for moderate severity transverse cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies range from:

- Crack fill without the use of routing to clean out the crack,

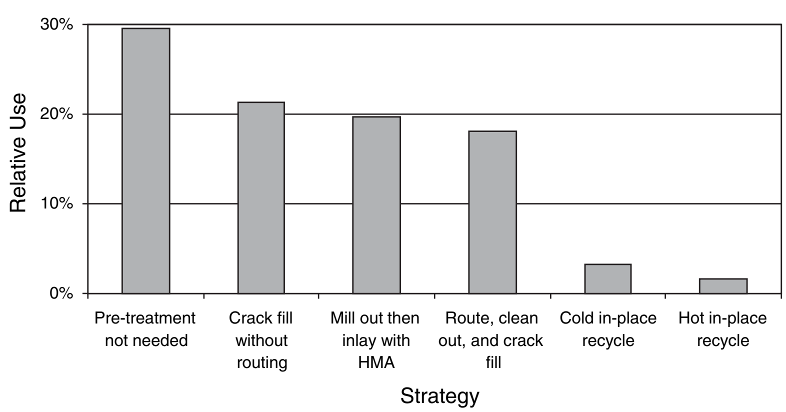


FIGURE 10 Longitudinal cracking—Moderate severity (61 responses).

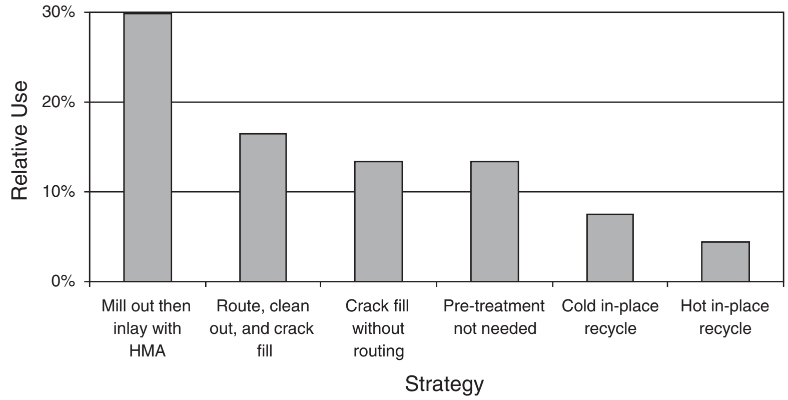


FIGURE 11 Longitudinal cracking—High severity (67 responses).

- Crack fill with the use of routing to clean out the crack, or
- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 12 are:

- Mill out, install a crack relief layer, and then inlay with HMA (3% relative use),
- Perform a partial-depth repair (3% relative use),
- Hot in-place recycle to a 2 in. depth (2% relative use),
- Apply a surface treatment (2% relative use), and
- Full-depth pulverization (2% relative use).

The primary strategy used for high severity transverse cracking is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before construction of the HMA overlay. The secondary strategies range from:

- Crack fill without the use of routing to clean out the crack,
- Crack fill with the use of routing to clean out the crack, or
- Cold in-place recycle to a depth of 3 to 4 in.

If a full-depth repair is used, then remove full-depth the affected existing HMA layer and replace with new HMA before construction of the HMA overlay. If the placement of a SAMI interlayer is used, the existing HMA layer is milled out 2 in.

Other employed pre-treatment strategies not shown in Figure 13 are:

- Mill out, install a crack relief layer, and then inlay with HMA (6% relative use);
- Mill out full-width (4% relative use);
- Full-depth pulverization (3% relative use);
- Full-depth reclamation (3% relative use);
- Apply a seal coat (1% relative use);
- Hot in-place recycle to a depth of 2 in. (1% relative use);
- Inject with fly-ash slurry (1% relative use);
- Mill out and install a SAMI (1% relative use); and
- Perform a partial-depth repair (1% relative use).

The literature review for both moderate and high severities suggests that the following strategies have varying degrees of success (Grogg et al. 2001):

- Place geotextiles or fabrics before the overlay,
- Install stress-relieving or stress-absorbing membrane interlayers, and
- Install crack-arresting interlayers.

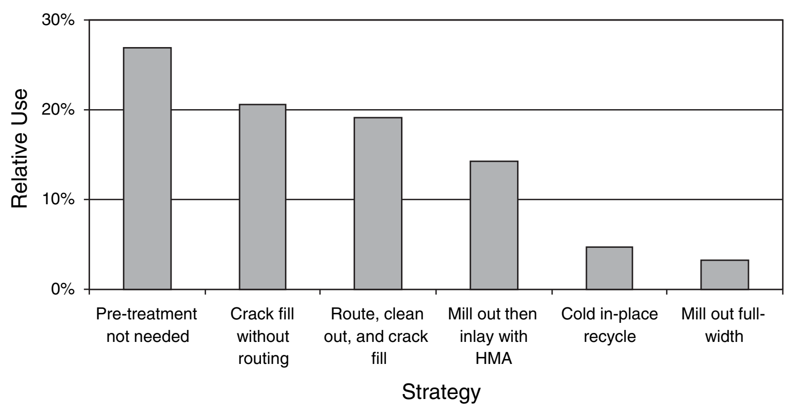


FIGURE 12 Transverse cracking—Moderate severity (63 responses).

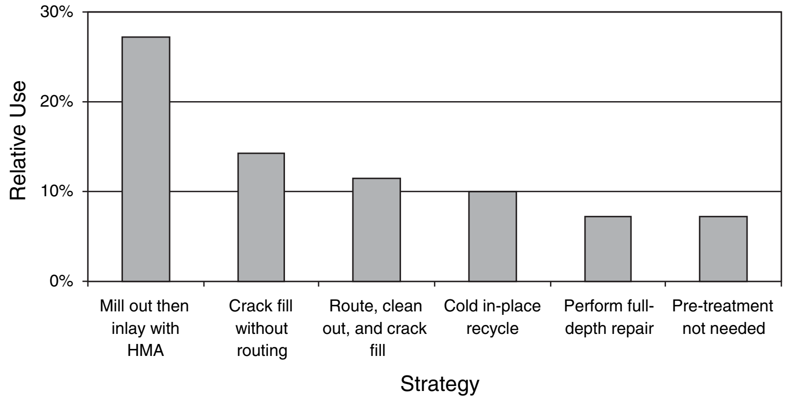


FIGURE 13 Transverse cracking—High severity (70 responses).

Patch/Patch Deterioration

The primary strategy used for moderate severity patch/patch deterioration is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies range from:

- Remove and replace the existing patch,
- Mill out 2 to 4 in. of the affected areas and then placing an HMA inlay before the construction of the HMA overlay, or
- Place a HMA patch directly over the existing HMA patch.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 14 are:

- Full-depth pulverization (2% relative use), and
- Crack fill with the use of routing to clean out the crack (2% relative use).

The literature indicates that all patches be removed and replaced before the placement of an HMA overlay (Grogg et al. 2001).

The primary strategies used for high severity patch/patch deterioration are:

- Remove and replace the existing patch,
- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay, or
- Place an HMA patch directly over the existing HMA patch.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 15 are:

- Hot in-place recycle to a depth of 2 in. (3% relative use);
- Apply a seal coat (2% relative use);
- Crack fill without the use of routing to clean out the crack (2% relative use);
- Full-depth pulverization (2% relative use); and
- Reclaim into select material (2% relative use).

Pothole

The primary strategy for moderate severity pothole repair is to patch before the construction of the HMA overlay (see

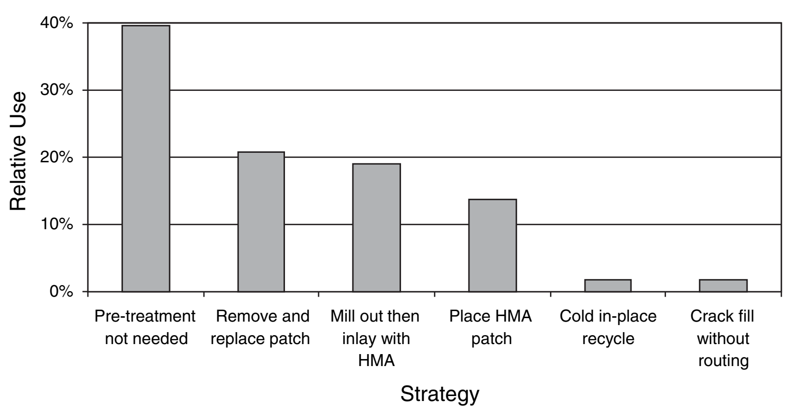


FIGURE 14 Patch/patch deterioration—Moderate severity (58 responses).

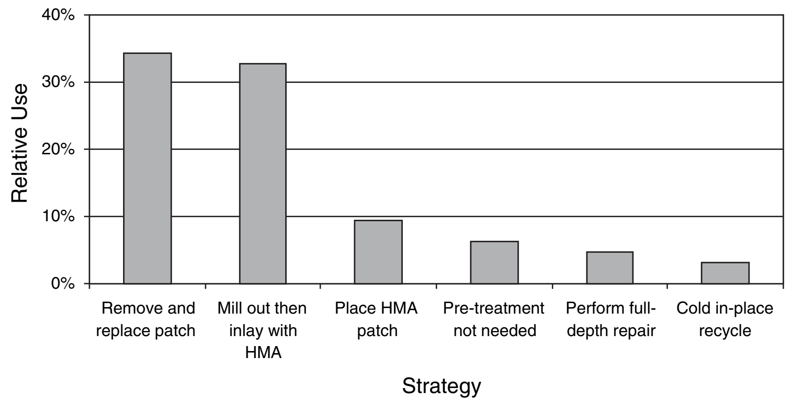


FIGURE 15 Patch/patch deterioration—High severity (64 responses).

Figure 16). For bituminous-based materials, about 43% of the responding agencies employ the throw-and-roll strategy, whereas the remainder employs semi-permanent strategies to fill and compact the patching material. Only two agencies responded that they use an automated procedure to repair potholes.

The primary strategy for high severity pothole repair is to remove and replace the existing patch, if present, and then patch with new HMA material (see Figure 17).

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

In the SHRP H-106 program, several different combinations of patching materials and methods were evaluated. The relevant findings of that study are:

- The overall survival rates for dry-freeze sites were significantly higher than for wet-freeze sites;
- The throw-and-roll technique proved just as effective as the semi-permanent procedures for those materials for which the two procedures were compared directly;
- Although pothole patches are considered temporary repairs, patches were predicted to have lives of one to four years depending on the climatic region, material, and patching method used;

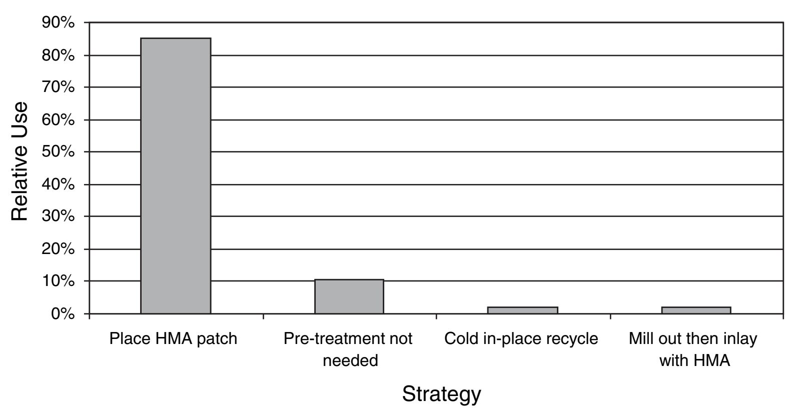


FIGURE 16 Pothole—Moderate severity (47 responses).

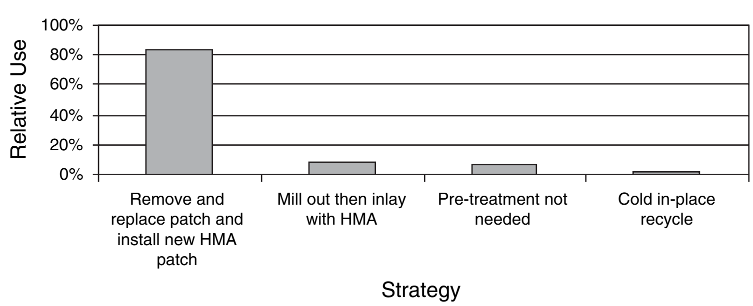


FIGURE 17 Pothole—High severity (48 responses).

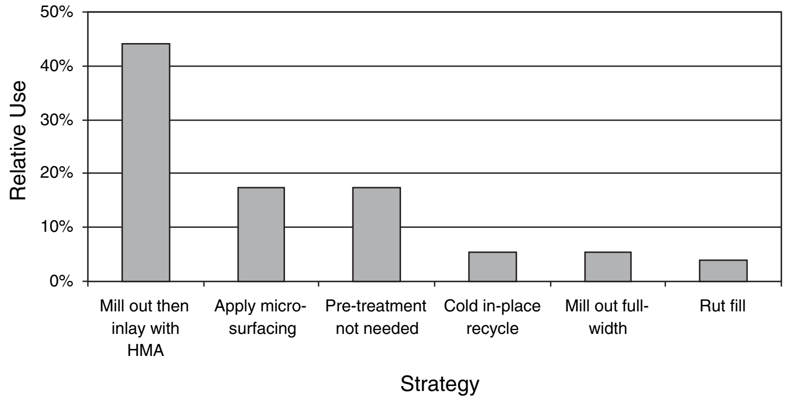


FIGURE 18 Rutting—All severities (75 responses).

- Spray-injection patching performed well;
- Three of the eight agencies participating in the experiment switched from their inexpensive cold-mixes to one of the materials evaluated in the experiment with superior performance; and
- There was not good correlation between laboratory characteristics and field performance (Grogg et al. 2001).

Rutting

The primary strategy used for all severities of rutting repair is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay. The secondary strategies range from:

- Place a micro-surface layer over the affected areas, or
- Not performing any pre-overlay treatment before placing the HMA overlay.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 18 are:

- Place an HMA patch (3% relative use),
- Overlay with HMA (1% relative use),
- Apply a surface treatment (1% relative use), and
- Full-depth pulverization (1% relative use).

The literature review suggests that milling the surface before overlay or by filling the ruts with a stable leveling course that is properly compacted before placement of the overlay are the recommended strategies (Grogg et al. 2001).

Shoving

The primary strategy used for all severities of shoving repair is to mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 19 are:

- Hot in-place recycle to a depth of 2 in. (2% relative use), and
- Apply micro-surfacing (2% relative use).

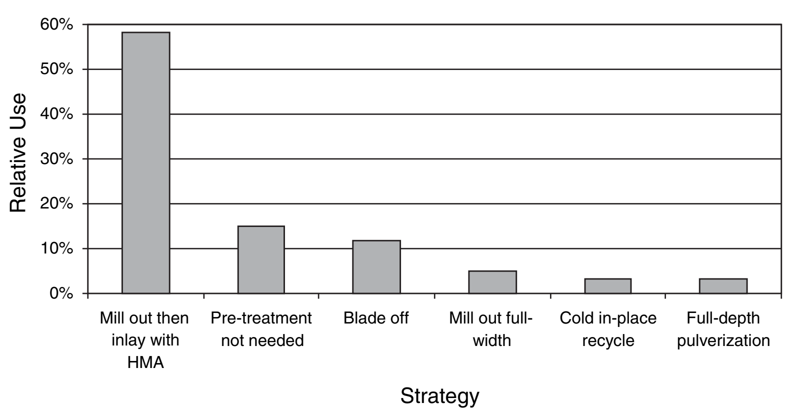


FIGURE 19 Shoving—All severities (60 responses).

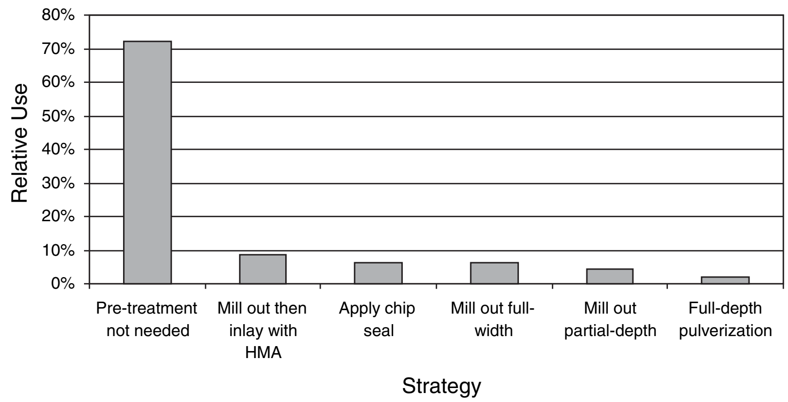


FIGURE 20 Bleeding (discolorization)—All severities (47 responses).

Bleeding (Discolorization)

The primary strategy used for all severity bleeding (discolorization) is to not perform any pre-overlay treatment before placing the HMA overlay (see Figure 20).

Bleeding (Loss of Texture)

The primary strategies used for all severities of bleeding (loss of texture) are:

- Not performing any pre-overlay treatment before placing the HMA overlay, or
- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay.

The secondary strategies used are:

- Chip seal over the affected areas, or
- Mill out full-width.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

One other employed pre-treatment strategy not shown in Figure 21 is to perform full-depth pulverization (1% relative use).

Bleeding (Aggregate Obscured)

The primary strategies used for all severities of bleeding (aggregate obscured) are:

- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay, or
- Not performing any pre-overlay treatment before placing the HMA overlay.

Other employed pre-treatment strategies not shown in Figure 22 are:

- Cold in-place recycle to a depth of 3 to 4 in. (2% relative use); and
- Full-depth pulverization (2% relative use).

Raveling (Loss of Fine Aggregate)

The primary strategy used for all severities of raveling (loss of fine aggregate) is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Chip seal over the affected areas, or
- Place a micro-surface layer over the affected areas.

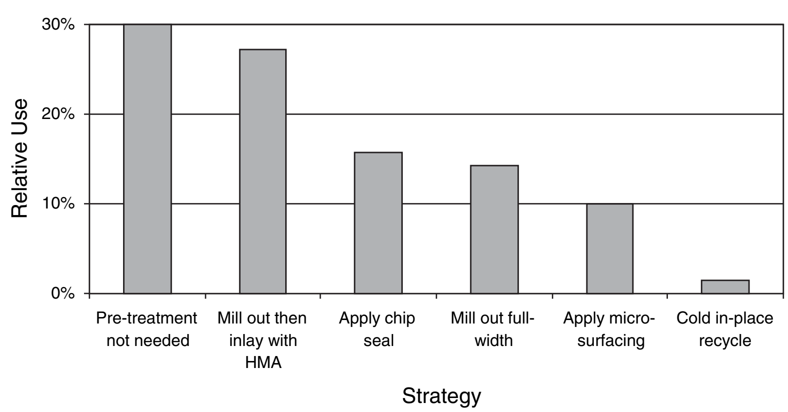


FIGURE 21 Bleeding (loss of texture)—All severities (70 responses).

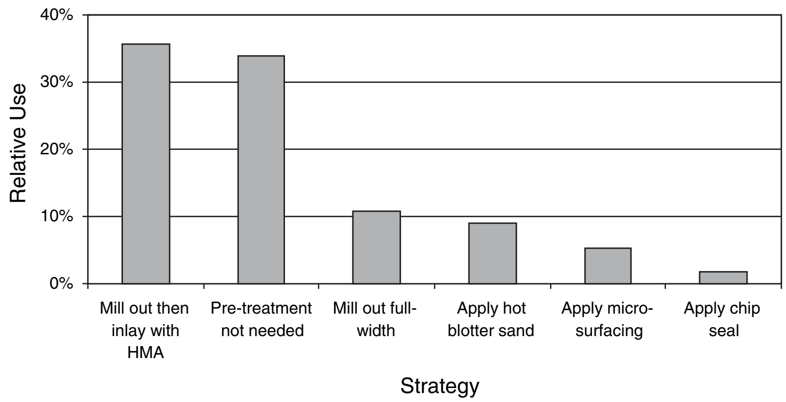


FIGURE 22 Bleeding (aggregate obscured)—All severities (56 responses).

Other employed pre-treatment strategies not shown in Figure 23 are:

- Mill out partial-depth (3% relative use), and
- Apply a sand seal (1% relative use).

Raveling (Loss of Fine and Some Coarse Aggregate)

The primary strategy used for all severities of raveling (loss of fine and some coarse aggregate) is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay,
- Chip seal over the affected areas,
- Place a micro-surface layer over the affected areas, or
- Mill out full-width the affected areas before the construction of the HMA overlay.

One other employed pre-treatment strategy not shown in Figure 24 is to place an HMA patch over the affected areas (2% relative use).

Raveling (Loss of Coarse Aggregate)

The primary strategy used for all severities of raveling (loss of coarse aggregate) is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Mill out 2 to 4 in. of the affected areas and then place an HMA inlay before the construction of the HMA overlay,
- Chip seal over the affected areas, or
- Place a micro-surface layer over the affected areas.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 25 are:

- Place an HMA patch over the affected areas (2% relative use),
- Perform a full-depth repair (2% relative use),
- Perform a partial-depth repair (2% relative use),
- Place a thin HMA overlay (2% relative use),
- Full-depth pulverization (2% relative use), and
- Apply a strip seal (2% relative use).

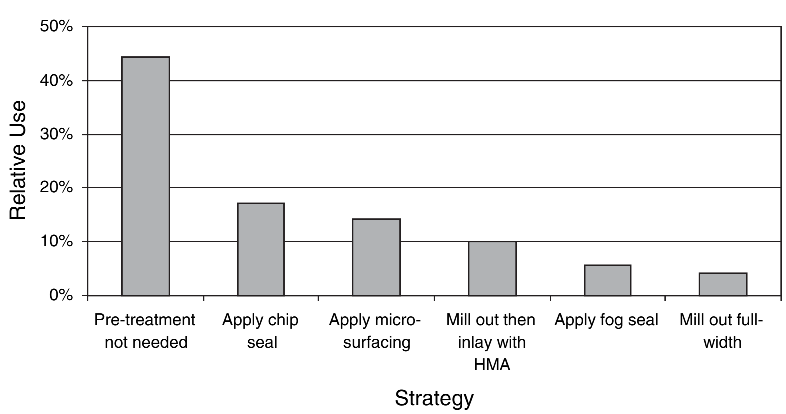


FIGURE 23 Raveling (loss of fine aggregates)—All severities (70 responses).

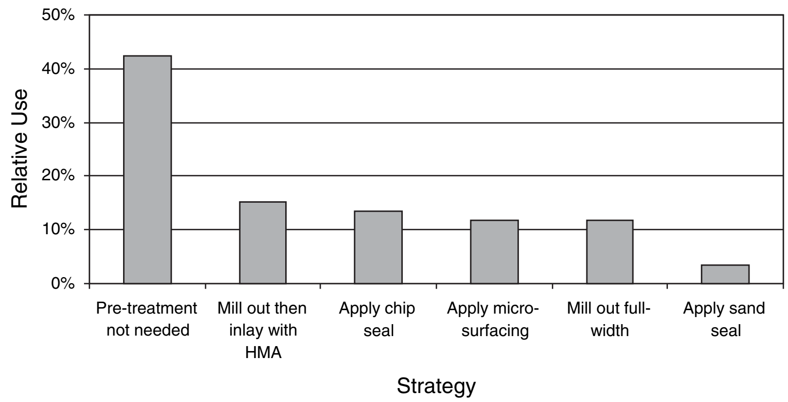


FIGURE 24 Raveling (loss of fine and some coarse aggregate)—All severities (59 responses).

Water Bleeding and Pumping

The primary strategy used for all severities of water bleeding and pumping is to identify the source of water and take the appropriate corrective measures. The secondary strategy used is to remove and replace the entire existing HMA structural section including the subgrade if it is saturated.

If cold in-place recycling is used, the average depth ranges from 3 to 4 in.

Other employed pre-treatment strategies not shown in Figure 26 are:

- Crack fill all cracks (3% relative use),
- Mill out and place a rubberize moisture barrier (1% relative use),
- Mill out and inlay with HMA (1% relative use), or
- Full-depth pulverization (1% relative use).

Polished Aggregate

The primary strategy used for all severities of polished aggregate is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Chip seal over the affected areas, or
- Place a micro-surface layer over the affected areas.

One other employed pre-treatment strategy not shown in Figure 27 is to apply a slurry seal over the affected area (2% relative use).

Roughness

The primary strategy used for all severities of roughness is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Diamond grind the existing surface, or
- Mill out then inlay with HMA.

If cold in-place recycling is used, the average depth ranges from 2 to 4 in. If hot in-place recycling is used, a 2 in. depth is used.

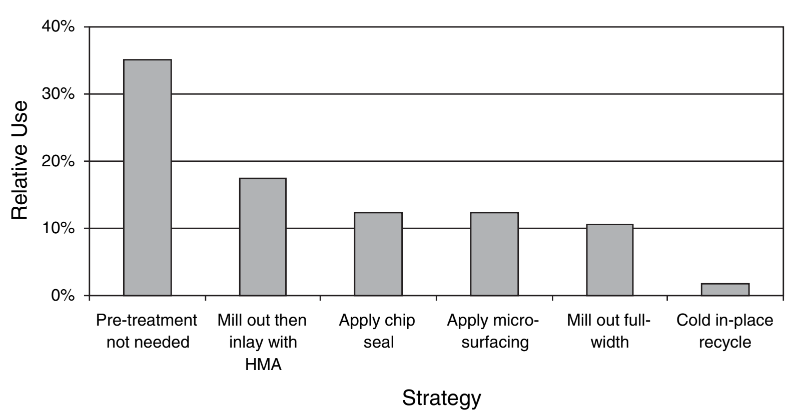


FIGURE 25 Raveling (loss of coarse aggregate)—All severities (57 responses).

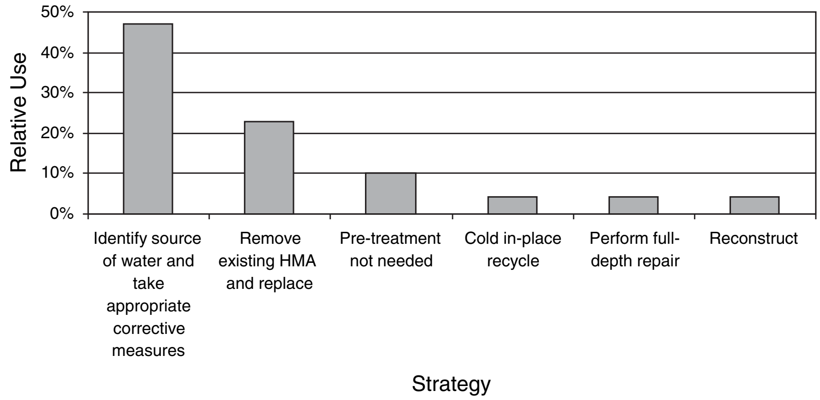


FIGURE 26 Water bleeding and pumping—All severities (70 responses).

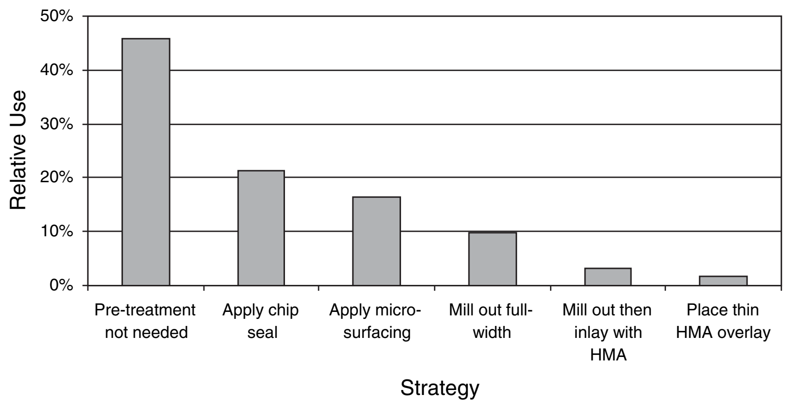


FIGURE 27 Polished aggregate—All severities (61 responses).

One other employed pre-treatment strategy not shown in Figure 28 is to pulverize the existing HMA layer (3% relative use).

All areas of localized roughness be identified and then diamond ground to an acceptable level of smoothness before the placement of a HMA overlay.

The primary strategy used is to mill out the affected areas and then inlay with HMA. The secondary strategy used is to diamond grind the existing surface.

If cold in-place recycling is used, a 2 to 4 in. depth is recommended. If hot in-place recycling is used, a 2 in. depth is recommended.

Other employed pre-treatment strategies not shown in Figure 29 are:

- Pulverize the existing HMA layer (3% relative use), and
- Reconstruct the full section and install underdrains (3% relative use).

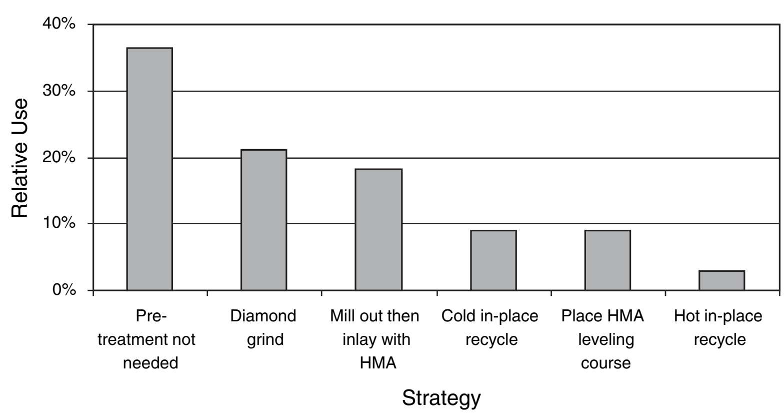


FIGURE 28 Roughness—Moderate severity (33 responses).

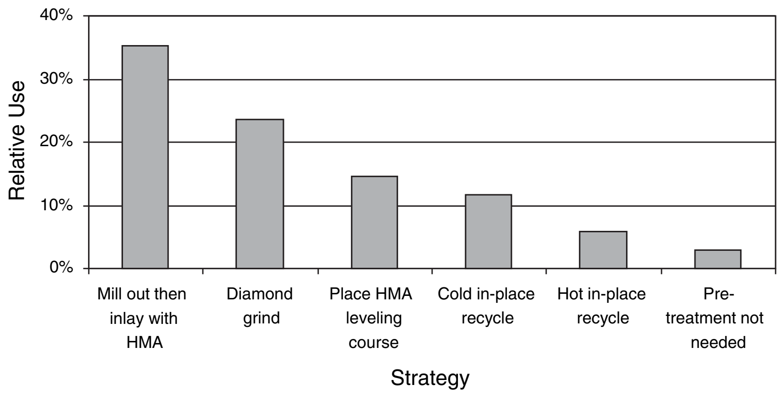


FIGURE 29 Roughness—High severity (34 responses).

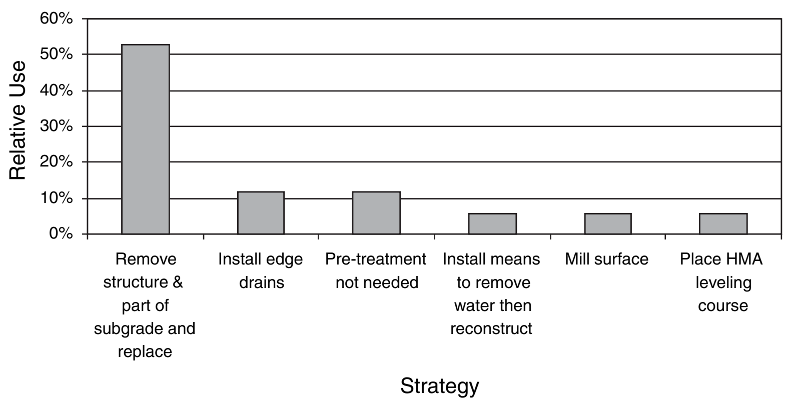


FIGURE 30 Frost-heave—All severities (17 responses).

Frost-Heave

The primary strategy used for all severities of frost-heave is to remove full-depth the affected areas, including the subgrade, and replace.

One other employed pre-treatment strategy not shown in Figure 30 is to remove the existing structure and some of the subgrade material and install a Styrofoam insulating blanket (5% relative use).

CHAPTER FOUR

JOINTED PLAIN CONCRETE PAVEMENT OVERLAY OVER EXISTING JOINTED PLAIN CONCRETE PAVEMENT PRE-OVERLAY TREATMENTS

INTRODUCTION

There are two primary types of JPCP overlays of existing JPCP pavements. They are differentiated by the pretreatment between the JPCP overlay and the existing JPCP pavement. They are classified as fully bonded and unbonded, and are summarized in Table 2.

Bonded

When building a bonded JPCP overlay, very specific measures need to be taken to create a bond between the JPCP overlay and the existing JPCP pavement. This requires extensive surface preparation of the existing JPCP pavement (e.g., shot blasting) and in some cases the placement of a cement grout (or other bonding agent) on the existing JPCP pavement just ahead of the paver. The intent of bonding an overlay to the existing pavement is to create a pavement system that behaves monolithically as shown in Figure 31.

Bonded overlays (2 to 5 in. thick) are used to increase the structural capacity of the pavement or to improve its overall ride quality. Bonded overlays are typically used where the underlying pavement is in relatively good condition ("Guidelines for Bonded Concrete Overlays" 1998; McGhee 1994). If distressed pavements are overlaid without substantial pre-overlay repair, significant reflection cracking and deterioration will occur in the new overlay because the two layers are not bonded together. A particular problem is the slab corners. If the two layers are not bonded the corners will curl and when loaded, will break. A bonding agent is sometimes applied to the existing JPCP pavement just before the placement of the new JPCP overlay; however, its use is rare. This is usually a cement grout, but occasionally an epoxy material is used.

The key to the performance of a bonded concrete overlay is a clean roughened surface. Different methods are used to prepare the surface including shotblasting (the most common), milling, and sandblasting. A bonding grout or epoxy is not needed. Milling can cause surface micro-cracking and fracturing of the exposed aggregate. If milling is used, the surface may require shotblasting or high pressure water to remove the micro-cracked aggregate. After shot blasting, the surface should be swept clean, followed by cleaning in front of the paver with compressed air ("Guide to Concrete Overlay Solutions" 2007).

When building a bonded JPCP overlay, the following pre-overlay actions should be taken:

- Repair of deteriorated joints and cracks;
- Adequate surface preparation to enhance mechanical and chemical bonding;
- Full-depth repair of severely deteriorated joints;
- Load transfer restoration or full-depth repair of working cracks (tight cracks left alone);
- Grinding of minor joint faulting and possible slab stabilization; and
- Cross stitching of longitudinal cracks, if the cracks are working.

Unbonded

When an unbonded JPCP is built, actions are taken to prevent bonding between the JPCP overlay and the existing JPCP pavement, separating the two layers so that they move independently of one another (see Figure 32). Most commonly used is a bond breaker of 1 to 2 in. of HMA covered with a membrane-curing compound placed on the existing pavement. Lime slurry and pigmented curing compounds are often used as a membrane layer.

Unbonded JPCP overlays are used when the existing pavement deterioration is so advanced that it cannot be effectively corrected before overlaying ("Guidelines for Unbonded Concrete Overlays" 1998). The purpose of that is to prevent the development of reflection cracking in the new JPCP overlay. A small amount (if any) of pre-overlay repair may be required and mismatching of the overlay joints and the existing JPCP pavement joints is sometimes done. In some cases, cracking/breaking and seating of the JPCP pavement is performed before the placement of the unbonded overlay. Typical unbonded JPCP overlay thicknesses range from 4 to 12 in.

An unbonded JPCP overlay requires the use of a separation medium. The purpose is to cover deterioration in the existing slabs and provide for isolation of the JPCP overlay. Polyethylene sheeting, roofing paper, and curing compound do not perform well.

Inadequate thickness of the separation medium can result in poor performance of an unbonded JPCP overlay. In most cases, an HMA layer, at least 1 in. thick, has been shown to provide the best results. The minimum thickness will depend

TABLE 2
SUMMARY OF JPCP OVERLAYS OF EXISTING JPCP PAVEMENT

Bonding Condition	How Condition Achieved	Condition of Existing Pavement	Pre-Overlay Repair
Bonded	• Cleaning and preparing surface (e.g., shot blasting) • Possible application of bonding agent	• Relatively good condition • No materials-related distress	• Most deteriorated cracks, joints, punch outs
Unbonded	• Placement of a separation layer to separate overlay from existing pavement	• Poor condition	• Limited repair

Source: Hoerner (2002).

on the nominal maximum size (NMS) of the aggregate used in the HMA layer. The thickness should be at least three times the nominal mean size of the aggregate ("Guidelines for Unbonded Concrete Overlays" 1998). If the JPCP overlay is placed during the summer months when temperatures are greater than 90°F, it is important that the surface be white-washed by spraying the surface with lime slurry of hydrated lime and water or white pigment curing compound.

When building an unbonded JPCP overlay the following pre-overlay actions should be taken (Smith et al. 2002; "Guide to Concrete Overlay Solutions" 2007):

- If faulting exceeds 3/8 in., a thicker separator layer should be used.
- If significant tenting occurs at the joints, full-depth repair should be considered.
- Badly shattered slabs should be removed and replaced.
- If significant pumping is occurring, the pavement should be repaired and a drainage system be considered.
- Full-depth repair of severely deteriorated joints and cracks should be done.
- Full-depth repair should be made of any punchouts in continuously reinforced concrete pavement (CRCP).

TECHNIQUES

This section provides a brief summary description of the various treatment techniques that state DOT agencies are presently using for pre-overlay treatments of JPCP surfaces.

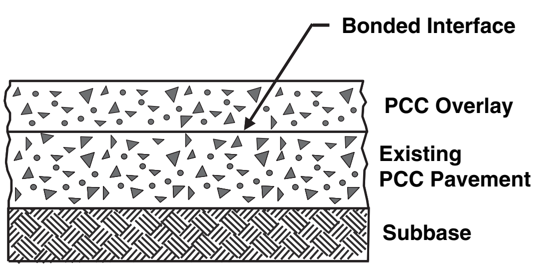


FIGURE 31 Bonded JPCP pavement overlay (McGhee 1994).

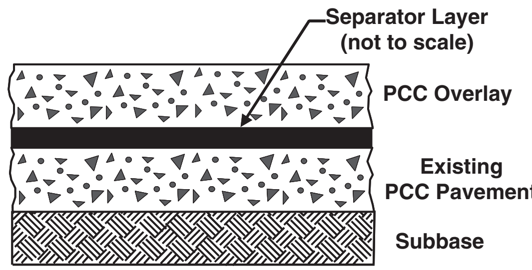


FIGURE 32 Unbonded JPCP pavement overlay (McGhee 1994).

Crack Fill Without Cleaning Out

Older JPCP pavements will have transverse and longitudinal cracking. This technique consists of filling those cracks with joint filler without cleaning and preparing the joint. This technique is only applicable to unbonded overlays.

Clean Out and Crack Fill

Free water entering joints or cracks can accumulate beneath the slab, contributing to distresses such as pumping, loss of support, faulting, and corner breaks. Therefore, joints in JPCP are generally filled with a joint sealant material. Before rehabilitation, agencies will clean out these joints by routing out the existing material, cleaning the joint, and then replacing the old joint material with new joint filler. This technique is applicable to unbonded overlays.

Dowel Bar Retrofit

Older JPCP pavements may rely on aggregate interlock for load transfer across joints. Over time these joints may have opened up and no longer provide load transfer. The amount of load transfer influences the magnitude of the deflections at the joints and cracks. As a result, load transfer becomes a major factor influencing the structural performance of a JPCP pavement. Poor load transfer across transverse joints can lead to problems with a JPCP overlay, especially a bonded overlay. The result can be pumping, faulting, and/or corner breaks in the new overlay. One way of addressing poor load transfer before it has resulted in continued deterioration of the pavement is by the placement of dowel bars or other mechanical devices across joints and/or cracks that exhibit poor load transfer. An FWD survey during the evaluation phase can identify if this problem exists.

Full-Depth Repair With or Without Tie Bars and Removal and Replacement of Slabs

Full-depth repairs extend the full depth of the existing slab. It requires the full-depth removal and replacement of full or half lane-width areas of an existing JPCP pavement that contain deterioration. In general, half lane-width repairs are used only on CRCP and are not recommended for JPCP. The minimum repair length specified is typically 6 ft. The repairs are made with PCC. HMA is not recommended because HMA patches allow horizontal movements of slabs and provide no load transfer across the transverse joints. Full-depth repairs are used to repair JPCP pavements that have transverse cracking, corner breaks, longitudinal cracking, deteriorated joints, and blowups.

Full-Depth Rubblization

Full-depth rubblization is a process of fracturing the existing JPCP pavement in-place into small, interconnected pieces that serve as a base course for a new HMA overlay. The rubblization process completely destroys slab action, eliminating the possibility of reflection cracking. The slabs are broken into pieces with either a resonant pavement breaker or a multiple head pavement breaker. The rubblization process will result in smaller size particles near the surface of the pavement ranging from sand size to 3 to 15 in. at the bottom of the rubblized layer on very thick JPCP pavements. The actual size will vary depending on the slab thickness, the type of reinforcement, the subgrade strength, and the equipment used to do the rubblization.

Partial-Depth Repair

Partial-depth repair is the placement of a concrete patch, generally along a joint, to correct surface defects and shallow joint spalling. These repairs are generally to a depth of less than one-third of the slab thickness. If a thicker repair is required, consideration should be given to a full-depth repair.

Placing a Hot-Mix Asphalt Separator Layer

This consists of placing an HMA layer on the surface of the existing JPCP pavement to act as a separator layer. This is usually required for an unbonded overlay over JPCP.

PRE-OVERLAY STRATEGIES

This section provides the state DOT questionnaire survey results in the form of bar charts. These bar charts will summarize what strategies the various state DOTs are presently using to address medium and high severity distresses associated with existing JPCP pavement structures before the placement of a JPCP overlay. These bar charts will present up to six of the most used strategies and are organized from the highest relative use strategy to the lowest relative use strategy. If more than six strategies are presently being used, the additional strategies are only mentioned.

Corner Breaks

The primary strategies used for moderate severity corner breaks are:

- No pre-overlay treatments are done before placing the JPCP overlay, or
- Remove the affected area and replace full-depth.

Other employed pre-treatment strategies not shown in Figure 33 are:

- Full-depth rubblization (4% relative use), and
- Underseal (4% relative use).

The primary strategy used for high severity corner breaks is to remove the affected area and replace the slab full-depth (see Figure 34).

The literature review suggests that for bonded and unbonded overlays, full-depth repair is recommended for both moderate and high severities (Smith et al. 2002).

Durability (“D”) Cracking

The primary strategy used for moderate severity durability (“D”) cracking is to not perform any pre-overlay treatment before placing the JPCP overlay; the secondary strategy is to

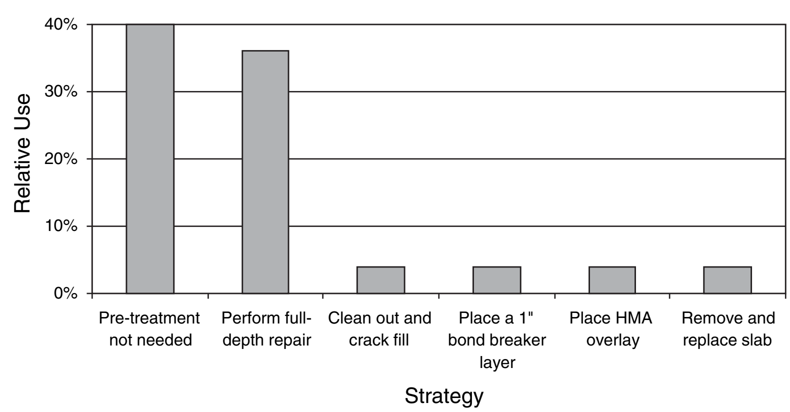


FIGURE 33 Corner breaks—Moderate severity (25 responses).

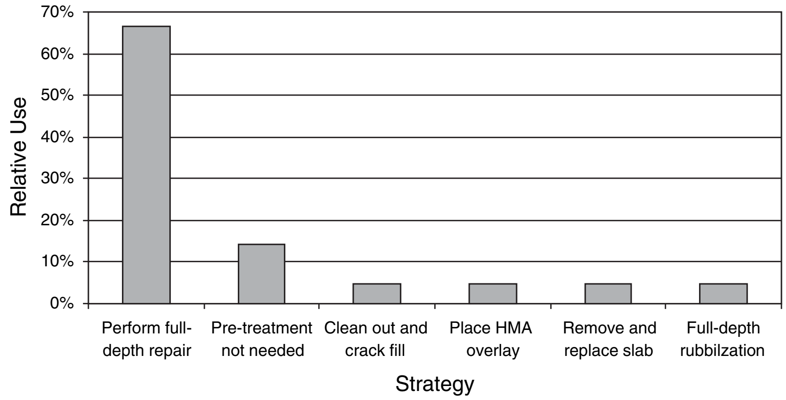


FIGURE 34 Corner breaks—High severity (21 responses).

remove the affected area and replace the existing slab full-depth (see Figure 35).

The primary strategy used for high severity "D" cracking is to remove the affected area and replace the existing slab full-depth. The secondary strategies used are:

- Not perform any pre-overlay treatment before placing the JPCP overlay, or
- Remove and replace the entire slab.

One other employed pre-treatment strategy not shown in Figure 36 is to perform a partial-depth repair of the affected areas (6% relative use).

Based on the literature review for bonded overlays, "D" cracking is typically a bottom up distress and, if it occurs in the concrete pavement to be overlaid, it will probably continue. Therefore, bonded concrete overlays should not be used on a pavement that has "D" cracking (Smith et al. 2002). For pavement with either moderate or high severity "D" cracking,

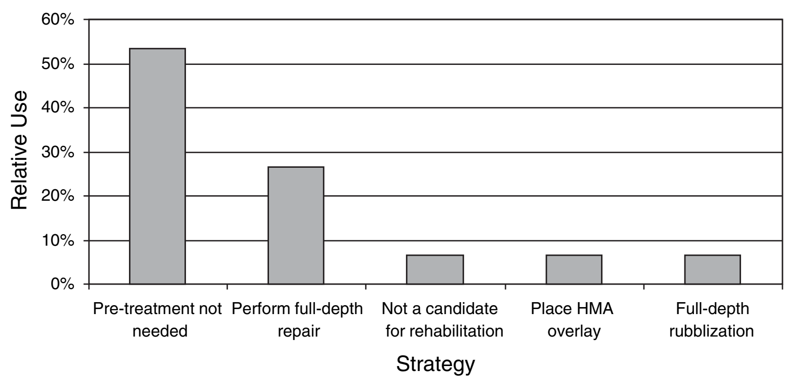


FIGURE 35 Durability ("D") cracking—Moderate severity (15 responses).

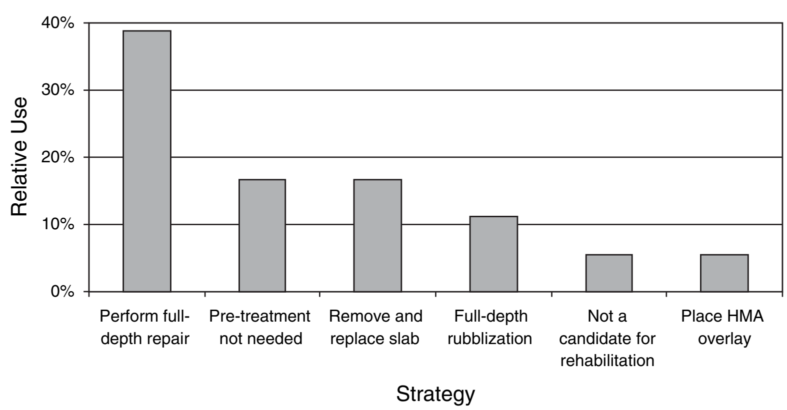


FIGURE 36 Durability ("D") cracking—High severity (18 responses).

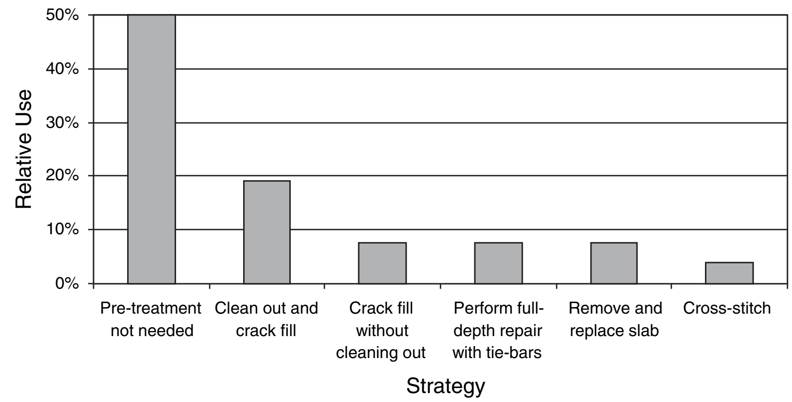


FIGURE 37 Longitudinal cracking—Moderate severity (26 responses).

many agencies are using rubblization. The rubblized layer will be weaker than a JPCP and therefore additional thickness may be required (McGhee 1994). Another option is to remove the "D" cracked area and replace it with full-depth HMA or PCC ("Guidelines for Unbonded Concrete Overlays" 1998).

Longitudinal Cracking

The primary strategy used for repairing moderate severity longitudinal cracking is to not perform any pre-overlay treatment before placing the JPCP overlay. The secondary strategy is to clean out the existing crack then crack fill.

One other employed pre-treatment strategy not shown in Figure 37 is to place an HMA overlay over the affected areas (4% relative use).

The primary strategy used for high severity longitudinal cracking is to remove and replace the entire slab. The secondary strategies used are:

- Not perform any pre-overlay treatment before placing the JPCP overlay, or
- Perform a full-depth repair using tie-bars.

Other employed pre-treatment strategies not shown in Figure 38 are:

- Cross-stitch (4% relative use), and
- Full-depth rubblization (4% relative use).

Based on the literature review for bonded overlays, longitudinal cracks at mid-slab normally are not load related. If they are not moving and the load support on both sides of the crack is good, no special preparation is needed for both moderate and high severity cracking (reflection cracking should be expected).

If longitudinal cracking occurs in the wheel path it is usually the result of structural deterioration and the slab should be considered for removal and replacement (McGhee 1994). Not all cracked slabs will require replacement. Replace any slabs that are severely deteriorated and have lost subbase/subgrade support ("Guidelines for Unbonded Concrete Overlays" 1998).

Transverse Cracking

The primary strategy used for moderate severity transverse cracking is to not perform any pre-overlay treatment

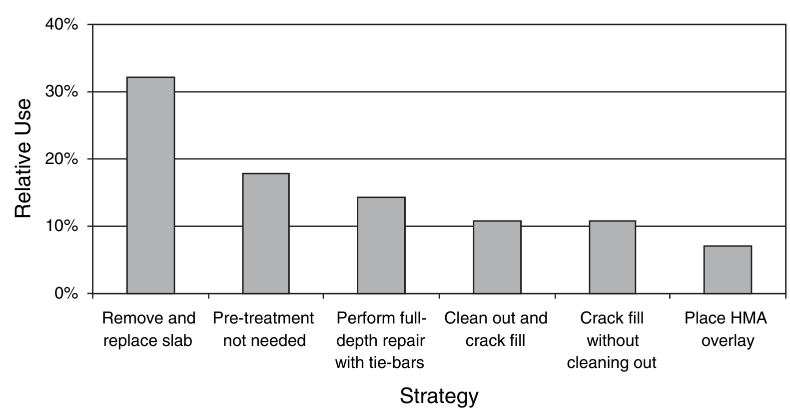


FIGURE 38 Longitudinal cracking—High severity (28 responses).

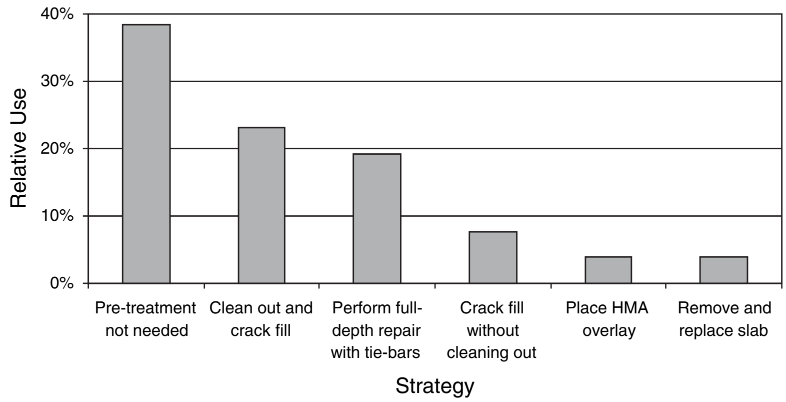


FIGURE 39 Transverse cracking—Moderate severity (26 responses).

before placing the JPCP overlay. The secondary strategies used are:

- Clean out the existing crack then crack fill, or
- Perform a full-depth repair using tie-bars.

One other employed pre-treatment strategy not shown in Figure 39 is to perform full-depth rubblization (4% relative use).

The primary strategies used for high severity transverse cracking are:

- Remove and replace the entire slab, or
- Perform a full-depth repair using tie-bars.

The secondary strategies used are:

- Clean out the existing crack then crack fill, or
- Do not perform any pre-overlay treatment before placing the JPCP overlay.

Other employed pre-treatment strategies not shown in Figure 40 are:

- Place an HMA overlay over the affected areas (3% relative use), and
- Full-depth rubblization (3% relative use).

Transverse cracks that are tight and do not move can be left untreated. Medium and high severity cracks should be replaced full depth (Smith et al. 2002).

Joint Seal Damage

The primary strategy used for moderate severity joint seal damage is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 41). The secondary strategy used is to clean out the existing joint and reseal.

The primary strategies used for high severity joint seal damage are (see Figure 42):

- Clean out the existing joint and reseal, or
- Not perform any pre-overlay treatment before placing the JPCP overlay.

Spalling of Longitudinal Joints

The primary strategy used for moderate severity spalling of a longitudinal joint is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 43). The secondary strategies used are:

- Crack fill without cleaning out the joint, or
- Perform a partial-depth repair.

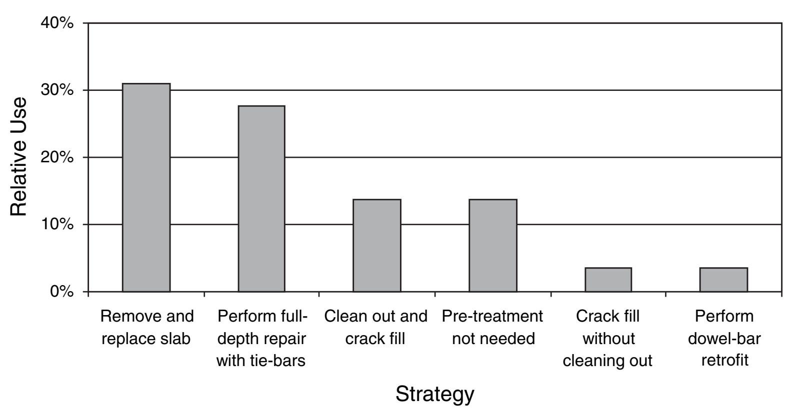


FIGURE 40 Transverse cracking—High severity (29 responses).

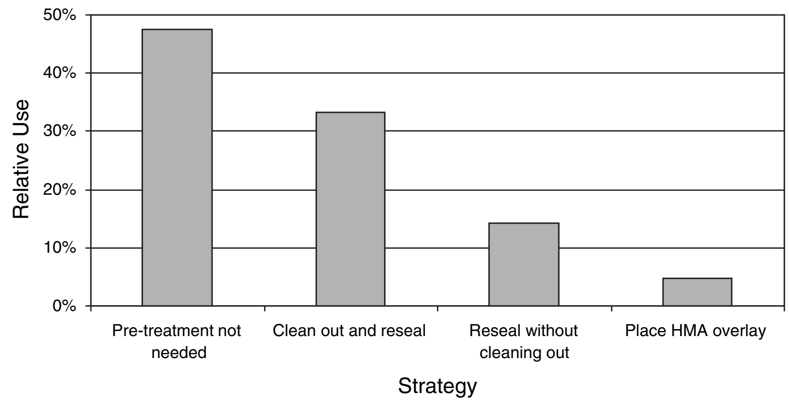


FIGURE 41 Joint seal damage—Moderate severity (21 responses).

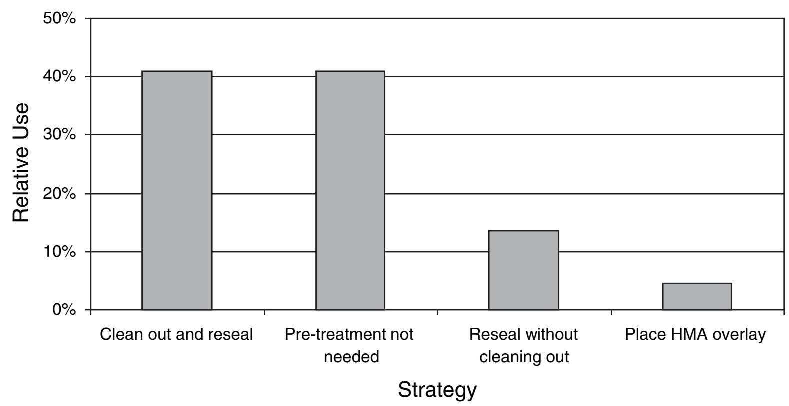


FIGURE 42 Joint seal damage—High severity (22 responses).

The technical literature review for bonded overlays if the spalling at the joint is the result of construction problems such as the over finishing of the concrete at the joint, then the surface should be repaired with a partial depth replacement. If the spalling is the result of movement at the joint, then the joint should be treated as a working longitudinal crack and the slab should be removed and replaced. For unbonded overlays no treatment may be necessary for spalling as a result of construction problems. However, if it is a working crack the slab should be removed and replaced.

The primary strategies used for high severity spalling of a longitudinal joint are (see Figure 44):

- Perform a full-depth repair with new dowel and/or tie-bars,
- Perform a partial-depth repair,
- Not perform any pre-overlay treatment before placing the JPCP overlay, or
- Crack fill without cleaning out the joint.

Based on the literature review for bonded and unbonded overlays, high severity spalling of the longitudinal joint is probably load related, and the load transfer across the joint should be established by full-depth repair (McGhee 1994).

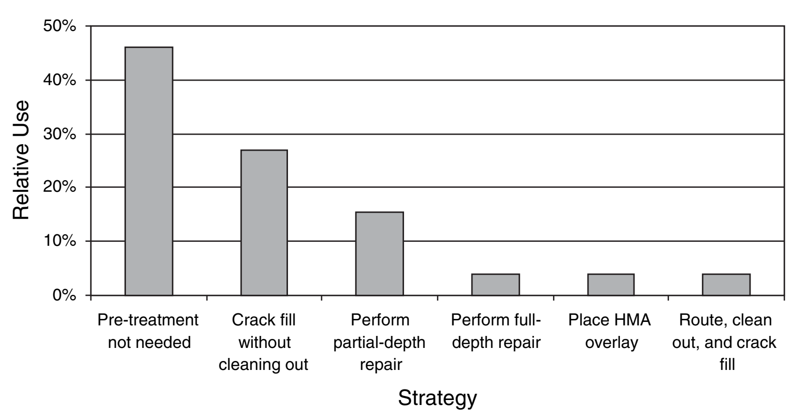


FIGURE 43 Spalling of longitudinal joint—Moderate severity (26 responses).

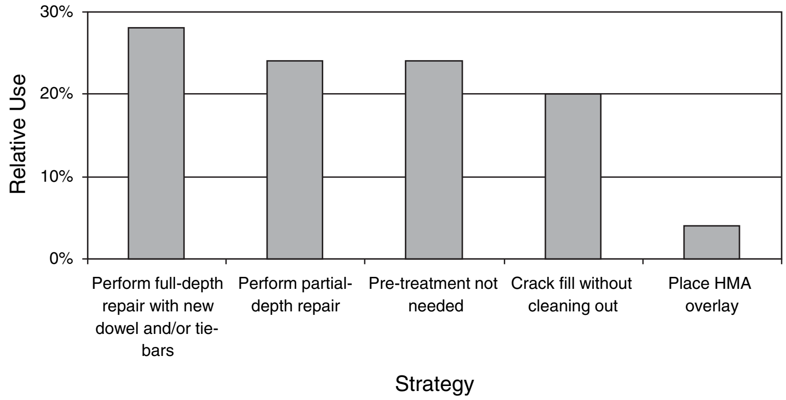


FIGURE 44 Spalling of longitudinal joint—High severity (25 responses).

Spalling of Transverse Joints

The primary strategy used for moderate severity spalling of transverse joints is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 45). The secondary strategies used are:

- Crack fill without cleaning out the joint, or
- Perform a partial-depth repair.

The primary strategy used for high severity spalling of transverse joints is to perform a full-depth repair with new dowel and/or tie-bars (see Figure 46). The secondary strategies used are:

- Perform a partial-depth repair, or
- Not perform any pre-overlay treatment before placing the JPCP overlay.

Based on the literature review for bonded and unbonded overlays, spalling of a transverse joint is generally the result of structural deterioration and inadequate subgrade support. Therefore, for both moderate and high severities, the slab containing the transverse crack should be removed and replaced

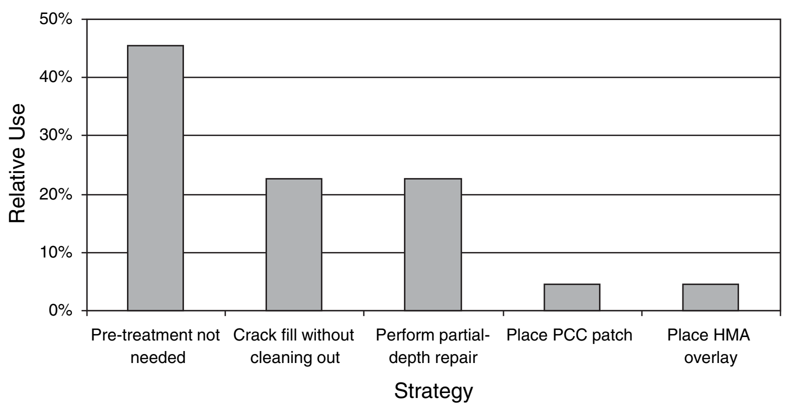


FIGURE 45 Spalling of transverse joints—Moderate severity (22 responses).

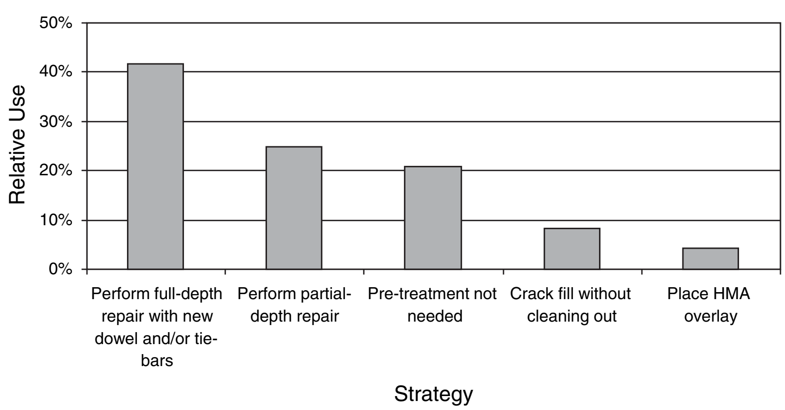


FIGURE 46 Spalling of transverse joints—High severity (24 responses).

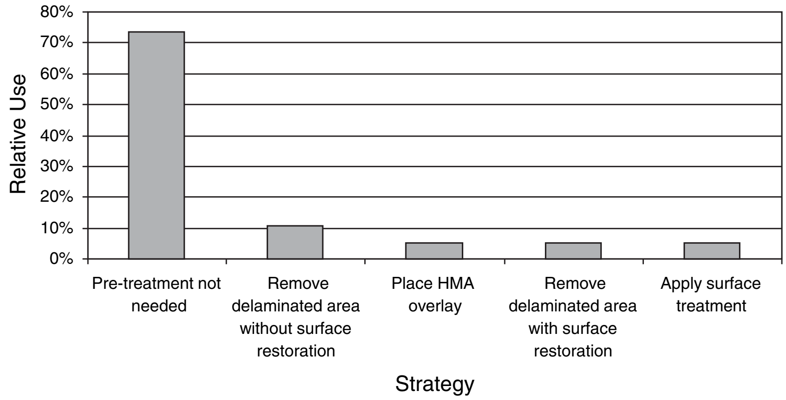


FIGURE 47 Map cracking—All severities (19 responses).

(McGhee 1994; "Guidelines for Unbonded Concrete Overlays" 1998).

Map Cracking

The primary strategy used for all severities of map cracking is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 47).

Based on the literature review for bonded overlays, to ensure a good bond between the bonded overlay and the existing JPCP pavement, the surface should be shotblasted or sandblasted to solid concrete (McGhee 1994).

Scaling

The primary strategy used for all severities of scaling is to not perform any pre-overlay treatment before placing the JPCP overlay. The secondary strategies used are:

- Remove the delaminated areas without surface restoration, or
- Remove the delaminated areas with surface restoration.

One other employed pre-treatment strategy not shown in Figure 48 is to perform full-depth rubblization (5% relative use).

Based on the literature review for bonded overlays, to ensure a good bond between the bonded overlay and the existing JPCP, the pavement surface should be shot or sand blasted to solid concrete (McGhee 1994; "Guide to Concrete Overlay Solutions" 2007).

Polished Aggregate

The primary strategy used for all severities of polished aggregate is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 49).

Popouts

The primary strategy used for all severities of popouts is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 50). The secondary strategy used is to repair the pop out.

Blowups

The primary strategy used for all severities of blowups is to remove the affected area and replace the full-depth of the slab (see Figure 51). The secondary strategy used is to remove and replace the entire slab.

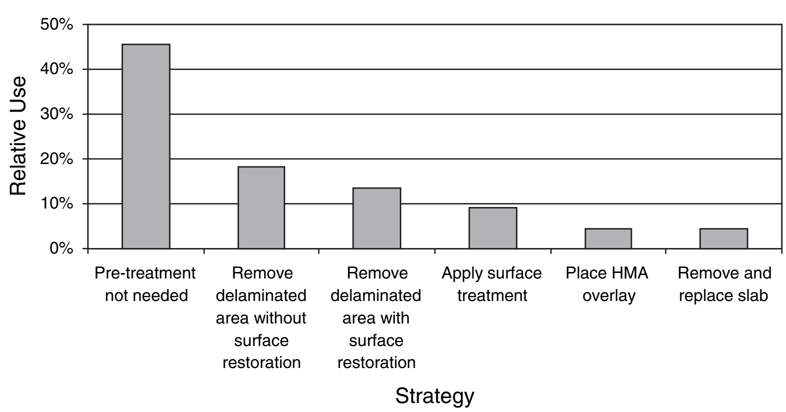


FIGURE 48 Scaling—All severities (22 responses).

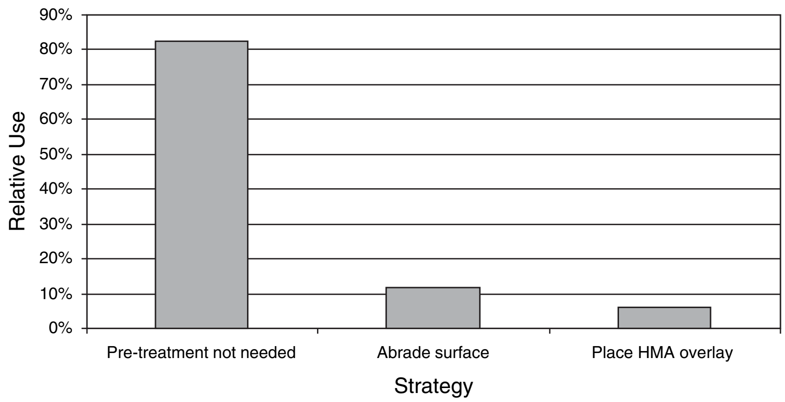


FIGURE 49 Polished aggregate—All severities (17 responses).

Based on the literature review for bonded and unbonded overlays, blowups require full-depth repair (McGhee 2002).

Faulting of Transverse Joints

The primary strategy used for all severities of faulting of transverse joints is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 52). The secondary strategies are:

- Diamond grind off the faulted joints, or
- Perform a dowel-bar retrofit.

Based on the literature review for bonded overlays, faulting is the result of loss of support and load transfer. The slabs need to be stabilized along with full-depth repair ("Guidelines for Bonded Concrete Overlays" 1998).

Based on the literature review for unbonded overlays, joints faulted more than 1/4 inch must be addressed by placing a

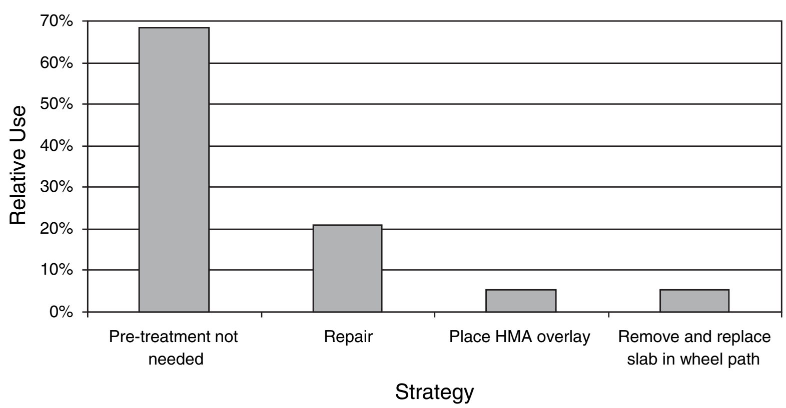


FIGURE 50 Popouts—All severities (19 responses).

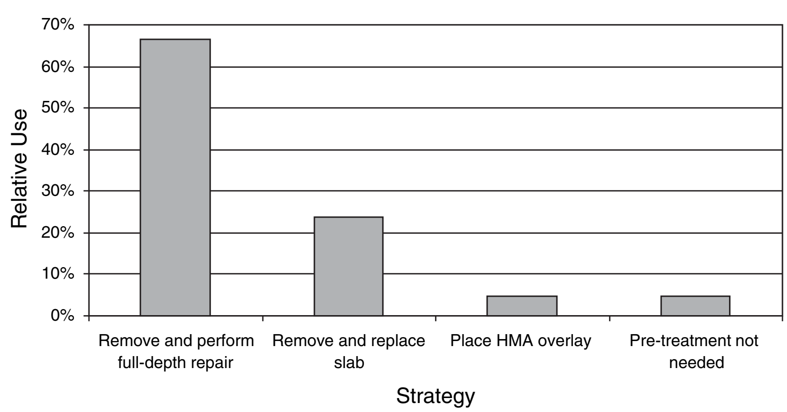


FIGURE 51 Blowups—All severities (21 responses).

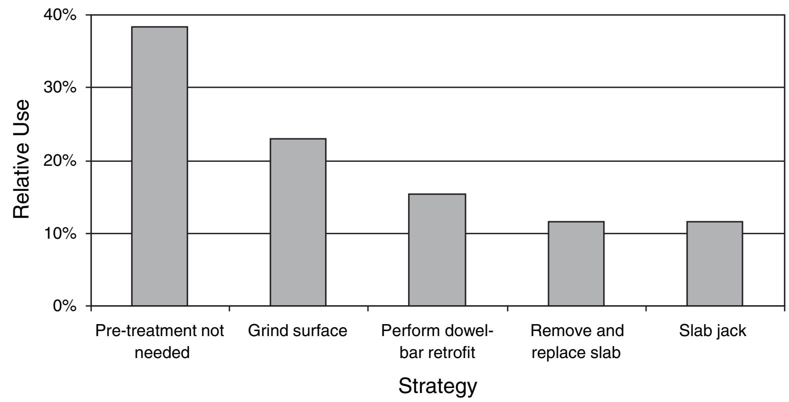


FIGURE 52 Faulting of transverse joints—All severities (26 responses).

thicker separation layer or by grinding the joint. The cause of the faulting should be identified and the need for slab stabilization or drainage improvements evaluated (McGhee 1994; "Guidelines for Unbonded Concrete Overlays" 1998). Diamond grinding should be conducted before faulting reaches critical levels (Hoerner et al. 2001).

Patch/Patch Deterioration

The primary strategies used for moderate severity patch/patch deterioration are (see Figure 53):

- Remove and replace the affected areas, or
- Not perform any pre-overlay treatment before placing the JPCP overlay.

The primary strategy used for high severity patch/patch deterioration is to remove and replace the affected areas. The secondary strategy used is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 54).

Based on the literature review for bonded overlays for both moderate and high severities, the patch should be removed and replaced with PCC (McGhee 1994).

Based on the literature review for unbonded overlays, for high severity patch deterioration the patch should be removed and replaced with either PCC or HMA.

Water Bleeding and Pumping

The primary strategy used for all severities of water bleeding and pumping is to install edge drains. The secondary strategy used is to remove and replace the entire slab.

One other employed pre-treatment strategy not shown in Figure 55 is to perform full-depth rubblization (3% relative use).

Based on the literature review for bonded and unbonded overlays, the cause should be evaluated and drainage improvements installed as needed (McGhee 1994).

Roughness

The primary strategy for moderate severity roughness is to not perform any pre-overlay treatment before placing the JPCP overlay (see Figure 56). The secondary strategy is to diamond grind smooth the existing JPCP surface.

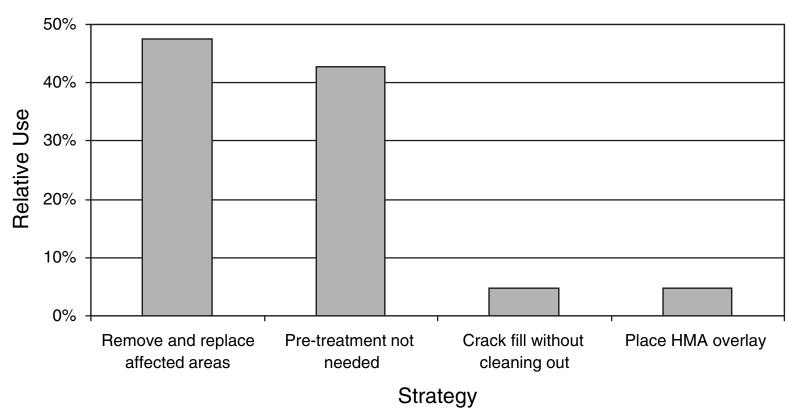


FIGURE 53 Patch/patch deterioration—Moderate severity (21 responses).

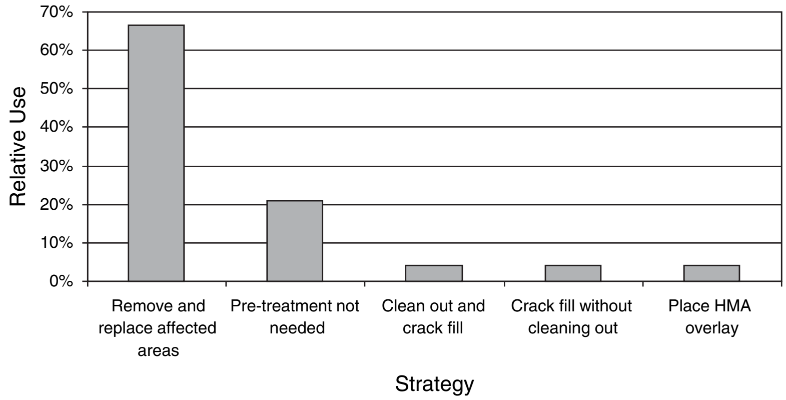


FIGURE 54 Patch/patch deterioration—High severity (24 responses).

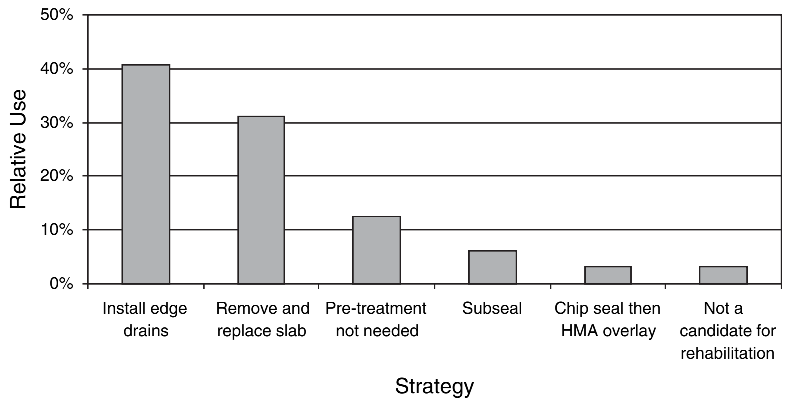


FIGURE 55 Water bleeding and pumping—All severities (32 responses).

The primary strategy for high severity roughness is to diamond grind smooth the existing JPCP surface (see Figure 57).

For unbonded overlays a HMA separator course will function as a leveling course and reduce the roughness before placement of the overlay.

Frost-Heave

Based on very limited survey response data, the primary strategy used for all severities of frost-heave is to remove full-depth the affected areas, including the subgrade, and replace (see Figure 58).

Alkali–Silica Reaction

Based on very limited survey response data, the primary strategy for all severities of alkali–silica reaction (ASR) used is to full-depth remove and replace the concrete layer (see Figure 59).

The literature states that a bonded concrete overlay should not be used on a PCC pavement with ASR problems and that on an unbonded concrete overlay a two inch HMA separator layer is sufficient ("Guide to Concrete Overlay Solutions" 2007).

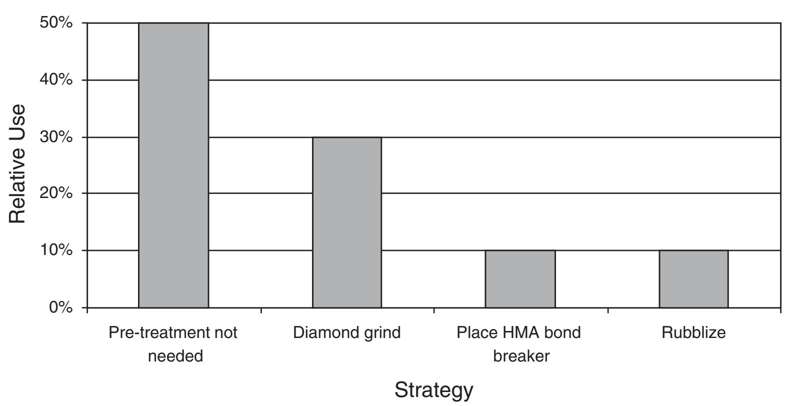


FIGURE 56 Roughness—Moderate severity (10 responses).

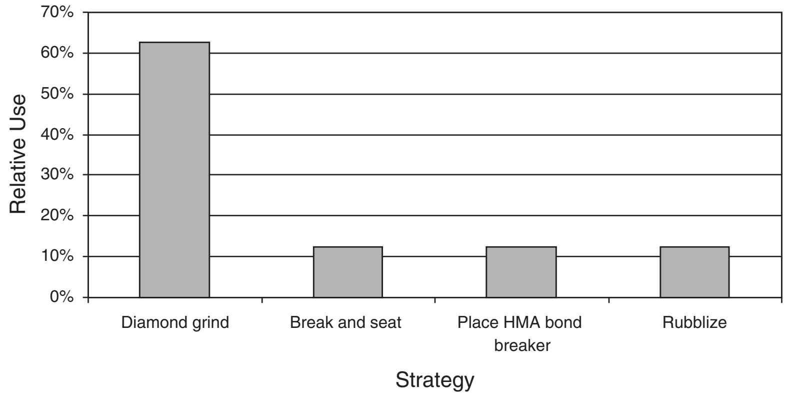


FIGURE 57 Roughness—High severity (8 responses).

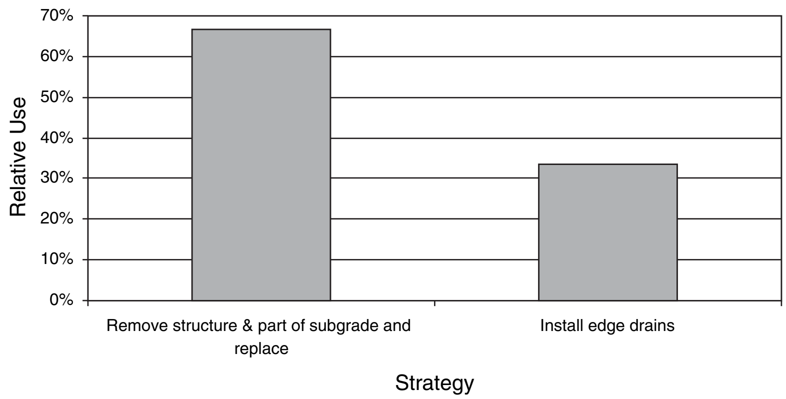


FIGURE 58 Frost-heave—All severities (3 responses).

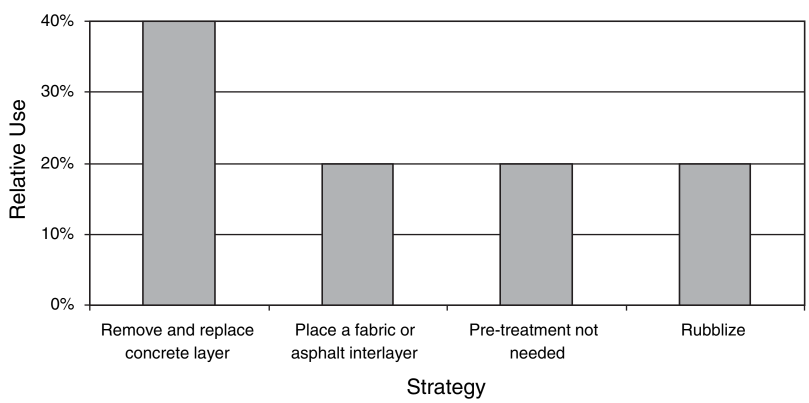


FIGURE 59 Alkali–silica reaction—All severities (5 responses).

CHAPTER FIVE

HOT-MIX ASPHALT OVERLAY OVER JOINTED PLAIN CONCRETE PAVEMENT PRE-OVERLAY TREATMENTS

INTRODUCTION

The placement of an HMA overlay is one of the most common PCC pavement rehabilitation techniques. HMA overlays are typically 2 in. or more thick, and are designed for specific projected traffic loadings. The condition of the underlying pavement has a great effect on the performance of HMA overlays; therefore, their placement is often preceded by other treatments, such as full-depth and partial-depth repair. The primary failure mode for HMA overlays is reflection cracking, in which the joints and cracks of the underlying PCC pavement reflect through the HMA overlay and deteriorate, resulting in failure of the overlay (Hoerner et al. 2001).

HOT-MIX ASPHALT OVERLAYS OVER JOINTED PLAIN CONCRETE PAVEMENTS

Unfractured Jointed Plain Concrete Pavements

The placement of an HMA overlay over an unfractured JPCP pavement may be undertaken provided that reflection cracking is addressed in the overlay design. The placement of an HMA overlay should not be done when the condition of the existing pavement structure dictates substantial removal and replacement when:

- The amount of deteriorated slab cracking and joint spalling is so great that complete removal and replacement of the existing surface is required, or
- A significant deterioration of the JPCP slab has occurred owing to severe durability problems (e.g., D-cracking or reactive aggregates) (*AASHTO Guide for Design of Pavement Structures* 1993, p. III-125).

Repairs

Full-depth repair of all working cracks, heaves, deteriorated joints, and slabs should be performed before the placement of the HMA overlay. All full-depth repairs and slab replacements in JPCP should use PCC and should be doweled or tied to provide the needed load transfer across the repair joints. Some agencies have placed full-depth HMA repairs in JPCP pavements before being overlaid. However, this has often resulted in rough spots in the HMA overlay, the opening of nearby joints and cracks, and rapid deterioration of reflection cracks at the HMA patch boundary. An HMA leveling course should be used to smooth faulting and fill localized settlements. In general, half lane-width repairs are used only on CRCP and are not recommended for JPCP ("HMA Rehabilitation of Existing Pavements" 2002).

Reflection Crack Control

In an HMA overlay of JPCP, reflection cracks typically develop relatively soon after the placement of the HMA overlay. The rate at which they develop and deteriorate depends on a number of factors including:

- Thickness of the HMA overlay,
- Traffic,
- Stiffness and load transfer in the existing pavement,
- Daily and seasonal temperature variations,
- Coefficient of thermal expansion of the existing pavement, and
- Spacing of the joints and cracks.

The proper repair of deteriorated joints and working cracks with full-depth doweled or tied PCC repairs reduces the rate of reflection crack occurrence and deterioration provided good load transfer is obtained at the full-depth repair joints. Other pre-overlay efforts that will discourage reflection crack occurrence and subsequent deterioration include:

- Subdrainage improvements,
- Subsealing slabs that have lost support, and
- Restoring load transfer at joints and cracks with dowels grouted in slots.

Varieties of reflection crack control measures have been used in attempts to control the rates of reflection crack occurrence and deterioration. Any of the following treatments may be employed in an effort to control reflection cracking in an HMA overlay of JPCP:

- Sawing and Sealing Joints in the HMA Overlay—This technique has been successful when applied to HMA overlays of JPCP pavements when the saw cut matches the joint.
- Increasing HMA Overlay Thickness—Reflection cracks will take more time to propagate through a thicker overlay and deteriorate more slowly.
- Granular Interlayers—Large-sized stone layers are placed between the jointed pavement and the HMA overlay.

- Proprietary Fabric Treatments—A number of products are available that claim to reduce reflection cracking in HMA overlays of JPCP pavements.
  – Fabrics are usually from polyester or polypropylene as a woven or nonwoven material. After pavement preparation, a binder or tack coat is applied to the old JPCP pavement surface to adequately bond the fabric and allow for the adsorption of asphalt. When installed over an existing JPCP pavement's surface that has a differential movement at the joints, fabrics may continue to act as a waterproofing membrane but will not stop reflection cracking if the movement is appreciable.

Reflection cracking can have a considerable, often controlling, influence on the life of an HMA overlay of JPCP pavements. Deteriorated reflection cracks will decrease a pavement's serviceability and require frequent maintenance such as sealing, milling, and patching. Reflection cracks also permit water to enter the pavement structure, which may result in:

- The loss of bond between the HMA and JPCP layers,
- Stripping in the HMA,
- Progression of D-cracking or reactive aggregate distress in JPCP slabs, and
- Softening of the base and subgrade.

For this reason, reflection cracks should be sealed as soon as they appear and resealed periodically throughout the life of the HMA overlay ("HMA Rehabilitation of Existing Pavements" 2002).

Fractured Jointed Plain Concrete Pavements

Reflection cracking is a major distress in HMA overlays of existing JPCP pavements. Rubblizing, break and seating, and crack and seat techniques are used to reduce the size of JPCP slabs to minimize the differential movements at existing cracks and joints, thereby minimizing the occurrence and severity of reflection cracking.

Rubblizing can be used on both JPCP and Jointed Reinforced Concrete Pavements (JRCP) in any condition, and is particularly recommended for reinforced pavements. Fracturing the slab into pieces less than 12 in. in size reduces the slab to a high-strength granular base ("HMA Rehabilitation of Existing Pavements" 2002).

Crack and seat is used only with JPCP and involves cracking the slab into pieces typically 1 to 3 ft in size. To avoid reflection cracking, it is recommended that no more than 5% of the fractured slabs have a modulus greater than 1 million psi. Effective slab cracking techniques are necessary to satisfy this criterion ("HMA Rehabilitation of Existing Pavements" 2002).

When slab fracturing is to be performed on an existing composite pavement, the HMA surface should be removed by cold milling to expose the underlying JPCP pavement. Better efficiency and control of the slab fracturing process is obtained. Any conditions that may not provide a uniform support after the slab fracturing process should be repaired before the placement of the HMA overlay ("HMA Rehabilitation of Existing Pavements" 2002).

TECHNIQUES

Break and Seat

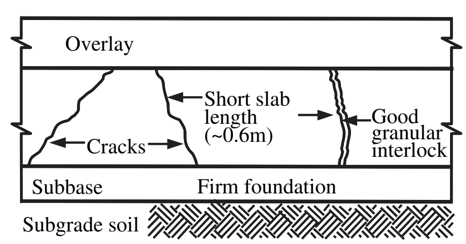
Break and seat reduces horizontal movements by rupturing the reinforcing steel or debonding the concrete from the steel. This effort generally requires that the existing PCC be broken into smaller pieces than required for the cracking and seating of JPCP, and thus there is a greater reduction in the structural capacity of the break and seat section (Hoerner et al. 2001).

Crack and Seat

Crack and seat reduces joint and crack movement by shortening the effective slab length and seating the broken concrete pieces into the supporting layer (see Figure 60). The JPCP slabs are cracked into small segments before overlaying. The intent of cracking and seating is to create concrete pieces that are small enough to reduce the movement caused by the low temperature thermal stresses and the cyclic, daily temperature stresses, while still being large enough to maintain structural stability. Seating of the broken slabs after cracking is believed to be necessary to re-establish firm support between the subbase and the slab, thereby limiting differential vertical movement under traffic (Hoerner et al. 2001).

Cold Milling

This technique may be used to remove small, deteriorated areas or as a surface preparation technique before overlaying. However, the use of cold milling as the substitute for diamond grinding or grooving is not recommended. The milling process effectively involves chipping material off the pavement surface. Cold milling using conventional equipment is generally



1 ft = 0.3048 m

FIGURE 60 A cracked and seated pavement (Hoerner et al. 2001).

not acceptable on PCC pavements because of the poor surface finish and spalling at the joints. However, recent advances in milling equipment, using drum-mounted, multiple-wrap carbide steel cutting bits have been shown to be effective in providing acceptable riding surface (Hoerner et al. 2001).

Crack-Arresting Interlayers

These are thick granular layers that arrest the development of reflection cracks by providing large void spaces that effectively blunt crack propagation (see Figure 61). Standard granular bases with low fines contents and large aggregates have been used for this purpose.

Cross-Stitching

Cross-stitching is a preservation method designed to strengthen nonworking longitudinal cracks that are in relatively good condition. The construction process consists of grouting tie bars into holes drilled across the crack at angles of 35 to 45 degrees to the pavement surface (see Figure 62). This process is effective at preventing vertical and horizontal movement or widening of the crack or joint, thereby keeping the crack tight, maintaining good load transfer, and slowing the rate of deterioration (Hoerner et al. 2001).

Diamond-Blade Grinding

This is the removal of a thin layer of hardened PCC pavement surface using closely spaced, diamond saw blades mounted on a rotating drum. The purpose of diamond grinding is to correct surface irregularities and provide a smooth riding surface. Diamond grinding also increases the pavement macrotexture, which results in increased surface friction levels (Hoerner et al. 2001).

Diamond Grooving

This is where grooves are cut into hardened PCC using diamond saw blades with a center-to-center blade spacing of ¾ in. or greater. The principal objective of grooving is to provide escape channels for surface water, thereby reducing the incidence of hydroplaning that can cause wet weather accidents (Hoerner et al. 2001).

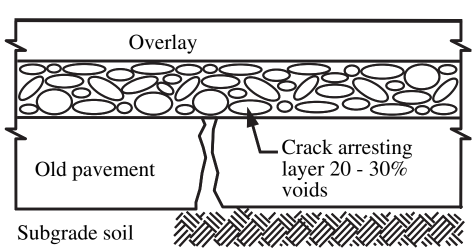


FIGURE 61 Cross section of a typical crack-arresting interlayer.

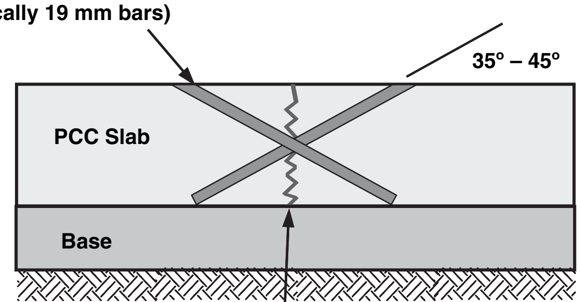


FIGURE 62 Cross-stitching of longitudinal crack (Hoerner et al. 2001).

Rubblization

A procedure that uses a resonant pavement breaker or a multi-head breaker to reduce the existing PCC slab into small pieces varying from sand-sized particles up to about 6 in. The resonant pavement breaker applies a 2-kip impact force at a frequency of 44 impacts per second to the pavement surface through a shoe that is attached to a massive steel beam. In essence, this beam acts as a "giant tuning fork," shattering the pavement into pieces having an average size of 1 to 2 in., with no pieces larger than 6 in. Multiple shoes have been used on equipment to increase production rates. Multi-head pavement breakers fracture the concrete by lifting and dropping rows of steel hammers onto the pavement and can cover a width of up to 13 ft (Hoerner et al. 2001).

Saw and Seal Joints

Saw and seal joints consist of marking joints and cracks in the existing pavement before overlaying and then sawing joint reservoirs in the HMA overlay directly over the underlying joints or cracks. These new reservoirs are then sealed and treated as joints.

Slab Jacking

This is the lifting or raising of a PCC slab by pressure inserting a stiff cement grout beneath the slab. It is used to level out a localized area of depression or settlement in a PCC pavement, thereby restoring rideability. Slab jacking should not be used to correct faulting (Hoerner et al. 2001).

Slab Stabilization

The pressure insertion of a material beneath the slab and/or stabilized subbase to both fill voids beneath the slab and provide a thin layer that reduces deflections and resists pumping action. Various terms have been used to describe this process, including pressure grouting, undersealing, and subsealing. Slab stabilization is not used to raise the slab (Hoerner et al. 2001).

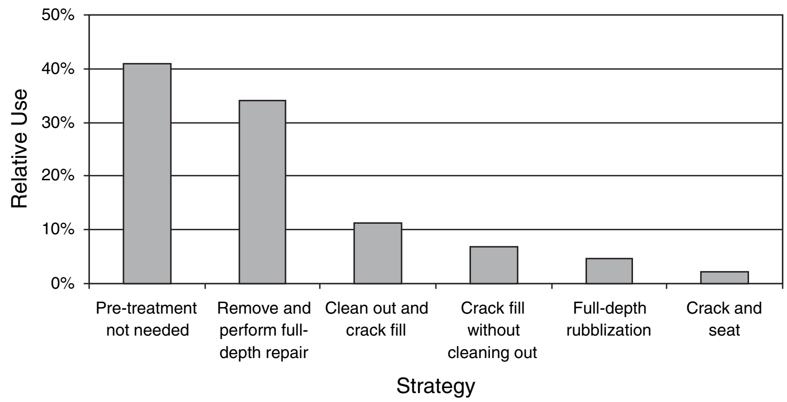


FIGURE 63 Corner breaks—Moderate severity (44 responses).

Stress-Relieving Interlayer

This dissipates movements and stresses developed at the joint or crack before they create stresses in the overlay. These installations generally include a rubber- or polymer-modified asphalt as the stress-relieving material, and can be constructed directly on the original pavement surface or applied through the use of a proprietary material.

PRE-OVERLAY STRATEGIES

This section provides survey results in the form of bar charts that summarize what strategies the various state DOTs are presently using to address medium and high severity distresses associated with existing JPCP pavement structures before placing an HMA overlay. The bar chart results are organized from the highest relative use strategy to the lowest relative use strategy.

Corner Breaks

The primary strategy used for moderate severity corner breaks is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to remove the affected area and replace full-depth (see Figure 63).

The primary strategy used for high severity corner breaks is to remove the affected area and replace full-depth.

Other employed pre-treatment strategies not shown in Figure 64 are:

- Clean out and crack fill (2% relative use), and
- Remove and replace the affected area and inlay with HMA (2% relative use).

The literature review suggests that for both moderate and high severities, removal and full-depth repair should be considered ("Guidelines for Full-Depth Repair" 1994).

Durability ("D") Cracking

The primary strategy used for moderate severity durability "D" cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Remove the affected area and perform a full-depth repair, or
- Remove the affected area and perform a partial-depth repair.

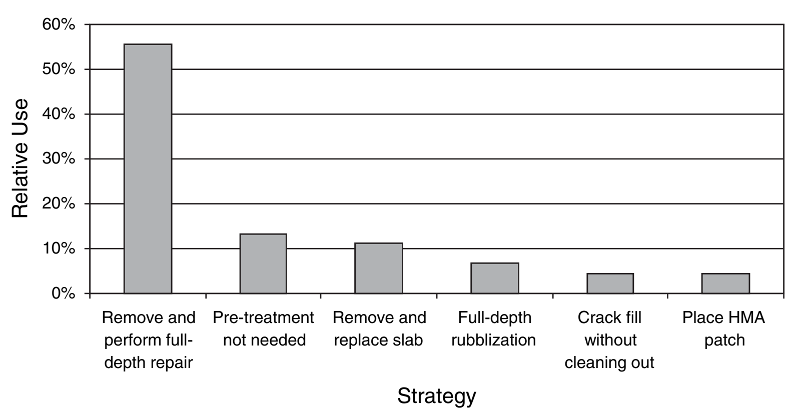


FIGURE 64 Corner breaks—High severity (45 responses).

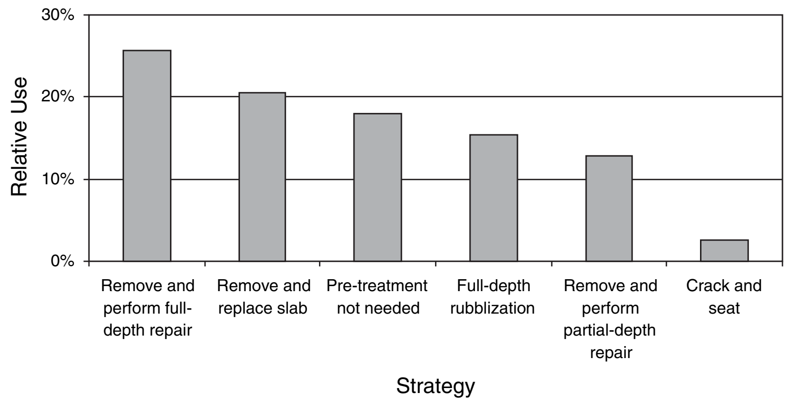


FIGURE 65 Durability ("D") cracking—Moderate severity (36 responses).

Other employed pre-treatment strategies not shown in Figure 65 are:

- Place a reinforcing fabric before overlay (3% relative use); and
- Apply a surface treatment (3% relative use).

The primary strategy used for high severity durability "D" cracking is to remove the affected area and perform a full-depth repair. The secondary strategies used are:

- Remove and replace the entire slab,
- Not perform any pre-overlay treatment before placing the HMA overlay,
- Full-depth rubblization, or
- Remove the affected area and perform a partial-depth repair.

Other employed pre-treatment strategies not shown in Figure 66 are:

- Place an HMA patch over the affected area (3% relative use), and
- Place a thicker HMA overlay over the affected area (3% relative use).

The literature review suggests that improving poor sub-drainage conditions will have a beneficial effect on the performance of the HMA overlay. Removal of excess water from the pavement cross section will reduce erosion and increase the strength of the base and subgrade, which in turn will reduce deflections. In addition, stripping in the HMA overlay and D-cracking in the underlying PCC pavement may be slowed by improved drainage (Hoerner et al. 2001).

Longitudinal Cracking

The primary strategy used for moderate severity longitudinal cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Clean out the existing crack then crack fill, or
- Perform a full-depth repair using tie-bars.

Other employed pre-treatment strategies not shown in Figure 67 are:

- Crack and seat (2% relative use),
- Place an HMA patch over the affected area (2% relative use),

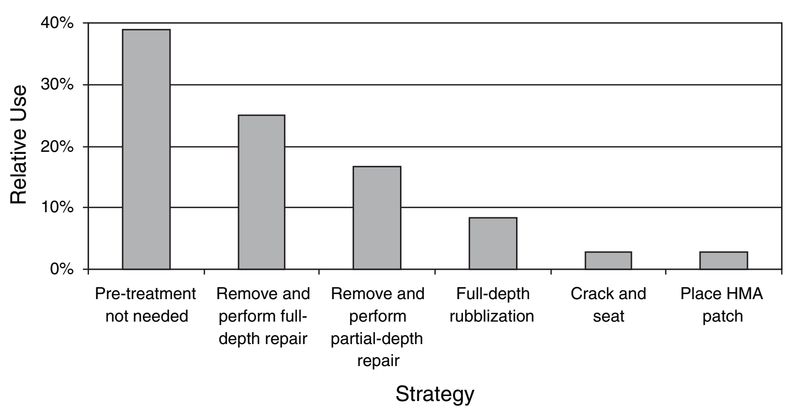


FIGURE 66 Durability ("D") cracking—High severity (39 responses).

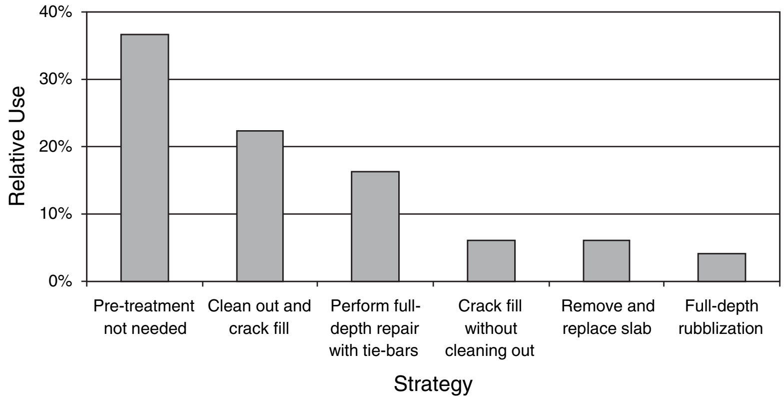


FIGURE 67 Longitudinal cracking—Moderate severity (49 responses).

- Perform a partial-depth repair (2% relative use), and
- Stitch (2% relative use).

The primary strategy used for high severity longitudinal cracking is to perform a full-depth repair using tie bars. The secondary strategies used are:

- Not perform any pre-overlay treatment before placing the HMA overlay,
- Remove and replace the entire slab, or
- Clean out the existing crack then crack fill.

Other employed pre-treatment strategies not shown in Figure 68 are:

- Crack fill without cleaning out (2% relative use),
- Perform a partial-depth repair (2% relative use), and
- Stitch (2% relative use).

The literature review suggests that transverse cracks of moderate and high severity are recommended for full-depth repairs. Nondeteriorated cracks in JPCP may be repaired by retrofitting dowels or tie-bars in lieu of full-depth repair ("Guidelines for Full-Depth Repair" 1995; Hoerner et al. 2001). Additionally, cross-stitching may be considered ("Stitching Concrete Pavement Cracks and Joints" 2001).

Transverse Cracking

The primary strategy used for moderate severity transverse cracking is to not perform any pre-overlay treatment before placing the HMA overlay; secondary strategies used are:

- Perform a full-depth repair using tie-bars, or
- Clean out the existing crack then crack fill.

Other employed pre-treatment strategies not shown in Figure 69 are:

- Crack and seat (4% relative use),
- Perform a partial-depth repair (2% relative use),
- Place a reflective crack interlayer before overlay (2% relative use), or
- Place an HMA patch over the affected area (2% relative use).

The primary strategy used for high severity transverse cracking is to perform a full-depth repair using tie-bars. The

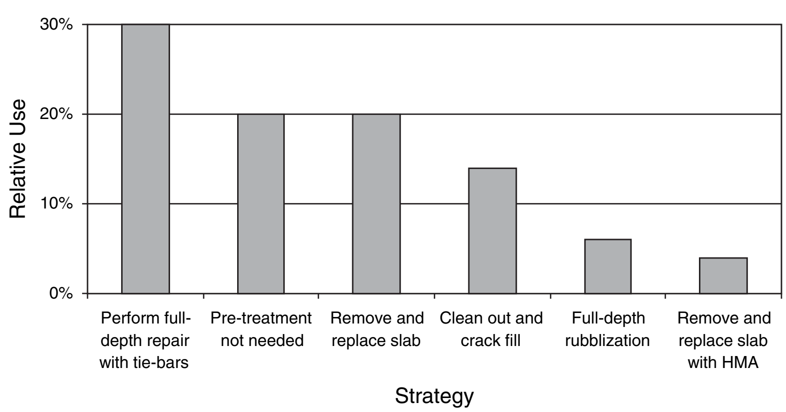


FIGURE 68 Longitudinal cracking—High severity (50 responses).

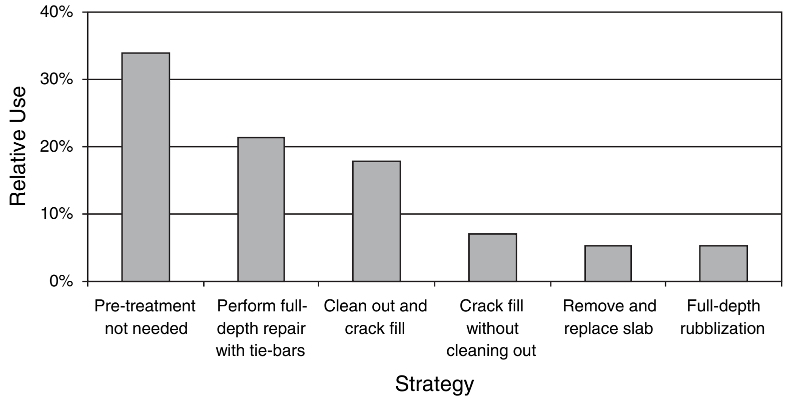


FIGURE 69 Transverse cracking—Moderate severity (56 responses).

secondary strategy used is to remove and replace the entire slab (see Figure 70).

Other employed pre-treatment strategies not shown on the above chart are:

- Crack fill without cleaning out the crack (5% relative use),
- Place an HMA patch over the affected area (5% relative use),
- Place a reflective crack interlayer before overlay (2% relative use), or
- Stitch (2% relative use).

The literature review suggests that transverse cracks of moderate and high severity are recommended for full-depth repairs. Nondeteriorated cracks in JPCP may be repaired by retrofitting dowels or tie bars in lieu of full-depth repair (Hoerner et al. 2001).

Joint Seal Damage

The primary strategy used for moderate severity joint seal damage is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy is to clean the existing crack then reseal the joint (see Figure 71).

The primary strategy used for high severity joint seal damage is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy is to clean the existing crack then reseal the joint.

One other employed pre-treatment strategy not shown in Figure 72 is to saw and seal the joint (2% relative use).

The literature review suggests that for both moderate and high severities, if joints are contaminated with incompressible material, they should be cleaned and resealed before the placement of the HMA overlay (Hoerner 2001).

Spalling of Longitudinal Joints

The primary strategy used for moderate severity spalling of longitudinal joints is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to perform a partial-depth repair of the affected area.

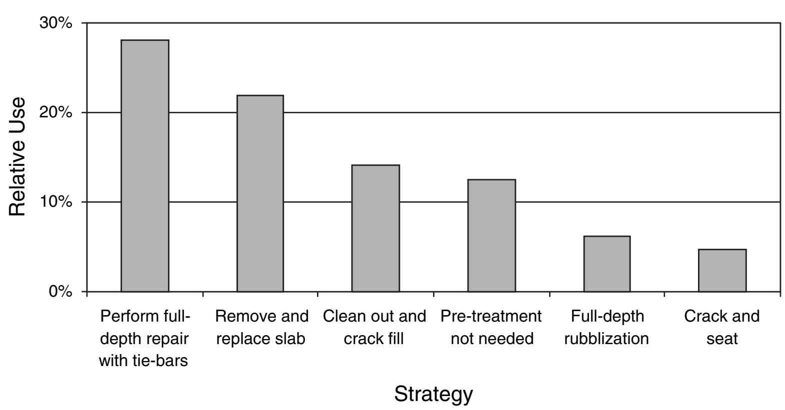


FIGURE 70 Transverse cracking—High severity (64 responses).

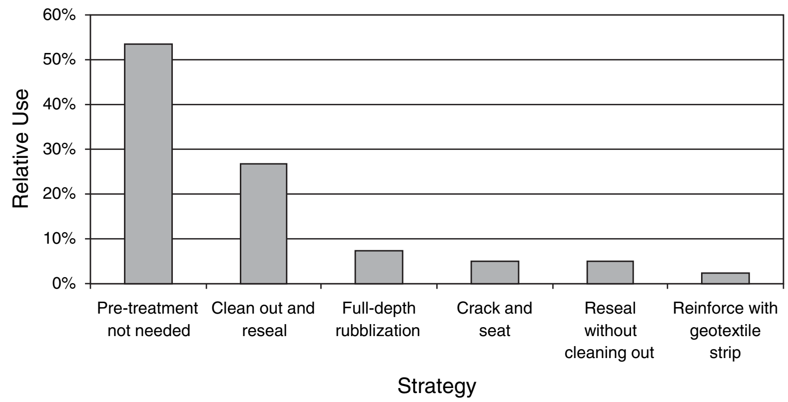


FIGURE 71 Joint seal damage—Moderate severity (41 responses).

One other employed pre-treatment strategy not shown in Figure 73 is to place a reflective crack interlayer before overlay (2% relative use).

The primary strategy used for high severity spalling of longitudinal joints is to perform a partial-depth repair of the affected area. The secondary strategies used are:

- Not perform any pre-overlay treatment before placing the HMA overlay, and
- Perform a full-depth repair with new dowel and/or tie-bars.

Other employed pre-treatment strategies not shown in Figure 74 are:

- Place an HMA patch over the affected area (4% relative use), or
- Remove and place an HMA patch (2% relative use).

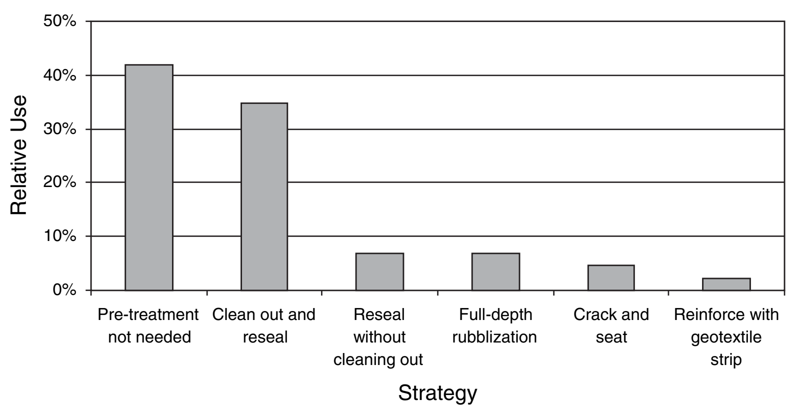


FIGURE 72 Joint seal damage—High severity (43 responses).

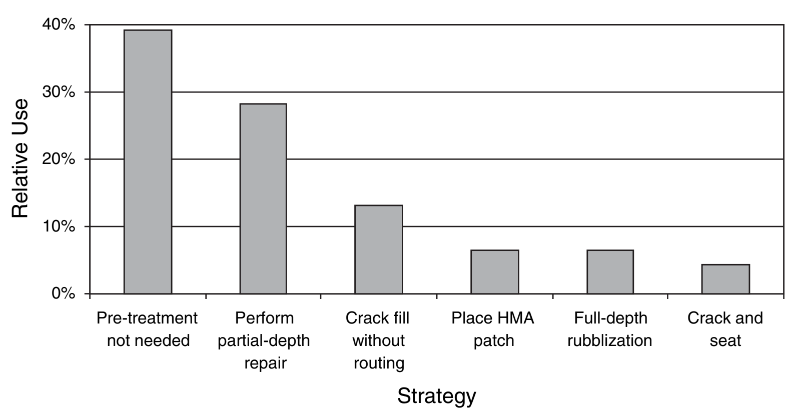


FIGURE 73 Spalling of longitudinal joints—Moderate severity (46 responses).

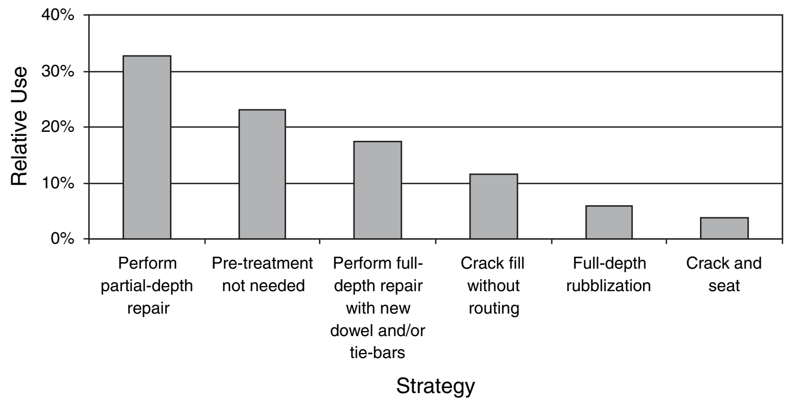


FIGURE 74 Spalling of longitudinal joints—High severity (52 responses).

The literature review suggests for both moderate and high severities, if joints are contaminated with incompressible materials, they should be cleaned and resealed before the placement of the HMA overlay. Partial-depth repairs replace concrete only and cannot accommodate the movements of working joints and cracks, load transfer devices, or reinforcing steel without experiencing high stresses and material damage. Thus, they are appropriate only for certain types of PCC pavement distresses that are confined to the top one-third of the slab. Distresses that have been successfully corrected with partial-depth repairs include:

- Spalls caused by the use of joint inserts,
- Spalls caused by intrusion of incompressible materials into the joints (typically associated with long-jointed slabs), and
- Spalls caused by localized areas of scaling, weak concrete, clay balls, or high steel.

Types of distresses that are *not* candidates for partial-depth repair include:

- Cracking and joint spalling caused by compressive stress buildup in long-jointed pavements;
- Spalling caused by dowel bar misalignment or lockup;
- Transverse or longitudinal cracking caused by improper joint construction techniques (late sawing, inadequate saw cut depth, or inadequate insert placement depth);
- Working longitudinal cracks caused by shrinkage, fatigue, or foundation movement; and.
- Spalls caused by D-cracking or reactive aggregate (NHI 131062).

Spalling of Transverse Joints

The primary strategy used for moderate severity of spalling of transverse joints is to perform a partial-depth repair of the affected area. The secondary strategy used is to not perform any pre-overlay treatment before placing the HMA overlay.

Other employed pre-treatment strategies not shown in Figure 75 are:

- Full-depth rubblization (4% relative use),
- Install joint tape (2% relative use), or
- Perform full-depth repair with new dowel and/or tie-bars (2% relative use).

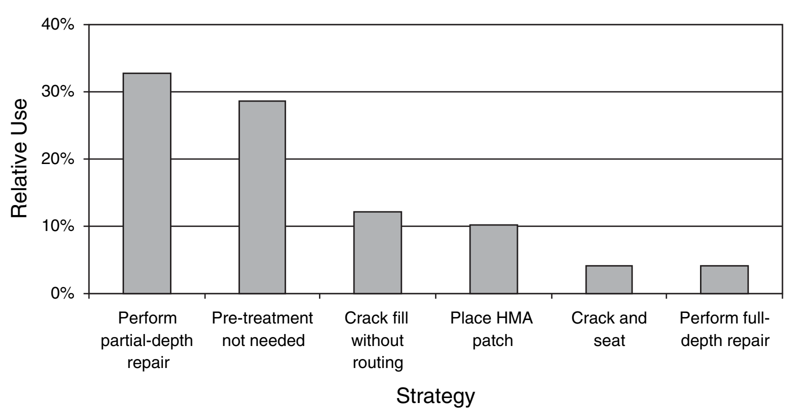


FIGURE 75 Spalling of transverse joints—Moderate severity (49 responses).

The primary strategy used for high severity of spalling of transverse joints is to perform a partial-depth repair of the affected area. The secondary strategies used are:

- Perform a full-depth repair with new dowel and/or tie-bars, or
- Not perform any pre-overlay treatment before placing the HMA overlay.

Other employed pre-treatment strategies not shown in Figure 76 are:

- Mill off and then inlay with HMA (4% relative use),
- Install joint tape (2% relative use),
- Place an HMA patch over the affected area (2% relative use), or
- Perform full-depth repair with new dowel and/or tie-bars (2% relative use).

The literature review suggests for both moderate and high severities, if joints are contaminated with incompressible materials, they should be cleaned and resealed before the placement of the HMA overlay. Partial-depth repairs replace concrete only and cannot accommodate the movements of working joints and cracks, load transfer devices, or reinforcing steel without experiencing high stresses and material damage. Thus, they are appropriate only for certain types of PCC pavement distresses that are confined to the top one-third of the slab. Distresses that have been successfully corrected with partial-depth repairs include:

- Spalls caused by the use of joint inserts;
- Spalls caused by intrusion of incompressible materials into the joints (typically associated with long-jointed slabs); and
- Spalls caused by localized areas of scaling, weak concrete, clay balls, or high steel.

Types of distresses that are *not* candidates for partial-depth repair include:

- Cracking and joint spalling caused by compressive stress buildup in long-jointed pavements;
- Spalling caused by dowel bar misalignment or lockup;
- Transverse or longitudinal cracking caused by improper joint construction techniques (late sawing, inadequate saw cut depth, or inadequate insert placement depth);
- Working longitudinal cracks caused by shrinkage, fatigue, or foundation movement; and
- Spalls caused by D-cracking or reactive aggregate (Hoerner et al. 2001).

Map Cracking

The primary strategy used for all severities of map cracking is to not perform any pre-overlay treatment before placing the HMA overlay.

Other employed pre-treatment strategies not shown in Figure 77 are:

- Place an HMA patch over the affected area (2% relative use), or
- Place a reflective crack interlayer before overlay (2% relative use).

Scaling

The primary strategy used for all severities of scaling is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Remove the delaminated areas without surface restoration, or
- Remove the delaminated areas with surface restoration.

Other employed pre-treatment strategies not shown in Figure 78 are:

- Place an HMA patch over the affected area (2% relative use), or
- Apply a surface treatment (2% relative use).

The literature review suggests that the affected areas should be removed by cleaning ("Guide to Concrete Overlay Solutions" 2007) or by diamond grinding ("Guidelines for Full-Depth Repair" 1995).

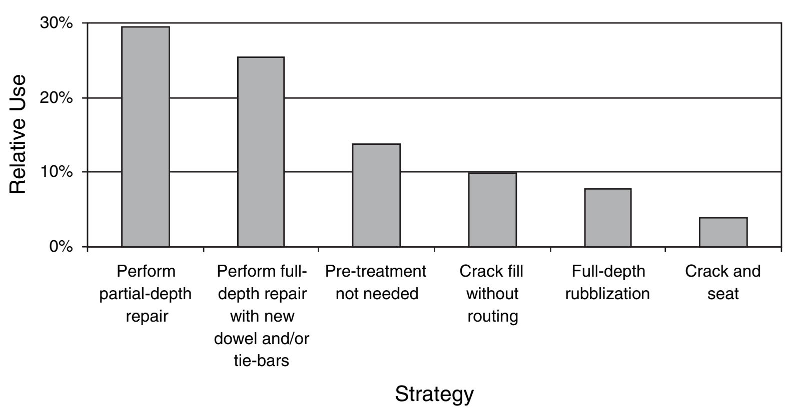


FIGURE 76 Spalling of transverse joints—High severity (51 responses).

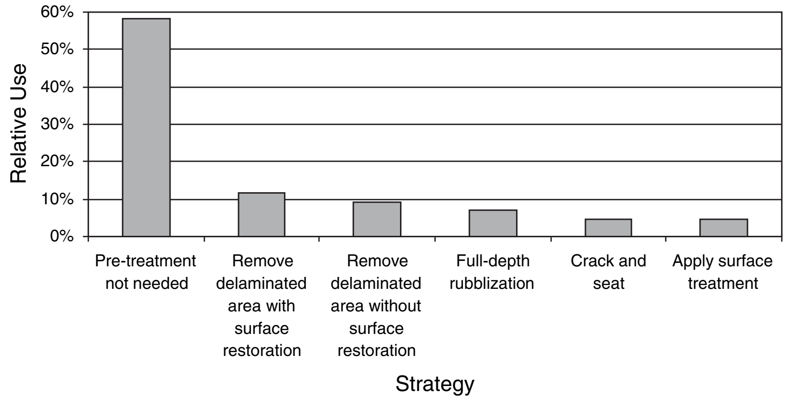


FIGURE 77 Map cracking—All severities (43 responses).

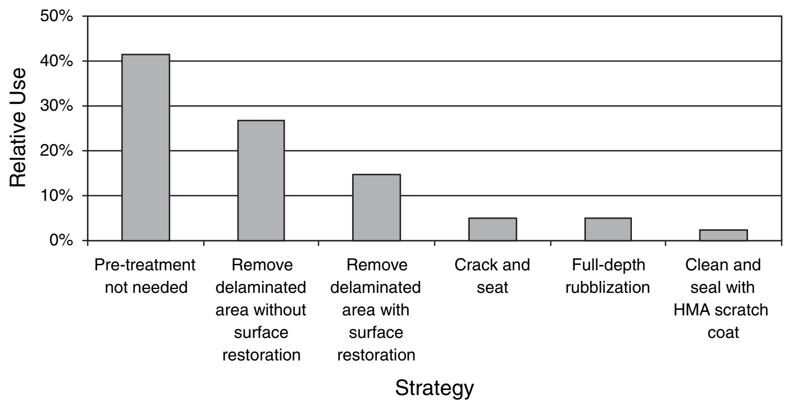


FIGURE 78 Scaling—All severities (41 responses).

Polished Aggregate

The primary strategy used for all severities of polished aggregate is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to mill out partial-depth of the affected areas (see Figure 79).

Popouts

The primary strategy used for all severities of popouts is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to repair the pop out (see Figure 80).

The literature review suggests that diamond grinding should be used ("Guidelines for Full-Depth Repair" 1995).

Blowups

The primary strategy used for all severities of blowups is to remove the affected area and perform a full-depth repair (see Figure 81).

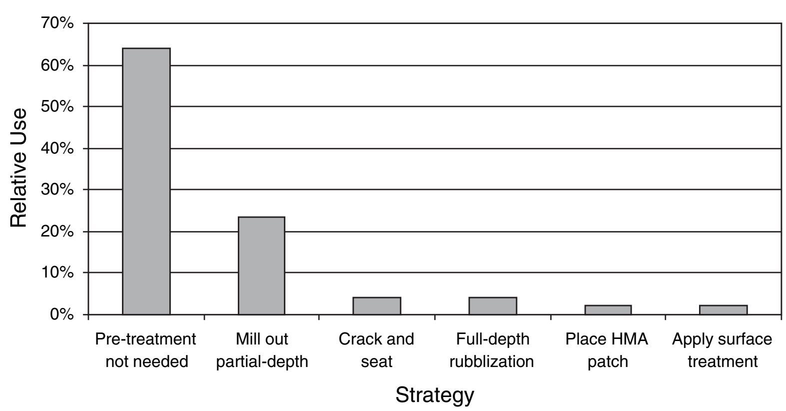


FIGURE 79 Polished aggregate—All severities (47 responses).

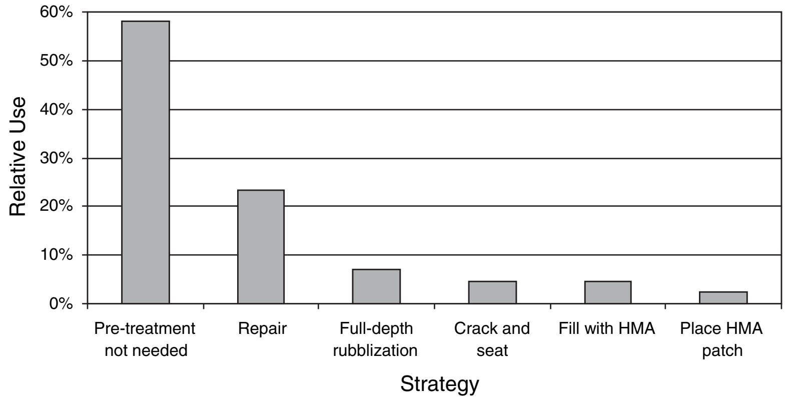


FIGURE 80 Popouts—All severities (43 responses).

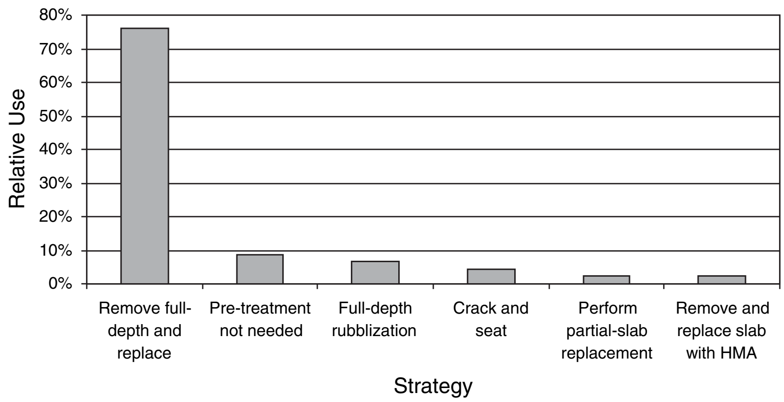


FIGURE 81 Blowups—All severities (46 responses).

The literature review also suggests that any severity warrants full-depth repair as a result of the localized disruption to pavement integrity and the potential safety hazard (Hoerner et al. 2001).

Faulting of Transverse Joints

The primary strategy used for all severities of faulting of transverse joints is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Diamond grind off the affected areas, or
- Perform a dowel-bar retrofit.

Other employed pre-treatment strategies not shown in Figure 82 are:

- Full-depth rubblization (5% relative use),
- Perform full-depth repair with tie-bars (3% relative use),
- Place an HMA patch over the affected area (2% relative use), or
- Remove and replace the affected slabs (2% relative use).

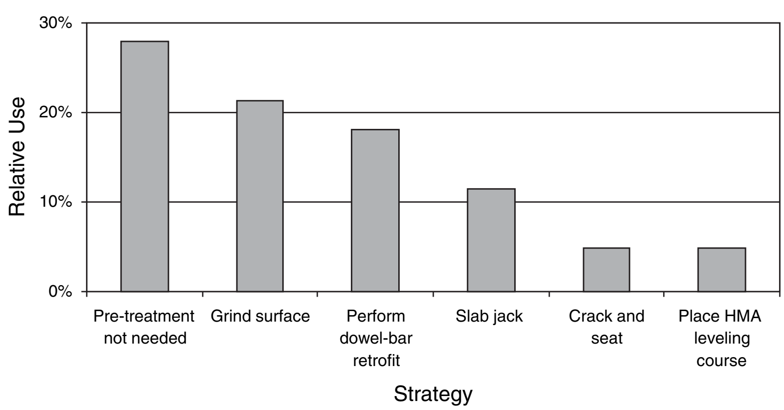


FIGURE 82 Faulting of transverse joints—All severities (61 responses).

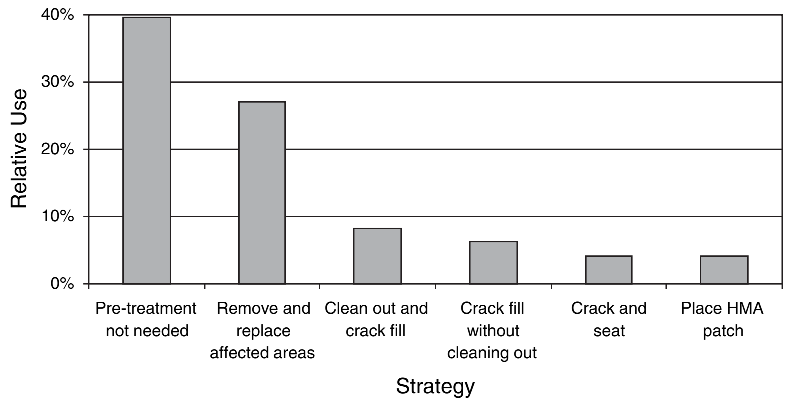


FIGURE 83 Patch/patch deterioration—Moderate severity (48 responses).

The literature review suggests that diamond grinding should be conducted before faulting reaches critical levels (Bendaña and Wang 1993; Hoerner et al. 2001).

Patch/Patch Deterioration

The primary strategy used for moderate severity patch/patch deterioration is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to remove and replace the affected slabs.

Other employed pre-treatment strategies not shown in Figure 83 are:

- Apply a surface treatment (4% relative use), and
- Place an HMA leveling course (2% relative use).

The primary strategy used for high severity patch/patch deterioration is to remove and replace the affected areas. The secondary strategy used is to not perform any pre-overlay treatment before placing the HMA overlay.

Other employed pre-treatment strategies not shown in Figure 84 are:

- Place an HMA patch over the affected area (4% relative use),
- Place a 2 to 3 in. HMA overlay over the affected area (2% relative use), and
- Apply a surface treatment (2% relative use).

The literature review suggests that either full-depth repair with PCC or diamond grinding should be considered for the pre-overlay treatment ("Guidelines for Full-Depth Repair" 1995; "Guide to Concrete Overlay Solutions" 2007).

Water Bleeding and Pumping

The primary strategy used for all severities of water bleeding and pumping is to install edge drains. The secondary strategy used is to remove and replace all affected slabs (see Figure 85).

The literature review suggests that the installation of edge drains, maintenance of existing edge drains, or other subdrainage improvements should be done before the placement of the HMA overlay if pumping or significant faulting is present. Additionally, improving poor subdrainage condi-

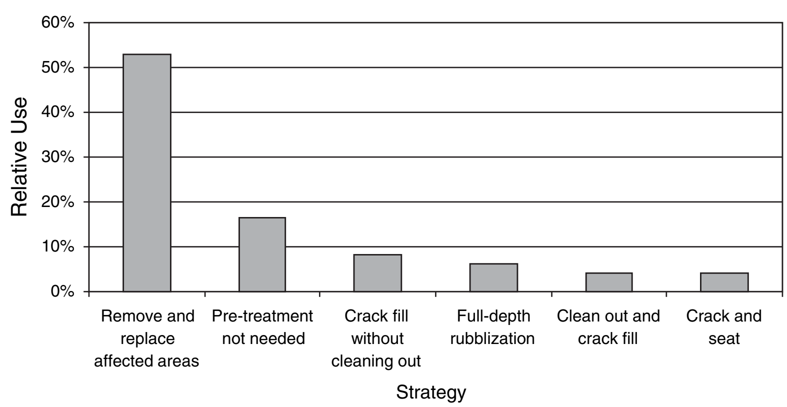


FIGURE 84 Patch/patch deterioration—High severity (49 responses).

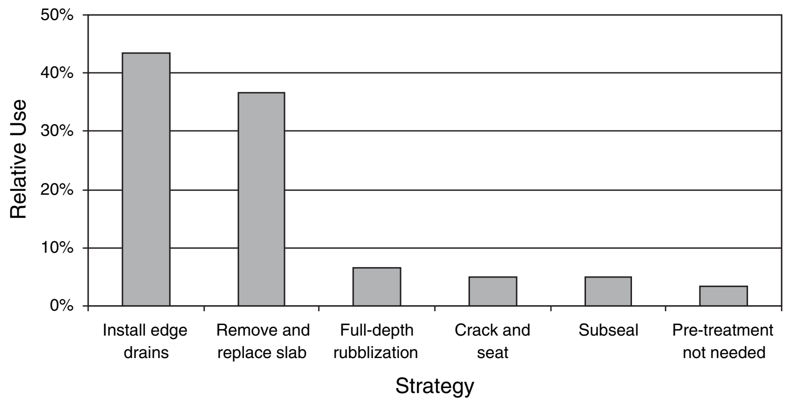


FIGURE 85 Water bleeding and pumping—All severities (60 responses).

tions will have a beneficial effect on the performance of the HMA overlay. Removal of excess water from the pavement cross section will reduce erosion and increase the strength of the base and subgrade, which in turn will reduce deflections. Stripping in the HMA overlay and D-cracking in the underlying PCC pavement may be slowed by improved drainage (Hoerner et al. 2001).

Roughness

The primary strategy for moderate severity roughness is to not perform any pre-overlay treatment before the placement of a HMA overlay. The secondary strategies used are to (see Figure 86):

- Place an HMA leveling course, or
- Diamond grind smooth the existing JPCP pavement's surface.

The primary strategy for high severity roughness is to diamond grind smooth the existing JPCP pavement's surface then place an HMA leveling course (see Figure 87).

Frost-Heave

The primary strategy used for all severities of frost-heave is to remove full-depth the affected areas, including the subgrade, and replace.

One other employed pre-treatment strategy not shown in Figure 88 is to rubblize (9% relative use).

The literature review suggests that diamond grinding should also be considered as a pre-overlay treatment (Hoerner et al. 2001).

Alkali–Silica Reaction

The primary strategy used for all severities of alkali–silica is to rubblize the existing pavement structure. The secondary strategy or strategies could not be determined from the survey response.

One other employed pre-treatment strategy not shown in Figure 89 is to rubblize (13% relative use).

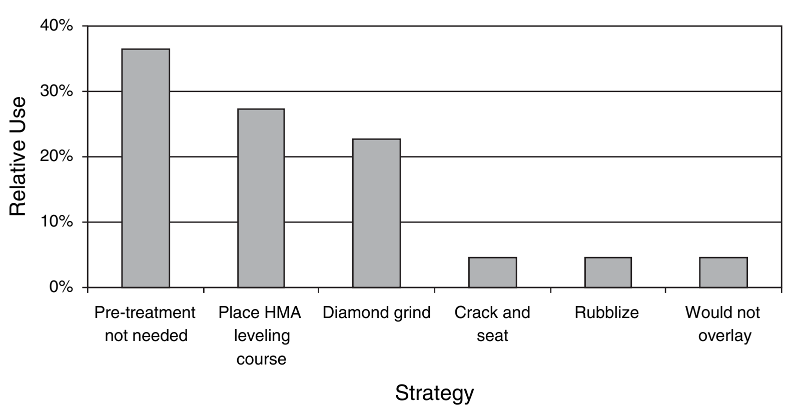


FIGURE 86 Roughness—Moderate severity (22 responses).

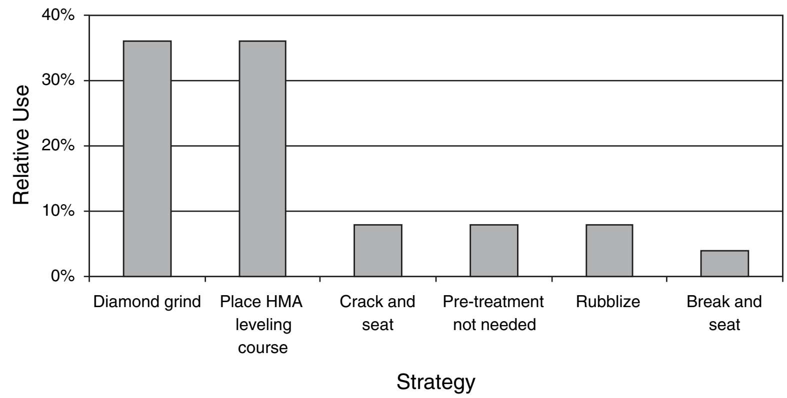


FIGURE 87 Roughness—High severity (25 responses).

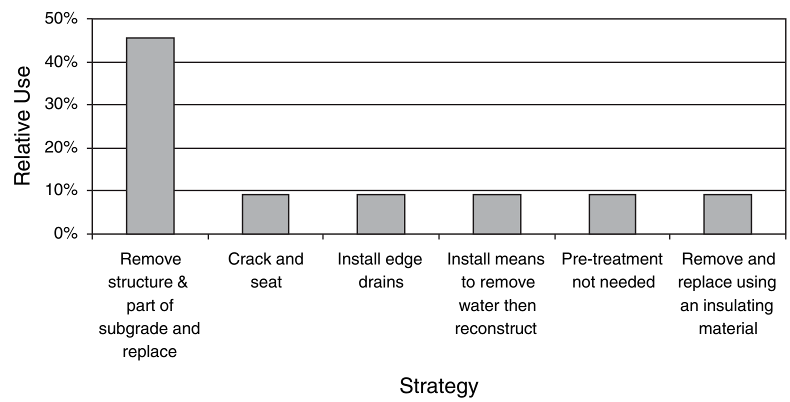


FIGURE 88 Frost-heave—All severities (11 responses).

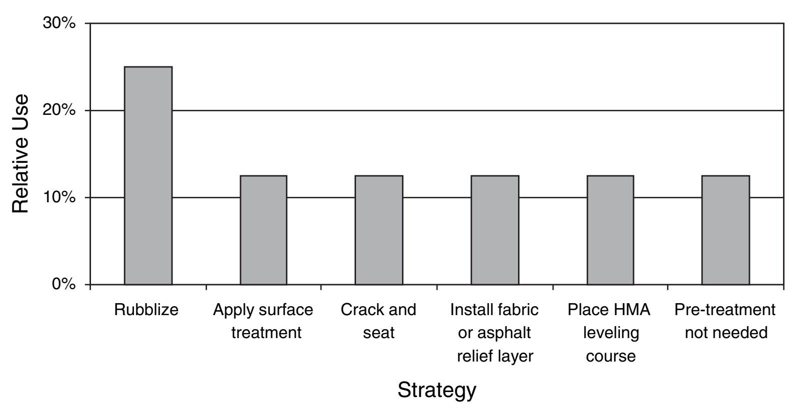


FIGURE 89 Alkali–silica reaction—All severities (8 responses).

CHAPTER SIX

HOT-MIX ASPHALT OVERLAY OVER CONTINUOUSLY REINFORCED CONCRETE PAVEMENT PRE-OVERLAY TREATMENTS

INTRODUCTION

The placement of an HMA overlay is one of the most common CRCP pavement rehabilitation techniques. HMA overlays are typically at least 2 in. or more thick, and are designed for specific projected traffic loadings. The condition of the underlying pavement has a great effect on the performance of HMA overlays; therefore, their placement is often preceded by other treatments, such as full-depth and partial-depth repair. The primary failure mode for HMA overlays is reflection cracking, in which the cracks of the underlying CRCP pavement reflect through the HMA overlay and deteriorate, resulting in failure of the overlay (Hoerner et al. 2001).

HOT-MIX ASPHALT OVERLAYS OVER CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

Unfractured Continuously Reinforced Concrete Pavements

The placement of an HMA overlay over an unfractured CRCP is a recommended alternative provided that reflection cracking is addressed in the overlay design. The placement of an HMA overlay is not a recommended alternative when the condition of the existing pavement structure dictates substantial removal and replacement when:

- The amount of cracking and joint spalling is so great that complete removal and replacement of the existing surface is required, or
- A significant deterioration of the CRCP pavement has occurred as a result of severe durability problems (e.g., D-cracking or reactive aggregates) (*AASHTO Guide for Design of Pavement Structures* 1993, III-125).

Repairs

Full-depth repairs in CRCP should be with PCC and be continuously reinforced with steel, which is tied or welded to reinforcing steel in the existing slab, to provide the needed load transfer across the joints and slab continuity. The continuity of reinforcement must be maintained through full-depth repairs. The new reinforcing steel installed in the repair area should match the original in grade, quality, and number. The new bars should be cut so that their ends are at least 2 in. from the joint faces and either tied, mechanically connected, or welded to the existing reinforcement. In placing the bars, chairs or other means of support should be provided to prevent the steel from being permanently bent down during placement of the concrete, and a minimum 2.5 in. cover should be provided ("HMA Rehabilitation of Existing Pavements" 2002).

Full-depth HMA repairs should not be used in CRCP before the placement of the HMA overlay and any existing HMA patches should be removed and replaced with PCC.

The installation of edge drains, maintenance of existing edge drains, or other subdrainage improvements should be done before the placement of the HMA overlay if pumping is present. If joints are contaminated with incompressible materials, they should be cleaned and resealed before the placement of the HMA overlay. An HMA leveling course should be used to smooth faulting and fill localized settlements (NCHRP 01-37A).

Reflection Crack Control

With an HMA overlay of CRCP, the permanent repair of punchouts and working cracks with tied or welded reinforced PCC full-depth repairs will delay the occurrence and deterioration of reflection cracks. Improving subsurface drainage conditions and subsealing in areas where the slab has lost support will also discourage reflection crack occurrence and deterioration. Reflection crack control treatments are not necessary for HMA overlays of CRCP, except for longitudinal joints and when CRCP repairs are used to repair deteriorated areas and cracks ("HMA Rehabilitation of Existing Pavements" 2002).

Fractured Continuously Reinforced Concrete Pavements

Reflection cracking is a major distress in HMA overlays of existing CRCP pavements. Rubblizing can be used on CRCP pavements in any condition. Fracturing the pavement into pieces of less than 12 in. reduces it to a high-strength granular base.

TECHNIQUES

Break and Seat

Break and seat reduces horizontal movements by rupturing the reinforcing steel or debonding the concrete from the steel. This effort generally requires that the existing CRCP be broken into smaller pieces than required for cracking and seating of JPCP, and thus there is a greater reduction in the structural capacity of the break and seat section (Hoerner et al. 2001).

Cold Milling

This technique may be used to remove small, deteriorated areas or as a surface preparation technique before overlaying; however, the use of cold milling as the substitute for diamond grinding or grooving is not recommended. The milling process effectively involves chipping material off the pavement surface. Cold milling using conventional equipment is generally not acceptable on CRCP pavements because of the poor surface finish and spalling at the joints. However, recent advances in milling equipment, using drum-mounted, multiple-wrap carbide steel cutting bits have been shown to be effective in providing acceptable riding surface (Hoerner et al. 2001).

Crack-Arresting Interlayers

Crack-arresting interlayers are thick granular layers that arrest the development of reflection cracks by providing large void spaces that effectively blunt crack propagation. Standard granular bases with low fines contents and large aggregates have been used for this purpose (see Figure 90).

Cross-Stitching

Cross-stitching is a preservation method designed to strengthen nonworking longitudinal cracks that are in relatively good condition. The construction process consists of grouting tie bars into holes drilled across the crack at angles of 35 to 45 degrees to the pavement surface (see Figure 91). This process is effective at preventing vertical and horizontal movement or the widening of the crack or joint, thereby keeping the crack tight, maintaining good load transfer, and slowing the rate of deterioration (Hoerner et al. 2001).

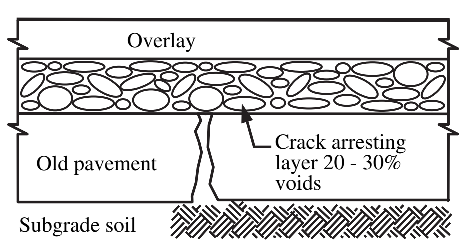


FIGURE 90 Cross section of a typical crack-arresting interlayer.

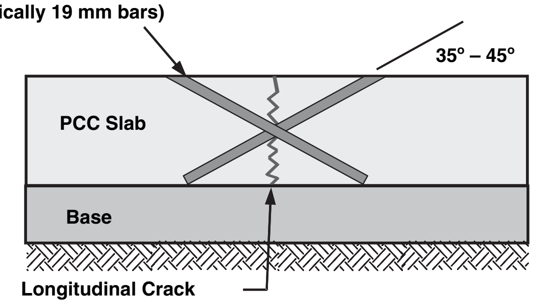


FIGURE 91 Cross-stitching of longitudinal crack (Hoerner et al. 2001).

Diamond-Blade Grinding

Diamond-blade grinding is the removal of a thin layer of hardened PCC pavement surface using closely spaced, diamond saw blades mounted on a rotating drum. The purpose of diamond grinding is to correct surface irregularities and provide a smooth riding surface. Diamond grinding also increases the pavement macrotexture, which results in increased surface friction levels (Hoerner et al. 2001).

Diamond Grooving

For diamond grooving, grooves are cut into hardened PCC using diamond saw blades with a center-to-center blade spacing of ¾ in. or greater. The principal objective of grooving is to provide escape channels for surface water, thereby reducing the incidence of hydroplaning that can cause wet weather accidents (Hoerner et al. 2001).

Rubblization

Rubblization is a procedure that uses a resonant pavement breaker or a multi-head breaker to reduce the existing CRCP slab into small pieces varying from sand-sized particles up to about 6 in. The resonant pavement breaker applies a 2-kip impact force at a frequency of 44 impacts per second to the pavement surface through a shoe that is attached to a massive steel beam. In essence, this beam acts as a giant tuning fork, shattering the pavement into pieces having an average size of 1 to 2 in., with no pieces larger than 6 in. Multiple shoes have been used on equipment to increase production rates. Multi-head pavement breakers fracture the concrete by lifting and dropping rows of steel hammers onto the pavement and can cover a width of up to 13 ft (Hoerner et al. 2001).

Slab Stabilization

Slab stabilization is the pressure insertion of a material beneath the slab and/or stabilized subbase to both fill voids beneath the slab and provide a thin layer that reduces deflections and resists pumping action. Various terms have been used to describe this process, including pressure grouting, under-

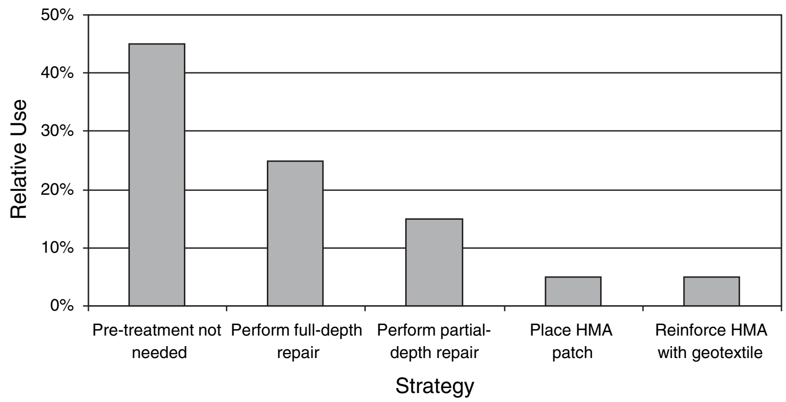


FIGURE 92 Durability ("D") cracking—Moderate severity (20 responses).

sealing, and subsealing. Slab stabilization is not used to raise the slab (Hoerner et al. 2001).

Stress-Relieving Interlayer

This procedure dissipates movements and stresses developed at the joint or crack before they create stresses in the overlay. These installations generally include a rubber- or polymer-modified asphalt as the stress-relieving material, and can be constructed directly on the original pavement surface or applied through the use of a proprietary material.

PRE-OVERLAY STRATEGIES

This section provides survey results in the form of bar charts that summarize what strategies the various state DOTs are presently using to address medium and high severity distresses associated with existing CRCP pavement structures before placing an HMA overlay. The bar chart results are organized from the highest relative use strategy to the lowest relative use strategy.

Durability ("D") Cracking

The primary strategy used for moderate severity durability "D" cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Remove the affected area and replace full-depth, or
- Remove the affected area and replace partial-depth.

One other employed pre-treatment strategy not shown in Figure 92 is to place a surface seal (5% relative use).

The primary strategy used for high severity durability "D" cracking is to remove the affected area and replace full-depth. The secondary strategies used are (see Figure 93):

- Remove the affected area and replace partial-depth, and
- Not perform any pre-overlay treatment before placing the HMA overlay.

The literature review suggests that improving poor subdrainage conditions will have a beneficial effect on the performance of the HMA overlay. Removal of excess water from the pavement cross section will reduce erosion and increase the strength of the base and subgrade, which in turn will reduce deflections. In addition, stripping in the HMA overlay and D-cracking in the underlying PCC pavement may be slowed by improved drainage (Hoerner et al. 2001).

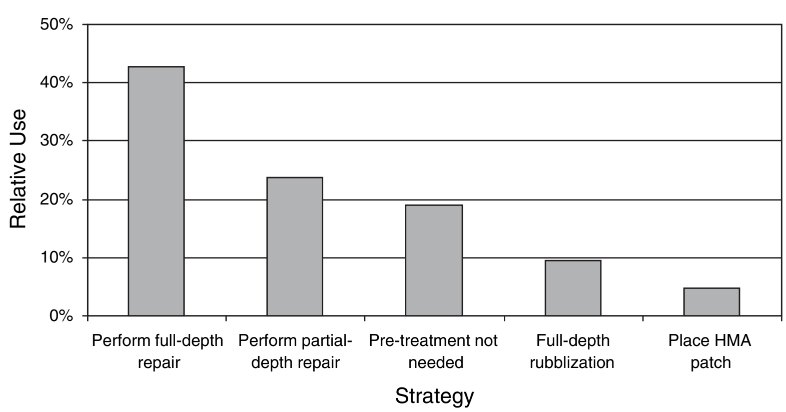


FIGURE 93 Durability ("D") cracking—High severity (20 responses).

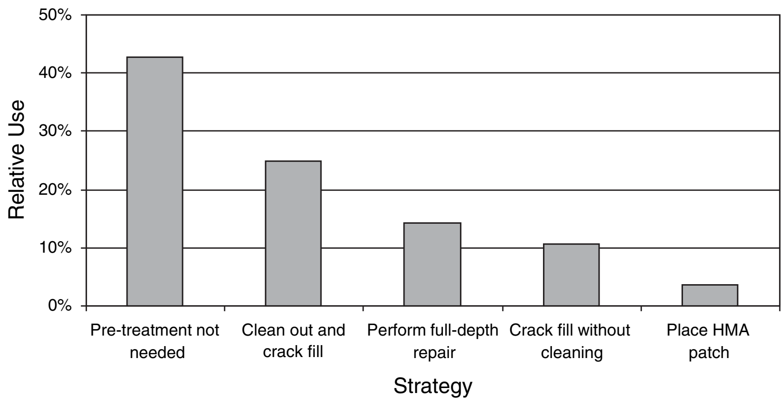


FIGURE 94 Longitudinal cracking—Moderate severity (28 responses).

Longitudinal Cracking

The primary strategy used for moderate severity longitudinal cracking is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are:

- Clean out the existing crack then crack fill, or
- Perform a full-depth repair.

One other employed pre-treatment strategy not shown in Figure 94 is to place a surface patch (4% relative use).

The primary strategy used for high severity longitudinal cracking is to perform a full-depth repair. The secondary strategies used are (see Figure 95):

- Not perform any pre-overlay treatment before placing the HMA overlay; or
- Clean out the existing crack then crack fill.

The literature review suggests that longitudinal cracks of medium and high severity warrant full-depth repair (Hoerner et al. 2001).

Transverse Cracking

The primary strategy used for moderate severity transverse cracking is to not perform any pre-overlay treatment before placing the HMA overlay.

One other employed pre-treatment strategy not shown in Figure 96 is to place a seal coat (4% relative use).

The primary strategy used for high severity transverse cracking is to perform a full-depth repair. The secondary strategies used are:

- Clean out the existing crack then crack fill, or
- Not perform any pre-overlay treatment before placing the HMA overlay.

One other employed pre-treatment strategy not shown in Figure 97 is to place a seal coat (4% relative use).

The literature review suggests that for transverse cracks of medium and high severity, full-depth repairs are warranted (Hoerner et al. 2001).

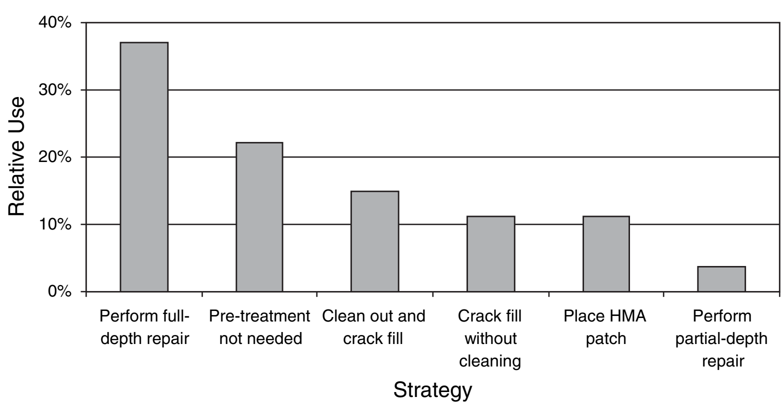


FIGURE 95 Longitudinal cracking—High severity (27 responses).

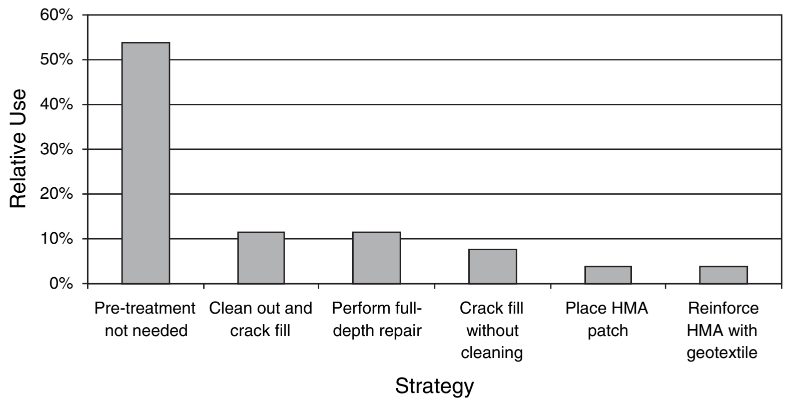


FIGURE 96 Transverse cracking—Moderate severity (26 responses).

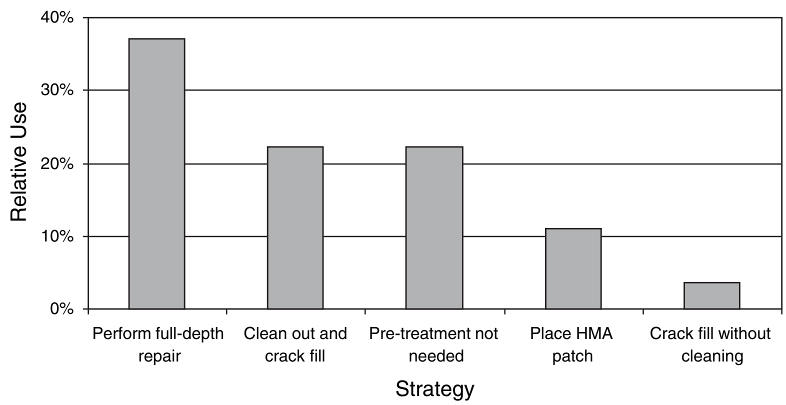


FIGURE 97 Transverse cracking—High severity (27 responses).

Map Cracking

The primary strategy used for all severities of map cracking is to not perform any pre-overlay treatment before placing the HMA overlay.

Other employed pre-treatment strategies not shown in Figure 98 are:

- Apply a surface seal (5% relative use), and
- Underseal (5% relative use).

Scaling

The primary strategy used for all severities of scaling is to not perform any pre-overlay treatment before placing the HMA

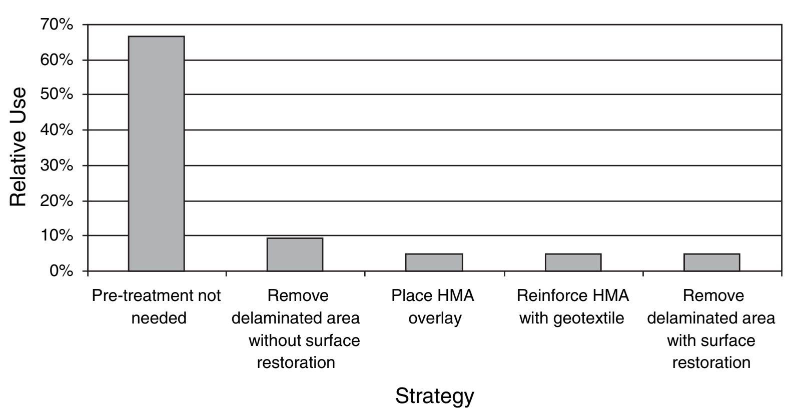


FIGURE 98 Map cracking—All severities (21 responses).

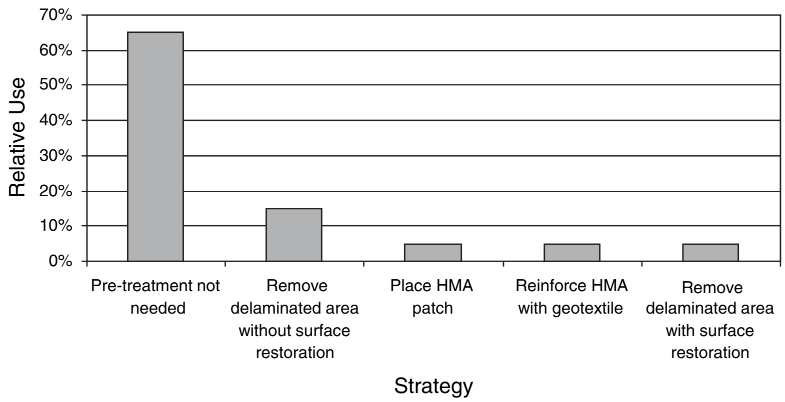


FIGURE 99 Scaling—All severities (20 responses).

overlay. The secondary strategy is to remove the delaminated areas without surface restoration.

One other employed pre-treatment strategy not shown in Figure 99 is to apply a surface treatment (5% relative use).

The literature review suggests that the affected areas should be removed by cleaning ("Guide to Concrete Overlay Solutions" 2007) or by diamond grinding ("Guidelines for Full-Depth Repair" 1995).

Polished Aggregate

The primary strategy used for all severities of polished aggregate is to not perform any pre-overlay treatment before placing the HMA overlay (see Figure 100).

Popouts

The primary strategy used for all severities of popouts is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to repair the pop out (see Figure 101).

The literature review suggests that diamond grinding should be used ("Guidelines for Full-Depth Repair" 1995).

Blowups

The primary strategy used for all severities of blowups is to remove the affected area and perform a full-depth repair (see Figure 102).

The literature review suggests that blowups of any severity warrant full-depth repair owing to the localized disruption to pavement integrity and the potential safety hazard (Hoerner et al. 2001).

Transverse Construction Joint Deterioration

The primary strategy used for moderate severity transverse construction joint deterioration is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are (see Figure 103):

- Perform a full-depth repair, or
- Clean out the existing joint and reseal.

The primary strategy used for high severity transverse construction joint deterioration is to perform a full-depth repair (see Figure 104).

The literature review suggests that medium- or high-severity spalling of construction joints are recommended

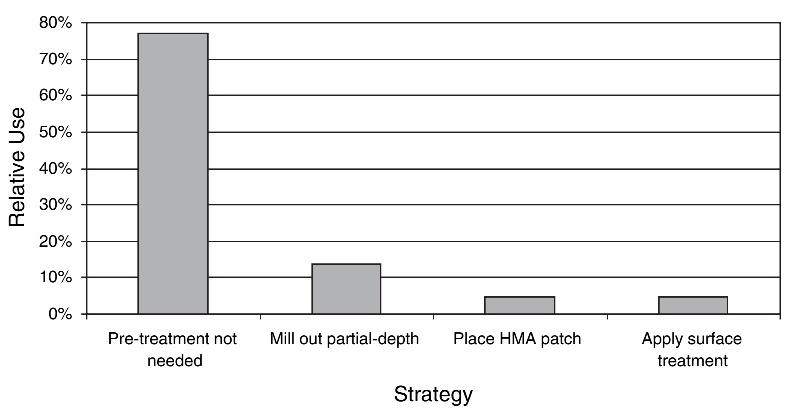


FIGURE 100 Polished aggregate—All severities (22 responses).

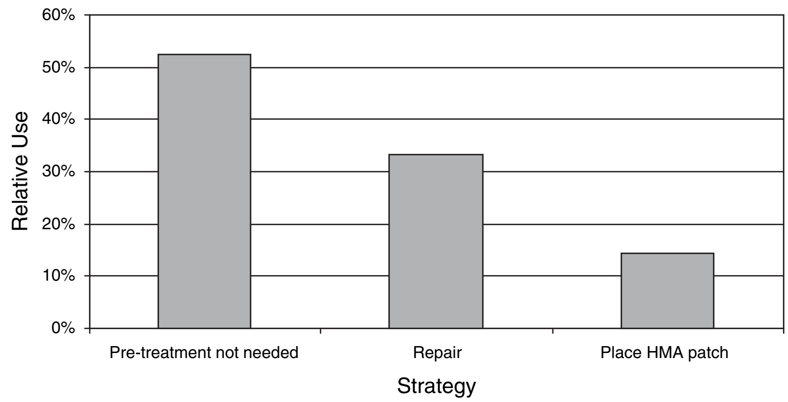


FIGURE 101 Popouts—All severities (21 responses).

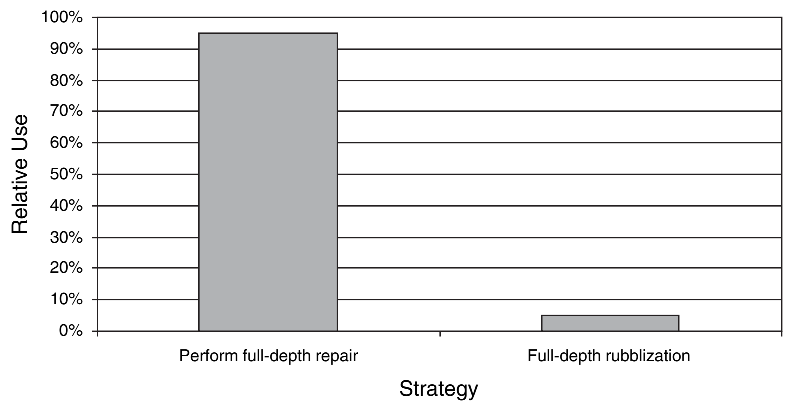


FIGURE 102 Blowups—All severities (20 responses).

for full-depth repairs unless it can be determined that the deterioration is limited to the upper one-third of the slab. If the distress is limited to the upper portion of the slab, partial-depth PCC repairs are a feasible alternative (Hoerner et al. 2001).

Patch/Patch Deterioration

The primary strategy used for moderate severity patch/patch deterioration is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies used are (see Figure 105):

- Mill out the affected areas and inlay with HMA, and
- Remove full-depth the affected areas and replace with PCC.

The primary strategy used for high severity patch/patch deterioration is to remove full-depth the affected areas and replace with PCC. The secondary strategies used are (see Figure 106):

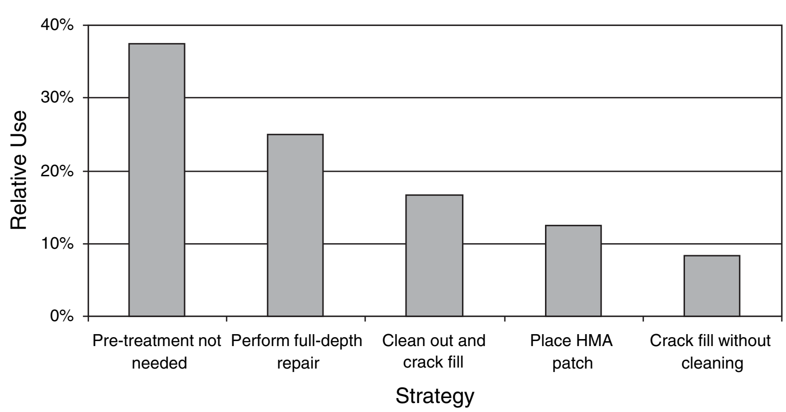


FIGURE 103 Transverse construction joint deterioration—Moderate severity (24 responses).

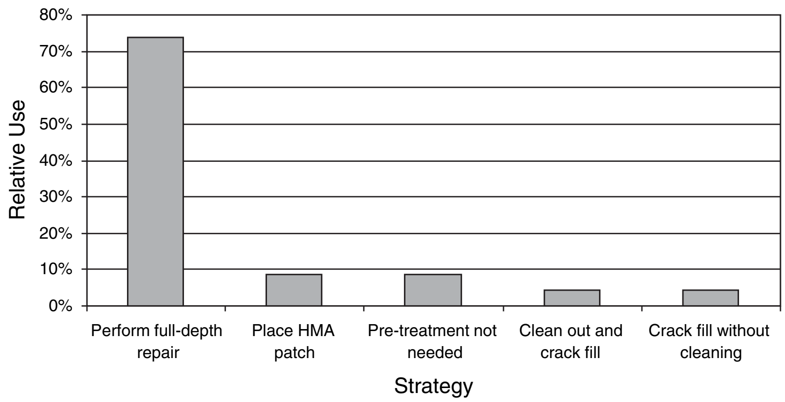


FIGURE 104 Transverse construction joint deterioration—High severity (23 responses).

- Mill out the affected areas then inlay with HMA, or
- Not perform any pre-overlay treatment before placing the HMA overlay.

The literature review suggests that either full-depth repair with PCC or diamond grinding should be considered for the pre-overlay treatment ("Guidelines for Full-Depth Repair" 1995; "Guide to Concrete Overlay Solutions" 2007).

Punchouts

The primary strategy used for moderate severity punchouts is to perform a full-depth repair of the affected areas. The secondary strategies used are (see Figure 107):

- Not perform any pre-overlay treatment before placing the HMA overlay, and
- Perform a partial-depth repair.

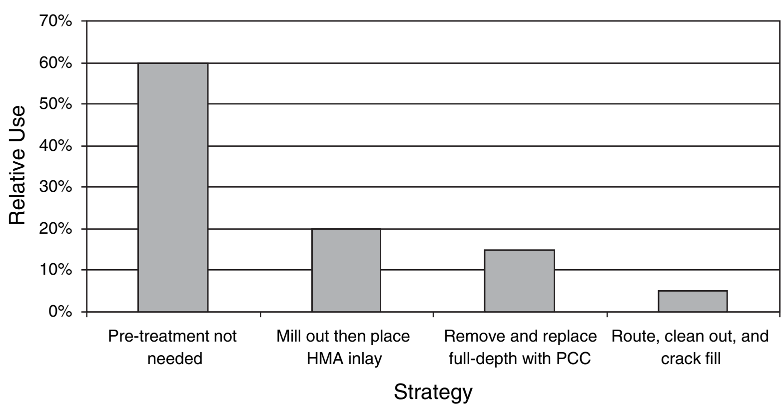


FIGURE 105 Patch/patch deterioration—Moderate severity (20 responses).

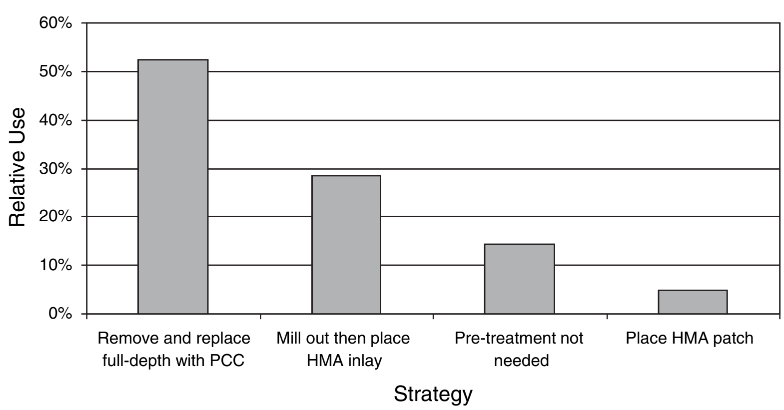


FIGURE 106 Patch/patch deterioration—High severity (21 responses).

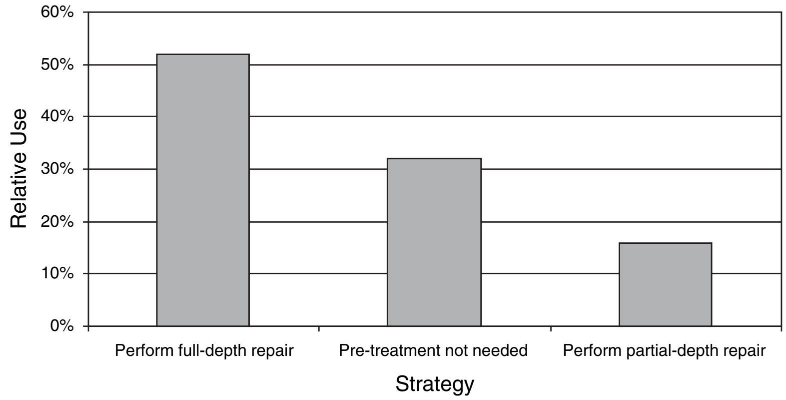


FIGURE 107 Punchouts—Moderate severity (25 responses).

The primary strategy used for high severity punchouts is to perform a full-depth repair of the affected areas (see Figure 108).

The literature review suggests that punchouts are candidates for full-depth repair as they represent a structural failure of the pavement. Even low severity punchouts should be repaired because they will deteriorate rapidly under additional traffic loadings (Hoerner et al. 2001).

Spalling of Longitudinal Joints

The primary strategy used for moderate severity spalling of longitudinal joints is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategy used is to perform a partial-depth repair of the affected areas.

One other employed pre-treatment strategy not shown in Figure 109 is to place a reinforcing fabric before overlay (4% relative use).

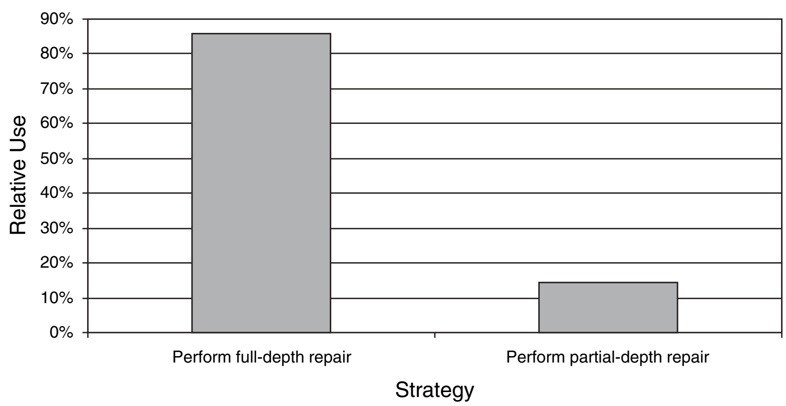


FIGURE 108 Punchouts—High severity (21 responses).

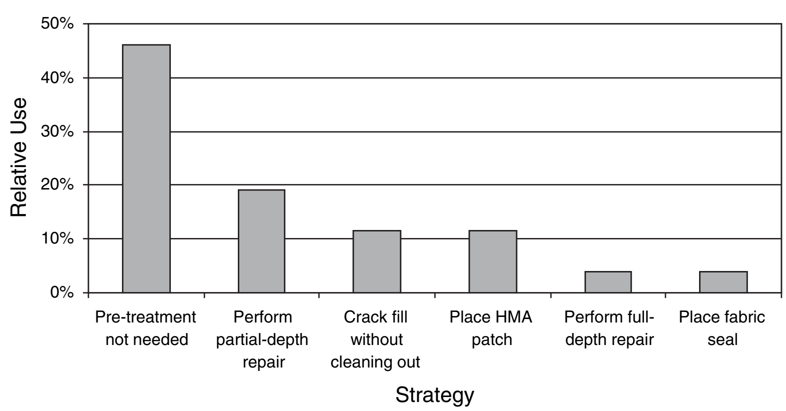


FIGURE 109 Spalling of longitudinal joints—Moderate severity (26 responses).

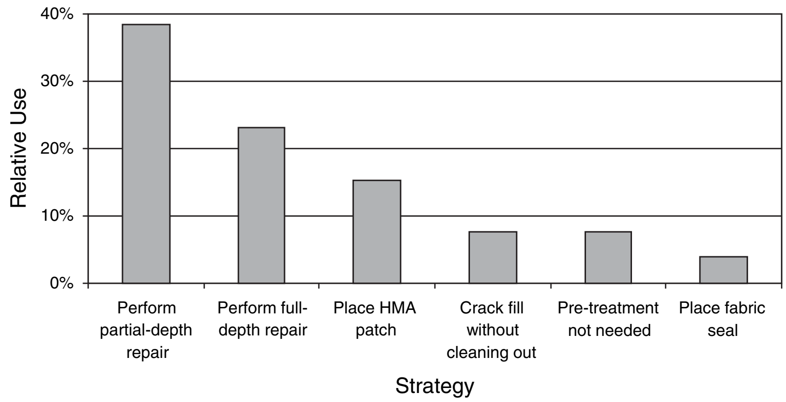


FIGURE 110 Spalling of longitudinal joints—High severity (26 responses).

The primary strategy used for high severity spalling of longitudinal joints is to perform a partial-depth repair of the affected areas. The secondary strategies used are:

- Perform a full-depth repair of the affected areas, or
- Place an HMA patch over the affected areas.

One other employed pre-treatment strategy not shown in Figure 110 is full-depth rubblization (4% relative use).

The literature review suggests that moderate or high severity spalling of longitudinal construction joints are recommended for full-depth repairs unless it can be determined that the deterioration is limited to the upper one-third of the slab. If the distress is limited to the upper portion of the slab, partial-depth PCC repairs are a feasible alternative (Hoerner et al. 2001).

Water Bleeding and Pumping

The primary strategy used for all severities of water bleeding and pumping is to install edge drains. The secondary strategy used is to perform a full-depth repair of the affected areas (see Figure 111).

The literature review suggests that the installation of edge drains, maintenance of existing edge drains, or other subdrainage improvements should be done before the placement of the HMA overlay if pumping or significant faulting is present. Additionally, improving poor subdrainage conditions will have a beneficial effect on the performance of the HMA overlay. Removal of excess water from the pavement cross section will reduce erosion and increase the strength of the base and subgrade, which in turn will reduce deflections. Stripping in the HMA overlay and D-cracking in the underlying CRCP pavement may be slowed by improved drainage (NHI 131062, Hoerner et al. 2001).

Roughness

The primary strategy for moderate severity roughness is to not perform any pre-overlay treatment before placing the HMA overlay. The secondary strategies are to (see Figure 112):

- Place an HMA leveling course, or
- Rubblize.

Based on limited survey response data, the primary strategy used for high severity roughness is to rubblize the exist-

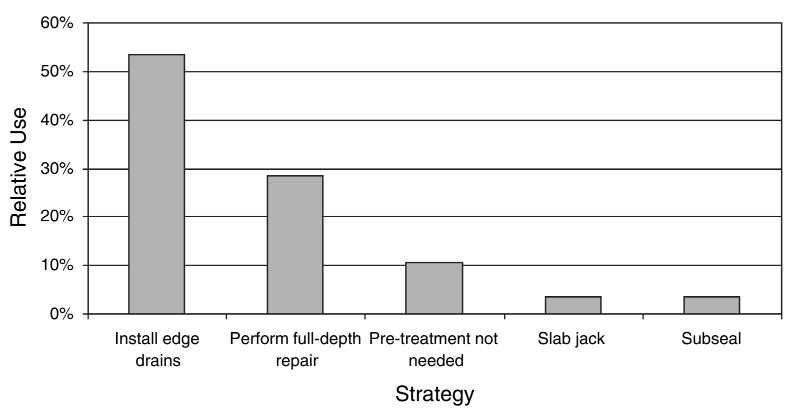


FIGURE 111 Water bleeding and pumping—All severities (28 responses).

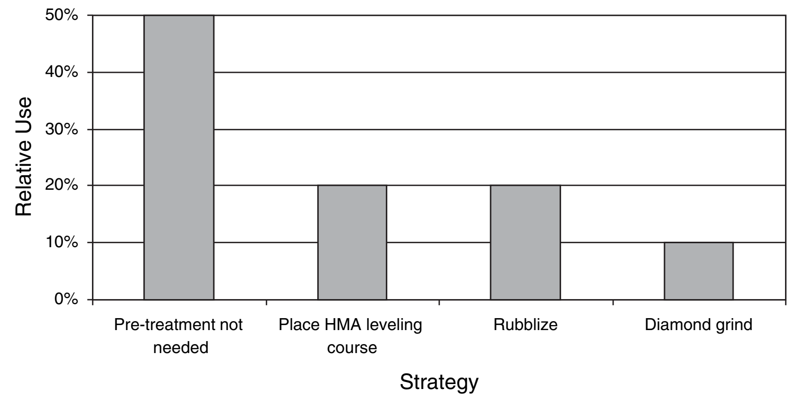


FIGURE 112 Roughness—Moderate severity (10 responses).

ing pavement surface layer. The secondary strategies used are to (see Figure 113):

- Diamond grind the existing surface smooth,
- Place an HMA leveling course before placing the HMA overlay, and
- Not perform any pre-overlay treatment before placing the HMA overlay.

Frost-Heave

The primary strategy for frost-heave cannot be determined based on the limited survey response (see Figure 114).

The literature review suggests that diamond grinding should also be considered as a pre-overlay treatment (Hoerner et al. 2001).

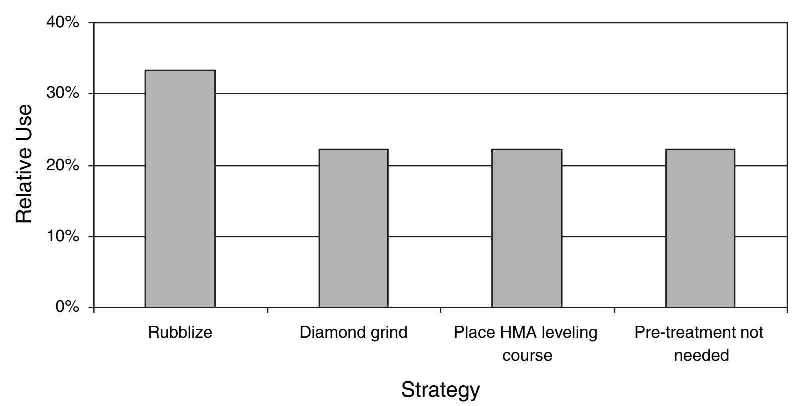


FIGURE 113 Roughness—High severity (9 responses).

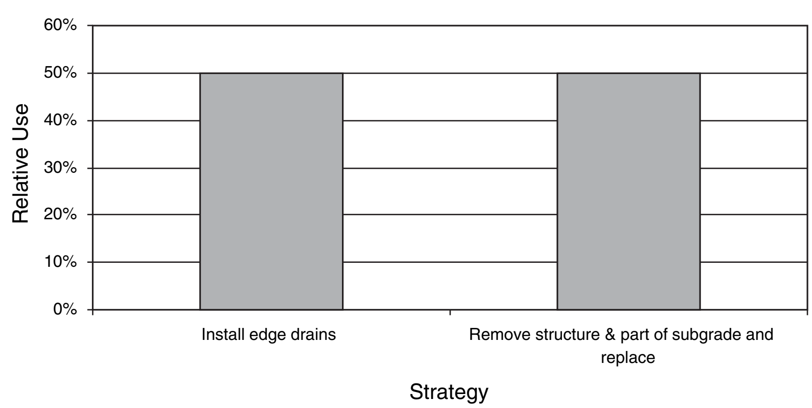


FIGURE 114 Frost-heave—All severities (2 responses).

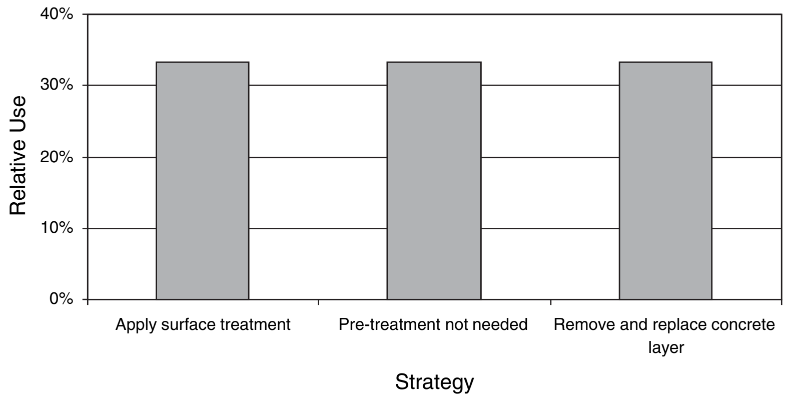


FIGURE 115 Alkali–silica reaction—All severities (3 responses).

Alkali–Silica Reaction

The primary strategy for alkali–silica reaction used cannot be determined based on the limited survey response (see Figure 115).

The literature review did not find any references to suggested pre-overlay treatments but it is the author's opinion that full-depth removal and replacement, rubblization, or break and seat may be considered.

CHAPTER SEVEN

JOINTED PLAIN CONCRETE PAVEMENT/CONTINUOUSLY REINFORCED CONCRETE PAVEMENT OVERLAYS OVER HOT-MIX ASPHALT PAVEMENT PRE-OVERLAY TREATMENTS

INTRODUCTION

The selection of a pre-overlay treatment before the construction of a PCC overlay on an existing HMA is traditionally called whitetopping (see Figure 116). There are two versions of concrete overlays over HMA that are defined as follows:

- Unbonded concrete overlay (UBCO) over HMA is the placement of a concrete overlay with thickness of approximately 4 in. or more, where the bond is not critical to satisfactory performance.
- Bonded concrete overlay (BCO) on HMA whitetopping is an overlay less than 4 in. thick. Steps are taken to bond the overlay to the underlying HMA pavement.

Table 3 presents a summary of the conventional and ultra-thin whitetopping techniques. For a BCO over HMA specific steps should be taken to bond the overlay to the HMA pavement so that the HMA pavement actually carries part of the traffic load ("Whitetopping—State of the Practice" 1998). The effectiveness of BCO applications is dependent on the condition of the underlying HMA and on the bond developed between the two materials (Hoerner et al. 2001). A minimum thickness of the existing HMA is required to ensure the performance of both BCO and UBCO overlays. A minimum thickness of 2 in., after any milling, is required for TWT whitetopping overlays (*Proceedings* 2005) and a minimum thickness of 3 to 6 in., after any milling, is required for BCO overlays (Hoerner et al. 2001). These minimum thickness values help ensure adequate support for UBCO overlays and adequate load carrying capacity for BCO overlays.

The amount of repair and treatment that is performed to an existing pavement before receiving any type of overlay can be a key factor influencing the future performance of the overlay. The following is a listing of the pre-overlay repairs or treatments that might be required for each type of whitetopping overlay (McGhee 1994; "Whitetopping—State of the Practice" 1998):

- UBCO over HMA:
  - Localized repair of failed areas caused by loss of base or subgrade support;
  - Filling of moderate- and high-severity potholes;
  - Milling or leveling of areas with rutting greater than 2 in.; and
  - Generally, repairs of alligator cracking are not required unless it is so severe that it might not provide uniform support to the new PCC overlay, especially for CRCP whitetopping overlays.
- BCO over HMA:
  - Localized repair of failed areas caused by loss of base or subgrade support;
  - Filling of moderate- and high-severity potholes;
  - Localized repair of severe alligator cracking or other areas that will not provide load-carrying capacity to the PCC overlay; and
  - Milling of the existing HMA surface to remove rutting, restore profile, and provide a roughened surface to enhance the bonding between the new PCC overlay and the existing HMA.

TECHNIQUES

Blading-Off

Blading-off is performed by a road grader's blade to remove existing rutting and shoving humps in existing HMA's surface.

Cold Milling

Cold milling is done to remove, by milling, small or large areas of the existing top portion of the HMA structural layer that exhibit moderate-to-severe structural and/or environmental related distresses. If small areas are removed within the project, then typically new HMA material is placed back and compacted to match the cold milled depth.

Crack Fill without Routing

Crack filling is performed to prevent incompressible materials from filling either nonworking or working cracks and/or to prevent surface water from entering the underlying pavement layers, thus reducing their strength and the effective strength of the HMA layer. In the technique described in this section, the crack is not cleaned out—rather, crack filling material is placed on the crack to seal it.

Full-Depth Removal and Replacement

Full-depth repair is done to remove full-depth defects in the existing HMA layer. The existing distressed areas of the HMA layer are removed by grinding or ripping, the exposed base layer is then recompacted, a tack coat is applied to all exposed

FIGURE 116 PCC overlay of HMA pavement (McGhee 1994).

surfaces, and then an HMA inlay is placed and compacted to match the surrounding existing HMA surface elevations.

Mill Out Full-Width

Cold milling is performed to remove, by grinding, small or large areas of the existing top portion of the HMA structural layer that exhibit moderate to severe structural and/or environmental related distresses. If large areas are cold milled, then these areas may or may not be replaced with HMA before the placement of the final JPCP or CRCP overlay. Additionally, cold milling may be used to correct surface profile defects. These surface defects may include rutted areas, restoration of cross-slope, or to improve the longitudinal profile of the existing HMA surface.

Place Hot-Mix Asphalt Overlay

If the existing HMA pavement is not of sufficient thickness for placement of the concrete overlay it may be necessary to place a thin layer of HMA to provide adequate support to the new overlay.

PRE-OVERLAY STRATEGIES

This section provides survey results in the form of bar charts that will summarize what strategies the various state DOTs are presently using to address medium and high severity distresses associated with existing HMA pavement structures before placing either a JPCP or CRCP overlay. The bar chart results are organized from the highest relative use strategy to the lowest relative use strategy.

Fatigue Cracking

The primary strategy used for moderate severity fatigue cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategies used are (see Figure 117):

- Mill out the affected areas and then inlay with HMA, or
- Remove the affected areas full-depth and replace.

The primary strategies for high severity fatigue cracking used are (see Figure 118):

- Mill out the affected areas and then inlay with HMA,
- Not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay, or
- Remove the affected areas full-depth and replace.

The literature review suggests that for UBCO both moderate and high severities areas that show subgrade failure and will not provide uniform support should be removed and replaced ("Whitetopping—State of the Practice" 1998). For BCO for both moderate and high severities the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

TABLE 3
SUMMARY OF CONCRETE OVERLAYS ON HMA

	Unbonded Concrete Overlay	Bonded Concrete Overlay
Typical Thicknesses	4 to 12 in.*	2 to 4 in.
Condition of Existing Pavement	All deteriorated HMA pavements	Low-volume deteriorated HMA pavements (particularly in areas where rutting is a problem)
Bonding Condition	Designed as unbonded, but some partial bonding occurs (and may enhance pavement performance)	Strong bond required between existing HMA pavement and new PCC overlay
Pre-overlay Repair	• Limited repair (failed areas only) • Possible milling to correct profile	• Repair of areas unable to contribute to load-carrying capacity • Milling of the HMA surface
Minimum Thickness of HMA	2 in. (after any milling)	3 to 6 in. (after any milling)
Special Design and Construction Considerations	• Adequate support critical to performance • Adequate joint design (including joint spacing and load transfer) • Placement of a whitewash on HMA surface on hot days	• Bonding with HMA pavement • PCC mix design is often high-strength and/or fiber modified • Extremely short joint spacings (2 to 6 ft)

Source: Hoerner (2001).
*Thicknesses typically are 8 to 12 in. on primary and Interstate highways, 5 to 7 in. on secondary roads.

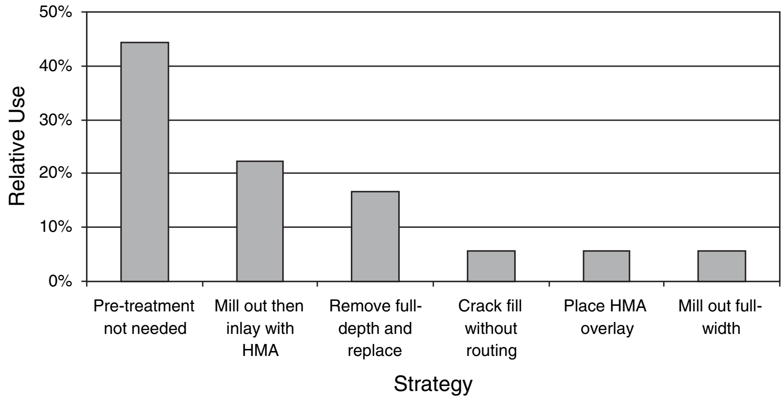


FIGURE 117 Fatigue cracking—Moderate severity (18 responses).

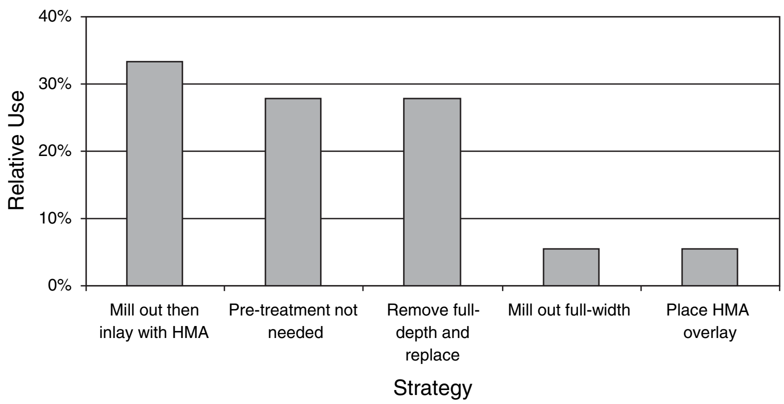


FIGURE 118 Fatigue cracking—High severity (18 responses).

Block Cracking

The primary strategy used for moderate severity block cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy used is to mill out the affected areas and then inlay with HMA (see Figure 119).

The primary strategy used for high severity block cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy used is to mill out the affected areas and then inlay with HMA (see Figure 120).

The literature review suggests that for UBCO on HMA for both moderate and high severities, no pretreatment is required (“Whitetopping—State of the Practice” 1998). For BCO on HMA for both moderate and high severities the surface should be milled full-width and cleaned with compressed air (“Whitetopping—State of the Practice” 1998).

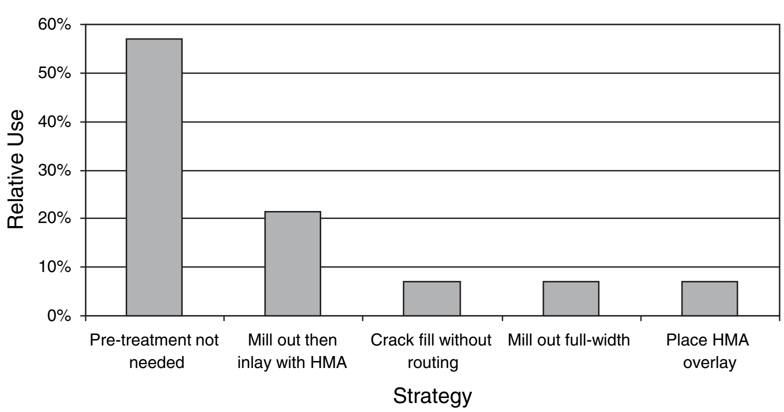


FIGURE 119 Block cracking—Moderate severity (14 responses).

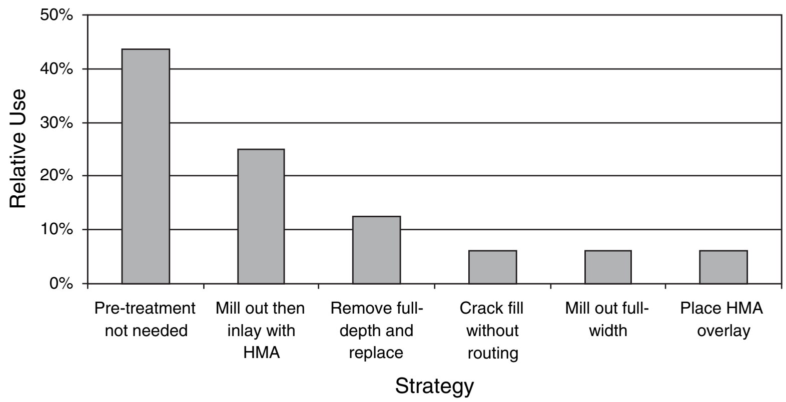


FIGURE 120 Block cracking—High severity (16 responses).

Edge Cracking

The primary strategy used for moderate severity edge cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy is to remove the affected areas full-depth and replace (see Figure 121).

The primary strategy used for high severity edge cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy is to remove the affected areas full-depth and replace (see Figure 122).

The literature review suggests that for UBCO over HMA for both moderate and high severities no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO over HMA for both moderate and high severities the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

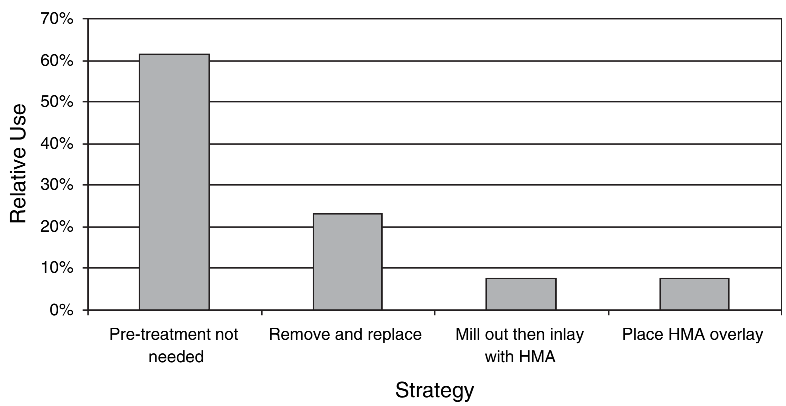


FIGURE 121 Edge cracking—Moderate severity (13 responses).

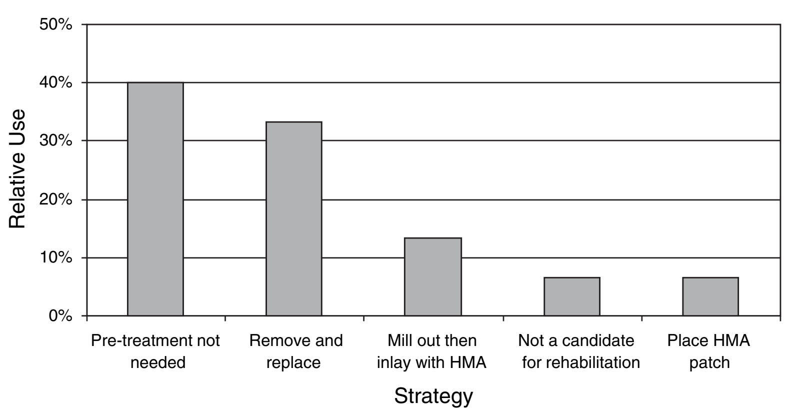


FIGURE 122 Edge cracking—High severity (15 responses).

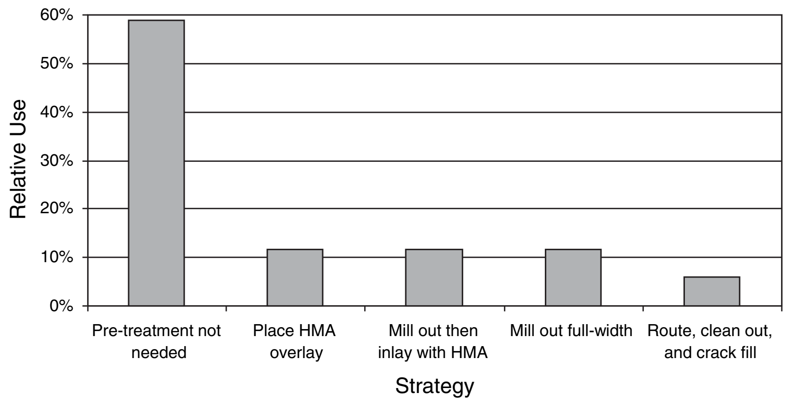


FIGURE 123 Longitudinal cracking—Moderate severity (17 responses).

Longitudinal Cracking

The primary strategy used for moderate severity longitudinal cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay (see Figure 123).

The primary strategy used for high severity longitudinal cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy used is to mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas (see Figure 124).

The literature review suggests that for conventional UBCO on HMA for both moderate and high severities no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA for both moderate and high severities the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Transverse Cracking

The primary strategy used for moderate severity transverse cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy used is to mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas (see Figure 125).

The primary strategy used for high severity transverse cracking is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategies used are (see Figure 126):

- Mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas, or
- Crack fill the existing cracks without routing to clean out the cracks.

One other employed pre-treatment strategy not shown in Figure 126 is to apply a sand seal (5% relative use).

The literature review suggests that for UBCO on HMA for both moderate and high severities no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA for both moderate and high severities the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Patch/Patch Deterioration

The primary strategy used for moderate severity patch/patch deterioration is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategies used are (see Figure 127):

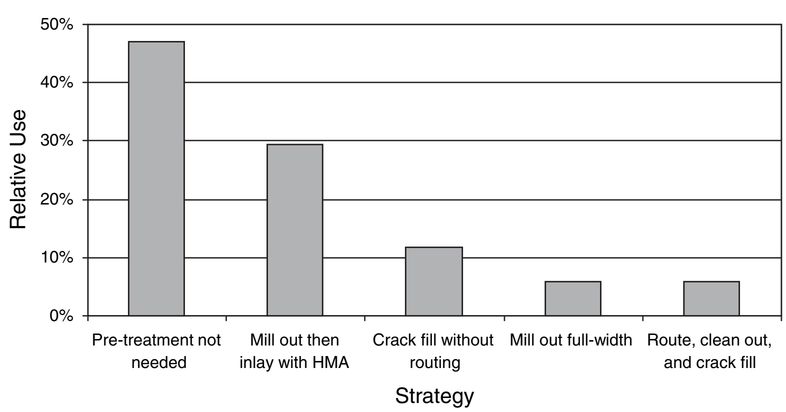


FIGURE 124 Longitudinal cracking—High severity (17 responses).

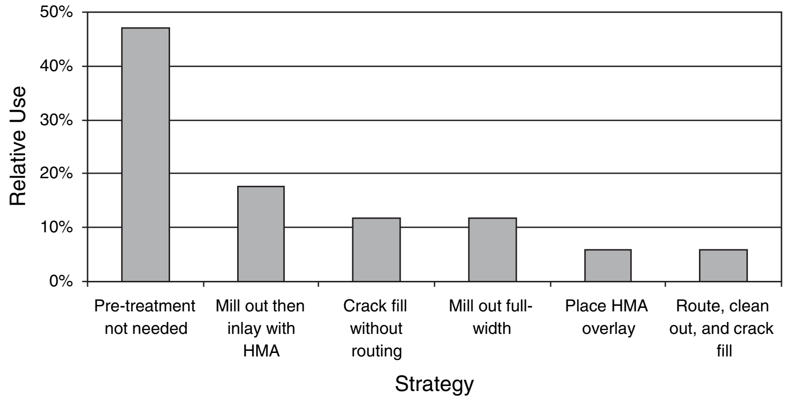


FIGURE 125 Transverse cracking—Moderate severity (17 responses).

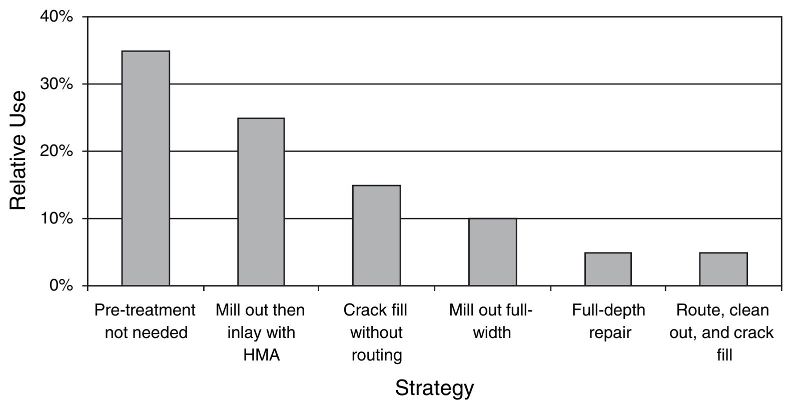


FIGURE 126 Transverse cracking—High severity (20 responses).

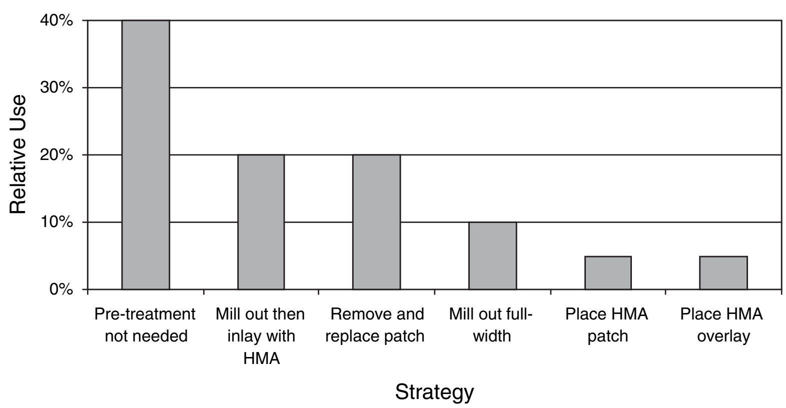


FIGURE 127 Patch/patch deterioration—Moderate severity (20 responses).

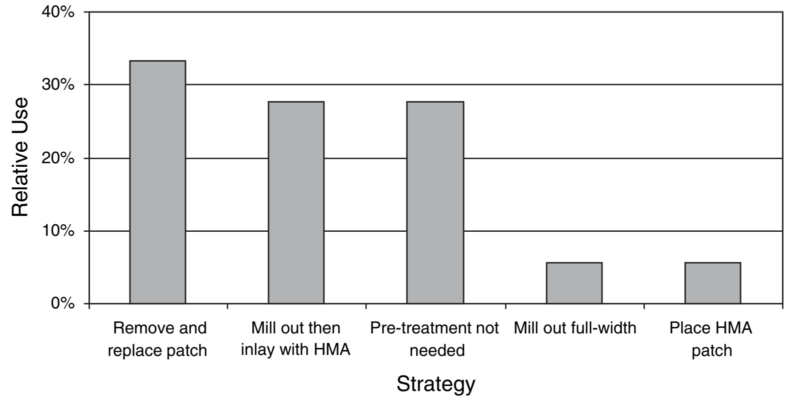


FIGURE 128 Patch/patch deterioration—High severity (18 responses).

- Mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas, or
- Remove the affected areas and replace.

The primary strategies used for high severity patch/patch deterioration are (see Figure 128):

- Remove the affected areas and replace,
- Mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas, and
- Not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay.

The literature review suggests that for conventional UBCO on HMA for both moderate and high severities no pretreatment is required (“Whitetopping—State of the Practice” 1998). For BCO on HMA for both moderate and high severities, the surface should be milled full-width and cleaned with compressed air (“Whitetopping—State of the Practice” 1998).

Pothole

The primary strategy used for moderate severity pothole repair is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy used is to place an HMA patch over the affected areas (see Figure 129).

The primary strategy used for high severity pothole repair is to place an HMA patch over the affected areas. The secondary strategies used are (see Figure 130):

- Not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay,
- Mill out and then inlay with HMA, or
- Place a 2 to 3 in. HMA overlay over the affected areas.

The literature review suggests that for UBCO on HMA for both moderate and high severities potholes should be filled with HMA and compacted (“Whitetopping—State of the Practice” 1998). For BCO on HMA for both moderate and high severities the surface should be milled full-width and cleaned with compressed air (“Whitetopping—State of the Practice” 1998).

Rutting

The primary strategy used for all severities of rutting is to mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected area. The secondary strategies used are (see Figure 131):

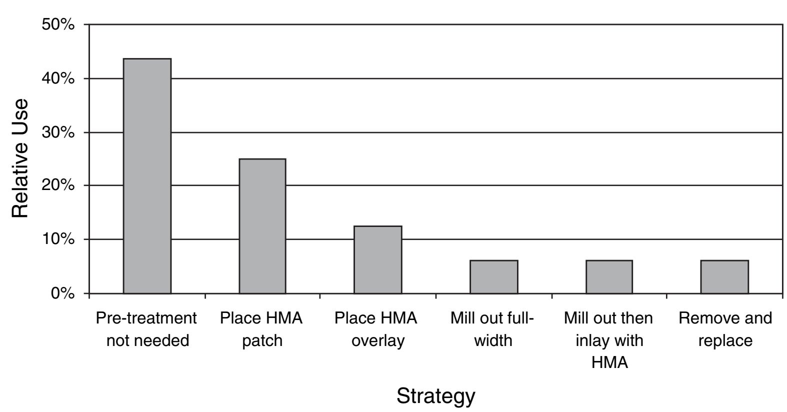


FIGURE 129 Pothole—Moderate severity (12 responses).

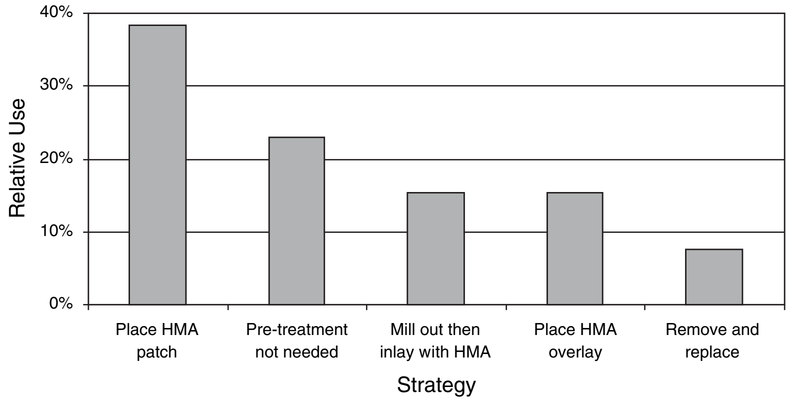


FIGURE 130 Pothole—High severity (13 responses).

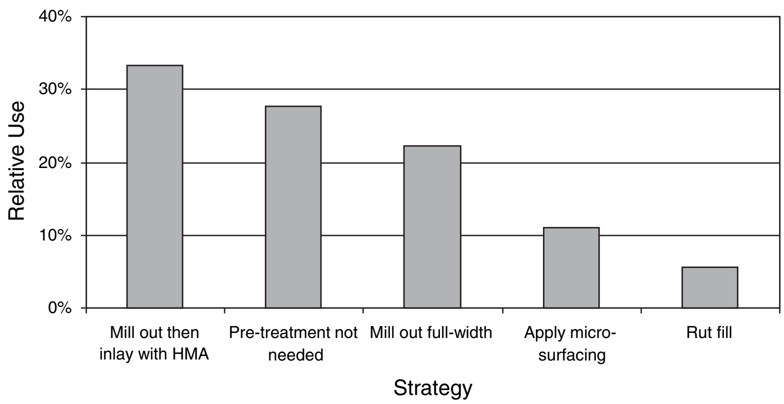


FIGURE 131 Rutting—All severities (18 responses).

- Not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay, or
- Mill out full-width.

The literature review suggests that for UBCO on HMA if the rutting exceeds 2 in. the surface should be milled. For BCO on HMA the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Shoving

The primary strategy used for all distresses of shoving is to mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas. The secondary strategies used are (see Figure 132):

- Using a motor grader, blade off the affected areas;
- Mill out full-width the affected areas; or

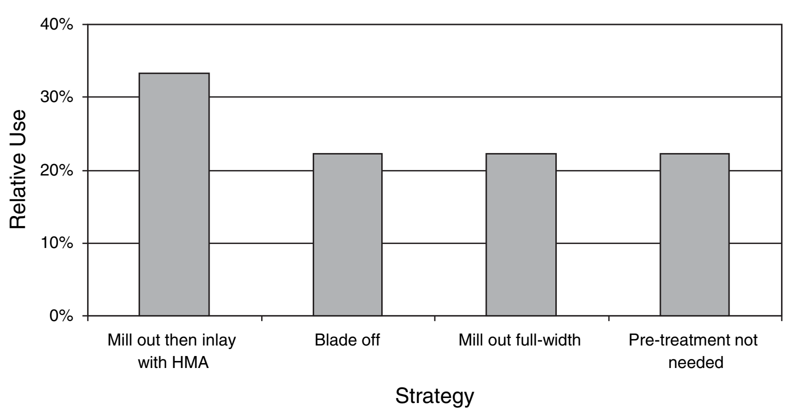


FIGURE 132 Shoving—All distresses (18 responses).

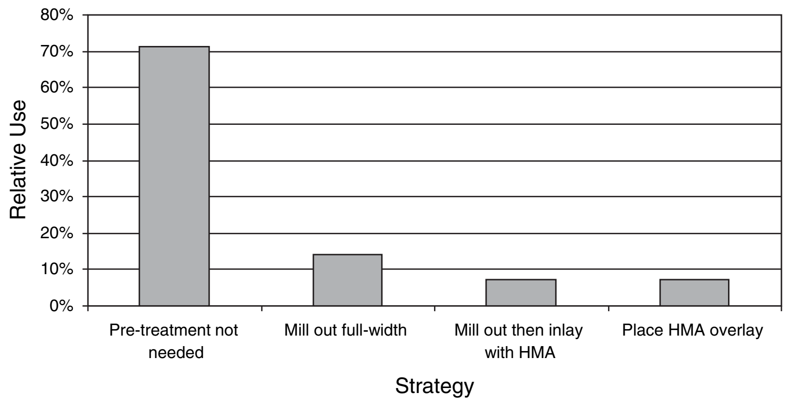


FIGURE 133 Bleeding (discolorization)—All severities (14 responses).

- Not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay.

The literature review suggests that for UBCO on HMA if the rutting exceeds 2 in. the surface should be milled. For BCO on HMA the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Bleeding (Discolorization)

The primary strategy used for all severities of bleeding (discolorization) is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay (see Figure 133).

The literature review suggests that for UBCO on HMA, no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA, the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Bleeding (Loss of Texture)

The primary strategy used for all severities of bleeding (loss of texture) is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategies used are (see Figure 134):

- Mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas, or
- Mill out full-width the affected areas.

The literature review suggests that for UBCO on HMA no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Bleeding (Aggregate Obscured)

The primary strategy used for all severities of bleeding (aggregate obscured) is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategies used are (see Figure 135):

- Mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas, or
- Mill out full-width the affected areas.

The literature review suggests that for UBCO on HMA no pretreatment is required ("Whitetopping—State of the

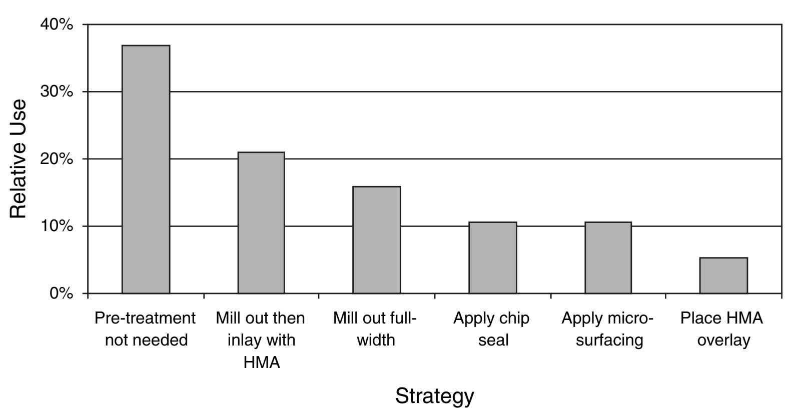


FIGURE 134 Bleeding (loss of texture)—All severities (19 responses).

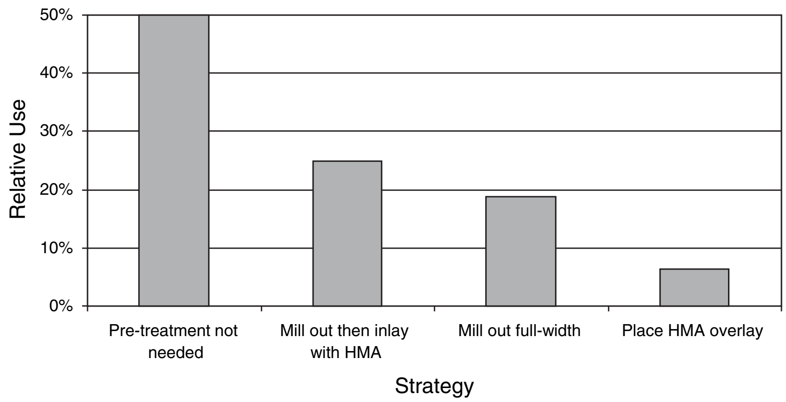


FIGURE 135 Bleeding (aggregate obscured)—All severities (16 responses).

Practice" 1998). For BCO on HMA the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Raveling (Loss of Fine Aggregate)

The primary strategy used for all severities of raveling (loss of fine aggregate) is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay (see Figure 136).

The literature review suggests that for UBCO on HMA, no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA, the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Raveling (Loss of Fine and Some Coarse Aggregate)

The primary strategy used for all severities of raveling (loss of fine and some coarse aggregate) is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy is to mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas (see Figure 137).

The literature review suggests that for UBCO on HMA, no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA, the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Raveling (Loss of Coarse Aggregate)

The primary strategy used for all severities of raveling (loss of coarse aggregate) is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay. The secondary strategy is to mill out 2 to 3 in. of the existing HMA and then inlay with HMA over the affected areas (see Figure 138).

The literature review suggests that for UBCO on HMA no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Water Bleeding and Pumping

The primary strategy used for all severities of water bleeding and pumping is to identify the source of water and take the

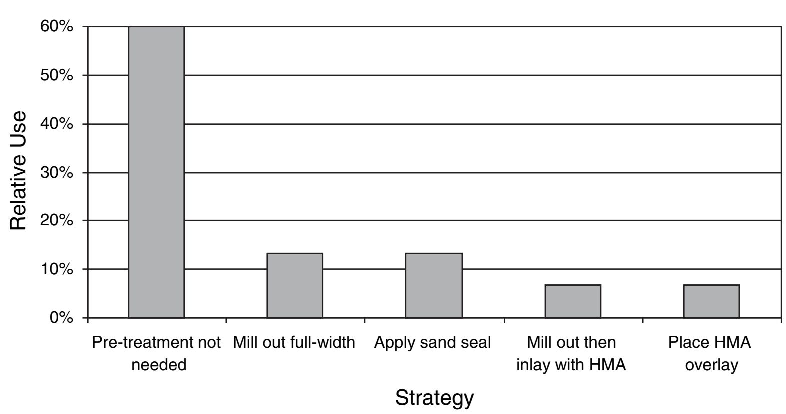


FIGURE 136 Raveling (loss of fine aggregate)—All severities (15 responses).

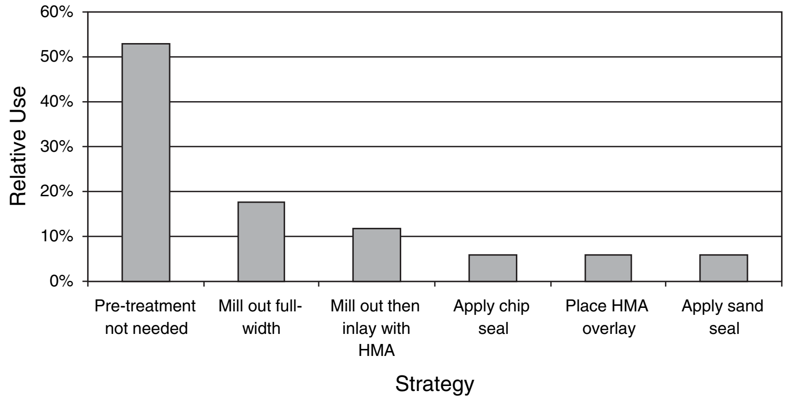


FIGURE 137 Raveling (loss of fine and some coarse aggregate)—All severities (17 responses).

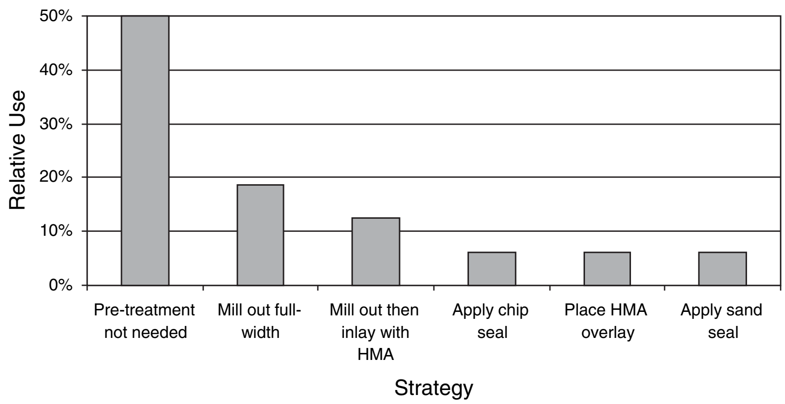


FIGURE 138 Raveling (loss of coarse aggregate)—All severities (16 responses).

appropriate corrective action. The secondary strategies used are (see Figure 139):

- Remove the affected existing HMA and replace, or
- Not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay.

A properly designed, constructed, and maintained edge drain system will help reduce future pumping, faulting, and cracking. When an asphalt separator layer is used, adequate drainage may be important in minimizing a possible stripping problem with a moisture susceptible HMA mixture.

Polished Aggregate

The primary strategy used for all severities of polished aggregate is to not perform any pre-overlay treatment before placing either a JPCP or CRCP overlay (see Figure 140).

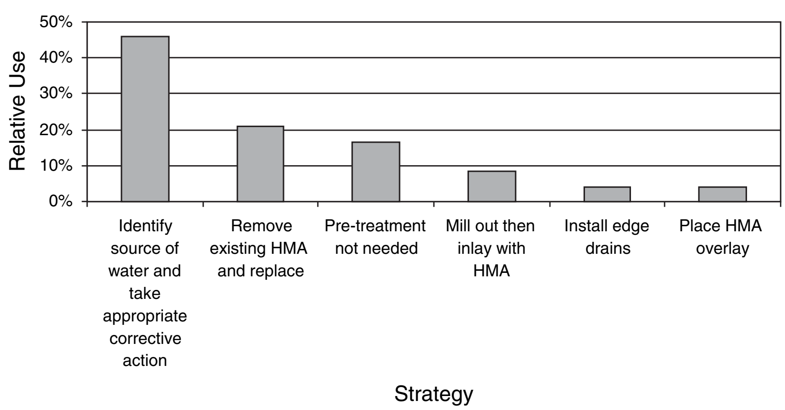


FIGURE 139 Water bleeding and pumping—All severities (24 responses).

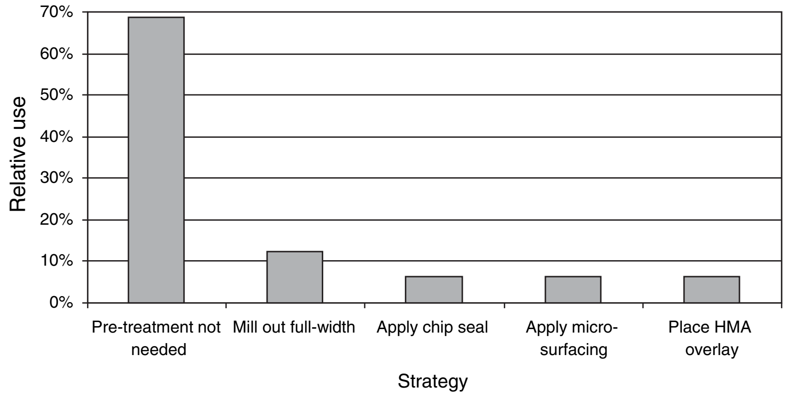


FIGURE 140 Polished aggregate—All severities (16 responses).

The literature review suggests that for UBCO on HMA, no pretreatment is required ("Whitetopping—State of the Practice" 1998). For BCO on HMA, the surface should be milled full-width and cleaned with compressed air ("Whitetopping—State of the Practice" 1998).

Roughness

Based on very limited survey response data, the primary strategy for moderate severity roughness is to diamond grind smooth the existing HMA's surface. The secondary strategy is to not perform any pre-overlay treatment before placing the HMA overlay (see Figure 141).

Based on extremely limited survey response data, the primary strategy for high severity roughness is to diamond grind smooth the existing HMA's surface (see Figure 142).

The literature indicates that for an unbonded concrete overlay no pretreatment is necessary and that for a bonded concrete

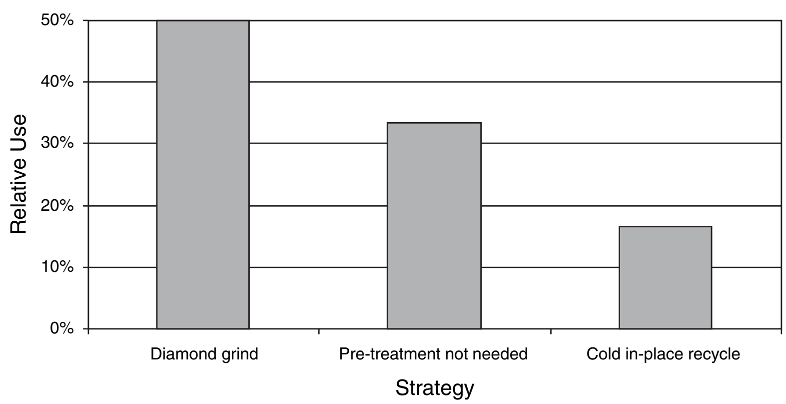


FIGURE 141 Roughness—Moderate severity (6 responses).

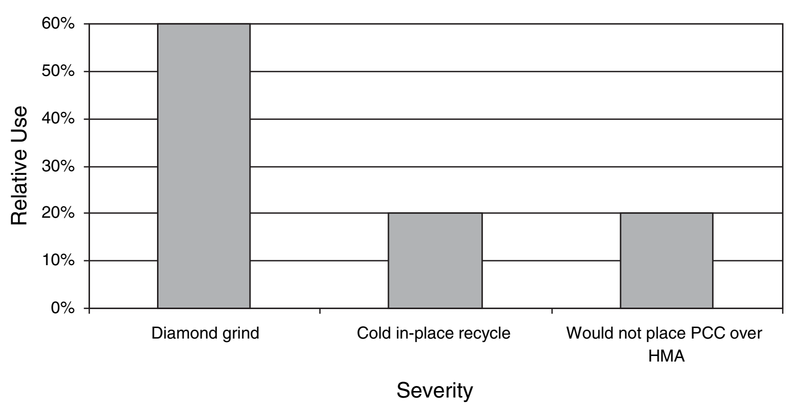


FIGURE 142 Roughness—High severity (5 responses).

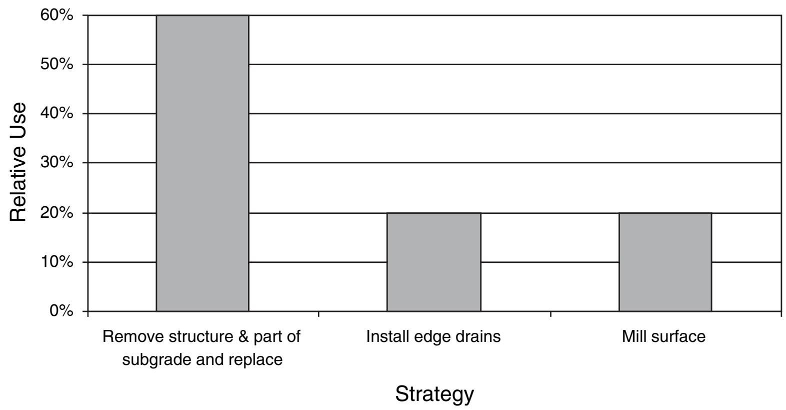


FIGURE 143 Frost-heave—All severities (5 responses).

overlay the existing HMA pavement should be milled and cleaned ("Guide to Concrete Overlay Solutions" 2007).

Frost-Heave

Based on extremely limited survey response data the primary strategy used for all severities of frost-heave is to remove full-depth the affected areas, including the subgrade, and replace (see Figure 143).

A review of the literature also shows that for areas showing frost-heave that the affected areas should be removed and replaced ("Guide to Concrete Overlay Solutions" 2007).

CHAPTER EIGHT

CONCLUSIONS

INTRODUCTION

This synthesis is not a definitive study determining the "best" pre-overlay treatment practices that are currently being used by the U.S. state departments of transportation (DOTs). It is intended only to provide a summary of the current pre-overlay treatment practices employed without detailed investigations into their overall effectiveness in terms of cost or performance. Additionally, it was not the intent of this synthesis to conduct an in-depth detailed literature review of past studies and to summarize their conclusions. Instead, the intent was to review and evaluate only current literature findings and, where these findings differ from the outcome of the U.S. state DOT survey results, to note that information within this synthesis.

The results of this synthesis will assist all new and experienced Pavement Designers in their selection of alternatives that they may want to consider prior to the construction of either a flexible or rigid overlay. It will also assist individuals, those who are not trained in the engineering principals associated with pavement design, to consider and plan their pre-overlay strategies based on the current practices of experienced Pavement Designers.

SURVEY DATA RESULTS

The data collected from the state DOT survey shows that responses range from having very strong agreements to having very diverse opinions as to what pre-overlay strategy should be performed to address a particular distress and distress severity. These U.S. state DOT survey opinions are based on the educational, passed-down, policy, and real-life experiences of the respondents. Variance in some reported responses was quite high. As such, a much more detailed study that incorporates long-term pavement management data, material properties, climate, and regional considerations should be undertaken to quantify the most effective cost and performance strategies.

The survey reflects the types of overlays that are considered by the various state DOTs based on the number of agencies that responded to the sections of the questionnaire. Table 4 summarizes the number of responses.

It appears that hot-mix asphalt (HMA) is the most used type of overlay, followed by jointed plain concrete pavement (JPCP) and then continuously reinforced concrete pavement (CRCP). When HMA overlays are specified, it is predominately over existing HMA and JPCP pavement structures. With JPCP overlays, it does appear that it may be specified over existing JPCP pavements more than existing HMA pavements.

- **Hot-Mix Asphalt Overlays over Existing Hot-Mix Asphalt Pavements**

The principal primary pre-overlay strategies that are used by the U.S. state DOTs are presented in Table 5. The principal primary strategy was determined based on the single highest relative use as derived from the survey results.

A strong response (70% relative use or greater) was indicated for the principal primary strategy that was used for moderate and high severity pothole distresses and all severity bleeding (discolorization).

These strategies are considered to be the most effective pre-overlay treatments by respondents to the survey.

A moderate response (40% to 69% relative use) was indicated for the principal primary strategy that was used for:

- High severity fatigue cracking,
- Moderate severity edge cracking,
- Moderate severity patch/patch deterioration,
- All severity rutting,
- All severity shoving,
- All severity raveling (loss of fine aggregate),
- All severity raveling (loss of fine/some coarse aggregate),
- All severity water bleeding and pumping,
- All severity polished aggregate, and
- All severity frost-heave.

These strategies are considered to be effective pre-overlay treatments by respondents to the survey.

The relative use of all other indicated principal primary strategies was less than 40%, which suggests a large variation of opinion in regard to their effective use as compared with another strategy or strategies.

- **Jointed Plain Concrete Pavement Overlay over Existing Jointed Plain Concrete Pavement**

TABLE 4
SUMMARY OF RESPONDING STATES

Type of Overlay	HMA			JPCP		CRCP
Existing Pavement	HMA	JPCP	CRCP	JPCP	HMA	HMA
No. of Responding U.S. State DOTs	39	34	18	16	13	13
Percentage	29	26	14	12	10	10
		69		22		10

TABLE 5
HMA OVER HMA PRINCIPAL PRIMARY STRATEGIES

Distress Type	Severity	Principal Primary Strategy					Relative Use
		Mill out then Inlay with HMA	Remove Full-Depth and Replace	Pre-Treatment Not Needed	Place HMA Patch	Identify Source and Take Appropriate Action	
Fatigue Cracking	Moderate	X					38%
	High		X				42%
Block Cracking	Moderate	X					29%
	High	X					33%
Edge Cracking	Moderate			X			48%
	High			X			32%
Longitudinal Cracking	Moderate			X			29%
	High	X					30%
Transverse Cracking	Moderate			X			28%
	High	X					28%
Patch/Patch Deterioration	Moderate			X			40%
	High		X				34%
Pothole	Moderate				X		85%
	High		X				83%
Rutting	All	X					44%
Shoving	All	X					58%
Bleeding (discolorization)	All			X			72%
Bleeding (loss of texture)	All			X			30%
Bleeding (aggregate obscured)	All	X					36%
Raveling (loss of fine aggregate)	All			X			44%
Raveling (loss of fine/some coarse aggregate)	All			X			42%
Raveling (loss of coarse aggregate)	All			X			35%
Water Bleeding and Pumping	All					X	47%
Polished Aggregate	All			X			46%
Roughness	Moderate			X			37%
	High	X					37%
Frost-Heave	All		X				52%

The principal primary pre-overlay strategies that are used by the U.S. state DOTs are presented in Table 6. The principal primary strategy was determined based on the single highest relative use per the survey results.

A strong response (70% relative use or greater) was indicated for the principal primary strategy that was used for all severity map cracking and all severity polished aggregate.

These strategies are considered to be the most effective pre-overlay treatments by the synthesis.

A moderate response (40% to 69% relative use) was indicated for the principal primary strategy that was used for:

- Moderate and high severity corner breaks,
- Moderate severity durability ("D") cracking,
- Moderate severity longitudinal cracking,
- Moderate severity joint seal damage,
- Moderate severity spalling of longitudinal joints,
- Moderate and high severity spalling of transverse joints,
- All severity scaling,
- All severity popouts,
- All severity blowups,
- Moderate and high severity patch/patch deterioration,
- All severity water bleeding and pumping,
- Moderate and high severity roughness,
- All severity frost-heave, and
- All severity alkali–silica reaction.

These strategies are considered to be effective pre-overlay treatments by the synthesis.

Relative use of all other indicated principal primary strategies was less than 40%, which suggests a large variation of opinion in regard to their effective use as compared with another strategy or strategies.

- **Hot-Mix Asphalt Overlay over Existing Jointed Plain Concrete Pavement**

TABLE 6
JPCP OVER JPCP PRINCIPAL PRIMARY STRATEGIES

Distress Type	Severity	Principal Primary Strategy								Relative Use
		Pre-Treatment not Needed	Perform Full-Depth Repair	Remove and Replace Slab	Install Edge Drains	Diamond Grind	Remove and Replace	Clean and Re-Seal	Full-Depth Repair with New Dowel and/or Tie Bars	
Corner Breaks	Moderate	X								40%
	High		X							67%
Durability "D" Cracking	Moderate	X								53%
	High		X							39%
Longitudinal Cracking	Moderate	X								50%
	High			X						32%
Transverse Cracking	Moderate	X								38%
	High			X						31%
Joint Seal Damage	Moderate	X								48%
	High	X						X		41%
Spalling of Longitudinal Joints	Moderate	X								46%
	High								X	28%
Spalling of Transverse Joints	Moderate	X								45%
	High								X	42%
Map Cracking	All	X								74%
Scaling	All	X								45%
Polished Aggregate	All	X								82%
Popouts	All	X								68%
Blowups	All		X							67%
Faulting of Transverse Joints	All	X								38%
Patch / Patch Deterioration	Moderate						X			48%
	High						X			67%
Water Bleeding and Pumping	All				X					41%
Roughness	Moderate	X								50%
	High					X				63%
Frost-Heave	All						X			67%
Alkali-Silica Reaction	All			X						40%

The principal primary pre-overlay strategies that are used by the U.S. state DOTs are presented in Table 7. The principal primary strategy was determined based on the single highest relative use per the survey results.

A strong response (70% relative use or greater) was indicated for the principal primary strategy that was used for all severity blowups. This strategy is considered to be the most effective pre-overlay treatment by the synthesis.

A moderate response (40% to 69% relative use) was indicated for the principal primary strategy that was used for:

- Moderate and high severity corner breaks,
- Moderate and high severity joint seal damage,
- All severity map cracking,
- All severity scaling,
- All severity polished aggregate,
- All severity popouts,
- Moderate and high severity patch/patch deterioration,
- All severity water bleeding and pumping, and
- All severity frost-heave.

These strategies are considered to be effective pre-overlay treatments by respondents to the survey.

The relative use of all other indicated principal primary strategies was less than 40%, which suggests a large variation of opinion in regard to their effective use as compared with another strategy or strategies.

- **Hot-Mix Asphalt Overlay over Existing Continuously Reinforced Concrete Pavement**

The principal primary pre-overlay strategies that are used by the U.S. state DOTs are presented in Table 8. The principal primary strategy was determined based on the single highest relative use per the survey results.

TABLE 7
HMA OVER JPCP PRINCIPAL PRIMARY STRATEGIES

Distress Type	Severity	Principal Primary Strategy								Relative Use
		Pre-Treatment not Needed	Perform Full-Depth Repair	Perform Partial-Depth Repair	Rubblize	Install Edge Drains	Diamond Grind	Perform Full-Depth Repair with New Dowel and/or Tie Bars	Remove and Replace	
Corner Breaks	Moderate	X								41%
	High		X							56%
Durability "D" Cracking	Moderate	X								39%
	High		X							26%
Longitudinal Cracking	Moderate	X								37%
	High							X		30%
Transverse Cracking	Moderate	X								34%
	High							X		28%
Joint Seal Damage	Moderate	X								54%
	High	X								42%
Spalling of Longitudinal Joints	Moderate	X								39%
	High			X						33%
Spalling of Transverse Joints	Moderate			X						33%
	High			X						29%
Map Cracking	All	X								58%
Scaling	All	X								41%
Polished Aggregate	All	X								64%
Popouts	All	X								58%
Blowups	All		X							76%
Faulting of Transverse Joints	All	X								28%
Patch / Patch Deterioration	Moderate	X								40%
	High								X	53%
Water Bleeding and Pumping	All					X				43%
Roughness	Moderate	X								36%
	High						X			36%
Frost-Heave	All								X	45%
Alkali-Silica Reaction	All				X					25%

TABLE 8
HMA OVER CRCP PRINCIPAL PRIMARY STRATEGIES

Distress Type	Severity	Principal Primary Strategy						Relative Use
		Pre-Treatment not Needed	Perform Full-Depth Repair	Perform Partial-Depth Repair	Rubblize	Install Edge Drains	Remove and Replace with PCC	
Durability "D" Cracking	Moderate	X						45%
	High		X					43%
Longitudinal Cracking	Moderate	X						43%
	High		X					37%
Transverse Cracking	Moderate	X						54%
	High		X					37%
Map Cracking	All	X						67%
Scaling	All	X						65%
Polished Aggregate	All	X						77%
Popouts	All	X						52%
Blowups	All		X					95%
Transverse Construction Joint Deterioration	Moderate	X						38%
	High		X					74%
Patch/Patch Deterioration	Moderate	X						60%
	High						X	52%
Punchouts	Moderate		X					52%
	High		X					86%
Spalling of Longitudinal Joints	Moderate	X						46%
	High			X				38%
Water Bleeding and Pumping	All					X		54%
Roughness	Moderate	X						50%
	High				X			33%
Frost-Heave	All							(*)
Alkali-Silica Reaction	All							(*)

*Principal primary strategy could not be determined due to lack of response data.

A strong response (70% relative use or greater) was indicated for the principal primary strategy that was used for:

- All severity polished aggregate,
- All severity blowups,
- High severity transverse construction joint deterioration, and
- High severity punchouts.

These strategies are considered to be the most effective pre-overlay treatments by the synthesis.

A moderate response (40% to 69% relative use) was indicated for the principal primary strategy that was used for:

- Moderate and high severity durability ("D") cracking,
- Moderate severity longitudinal cracking,
- Moderate severity transverse cracking,
- All severity map cracking,
- All severity scaling,
- All severity popouts,
- Moderate and high severity patch/patch deterioration,
- Moderate severity punchouts,
- Moderate severity spalling of longitudinal joints,
- All severity water bleeding and pumping, and
- Moderate severity roughness.

These strategies are considered to be effective pre-overlay treatments by the synthesis.

The relative use of all other indicated principal primary strategies was less than 40%, which suggests a large variation of opinion in regard to their effective use as compared with another strategy or strategies.

- **Jointed Plain Concrete Pavement or Continuously Reinforced Concrete Pavement over Existing Hot-Mix Asphalt**

The principal primary pre-overlay strategies that are used by the U.S. state DOTs are presented in Table 9. The principal primary strategy was determined based on the single highest relative use per the survey results.

A strong response (70% relative use or greater) was indicated for the principal primary strategy that was used for all bleeding (discolorization). This strategy is considered to be the most effective pre-overlay treatment by the synthesis.

TABLE 9
JPCP OR CRCP OVER HMA PRINCIPAL PRIMARY STRATEGIES

Distress Type	Severity	Principal Primary Strategy							Relative Use
		Mill out then Inlay with HMA	Remove and Replace Patch	Remove and Replace Structure	Diamond Grind	Pre-Treatment Not Needed	Place HMA Patch	Identify Source and Take Appropriate Action	
Fatigue Cracking	Moderate					X			44%
	High	X							33%
Block Cracking	Moderate					X			57%
	High					X			43%
Edge Cracking	Moderate					X			61%
	High					X			40%
Longitudinal Cracking	Moderate					X			58%
	High					X			47%
Transverse Cracking	Moderate					X			47%
	High					X			35%
Patch / Patch Deterioration	Moderate					X			40%
	High		X						33%
Pothole	Moderate					X			43%
	High						X		38%
Rutting	All	X							33%
Shoving	All	X							33%
Bleeding (discolorization)	All					X			71%
Bleeding (loss of texture)	All					X			37%
Bleeding (aggregate obscured)	All					X			50%
Raveling (loss of fine aggregate)	All					X			60%
Raveling (loss of fine/some coarse aggregate)	All					X			53%
Raveling (loss of coarse aggregate)	All					X			50%
Water Bleeding and Pumping	All							X	46%
Polished Aggregate	All					X			68%
Roughness	Moderate				X				43%
	High				X				58%
Frost-Heave	All			X					50%

A moderate response (40% to 69% relative use) was indicated for the principal primary strategy that was used for:

- Moderate severity fatigue cracking,
- Moderate and high severity block cracking,
- Moderate and high edge cracking,
- Moderate and high longitudinal cracking,
- Moderate transverse cracking,
- Moderate patch/patch deterioration,
- Moderate pothole,
- All severity bleeding (aggregate obscured),
- All severity raveling (loss of fine aggregate),
- All severity raveling (loss of fine and some coarse aggregate),
- All severity raveling (loss of coarse aggregate),
- All severity water bleeding and pumping,
- All severity polished aggregate,
- Moderate and high severity roughness, and
- All severity frost-heave.

These strategies are considered to be effective pre-overlay treatments by the synthesis.

The relative use of all other indicated principal primary strategies was less than 40%, which suggests a large variation of opinion with regard to their effective use as compared with another strategy or strategies.

REFERENCES

AASHTO Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C., 1993.

A Basic Asphalt Emulsion Manual, Manual Series No. 19, 3rd ed., Asphalt Institute, Lexington, Ky., 2001.

Bay, J. and K.H. Stokoe, "Development of a Rolling Dynamic Deflectometer for Continuous Deflection Testing of Pavements," FHWA Report No. TX-99/1422-3F, Center for Transportation Research, The University of Texas at Austin, 1998.

Bendaña, L.J. and W.S. Wang, "Rehabilitation Procedures for Faulted Rigid Pavements," *Transportation Research Record 1388,* Transportation Research Board, National Research Council, Washington, D.C., 1993, pp. 200–210.

Grogg, M.G., K.D. Smith, S.B. Seeds, T.E. Hoerner, D.G. Peshkin, and H.T. Yu, *HMA Pavement Evaluation and Rehabilitation Reference Manual,* National Highway Institute Course No. 131063, National Highway Institute, Arlington, Va., Sep. 2001.

"Guidelines for Bonded Concrete Overlays," American Concrete Pavement Association, Skokie, Ill., 1998.

"Guidelines for Full-Depth Repair," Technical Bulletin TB-004.02, American Concrete Pavement Association, Skokie, Ill., 1995.

"Guidelines for Unbonded Concrete Overlays," American Concrete Pavement Association, Skokie, Ill., 1998.

"Guide to Concrete Overlay Solutions," National Concrete Pavement Technology Center, Skokie, Ill., 2007.

Hall, K.T., C.E. Correa, and A.L. Simpson, *LTPP Data Analysis: Effectiveness of Pavement Maintenance and Rehabilitation Options,* Project 20-50 (3/4), Transportation Research Board, National Research Council, Washington, D.C., Dec. 2000.

"HMA Rehabilitation of Existing Pavements," Part 3, Chapter 6, In *2002 Design Guide Online Documents,* Version 1.000, NCHRP Project 1-37A, Transportation Research Board, National Research Council, Washington, D.C., 2002.

Hoerner, T.E., K.D. Smith, H.T. Yu, D.G. Peshkin, and M.J. Wade, "PCC Pavement Evaluation and Rehabilitation," National Highway Institute Course No. 131062, National Highway Institute, Arlington, Va., Oct. 2001.

McGhee, K.H., *Synthesis of Highway Practice 204: Portland Cement Concrete Resurfacing,* Transportation Research Board, National Research Council, Washington, D.C., 1994, 67 pp.

"Mechanistic Empirical Pavement Design Guide," Version 1.000, Software Help Documentation, Glossary, NCHRP Project 1-40, Transportation Research Board, National Research Council, Washington, D.C.

"Pavement Design Guide, Part 2—Design Inputs, Chapter 5—Evaluation of Existing Pavements for Rehabilitation," Table 2.5.2, Minnesota Department of Transportation, St. Paul, 2006 [Online]. Available: http://www.mrr.dot.state.mn.us/pavement/PvmtDesign/DesignGuide/documentation/Part2_Chapter5_Evaluation.pdf.

Pavement Design Guide, Texas Department of Transportation, Austin, Oct. 2006.

Proceedings, International Conference on Best Practices for Ultra-Thin and Thin Whitetoppings, Federal Highway Administration, Washington, D.C., Apr. 12–15, 2005.

Rauhut, J.B., H.L. Von Quintas, and A.A. Eltahan, *Performance of Rehabilitated Asphalt Concrete Pavements in LTPP Experiments—Data Collected Through February 1997,* Research Report FHWA-RD-00-029, Long-Term Pavement Performance Program, Federal Highway Administration, Washington, D.C., June 2000.

Smith, K.D., H.T. Yu, and D.G. Peshkin, *Portland Cement Concrete Overlays—State of the Technology Synthesis,* Report FHWA-IF-02-045, Federal Highway Administration, Washington, D.C., 2002.

"Stitching Concrete Pavement Cracks and Joints," Draft Special Report, American Concrete Pavement Association, Skokie, Ill., 2001.

Von Quintas, H.L., A.L. Simpson, and A.A. Eltahan, *Rehabilitation of Asphalt Concrete Pavements—Initial Evaluation of the SPS-5 Experiment Final Report,* Research Report FHWA-RD-01-168, Long-Term Pavement Performance Program, Federal Highway Administration, Washington, D.C., Oct. 2000.

"Whitetopping—State of the Practice," *Engineering Bulletin,* American Concrete Pavement Association, Skokie, Ill., 1998.

BIBLIOGRAPHY

The Asphalt Handbook, Manual Series No. 4, Asphalt Institute, Lexington, Ky., 1989.

Asphalt Paving Design Guide, Asphalt Paving Association of Iowa, Ames.

Bureau of Design and Environmental Manual, Chapter 53, "Pavement Rehabilitation," Illinois Department of Transportation, Springfield.

"Comprehensive Pavement Design Manual," New York Department of Transportation, Albany, July 2002.

Dimillo, A., *A Quarter Century of Geotechnical Research,* Report No. FHWA-RD-98-139, Federal Highway Administration, Washington, D.C., 1998.

Flexible Pavement Design Manual, Florida Department of Transportation, Tallahassee, Jan. 2002.

"Flexible Pavement Rehabilitation Manual," State of California Department of Transportation, Sacramento, June 2001.

"Guidelines for the Surface Preparation/Rehabilitation of Existing Concrete and Asphaltic Pavements prior to an Asphaltic Concrete Overlay," Wisconsin Highway Research Program, Madison, Aug. 2005.

"Guide to the Investigation and Remediation of Distress in Flexible Pavements: Field Manual," Caltrans Flexible Pavement Materials Program, State of California Department of Transportation, Sacramento, Dec. 2002.

"Key Findings from LTPP Analysis 1990–1999," Research Report FHWA-RD-00-085, Federal Highway Administration, Washington, D.C., 2000.

"Key Findings from LTPP Analysis 2000–2003—Pavement Rehabilitation," Federal Highway Administration, Washington, D.C. [Online]. Available: http://www.tfhrc.gov/pavement/ltpp/reports/04032/pvmtrehab.htm#rrehab.

"Pavement Design Guide for Subdivision and Secondary Roads," Utah Department of Transportation, Salt Lake City, Aug. 2000.

Pavement Design Manual, Alberta Transportation and Utilities, Edmonton, June 1997.

Pavement Design Manual, Colorado Department of Transportation, Denver, 2007.

"Pavement Rehabilitation Techniques," State Highway Administration, Maryland Department of Transportation, Baltimore, 2006.

APPENDIX A
Questionnaire

The attached questionnaire was sent to each state Department of Transportation for their individual responses. Once completed, it was returned for analysis in which the results are presented in this synthesis.

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Project 20-5, Synthesis 38-06

Pre-Overlay Treatment of Existing Pavement

QUESTIONNAIRE

PURPOSE OF THE SYNTHESIS

Billions of dollars are spent on the American roadway infrastructure. Federal and state highway agencies are shifting their emphasis from new construction to rehabilitation projects and, at the same time, are losing experienced pavement evaluation and design personnel. The future performance of hot-mix asphalt (HMA) and Portland Cement Concrete (PCC) overlays are dependent on existing pavement structures being properly evaluated and treated prior to the overlay being constructed to reduce the potential for premature pavement deterioration.

The results of this synthesis study will identify the current state of the art practices for selecting pre-overlay treatment of pavement structures prior to rehabilitation and **will not address "stop gap" or routine maintenance treatments**. Additionally, the results of this synthesis will compliment the information contained in the rehabilitation component of the NCHRP M-E Pavement Design Guide, and aid agencies in making appropriate decisions for pre-overlay treatments. Finally, this synthesis could be the foundation for a future study to develop a best practices guidebook.

RESPONDING AGENCY/INDIVIDUAL IDENTIFICATION INFORMATION

Please complete the following identification information to aid in the processing of this questionnaire:

Name:

Title:

Agency:

Division/Bureau:

Address:

City, State, and Zip Code:

Work Telephone:

E-Mail:

Remarks or Comments (If Any):

PLEASE E-MAIL, FAX, OR MAIL YOUR COMPLETED QUESTIONNAIRE BY FEBRUARY 28, 2007 TO THE FOLLOWING INVESTIGATOR:

John H. Tenison, P.E.
Senior Materials Engineer
AMEC Earth and Environmental, Inc.
8519 Jefferson, NE
Albuquerque, New Mexico 87113

Telephone: (505) 821-1801 ext 7302
Fax: (505) 821-7371
E-Mail: john.tenison@amec.com

If you may have any questions concerning this questionnaire, please contact either of the two following investigators:

John H. Tenison, P.E.
Senior Materials Engineer
AMEC Earth and Environmental, Inc.
8519 Jefferson, NE
Albuquerque, New Mexico 87113

Telephone: (505) 821-1801 ext 7302
Fax: (505) 821-7371
E-Mail: john.tenison@amec.com

Douglas I. Hanson, P.E.
Senior Materials Engineer
AMEC Earth and Environmental, Inc.
1405 West Auto Drive
Tempe, Arizona 85284-1016

Telephone: (480) 940-2320 ext 204
Fax: (480) 785-0970
E-Mail: doug.hanson@amec.com

GENERAL QUESTIONNAIRE INSTRUCTIONS:

Please be as concise as possible with your answers because many of the questions and/or presented situations may be open-ended and may require the investigators to conduct a follow-up telephone conversation for more in-depth information. **Please provide any information you believe is relevant to the answers provided in the questionnaire, including applicable procedures, policies, or other information that might be of interest to other state highway agencies**.

If you perform:

HMA overlays over HMA	Please answer Section 1	Pages 3 to 12
PCC overlays over HMA	Please answer Section 2	Pages 13 to 22
PCC overlay over JCP	Please answer Section 3	Pages 23 to 31
HMA overlay over JCP	Please answer Section 4	Pages 32 to 40
PCC overlay over CRCP	Please answer Section 5	Pages 41 to 47
HMA overlay over CRCP	Please answer Section 6	Pages 48 to 54

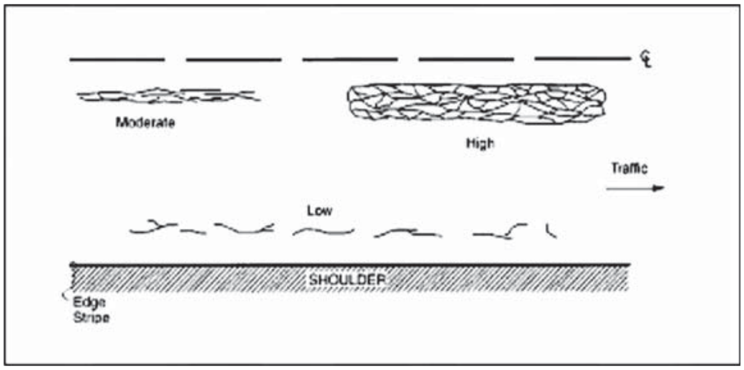
Please note: You do not need to answer the questions associated with operations that you do not use.

We know how very valuable your time is and what other activities you have to accomplish which may be delayed by completing this questionnaire. We have strived to keep this questionnaire as short and concise as possible and we ask you or someone who is very knowledgeable on your staff to completely respond to this questionnaire. With the continued loss of experienced personnel, the results of this synthesis will help all state highway agencies to construct better and longer lasting pavement overlays using the limited financial resources that each state highway agency has available.

SECTION 1: HMA Overlay on Existing HMA Pavement Structure

Specific Instructions: A picture for each considered distress type is presented with various alternatives. Please select the alternative that your agency would use or if not shown, please briefly describe the pre-overlay treatment that would be used, if any. A moderate extent should be assumed.

1.01 Fatigue Cracking – Occurs in areas subjected to repeated traffic loadings (wheel paths). Can be a series of interconnected cracks in early stages of development. Develops into many-sided, sharp-angled pieces, usually less than 0.3 m (2 ft) on the longest side, characteristically with a chicken wire/alligator pattern in later stages.



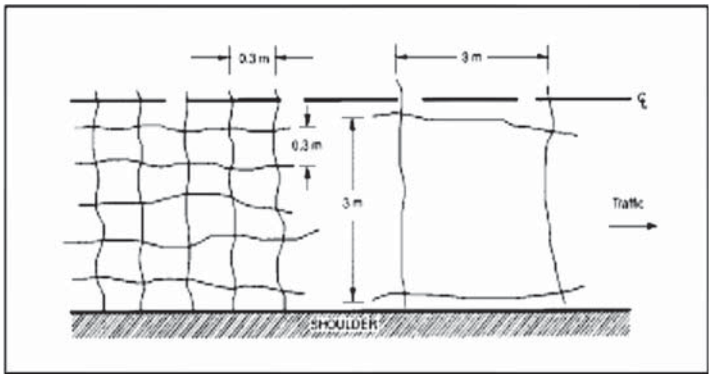
Moderate Severity - Area of interconnected cracks forming a complete pattern; cracks may be slightly spalled, cracks may be sealed; pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove full-depth and replace
- ☐ Other:

High Severity – Area of moderately or severely spalled interconnected cracks forming a complete pattern; pieces may move when subjected to traffic; cracks may be sealed; pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove full depth and replace
- ☐ Other:

1.02 Block Cracking – A pattern of cracks that divides the pavement into approximately rectangular pieces. Rectangular blocks range in size from approximately 0.1 m^2 (0.1 ft^2) to 10 m^2 (11 yd^2).



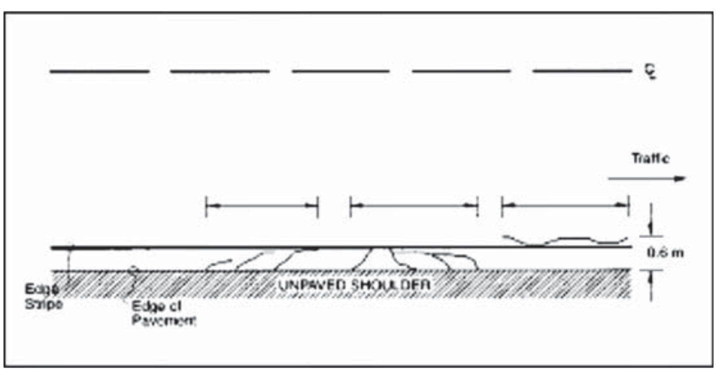
Moderate Severity – Cracks with a mean width > 6 mm (1/4 in) and ≤ 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent low severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

High Severity – Cracks with a mean width > 19 mm (3/4 in); or any crack with a mean width ≤ 19mm (3/4 in) and adjacent moderate to high severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Remove full depth and replace
- ☐ Other:

<u>1.03 Edge Cracking</u> – Applies only to pavements with unpaved shoulders. Crescent-shaped cracks or fairly continuous cracks which intersect the pavement edge and are located within 0.6 m (2 ft) of the pavement edge, adjacent to the shoulder. Includes longitudinal cracks outside of the wheel path and within 0.6 m (2 ft) of the pavement edge.



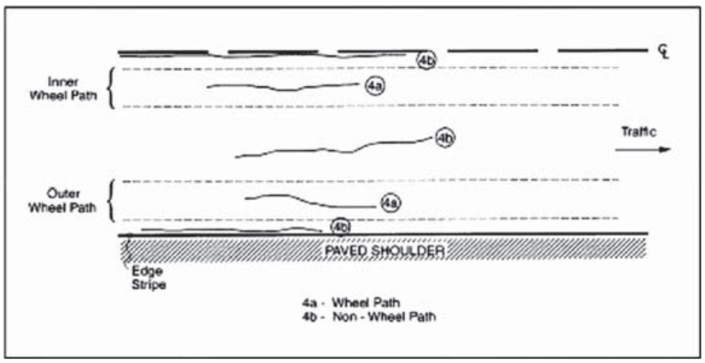
Moderate Severity – Cracks with some breakup and loss of material for up to 10 percent of the length of the affected portion of the pavement.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Other:

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

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Other:

<u>1.04 Longitudinal Cracking</u> – Cracks predominately parallel to pavement centerline. Location within the lane (wheel path versus no-wheel path) is significant.



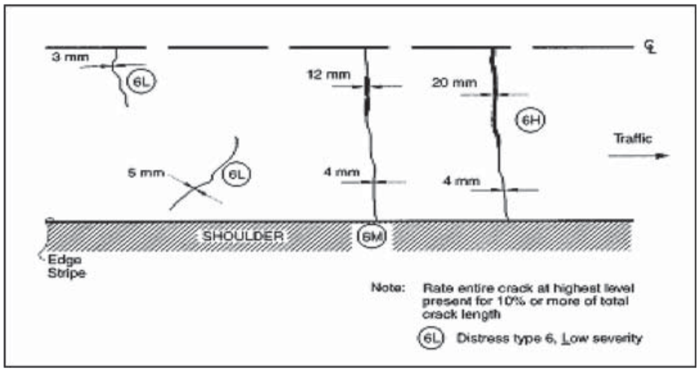
Moderate Severity – Any crack with a mean width > 6mm (1/4 in) and ≤ 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent low severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

High Severity – Any crack with a mean width > 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent moderate to high severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

<u>1.05 Transverse Cracking</u> – Cracks that are predominately perpendicular to pavement certerline.



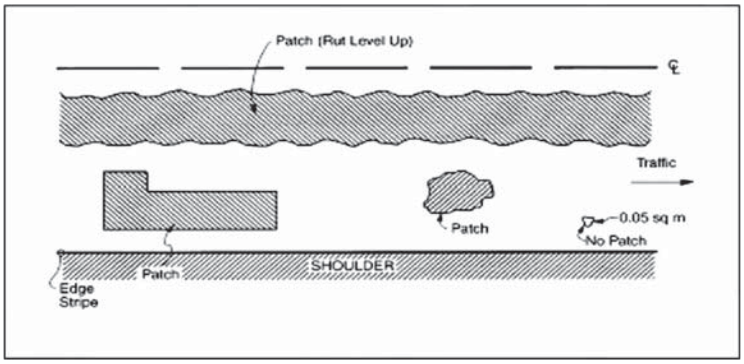
Moderate Severity – Any crack with a mean width > 6 mm (1/4 in) and < 19 mm (3/4 in); or any crack with a mean width < 19 mm (3/4 in) and adjacent low severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

High Severity – Any crack with a mean width > 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent moderate to high random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

<u>1.06 Patch/Patch Deterioration</u> – Portion of pavement surface, greater than 0.1 m^2 (0.1 ft^2), that has been removed and replaced or additional material applied to the pavement after original construction.



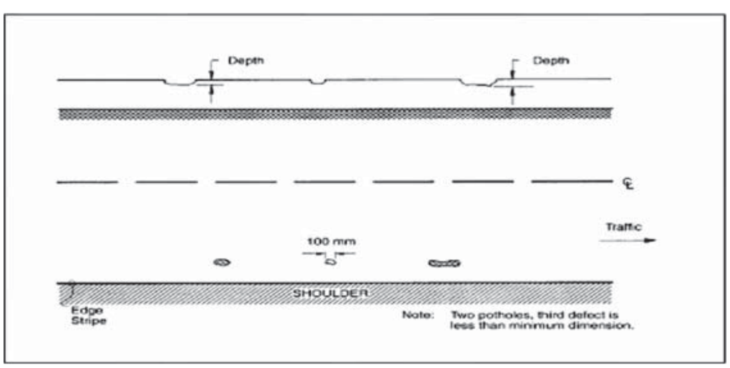
Moderate Severity – Patch has moderate severity distress of any type or rutting from 6 mm (1/4 in) to 12 mm (1/2 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Patch over
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove and replace patch
- ☐ Other:

High Severity – Patch has high severity distress of any type including rutting > 12 mm (1/2 in) or the patch has additional different patch material within it; pumping may be evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Patch over
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove and replace patch
- ☐ Other:

1.07 Potholes – Bowl-shaped holes of various sizes in the pavement surface. Minimum plan dimension is 150 mm (6 in).



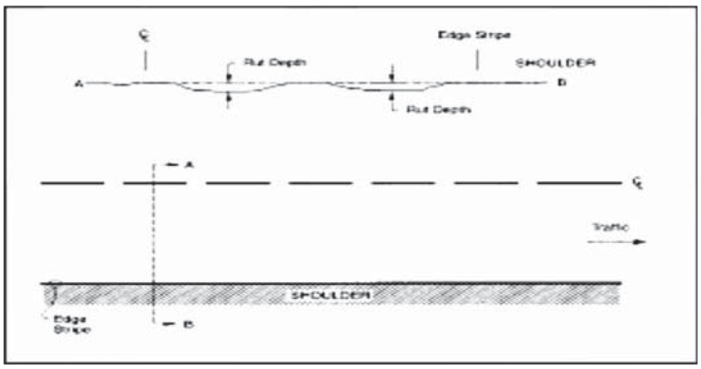
Moderate Severity - Depth ≥ 25 mm (1 in) and < 50 mm (2 in).

☐ No pretreatment required
☐ Patch (briefly describe procedure)
☐ Other:

High Severity – Depth > 50 mm (2 in).

☐ No pretreatment required
☐ Patch (briefly describe procedure)
☐ Other:

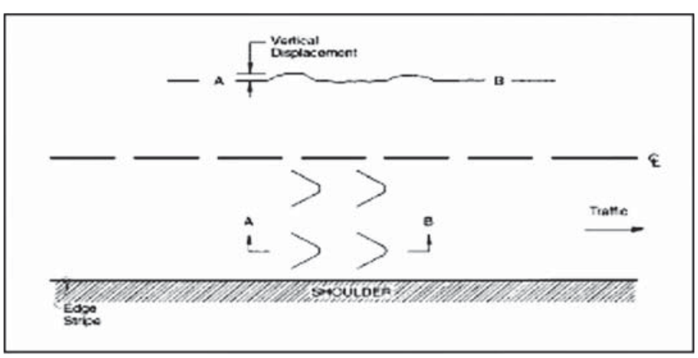
<u>1.08 Rutting</u> – A rut is a longitudinal surface depression in the wheel path. It may have associated transverse displacement.



Severity – Not applicable.

☐ No pretreatment required
☐ Patch (briefly describe procedure)
☐ Micro-surface
☐ Mill out ruts then inlay with HMA
☐ Cold in-place recycle to a depth of   inches
☐ Hot in-place recycle to a depth of   inches
☐ Other:

<u>1.09 Shoving</u> – Shoving is a longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles and is usually located on hills, curves, or at intersections. It may also have associated vertical displacement.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Blade off
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

1.10 Bleeding (Discolorization) – Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. Surface discolorization relative to the remainder of the pavement.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Other:

1.11 Bleeding (Loss of Texture) - Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. Surface is losing surface texture because of excess asphalt.

Severity – Not applicable

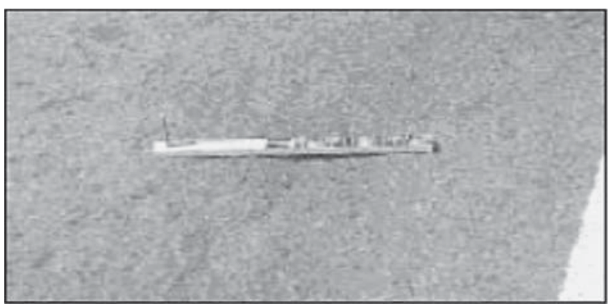
- ☐ No pretreatment required
- ☐ Micro-surface
- ☐ Chip seal
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

1.12 Bleeding (Aggregate Obscured) - Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. The aggregate is obscured by excess asphalt possibly with a shiny, glass-like, reflective surface that may be tacky to the touch.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Treat with hot blotter sand
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

1.13 Raveling (Loss of Fine Aggregate) – Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.



Severity – Not applicable

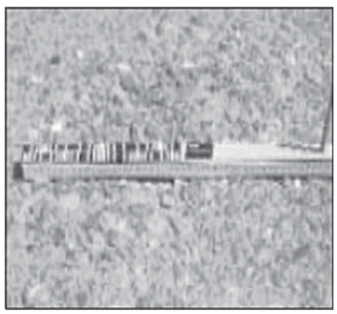
- ☐ No pretreatment required
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

1.14 Raveling (Loss of Fine Aggregate and Some Coarse Aggregate) - Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

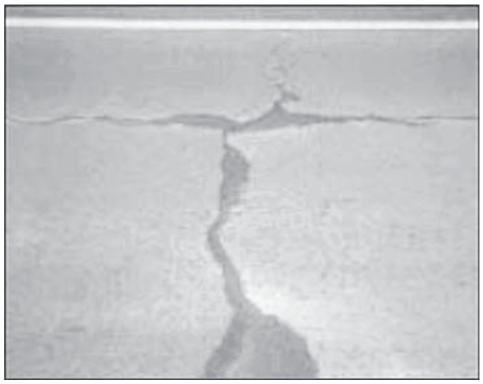
1.15 Raveling (Loss of Coarse Aggregate) - Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

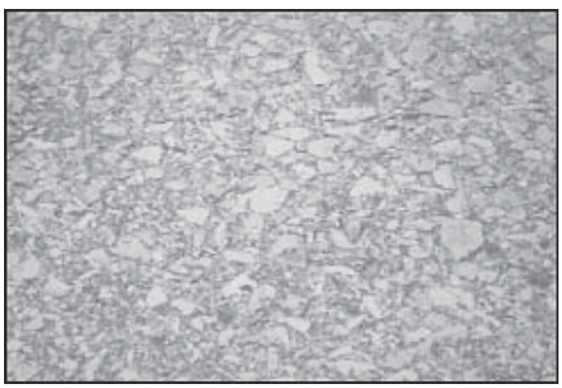
1.16 Water Bleeding and Pumping – Seeping or ejection of water from beneath the pavement through cracks. In some cases, detectable by deposits of fine material left on the pavement surface which were eroded (pumped) from the support layers and have stained the surface.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Identify source of water and take appropriate corrective measures
- ☐ Remove existing HMA and replace
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

<u>1.17 Polished Aggregate</u> – Surface binder worn away to expose coarse aggregate.



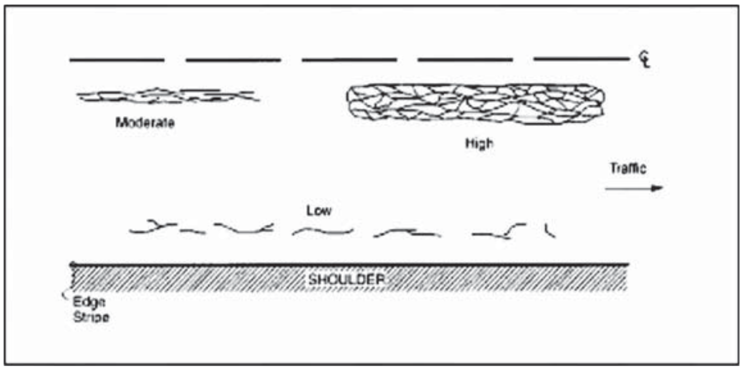
Severity – Not applicable

- ☐ No pretreatment required
- ☐ Slurry seal
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

SECTION 2: PCC Overlay on Existing HMA Pavement Structure

Specific Instructions: A picture for each considered distress type is presented with various alternatives. Please select the alternative that your agency would use or if not shown, please briefly describe the pre-overlay treatment that would be used, if any. A moderate extent should be assumed.

2.01 Fatigue Cracking – Occurs in areas subjected to repeated traffic loadings (wheel paths). Can be a series of interconnected cracks in early stages of development. Develops into many-sided, sharp-angled pieces, usually less than 0.3 m (2 ft) on the longest side, characteristically with a chicken wire/alligator pattern in later stages.



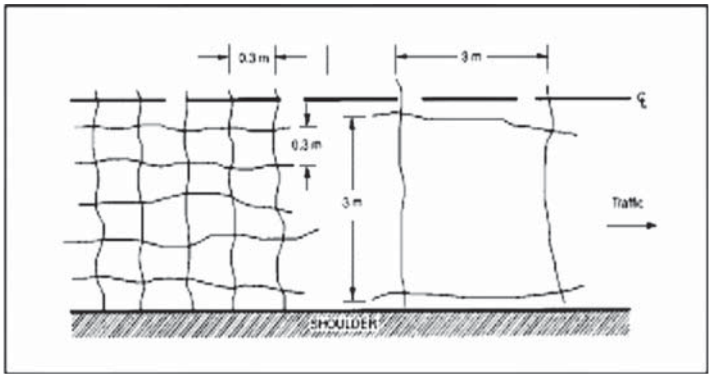
Moderate Severity - Area of interconnected cracks forming a complete pattern; cracks may be slightly spalled, cracks may be sealed; pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove full-depth and replace
- ☐ Other:

High Severity – Area of moderately or severely spalled interconnected cracks forming a complete pattern; pieces may move when subjected to traffic; cracks may be sealed; pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove full depth and replace
- ☐ Other:

2.02 Block Cracking – A pattern of cracks that divides the pavement into approximately rectangular pieces. Rectangular blocks range in size from approximately 0.1 m^2 (0.1 ft^2) to 10 m^2 (11 yd^2).



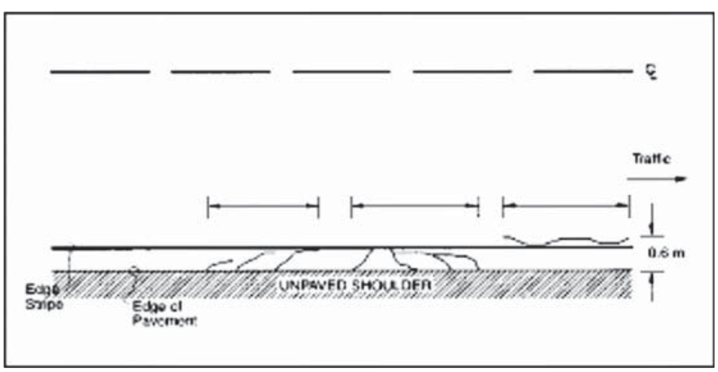
Moderate Severity – Cracks with a mean width > 6 mm (1/4 in) and ≤ 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent low severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

High Severity – Cracks with a mean width > 19 mm (3/4 in); or any crack with a mean width ≤ 19mm (3/4 in) and adjacent moderate to high severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Remove full depth and replace
- ☐ Other:

2.03 Edge Cracking – Applies only to pavements with unpaved shoulders. Crescent-shaped cracks or fairly continuous cracks which intersect the pavement edge and are located within 0.6 m (2 ft) of the pavement edge, adjacent to the shoulder. Includes longitudinal cracks outside of the wheel path and within 0.6 m (2 ft) of the pavement edge.



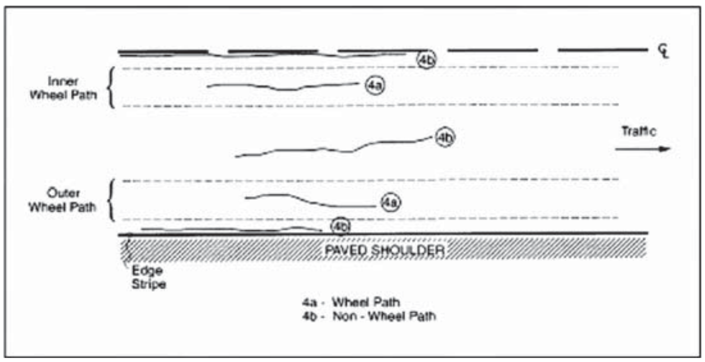
Moderate Severity – Cracks with some breakup and loss of material for up to 10 percent of the length of the affected portion of the pavement.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Other:

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

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Other:

2.04 Longitudinal Cracking – Cracks predominately parallel to pavement centerline. Location within the lane (wheel path versus no-wheel path) is significant.



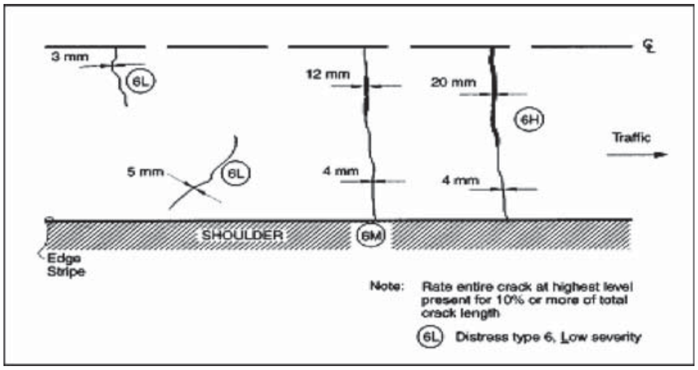
Moderate Severity – Any crack with a mean width > 6mm (1/4 in) and ≤ 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent low severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

High Severity – Any crack with a mean width > 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent moderate to high severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

<u>2.05 Transverse Cracking</u> – Cracks that are predominately perpendicular to pavement certerline.



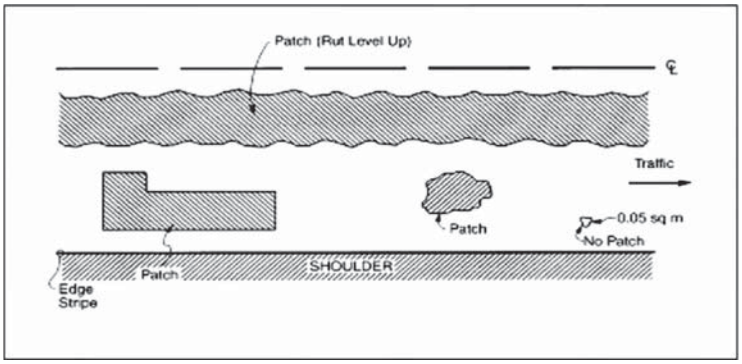
Moderate Severity – Any crack with a mean width > 6 mm (1/4 in) and < 19 mm (3/4 in); or any crack with a mean width < 19 mm (3/4 in) and adjacent low severity random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

High Severity – Any crack with a mean width > 19 mm (3/4 in); or any crack with a mean width ≤ 19 mm (3/4 in) and adjacent moderate to high random cracking.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Other:

<u>2.06 Patch/Patch Deterioration</u> – Portion of pavement surface, greater than 0.1 m^2 (0.1 ft^2), that has been removed and replaced or additional material applied to the pavement after original construction.



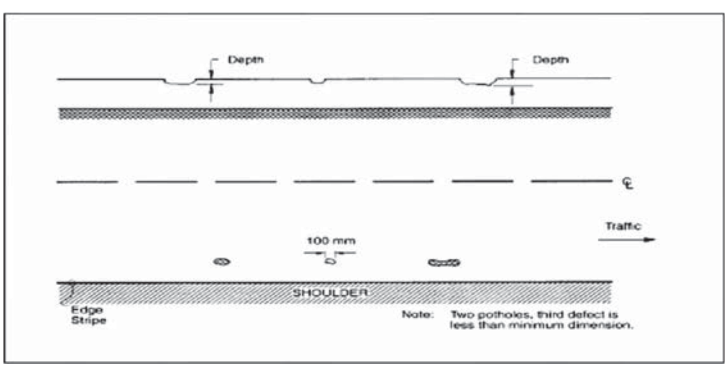
Moderate Severity – Patch has moderate severity distress of any type or rutting from 6 mm (1/4 in) to 12 mm (1/2 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Patch over
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Remove and replace patch
- ☐ Other:

High Severity – Patch has high severity distress of any type including rutting > 12 mm (1/2 in) or the patch has additional different patch material within it; pumping may be evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Patch over
- ☐ Mill out   inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of   inches
- ☐ Hot in-place recycle to a depth of   inches
- ☐ Remove and replace patch
- ☐ Other:

2.07 Potholes – Bowl-shaped holes of various sizes in the pavement surface. Minimum plan dimension is 150 mm (6 in).



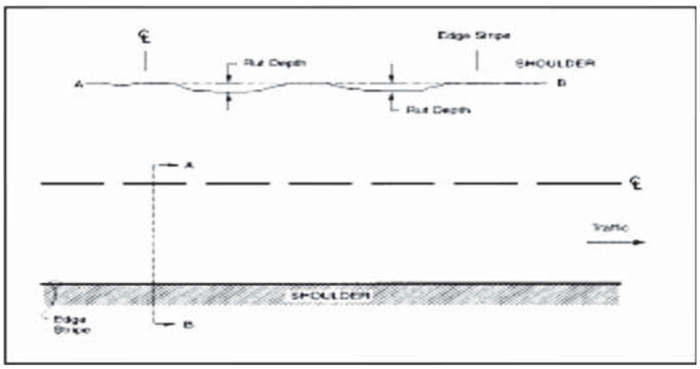
Moderate Severity - Depth ≥ 25 mm (1 in) and < 50 mm (2 in).

☐ No pretreatment required
☐ Patch (briefly describe procedure)
☐ Other:

High Severity – Depth > 50 mm (2 in).

☐ No pretreatment required
☐ Patch (briefly describe procedure)
☐ Other:

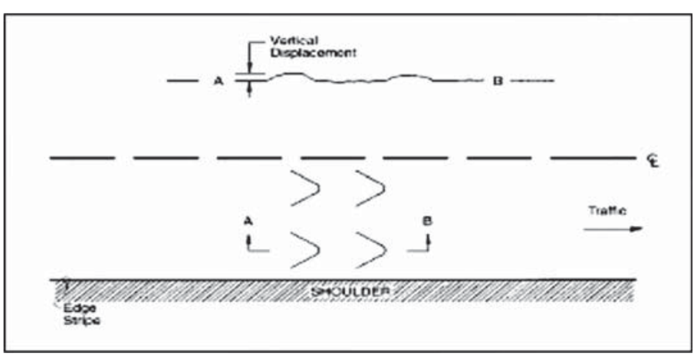
<u>2.08 Rutting</u> – A rut is a longitudinal surface depression in the wheel path. It may have associated transverse displacement.



Severity – Not applicable.

☐ No pretreatment required
☐ Patch (briefly describe procedure)
☐ Micro-surface
☐ Mill out ruts then inlay with HMA
☐ Cold in-place recycle to a depth of   inches
☐ Hot in-place recycle to a depth of   inches
☐ Other:

<u>2.09 Shoving</u> – Shoving is a longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles and is usually located on hills, curves, or at intersections. It may also have associated vertical displacement.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Blade off
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

2.10 Bleeding (Discolorization) – Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. Surface discolorization relative to the remainder of the pavement.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Other:

2.11 Bleeding (Loss of Texture) - Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. Surface is losing surface texture because of excess asphalt.

Severity – Not applicable

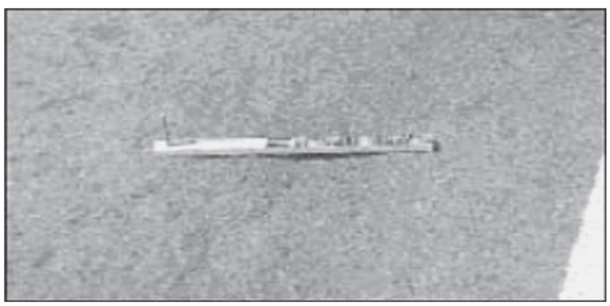
- ☐ No pretreatment required
- ☐ Micro-surface
- ☐ Chip seal
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

2.12 Bleeding (Aggregate Obscured) - Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. The aggregate is obscured by excess asphalt possibly with a shiny, glass-like, reflective surface that may be tacky to the touch.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Treat with hot blotter sand
- ☐ Mill out inches then inlay with HMA
- ☐ Cold in-place recycle to a depth of inches
- ☐ Hot in-place recycle to a depth of inches
- ☐ Other:

2.13 Raveling (Loss of Fine Aggregate) – Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.



Severity – Not applicable

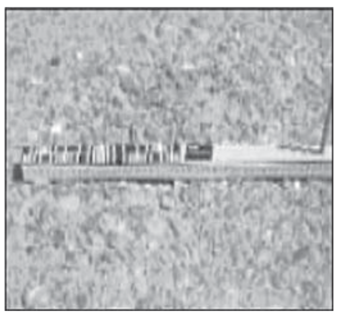
- ☐ No pretreatment required
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

2.14 Raveling (Loss of Fine Aggregate and Some Coarse Aggregate) - Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

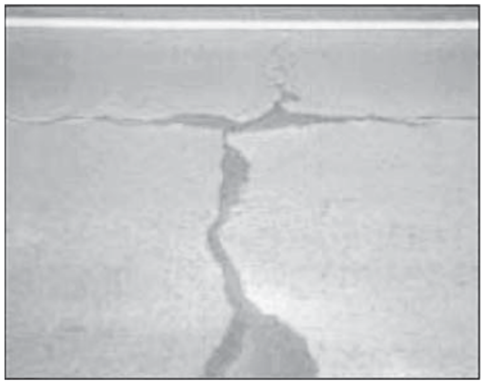
2.15 Raveling (Loss of Coarse Aggregate) - Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

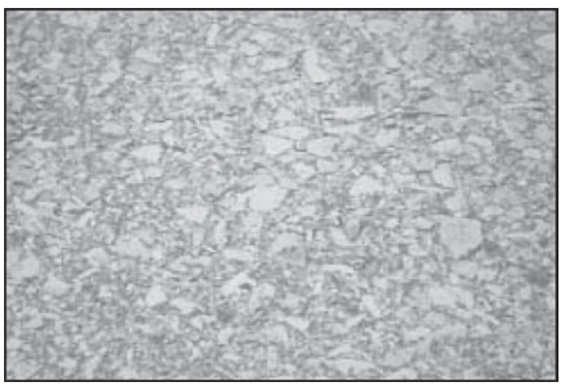
2.16 Water Bleeding and Pumping – Seeping or ejection of water from beneath the pavement through cracks. In some cases, detectable by deposits of fine material left on the pavement surface which were eroded (pumped) from the support layers and have stained the surface.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Identify source of water and take appropriate corrective measures
- ☐ Remove existing HMA and replace
- ☐ Other:

<u>2.17 Polished Aggregate</u> – Surface binder worn away to expose coarse aggregate.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Slurry seal
- ☐ Sand seal
- ☐ Chip seal
- ☐ Micro-surface
- ☐ Other:

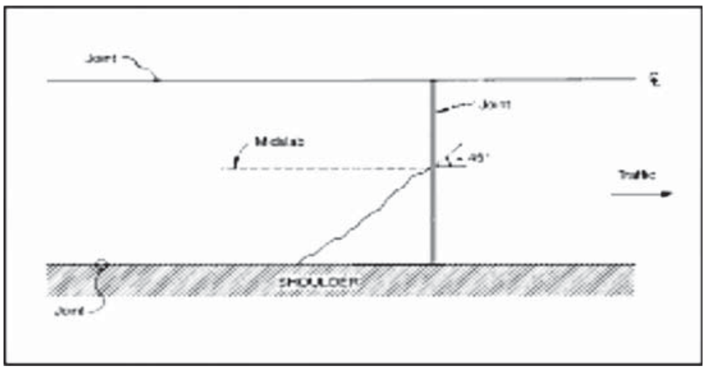
SECTION 3: PCC Overlay on Existing Jointed Concrete Pavement (JCP) Structure

Specific Instructions: A picture for each considered distress type is presented with various alternatives. Please select the alternative that your agency would use or if not shown, please briefly describe the pre-overlay treatment that would be used, if any. A moderate extent should be assumed.

3.01 Rubblization – Does your agency consider rubblization before overlay? Yes ☐ No ☐

3.02 Crack and Seat – Does you agency consider crack and seating before overlay? Yes ☐ No ☐

3.03 Corner Breaks – A portion of the slab separated by a crack, which intersects the adjacent transverse and longitudinal joints describing approximately a 45-degree angle with the direction of traffic. The length of the sides is from 0.3 m (2 ft) to one-half the width of the slab on each side of the corner.



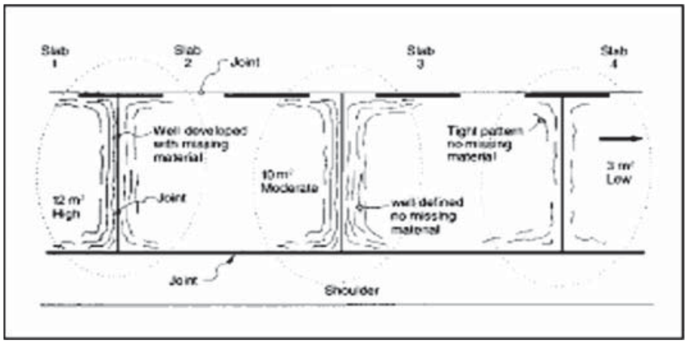
Moderate Severity – Crack is spalled at low severity for more than 10 percent of its total length; or faulting of crack or joint is < 13 mm (1/2 in); and the corner piece is not broken into two or more pieces.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out and crack fill
- ☐ Slab jack
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

High Severity – Crack is spalled at moderate to high severity for more than 10 percent of its total length; or faulting of the crack or joint is $\geq$ 13 mm (1/2 in); or the corner piece is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out and crack fill
- ☐ Slab jack
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

<u>3.04 Durability (“D”) Cracking</u> – Closely spaced crescent-shaped hairline cracking pattern. Occurs adjacent to joints, cracks, or free edges; initiating in slab corners. Dark coloring of the cracking pattern and surrounding area.



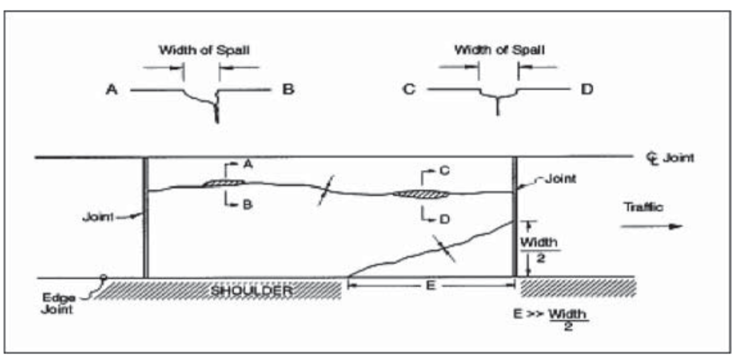
Moderate Severity – “D” cracks are well defined and some small pieces are loose or have been displaced.

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Other:

High Severity – “D” cracking has a well-developed pattern with a significant amount of loose or missing material.

- ☐ No pretreatment required
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

<u>3.05 Longitudinal Cracking</u> – Cracks that are predominately parallel to the pavement centerline.



Moderate Severity – Crack width ≥ 3 mm (1/8 in) and < 13 mm (1/2 in); or with spalling < 75 mm (3 in); or faulting up to 13 mm (1/2 in).

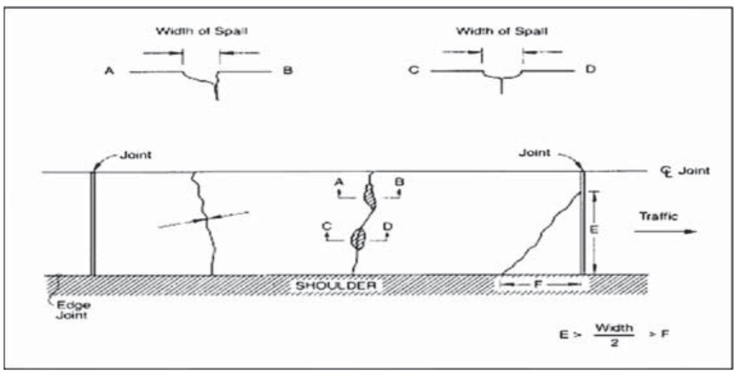
- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out and crack fill

☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

High Severity – Crack width ≥ 13 mm (1/2 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 13 mm (1/2 in).

☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out and crack fill
☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

<u>3.06 Transverse Cracking</u> – Cracks that are predominately perpendicular to the pavement centerline.



Moderate Severity – Crack widths ≥ 3 mm (1/8 in) and < 6 mm (1/4 in); or with spalling < 75 mm (3 in); or faulting up to 6 mm (1/4 in).

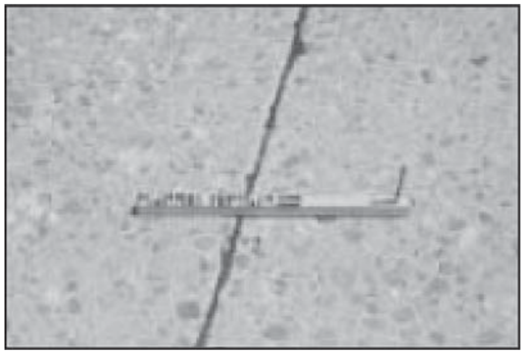
☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out and crack fill
☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

High Severity – Crack widths ≥ 6 mm (1/4 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 6 mm (1/4 in).

☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out and crack fill
☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

<u>3.07 Joint Seal Damage</u> – Any condition that enables incompressible materials or water to infiltrate the joint from the surface. Typical types of joint seal damage are extrusion, hardening, adhesive failure (bonding), cohesive failure (splitting), or complete loss of sealant.

Moderate Severity – 10 percent to 50 percent of the joint will allow incompressible materials or water to infiltrate the joint from the surface.



- ☐ No pretreatment required
- ☐ Reseal without cleaning out
- ☐ Clean out and reseal
- ☐ Other:

High Severity – More than 50 percent of the joint will allow incompressible materials or water to infiltrate the joint from the surface.

- ☐ No pretreatment required
- ☐ Reseal without cleaning out
- ☐ Clean out and reseal
- ☐ Other:

3.08 Spalling of Longitudinal Joints – Cracking, breaking, chipping, or fraying of slab edge within 0.3 m (2 ft) from the face of the longitudinal joint.

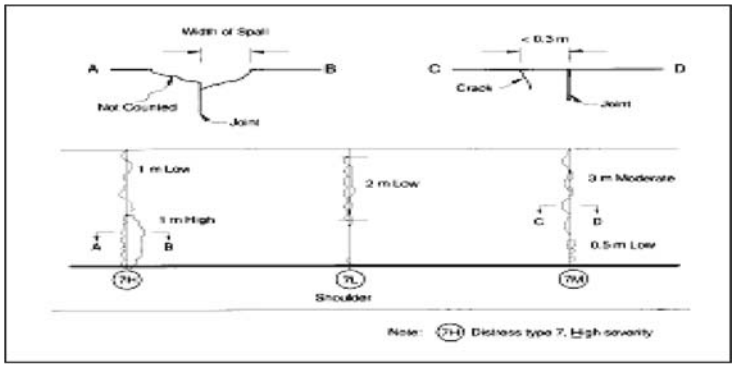
Moderate Severity – Spalls 75 mm (3 in) to 150 mm (6 in) wide, measured to the face of the joint, with loss of material.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Perform a partial-depth spall repair
- ☐ Other:

High Severity – Spalls > 150 mm (6 in) wide, measured to the face of the joint, with loss of material or is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Perform a partial-depth spall repair
- ☐ Perform a full-depth spall repair with new dowel and/or tie bars
- ☐ Other:

<u>3.09 Spalling of Transverse Joints</u> - Cracking, breaking, chipping, or fraying of slab edge within 0.3 m (2 ft) from the face of the transverse joint.



Moderate Severity – Spalls 75 mm (3 in) to 150 mm (6 in) wide, measured to the face of the joint, with loss of material.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Perform a partial-depth spall repair
- ☐ Other:

High Severity – Spalls > 150 mm (6 in) wide, measured to the face of the joint, with loss of material or is broken into two or more pieces or contains patch material.

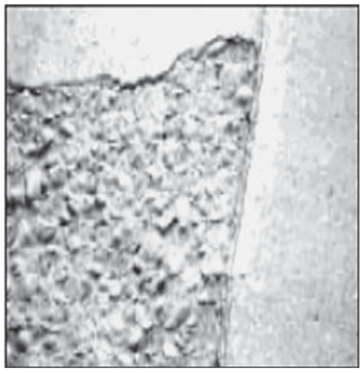
- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Perform a partial-depth spall repair
- ☐ Perform a full-depth spall repair with new dowel and/or tie bars
- ☐ Other:

<u>3.10 Map Cracking</u> – A series of cracks that extend only into the upper surface of the slab. Larger cracks frequently are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.

Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove delaminated area without surface restoration
- ☐ Remove delaminated area with surface restoration
- ☐ Other:

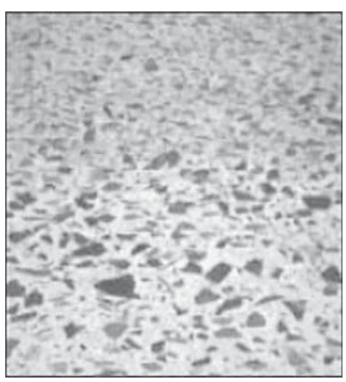
<u>3.11 Scaling</u> – Scaling is the deterioration of the upper concrete slab surface, normally 3mm (1.8 in) to 13 mm (1/2 in), and may occur anywhere over the pavement.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove delaminated area without surface restoration
- ☐ Remove delaminated area with surface restoration
- ☐ Other:

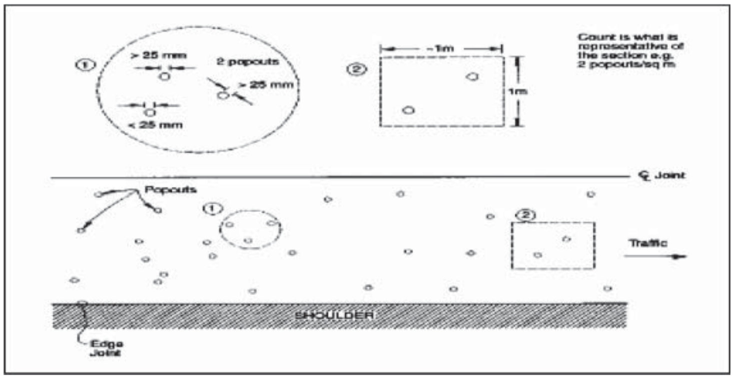
<u>3.12 Polished Aggregate</u> – Surface mortar and texturing worn away to expose coarse aggregate.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Abrade surface – type of abrasion used
- ☐ Other:

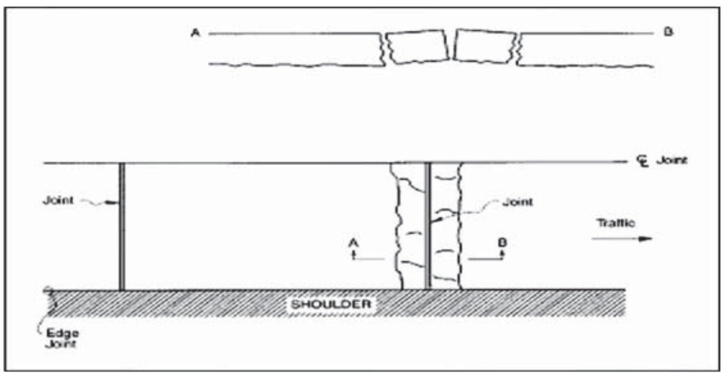
<u>3.13 Popouts</u> – Small pieces of pavement broken loose from the surface, normally ranging in diameter from 25 mm (1 in) to 100 mm (4 in), and depth from 13 mm (1/2 in) to 50 mm (2 in).



Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Repair
- ☐ Other:

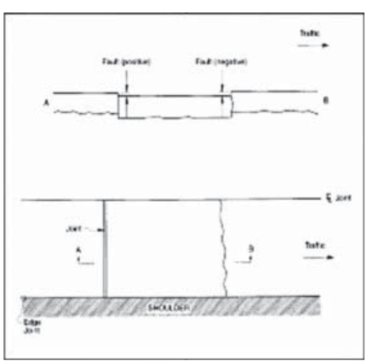
3.14 Blowups – Localized upward movement of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

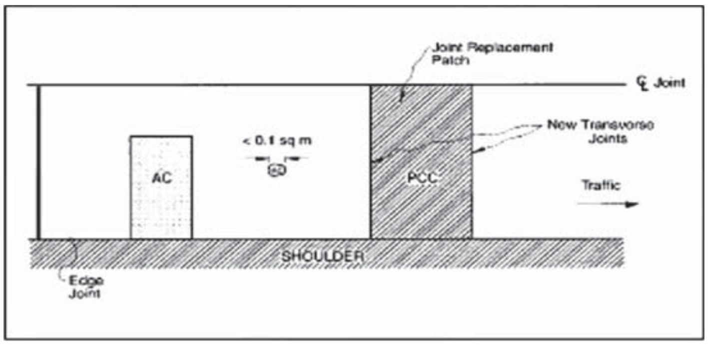
3.15 Faulting of Transverse Joints – Difference in elevation across a joint or crack.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Slab jack
- ☐ Dowel-bar retrofit
- ☐ Grind surface
- ☐ Other:

<u>3.16 Patch/Patch Deterioration</u> – A portion, greater than 0.1 m^2 (0.1 ft^2), or all of the original concrete slab that has been removed and replaced, or additional material applied to the pavement after original construction.



Moderate Severity – Patch has moderate severity distress of any kind or faulting or settlement up to 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Surface seal
- ☐ Remove and replace effected areas
- ☐ Other:

High Severity – Patch has a high severity distress of any kind or faulting or settlement > 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Surface seal
- ☐ Remove and replace effected areas
- ☐ Other:

<u>3.17 Water Bleeding and Pumping</u> – Seeping or ejection of water from beneath the pavement through cracks. In some cases, detectable by deposits of fine material left on the pavement surface which were eroded (pumped) from the support layers and have stained the surface.

Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Install edge drains
- ☐ Subseal
- ☐ Remove and replace slab/s
- ☐ Other:

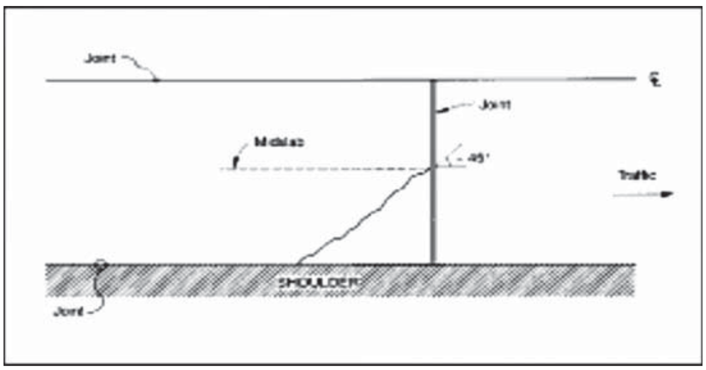
SECTION 4: HMA Overlay on Existing Jointed Concrete Pavement (JCP) Structure

Specific Instructions: A picture for each considered distress type is presented with various alternatives. Please select the alternative that your agency would use or if not shown, please briefly describe the pre-overlay treatment that would be used, if any. A moderate extent should be assumed.

4.01 Rubblization – Does your agency consider rubblization before overlay? Yes ☐ No ☐

4.02 Crack and Seat – Does you agency consider crack and seating before overlay? Yes ☐ No ☐

4.03 Corner Breaks – A portion of the slab separated by a crack, which intersects the adjacent transverse and longitudinal joints describing approximately a 45-degree angle with the direction of traffic. The length of the sides is from 0.3 m (2 ft) to one-half the width of the slab on each side of the corner.



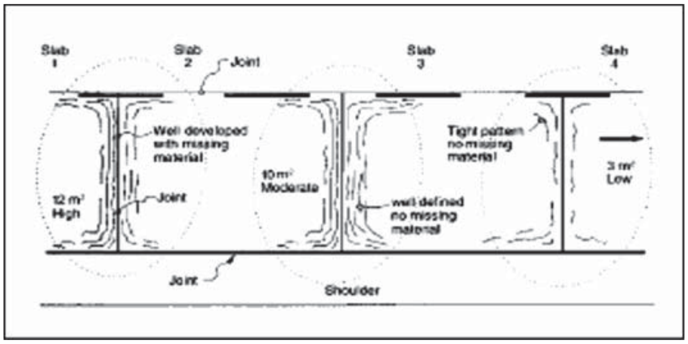
Moderate Severity – Crack is spalled at low severity for more than 10 percent of its total length; or faulting of crack or joint is < 13 mm (1/2 in); and the corner piece is not broken into two or more pieces.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out and crack fill
- ☐ Slab jack
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

High Severity – Crack is spalled at moderate to high severity for more than 10 percent of its total length; or faulting of the crack or joint is $\geq$ 13 mm (1/2 in); or the corner piece is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out and crack fill
- ☐ Slab jack
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

<u>4.04 Durability ("D") Cracking</u> – Closely spaced crescent-shaped hairline cracking pattern. Occurs adjacent to joints, cracks, or free edges; initiating in slab corners. Dark coloring of the cracking pattern and surrounding area.



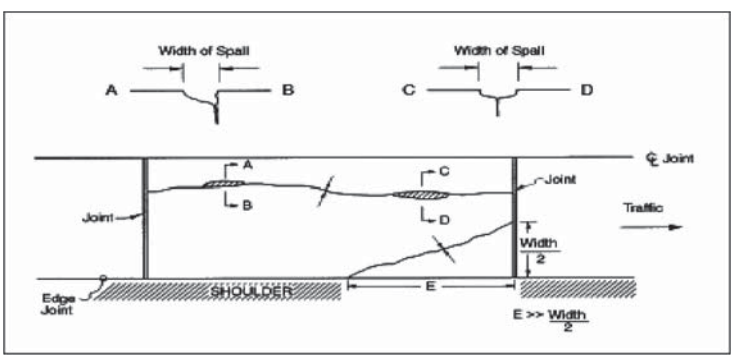
Moderate Severity – "D" cracks are well defined and some small pieces are loose or have been displaced.

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Other:

High Severity – "D" cracking has a well-developed pattern with a significant amount of loose or missing material.

- ☐ No pretreatment required
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

<u>4.05 Longitudinal Cracking</u> – Cracks that are predominately parallel to the pavement centerline.



Moderate Severity – Crack width ≥ 3 mm (1/8 in) and < 13 mm (1/2 in); or with spalling < 75 mm (3 in); or faulting up to 13 mm (1/2 in).

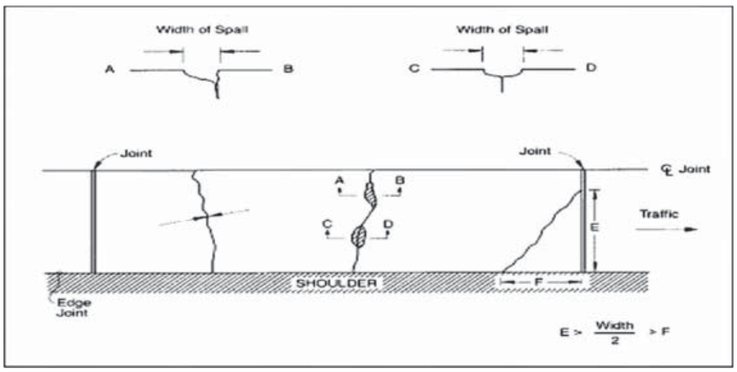
- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out and crack fill

☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

High Severity – Crack width ≥ 13 mm (1/2 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 13 mm (1/2 in).

☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out and crack fill
☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

<u>4.06 Transverse Cracking</u> – Cracks that are predominately perpendicular to the pavement centerline.



Moderate Severity – Crack widths ≥ 3 mm (1/8 in) and < 6 mm (1/4 in); or with spalling < 75 mm (3 in); or faulting up to 6 mm (1/4 in).

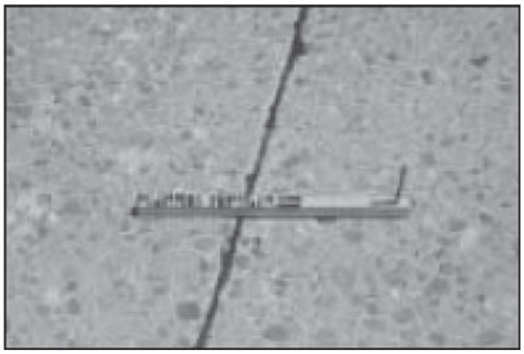
☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out and crack fill
☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

High Severity – Crack widths ≥ 6 mm (1/4 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 6 mm (1/4 in).

☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out and crack fill
☐ Perform a full-depth repair with tie-bars
☐ Remove and replace slab
☐ Other:

<u>4.07 Joint Seal Damage</u> – Any condition that enables incompressible materials or water to infiltrate the joint from the surface. Typical types of joint seal damage are extrusion, hardening, adhesive failure (bonding), cohesive failure (splitting), or complete loss of sealant.

Moderate Severity – 10 percent to 50 percent of the joint will allow incompressible materials or water to infiltrate the joint from the surface.



- ☐ No pretreatment required
- ☐ Reseal without cleaning out
- ☐ Clean out and reseal
- ☐ Other:

High Severity – More than 50 percent of the joint will allow incompressible materials or water to infiltrate the joint from the surface.

- ☐ No pretreatment required
- ☐ Reseal without cleaning out
- ☐ Clean out and reseal
- ☐ Other:

4.08 Spalling of Longitudinal Joints – Cracking, breaking, chipping, or fraying of slab edge within 0.3 m (2 ft) from the face of the longitudinal joint.

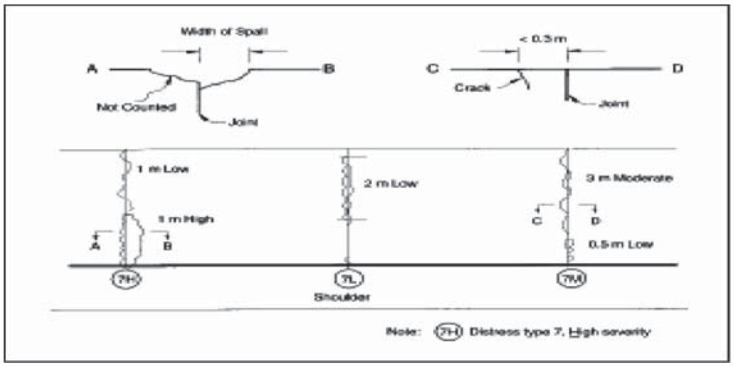
Moderate Severity – Spalls 75 mm (3 in) to 150 mm (6 in) wide, measured to the face of the joint, with loss of material.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Perform a partial-depth spall repair
- ☐ Other:

High Severity – Spalls > 150 mm (6 in) wide, measured to the face of the joint, with loss of material or is broken into two or more pieces or contains patch material.

☐ No pretreatment required
☐ Crack fill without routing
☐ Perform a partial-depth spall repair
☐ Perform a full-depth spall repair with new dowel and/or tie bars
☐ Other:

<u>4.09 Spalling of Transverse Joints</u> - Cracking, breaking, chipping, or fraying of slab edge within 0.3 m (2 ft) from the face of the transverse joint.



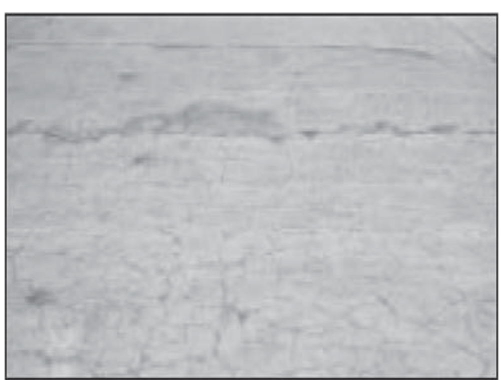
Moderate Severity – Spalls 75 mm (3 in) to 150 mm (6 in) wide, measured to the face of the joint, with loss of material.

☐ No pretreatment required
☐ Crack fill without routing
☐ Perform a partial-depth spall repair
☐ Other:

High Severity – Spalls > 150 mm (6 in) wide, measured to the face of the joint, with loss of material or is broken into two or more pieces or contains patch material.

☐ No pretreatment required
☐ Crack fill without routing
☐ Perform a partial-depth spall repair
☐ Perform a full-depth spall repair with new dowel and/or tie bars
☐ Other:

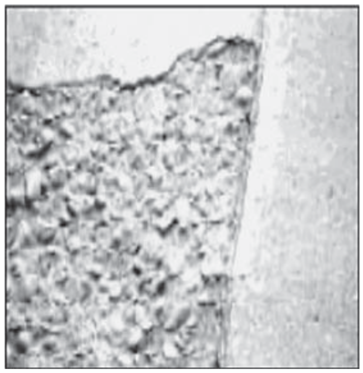
<u>4.10 Map Cracking</u> – A series of cracks that extend only into the upper surface of the slab. Larger cracks frequently are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.



Severity – Not applicable.

☐ No pretreatment required
☐ Surface seal
☐ Remove delaminated area without surface restoration
☐ Remove delaminated area with surface restoration
☐ Other:

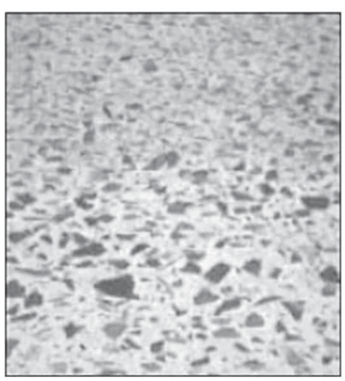
4.11 Scaling – Scaling is the deterioration of the upper concrete slab surface, normally 3mm (1.8 in) to 13 mm (1/2 in), and may occur anywhere over the pavement.



Severity – Not applicable

☐ No pretreatment required
☐ Surface seal
☐ Remove delaminated area without surface restoration
☐ Remove delaminated area with surface restoration
☐ Other:

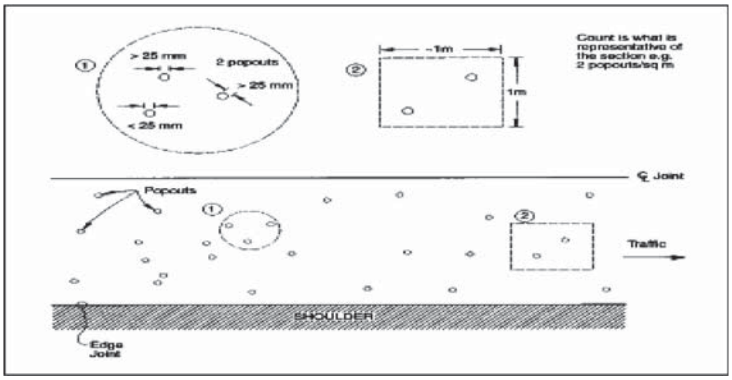
4.12 Polished Aggregate – Surface mortar and texturing worn away to expose coarse aggregate.



Severity – Not applicable

☐ No pretreatment required
☐ Abrade surface – type of abrasion used
☐ Other:

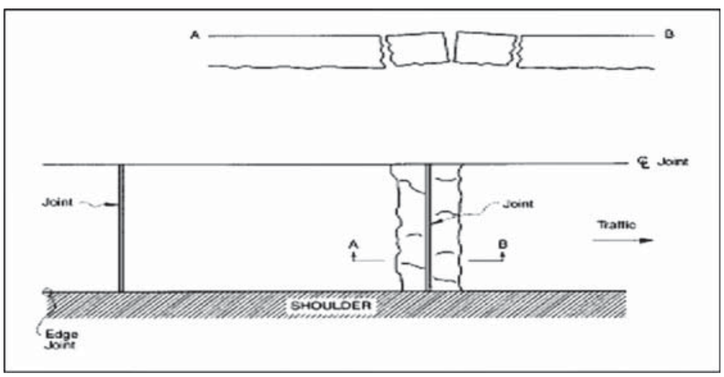
4.13 Popouts – Small pieces of pavement broken loose from the surface, normally ranging in diameter from 25 mm (1 in) to 100 mm (4 in), and depth from 13 mm (1/2 in) to 50 mm (2 in).



Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Repair
- ☐ Other:

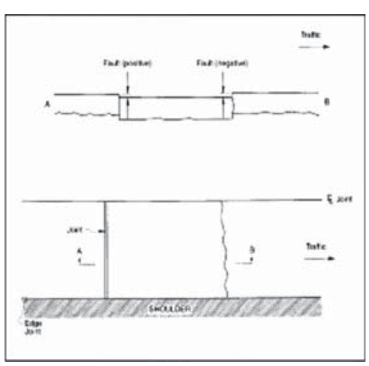
<u>4.14 Blowups</u> – Localized upward movement of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Remove and perform a full-depth repair
- ☐ Remove and replace slab
- ☐ Other:

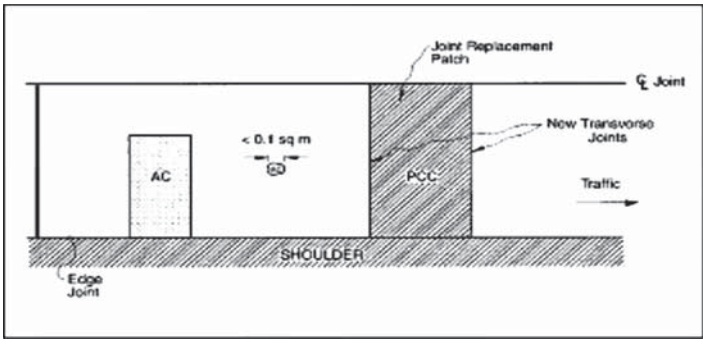
<u>4.15 Faulting of Transverse Joints</u> – Difference in elevation across a joint or crack.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Slab jack
- ☐ Dowel-bar retrofit
- ☐ Grind surface
- ☐ Other:

<u>4.16 Patch/Patch Deterioration</u> – A portion, greater than 0.1 m^2 (0.1 ft^2), or all of the original concrete slab that has been removed and replaced, or additional material applied to the pavement after original construction.



Moderate Severity – Patch has moderate severity distress of any kind or faulting or settlement up to 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Surface seal
- ☐ Remove and replace effected areas
- ☐ Other:

High Severity – Patch has a high severity distress of any kind or faulting or settlement > 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Surface seal
- ☐ Remove and replace effected areas
- ☐ Other:

<u>4.17 Water Bleeding and Pumping</u> – Seeping or ejection of water from beneath the pavement through cracks. In some cases, detectable by deposits of fine material left on the pavement surface which were eroded (pumped) from the support layers and have stained the surface.

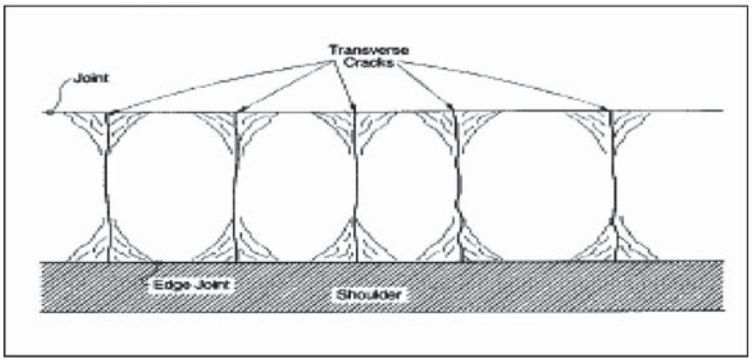
Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Install edge drains
- ☐ Subseal
- ☐ Remove and replace slab/s
- ☐ Other:

SECTION 5: PCC Overlay on Existing Continually Reinforced Concrete Pavement (CRCP) Structure

Specific Instructions: A picture for each considered distress type is presented with various alternatives. Please select the alternative that your agency would use or if not shown, please briefly describe the pre-overlay treatment that would be used, if any. A moderate extent should be assumed.

5.01 Durability ("D") Cracking – Closely spaced crescent-shaped hairline cracking pattern. Occurs adjacent to joints, cracks, or free edges; initiating in slab corners. Dark coloring of the cracking pattern and surrounding area.



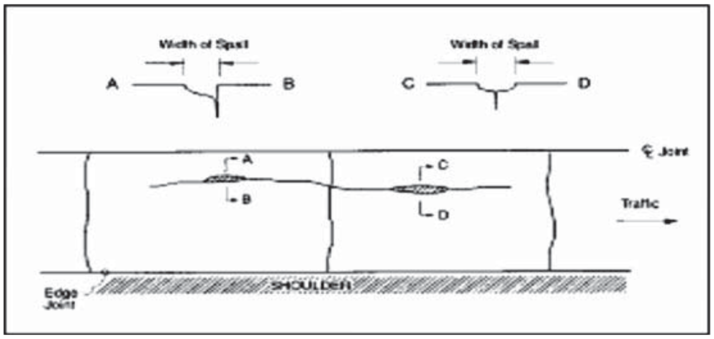
Moderate Severity – "D" cracks are well defined and some small pieces are loose or have been displaced.

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Other:

High Severity – "D" cracking has a well-developed pattern with a significant amount of loose or missing material.

- ☐ No pretreatment required
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Other:

<u>5.02 Longitudinal Cracking</u> – Cracks that are predominately parallel to the pavement centerline.



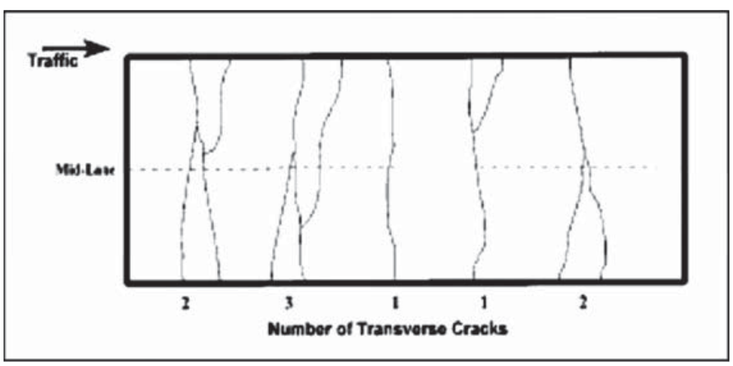
Moderate Severity – Crack width ≥ 3 mm (1/8 in) and < 13 mm (1/2 in); or with spalling < 75 mm (3 in); or faulting up to 13 mm (1/2 in).

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Crack width ≥ 13 mm (1/2 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 13 mm (1/2 in).

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

<u>5.03 Transverse Cracking</u> – Cracks that are predominately perpendicular to the pavement centerline.



Moderate Severity – Crack widths ≥ 3 mm (1/8 in) and < 6 mm (1/4 in); or with spalling < 75 mm (3 in); or faulting up to 6 mm (1/4 in).

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Crack widths ≥ 6 mm (1/4 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 6 mm (1/4 in).

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

5.04 Map Cracking – A series of cracks that extend only into the upper surface of the slab. Larger cracks frequently are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.

Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove delaminated area without surface restoration
- ☐ Remove delaminated area with surface restoration
- ☐ Other:

5.05 Scaling – Scaling is the deterioration of the upper concrete slab surface, normally 3mm (1.8 in) to 13 mm (1/2 in), and may occur anywhere over the pavement.

Severity – Not applicable

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove delaminated area without surface restoration

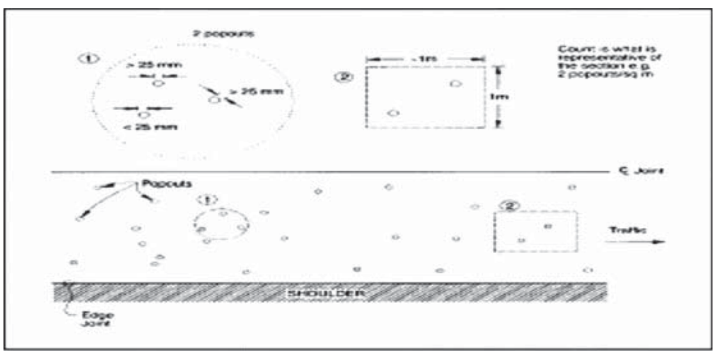
☐ Remove delaminated area with surface restoration
☐ Other:

<u>5.06 Polished Aggregate</u> – Surface mortar and texturing worn away to expose coarse aggregate.

Severity – Not applicable

☐ No pretreatment required
☐ Abrade surface – type of abrasion used
☐ Other:

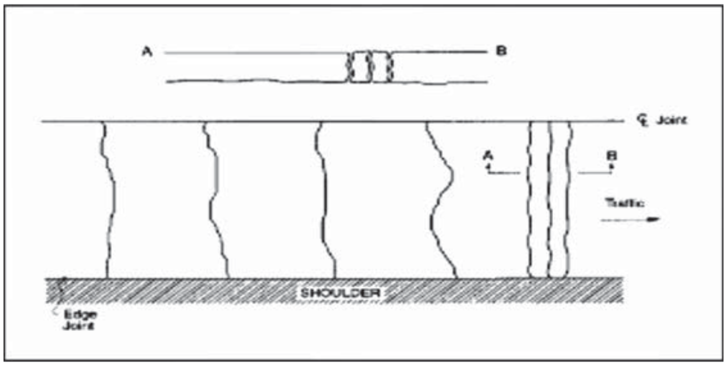
<u>5.07 Popouts</u> – Small pieces of pavement broken loose from the surface, normally ranging in diameter from 25 mm (1 in) to 100 mm (4 in), and depth from 13 mm (1/2 in) to 50 mm (2 in).



Severity – Not applicable.

☐ No pretreatment required
☐ Repair
☐ Other:

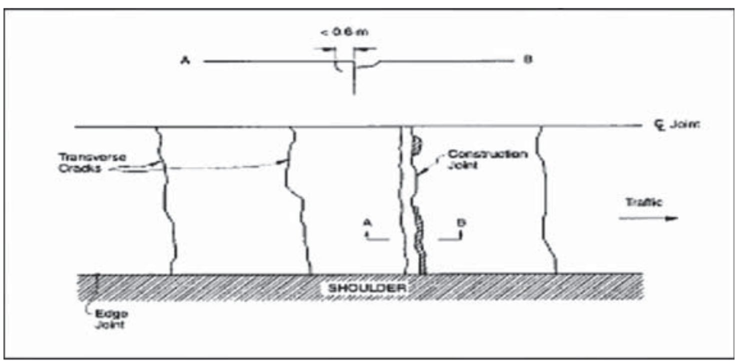
<u>5.08 Blowups</u> – Localized upward movement of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Remove and perform full-depth repair
- ☐ Other:

5.09 Transverse Construction Joint Deterioration – Series of closely spaced transverse cracks or a large number of interconnecting cracks occurring near the construction joint.



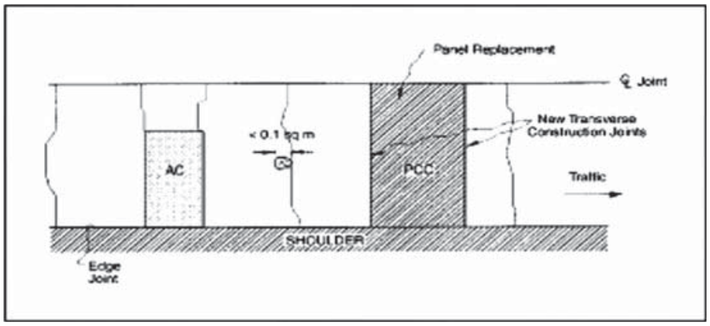
Moderate Severity – Spalling < 75 mm (3 in) exists within 0.6 m (2 ft) of the construction joint.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Spalling $\geq$ 75 mm (3 in) and breakup exists within 0.6 m (2 ft) of the construction joint.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

5.10 Patch/Patch Deterioration – A portion, greater than 0.1 m^2 (0.1 ft^2), or all of the original concrete slab that has been removed and replaced, or additional material applied to the pavement after original construction.



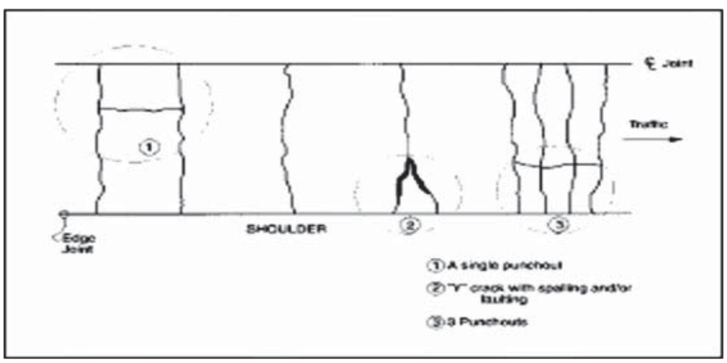
Moderate Severity – Patch has moderate severity distress of any kind or faulting or settlement up to 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out with HMA inlay
- ☐ Other:

High Severity – Patch has a high severity distress of any kind or faulting or settlement > 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out with HMA inlay
- ☐ Other:

5.11 Punchouts – The area enclosed by two closely spaced (usually < 0.6 m (2 ft)) transverse cracks, a short longitudinal crack, and the edge of the pavement or a longitudinal joint. Also includes "Y" cracks that exhibit spalling, breakup, or faulting.



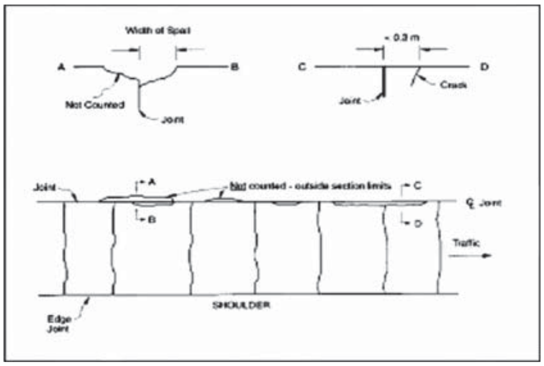
Moderate Severity – Spalling ≥ 75 mm (3 in) and < 150 mm (6 in) or faulting ≥ 6 mm (1/4 in) and < 13 mm (1/2 in).

- ☐ No pretreatment required
- ☐ Perform a partial-depth repair
- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Spalling ≥ 150 mm (6 in) or concrete within the punch-out is punched down by ≥ 13 mm (1/2 in) or is loose and moves under traffic or is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Perform a partial-depth repair
- ☐ Perform a full-depth repair
- ☐ Other:

<u>5.12 Spalling of Longitudinal Joints</u> – Cracking, breaking, chipping, or fraying of slab edges within 0.3 m (2 ft) of the longitudinal joint.



Moderate Severity - Spalls 75 mm (3 in) wide, measured to the face of the joint, with loss of material.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Perform a partial-depth spall
- ☐ Other:

High Severity - Spalls > 150 mm (6 in) wide, measured to the face of the joint, with loss of material or is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Perform a partial-depth spall
- ☐ Perform a full-depth spall
- ☐ Other:

<u>5.13 Water Bleeding and Pumping</u> – Seeping or ejection of water from beneath the pavement through cracks. In some cases, detectable by deposits of fine material left on the pavement surface which were eroded (pumped) from the support layers and have stained the surface.

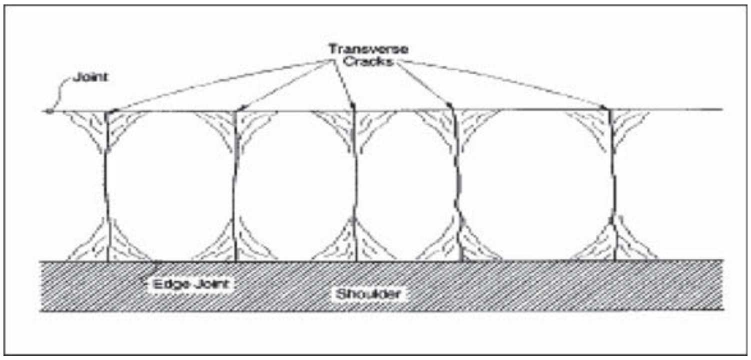
Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Install edge drains
- ☐ Subseal
- ☐ Perform a full-depth repair
- ☐ Other:

SECTION 6: HMA Overlay on Existing Continually Reinforced Concrete Pavement (CRCP) Structure

Specific Instructions: A picture for each considered distress type is presented with various alternatives. Please select the alternative that your agency would use or if not shown, please briefly describe the pre-overlay treatment that would be used, if any. A moderate extent should be assumed.

6.01 Durability ("D") Cracking – Closely spaced crescent-shaped hairline cracking pattern. Occurs adjacent to joints, cracks, or free edges; initiating in slab corners. Dark coloring of the cracking pattern and surrounding area.



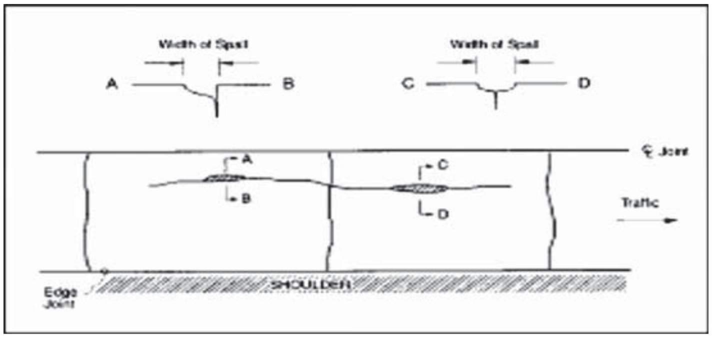
Moderate Severity – "D" cracks are well defined and some small pieces are loose or have been displaced.

- ☐ No pretreatment required
- ☐ Surface seal
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Other:

High Severity – "D" cracking has a well-developed pattern with a significant amount of loose or missing material.

- ☐ No pretreatment required
- ☐ Remove and perform a partial-depth repair
- ☐ Remove and perform a full-depth repair
- ☐ Other:

6.02 Longitudinal Cracking – Cracks that are predominately parallel to the pavement centerline.



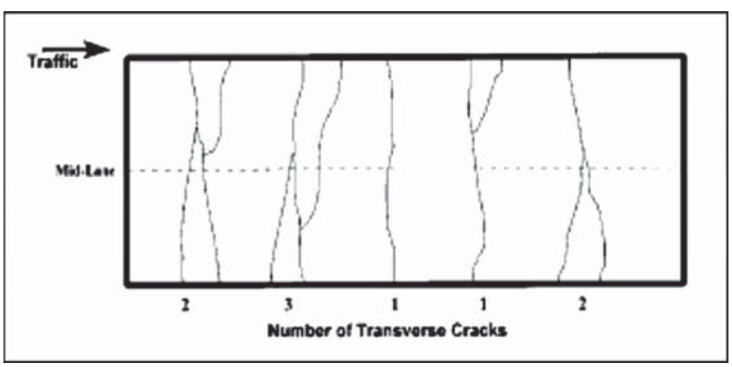
Moderate Severity – Crack width ≥ 3 mm (1/8 in) and < 13 mm (1/2 in); or with spalling < 75 mm (3 in); or faulting up to 13 mm (1/2 in).

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Crack width ≥ 13 mm (1/2 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 13 mm (1/2 in).

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

6.03 Transverse Cracking – Cracks that are predominately perpendicular to the pavement centerline.



Moderate Severity – Crack widths ≥ 3 mm (1/8 in) and < 6 mm (1/4 in); or with spalling < 75 mm (3 in); or faulting up to 6 mm (1/4 in).

☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out, and crack fill
☐ Perform a full-depth repair
☐ Other:

High Severity – Crack widths ≥ 6 mm (1/4 in); or with spalling ≥ 75 mm (3 in); or faulting ≥ 6 mm (1/4 in).

☐ No pretreatment required
☐ Crack fill without cleaning out
☐ Clean out, and crack fill
☐ Perform a full-depth repair
☐ Other:

6.04 Map Cracking – A series of cracks that extend only into the upper surface of the slab. Larger cracks frequently are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.

Severity – Not applicable.

☐ No pretreatment required
☐ Surface seal
☐ Remove delaminated area without surface restoration
☐ Remove delaminated area with surface restoration
☐ Other:

6.05 Scaling – Scaling is the deterioration of the upper concrete slab surface, normally 3mm (1.8 in) to 13 mm (1/2 in), and may occur anywhere over the pavement.

Severity – Not applicable

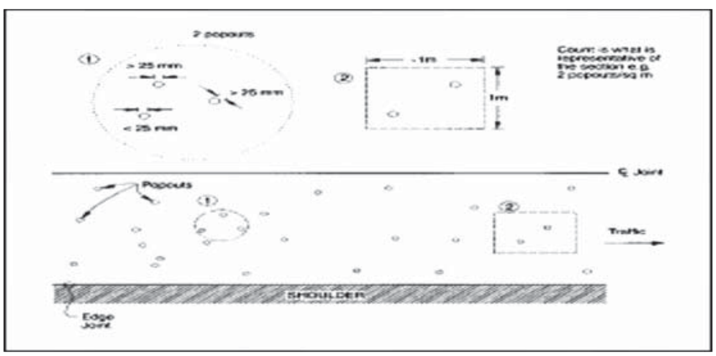
☐ No pretreatment required
☐ Surface seal
☐ Remove delaminated area without surface restoration
☐ Remove delaminated area with surface restoration
☐ Other:

<u>6.06 Polished Aggregate</u> – Surface mortar and texturing worn away to expose coarse aggregate.

Severity – Not applicable

☐ No pretreatment required
☐ Abrade surface – type of abrasion used
☐ Other:

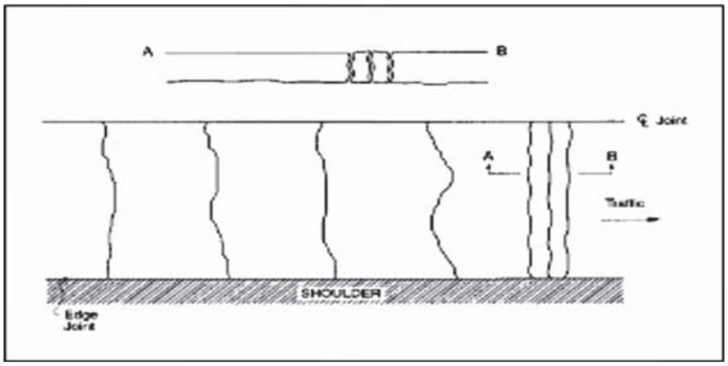
<u>6.07 Popouts</u> – Small pieces of pavement broken loose from the surface, normally ranging in diameter from 25 mm (1 in) to 100 mm (4 in), and depth from 13 mm (1/2 in) to 50 mm (2 in).



Severity – Not applicable.

☐ No pretreatment required
☐ Repair
☐ Other:

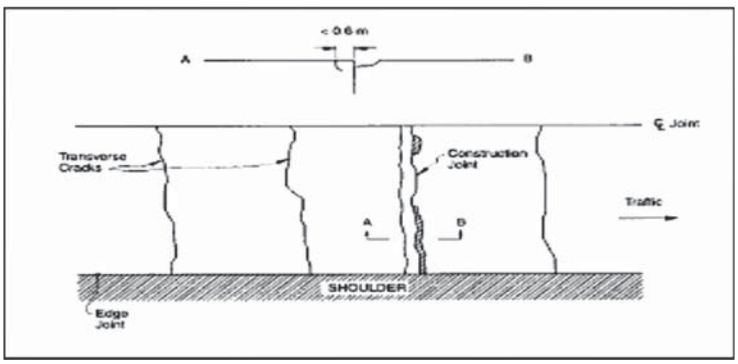
<u>6.08 Blowups</u> – Localized upward movement of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area.



Severity – Not applicable

- ☐ No pretreatment required
- ☐ Remove and perform full-depth repair
- ☐ Other:

<u>6.09 Transverse Construction Joint Deterioration</u> – Series of closely spaced transverse cracks or a large number of interconnecting cracks occurring near the construction joint.



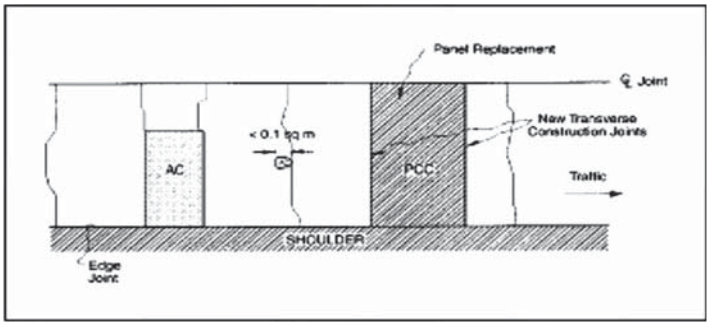
Moderate Severity – Spalling < 75 mm (3 in) exists within 0.6 m (2 ft) of the construction joint.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Spalling ≥ 75 mm (3 in) and breakup exists within 0.6 m (2 ft) of the construction joint.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Clean out, and crack fill
- ☐ Perform a full-depth repair
- ☐ Other:

6.10 Patch/Patch Deterioration – A portion, greater than 0.1 m^2 (0.1 ft^2), or all of the original concrete slab that has been removed and replaced, or additional material applied to the pavement after original construction.



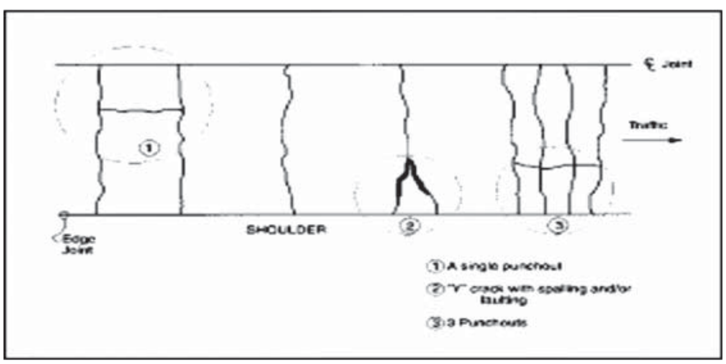
Moderate Severity – Patch has moderate severity distress of any kind or faulting or settlement up to 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out with HMA inlay
- ☐ Other:

High Severity – Patch has a high severity distress of any kind or faulting or settlement > 6 mm (1/4 in); pumping is not evident.

- ☐ No pretreatment required
- ☐ Crack fill without routing
- ☐ Route, clean out, and crack fill
- ☐ Mill out with HMA inlay
- ☐ Other:

6.11 Punchouts – The area enclosed by two closely spaced (usually < 0.6 m (2 ft)) transverse cracks, a short longitudinal crack, and the edge of the pavement or a longitudinal joint. Also includes "Y" cracks that exhibit spalling, breakup, or faulting.



Moderate Severity – Spalling ≥ 75 mm (3 in) and < 150 mm (6 in) or faulting ≥ 6 mm (1/4 in) and < 13 mm (1/2 in).

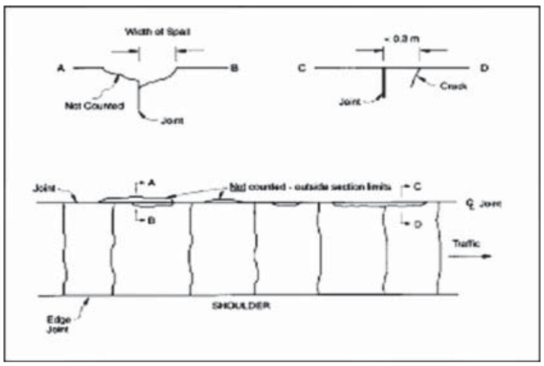
- ☐ No pretreatment required
- ☐ Perform a partial-depth repair

- ☐ Perform a full-depth repair
- ☐ Other:

High Severity – Spalling ≥ 150 mm (6 in) or concrete within the punch-out is punched down by ≥ 13 mm (1/2 in) or is loose and moves under traffic or is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Perform a partial-depth repair
- ☐ Perform a full-depth repair
- ☐ Other:

<u>6.12 Spalling of Longitudinal Joints</u> – Cracking, breaking, chipping, or fraying of slab edges within 0.3 m (2 ft) of the longitudinal joint.



Moderate Severity - Spalls 75 mm (3 in) wide, measured to the face of the joint, with loss of material.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Perform a partial-depth spall
- ☐ Other:

High Severity - Spalls > 150 mm (6 in) wide, measured to the face of the joint, with loss of material or is broken into two or more pieces or contains patch material.

- ☐ No pretreatment required
- ☐ Crack fill without cleaning out
- ☐ Perform a partial-depth spall
- ☐ Perform a full-depth spall
- ☐ Other:

<u>6.13 Water Bleeding and Pumping</u> – Seeping or ejection of water from beneath the pavement through cracks. In some cases, detectable by deposits of fine material left on the pavement surface which were eroded (pumped) from the support layers and have stained the surface.

Severity – Not applicable.

- ☐ No pretreatment required
- ☐ Install edge drains
- ☐ Subseal
- ☐ Perform a full-depth repair
- ☐ Other:

- END OF QUESTIONNAIRE AND THANK YOU -

Abbreviations used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation