PROJECT NO. 09-11

Pavement Maintenance Guidelines for General Aviation Airport Management

DRAFT FINAL GUIDEBOOK

Prepared for
Airport Cooperative Research Program
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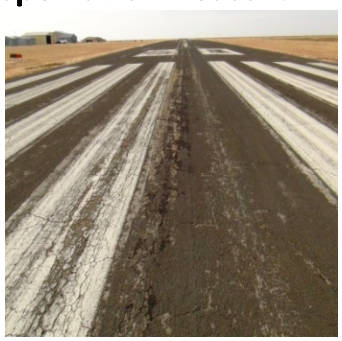

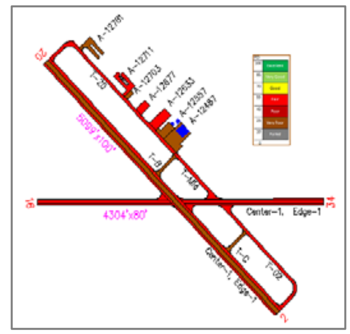



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DISCLAIMER

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AUTHOR ACKNOWLEDGEMENTS

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Thomas J. Freeman, Program Manager of the Pavement Mangement Program was the Project Director and Principal Investigator. The other authors of this report are Dr. Jeff Boroweic, Dr. Bryan Wilson, Dr. Maryam Sakhaifar, Assistant Professor of Civil Engineering, Texas A&M University. In addition, the work of Dr. Wayne J. Seiler, P.E., All About Pavements, Inc. was instrumental in developing the questionnaire and decision trees. Mark Coppock and Chris Bratlein were the principal programmers on the Airport pavement Maintenance Tool.

ABSTRACT

This report documents the recommended and acceptable maintenance treatments for General Aviation airports. A questionnaire was developed and submitted to experienced aviation personnel from different regions, states, and airports of different sizes that captured their thinking on what treatments should be applied to airport pavements with different combinations of distress, severity, and extent of distress. The answers were collated, massaged, and put into decision matrices that reflect the sorting criteria listed above of climatic zone, airport classification, and pavement type.

The estimated cost of performing the repairs was calculated and a relative benefit was determined. A web-based airport pavement maintenance recommendation tool was developed that walks the user through the decision process provides maintenance options as outputs in PDF format. Both the recommended and acceptable treatments for those conditions are provided.

SUMMARY

In this project, a questionnaire was developed to capture the thought process of experienced airport practitioners from different regions, states, and airports of different sizes on what treatments should be applied to airport pavements with different combinations of distress, severity, and extent of distress. Their answers were collated, massaged, and put into decision matrices that reflect the sorting criteria listed above of climatic zone, airport classification, and pavement type.

After calculating, using MicroPAVER, the Pavement Condition Index (PCI), for each distress type, severity, and extent in the questionnaire, the impact (in terms of change in PCI and life of the treatment) and cost of performing each repair type selected were calculated and a relative benefit was determined, based on the responses in the questionnaire for the length of time a specific treatment lasts and modifying a default PCI performance curve by reducing the deterioration rate for the length of time the treatment lasts.

A web-based airport pavement maintenance recommendation tool was developed that walks the user through the decision process which provides help in explaining distresses and severities, treatment type desciptions, explains benefits and costs, allows multiple distress type-severity-extent combinations, and outputs in PDF format, the recommended and acceptable treatments for those conditions.

CHAPTER 1. INTRODUCTION

Project Overview

General Aviation (GA) facilities are the lifeblood of many communities and according to the International Council of Aircraft Owner and Pilot Associations (IOAPA), GA includes “approximately 370,000 aircraft and 1,300,000 pilots.” They also note that GA activities “create hundreds of thousands of jobs and tens of billions of dollars for the countries these activities serve.” In spite of this vast impact on the economy, most GA airports do not have pavement expertise on staff. Many of the lower volume airports are unattended and do not have any staff staff familiar with distresses types, treatment types, or pavement performance. To address this need for expertise, this research project will provide an easy to use guide to identify distress types, descriptions of common maintenance treatments, and the appropriate maintenance techniques for different levels of service.

The objective of this research was to develop guidance and a web-based airport pavement maintenance recommendation tool to assist airport management at general aviation airports to determine the most efficient and effective maintenance options to optimize pavement life.

Layout of the Guidebook

The guidebook includes:

- Identification of pavement maintenance treatment methods and techniques;
- Ways to identify the cause of pavement distress;
- Lists of the pros/cons of each pavement maintenance treatment option;
- Treatment life expectancies;
- Expected treatment costs by region;
- A cost benefit analysis of the pavement maintenance options;
- A web-based airport pavement maintenance recommendation tool to help the airport manager decide the best course of action based on the condition of the pavement, the type and frequency of aircraft activity, their climatic region, and when maintenance activities are no longer an effective approach;
- Photos/graphics of actual pavement issues to assist in pavement distress identification; and,
- List of resources.

Questionnaire Development

In order to properly and accurately guide the user through the treatment selection process, a questionnaire was developed that would lead the experienced aviation professional through a series of text and pictures of pavements, with the most common airport distresses, and in different conditions (severity and extent) to capture the decisions of experience airport personnel and arrive at a specific treatment (Figure 1).   The list of distress combinations was prepared prior to sending the questionnaire, but the results from the questionnaire (Table 1 and 2) affirm the selection of these distress combinations.   Tables 3 and 4 list the distress type/severity/extents used in the questionnaire for both asphalt (AC) and concrete (PCC) pavements.

Transverse cracking:

Cracks extending across the pavement at approximately right angles to the center line or laydown direction.

Which treatments, if any, would you recommend?

CONDITION:
TRANSVERSE cracks spaced **50 FT APART** - LOW severity (< 1/4" wide)

	Recommendation	
	Acceptable	Best
DO NOTHING	☐	☐
Crack seal / fill	☐	☐
Rejuvinator	☐	☐
Fog seal OR coal tar seal	☐	☐
Slurry / micro OR sand seal	☐	☐
Chip seal OR cape seal	☐	☐
Asphalt overlay OR mill+overlay	☐	☐
Patch OR reconstruct area	☐	☐
TOO SEVERE (Rehab. / reconstruct)	☐	☐
Other	☐	☐

Figure 1. Layout of Asphalt Distress Type Selection Survey.

Table 1. Responses to Question on Asphalt Distress Types.

Question: Which of these ASPHALT distress types do you HAVE or HAVE HAD at your airport or general aviation airports you support?				
Answer	**Percentage of responses to each option**			
	Little or none	Some	Prevalent	I'm unsure/ No response
Weathering	12%	53%	30%	5%
Raveling	26%	44%	20%	10%
Longitudinal cracking	5%	32%	59%	4%
Edge Cracking	14%	49%	28%	9%
Transverse Cracking	5%	38%	52%	5%
Block Cracking	32%	38%	16%	14%
Reflection Cracking	21%	48%	20%	11%
Fatigue Cracking	23%	47%	23%	6%
Potholes	73%	15%	2%	10%
Rutting	63%	25%	5%	7%
Bleeding	56%	20%	4%	21%
Patching	30%	47%	14%	10%
Roughness (bumps, sags, swells)	42%	43%	6%	9%
Other	11%	5%	1%	83%

Table 2. Responses to Question on Concrete Distress Types

Question: Which of these CONCRETE distress types do you HAVE or HAVE HAD at your airport or general aviation airports you support?				
	Little or none	Some	Prevalent	I'm unsure/ No response
Joint seal damage	3%	63%	30%	5%
Joint / corner spalls	15%	53%	25%	8%
Joint separation	33%	43%	13%	13%
Corner breaks	15%	63%	20%	2%
Mid-slab cracking (transverse, linear, or diagonal)	28%	50%	18%	5%
Faulting / settlement	40%	50%	3%	8%
Patching	28%	53%	13%	8%
Popouts	43%	45%	5%	8%
Pumping	60%	28%	3%	10%
Map cracking / scaling	28%	48%	10%	15%
Durability "D" cracking	35%	40%	8%	18%
ASR (alkali silica reaction)	40%	28%	13%	20%
Shattered slab	48%	33%	8%	13%
Other	10%	3%	0%	88%

Table 3. AC Distress Types Used in the Questionnaire.

Starting to weather (losing fines)
Definitely Weathering (losing fines)
Starting to ravel (larger rock starting to pop out)
Definitely raveling and losing rock
A few longitudinal cracks or joints Low severity (< ¼” wide)
A few longitudinal cracks or joints Medium severity (> ¼” to <1” wide or starting to break down
A few longitudinal cracks or joints High severity (> 1” wide or severely spalled causing FOD
Many longitudinal cracks- Low severity (< ¼”” wide)
Many longitudinal cracks- Medium severity (> ¼” and < 1” wide or starting to break down)
Many longitudinal cracks- High severity (> 1” wide or severely spalled and causing FOD.)
Few edge cracks- Low severity (< ¼” wide)
Few edge cracks- Medium severity (> ¼” to < 1” wide, or starting to break down)
Few edge cracks- High severity (> 1” wide, or sev spall causing FOD)
Transverse cracks spaced 50 feet apart Low severity (< ¼”” wide)
Transverse cracks spaced 50 feet apart Medium severity (> ¼” and < 1” wide, or start to break down)
Transverse cracks spaced 50 feet apart High severity (> 1” wide, or severely spalled with FOD)
Transverse cracks spaced 20 feet apart Low severity (< ¼” wide)
Transverse cracks spaced 20 feet apart Medium severity (> ¼” and < 1” wide, or start to break down)
Transverse cracks spaced 20 feet apart High severity (> 1” wide, or severely spall with FOD)
Block crack Low severity (< ¼” wide)
Block crack Medium severity (> ¼” and < 1” wide or starting to break down)
Block crack High severity (> 1” wide or severely spalled with FOD)
Reflection crack Low severity (< ¼” wide)
Reflection crack Medium severity (> ¼” and < 1” wide or starting to break down)
Reflection crack High severity (> 1” wide, or severely spalled causing FOD)
Fatigue crack 10% area Low severity (fine longitudinal cracks, few interconnecting cracks)
Fatigue crack 10% of area Medium severity (cracking is developed into a pattern, some spalling)
Fatigue crack 10% of area High severity (interconnected cracking pattern is well defined, spalled edges, pieces are missing or move under traffic)
Fatigue crack 30% of area Low severity (fine longitudinal cracks with few interconnecting cracks)
Fatigue crack 30% of area Medium severity (cracking is developed into a pattern, some spalling)
Fatigue crack 30% of area High severity (interconnected cracking pattern is well defined, spalled edges, pieces are missing or move under traffic)
Patch 10% of area Low severity (patches in good condition)
Patch 10% of area Medium severity (patches somewhat deteriorated)
Patch 10% of area High severity (patches are deteriorated and rough)
Patch 30% of area Low severity (patches in good condition)
Patch 30% of area Medium severity (patches somewhat deteriorated)
Patch 30% of area High severity (patches are deteriorated and rough)
Roughness, minimal distress, isolated, long wavelength swells
Roughness, minimal distress, many long wavelength swells
Roughness, minimal distress, no swells, many short wavelength bumps

Table 4. PCC Distress Types Used in the Questionnaire.

Joint seal is about 5 years old still in Good condition
Joint seal damage Low severity (8 years old, getting stiff, losing some adhesion, mostly intact)

Joint seal damage Medium severity (less than 10% of length has stripping, extrusion, weed growth, hardening, loss of bond, or missing)
Joint seal damage High severity (significant length has stripping, extrusion, weed growth, hardening, loss of bond, or missing
Joint and corner spalls Low severity (little or no FOD)
Joint and corner spalls Medium severity (some FOD, broken into 2-3 pieces, loose pieces)
Joint and corner spalls High severity (significant FOD, severely frayed or broken)
Mid-panel cracking on 20% of the slabs Low severity (< 1/8" wide or sealed, minor or no spalling)
Mid-panel cracking on 20% of the slabs Medium severity (> 1/8" to 1" wide, or moderately spalled (some FOD), or filled unsatisfactorily)
Mid-panel cracking on 20% of the slabs High severity (severely spalled with definite FOD, or unsealed >1")
Mid-panel cracking on 40% of the slabs Low severity (< 1/8" wide or sealed, minor or no spalling)
Mid-panel cracking on 40% of the slabs Medium severity (> 1/8" to 1" wide, or moderately spalled (some FOD), or filled unsatisfactorily.)
Mid-panel cracking on 40% of the slabs High severity (severely spalled with definite FOD, or unsealed >1")
Corner break on 10% of the slabs Low severity (< 1/8" wide, or sealed, and little or minor spalling (no FOD))
Corner break on 10% of the slabs Medium severity (> 1/8" and < 1" wide, moderately spalled (some FOD), sealant in unsatisfactory condition or the broken corner is lightly cracked)
Corner break on 10% of the slabs High severity (> 1" wide, filled or non-filled crack is severely spalled, definite FOD potential, or area between the corner break is severely cracked)
Corner break on 30% of the slabs Low severity (< 1/8" wide, or sealed, and little or minor spalling (no FOD))
Corner break on 30% of the slabs Medium severity (> 1/8" and < 1" wide, moderately spalled (some FOD), sealant in unsatisfactory condition or the broken corner is lightly cracked)
Corner break on 30% of the slabs High severity (> 1" wide, filled or non-filled crack is severely spalled, definite FOD potential, or area between the corner break is severely cracked)
10% of slabs are Shattered Low severity (broken into 4-5 pieces predominantly defined by low severity cracks)
10% of slabs are Shattered Medium severity (broken into 4-5 pieces with 15% of the cracks of medium severity (no high severity cracks); or slab is broken into 6+ or more pieces with over 85% cracks low severity)
10% of slabs are Shattered High severity (broken into 4-5 pieces with some or all cracks high severity; or slab is broken into 6+ pieces with over 15% of medium or high severity.
30% of slabs are Shattered Low severity (broken into 4-5 pieces predominantly defined by low severity cracks)
30% of slabs are Shattered Medium severity (broken into 4-5 pieces with 15% of the cracks of medium severity (no high severity cracks), or slab is broken into 6+ or more pieces with over 85% cracks low severity)
30% of slabs are Shattered High severity (broken into 45 pieces with some or all cracks high severity; or slab is broken into 6+ pieces with over 15% of medium or high severity
30% of area has Patches Low severity (good condition)
30% of area has Patches Medium severity (somewhat deteriorated)
30% of area has Patches High severity (deteriorated and rough)
50% of area has Patches Low severity (good condition)
50% of area has Patches Medium severity (somewhat deteriorated)
50% of area has Patches High severity (deteriorated and rough)

10% of slabs are Faulted Low severity (< 1/4" difference)
10% of slabs are Faulted Medium severity (> 1/4" and < 1/2" difference)
10% of slabs are Faulted High severity (> 1/2" difference)
30% of slabs are Faulted Low severity (< 1/4" difference)
30% of slabs are Faulted Medium severity (> 1/4" and < 1/2" difference)
30% of slabs are Faulted High severity (> 1/2" difference)

Chapter 2 and Appendix A and Appendix B describe airfield pavement distress. This information is also contained in the web-based airport pavement maintenance recommendation tool.

The questions were reviewed and refined to provide the proper focus. The revised questionnaire was sent to selected airport personnel in Texas with whom we are closely acquainted (two at the Texas Department of Transportation, Aviation Division and two from general aviation airports) to help locate areas that still needed improvement. During this evaluation, the researchers asked and explained each question.

Improvements were made to the survey after the first four aviation personnel completed the survey. One of the most important changes from this review was that the respondents strongly preferred to take the survey at their own pace rather than our original plan of walking them through the survey. The revised questionnaire required several hours to complete and respondents wanted the option to start and stop as their schedules allowed. The original questionnaire had separate treatment selections for Aprons and Taxiways, but due to the length of the survey, these had to be eliminated.

The survey was revised to use the Qualtrics survey software. This was different survey software than initially selected, but Texas A&M University switched to Qualtrics after the survey was initially revised. An advantage of the Qualtrics survey software was that it allowed for logical routing of the respondent. For example, if the respondent had only asphalt pavement, no questions regarding concrete were displayed. In addition, if the response was that the respondent had less than six years of experience, or four years plus a degree in a related field, they were not shown questions on the life of the treatments. Our approach was to have only experienced personnel take the survey, but this was not always successful.

The re-revised survey was finalized in Qualtrics and research personnel were assigned a list of states to call. Previously, a list of aviation or aeronautic officials and their contact information for each state had been developed. A list of FAA Division personnel to be called was also compiled.

Airport Classifications

The FAA classifies airports in its National Plan of Integrated Airport Systems (NPIAS) according to the type of services provided. This is done to define which airports are eligible for Airport Improvement Program (AIP) funding. The first four categories (commercial service, primary, cargo service, and reliever) all have distinct descriptions of use type and quantitative measures to aid in classifications. The final category, general aviation, is simply defined as an airport that does not meet any of the other criteria. In the past, congress has provided a few sub-categories for general aviation (Table 5), though these definitions were inadequate, with notable discrepancies in airport function vs. category. There was still a very large group of airports lumped under the “general aviation” term with no categorical distinction.

Table 5. Statutory Definitions of General Aviation Airports (*General Aviation Airports: A National Asset.* Federal Aviation Administration, May 2012.

Nonprimary commercial service airports (121) are publically owned airports with scheduled air carrier service and annual passenger boardings between 2,500 and 10,000.
Reliever airports (268) are high activity general aviation airports that provide general aviation with alternatives to congested hubs (where their presence might cause additional delay).
General aviation airports (2,563) are defined as public airports in a state that have at least 2,500 passenger boardings each year and is receiving scheduled passenger aircraft service.

Therefore, beginning in 2010 the FAA funded research to develop a classification system for this final category of airports. This work is summarized in the publication *General Aviation Airports: A National Asset*. The study assigned general aviation airports into the following sub-categories: National, Regional, Local, and Basic. The categories are intended to focus on the role of the airport in communities and the nation, and not necessarily on airport size and features. A description of each category is given in Table 6. With the 2010 study and a follow-up study, over 90 percent of the nearly 3,000 GA airports were successfully categorized (*General Aviation Airports: A National Asset.* Federal Aviation Administration, May 2012).

Table 6. New Category Definitions of General Aviation Airports (*General Aviation Airports: A National Asset.* Federal Aviation Administration, May 2012).

Criteria Used to Define the New National Category (all numbers are annualized)
1) 5,000+ instrument operations, 11+ based jets, 20+ international flights, or 500+ interstate departures; or
2) 10,000+ enplanements and at least 1 charter enplanement by a large certificated air carrier; or
3) 500+ million pounds of landed cargo weight.

Criteria Used to Define the New Regional Category (all numbers are annualized)
1) Metropolitan Statistical Area (MSA) (Metro or Micro) and 10+ domestic flights over 500 miles, 1,000+ instrument operations, 1+ based jet, or 100+ based aircraft; or
2) The airport is located in a metropolitan or micropolitan statistical area, and the airport meets the definition of commercial service.

Criteria Used to Define the New Local Category (all numbers are annualized)
1) 10+ instrument operations and 15+ based aircraft; or
2) 2,500+ passenger enplanements.

Criteria Used to Define the New Basic Category (all numbers are annualized)
1) 10+ based aircraft; or
2) 4+ based helicopters, or
3) The airport is located 30+ miles from the nearest NPIAS airport; or
4) The airport is identified and used by the U.S. Forest Service, or U.S. Marshals, or U.S. Customs and Border Protection (designated, international, or landing rights), or U.S. Postal Service (air stops), or has Essential Air Service; or
5) The airport is a new or replacement facility activated after January 1, 2001; and
6) Publicly owned or privately owned and designated as a reliever with a minimum of 90 based aircraft.

Climatic Zone

Another factor in the decision making process is the climate where the airport is located. There are different stresses, needs, and potentially maintenance treatments for an airport in the dry-cold areas versus the wet-warm areas. In dry areas, crack sealing can be less important than in wet areas. Similarly, cold areas have to plan for snow removal which would be rare in the warm areas. To account for these potential differences in treatments and timing of treatments, responses were classified according to the appropriate climate zone (Figure 2). These climatic zones were developed as part of the Long-Term Pavement Performance (LTPP) research.

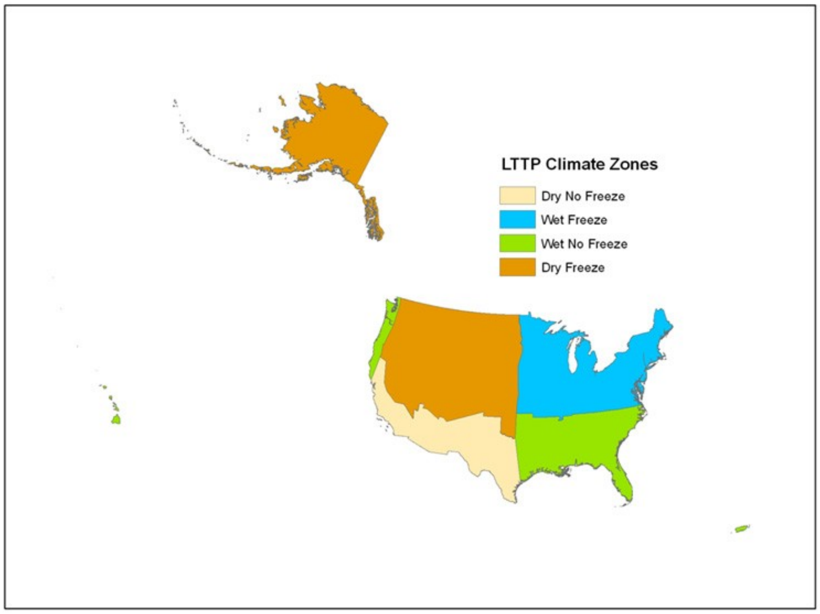


Figure 2. LTPP Climatic Zones (Federal Highway Administration, Office of Highway Policy Information, Field Manual, Chapter 4: DATA REQUIREMENTS AND SPECIFICATIONS, March 2014).

Data Collection

Initial calls began in mid-February 2015 and continued through mid-May 2015. As part of the call, ACRP and TTI were identified, the purpose of the survey and an outline of the proposed tool were explained. The February and early March calls were mostly unsuccessful as there were several blizzards and heavy snowfall events that shut down many governmental agencies. Starting in mid-March, calls were more successful. Once a state agency was contacted and the correct person was reached, an e-mail containing a brief introduction to the survey and a user-specific link to the survey was sent. One question that was asked only of State aviation officials was to recommend up to four GA airports (National, Regional, Local, or Basic) in their state that had experienced personnel, who were then added to the list of people to be contacted. If after five attempts a state or airport could not be reached and did not return any phone calls, they were moved further down the list of priorities. All states were called and 36 states sent responses. As part of that response, each state agency was to answer the treatment selection questions as though they were an airport manager at a National, Regional, Local, or Basic an airport type.

A tremendous number of calls and e-mails were made and sent. Multiple calls were made to 163 individuals or agencies and e-mails were sent to 137. Those that were contacted and sent a survey, but had not responded in a timely manner (two weeks) received follow up e-mails and calls (87 people). A final e-mail stating that the active portion of the survey was being closed on May 8, 2015. Eighty-nine responses were received, although some were incomplete.

The distribution of responses seems to provide a representative cross section of states, regions, and airport types (Table 7 on following page).

Table 7. Distribution of Responses.

Responses			Representing Airports	
State Aviation/Aeronautics	36		National Airport	11
National Airport	7		Regional Airport	26
Regional Airport	15		Local Airport	28
Local Airport	18		Basic Airport	24
Basic Airport	13		**Total**	**89**
Total	**89**			

By FAA Region	
Alaskan	0
Western Pacific	9
Central	8
Eastern	8
Great Lakes	14
New England	12
NW Mountain	13
Southern	17
Southwest	8
Total	**89**

Again, not all questions were completed so the number of responses to an individual question will vary.

CHAPTER 2. AIRFIELD PAVEMENT DISTRESS

Pavement Management Principles

The goal of an airport pavement management program is to maintain operational and safe pavement assets in the most cost effective manner, while minimizing the long-term pavement costs. Historic management practices involved choosing a treatment to address the **current** needs (i.e. applying a “fix” after a problem has significantly developed). In many cases, the airport sponsor will only rotate through a few familiar treatments without considering which treatment is actually the best long-term approach (Federal Aviation Administration, *Airport Pavement Management Program.* FAA Advisory Circular, AC No. 150/5380-7A, U.S. Department of Transportation, September 2006). While we call this “historic” practice, the truth is this is the current practice at the majority of GA airports in the country.

To illustrate the ideal approach for pavement management, an example pavement condition life cycle curve is shown in Figure 3. The pavement condition creeps along the *Satisfactory* and *Fair* range for several years before entering into the *Poor* range and quickly dropping through *Very poor* and into *Serious* rating. Preventative maintenance should be done in the *Good-Fair* range which delays the significant drop in condition. Just before this drop, at the transition of *Fair* to *Poor*, a rehabilitation treatment should be done to avoid very costly rehabilitation/ reconstruction work if the condition were to drop into serious disrepair. Too often, GA management is spending their scarce resources at the bottom of this curve and not making incremental investments for preservation at the top.

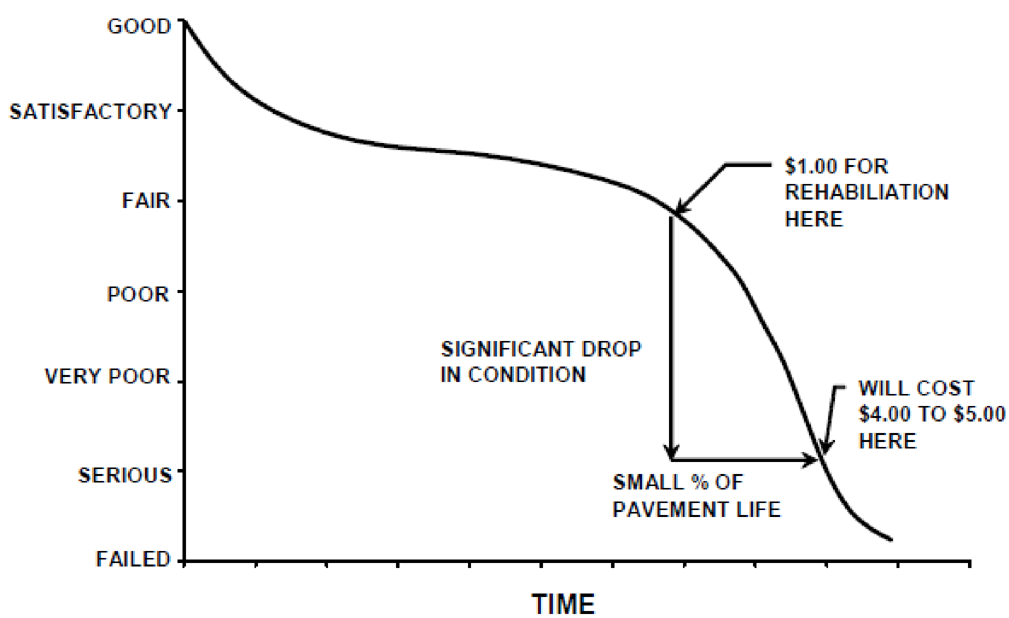


Figure 3. Typical Pavement Condition Life Cycle (Shahin, M. Y. *Pavement Preservation for Airports, Roads, and Parking Lots*. Springer, 2005).

The goal of a formal airport pavement management system (APMS) is to take the guess work out of when and what type of treatment to apply. It will help the airport sponsor inventory the pavement, track pavement condition over time, and recommend the right treatment at the correct time for preventative maintenance and rehabilitation activities. The recommendation of the APMS then assists the sponsor in lobbying for maintenance funding by clearly illustrating a monetary benefit for investing in preventative maintenance (Hajek, J., J. W. Hall, and D. K. Hein. *Common Airport Pavement Maintenance Practices: A Synthesis of Airport Practice.* Airport Cooperative Research Program, Transportation Research Board of the National Academies, Washington, D.C.).

The essential components of an APMS, as defined in a 2006 FAA Advisory Circular (FAA Advisory Circular, AC No. 150/5380-7A) are:

- **Data base** to store information about pavement structure, maintenance history, traffic data, and pavement condition.
- **System capabilities.** Predicting future pavement condition; Determining optimum M&R plans for the budget; Determining budget requirements; and Facilitating prioritization of M&R projects.

These components, however, are only useful if routine pavement evaluations are conducted using objective measures of pavement condition. This process will be described later in this guidebook.

Applications to GA Airports

While the benefits of an APMS are understandable and well-documented, the reality is that most GA airports will have a very hard time buying into this approach. The challenges come down to two common points: little or no training, and very limited funding.

- **Little or No Training**
  - Do not understand basic principles of pavement management (their expertise is often in other fields of aviation or something else entirely).
  - No training to perform objective condition assessments.
  - Not familiar with APMS software.
  - Excessive personnel turnover.

- **Very Limited Funding**
  - Struggle to justify purchase of APMS software.
  - No full-time personnel to assist in pavement management.
  - Limited funding to contract for pavement assessment.
  - Limited or delayed funding to apply optimal maintenance or rehabilitation treatments at the right time. (Resulting in “too-little too-late.”).

As one engineer stated, “Given the choice of spending $10,000 to fund a study for future maintenance needs or to keep their lights on, [General Aviation airport sponsors] are likely going to pay to keep the lights on” (Humphries, E. and S.-J. Lee. *An Evaluation of Pavement Preservation Maintenance Activities at General Aviation Airports in Texas: Current Practices, Perceived Effectiveness, Costs, and Planning.* San Marcos).

Condition Assessment of Airfield Pavements

Pavement condition is a broad and widely researched topic. However condition is measured, it should relate to the ability of the pavement to perform its function effectively and safely. For a runway, the condition indicators should relate to the ability of aircrafts to accelerate or decelerate in a smooth manner, and also relate to the frictional capacity needed to stop the plane at landing. Often a condition indicator is not a direct measurement of the pavement functionality, but rather a surrogate measure of properties that relate to, or signal future risks to, the desired functionality.

There are various guidelines for defining and quantifying these distresses. These include the LTPP Program (Miller, J. S. and W. Y. Bellinger. *Distress Identification Manual for the Long-Term Pavement Performance Program.* Report No. FHWA-RD-03-031, U.S. Department of Transportation: Federal Highway Administration, June 2003) and various state- and other agency-specific guidelines (Lenz, R. W. *Pavement Design Guide*, TxDOT Manual System, Texas Department of Transportation, http://onlinemanuals.txdot.gov/txdotmanuals /pdm/pavement_evaluation.htm., and *Pavement Preservation Manual - Part 2: Pavement Condition Data*, Office of Asset Management, Utah Department of Transportation, Salt Lake City, UT). Airport pavements are almost exclusively measured by the guidelines developed by the U.S. Army Corps of Engineers, published in *FAA Advisory Circular on Guidelines and Procedures for Maintenance of Airport Pavements (*FAA Federal Aviation Administration. *Guidelines and Procedures for Maintenance of Airport Pavements,* U.S. Department of Transportation, September 28, 2007*)* and ASTM D5340 (Standard Test Method for Airport Pavement Condition Index Surveys).

The most widely used indicator for airfield pavements is surface distress. Measurements of several distresses are often consolidated to a single value like the Pavement Condition Index (PCI). Other condition indicators include friction (skid number), roughness, foreign object debris, and structural integrity (modulus from non-destructive testing). A survey of the use of these indicators is given in Table 8.

To decide which data is most important to collect, one may follow the procedures in ASTM E1777-09 (Standard Guide for Prioritization of Data Needs for Pavement Management).

Table 8. Use of Performance Indicators for Pavement Condition Assessment (Hajek, J., J. W. Hall, and D. K. Hein).

Pavement Characteristic	Runways		Taxiways and Other Facilities	
	Usage (%)	Average Frequency, years	Usage (%)	Average Frequency, years
PCI	78	3.4	54	3.3
Roughness	12	N/A	4	N/A
Friction	22	N/A	8	N/A
FWD testing	18	3.7	12	N/A

Based on the survey.
Notes: FWD = Falling Weight Deflectometer; N/A = Data are not available or are insufficient.

The most critical pavement condition index of concern for GA, as pavement maintenance is concerned, is surface distress. Surface distress is any visible imperfection of the pavement that indicates a structural deficiency.

Checking for foreign object debris (FOD) should be done on a routine basis, but should not be passed off as a distress survey. Routine skid, roughness, and structural measurements may not be necessary, if at all, for most GA airports. These can be contracted out on an as-needed basis.

A brief discussion of each of the surface distresses is included as Appendix A and B and is contained in the web-based airport pavement maintenance recommendation tool. Each entry describes the appearance of the distress, possible root causes, and how it is measured.

Pavement Condition Rating

Individual distress measurements are often consolidated into a distress index to simplify condition analysis and decision making. The Pavement Condition Index (PCI), used by airports, is also described in the FAA Advisory Circular 150/5380-7B, “Aiport Pavement Management Program (PMP)”. Over a given area of pavement, distress types are recorded and assigned a unique deduct value based on severity and extent. All the deduct values are then analyzed to produce a “corrected” deduct value, which is subtracted from 100 to obtain the PCI. A PCI of 100, therefore, represents a perfect condition, while a PCI value of 0 represents a completely failed condition. Values in between these limits are interpreted from the rating scale shown in Table 9. The table also gives guidance on the generally recommended pavement treatment approach for a given condition rating (Hajek, J., J. W. Hall, and D. K. Hein).

Table 9. Pavement Condition Index Rating and Recommended Pavement Treatment.

PCI	Rating	Description	Pavement Treatment
100	Good	Only minor distresses.	Routine maintenance only
85	Satisfactory	Low and medium distresses.	Preventative maintenance
70	Fair	Some distresses are severe.	Corrective maintenance and rehabilitation
55	Poor	Severity of some of the distresses can cause operational problems.	Rehabilitation or reconstruction
40	Very Poor	Severe distresses cause operational problems.	Rehabilitation or reconstruction
25	Serious	Many severe distresses cause operational restrictions.	Immediate reparis and reconstruction
10	Failed	Pavement deterioration prevents safe aircract operations.	Reconstruction
0			

When PCI is measured, the pavement network is divided up into branches, sections, and sample units, so the pavement measurement is only a sample of the larger network. At each section, additional measurements can be made such as the pavement structure, subgrade and drainage characteristics, maintenance history, and traffic data.

For the purpose of using the tool, it is unnecessary to ask GA management to acquaint themselves will all the steps of PCI data collection: sectioning off their pavement network and correctly classifying and rating the distresses. The work of calculating the PCI and impacts of maintenance activities has already been done in the tool we created for this project.

Alternative Condition Indicators

Though surface distress, measured through PCI, is most critical for pavement maintenance decisions, other pavement condition indicators can play a role. These are surface friction, roughness, foreign object debris, and structural integrity.

Surface Friction (Skid Resistance)

Surface friction, or skid resistance, is the force that resists the sliding motion of a tire across the pavement surface. It is an essential aspect of aircraft safety during landing. There are several factors affecting skid resistance including the pavement surface, tire properties, aircraft speed, and environmental conditions. This property does not impact the deterioration of the pavement, as previously illustrated in Figure , but if it is ever an issue, it should be addressed to provide the necessary pavement safety.

Guidance for measuring skid resistance is given in the FAA Advisory Circular on *Measurement, Construction, and Maintenance of Skid-resistant Airport Pavement Surfaces (*Federal Aviation Administration. *Measurement, Construction, and Maintenance of Skid-resistant Airport Pavement Surfaces.* FAA Advisory Circular, U.S. Department of Transportation, 2004*)*. Skid resistance can be measured directly from the resistance force of a sliding tire, most often with a trailer mounted system. Common trailer systems used to monitor runways in the U.S. are the Mu-meter and the Grip-Tester. Other measurement options with suggested levels of *good*, *fair,* and *poor* performance are summarized by Greene et al. (Greene, J., M. Y. Shahin, and D. R. Alexander. Airfield Pavement Condition Assessment, in *Transportation Research Record: Journal of the Transportation Research Board*, Transportation Research Board of the National Academies, Washington D.C., 2004). Two standard tires, smooth and ribbed, are used which yield slightly different results; a smooth tire is sensitive to surface macro-texture while a ribbed tire is sensitive to micro-texture. In one study, the skid number from a smooth tire was lower than for a ribbed tire by about 20 on dense-graded surfaces, but nearly the same on open-graded surfaces (Choubane, B., C. R. Holzshuher, S. Gokhale, and J. Fletcher. Precision of Smooth and Ribbed Tire Locked Wheel Testers for Measurement of Roadway Surface Characteristics).

Roughness

Roughness describes the ride quality, or the bumpiness. Roughness can be caused by poor construction or by distress. It can cause undue fatigue on aircraft system components, cause rider discomfort, and potentially raise safety concerns. Roughness is often considered a lagging indicator because problems noted by roughness usually occur *after* distress has already developed. Knowing the roughness condition, however, can play a part in treatment selection as some treatments will not improve roughness. Roughness can be calculated in terms of the Boeing Bump Index, which evaluates the maximum bump height/bump length parallel to the runway centerline. For further information, see the FAA Advisory circular on *Guidelines and Procedures for Measuring Airfield Pavement Roughness*.

Foreign Object Debris

According to the FAA, foreign object debris (FOD) is “any object, live or not, located in an inappropriate location in the airport environment that has the capacity to injure airport or air carrier personnel and damage aircraft” (*FAA Foreign Object Debris*, Federal Aviation Administration. http://www.faa.gov/airports/airport_safety/fod/). FOD can take any form: trash, debris from aircraft, loose and broken pavement material, animals or animal remains, etc. Routine scanning of the runways should be done to identify and remove FOD found on the airfield. An index was recommended to account for the potential of FOD based on the type of pavement distress (Greene, J., M. Y. Shahin, and D. R. Alexander, 2004).

Structural Integrity

Structural integrity can be evaluated in a number of ways. One common method is the Aircraft Classification Number–Pavement Classification Number (ACN-PCN) method outlined in the *FAA*

Advisory Circular on Standardized Method of Reporting Airport Pavement Strength—PCN (2009). The structural capacity could be measured with a falling-weight deflectometer (FWD). These kinds of measurements are typically only collected at larger airports (Hajek, J., J. W. Hall, and D. K. Hein).

CHAPTER 3. MAINTENANCE TREATMENTS

Pavement Maintenance Treatments

The types and uses of various pavement maintenance treatments is well-documented for both airport and highway applications. The typical, most common maintenance treatments were included in the questionnaire, along with an option for providing an "other" treatment. The maintenance types used in the questionnaire are listed below (Table 10).

Table 10. Pavement Preservation, Maintenance, and Rehabilitation Option.

AC Treatments	PCC Treatments
Do nothing	Do Nothing
Crack seal/ fill	Crack/Joint Seal
Rejuvenator	Partial Depth Repair
Fog/Coal tar seal	Full-depth Repair (localized)
Slurry/micro	Cross-stitching/dowelbar Retrofit
Chip/cape seal	Slab stabilization/jacking/underseal
AC overlay/ Mill+ overlay	Concrete/asphalt overlay
Patch/Reconstruct Area	Grinding/grooving
Too Severe-Rehab/Reconstruct	Too Severe (Rehab/Reconstruct)

The responses received for the questionnaire support the choices of these treatments (Table 11 and 12).

Table 11. Responses to use of Asphalt Treatment Types.

Question: HOW OFTEN have these ASPHALT treatments been used in the past or present at your current airport / agency?					
	Never	Rarely	Sometimes	Often	I'm unsure/ No response
Crack fill (no routing)	5%	5%	20%	63%	7%
Crack seal (with routing)	6%	15%	17%	57%	5%
Rejuvenator	22%	23%	25%	14%	16%
Fog seal	40%	17%	15%	9%	20%
Coal tar seal	32%	17%	25%	7%	19%
Slurry seal / micro	31%	20%	23%	11%	15%
Sand seal	54%	16%	5%	4%	21%
Chip seal	63%	15%	6%	1%	15%
Cape seal (chip seal then slurry/micro)	69%	7%	2%	1%	20%
Patching	9%	14%	51%	21%	6%
Asphalt overlay	15%	14%	40%	27%	5%
Mill+ asphalt overlay	12%	11%	36%	35%	6%
Other	6%	4%	1%	1%	88%

Table 12. Responses to use of Concrete Treatment Types.

Question: Which of these CONCRETE distress types do you HAVE or HAVE HAD at your airport or general aviation airports you support?				
	Little or none	Some	Prevalent	I'm unsure/No response
Joint seal damage	3%	63%	30%	5%
Joint / corner spalls	15%	53%	25%	8%
Joint separation	33%	43%	13%	13%
Corner breaks	15%	63%	20%	2%
Mid-slab cracking (transverse, linear, or diagonal)	28%	50%	18%	5%
Faulting / settlement	40%	50%	3%	8%
Patching	28%	53%	13%	8%
Popouts	43%	45%	5%	8%
Pumping	60%	28%	3%	10%
Map cracking / scaling	28%	48%	10%	15%
Durability "D" cracking	35%	40%	8%	18%
ASR (alkali silica reaction)	40%	28%	13%	20%
Shattered slab	48%	33%	8%	13%
Other	10%	3%	0%	88%

The recent ACRP synthesis, *Common Airport Pavement Maintenance Practices: A Synthesis of Airport Practice* provides a thorough catalogue of most of these treatment options (Hajek, J., J. W. Hall, and D. K. Hein). The catalogue includes construction descriptions/ illustration, treatment selection criteria, typical service life/costs, and additional resources. This same synthesis also includes data of the frequency of treatment application and the perceived performance.

A considerable portion of Appendix B from the synthesis is included in Appendix C and is a part of the web-based airport pavement maintenance recommendation tool that was developed.

Treatment Decision Trees/Matrices

There are two common approaches described by the Federal Highway Administration to select a treatment. These are *decision trees* and *decision matrices*. The tools are essentially the same but organize and present the information in a different form. Hicks and Seeds suggest the following (Hicks, R. G. and S. B. Seeds. *Selecting a Preventative Maintenance Treatment for Flexible Pavements.* Foundation for Pavement Preservation, Washington, D.C., June 14, 2000):

- Pavement surface type
- Facility type (classification/traffic level)
- At least one current condition index (distress and/or roughness)
- Specific distress information (any prominent distress)

- Geometrics (in case pavement widening/shoulder repair is necessary)
- Environmental conditions

Many more examples of decision trees and matrices, and other treatment selection methods were reviewed and are contained in the first interim report. All of these data sources were reviewed during the creation of decision trees/matrices for this project.

As part of the survey, respondents were presented with many common airport pavement distress conditions (Tables 3 and 4) and asked to select the "Best" treatment (since relabeled as "Recommended"), and then select other treatments that were "Acceptable" from a set of common maintenance treatments (Table 10 and Figure 1).

The responses were catalogued by climatic region and airport type, as described earlier. Sixteen tables (four climatic zones based on the Strategic Highway Research Program Long-Term Pavement Performance (SHRP-LTPP) and four airport types (National, Regional, Local, and Basic)) were developed from the data received and are used as the decision tree for each combination of climatic region and airport type.

Some adjustments made to the data. Where the response was that a certain treatment type was the "Best" (Recommended), it was also included as "Acceptable" for the purpose of selecting treatments. In some instances the response was "Other", but the description indicated that it was a variation of one of the existing treatments. For example, the response of "Other" included killing the grass and weeds in the crack. This was coded as "Crack Seal/Fill". Where possible, the responses from the survey were used, but in other instances a response did not follow what the project team believed to be proper engineering practice. For example, when the question was about high severity joint seal damage, the response of "Rehab/Reconstruction" was determined to be excessive and not in keeping with proper maintenance practice. In other cases, the "Best" and "Acceptable" were switched to be consistent with that respondents other responses. Part of the philosophy for building the decision tree was that the responses to the "Best" treatment should be more intensive as the distress severity and quantity increases. Each of these changes is indicated in the tables by a shaded response. If no response was received for a question, it is also shaded. For example, if all of the responses to the question shown in Figure 1 were "Crack Seal/Fill" as the "Best" treatment, but there were no other treatments selected as "Acceptable", the "Acceptable" response was shaded. If there were no responses received at all, as for the National-Dry Freeze category, all responses are shaded. The responses to the questions where there was no available response were taken from other responses in adjacent categories. Occasionally, there were several equivalent responses to the question so both responses were recorded. Table 13 contains a portion of one of the 16 tables and serves as an example of the decision trees.

The final treatment assignments for Asphalt pavements are included in Appendix D. The treatment assignments for concrete pavements are included as Appendix E. The following describes the tables in Appendix D and E.

Tables D1-D16. 16 Asphalt Decision Trees
National – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze
Regional – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze
Local – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze
Basic – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze

Tables E1-E16. 16 Concrete Decision Trees
National – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze
Regional – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze
Local – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze
Basic – Wet Freeze, Dry Freeze, Dry No Freeze, Wet No Freeze

Table 13. Example Decision Tree Response

Condition	Acceptable	Recommended
Starting to weather (losing fines)	Do Nothing	Rejuvenator, or Fog/Coal Tar Seal
Definitely Weathering (losing fines)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Definitely raveling and losing rock	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack seal/ fill
Few longitudinal cracks or joints Med severity	Crack seal/fill	Crack seal/ fill
Few longitudinal cracks or joints- High severity	Crack seal/fill	Patch/Reconstruct area

The user will be allowed to select multiple decision points (distress type/severity/extent combinations. The combination will be compared to the appropriate pavement type/climatic zone/airport type table and a “Best” (Recommended) and “Acceptable” (Alternate) treatment will be identified. When a second (or more) combination is entered and a treatment identified, those treatment will be compared to Tables 14 and 15 which contain the treatment hierarchy. That is, if crack sealing and rehab/reconstruct are the identified treatments, only the rehab/reconstruct treatment would be performed as it supersedes the crack seal. If the combination were crack seal and rejuvenator, both would be identified as these treatments do not interfere. The purpose of this table is to ensure that the most severe distress combination is always addressed. These examples are highlighted in Table 14.

Once a set of “Best” (Recommended) and “Acceptable” (Alternate) treatment has been identified, the relative total benefit and a cost/benefit calculation will be displayed.

Table 14. Order of Precedence (Hierarchy) – Asphalt Pavements

2nd Treatment	1st Treatment								
	Do Nothing	**Crack seal/fill**	**Rejuvenator**	**Fog/Coal tar seal**	**Slurry/ micro**	**Chip/ cape seal**	**AC overlay/ Mill+ overlay**	**Patch/ Recon area**	**Rehab/ Recon**
Do nothing	Do Nothing	Crack seal/fill	Rejuvenator	Fog/Coal tar seal	Slurry/ micro	Chip/ cape seal	AC overlay/ Mill+ overlay	Patch/ Recon area	Rehab/ Recon
Crack seal/fill	Crack seal/ fill	Crack seal/fill	Both	Both	Both	Both	Both	Both	Rehab/ Recon
Rejuvenator	Rejuvenator	Both	Rejuvenator	Fog/Coal tar seal	Slurry/ micro	Chip/ cape seal	AC overlay/ Mill+ overlay	Both	Rehab/ Recon
Fog/Coal tar seal	Fog/Coal tar seal	Both	Fog/Coal tar seal	Fog/Coal tar seal	Slurry/ micro	Chip/ cape seal	AC overlay/ Mill+ overlay	Both	Rehab/ Recon
Slurry/micro	Slurry/micro	Both	Slurry/ micro	Slurry/micro	Slurry/ micro	Chip/ cape seal	AC overlay/ Mill+ overlay	Both	Rehab/ Recon
Chip/cape seal	Chip/ cape seal	Both	Chip/ cape seal	Chip/cape seal	Chip/ cape seal	Chip/ cape seal	AC overlay/ Mill+ overlay	Both	Rehab/ Recon
AC overlay /Mill+ overlay	AC overlay/ Mill+ overlay	Both	AC overlay/ Mill+ overlay	AC overlay/ Mill+ overlay	AC overlay/ Mill+ overlay	AC overlay/ Mill+ overlay	AC overlay/ Mill+ overlay	Both	Rehab/ Recon
Patch/Recon	Patch/Recon	Both	Both	Both	Both	Both	Both	Patch/ Recon area	Rehab/ Recon
Rehab/ Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/Recon)	Rehab/ Recon

Table 15. Order of Precedence (Hierarchy) – Concrete Pavements

2nd Treatment	1st Treatment: Do Nothing	Crack/ joint seal	Partial depth repair	Full-depth repair (local)	Cross-stitch/ dowelbar retrofit	Slab stabilization /jack/underseal	PCC/AC overlay	Grind/ groove	Rehab/ Recon
Do Nothing	Do Nothing	Crack/ joint seal	Partial depth repair	Full-depth repair (local)	Cross-stitch/ dowelbar retrofit	Slab stabilization/ jack/underseal	PCC/AC overlay	Grind/ groove	Rehab/ Recon
Crack/ joint seal	Crack/ joint seal	Crack/ joint seal	Both	Both	Both	Both	Both	Both	Rehab/ Recon
Partial depth repair	Partial depth repair	Both	Partial depth repair	Full-depth repair (local)	Cross-stitch/ dowelbar retrofit	Slab stabilization/ jack/underseal	Both	Both	Rehab/ Recon
Full-depth repair (local)	Full-depth repair (local)	Both	Full-depth repair (local)	Full-depth repair (local)	Cross-stitch/ dowelbar retrofit	Both	Both	Both	Rehab/ Recon
Cross-stitch/ dowel bar retrofit	Cross-stitch/ dowelbar retrofit	Both	Cross-stitch/ dowelbar retrofit	Cross-stitch/ dowel bar retrofit	Cross-stitch/ dowelbar retrofit	Slab stabilization/ jack/underseal	Both	Both	Rehab/ Recon
Slab stabilization/ jack/underseal	Slab stabilization/ jack/underseal	Both	Slab stabilization/ jack/underseal	Both	Slab stabilization/ jack/underseal	Slab stabilization/ jack/underseal	Both	Both	Rehab/ Recon
PCC/AC overlay	PCC/AC overlay	Both	Both	Both	Both	Both	PCC/AC overlay	PCC/ AC overlay	Rehab/ Recon
Grind/groove	Grind/groove	Both	Both	Both	Both	Both	PCC/AC overlay	Grind/ groove	Rehab/ Recon
Rehab/Recon	Rehab/Recon	Rehab/Recon	Rehab/Recon	Rehab/Recon	Rehab/Recon	Rehab/ Recon	Rehab/ Recon	Rehab/ Recon	Rehab/ Recon

Benefit-Cost and Other Comparisons

With the tool just described, the user will narrow down the list of available treatments to a two or three specific treatments for a given set of pavement conditions, airport type (traffic level), climate, etc. From there, a decision still needs to be made about the optimal treatment. Ideally, the user will have information on the expected treatment life (which can also vary), general material unit costs, and particular details of the construction procedure (expected down-time, specialized contractor training, seasonal availability, etc.)

Upfront cost information should never be considered in isolation. Rather, one should consider the benefit-cost of the treatment. There are many ways to measure benefit-cost, including life-cycle costing, cost-effectiveness analysis, and longevity cost index. However, the most straight-forward method is the one that will be of greatest use for GA managers, which is benefit-cost.

Calculation of Relative Benefit

For this study, the relative benefit was defined as the sum of the condition (expressed as PCI score) after applying a treatment, minus the condition had the treatment not been applied (expressed as a net PCI increase) for each year until the PCI score with treatment reaches the threshold value of 40, summed over the reported as PCI-Years (Figure 4). This is described in more detail below. The calculations are only conducted for situations where the treatment was selected for a given decision point. For example, there are no calculations for Rehab/Reconstruct for the decision point of "A few longitudinal cracks or joints Low severity (< ¼" wide)" because that repair was never selected for that condition.

The calculation of relative total benefit was performed in the following manner. Typical asphalt and concrete airfield pavement deterioration curves were developed based on the experience of the research team. Figures 5 and 6 illustrate these curves.

Assumption – The curves are a fair representation of a deterioration curve.

A PCI threshold score of 40 was used as the lower limit of benefit in these curves. That is, when the PCI score drops below a PCI score of 40, there is no additional marginal benefit with respect to preventive maintenance. At a score of 40 or below, preventive maintenance has not typically been an option. This condition level is often listed as the level below which reconstruction is the best option. There are certainly instances where maintenance is done at a score below 40, but those are probably best described as "Stop Gap" maintenance or localized corrective maintenance.

Assumption – For a PCI below 40, there is no additional benefit.

In the next step (Tables 16 and 17), the PCI for each combination of distress type/code (DC), severity (Sev), and extent/quantity (Quan) decision point was calculated using MicroPAVER with the assumption that the combination being investigated was the ONLY distress for that pavement. Sample unit sizes of 5000 square feet were used for asphalt pavements and 20 slabs were used for concrete pavement.

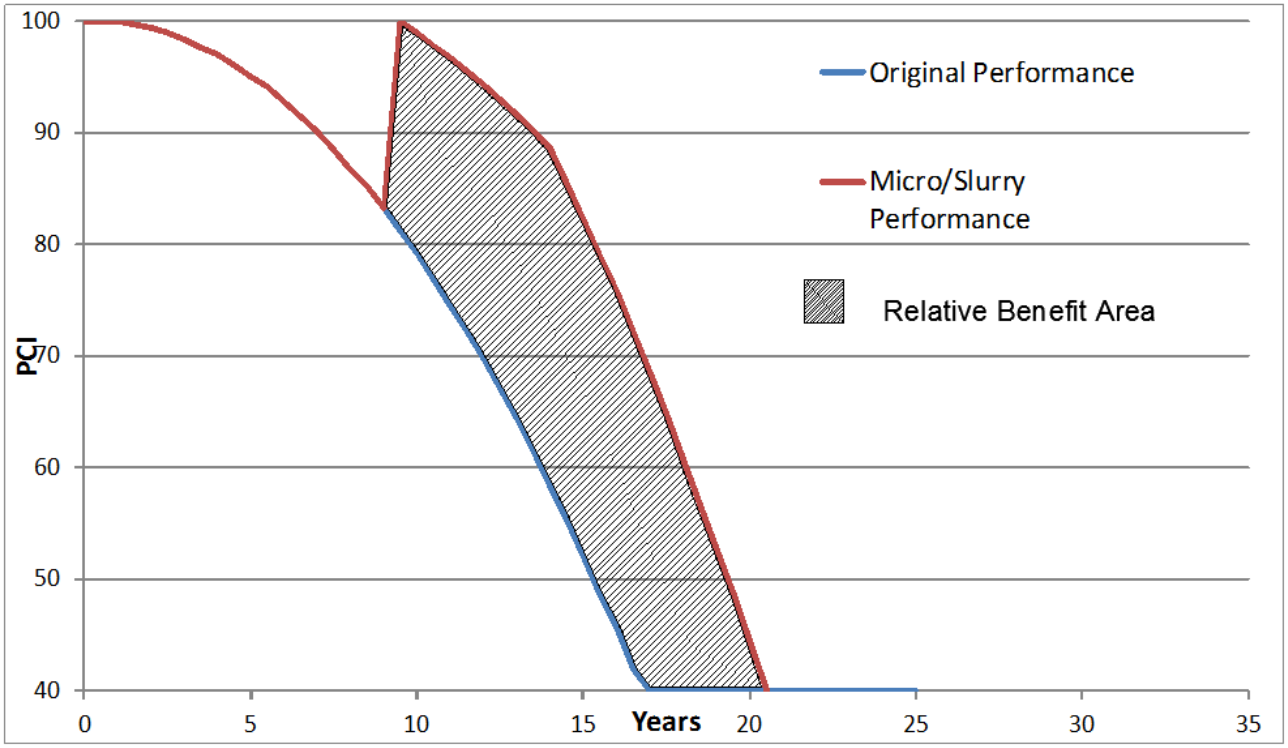


Figure 4. Illustration of Relative Benefit.

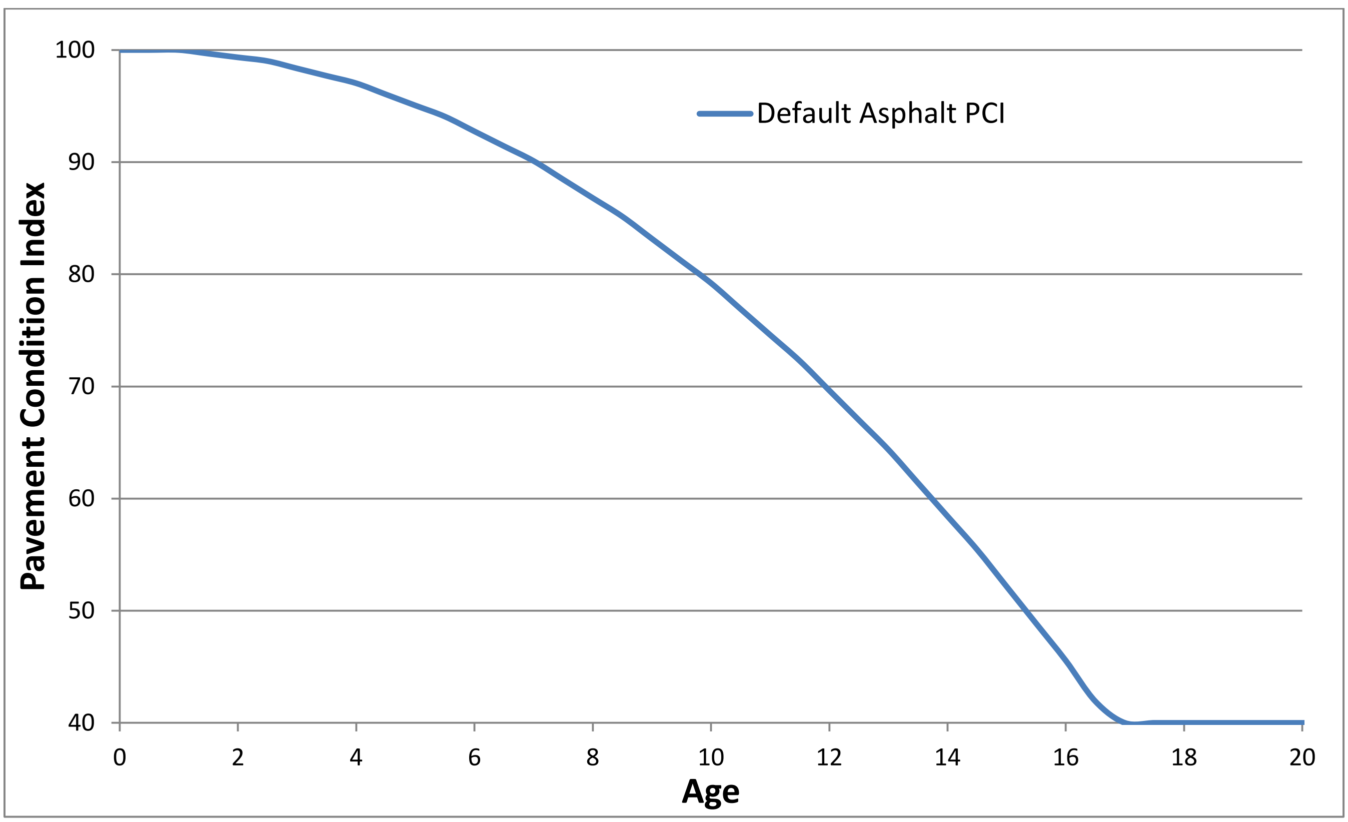


Figure 5. Default PCI vs Age for Asphalt Pavement.

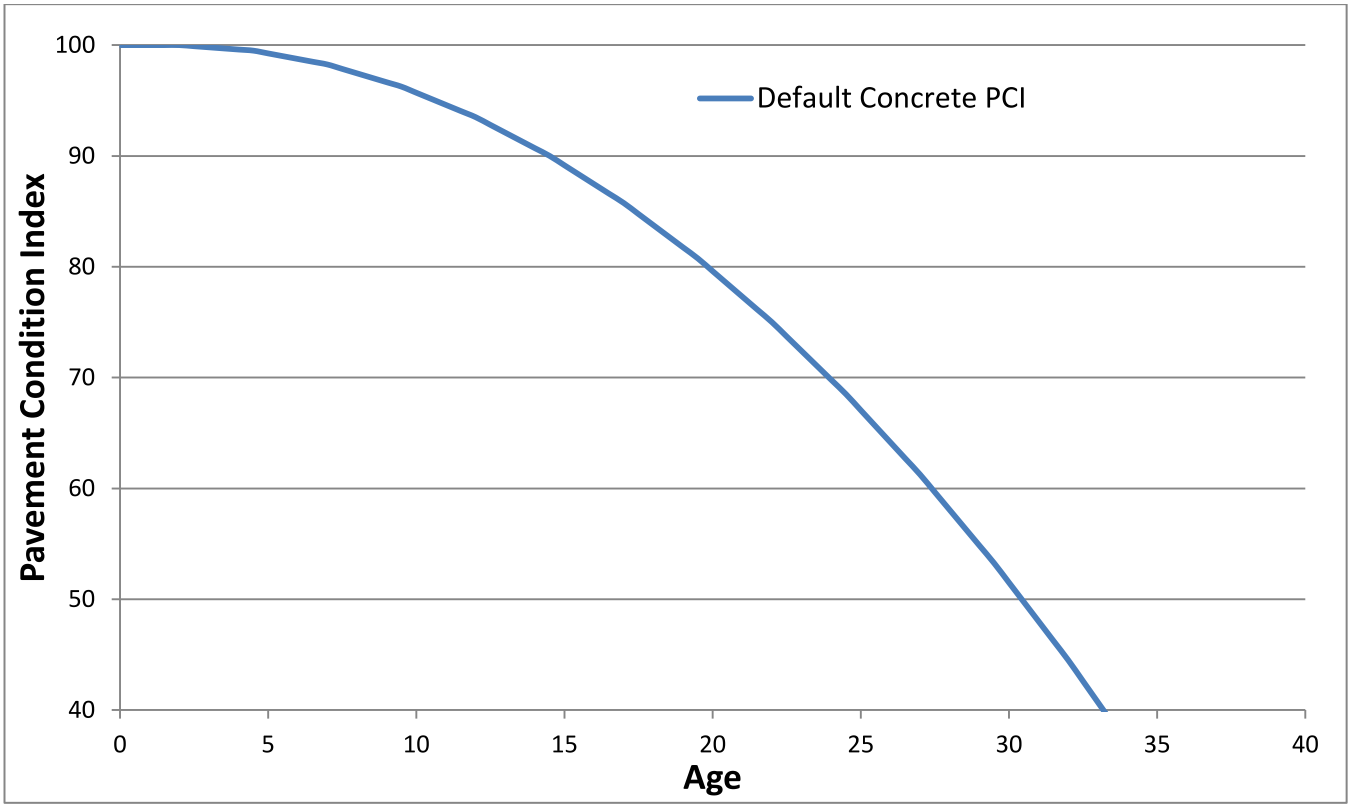


Figure 6. Default PCI vs Age for Concrete Pavement.

Table 16. Distress Type, Severity, Quantity, and Calculated PCI – AC Pavements.

Distress Description	DC	Sev	Quan	PCI
Starting To Weather	57	L	5000	94
Definitely Weathering	57	M	5000	81
Starting To Ravel	52	L	5000	74
Definitely Raveling	52	H	5000	43
A Few Longitudinal Cracks Or Joints Low	48	L	150	90
A Few Longitudinal Cracks Or Joints Medium	48	M	150	81
A Few Longitudinal Cracks Or Joints High	48	H	150	67
Many Longitudinal Cracks- Low	48	L	400	80
Many Longitudinal Cracks- Medium	48	M	400	67
Many Longitudinal Cracks- High	48	H	400	50
A Few Edge Cracks- Low	48	L	150	90
A Few Edge Cracks- Medium	48	M	150	81
A Few Edge Cracks- High	48	H	150	67
Transverse Cracks Spaced 50 Ft Apart Low	48	L	100	93
Transverse Cracks Spaced 50 Ft Apart Medium	48	M	100	84
Transverse Cracks Spaced 50 Ft Apart High	48	H	100	73
Transverse Cracks Spaced 20 Ft Apart- Low	48	L	250	85
Transverse Cracks Spaced 20 Ft Apart Medium	48	M	250	74
Transverse Cracks Spaced 20 Ft Apart High	48	H	250	59
Block Cracking Low	43	L	5000	64
Block Cracking Medium	43	M	5000	47

Block Cracking High	43	H	5000	22
Reflection Cracking Low	47	L	250	85
Reflection Cracking Medium	47	M	250	74
Reflection Cracking High	47	H	250	59
Fatigue Cracking- 10% Of Area Low	41	L	500	57
Fatigue Cracking- 10% Of Area Medium	41	M	500	44
Fatigue Cracking- 10% High	41	H	500	29
Fatigue Cracking- 30% Low	41	L	1500	43
Fatigue Cracking- 30% Medium	41	M	1500	29
Fatigue Cracking- 30% High	41	H	1500	11
Patching- 10% Of Low	50	L	500	85
Patching- 10% Medium	50	M	500	72
Patching- 10% High	50	H	500	58
Patching- 30% Low	50	L	1500	76
Patching- 30% Medium	50	M	1500	55
Patching- 30% High	50	H	1500	35
Roughness, Long Wavelength Swells	56	M	1000	56
Roughness- Many Long Wavelength Swells	56	M	3000	36
Roughness- Many Short Wavelength Bumps	44	M	2500	16

Table 17. Distress Type, Severity, Quantity, and Calculated PCI – PCC Pavements

Distress	DC	Sev	Quan	PCI
Joint Seal Is About 5 Years Old Still In Good Condition	-	-	-	100
Joint Seal Damage Low Severity	65	L	20	98
Joint Seal Damage Medium	65	M	20	93
Joint Seal Damage High Severity	65	H	20	88
Joint And Corner Spalls Low Severity	74	L	5	93
Joint And Corner Spalls Medium Severity	74	M	5	84
Joint And Corner Spalls High Severity	74	H	5	68
Mid-Panel Cracking On 20% Of The Slabs Low Severity	63	L	4	86
Mid-Panel Cracking On 20% Of The Slabs Medium	63	M	4	72
Mid-Panel Cracking On 20% Of The Slabs High	63	H	4	60
Mid-Panel Cracking On 40% Of The Slabs Low Severity	63	L	8	81
Mid-Panel Cracking On 40% Of The Slabs Medium	63	M	8	60
Mid-Panel Cracking On 40% Of The Slabs High	63	H	8	42
Corner Break On 10% Of The Slabs Low	62	L	2	92
Corner Break On 10% Of The Slabs Medium	62	M	2	85
Corner Break On 10% Of The Slabs High	62	H	2	77
Corner Break On 30% Of The Slabs Low	62	L	6	79
Corner Break On 30% Of The Slabs Medium	62	M	6	68
Corner Break On 30% Of The Slabs High	62	H	6	54
10% Of Slabs Are Shattered Low	72	L	2	83
10% Of Slabs Are Shattered Medium	72	M	2	73
10% Of Slabs Are Shattered High	72	H	2	60
30% Of Slabs Are Shattered Low	72	L	6	68
30% Of Slabs Are Shattered Medium	72	M	6	53
30% Of Slabs Are Shattered High	72	H	6	39
30% Of Area Has Patches Low	67	L	6	86
30% Of Area Has Patches Medium	67	M	6	71
30% Of Area Has Patches High	67	H	6	48
50% Of Area Has Patches Low	67	L	10	82
50% Of Area Has Patches Medium	67	M	10	62
50% Of Area Has Patches High	67	H	10	33
10% Of Slabs Are Faulted Low	71	L	2	92
10% Of Slabs Are Faulted Medium	71	M	2	86
10% Of Slabs Are Faulted High	71	H	2	74
30% Of Slabs Are Faulted Low	71	L	6	80
30% Of Slabs Are Faulted Medium	71	M	6	70
30% Of Slabs Are Faulted High	71	H	6	51

Next, the resulting PCI or PCI increase for each combination of decision point and treatment type was calculated. Table 18 contains the data for asphalt pavements and Table 19 contains the data for concrete pavements. The following explains the terms used in Tables 18 and 19:

"-" means that the treatment was not selected as "Best" or "Acceptable" in any of the 16 treatment assignment tables,

"Deter" means there was no increase in PCI, and only the deterioration rate was affected (Figure 7),

"Low(+9)" means the distress was converted to a low severity distress of the same type and the PCI was increased to the PCI of a low severity distress. In this example 9 points (Figure 8),

"Med(+14)" means the distress was converted to a medium severity distress of the same type and the PCI was increased to the PCI of a medium severity distress. In this example 14 points,

"Pat L(+20)" means the distress was converted to patching and the PCI was increased to the PCI of low severity patching, or 20 points,

"Elim(+6)" means the distress was eliminated and the PCI was set to 100 (Figure 9). The number in parenthesis is the approximate PCI increase, and

"Recon" means the distress was eliminated and the PCI curve was reset at that point (Figure 10).

Assumption – Applying a treatment increases the PCI by changing or eliminating the distress type, severity, and quantity.

Table 18. Resulting Distress and PCI Increase - Asphalt Pavements

Distress Description	Crack Seal/Fill	Rejuv enator	Fog/Coal tar seal	Slurry/ Micro	Chip/ Cape	Overlay/ Mill+overlay	Patch/ Recon Area	Rehab/ Recon
Starting to weather	-	Elim(+6)	Elim(+6)	Elim(+6)	Elim(+6)	-	-	-
Definitely Weathering	-	Elim(+19)	Elim(+19)	Elim(+19)	Elim(+19)	-	-	-
Starting to ravel	-	Elim(+26)	Elim(+26)	Elim(+26)	Elim(+26)	Elim(+26)	-	-
Definitely raveling	-	-	Elim(+57)	Elim(+57)	Elim(+57)	Elim(+57)	-	-
Few longitudinal crack or joints Low sev	Deter	Deter	-	-	-	-	-	-
Few longitudinal crack or joints Medium sev	Low (+9)	-	-	-	-	-	-	-
Few longitudinal crack or joints High sev	Low(+23)	-	-	-	-	Elim(+33)	Pat L(+26)	-
Many longitudinal crack Low sev	Deter	Deter	Deter	-	Elim(+20)	Elim(+20)	-	-
Many longitudinal crack Medium sev	Low(+23)	-	Low(+13)	Elim(+33)	Elim(+33)	Elim(+33)	Pat L(+20)	-
Many longitudinal crack High sev	Low(+40)	-	-	-	-	Elim(+50)	Pat L(+37)	Recon
Few edge crack, Low sev	Deter	Deter	Deter	-	-	-	-	-
Few edge crack, Med sev	Low(+9)	-	-	-	-	Elim(+19)	Pat L(+12)	-
Few edge crack, High sev	Low(+23)	Med(+14)	-	-	-	Elim(+33)	Pat L(+26)	-
Transverse crack spaced 50 ft apart low sev	Deter	-	-	-	-	-	-	-
Transverse crack spaced 50 ft apart Medium sev	Low(+9)	Low(+9)	Low (+9)	-	-	Elim(+16)	-	-
Transverse crack spaced	Low(+20)	-	-	-	-	Elim(+27)	Pat L(+22)	-

50 ft apart High sev								
Transverse crack spaced 20 ft apart- Low sev	Deter	-	Deter	-	-	-	-	-
Transverse crack spaced 20 ft apart Medium sev	Low(+11)	-	-	-	Elim(+26)	Elim(+26)	-	-
Transverse crack spaced 20 ft apart High sev	Low(+26)	-	-	-	Elim(+41)	Elim(+41)	-	-
Block crack Low sev	Deter	-	Deter	-	Elim(+36)	-	-	-
Block crack Medium sev	Low(+17)	Low(+17)	-	-	Elim(+53)	Elim(+53)	-	-
Block crack High sev	Low(+42)	-	-	-	Elim(+78)	Elim(+78)	Pat L(+62)	Recon
Reflection crack Low sev	Deter	-	-	-	-	-	-	-
Reflection crack Med sev	Low(+16)	-	-	-	Elim(+26)	Elim(+26)	-	-
Reflection crack High sev	Low(+27)	-	-	-	-	Elim(+41)	Pat L(+31)	Recon
Fatigue crack 10% area Low sev	Deter	Deter	Deter	-	-	-	Pat L(+29)	-
Fatigue crack 10% area Medium sev	Low(+13)	Low(+13)	Low (+13)	-	Elim(+56)	-	Pat L(+42)	-
Fatigue crack 10% area High sev	Low(+28)	Med(+15)	-	-	Elim(+71)	Elim(+71)	Pat L(+56)	Recon
Fatigue crack 30% area Low sev	-	Deter	Deter	-	Elim(+57)	Elim(+57)	Pat L(+32)	Recon
Fatigue crack 30% area Medium sev	-	-	-	-	Elim(+71)	Elim(+71)	Pat L(+46)	Recon
Fatigue crack 30% area High sev	-	-	-	-	-	Elim(+89)	Pat L(+65)	Recon
Patch 10% area Low sev	Deter	-	-	-	-	-	-	-
Patch 10% area Med sev	Deter	-	Deter	Elim(+28)	-	-	Pat L(+13)	-
Patch 10% area High sev	-	-	Deter	Elim(+42)	Elim(+42)	Elim(+42)	Pat L(+28)	-
Patch 30% area Low sev	Deter	-	Deter	Elim(+24)	Elim(+24)	Elim(+24)	-	-
Patch 30% area Med sev	-	-	Deter	Elim(+45)	Elim(+45)	Elim(+45)	Pat L(+21)	Recon
Patch 30% area High sev	-	-	-	Elim(+65)	Elim(+65)	Elim(+65)	Pat L(+41)	Recon
Roughness, long wavelength bumps	-	-	-	-	-	Elim(+44)	Pat L(+24)	-
Roughness, many long wavelength bumps	-	-	-	-	-	Elim(+64)	Pat L(+33)	Recon
Roughness, many short wavelength bumps	-	-	-	-	-	Elim(+84)	Pat L(+54)	-

Table 19. Resulting Distress and PCI Increase - Concrete Pavements

Distress	**Crack/Jt seal**	**Partial depth repair**	**Full-depth repair (local)**	**PCC Overlay**	**AC Overlay**	**Rehab/ Recon**	**Grind/ groove**	**Slab stab/ jack/ underseal**	**Crosstitch /dowelbar retro**
Jt Seal 5 Year Old, Good Condition	-	-	-	-	-	-	-	-	-
Joint seal damage Low sev	Deter	-	-	-	-	-	-	-	-

Joint seal damage Medium sev	Elim(+7)	-	-	-	-	-	-	-	-
Joint seal damage High sev	Elim(+12)	-	-	-	-	-	-	-	-
Joint/corner spall Low sev	Elim(+7)	PatL(+3)	-	-	-	-	-	-	-
Joint/corner spall Medium sev	Low(+9)	PatL(+12)	-	-	-	-	-	-	-
Joint/corner spall High sev	Low(+25)	PatL(+28)	-	-	-	-	-	-	-
Mid-panel crack 20% slabs Low sev	Deter	-	-	-	-	-	-	-	-
Mid-panel crack 20% slabs Med sev	Low(+14)	PatL(+18)	PatL(+18)	-	-	-	-	-	-
Mid-panel crack 20% slab High sev	Low(+26)	PatL(+29)	PatL(+29)	Elim(+12)	Elim(+12)	-	-	-	-
Mid-panel crack 40% slab Low sev	Deter	PatL(+3)	PatL(+3)	Elim(+12)	Elim(+12)	-	-	-	-
Mid-panel crack 40% slabs Med sev	Low(+21)	PatL(+24)	PatL(+24)	Elim(+12)	Elim(+12)	Recon	-	-	-
Mid-panel crack 40% slab High sev	Low(+39)	PatL(+42)	PatL(+42)	Elim(+12)	Elim(+12)	Recon	-	-	-
Corner break 10% slabs Low sev	Deter	-	PatL(+2)	-	-	-	-	-	-
Corner break 10% slabs Medium sev	Low(+7)	-	PatL(+9)	-	-	-	-	-	-
Corner break 10% slabs High sev	Low(+15)	-	PatL(+17)	-	-	-	-	-	-
Corner break 30% slabs Low sev	Deter	-	PatL(+7)	-	-	-	-	-	-
Corner break 30% slabs Medium sev	Low(+11)	-	PatL(+18)	Elim(+32)	Elim(+32)	-	-	-	-
Corner break 30% slabs High sev	Low(+25)	-	PatL(+32)	-	-	Recon	-	-	-
10% Shatter slab Low sev	Deter	-	PatL(+17)	-	-	-	-	-	-
10% Shatter slab Medium sev	Low(+10)	-	PatL(+27)	-	-	-	-	-	-
10% Shatter slab High sev	-	-	PatL(+40)	Elim(+40)	Elim(+40)	-	-	-	-
30% Shatter slab Low sev	Deter	-	PatL(+32)	Elim(+32)	Elim(+32)	Recon	-	-	-
30% Shatter slab Medium sev	Low(+15)	-	PatL(+47)	Elim(+47)	Elim(+47)	Recon	-	-	-
30% Shatter slab High sev	-	-	PatL(+61)	Elim(+61)	Elim(+61)	Recon	-	-	-
30% Patch Low sev	-	-	-	-	-	-	-	-	-
30% Patch Med sev	Low(+15)	PatL(+15)	PatL(+15)	-	-	-	-	-	-
30% Patch High	-	PatL(+38)	PatL(+38)	-	-	Recon	-	-	-

sev									
50% Patch Low sev	-	-	-	Elim(+18)	Elim(+18)	-	-	-	-
50% Patch Medium sev	-	PatL(+20)	PatL(+20)	Elim(+38)	Elim(+38)	-	-	-	-
50% Patch High sev	-	PatL(+49)	PatL(+49)	Elim(+67)	Elim(+67)	Recon	-	-	-
10% slabs Fault Low sev	Elim(+8)	PatL(+2)	-	-	-	-	Elim(+8)	-	-
10% slabs Fault Medium sev	Low(+6)	PatL(+8)	-	-	-	-	Elim(+14)	Elim(+14)	-
10% slabs Fault High sev	-	PatL(+20)	PatL(+20)	-	-	-	Elim(+26)	-	Elim(+26)
30% slabs Fault Low sev	Elim(+20)	PatL(+6)	-	Elim(+20)	Elim(+20)	-	Elim(+20)	Elim(+20)	-
30% slabs Fault Medium sev	-	-	-	Elim(+30)	Elim(+30)	Recon	Elim(+30)	Elim(+30)	Elim(+30)
30% slabs Fault High sev	-	-	PatL(+35)	Elim(+49)	Elim(+49)	Recon	Elim(+49)	Elim(+49)	-

For all treatments, the deterioration rate at the intervention point (PCI in Tables 16 and 17 prior to applying the treatment) was reduced to half of the default deterioration rate for the life of the treatment (Tables 20 and 21). This method provided the most realistic curves of any method we investigated, including different deterioration curves, not modifying the deterioration rate, resetting the deterioration rate, and others.

Assumption – During the life of the treatment, the deterioration rate is cut in half.

This is an area for future research where specific treatment curves need to be developed for different climatic zones and airport types.

Calculation of Treatment Life

The service life of each treatment was calculated based on the survey results (Table 20 and 21). Outlier responses, identified as values greater than 2.3 standard deviations (99 percent of the data) from the mean value, were not considered part of the data set. The remaining values were used to calculate a corrected average treatment life and standard deviation. The maximum treatment life was then chosen as the smaller of the average plus one standard deviation, or the maximum value. The minimum treatment life was chosen as the larger of either the average minus one standard deviation, or the minimum value. For the calculation of benefit, the average treatment life was used.

These results are comparable to the data in the 2009 AAPTP "Project 05-07 Techniques for Prevention and Remediation of Non-Load Related Distresses on HMA Airport Pavements (Phase I)" study where the life extensions for fog seals was 1 year (less than reported in this study), chip and slurry seals was 5-7 years, Micro-surfacing was 8-12 years (less than reported in this study) and overlays were 10-12 years.

It is important to note that the questionnaire for this study asked "How long do these treatments last?" and not "What is the life extension of using these treatments?" The respondents were not typically pavement engineers to whom a life extension question would make sense. Instead these were airport practitioners with knowledge on how long the treatment would last.

Table 20. AC Pavement Treatment Life.

Treatment Life	Avg	Max	Min
Crack fill (no routing)	2.7	4.3	1.2

Table 21. PCC Pavement Treatment Life.

Treatment Life	Avg	Max	Min
Crack / joint seal	6.3	8.8	3.7

Crack seal (with routing)	3.9	5.8	2.1
Rejuvinator	4.9	6.8	2.9
Fog seal	3.1	4.8	1.3
Coal tar seal	4.9	7.2	2.6
Slurry seal / micro	5.0	6.5	3.5
Sand seal	3.7	5.5	2.0
Chip seal	5.7	8.9	2.5
Cape seal	6.2	9.6	4.0
Patching	5.3	7.8	2.8
Asphalt overlay	11.4	15.2	7.6
Mill+asphalt overlay	14.9	18.7	11.1

Partial-depth repair with PCC	9.8	12.0	7.6
Partial-depth repair with AC	6.6	9.4	3.7
Partial-depth repair with Epoxy	10.3	12.0	8.5
Full-depth repair	14.4	18.3	10.5
Cross-stitching	7.0	9.0	5.0
Dowel bar retrofit	12.3	15.1	9.4
Slab stabilization	7.7	9.4	6.0
Slab jacking	8.5	11.4	6.0
Underseal	6.0	6.0	6.0
Concrete overlay	18.5	22.4	14.6
Asphalt overlay	14.3	17.9	10.6
Grinding / grooving	13.3	15.4	11.3

The benefit is determined by summing the difference between the PCI value on the "With Treatment" curve and the PCI value on the "Default" curve for all years (in 0.5 year increments) until the "With Treatment" value drops below a PCI of 40. The "Default" curve is never allowed to drop below 40. The summed values to determine the relative benefit are PCI-Years.

Figure 7 illustrates the benefit for crack seal on low severity cracks, where there is no increase in PCI and the deterioration rate is reduced for the life of the treatment (3.5 years). In Figure 8, there is an increase in PCI equivalent to the difference between having High severity cracks and Low severity cracks as crack sealing a high severity crack converts it to a low severity crack. Figure 9 illustrates the situation where the distress is eliminated and the PCI is increased to 100 (the numbers in Tables 18 and 19 are approximate as the PCI is limited to a maximum value of 100), while Figure 10 illustrates the impact of reconstruction, which resets the PCI curve. As a reminder, Figure 4 graphically represents the calculation of relative benefit. The calculated relative benefit values are shown in Tables 22 and 23.

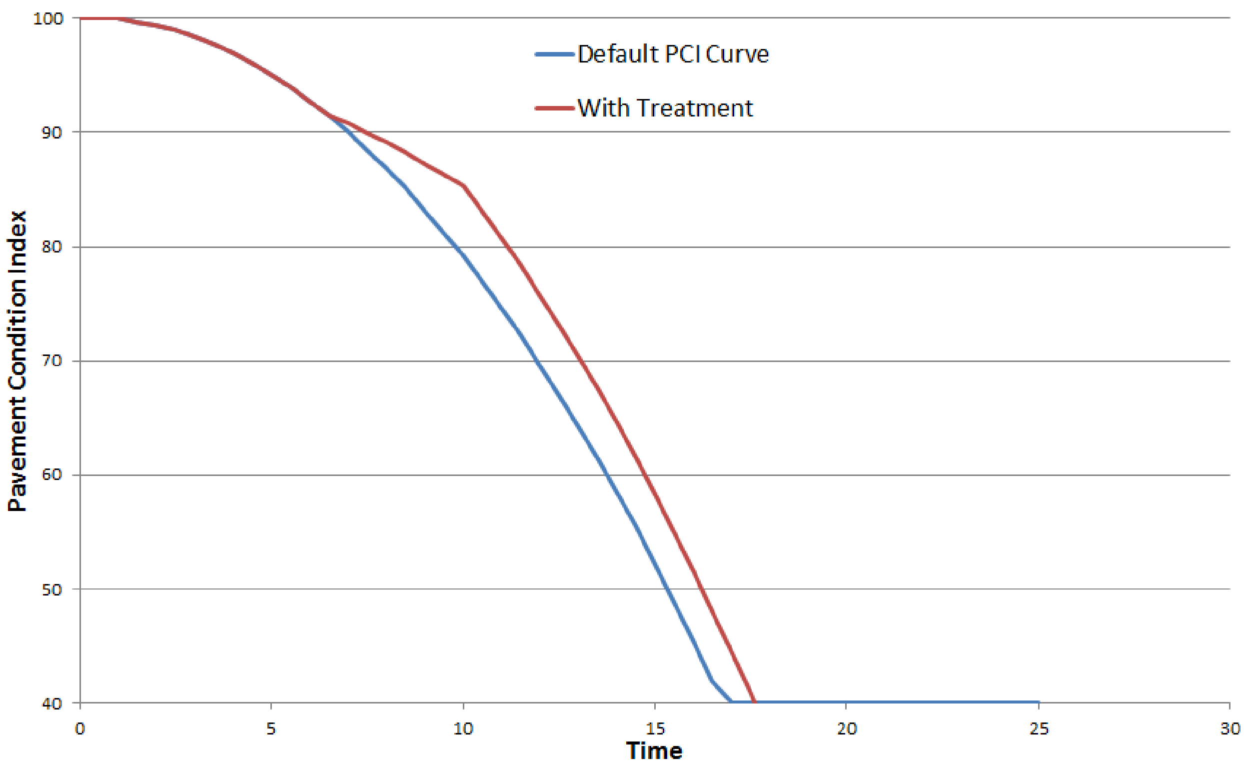


Figure 7. Example of Treatment Changing Deterioration Rate Only.

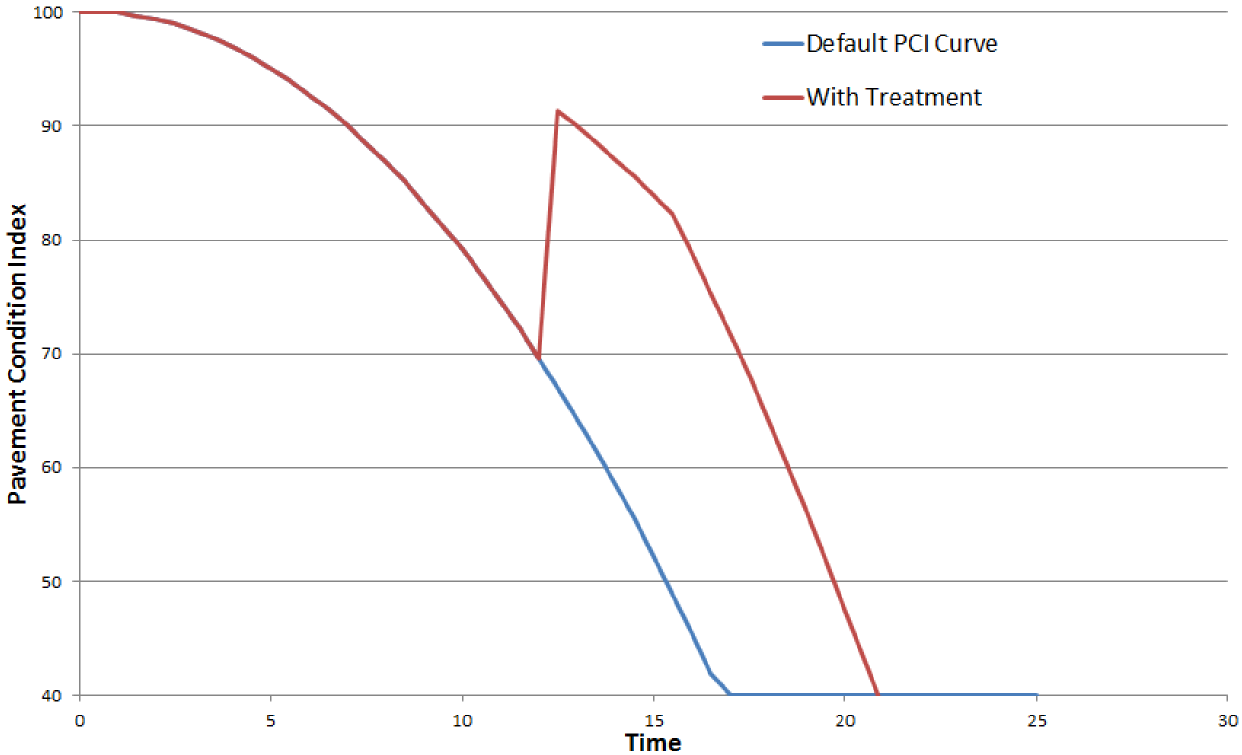


Figure 8. Example of Treatment Increasing PCI and Changing Deterioration Rate.

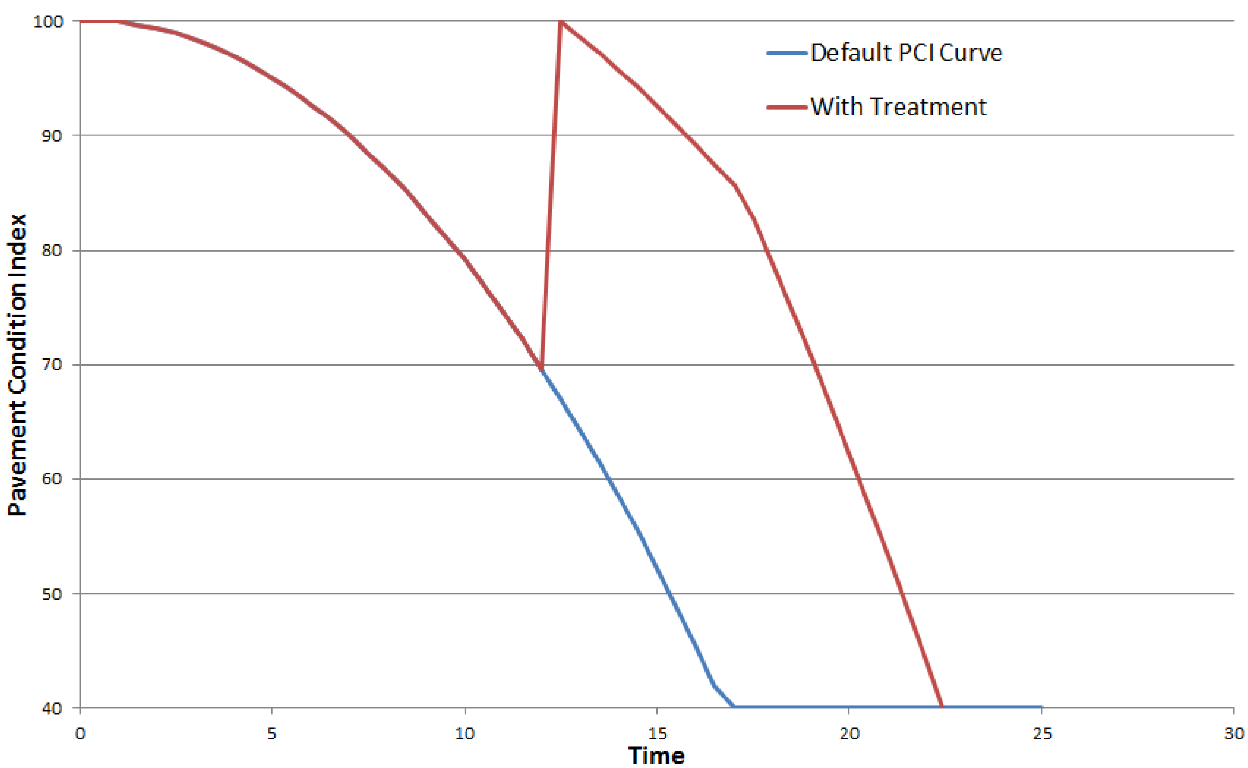


Figure 9. Example of Treatment Increasing PCI to 100 and Changing Deterioration Rate.

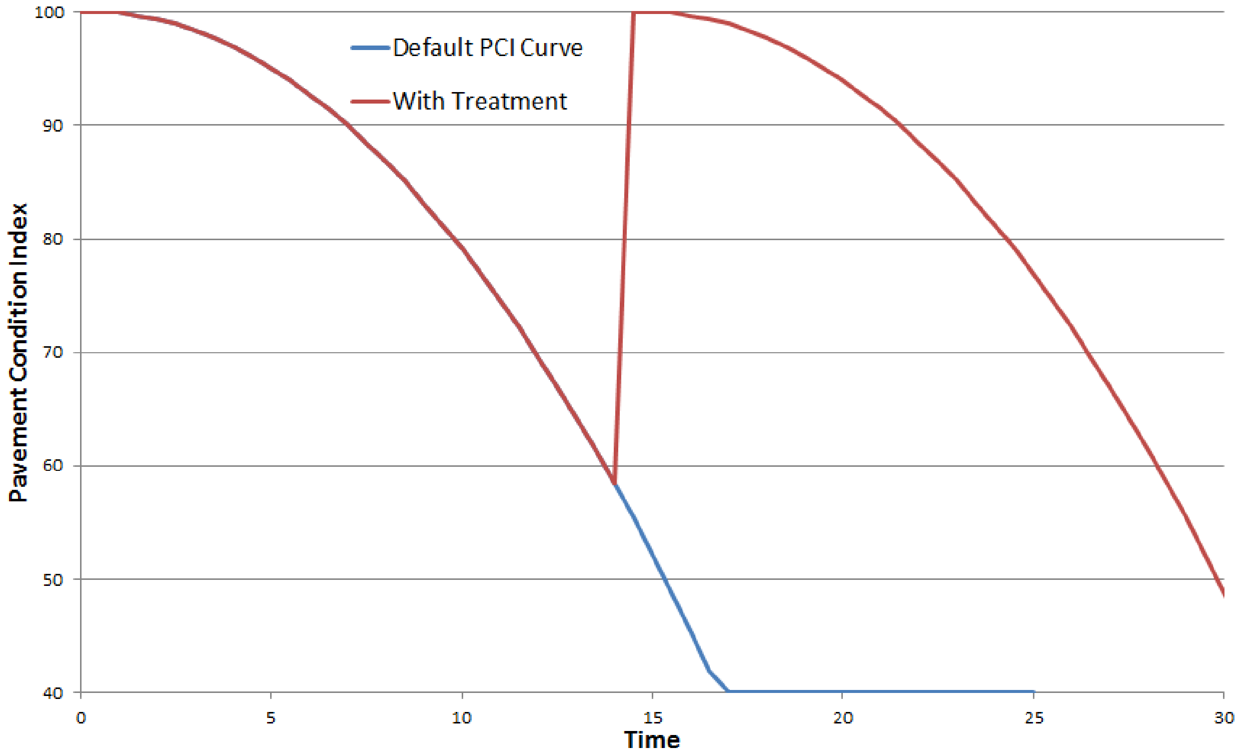


Figure 10. Example of Reconstruct Treatment Resetting PCI Curve.

Table 22. Relative Benefit (PCI-Years) - Asphalt Pavements

Distress Description	Do Nothing	Crack Seal/fill	Rejuvenator	Fog/Coal tar seal	Slurry /Micro	Chip/ Cape	Overlay /Mill+OL	Patch/ Recon	Rehab
Starting to weather	0	0	146	128	146	165	0	0	0
Definitely Weathering	0	0	255	235	255	275	0	0	0
Starting to ravel	0	0	289	268	289	308	402	0	0
Definitely raveling	0	0	0	314	334	352	414	0	0
Few longitudinal cracks, Low	0	54	78	0	0	0	0	0	0
Few longitudinal cracks, Medium	0	125	0	0	0	0	0	0	0
A few longitudinal cracks, High	0	197	0	0	0	0	420	248	0
Many longitudinal cracks, Low	0	50	70	57	0	286	384	0	0
Many longitudinal cracks, Medium	0	117	0	122	315	334	420	247	0
Many longitudinal cracks, High	0	159	0	0	0	0	424	229	683
Few edge cracks, Low	0	54	78	62	0	0	0	0	0
Few edge cracks, Medium	0	125	0	0	0	0	376	187	0
Few edge cracks, High	0	197	142	0	0	0	420	247	0
Transverse cracks, 50 ft apart, Low	0	53	0	0	0	0	0	0	0
Transverse cracks, 50 ft apart, Med	0	140	165	148	0	0	366	0	0
Transverse cracks, 50 ft apart, High	0	204	0	0	0	0	408	249	0
Transverse cracks, 20 ft apart, Low	0	54	0	62	0	0	0	0	0
Transverse cracks, 20 ft apart, Med	0	119	0	0	0	308	402	0	0
Transverse cracks, 20 ft apart, High	0	177	0	0	0	351	427	0	0
Block cracking Low	0	34	0	38	0	340	0	0	0
Block cracking Medium	0	68	74	0	0	354	419	0	0
Block cracking High	0	64	0	0	0	328	377	201	692
Reflection cracking Low	0	58	0	0	0	0	0	0	0
Reflection cracking Medium	0	172	0	0	0	308	402	0	0
Reflection cracking High	0	210	0	0	0	0	427	244	660
Fatigue crack, 10% of area, Low	0	21	23	22	0	0	0	213	0
Fatigue crack, 10% of area, Medium	0	39	40	40	0	352	0	218	0
Fatigue crack, 10% of area, High	0	37	3	0	0	333	384	201	692
Fatigue crack, 30% of area, Low	0	0	2	2	0	352	414	146	691
Fatigue crack, 30% of area, Medium	0	0	0	0	0	333	384	136	692
Fatigue crack, 30% of area, High	0	0	0	0	0	0	357	132	692
Patching, 10% area, Low	0	54	0	0	0	0	0	0	0
Patching, 10% area, Medium	0	44	0	50	298	0	0	158	0
Patching, 10% area, High	0	0	0	28	332	351	427	207	0
Patching, 30% area, Low	0	47	0	52	289	297	394	0	0
Patching, 30% area, Medium	0	0	0	22	335	353	427	136	670
Patching, 30% area, High	0	0	0	0	324	343	398	144	692
Rough, Long wave swells	0	0	0	0	0	0	427	167	0
Rough, Many long wave swells	0	0	0	0	0	0	398	99	692
Rough, Many short wave bumps	0	0	0	0	0	0	364	99	0

Table 23. Relative Benefit (PCI-Years) - Concrete Pavements

Distress	Do Nothing	Crack /Joint seal	Partial depth repair	Full-depth repair (local)	PCC overlay	AC overlay	Rehab/ Recon	Grind/ groove	Slab stabiliz/ jack/ underseal	Crossstitch /dowelbar retrofit
Jt Seal 5 Year Old, Good Condition	0	59	0	0	0	0	0	0	0	0
Joint seal damage Low sev	0	128	0	0	0	0	0	0	0	0
Joint seal damage Med sev	0	253	0	0	0	0	0	0	0	0
Joint seal damage High sev	0	333	0	0	0	0	0	0	0	0
Joint/corner spall Low sev	0	253	227	0	0	0	0	0	0	0
Joint/corner spall Med sev	0	256	386	0	0	0	0	0	0	0
Joint/corner spall High sev	0	406	529	0	0	0	0	0	0	0
Mid-panel crack 20% slabs Low sev	0	97	0	0	0	0	0	0	0	0
Mid-panel crack 20% slabs Medium sev	0	262	375	438	0	0	0	0	0	0
Mid-panel crack 20% slab High sev	0	349	450	508	768	712	0	0	0	0
Mid-panel crack 40% slab Low sev	0	92	185	240	641	584	0	0	0	0
Mid-panel crack 40% slabs Medium sev	0	274	361	408	768	712	1311	0	0	0
Mid-panel crack 40% slab High sev	0	305	386	426	759	711	1372	0	0	0
Corner break 10% slabs Low sev	0	95	0	258	0	0	0	0	0	0
Corner break 10% slabs Medium sev	0	222	0	392	0	0	0	0	0	0
Corner break 10% slabs High sev	0	316	0	482	0	0	0	0	0	0
Corner break 30% slabs Low sev	0	89	0	316	0	0	0	0	0	0
Corner break 30% slabs Medium sev	0	204	0	406	740	679	0	0	0	0
Corner break 30% slabs High sev	0	270	0	466	0	0	1345	0	0	0
10% Shatter slab Low sev	0	94	0	561	0	0	0	0	0	0
10% Shatter slab Med sev	0	216	0	656	0	0	0	0	0	0
10% Shatter slab High sev	0	0	0	712	768	712	0	0	0	0
30% Shatter slab Low sev	0	69	0	679	740	679	1236	0	0	0
30% Shatter slab Med sev	0	146	0	720	772	720	1345	0	0	0
30% Shatter slab High sev	0	0	0	702	747	702	1373	0	0	0
30% Patch Low sev	0	0	0	0	0	0	0	0	0	0
30% Patch Medium sev	0	274	331	387	0	0	0	0	0	0
30% Patch High sev	0	0	423	470	0	0	1362	0	0	0
50% Patch Low sev	0	0	0	0	641	573	0	0	0	0
50% Patch Medium sev	0	0	325	368	764	707	0	0	0	0

50% Patch High sev	0	0	346	379	728	685	1373	0	0	0
10% slabs Fault Low sev	0	267	183	0	0	0	0	396	0	0
10% slabs Fault Med sev	0	207	304	0	0	0	0	504	415	0
10% slabs Fault High sev	0	0	444	515	0	0	0	630	0	511
30% slabs Fault Low sev	0	444	243	0	663	596	0	579	489	0
30% slabs Fault Med sev	0	0	0	0	734	672	1221	655	567	592
30% slab Fault High sev		0	0	468	773	721	1352	706	622	0

Development of Cost Data

Based on data found in “Guildelines for the Preservation of High-Volume-Traffic Roadways”, Transportation Research Board, 2011, by D. Peshkin, K. Smith, A. Wolters, J. Krstluovich, J. Moulthrop and C. Alvarado, and "Preventive Maintenace at General Aviation Airports, ACRP Report 138, Volume 2: Guidebook,," Airport Cooperative Research Board, Transportation Research Board, 2015, by D. Ploeger, R. Chapman, D. Peshkin and D. Speidel, the data in Tables 24 and 25 were developed.

The intention of these cost estimates was to provide general benefit-cost comparisons among treatments, and not to make a definitive statement about treatment cost. These costs vary significantly among regions and contractors, and also change drastically over time and with market dynamics. For example, during the development of treatment cost data it was found that the California paving asphalt price index reported that their cost basis was $573 in July 2014 and $252 in January 2015 for a factor of 0.44. Because of this tremendous potential variation in costs, the user is allowed, and encouraged, to obtain quotes from a local contractor and input their own cost estimates for the analysis. The tool will allow the user to modify the cost data, enter the dimension of the feature (runway, apron, or taxiway) in which they are interested and from that calculate an approximate cost.

Table 24. Asphalt Pavement Treatment Costs.

Treatment	Relative Cost	Unit Cost for Reference Year 2015	Low Sev	Med Sev	Hi Sev	Unit
Crack Seal/Fill	$	$0.1- $1.50	$0.50	$0.75	$1.00	LF
Rejuvenator	$	$0.25- $0.50	$0.37	$0.37	$0.37	yd^2
Fog/Coal Tar Seal	$	$0.25- $0.50	$0.37	$0.37	$0.37	yd^2
Slurry Seal/ Microsurfacing	$$	$0.75- $3.50	$2.00	$2.50	$3.00	yd^2
Chip/Cape Seal	$$	$1.50 - $4.00	$2.50	$2.75	$3.00	yd^2
Asphalt Overlay/ Mill+Overlay	$$$	Without milling: $2.00-$6.00 With milling: $5.00-$10.00	$3.50 $6.50	$4.00 $7.50	$4.50 $8.50	yd^2
Patch or Reconstruct Area		$50[1]	$50	$50	$50	SF
Rehabilitate or Reconstruct	$$$$	$100[1]	$65	$75	$100	yd^2

[1] – Data from TxDOT Aviation Division personnel

Table 25. Concrete Pavement Treatment Costs.

Treatment	Relative Cost	Unit Cost for Reference Year 2015	Low Sev	Med Sev	Hi Sev	Unit
Crack/joint seal	$	$0.75- $2.50	$1.50	$1.75	$2.00	LF
Partial-depth repair (concrete or asphalt)	$$$	$75-$150	$100	$100	$100	yd^2
Full-depth repair (localized)	$$$	$75-$150	$100	$100	$100	yd^2
Cross-stitching or dowel bar retrofit	$$$	$25-$35/ dowel bar ($3.75 to $5.25/ yd^2, based on 6 bars per 12-ft crack/ joint and crack/ joint retrofit every 30 ft)	$30/ dowel	$30/ dowel	$30/ dowel	Each
Slab stabilization or jacking or underseal[3]	$$$	$80-180	$110	$130	$150	yd^2
Concrete or asphalt overlay	$$$/ $$$$	Asphalt overlay: $2.00-$6.00 Concrete Overlay: $15.00 to $25.00	$3.50 $17.50	$4.00 $20.00	$4.50 $22.50	yd^2
Grinding/ grooving	$$	$1.25- $5.50	$2.50	$3.50	$4.50	yd^2
Rehabilitation or reconstruction	$$$$	$100	$100	$100	$100	yd^2

Cost Basis

Using the above cost data, the repair costs for each distress type/severity/quantity/treatment type, was calculated based on the distresses found within an idealized 5000 square foot (100 feet long by 50 feet wide) or 20 slab sample (typical slabs assumed to be 20 feet by 20 feet). Since most of the cost data was based on cost/square yard, in the following tables the 5000 square foot sample unit was converted to 555.6 square yards. Table 26 is the repair quantities and cost table for the crack seal/fill maintenance treatment. Appendix F and G contain the data for the other asphalt and concrete treatments, respectively.

Table 26. Repair Quantities and Costs for Crack Seal/Fill.

Distress Description	DC	Sev	Quan	Cost	Unit	$/Unit	Basis for Quantities
Starting to weather	57	L	5000				Not used
Definitely Weathering	57	M	5000				
Starting to ravel	52	L	5000				
Definitely raveling	52	M	5000				
Few longitudinal cracks, Low	48	L	150	$75	150	$0.50	Cracks sealed
Few longitudinal cracks, Medium	48	M	150	$113	150	$0.75	
A few longitudinal cracks, High	48	H	150	$150	150	$1.00	
Many longitudinal cracks, Low	48	L	400	$200	400	$0.50	Cracks sealed
Many longitudinal cracks, Medium	48	M	400	$300	400	$0.75	
Many longitudinal cracks, High	48	H	400	$400	400	$1.00	
Few edge cracks, Low	48	L	150	$75	150	$0.50	Cracks sealed
Few edge cracks, Medium	48	M	150	$113	150	$0.75	
Few edge cracks, High	48	H	150	$150	150	$1.00	
Transverse cracks, 50 ft apart, Low	48	L	100	$50	100	$0.50	2 cracks @ 50 foot
Transverse cracks, 50 ft apart, Medium	48	M	100	$75	100	$0.75	
Transverse cracks, 50 ft apart, High	48	H	100	$100	100	$1.00	
Transverse cracks, 20 ft apart, Low	48	L	500	$125	250	$0.50	5 cracks @ 50 foot
Transverse cracks, 20 ft apart, Medium	48	M	500	$188	250	$0.75	
Transverse cracks, 20 ft apart, High	48	H	500	$250	250	$1.00	
Block cracking Low	43	L	5000	$625	1250	$0.50	6 long cracks@100, 13 trans@50, based on 7.5x7.5 block
Block cracking Medium	43	M	5000	$938	1250	$0.75	
Block cracking High	43	H	5000	$1,250	1250	$1.00	
Reflection cracking Low	47	L	200	$100	200	$0.50	Cracks sealed
Reflection cracking Medium	47	M	200	$150	200	$0.75	
Reflection cracking High	47	H	200	$200	200	$1.00	
Fatigue crack, 10% of area, Low	41	L	500	$250	500	$0.50	Cracks sealed
Fatigue crack, 10% of area, Medium	41	M	500	$750	1000	$0.75	
Fatigue crack, 10% of area, High	41	H	500	$2,000	2000	$1.00	
Fatigue crack, 30% of area, Low	41	L	1500				Not used
Fatigue crack, 30% of area, Medium	41	M	1500				
Fatigue crack, 30% of area, High	41	H	1500				
Patching, 10% area, Low	50	L	500	$200	400	$0.50	500 sf =20@ 5'x5' =400 lf perimeter
Patching, 10% area, Medium	50	M	500	$300	400	$0.75	
Patching, 10% area, High	50	H	500				

Patching, 30% area, Low	50	L	1500	$600	1200	$0.50	3 times 10% amount
Patching, 30% area, Medium	50	M	1500				Not used
Patching, 30% area, High	50	H	1500				
Rough, Long wave swells	56	M	1000				
Rough, Many long wave swells	56	M	3000				
Rough, Many short wave bumps	44	M	2500				

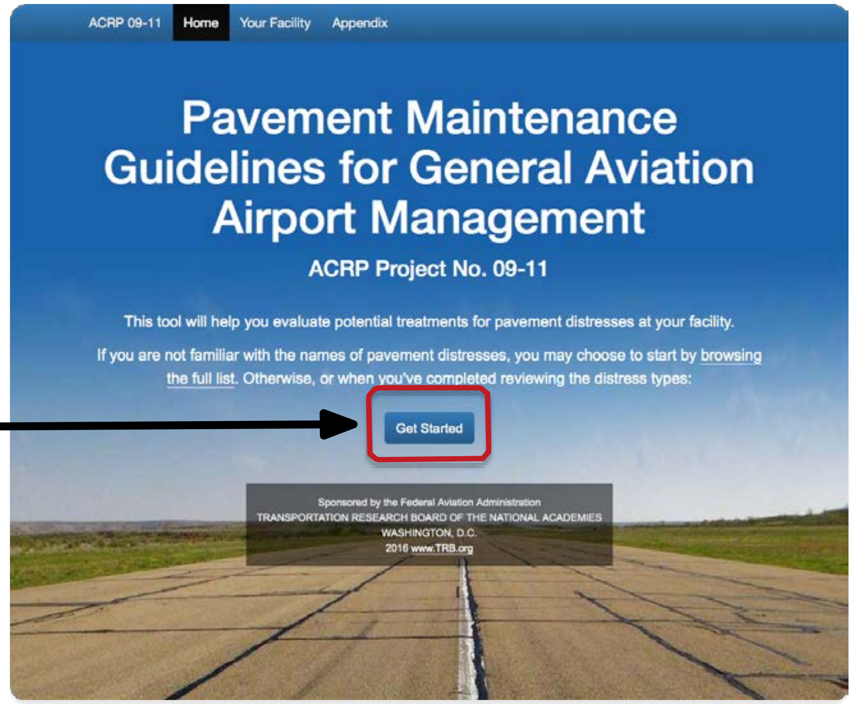
Applications to GA

GA airport managers certainly face the cycle of treating “worst-first.” This is the natural result of under budgeting. But given the fact that the “worst-first” approach is *more* costly in the long run, GA airports would benefit from using this tool to see the impacts and cost savings from intervening earlier in the pavement life-cycle. The airport pavement maintenance recommendation tool will allow them to investigate these impacts.

CHAPTER 4. PAVEMENT MAINTENANCE SELECTION TOOL

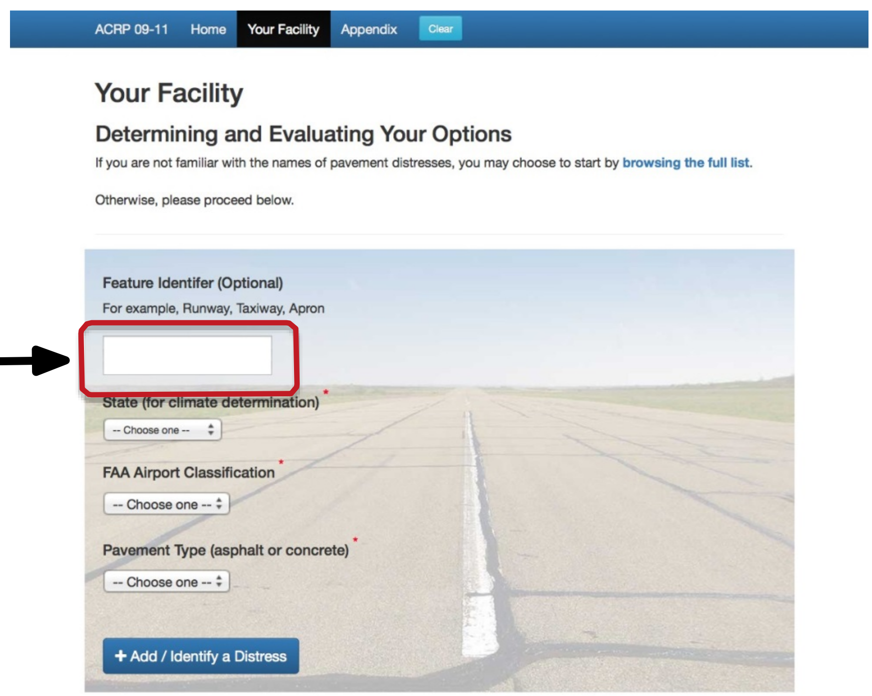
Homepage for the ACRP Pavement Maintenance Guidelines for General Aviation Airport Management Website

Choose **Get Started** or **Your Facility** from the navigation menu at top to begin.

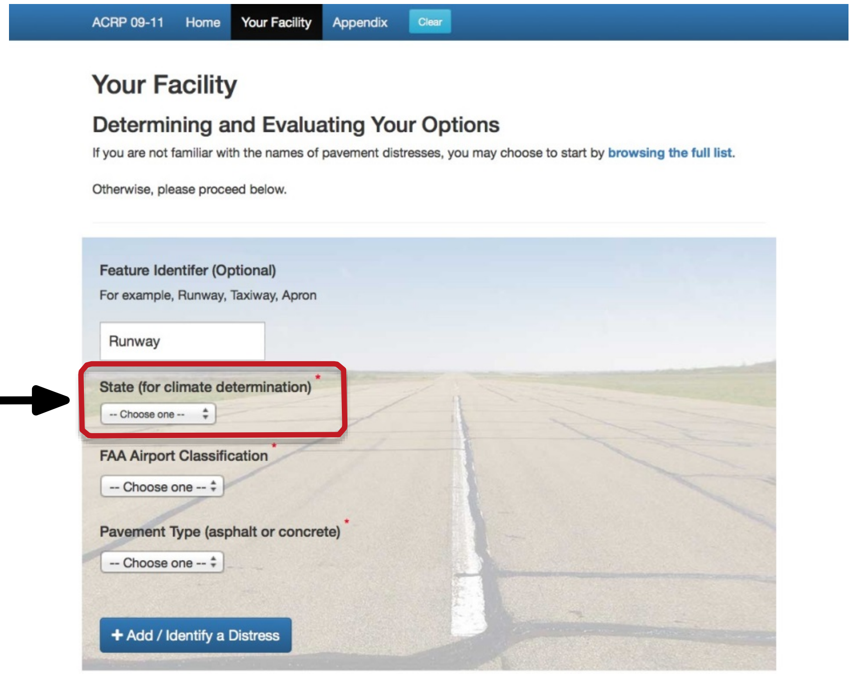


Determining and Evaluating Your Options

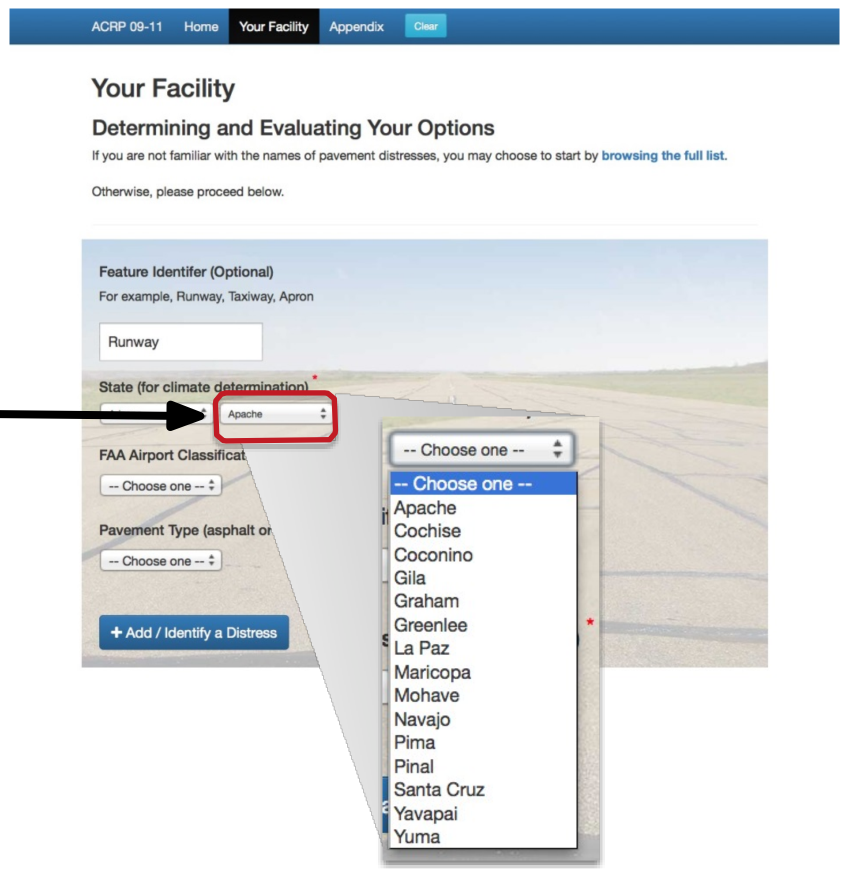
Enter an optional, identifying word or phrase to designate the feature being evaluated.



Enter your state. This is a required field.

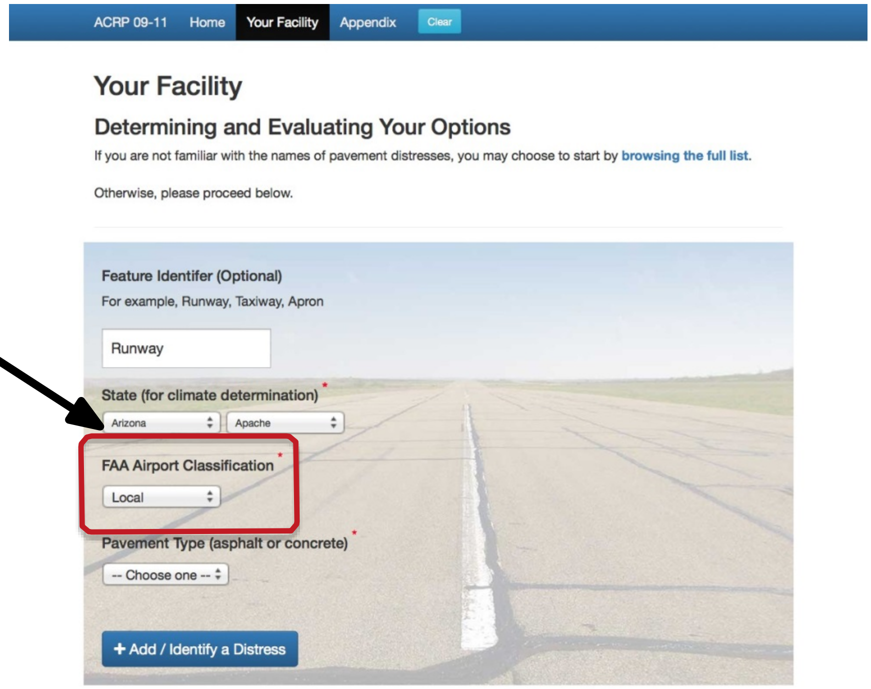


Note that for some states, adding a county will be required to determine your facility's climate zone.

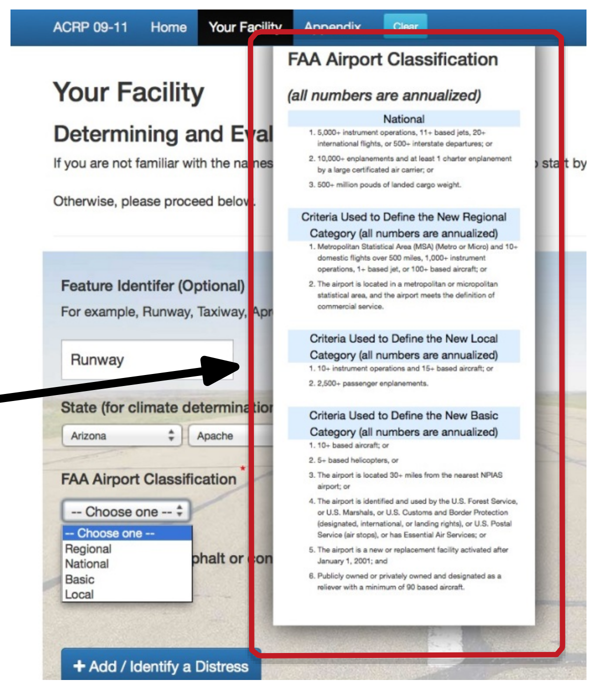


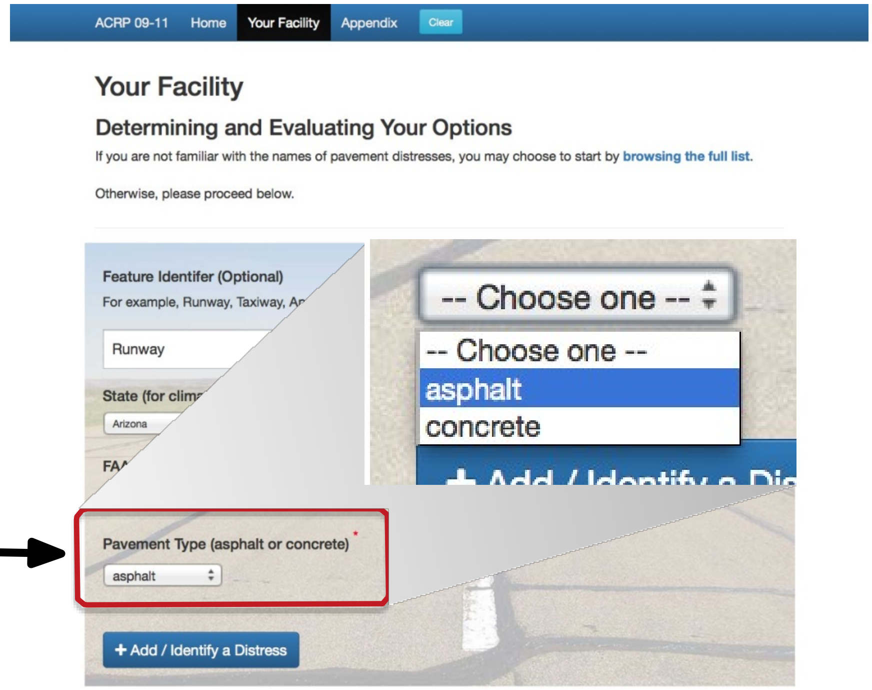
Pick your facility's FAA Airport Classification.

Note that your entries up to this point will be retained on your computer or tablet for subsequent evaluations with the tool.

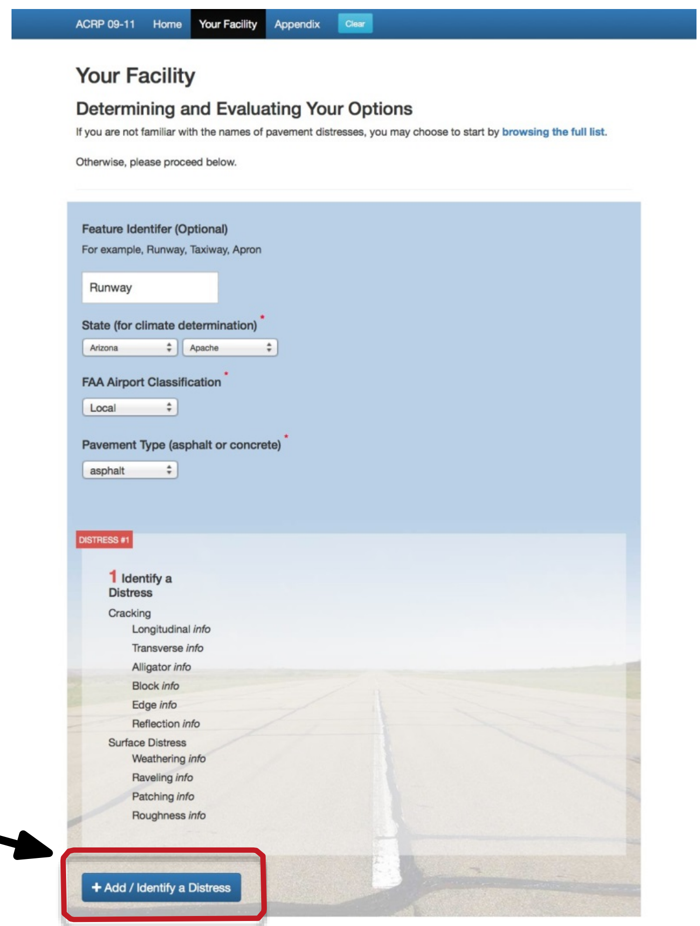


Note that when you put your cursor over each choice, details are provided to assist.



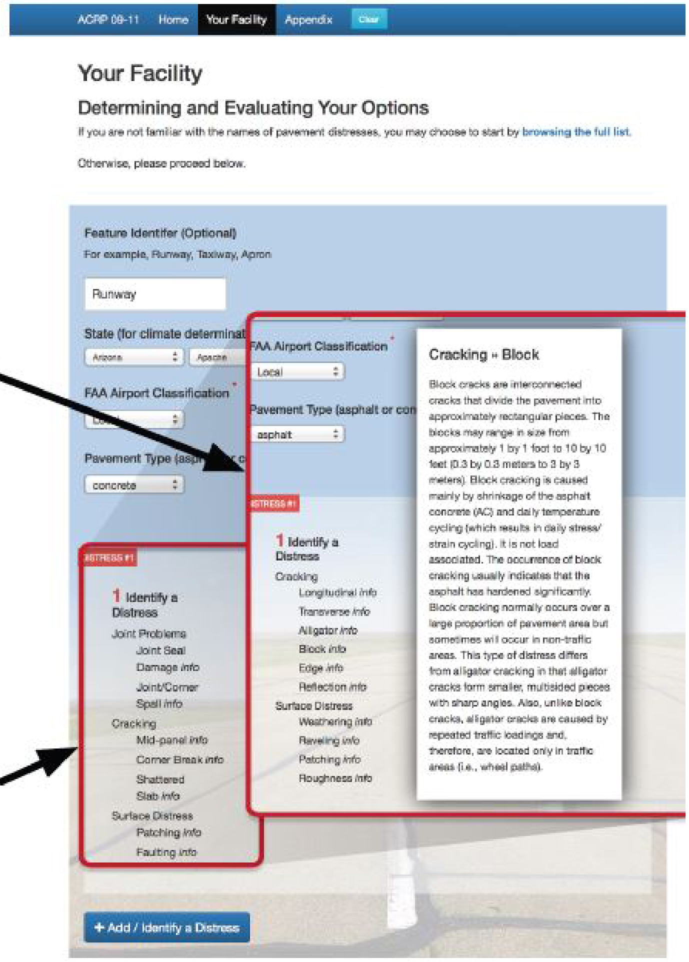


Choose the type of pavement used in the feature being evaluated.



Click **Add/Identify a Distress** to begin describing the distress(es) observed in the current feature. Observe that a list of distresses possible for the chosen pavement type will appear.

Note that when you move your cursor over the distress names, an information box will appear describing the distresses.

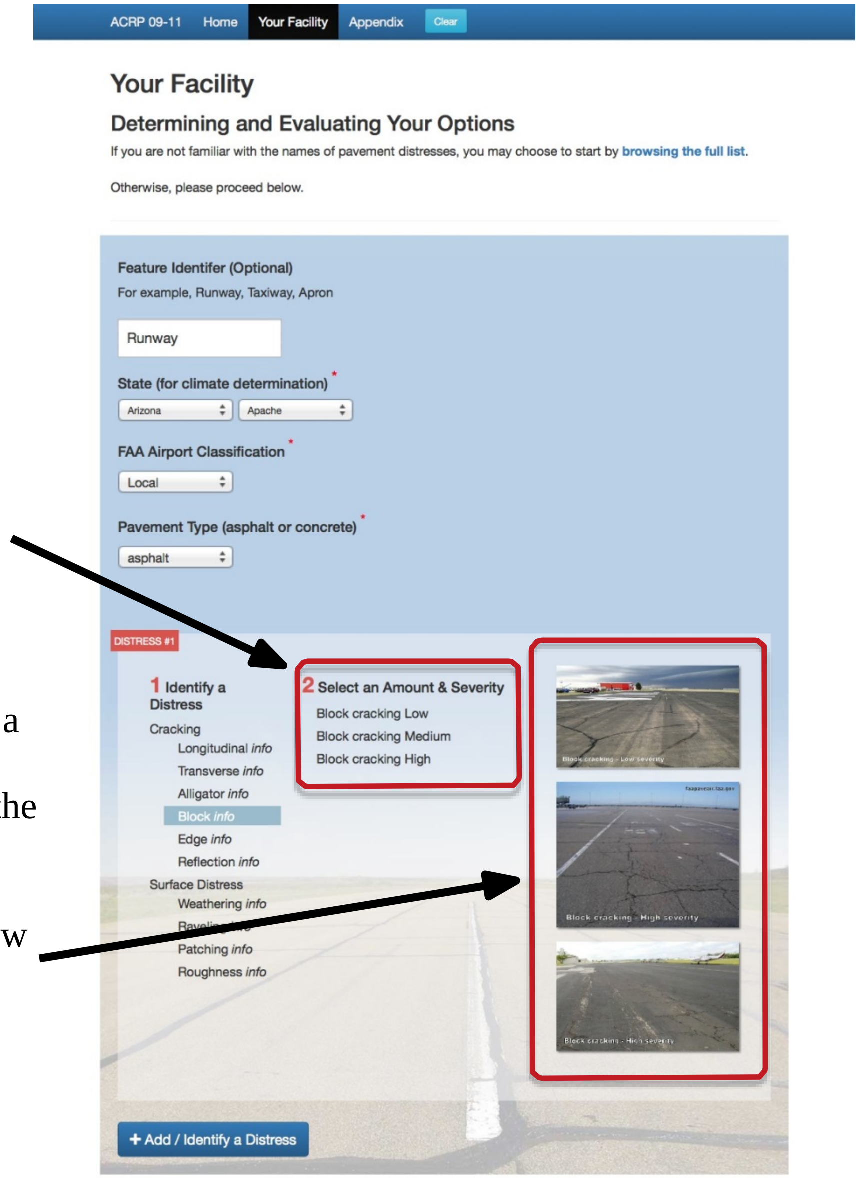


Note the differing distresses associated with concrete versus asphalt pavements.

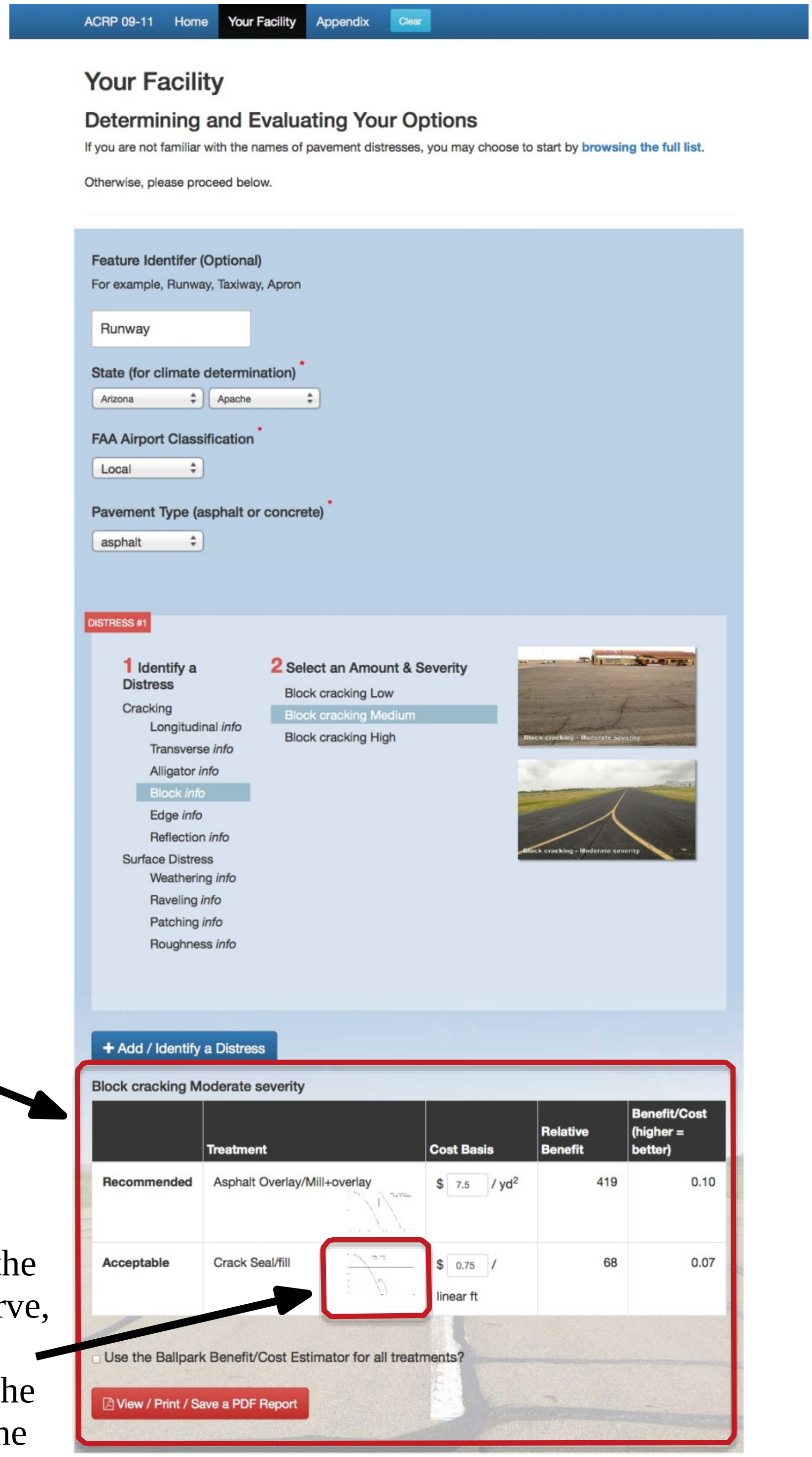
Select an appropriate choice under **Select an Amount & Severity**.

When you choose a distress, a second group of choices will appear, as well as photos of the distress.

Click a photo for a larger view to help you determine which distress your features is experiencing.



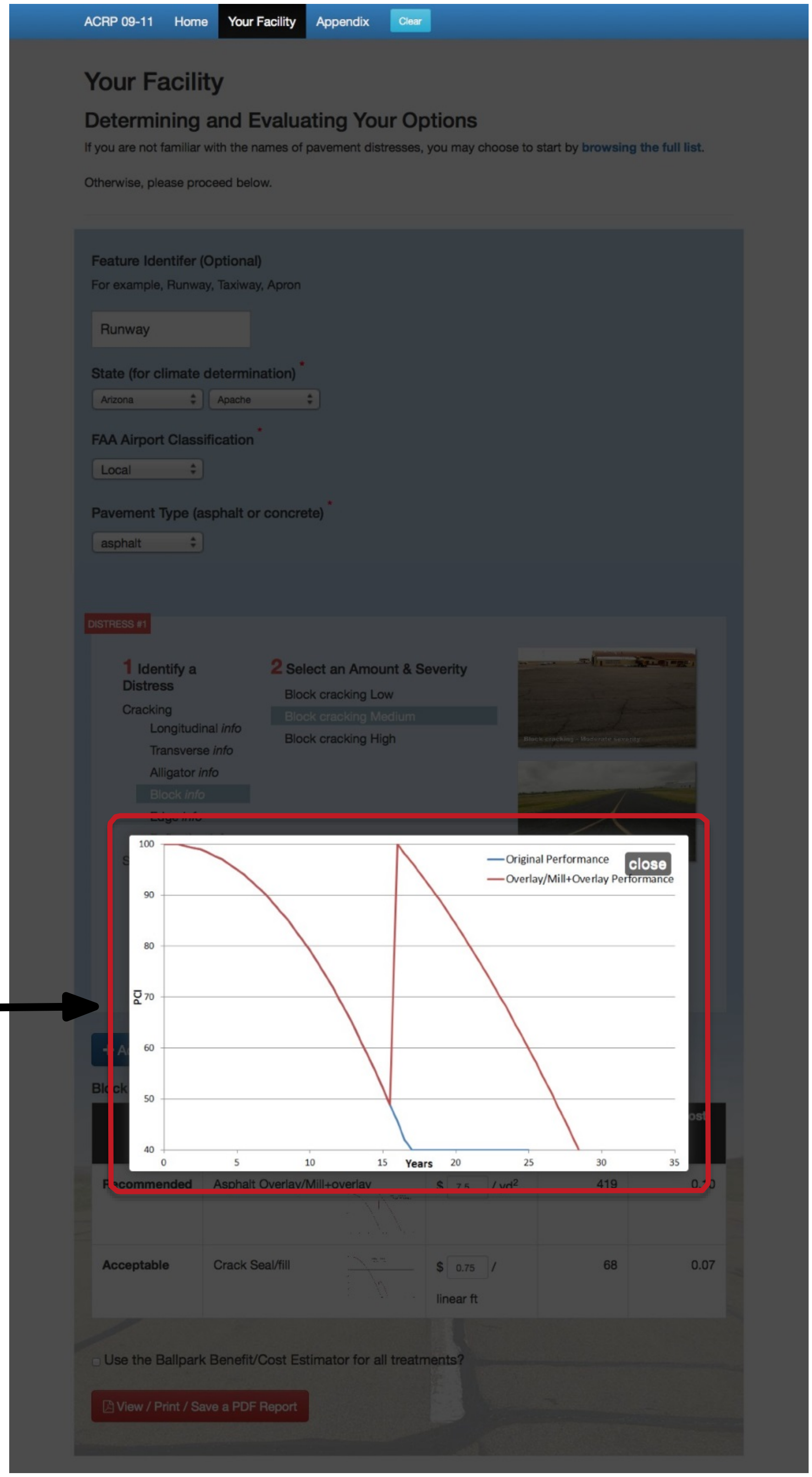
When you do so, a summary table appears listing a recommended and acceptable treatment.

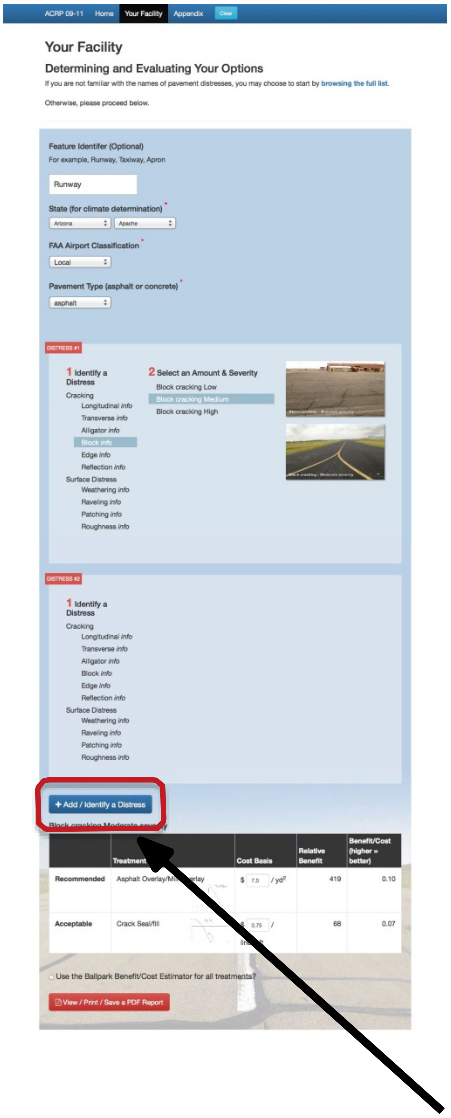


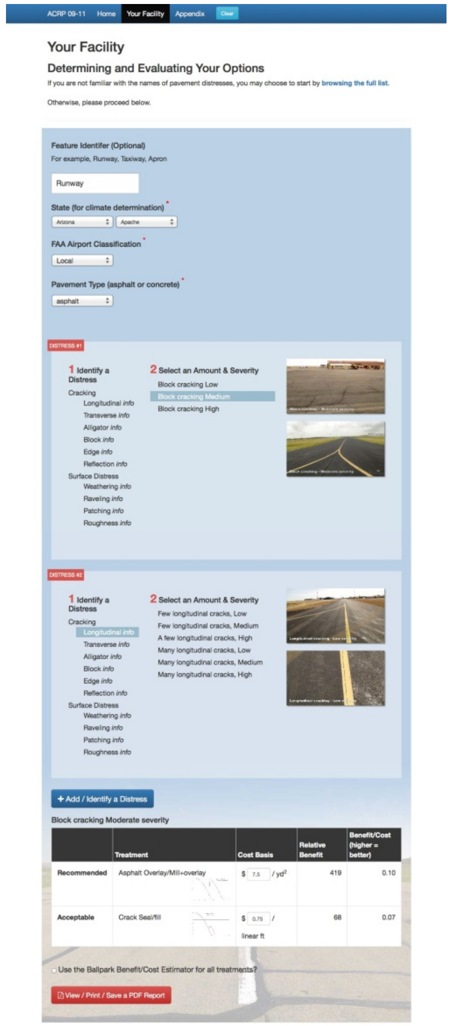
In the treatment cells, click the graph icon to view a PCI curve, indicating the estimated increased performance that the treatment can do to extend the life of the pavement being evaluated.

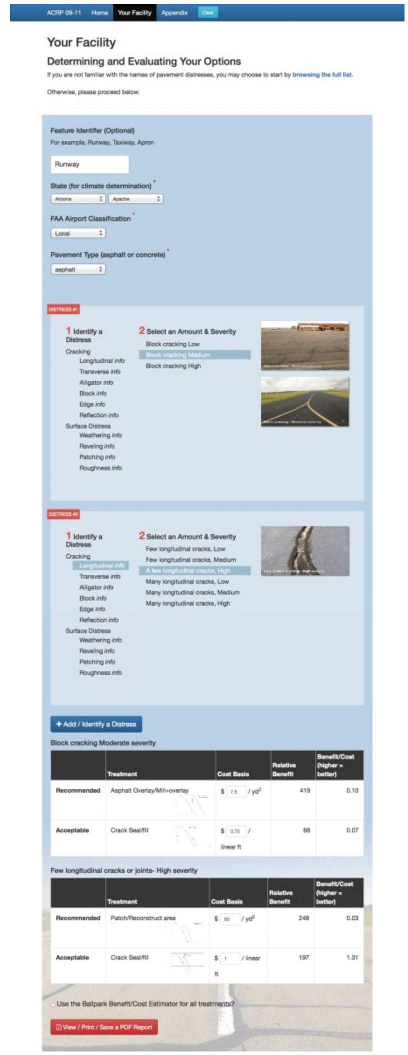
See Chapter 3 in this Guidebook for information about the relative benefit and benefit/cost numbers.

If the current feature is experiencing just one distress, skip to page 10 to use the Ballpark Estimator.



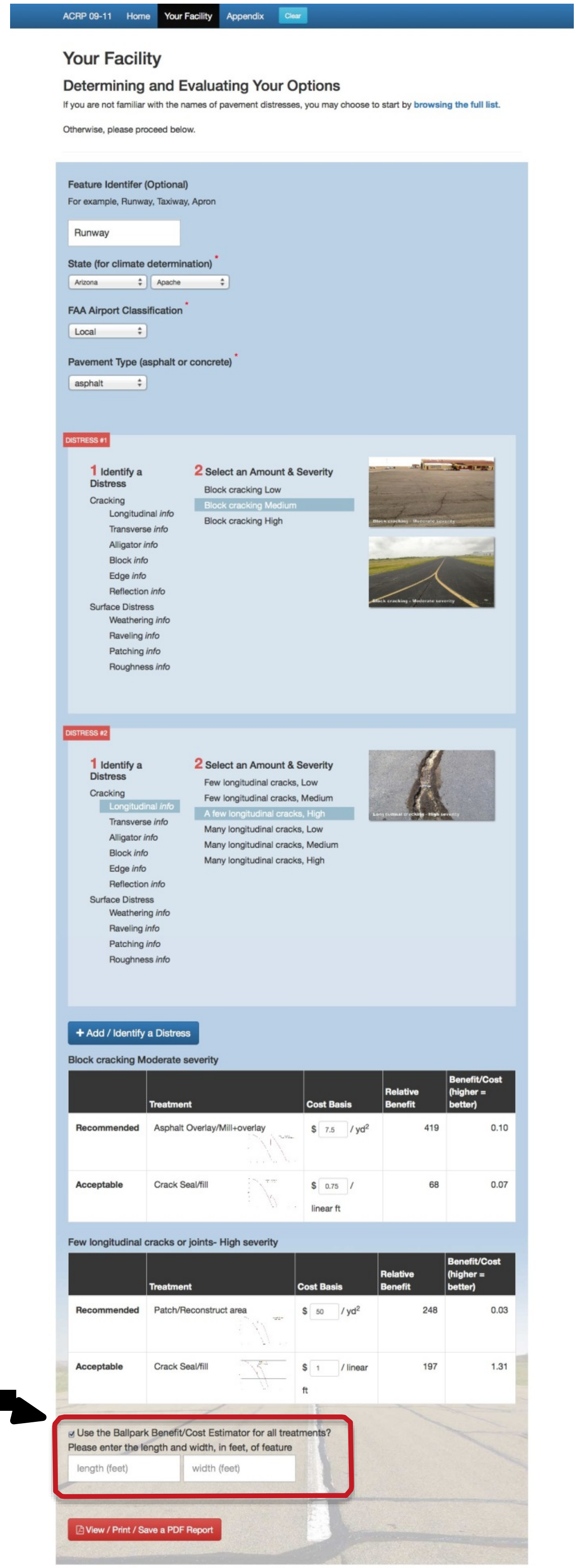






If the current feature is experiencing more than one distress, again click **Add/Identify a Distress** and follow the preceding steps to identify as many distresses as applicable.

Note that in most cases, a single treatments table will appear, combining the recommended and acceptable treatments for the distresses identified.
Pictured is an instance where differing recommended treatments exist, so multiple tables are shown.

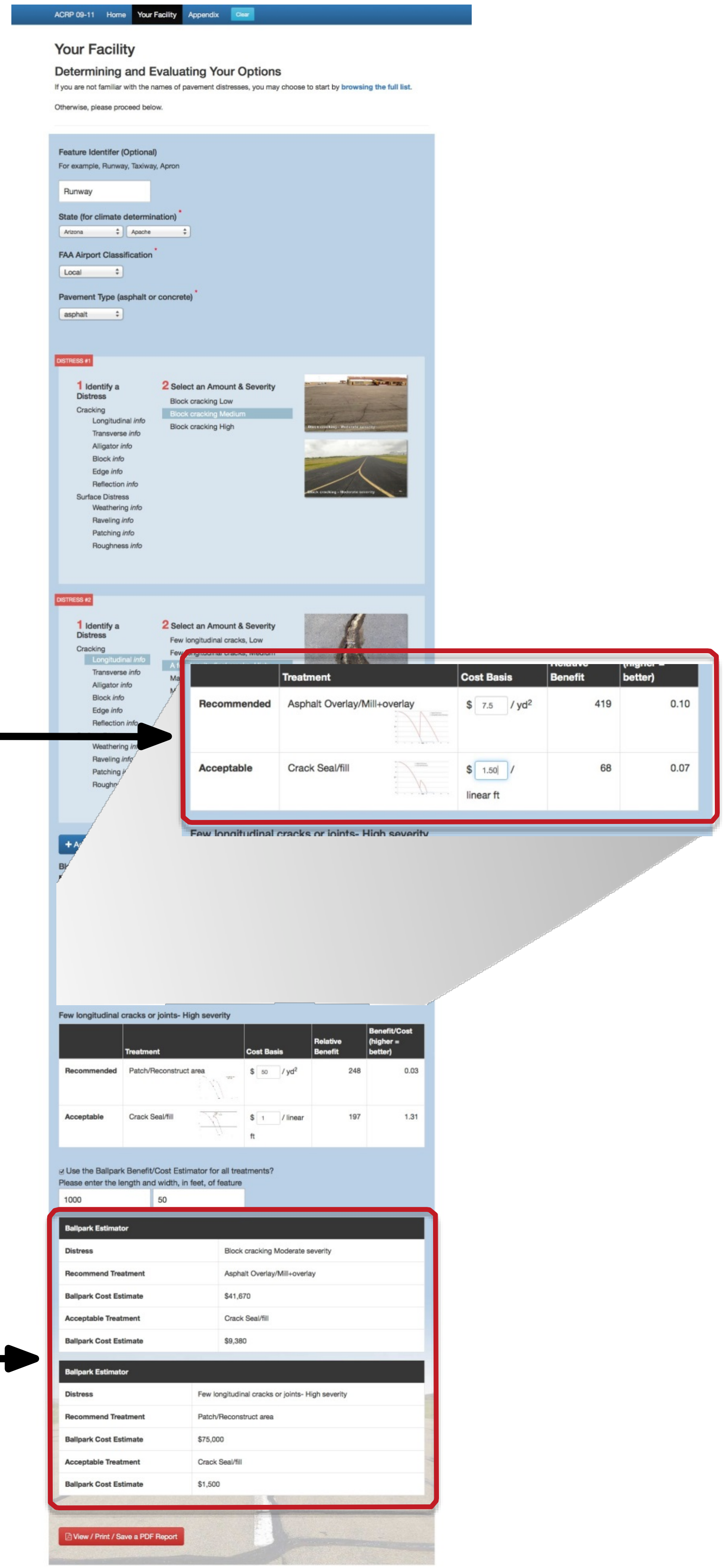


Click the **Use the Ballpark Benefit/Cost Estimator for all treatments?** checkbox to view and adjust cost estimates for treating the current feature.

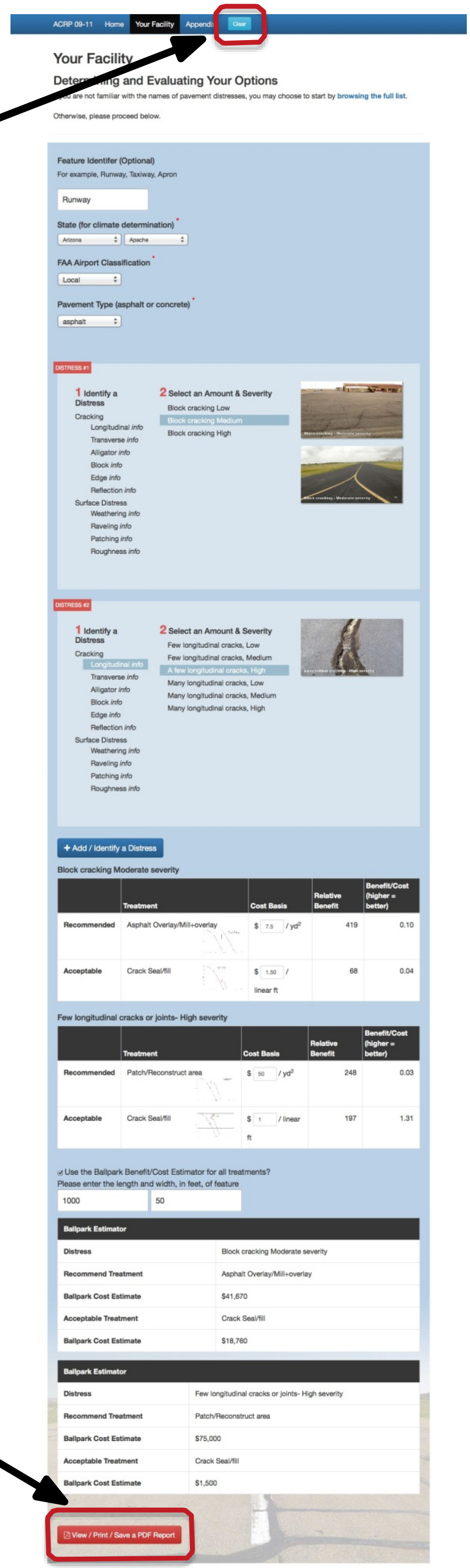
These costs are based on the cost basis numbers for each treatment. You may adjust these costs as needed per treatment.

Note that as you change cost basis numbers and tab to the next field, that the corresponding ballpark cost estimate will change as well.

When you enter a length and width for your feature, (a) Ballpark Estimator table(s) will appear with estimated costs.



To clear your feature inputs to start evaluating another feature, click **Clear**.



To save your results for each feature, either print the screen from your browser or click the **View / Print / Save a PDF Report** button.

APPENDIX A – AC DISTRESS TYPES AND DESCRIPTIONS

AC Airfields. (Taken from FAA Advisory Circular 150/5380-7B, “Airport Pavement Management Program (PMP)”)

Alligator or Fatigue Cracking

Description—Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the AC surface under repeated traffic loading. The cracking initiates at the bottom of the AC surface (or stabilized base) where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading, the cracks connect, forming many-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are less than 2 feet (0.6 m) on the longest side.

Alligator cracking occurs only in areas that are subjected to repeated traffic loadings, such as wheel paths. Therefore, it would not occur over an entire area unless the entire area was subjected to traffic loading. (Pattern-type cracking that occurs over an entire area that is not subjected to loading is rated as block cracking, that is, not a load-associated distress.)

Alligator cracking is considered a major structural distress.

Severity Levels:

L (Low)—Fine, longitudinal hairline cracks running parallel to one another with none or only a few interconnecting cracks. The cracks are not spalled.

M (Medium)—Further development of light alligator cracking into a pattern or network of cracks that may be lightly spalled. Medium-severity alligator cracking is defined by a well-defined pattern of interconnecting cracks, where all pieces are securely held in place (good aggregate interlock between pieces).

H (High)—Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges; some of the pieces rock under traffic and may cause FOD potential.

How to Measure—Alligator cracking is measured in square feet (square meters) of surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distressed area. If these portions can be easily distinguished from one another, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present. If alligator cracking and rutting occur in the same area, each is recorded separately as its respective severity level.

Bleeding

Description—Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glass-like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix or low-air void content, or both. It occurs when asphalt fills the voids of the mix during hot weather and then expands out onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface.

Severity Levels—No degrees of severity are defined.

How to Measure—Bleeding is measured in square feet (square meters) of surface area.

Block Cracking
Description—Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 foot to 10 by 10 foot (0.3 by 0.3 m to 3 by 3 m). Block cracking is caused mainly by shrinkage of the AC and daily temperature cycling (that results in daily stress/strain cycling). It is not load associated. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of pavement area, but sometimes will occur only in non-traffic areas. This type of distress differs from alligator cracking in that the alligator cracks form smaller, many-sided pieces with sharp angles. Also unlike block cracks, alligator cracks are caused by repeated traffic loadings and are, therefore, located only in traffic areas (that is, wheel paths).
Severity Levels:
L—Blocks are defined by cracks that are non-spalled (sides of the crack are vertical) or lightly spalled, causing no FOD potential. Non-filled cracks have ¼ inch (6 mm) or less mean width and filled cracks have filler in satisfactory condition.
M—Blocks are defined by either: filled or non-filled cracks that are moderately spalled (some FOD potential); non-filled cracks that are not spalled or have only minor spalling (some FOD potential), but have a mean width greater than approximately ¼ inch (6 mm); or filled cracks greater than ¼ inch that are not spalled or have only minor spalling (some FOD potential), but have filler in unsatisfactory condition.
H—Blocks are well defined by cracks that are severely spalled, causing a definite FOD potential.

How to Measure—Block cracking is measured in square feet (square meters) of surface area, and usually occurs at one severity level in a given pavement section; however, any areas of the pavement section having distinctly different levels of severity should be measured and recorded separately. For asphalt pavements, not including AC over PCC, if block cracking is recorded, no longitudinal and transverse cracking should be recorded in the same area. For asphalt overlay over concrete, block cracking, joint reflection cracking, and longitudinal and transverse cracking reflected from old concrete should all be recorded separately.

Corrugation
Description—Corrugation is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals (usually less than 5 feet) (1.5 m) along the pavement. The ridges are perpendicular to the traffic direction. Traffic action combined with an unstable pavement surface or base usually causes this type of distress.

Severity Levels:
L—Corrugations are minor and do not significantly affect ride quality (see measurement criteria below).

How to Measure—Corrugation is measured in square feet (square meters) of surface area. The mean elevation difference between the ridges and valleys of the corrugations indicates the level of severity. To determine the mean elevation difference, a 10-ft (3-m) straightedge should be placed perpendicular to the corrugations so that the depth of the valleys can be measured in inches (millimeters). The mean depth is calculated from five such measurements.

Severity	Runways and High-Speed Taxiways	Taxiways and Aprons
L	< ¼ inch (6 mm)	< ½ inch (13 mm)

M	¼ to ½ inch (6 to 13 mm)	½ to 1 inch (13 to 25 mm)
H	> ½ inch (13 mm)	> 1 inch (25 mm)

Depression

Description—Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; but the depressions can also be located without rain because of stains created by ponding of water. Depressions can be caused by settlement of the foundation soil or can be built during construction. Depressions cause roughness and, when filled with water of sufficient depth, could cause hydroplaning of aircraft.

Severity Levels:

L—Depression can be observed or located by stained areas, only slightly affects pavement riding quality, and may cause hydroplaning potential on runways (see measurement criteria below).
M—The depression can be observed, moderately affects pavement riding quality, and causes hydroplaning potential on runways (see measurement criteria below).
H—The depression can be readily observed, severely affects pavement riding quality, and causes definite hydroplaning potential (see measurement criteria below).

How to Measure—Depressions are measured in square feet (square meters) of surface area. The maximum depth of the depression determines the level of severity. This depth can be measured by placing a 10-ft (3-m) straightedge across the depressed area and measuring the maximum depth in inches (millimeters). Depressions larger than 10 feet (3 m) across must be measured by using a stringline:

	Maximum Depth of Depression	
Severity	Runways and High-Speed Taxiways	Taxiways and Aprons
L	⅛ to ½ inch (3 to 13 mm)	½ to 1 inch (13 to 25 mm)
M	½ to 1 inch (13 to 25 mm)	1 to 2 inch (25 to 51 mm)
H	> 1 inch (> 25 mm)	> 2 inch (> 51 mm)

Jet-Blast Erosion

Description—Jet-blast erosion causes darkened areas on the pavement surface where bituminous binder has been burned or carbonized. Localized burned areas may vary in depth up to approximately ½ inch (13 mm).

Severity Levels—No degrees of severity are defined. It is sufficient to indicate that jet-blast erosion exists.

How to Measure—Jet-blast erosion is measured in square feet (square meters) of surface area.

Joint Reflection Cracking From PCC (Longitudinal and Transverse)

Description—This distress occurs only on pavements having an asphalt or tar surface over a PCC slab. This category does not include reflection cracking from any other type of base (that is, cement stabilized, lime stabilized). Such cracks are listed as longitudinal and transverse cracks. Joint reflection cracking is caused mainly by movement of the PCC slab beneath the AC surface because of thermal and moisture changes; it is not load-related. However, traffic loading may cause a breakdown of the AC near the crack, resulting in spalling and FOD potential. If the pavement is fragmented along a crack, the crack is said to be spalled. Knowledge of slab dimensions beneath the AC surface will help to identify these cracks.

Severity Levels:
L—Cracks have only light spalling (little or no FOD potential) or no spalling, and can be filled or non-filled. If non-filled, the cracks have a mean width of ¼ inch (6 mm) or less; filled cracks are of any width, but their filler material is in satisfactory condition.
M—One of the following conditions exists: cracks are moderately spalled (some FOD potential) and can be either filled or non-filled of any width; filled cracks are not spalled or are lightly spalled, but filler is in unsatisfactory condition; non-filled cracks are not spalled or are only lightly spalled, but the mean crack width is greater than ¼ inch (6 mm); or light random cracking exists near the crack or at the corners of intersecting cracks.
H—Cracks are severely spalled with pieces loose or missing causing definite FOD potential. Cracks can be either filled or non-filled of any width.

How to Measure—Joint reflection cracking is measured in linear feet (meters). The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion should be recorded separately. For example, a crack that is 50 feet (15 m) long may have 10 feet (3 m) of a high severity, 20 feet (6 m) of a medium severity, and 20 feet (6 m) of a light severity. These would all be recorded separately. If the different levels of severity in a portion of a crack cannot be easily divided, that portion should be rated at the highest severity present.

Longitudinal and Transverse Cracking (Non-PCC Joint Reflective)

Description—Longitudinal cracks are parallel to the pavement's center line or laydown direction. They may be caused by (1) a poorly constructed paving lane joint, (2) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (3) a reflective crack caused by cracks beneath the surface course, including cracks in PCC slabs (but not at PCC joints). Transverse cracks extend across the pavement at approximately right angles to the pavement's center line or direction of laydown. They may be caused by (2) or (3). These types of cracks are not usually load associated. If the pavement is fragmented along a crack, the crack is said to be spalled.

Severity Levels:
L—Cracks have only light spalling (little or no FOD potential) or no spalling, and can be filled or non-filled. If non-filled, the cracks have a mean width of ¼ inch (6 mm) or less; filled cracks are of any width, but their filler material is in satisfactory condition.
M—One of the following conditions exists: (1) cracks are moderately spalled (some FOD potential) and can be either filled or non-filled of any width; (2) filled cracks are not spalled or are lightly spalled, but filler is in unsatisfactory condition; (3) non-filled cracks are not spalled or are only lightly spalled, but the mean crack width is greater than ¼ inch (6 mm), or (4) light random cracking exists near the crack or at the corners of intersecting cracks.
H—Cracks are severely spalled and pieces are loose or missing causing definite FOD potential. Cracks can be either filled or non-filled of any width.

Porous Friction Courses: Severity Levels:
L—Average raveled area around the crack is less than ¼ inch (6 mm) wide.
M—Average raveled area around the crack is between ¼ to 1 inch (6 to 25 mm) wide.
H—Average raveled area around the crack is greater than 1 inch (25 mm) wide.

How to Measure—Longitudinal and transverse cracks are measured in linear feet (meters). The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example see “Joint Reflection Cracking.” If block cracking is recorded, longitudinal and transverse cracking is not recorded in the same area.

Oil Spillage

Description—Oil spillage is the deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents.

Severity Levels—No degrees of severity are defined. It is sufficient to indicate that oil spillage exists.

How to Measure—Oil spillage is measured in square feet (square meters) of surface area. A stain is not a distress unless material has been lost or binder has been softened. If hardness is approximately the same as on surrounding pavement, and if no material has been lost, do not record as a distress.

Patching and Utility Cut Patch

Description—A patch is considered a defect, no matter how well it is performing.

Severity Levels:
L—Patch is in good condition and is performing satisfactorily.
M—Patch is somewhat deteriorated and affects ride quality to some extent. Moderate amount of distress is present within the patch or has FOD potential, or both.
H—Patch is badly deteriorated and affects ride quality significantly or has high FOD potential. Patch soon needs replacement.

Porous Friction Courses—The use of dense-graded AC patches in porous friction surfaces causes a water damming effect at the patch which contributes to differential skid resistance of the surface. Low-severity dense-graded patches should be rated as medium severity due to the differential friction problem. Medium- and high-severity patches are rated the same as above.

How to Measure:
Patching is measured in square feet (square meters) of surface area. However, if a single patch has areas of differing severity levels, these areas should be measured and recorded separately. For example, a 25 sf ($2.5m^2$) patch may have 10 sf ($1\ m^2$) of medium severity and 15 sf ($1.5\ m^2$) of low severity. These areas should be recorded separately. Any distress found in a patched area will not be recorded; however, its effect on the patch will be considered when determining the patch's severity level.
X1.11.4.2 A very large patch, (area > 2500 sf ($230\ m^2$)) or feathered-edge pavement, may qualify as an additional sample unit or as a separate section.

Polished Aggregate

Description—Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.

Severity Levels—No degrees of severity are defined. However, the degree of polishing should be clearly evident in the sample unit, in that the aggregate surface should be smooth to the touch.

How to Measure—Polished aggregate is measured in square feet (square meters) of surface area. Polished aggregate areas should be compared visually with adjacent non-traffic areas. If the surface texture is substantially the same in both traffic and non-traffic areas, polished aggregate should not be counted.

Raveling

Description—Raveling is the dislodging of coarse aggregate particles from the pavement surface.

Dense Mix Severity Levels—As used herein, coarse aggregate refers to predominant coarse aggregate sizes of the asphalt mix. Aggregate clusters refer to when more than one adjoining coarse aggregate piece is missing. If in doubt about a severity level, three representative areas of one square yard each (one square meter) should be examined and the number of missing coarse aggregate particles counted.
L—(1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is between 5 and 20, and/or (2) missing aggregate clusters are less than 2 percent of the examined square yard (square meter) area. In low severity raveling, there is little or no FOD potential.
M—(1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is between 21 and 40, and/or (2) missing aggregate clusters are between 2 and 10 percent of the examined square yard (square meter) area. In medium severity raveling, there is some FOD potential.
H—(1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is over 40, and/or (2) missing aggregate clusters are more than 10 percent of the examined square yard (square meter) area. In high severity raveling, there is significant FOD potential.

Slurry Seal/Coal Tar Over Dense Mix Severity Levels
L—(1) The scaled area is less than 1%. (2) In the case of coal tar where pattern cracking has developed, the surface cracks are less than ¼ inch (6 mm) wide.
M—(1) The scaled area is between 1 and 10%. (2) In the case of coal tar where pattern cracking has developed, the cracks are ¼ inch (6 mm) wide or greater.
H—(1) The scaled area is over 10%. (2) In the case of coal tar the surface is peeling off.

Porous Friction Course Severity
L—(1) In a square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is between 5 and 20 and/or the number of missing aggregate clusters does not exceed 1.
M—(1) In a square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is between 21 and 40 and/or the number of missing aggregate clusters is greater than 1 but does not exceed 25% of the area.
H—(1) In a square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is over 40 and/or the number of missing aggregate clusters is greater than 25% of the area.

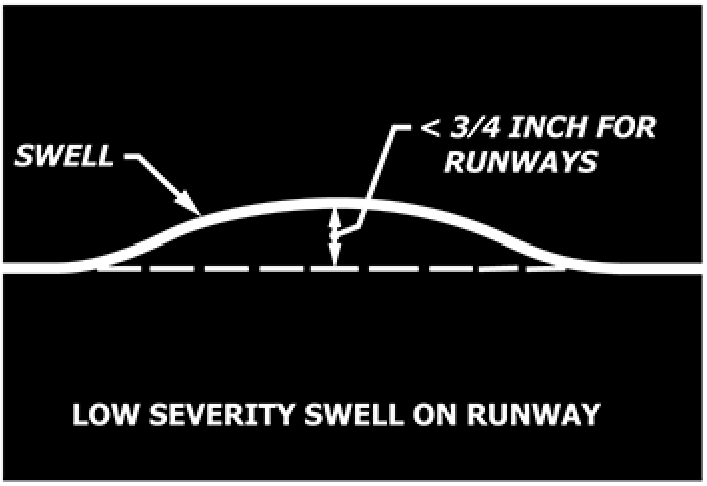
How to Measure—Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.

Rutting

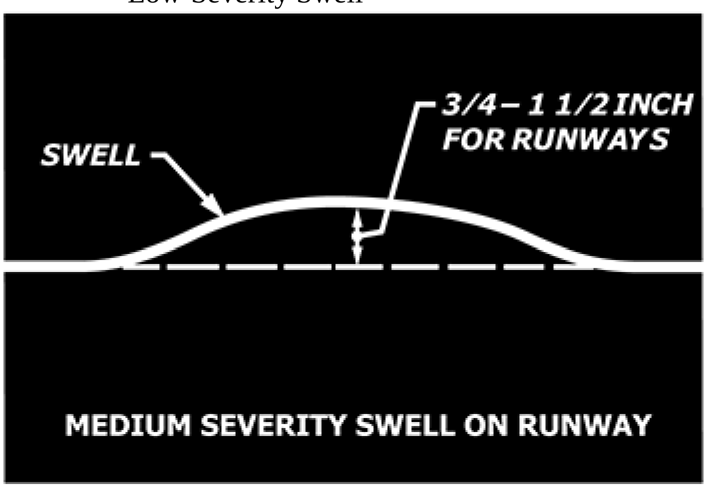
Description—A rut is a surface depression in the wheel path. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade, usually caused by consolidation or lateral movement of the materials due to traffic loads. Significant rutting can lead to major structural failure of the pavement.

Severity Levels:

Severity	All Pavement Sections
L	¼ to ½ inch (< 6 to 13 mm)
M	> ½ to 1 inch (> 13 to < 25 mm)
H	> 1 inch (> 25 mm)



Low-Severity Swell



Medium-Severity Swell

How to Measure—Rutting is measured in square feet (square meters) of surface area, and its severity is determined by the mean depth of the rut. To determine the mean depth, a straightedge should be laid across the rut and the depth measured. The mean depth in inches (millimeters) should be computed from measurements taken along the length of the rut. If alligator cracking and rutting occur in the same area, each is recorded at the respective severity level.

Shoving of Asphalt Pavement by PCC Slabs

Description—PCC pavements occasionally increase in length at ends where they adjoin flexible pavements (commonly referred to as “pavement growth”). This “growth” shoves the asphalt- or tar-surfaced pavements, causing them to swell and crack. The PCC slab “growth” is caused by a gradual opening up of the joints as they are filled with incompressible materials that prevent them from reclosing.

Severity Level:

Severity	Height Differential
L	< ¾ inch (< 20 mm)
M	¾ to 1½ inch (> 20 to 40 mm)
H	> 1½ inch (> 40 mm)

Note: As a guide, the swell table (above) may be used to determine the severity levels of shoving. At the present time, no significant research has been conducted to quantify levels of severity of shoving.
L—A slight amount of shoving has occurred and no breakup of the asphalt pavement.
M—A significant amount of shoving has occurred, causing moderate roughness and little or no breakup of the asphalt pavement.
H—A large amount of shoving has occurred, causing severe roughness or breakup of the asphalt pavement.

How to Measure—Shoving is measured by determining the area in square feet (square meters) of the swell caused by shoving.

Slippage Cracking

Description—Slippage cracks are crescent- or half-moon-shaped cracks having two ends pointed away from the direction of traffic. They are produced when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low-strength surface mix or poor bond between the surface and next layer of pavement structure.

Severity Levels—No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists.

How to Measure—Slippage cracking is measured in square feet (square meters) of surface area.

Swell-Distress

Description—Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a small swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab.

Severity Levels:
L—Swell is barely visible and has a minor effect on the pavement's ride quality. (Low-severity swells may not always be observable, but their existence can be confirmed by driving a vehicle over the section. An upward acceleration will occur if the swell is present).
M—Swell can be observed without difficulty and has a significant effect on the pavement's ride quality.
H—Swell can be readily observed and severely affects the pavement's ride quality.

How to Measure:

The surface area of the swell is measured in square feet (square metres). The severity rating should consider the type of pavement section (that is, runway, taxiway, or apron). For example, a swell of sufficient magnitude to cause considerable roughness on a runway at high speeds would be rated as more severe than the same swell located on an apron or taxiway where the normal aircraft operating speeds are much lower.
For short wavelengths, locate the highest point of the swell. Rest at 10-ft (3-m) straightedge on that point so that both ends are equal distance above pavement. Measure this distance to establish severity rating.

The following guidance is provided for runways:

Severity	Height Differential
L	< ¾ inch (20 mm)
M	¾ to 1½ inch (20 to 40 mm)
H	> 1½ inch (40 mm)

Rate severity on high-speed taxiways using measurement criteria provided above. Double the height differential criteria for other taxiways and aprons.

Weathering (Surface Wear)—Dense Mix Asphalt
Description—The wearing away of the asphalt binder and fine aggregate matrix from the pavement surface.

Severity Levels:
L—Asphalt surface beginning to show signs of aging which may be accelerated by climatic conditions. Loss is the fine aggregate matrix is noticeable and may be accompanied by fading of the asphalt color. Edges of the coarse aggregates are beginning to be exposed (less than 1 mm or 0.05 inches). Pavement may be relatively new (as new as 6 months old).
M—Loss of fine aggregate matrix is noticeable and edges of coarse aggregate have been exposed up to ¼ width (of the longest side) of the coarse aggregate due to the loss of fine aggregate matrix.
H—Edges of coarse aggregate have been exposed greater than ¼ width (of the longest side) of the coarse aggregate. There is considerable loss of fine aggregate matrix leading to potential or some loss of coarse aggregate.

How to Measure—Surface wear is measured in square feet (square meters). Surface wear is not recorded if medium or high severity raveling is recorded.

APPENDIX B – PCC DISTRESS TYPES AND DESCRIPTIONS

PCC Airfields. (Taken from FAA Advisory Circular 150/5380-7B, “Aiport Pavement Management Program (PMP)”)

Blowup

Description—Blowups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. The insufficient width is usually caused by inflation of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. The main reason blowups are included here is for reference when closed sections are being evaluated for reopening.

Severity Levels:

At the present time, no significant research has been conducted to quantify severity levels for blowups. Future research may provide measurement guidelines:

	Difference in Elevation	
	Runways and High-Speed Taxiways	Aprons and Other Taxiways
L	< ½ inch (< 13 mm)	¼ < 1 inch (6 to 25 mm)
M	½ to 1 inch (13 to 25 mm)	1 to 2 inch (25 to 51 mm)
H	inoperable	inoperable

Note: The elevations are twice the heights used for settlement/faulting. These are preliminary elevations, and subject to change.

L (Low)—Buckling or shattering has not rendered the pavement inoperable and only a slight amount of roughness exists.
M (Medium)—Buckling or shattering has not rendered the pavement inoperable, but a significant amount of roughness exists.
H (High)—Buckling or shattering has rendered the pavement inoperable.
For the pavement to be considered operational, all foreign material caused by the blowup must have been removed.

How to Count:

A blowup usually occurs at a transverse crack or joint. At a crack, it is counted as being in one slab, but at a joint, two slabs are affected and the distress should be recorded as occurring in two slabs.
Record a blowup on a slab only if the distress is evident on that slab. Severity may be different on adjacent slabs. If blowup has been repaired by patching, establish severity by determining the difference in elevation between the two slabs.

Corner Break

Description—A corner break is a crack that intersects the joints at a distance less than or equal to one half of the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 25 by 25 feet (7.5 by 7.5 m) that has a crack intersecting the joint 5 feet (1.5 m) from the corner on one side and 17 feet (5 m) on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 7 feet (2 m) on one side and 10 feet (3 m) on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually cause corner breaks.

Severity Levels:
L—Crack has little or minor spalling (no FOD potential). If non-filled, it has a mean width less than approximately ⅛ inch (3 mm). A filled crack can be of any width, but the filler material must be in satisfactory condition. The area between the corner break and the joints is not cracked.
M—One of the following conditions exists: (1) filled or non-filled crack is moderately spalled (some FOD potential); (2) a non-filled crack has a mean width between ⅛ and 1 inch (3 and 25 mm); (3) a filled crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition; or (4) the area between the corner break and the joints is lightly cracked. Lightly cracked means one low-severity crack dividing the corner into two pieces.
H—One of the following conditions exists: (1) filled or non-filled crack is severely spalled, causing definite FOD potential; (2) a non-filled crack has a mean width greater than approximately 1 inch (25 mm), creating a tire damage potential; or (3) the area between the corner break and the joints is severely cracked.

How to Count:
A distress slab is recorded as one slab if it contains a single corner break, contains more than one break of a particular severity, or contains two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both light and medium-severity corner breaks should be counted as one slab with a medium corner break. Crack widths should be measured between vertical walls, not in spalled areas of the crack.
If the corner break is faulted ⅛ inch (3 mm) or more, increase severity to the next higher level. If the corner is faulted more than ½ inch (13 mm), rate the corner break at high severity. If faulting in corner is incidental to faulting in the slab, rate faulting separately.
The angle of crack into the slab is usually not evident at low severity. Unless the crack angle can be determined, to differentiate between the corner break and corner spall, use the following criteria. If the crack intersects both joints more than 2 feet (600 mm) from the corner, it is a corner break. If it is less than 2 feet, unless you can verify the crack is vertical, call it a spall.

Longitudinal, Transverse, and Diagonal Cracks
Description—These cracks, that divide the slab into two or three pieces, are usually caused by a combination of load repetition, curling stresses, and shrinkage stresses. (For slabs divided into four or more pieces.) Low-severity cracks are usually warping- or friction-related and are not considered major structural distresses. Medium- or high-severity cracks are usually working cracks and are considered major structural distresses.
Note: Hairline cracks that are only a few feet long and do not extend across the entire slab are rated as shrinkage cracks.

Severity Levels:
L—Crack has little or minor spalling (no FOD potential). If non-filled, it has a mean width less than approximately ⅛ inch (3 mm). A filled crack can be of any width, but the filler material must be in satisfactory condition; or the slab is divided into three pieces by low-severity cracks.
M—One of the following conditions exists: (1) filled or non-filled crack is moderately spalled (some FOD potential); (2) a non-filled crack has a mean width between ⅛ and 1 inch (3 and 25 mm); (3) a filled

crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition; or (4) the slab is divided into three pieces by two or more cracks, one of which is at least medium severity.
H—One of the following conditions exists: (1) filled or non-filled crack is severely spalled, causing definite FOD potential; (2) a non-filled crack has a mean width greater than approximately 1 inch (25 mm), creating a tire damage potential; or (3) the slab is divided into three pieces by two or more cracks, one of which is at least high severity.

<u>How to Count</u>:
Once the severity has been identified, the distress is recorded as one slab. If the slab is divided into four or more pieces by cracks, refer to the distress type Shattered Slab.
Cracks used to define and rate corner breaks, "D" cracks, patches, shrinkage cracks, and spalls are not recorded as L/T/D cracks.

Durability ("D") Cracking
Description—Durability cracking is caused by the concrete's inability to withstand environmental factors, such as freeze-thaw cycles. It usually appears as a pattern of cracks running parallel to a joint or linear crack. A dark coloring can usually be seen around the fine durability cracks. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (0.3 to 0.6 m) of the joint or crack.

<u>Severity Levels</u>:
L—"D" cracking is defined by hairline cracks occurring in a limited area of the slab, such as one or two corners or along one joint. Little or no disintegration has occurred. No FOD potential.
M—"D" cracking has developed over a considerable amount of slab area with little or no disintegration or FOD potential; or "D" cracking has occurred in a limited area of the slab, such as one or two corners or along one joint, but pieces are missing and disintegration has occurred. Some FOD potential.
H—"D" cracking has developed over a considerable amount of slab area with disintegration or FOD potential.

<u>How to Count</u>—When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level is found, the slab is counted as having the higher severity distress. For example, if low- and medium-durability cracking are located on one slab, the slab is counted as having medium only. If "D" cracking is counted, scaling on the same slab should not be recorded.

Joint Seal Damage
<u>Description</u>—Joint seal damage is any condition that enables soil or rocks to accumulate in the joints or allows significant infiltration of water. Accumulation of incompressible materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from accumulation of materials and also prevents water from seeping down and softening the foundation supporting the slab. Typical types of joint seal damage are: (1) stripping of joint sealant, (2) extrusion of joint sealant, (3) weed growth, (4) hardening of the filler (oxidation), (5) loss of bond to the slab edges, and (6) lack or absence of sealant in the joint.

<u>Severity Levels</u>:
L—Joint sealer is in generally good condition throughout the sample. Sealant is performing well with only a minor amount of any of the above types of damage present. Joint seal damage is at low severity if a few of the joints have sealer which has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between sealer and joint face without resistance.
M—Joint sealer is in generally fair condition over the entire surveyed sample with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within two years. Joint

seal damage is at medium severity if a few of the joints have any of the following conditions: (1) joint sealer is in place, but water access is possible through visible openings no more than ⅛ inch (3 mm) wide. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist; (2) pumping debris are evident at the joint; (3) joint sealer is oxidized and "lifeless" but pliable (like a rope), and generally fills the joint opening; or (4) vegetation in the joint is obvious, but does not obscure the joint opening.
H—Joint sealer is in generally poor condition over the entire surveyed sample with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement. Joint seal damage is at high severity if 10 % or more of the joint sealer exceeds limiting criteria listed above, or if 10 % or more of sealer is missing.

How to Count:
Joint seal damage is not counted on a slab-by-slab basis, but is rated based on the overall condition of the sealant in the sample unit.
Joint sealer is in satisfactory condition if it prevents entry of water into the joint, it has some elasticity, and if there is no vegetation growing between the sealer and joint face.
Premolded sealer is rated using the same criteria as above except as follows: (1) premolded sealer must be elastic and must be firmly pressed against the joint walls; and (2) premolded sealer must be below the joint edge. If it extends above the surface, it can be caught by moving equipment such as snow plows or brooms and be pulled out of the joint. Premolded sealer is recorded at low severity if any part is visible above joint edge. It is at medium severity if 10 % or more of the length is above joint edge or if any part is more than ½ inch (12 mm) above joint edge. It is at high severity if 20 % or more is above joint edge or if any part is more than 1 in. (25 mm) above joint edge, or if 10 % or more is missing.

Rate joint sealer by joint segment. Sample unit rating is the same as the most severe rating held by at least 20 % of segments rated.
Rate only the left and upstation joints along sample unit boundaries.
In rating oxidation, do not rate on appearance. Rate on resilience. Some joint sealer will have a very dull surface, and may even show surface cracks in the oxidized layer. If the sealer is performing satisfactorily and has good characteristics beneath the surface, it is satisfactory.

Patching, Small (Less Than 5 sf (0.5 m^2))
Description—A patch is an area where the original pavement has been removed and replaced by a filler material. For condition evaluation, patching is divided into two types: small (less than 5 sf (0.5 m^2)) and large (over 5 sf). Large patches are described in the next section.

Severity Levels:
L—Patch is functioning well with little or no deterioration.
M—Patch that has deterioration or moderate spalling, or both, can be seen around the edges. Patch material can be dislodged with considerable effort (minor FOD potential).
H—Patch deterioration, either by spalling around the patch or cracking within the patch, to a state that warrants replacement.

How to Count:
If one or more small patches having the same severity level are located in a slab, it is counted as one slab containing that distress. If more than one severity level occurs, it is counted as one slab with the higher severity level being recorded.
If a crack is repaired by a narrow patch (that is, 4 to 10 in. (102 to 254 mm) wide), only the crack and not the patch should be recorded at the appropriate severity level.

Patching, Large (Over 5 sf (0.5 m^2)) and Utility Cut
Description—Patching is the same as defined in the previous section. A utility cut is a patch that has replaced the original pavement because of placement of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels:
L—Patch is functioning well with very little or no deterioration.
M—Patch deterioration or moderate spalling, or both, can be seen around the edges. Patch material can be dislodged with considerable effort, causing some FOD potential.
H—Patch has deteriorated to a state that causes considerable roughness or high FOD potential, or both. The extent of the deterioration warrants replacement of the patch.

Popouts
Description—A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 to 4 inch (25 to 100 mm) in diameter and from ½ to 2 inch (13 to 51 mm) deep.

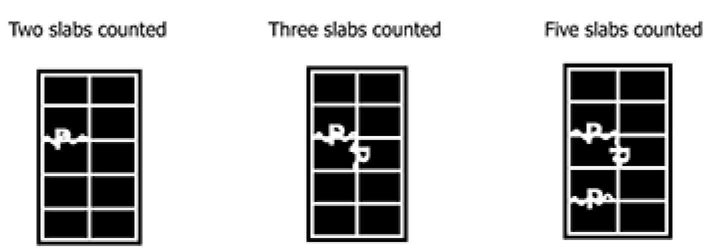
Severity Levels—No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress; that is, average popout density must exceed approximately three popouts per square yard (per square meter) over the entire slab area.

How to Count—The density of the distress must be measured. If there is any doubt about the average being greater than three popouts per square yard (per square meter), at least three random 1-yd2 (1-m2) areas should be checked. When the average is greater than this density, the slab is counted.

Pumping
Description—Pumping is the ejection of material by water through joints or cracks caused by deflection of the slab under passing loads. As water is ejected, it carries particles of gravel, sand, clay, or silt resulting in a progressive loss of pavement support. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates poor joint sealer and loss of support, which will lead to cracking under repeated loads. The joint seal must be identified as defective before pumping can be said to exist. Pumping can occur at cracks as well as joints.

Severity Levels—No degrees of severity are defined. It is sufficient to indicate that pumping exists.

How to Count—Slabs are counted as follows: one pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.



Slab Counting Procedure for Distresses

Scaling

Description—Surface deterioration caused by construction defects, material defects and environmental factors. Generally scaling is exhibited by delamination or disintegration of paste on the slab surface to the depth of the defect. Construction defects include: over-finishing, addition of water to the pavement surface during finishing, lack of curing, attempted surface repairs of fresh concrete with mortar. Generally this occurs over a portion of a slab. Material defects include: inadequate air entrainment for the climate. Generally this occurs over several slabs that were affected by the concrete batches. Environmental factors: freezing of concrete before adequate strength gained or thermal cycles from certain aircraft. Generally over a large area for freezing, and isolated areas for thermal effects. Typically, the FOD from scaling is removed by sweeping, but the concrete will continue to scale until the affected depth is removed or expended.

Severity Levels:
L—Minimal loss of surface paste that poses no FOD hazard, limited to less than 1% of the slab area. No FOD potential.
M—The loss of surface paste that poses some FOD potential including isolated fragments of loose mortar, exposure of the sides of coarse aggregate (Less than ¼ of the width of coarse aggregate), or evidence of coarse aggregate coming loose from the surface. Surface paste loss is greater than 1% of the slab area but less than 10%.
H—High severity is associated with low durability concrete that will continue to pose a high FOD hazard; normally the layer of surface mortar is observable at the perimeter of the scaled area, and is likely to continue to delaminate or disintegrate due to environmental or other factors. Routine sweeping is not sufficient to avoid FOD issues, is an indication that high FOD hazard is present. Surface paste loss is greater than 10% of the slab area.

How to Count—If two or more levels of severity exist on a slab, the slab is counted as one slab having the maximum level of severity. For example, if both low-severity crazing and medium scaling exist on one slab, the slab is counted as one slab containing medium scaling. If "D" cracking is counted, scaling is not counted.

Settlement or Faulting

Description—Settlement or faulting is a difference of elevation at a joint or crack caused by upheaval or consolidation.

Severity Levels—Severity levels are defined by the difference in elevation across the fault and the associated decrease in ride quality and safety as severity increases:

	Runways/Taxiways	Aprons
L	< ¼ inch (6 mm)	1/8 < ½ inch (3 to 13 mm)
M	¼ to ½ inch (6 to 13 mm)	½ to 1 inch (13 to 25 mm)
H	> ½ inch (13 mm)	> 1 inch (25 mm)

How to Count:
In counting settlement, a fault between two slabs is counted as one slab. A straightedge or level should be used to aid in measuring the difference in elevation between the two slabs.

Construction-induced elevation differential is not rated in PCI procedures. Where construction differential exists, it can often be identified by the way the high side of the joint was rolled down by finishers (usually within 6 in. (150 mm) of the joint) to meet the low-slab elevation.

Shattered Slab/Intersecting Cracks

Description—Intersecting cracks are cracks that break the slab into four or more pieces due to overloading or inadequate support, or both. The high-severity level of this distress type, as defined as follows, is referred to as shattered slab. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

Severity Levels:
L—Slab is broken into four or five pieces predominantly defined by low-severity cracks.
M—Slab is broken into four or five pieces with over 15 % of the cracks of medium severity (no high-severity cracks); slab is broken into six or more pieces with over 85 % of the cracks of low severity.
H—At this level of severity, the slab is called shattered: (1) slab is broken into four or five pieces with some or all cracks of high severity; or (2) slab is broken into six or more pieces with over 15 % of the cracks of medium or high severity.

How to Count—No other distress such as scaling, spalling, or durability cracking should be recorded if the slab is medium- or high-severity level since the severity of this distress would affect the slab's rating substantially. Shrinkage cracks should not be counted in determining whether or not the slab is broken into four or more pieces.

Shrinkage Cracking

Description—Shrinkage cracking is typically categorized in two forms; drying shrinkage that occurs over time as moisture leaves the pavement and plastic shrinkage that occurs shortly after the pavement is placed and rapid drying of the surface occurs while the pavement is still plastic. Drying shrinkage cracks occur when a hardened pavement continues to shrink as excess water not needed for cement hydration evaporates. They form when subsurface resistance to the shrinkage is present and may extend through the entire depth of the slab. Plastic shrinkage occurs when there is a rapid loss of water in the surface of a recently placed pavement caused by evaporation. High winds, low humidity, and/or high ambient and/or concrete temperatures are contributing factors to evaporation. These cracks can appear as a series of parallel cracks, usually 1 to 3 feet (.3 to .9 meters) apart and do not extend very deep into the pavement's surface. Another form of plastic shrinkage occurs while a pavement is still plastic and can result from overfinishing/overworking the pavement during construction or finishing the pavement while bleed water is on the surface. This results in an increase in mortar and fines and higher water content at the surface, making the immediate surface weak and susceptible to shrinkage. These shrinkage cracks appear as a series of inter-connected hairline cracks, or pattern cracking, and are often observed over a majority of the slab surface. This condition is also referred to as map cracking or crazing.

Severity Levels—No degrees of severity are defined. It is sufficient to indicate that shrinkage cracking exists.

How to Count—If one or more shrinkage cracks or area of pattern cracking (map cracking) exist on one particular slab, and a FOD hazard or potential is not present, the slab is counted as one slab with shrinkage cracking.

Spalling (Transverse and Longitudinal Joint)

Description—Joint spalling is the breakdown of the slab edges within 2 feet (0.6 m) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Spalling results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic load. Weak concrete at the joint (caused by overworking) combined with traffic loads is another cause of spalling.
Note: Frayed condition as used in this test method indicates material is no longer in place along a joint or crack. Spalling indicates material may or may not be missing along a joint or crack.

Severity Levels:
L—Spall over 2 feet (0.6 m) long: (1) spall is broken into no more than three pieces defined by low- or medium-severity cracks; little or no FOD potential exists; or (2) joint is lightly frayed; little or no FOD potential. Spall less than 2 feet long is broken into pieces or fragmented with little FOD or tire damage potential exists. Lightly frayed means the upper edge of the joint is broken away leaving a spall no wider than 1 in. (25 mm) and no deeper than ½ inch (13 mm). The material is missing and the joint creates little or no FOD potential.
M—Spall over 2 feet (0.6 m) long: (1) spall is broken into more than three pieces defined by light or medium cracks; (2) spall is broken into no more than three pieces with one or more of the cracks being severe with some FOD potential existing; or (3) joint is moderately frayed with some FOD potential. Spall less than 2 feet long: spall is broken into pieces or fragmented with some of the pieces loose or absent, causing considerable FOD or tire damage potential. Moderately frayed means the upper edge of the joint is broken away leaving a spall wider than 1 in. (25 mm) or deeper than ½ inch (13 mm). The material is mostly missing with some FOD potential.
H—Spall over 2 feet (0.6 m) long: (1) spall is broken into more than three pieces defined by one or more high-severity cracks with high FOD potential and high possibility of the pieces becoming dislodged, or (2) joint is severely frayed with high FOD potential.

How to Count—If the joint spall is located along the edge of one slab, it is counted as one slab with joint spalling. If spalling is located on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling. If a joint spall is small enough, less than 3 in. (76 mm) wide, to be filled during a joint seal repair, it should not be recorded.
Note: If less than 2 feet (0.6 m) of the joint is lightly frayed, the spall should not be counted.

Spalling (Corner)
Description—Corner spalling is the raveling or breakdown of the slab within approximately 2 feet (0.6 m) of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab.

Severity Levels:
L—One of the following conditions exists: (1) spall is broken into one or two pieces defined by low-severity cracks (little or no FOD potential); or (2) spall is defined by one medium-severity crack (little or no FOD potential).
M—One of the following conditions exists: (1) spall is broken into two or more pieces defined by medium-severity crack(s), and a few small fragments may be absent or loose; (2) spall is defined by one severe, fragmented crack that may be accompanied by a few hairline cracks; or, (3) spall has deteriorated to the point where loose material is causing some FOD potential.
H—One of the following conditions exists: (1) spall is broken into two or more pieces defined by high-severity fragmented crack(s) with loose or absent fragments; (2) pieces of the spall have been displaced to the extent that a tire damage hazard exists; or (3) spall has deteriorated to the point where loose material is causing high FOD potential.

How to Count:
If one or more corner spalls having the same severity level are located in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab having the higher severity level.
A corner spall smaller than 3 inches (76 mm) wide, measured from the edge of the slab, and filled with sealant is not recorded.

Alkali Silica Reaction (ASR)
Description—ASR is caused by chemical reaction between alkalis and certain reactive silica minerals which form a gel. The gel absorbs water, causing expansion which may damage the concrete and adjacent structures. Alkalis are most often introduced by the Portland cement within the pavement. ASR cracking may be accelerated by chemical pavement deicers. Visual indicators that ASR may be present include:
(1) Cracking of the concrete pavement (often in a map pattern)
(2) White, brown, gray or other colored gel or staining may be present at the crack surface
(3) Aggregate popouts
(4) Increase in concrete volume (expansion) that may result in distortion of adjacent or integral structures or physical elements. Examples of expansion include shoving of asphalt pavements, light can tilting, slab faulting, joint misalignment, and extrusion of joint seals or expansion joint fillers.
Because ASR is material-dependent, ASR is generally present throughout the pavement section. Coring and concrete petrographic analysis is the only definitive method to confirm the presence of ASR. The following should be kept in mind when identifying the presence of ASR through visual inspection:
(1) Generally ASR distresses are not observed in the first few years after construction. In contrast, plastic shrinkage cracking can occur the day of construction and is apparent within the first year.
(2) ASR is differentiated from D-Cracking by the presence of cracking perpendicular to the joint face. D-Cracking predominantly develops as a series of parallel cracks to joint faces and linear cracking within the slab.
(3) ASR is differentiated from Map Cracking/Scaling by the presence of visual signs of expansion.

Severity Levels:
L—Minimal to no FOD potential from cracks, joints or ASR-related popouts; cracks at the surface are tight (predominantly 1.0 mm or less). Little to no evidence of movement in pavement or surrounding structures or elements.
M—Some FOD potential; but increased sweeping or other FOD removal methods may be required. May be evidence of slab movement or some damage (or both) to adjacent structures or elements. Medium ASR distress is differentiated from low by having one or more of the following: increased FOD potential, crack density increases, some fragments along cracks or at crack intersections present, surface popouts of concrete may occur, pattern of wider cracks (predominantly 1.0 mm or wider) that may be subdivided by tighter cracks.
H—One or both of the following exist: (1) Loose or missing concrete fragments and poses high FOD potential, (2) Slab surface integrity and function significantly degraded and pavement requires immediate repairs; may also require repairs to adjacent structures or elements.

APPENDIX C – AIRPORT MAINTENANCE TREATMENTS

Taken from "*Common Airport Pavement Maintenance Practices: A Synthesis of Airport Practice*", (Hajek, J., J. W. Hall, and D. K. Hein), which provides a thorough catalogue of most common treatment options

APPENDIX B
Catalog of Airport Pavement Preservation Treatments

CONTENTS

INTRODUCTION

The objective of the *Catalog of Airport Pavement Preservation Treatments* is to describe common airport pavement preservation treatments for both asphalt concrete (AC) and portland cement concrete (PCC) airfield pavements, and to include materials, methods, and applications. The information is organized in the form of Fact Sheets. Each pavement preservation treatment is described on a separate Fact Sheet using a set format.

Selection of Treatments Included in the Catalog

This appendix includes 24 Fact Sheets, each describing pavement preservation treatments as listed in Table B1. These 24 treatments were compiled from responses to the questionnaire sent to airport managers and engineers that identified 38 separate treatments as part of this synthesis project. Additional information was obtained from the 35 referenced documents listed in the Resource sections of this appendix. The survey is described in chapter one, the survey questionnaire in Appendix A, the key survey results are described throughout the report and additional survey results are summarized in Appendix A.

Briefly, 50 survey responses were obtained from a geographically diverse set of airports ranging in size from one to approximately 3,000 daily aircraft operations. Thirty-eight pavement preservation treatments were included on the survey form for respondents to review; these encompassed commonly used pavement preservation treatments for AC and PCC pavements. The 24 treatments included in the catalog were taken from the 50 responses and each of these has been used routinely by at least one of the airports surveyed, or they have been tried by at least 10% of the airports. All treatments included in the survey satisfied these inclusion criteria with the exception of microsurfacing used for PCC pavements.

The 38 treatments included in the survey were reduced to 24 treatments included in the catalog by combining treatments that differed primarily by the material used or by the pavement type to which the treatment is applied. An example of combining treatments that differ only by the material used is the combination of two types of crack sealing of AC pavements (using hot-poured sealant or using cold-applied sealant) into one treatment (sealing and filling of cracks of AC pavement). An example of combining treatments that differ primarily by the pavement type is microsurfacing of AC pavements and microsurfacing of PCC pavements, which became one treatment—microsurfacing. As a result, the *Catalog* includes 3 pavement preservation treatments applicable to both AC and PCC pavements, 12 treatments applicable to AC pavements, and 9 treatments applicable to PCC pavements (see Table B1).

TABLE B1
AIRPORT PAVEMENT PRESERVATION TREATMENTS INCLUDED IN THE CATALOG

Both Pavement Types 3 treatments	Asphalt Concrete 12 treatments	Portland Cement Concrete 9 treatments
1) Texturization using shot blasting 2) Diamond grinding 3) Microsurfacing	4) Sealing and filling of cracks (with hot or cold applied sealants) 5) Small area patching (using hot mix, cold mix, or proprietary material) 6) Spray patching (manual chip seal and mechanized spray patching) 7) Machine patching with AC material 8) Rejuvenators and seals 9) Texturization using fine milling 10) Surface treatment (chip seal, chip seal coat) 11) Slurry seal 12) Hot-mix overlay (includes milling of AC pavements) 13) Hot in-place recycling 14) Cold in-place recycling 15) Ultra-thin whitetopping	16) Joint and crack sealing (with bituminous, silicone, or compression sealants) 17) Partial depth repairs (using AC, PCC, and proprietary materials 18) Full-depth repairs (using AC, PCC, and proprietary materials 19) Machine patching using hot mix 20) Slab stabilization and slab-jacking 21) Load transfer 22) Crack and joint stitching 23) Hot-mix overlays 24) Bonded PCC overlay

Sources of Information

Information sources used for the preparation of the catalog were similar to those used for the report and are described in the Methodology section in chapter one of the synthesis report. In addition, each Fact Sheet contains a section titled "Resources," which typically contains two or three source references and additional information. The main purpose of these references is to direct the reader to key publications containing general and specific information on the treatment. The number of references listed on the Fact Sheets was restricted for brevity.

References used in development of the fact sheets included:

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.
Michigan Department of Transportation, *Capital Preventive Maintenance,* 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.
Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines,* Office of Pavement Engineering, Columbus, May 2001.
Minnesota Department of Transportation, *Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements*, Report MN/RC-2009-18, Office of Materials and Road Research, Maplewood, May 2009.
Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.
Wu, Z., J.L. Groeger, A.L. Simpson, and G.R. Hicks, *Performance Evaluation of Various Rehabilitation and Preservation Treatments,* Office of Asset Management, Federal Highway Administration, Washington, D.C., Jan. 2010.

Organization of the Catalog

The *Catalog* consists of 24 Fact Sheets, each describing a separate pavement preservation treatment. Although the pavement preservation treatments are described separately, several treatments can be used on the same pavement section at the same time, or at different times, as part of a single pavement rehabilitation project or strategy. For example, a single

PCC pavement rehabilitation project may include four maintenance and rehabilitation (M&R) treatments: shallow patch repair, full-depth repair, diamond grinding, and joint/crack resealing.

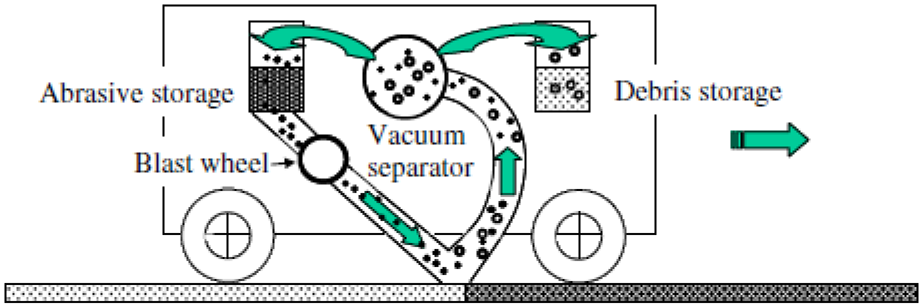
The order in which the M&R treatments are described in the *Catalog* was set up according to the following rules:

1. Treatments that can be applied to both AC and PCC pavements without any substantial modification are described first, followed by the description of treatments applicable to AC pavements and PCC pavements.
2. For each pavement type, the treatments are arranged in an approximate order of their increasing contribution to restoring pavement serviceability.

The Fact Sheets describe treatments using a uniform format. Each Fact Sheet starts with a sketch showing a sequence of operations, and a short definition of the treatment.

Service lives and unit costs of the pavement preservation treatments given in the Fact Sheets provide relative information that can be used for orientation and comparison purposes only. The service lives and costs are based on a literature review and apply to typical situations only. The synthesis survey included questions on the usage and performance of pavement preservation treatments, but not on their life spans and costs.

Fact Sheet 1—Texturization Using Shot Blasting (from ACRP Synthesis 22)



Schematic of Shot Blasting Operation

Shot blasting is a texturization technique that uses a self-propelled machine that blasts abrasive particles onto the pavement surface as shown in the above schematic. The objective is to remove contaminants, such as rubber deposits and excess asphalt cement (AC), and to abrade deteriorated surface material to restore both micro- and macrotexture. Surface retexturing with shot blasting can be used for both AC and PCC (Portland cement concrete) pavements to improve pavement friction.

Sources of Information and Additional Resources

The source document and additional general information is from Gransberg, "Life-Cycle Cost Analysis of Surface Retexturing with Shotblasting as an Asphalt Pavement Preservation Tool," *Transportation Research Record: Journal of the Transportation Research Board, No. 2108,* Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 46–52.

Purpose and Selection Criteria

Unlike fine milling and diamond grinding, shot blasting does not improve pavement smoothness. It can be used to improve pavement friction by removing materials from the pavement surface, to clean pavement surface before the application of sealants, and to remove traffic control lines and signs. The best improvement in pavement surface friction by shot blasting is achieved when abrasion-resisting aggregate particles are embedded in a mortar that can be abraded by shot blasting.

Typical Service Life and Costs

When used to restore pavement friction by removing softer or deteriorated material, the treatment effectiveness may last 1 to 6 years. When used to remove rubber deposits on runways, the effectiveness depends on the formation of new rubber deposits. The cost is typically lower than for diamond grinding and is in the range of approximately $2 to $10 per square yd.

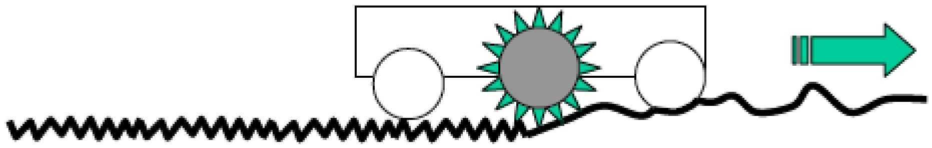
Materials and Construction

There are several types of proprietary equipment that can produce a pattern width ranging from approximately 6 in. to 6 ft. The equipment includes a system that propels abrasive particles, such as small round steel pellets, onto the pavement surface, vacuums up the resulting pavement material debris and abrasive particles, separates the abrasive particles from debris for re-use, and stores the debris for disposal. The technique is commonly applied to PCC pavements, but has also been successfully used on both AC and surface treated surfaces.

Airport Experience

Just over 20% of airports surveyed reported that they have tried using shot blasting for PCC or for AC pavements. None of the airports reported routine use of shot blasting for either pavement type. Typically, the performance of shot blasting was reported as good.

Fact Sheet 2—Diamond Grinding (from ACRP Synthesis 22)



Schematic of Diamond Grinding Operation

Diamond grinding is a rehabilitation technique that removes a shallow depth of pavement surface material by saw cutting closely spaced grooves into the pavement surface using diamond-tipped blades. The above illustration shows a self-propelled diamond grinding machine.

Sources of Information and Additional Resources
California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.
Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.
Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines,* Office of Pavement Engineering, Columbus, May 2001.

Additional resources include a comprehensive manual of practice; the *Concrete Pavement Repair Manual* was issued by American Concrete Pavement Association (ACPA) in 2003 and is available from www.pavement.com. American Concrete Pavement Association, *Diamond Grinding and Concrete Pavement Restoration,* Report TB008P, Skokie, Ill., 2000.

Purpose and Selection Criteria
The purpose of diamond grinding is to improve pavement smoothness and/or improve pavement surface friction. When used to improve pavement smoothness, diamond grinding is applied only to selected areas of the pavement. For example, to remove slab stepping (faulting), grinding can be applied to selected transverse joints. When used to improve pavement surface friction, diamond grinding is typically used over the entire pavement area.
Diamond grinding can remove up to 3⁄4 in. from the pavement surface and can remove surface defects and irregularities such as polished or scaling surface and faulting, and improve pavement surface smoothness. When used to correct faulting, the faulting is expected to be relatively stable in terms of progression and typically does not exceed approximately 1⁄4 in. Diamond grinding is often used as the penultimate treatment in a PCC rehabilitation project, done after load transfer restoration, and partial and full-depth repairs. The last treatment is for joint and crack resealing. Diamond grinding will not address the underlying cause of pavement structural problems and is inappropriate for surfaces with material problems such as durability (D)-cracking or alkali-reactive aggregate.

Typical Service Life and Costs
The restoration of pavement surface friction by diamond grinding may last 5 to 12 years. Grinding to improve pavement smoothness on faulted slabs may last only a few years, particularly if the original faulting was progressing and the underlying reasons for the faulting were not addressed.
Typical cost of diamond grinding is in the range of $4 to $12 per square yard, depending on quantities and the hardness of the aggregate.

Materials and Construction
Diamond grinding employs a large drum, equipped with closely spaced diamond-tipped teeth, mounted on a moving heavy-set framework.
The best results are achieved with continuous operation employing wide grinding drums. When several grinding passes are required to cover one traffic lane, the passes typically overlap by less than 2 in. The diamond grinding operation is carried out in the longitudinal direction, and preferably against the predominant direction of aircraft operations.

The spacing between the diamond-tipped saw blades is such that the ridges (or fins) left between the blades break readily, approximately 2 or 3 mm, depending on the strength of the concrete (Figure B1). If the ridges do not break off readily, the spacing between the blades can be reduced. Diamond grinding results in a characteristic corduroy texture with high pavement surface friction produced by the combination of smoothly cut channels and rough surface where the ridges have broken off.

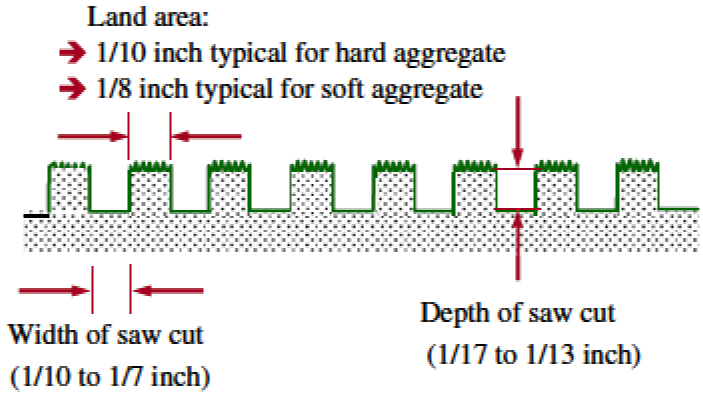


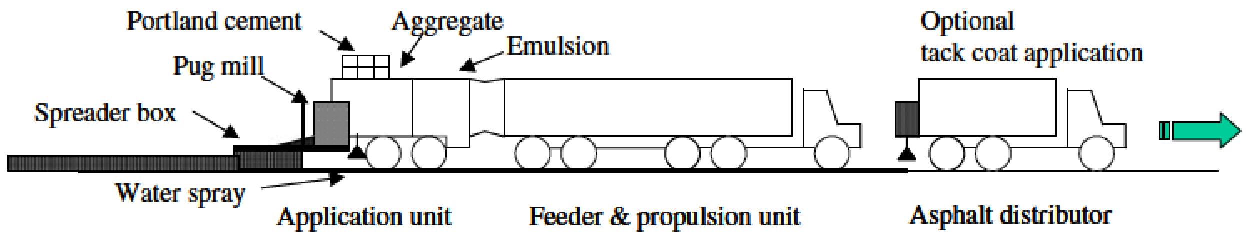
FIGURE B1 Profile of diamond-grooved surface. Improved pavement surface friction is provided by the land area created by the broken-off ridges.

Slurry resulting from the grinding operation (water is used to cool diamond-tipped blades and suppress dust) is continuously vacuumed and collected. Diamond grinding done only to improve pavement surface friction on relatively new pavements may not require resealing of joints. Grinding done to correct faulting on older pavements is typically followed up by joint resealing.

Airport Use

About 8% of airports surveyed use diamond grinding routinely, and approximately 46% of airports surveyed have tried using it. All airports that routinely use or have tried using diamond grinding rated its performance as very good or good.

Fact Sheet 3—Microsurfacing (from ACRP Synthesis 22)



Schematic of Microsurfacing Operation

Microsurfacing is an unheated mixture of polymer-modified asphalt emulsion, high-quality frictional aggregate, mineral filler, water, and other additives, mixed and spread over the pavement surface as a slurry. The construction of microsurfacing using a self-propelled truck-mounted continuous-feed mixing machine is illustrated by the schematic above.

The aggregate skeleton used for microsurfacing consists of high-quality interlocking crushed aggregate particles. Consequently, it is possible to place microsurfacing in layers thicker than the largest aggregate size, or in multiple layers, without the risk of permanent deformation.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines*, Office of Pavement Engineering, Columbus, May 2001.

Minnesota Department of Transportation, *Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements*, Report MN/RC–2009-18, Office of Materials and Road Research, Maplewood, May 2009.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

The International Slurry Surfacing Association (ISSA) maintains a website at www.slurry.org, which contains recommended specifications and useful guidance for microsurfacing (*Recommended Performance Guidelines for Micro-Surfacing*, A143).

Purpose and Selection Criteria

Microsurfacing is used to correct surficial distresses such as slight block cracking, raveling and segregation, flushing, and loss of pavement friction. Because microsurfacing contains high-quality crushed aggregate it is also used to fill in ruts and surface deformation to the depth of up to 13⁄4 in. Microsurfacing can also be used to extend the service life of the pavement until a more permanent restoration can be completed.

As a preventive maintenance treatment it can be used to seal the surface of the pavement, protecting the pavement from water infiltration and greatly reducing the rate at which the existing AC surface oxidizes. Microsurfacing is also used on PCC pavements to improve or maintain frictional resistance and smoothness.

Typical Service Life and Costs

When used to protect the existing pavement structure as a preventive maintenance treatment, microsurfacing can prolong pavement life span by 4 to 6 years. When used to restore or improve pavement surface; for example, to restore pavement friction or to repair wheel track rutting, microsurfacing can last 5 to 8 years.

The cost of one application of microsurfacing is approximately $3 to $6 per square yard, typically approximately 75% of the cost of a single hot-mix overlay.

Materials and Construction

Microsurfacing mix is always designed by a contractor or an emulsion supplier. Figure B2 shows a finished product a year after construction.

The ISSA recommends two types of gradations, Type II and Type III. The Type II gradation is finer, with 90% to 100% passing a 4.75 mm sieve. The Type III gradation is coarser with 70% to 90% of aggregate passing the No. 4 sieve size, and can be used on runways. A minimum thickness of microsurfacing mix using Type III gradation is 0.4 in. for a single course.

FIGURE B2 Microsurfacing texture one year after construction; diameter of the coin is 1 in.

The surface on which microsurfacing is applied is expected to have uniform pavement condition. Areas that exhibit significantly more severe defects than the remainder of the section (e.g., raveling, cracking, or rutting) are repaired. The repairs can by made using an additional course of microsurfacing or by other means depending on the type, extent, and severity of the defects. On high traffic volume facilities, and/or when the surface of the pavement has minor distortions and/or has ruts exceeding approximately 1⁄4 in., two courses of microsurfacing are used. The first (scratch) course is intended to improve the profile of the pavement and the second course provides the wearing surface. Ruts exceeding 1⁄2 in. are typically filled with microsurfacing material using a rut-filling spreader box.

After the microsurfacing application, traffic can use the pavement without restrictions in about 45 to 120 minutes, depending on setting time of the asphalt emulsion, weather, and traffic conditions. Microsurfacing is typically carried out only during the warmer, dryer months. Cooler temperatures and wetter conditions can result in longer curing times during which the microsurfacing can be damaged by traffic.

Airport Experience

Microsurfacing can be used for both AC and PCC pavements. For AC pavements, only one airport surveyed used microsurfacing routinely, and two airports surveyed have tried using it. For PCC pavements, only one of the surveyed airports indicated use of microsurfacing.

Fact Sheet 4—Sealing and Filling Cracks in AC Pavement (from ACRP Synthesis 22)

Illustration of Crack Routing, Cleaning, and Sealing

Crack sealing is a maintenance technique that cleans cracks and seals them with a rubberized bituminous compound. The crack sealing typically includes routing of the crack to create a reservoir for the sealant at the top of the crack, as shown in the illustration above. Crack sealing without routing is called crack filling. Crack filling is not as cost-effective as crack sealing and is easily damaged by snow plows. For this reason, this Fact Sheet concentrates only on crack sealing.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, April 2010.

Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines*, Office of Pavement Engineering, Columbus, May 2001.

Minnesota Department of Transportation, *Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements*, Report MN/RC–2009-18, Office of Materials and Road Research, Maplewood, May 2009.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

Michigan Department of Transportation produced a manual, *Sealing and Filling of Cracks for Bituminous Concrete Pavements, Selection and Installation Procedures*, which is available on CD and distributed by Foundation for Pavement Preservation, Austin, TX [Online]. Available: www.fp2.org.

A useful summary of information is available from *Crack Seal Application, Pavement Preservation Checklist Series*, Publication FHWA-IF-02-005, produced by the Foundation for Pavement Preservation, Austin, Tex. [Online]. Available: www.fp2.org. UFC 3-250-08FA, *Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements.*

Purpose and Selection Criteria

The purpose of crack sealing is to prevent water from entering the pavement structure and damaging it. Crack sealing is most effective in a wet-freeze environment. It is applied to “working or active” cracks. These cracks change in width during the year because of temperature changes, and include both transverse cracks and longitudinal cracks. Figure B3 shows how water from melting snow enters the pavement through unsealed cracks. Infiltrated water, together with the effect of freeze–thaw cycles and pavement loads, leads to heaving of the cracks (Figure B4) and to the deterioration of the pavement structure beneath the crack. The additional benefit of sealing is the prevention of spalling and raveling of unsealed crack edges.

Crack sealing is typically done soon after transverse and longitudinal cracks develop, often when the pavement is 2 to 5 years old. At that time, the crack pattern would be well-developed and the crack would reach the width of 0.1 to 0.4 in. at moderate temperatures. The initial crack sealing is typically followed by a second sealing carried out when new cracks appear or when the original sealant no longer works, often after another 3 to 5 years.

Crack sealing is most cost-effective for thick AC pavements. It is typically not cost-effective for thin AC pavements with the total thickness of the AC layer less than 3 in. Thin pavements tend to develop many secondary cracks that cannot be effectively sealed or filled.

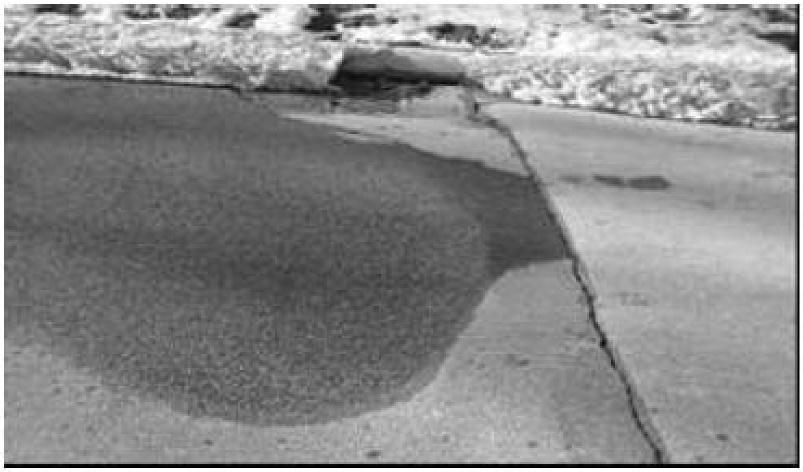


FIGURE B3 Water from melting snow readily enters pavement structure through a transverse crack.

Typical Service Life and Costs
The expected life of crack sealing is about 2 to 7 years. The crack sealing performance depends on the crack and pavement condition, sealant material, rout configuration, and construction procedures. Typical cost of rout-and-seal treatment is approximately $2 to $3 per linear yard.

Materials and Construction
There are many AC sealants on the market and their performance can differ significantly. Hot-poured rubberized bituminous sealants are most often used. Some agencies are not satisfied with the existing specifications for sealants (e.g., ASTM D6690 or AASHTO T187-60) and have modified them.

The reservoir for the sealant at the top of the crack is created by a router. The opinions regarding the size and shape of the most effective reservoir differ. It is generally agreed that routs with greater width than depth and a rectangular shape are preferable. The routed crack is typically cleaned before sealing.

The sealant is heated in a double-jacketed kettle to avoid exposure of the sealant to direct heat. It is important to avoid overheating or re-heating the sealant, and dispersing the sealant into the crack by a device (a pump wand) that maintains the sealant at a desired temperature. Because the sealant shrinks after the installation and cooling, the hot sealant is installed “proud” of the surface.

Until the sealant hardens and there is no danger that it will be picked up by passing tires, it is covered by a bond-breaking material such as sawdust or flour. The use of cement or mineral dust is typically avoided. Occasionally, it is necessary to seal cracks wider than 30 mm. These cracks can be temporarily repaired by fine aggregate hot mix or liquefied patching materials similar to a slurry material.

Airport Use
Based on the survey, a majority of all airports routinely perform crack sealing using a hot-poured bituminous sealant. The majority of the airports surveyed reported good performance of crack sealing. Only a small minority of airports surveyed use cold-applied sealants routinely. The majority of airports surveyed rout cracks prior to sealing.

Fact Sheet 5—Small-Area Patching (from ACRP Synthesis 22)

The Sequence of Operations for Small Patching Repairs

Small-area patching is a maintenance treatment that includes placing and spreading of bituminous mixtures, hot or cold, to repair potholes and other pavement distresses without the use of mechanical pavers or graders. The illustration shows the sequence of operations. The patching with hot mix or cold mix can be used for both bituminous pavements and PCC pavements; however, permanent repairs of PCC pavements are typically done using PCC material. If pavers or graders are used, the treatment is called machine patching and is described on a separate Fact Sheet.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Additional resources include:

A useful manual of practice was issued by the Federal Highway Administration as Report FHWA-RD-99-168, *Materials and Procedures for Repair of Potholes in Asphalt-Surfaced Pavements: Manual of Practice,* and is available at www.tfhc.gov/pavement/ltpp/pdf/99168.pdf.

Several highway agencies have developed manuals for patching of AC pavements. One of the most comprehensive has been published by the Minnesota Technology Transfer Center, *Best Practices Handbook on Asphalt Pavement Maintenance,* Manual No. 2000-04, Minneapolis, 2000.

Purpose and Selection Criteria

Small-area patching is used to repair localized defects such as potholes, distortion resulting from utility cuts, and small areas with severe ravelling and/or alligator cracking. The repair of potholes such as the one shown in Figure B5 reduces pavement roughness and the rate of pavement deterioration by improving drainage and reducing dynamic traffic loads. The repairs may be permanent, semi-permanent, or temporary.

Permanent repairs—Permanent repairs are used on pavements that are in good condition to bring the life span of the repaired area in line with that of the rest of the pavement. Permanent repairs require the use of appropriate patching materials and techniques, with the goal of addressing the underlying cause of the defects being repaired. Unless the original cause for the pavement defects is corrected, the repairs are susceptible to early failure.

Semi-permanent repairs—Semi-permanent repairs have a typical life expectancy of one or two years. Usually, the area is not saw cut and may be repaired with cold mix.

Temporary repair—Temporary repairs are used to hold the pavement until it can be resurfaced or permanently repaired. They are also used as emergency repairs when the pavement condition may pose a hazard to airplane operations.

Typical Service Life and Costs

Temporary patching repairs may last one year or less; permanent repairs may last 10 years or more. The cost of small-area patching is highly dependent on the extent of the repairs and on the selection of patching material. A typical unit cost for small-area patching is $20 to $40 per square yard.

FIGURE B5 Untreated pothole collects water and accelerates pavement deterioration.

Materials and Construction

The main types of patching materials include hot mix, local or agency-specified cold mix, and proprietary cold mix. A tack coat, if used, is typically an emulsion diluted with additional water. Hot-mix AC patching material provides the most durable treatment. Some suppliers of proprietary cold patching mixes suggest that their products can achieve similar performance and that their products can be successfully applied to potholes containing water. Cold mixes with single-size aggregate may not perform well in relatively large repairs. The single-size aggregate mix has low stability and is susceptible to rutting and ravelling.

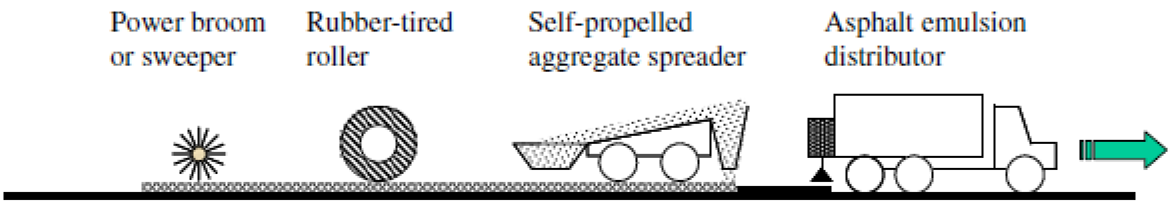
Typically, small-area *permanent* patching repair includes the following steps:

- Removal of broken pavement material in the patch area by jack hammering, cold milling, and/or pavement sawing.
- Cleaning out loose material from the patch area by blowing or brushing.
- Applying a tack coat to provide a bond between the existing pavement and the patching material.
- Placing the bituminous mix into the patch area. If the patch area is deeper than 2 in., the mix is placed and compacted in lifts until the level of the surrounding pavement is reached.
- Compacting the mix with a steel or rubber-tire roller, a vibratory plate compactor, or a hand tamper. Depending on the size and depth of the repair, and the material used, the finished repair will have crown of 0.1 to 0.4 in.
- Sealing the joint between the patch and the original pavement with hot-poured crack sealant. Sealing is typically done for larger and deeper repair areas.

Airport Experience

Patching is one of the most common pavement maintenance treatments. According to survey respondents, the majority of airports (that have AC pavements) routinely use small-area patching using hot mix and a minority of airports routinely use cold mix. None of the agencies surveyed reported poor performance of repairs using hot mix, whereas approximately 20% of agencies surveyed reported poor results using cold mix. A small minority of agencies surveyed routinely used a proprietary mix.

Fact Sheet 6 - Spray Patching (Manual Chip Seal and Mechanized Spray Patching) (from ACRP Synthesis 22)



Schematic of Chip Seal Operation

Spray patching is a maintenance treatment that includes the application of bituminous material followed by spreading of cover aggregate. The technological sequence is shown in the above schematic. Spray patching can be done manually or by specialized self-propelled equipment that sprays an emulsion, applies the cover aggregate, and provides the initial compaction—all in one pass. Mechanized spray patching applied on the full-width of a facility, such as a taxiway, and that is longer than 100 ft, is called surface treatment. The *Catalog* contains a separate Fact Sheet for surface treatments.

Sources of Information and Additional Resources

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Asphalt Recycling and Reclaiming Association, *Basic Asphalt Recycling Manual,* Annapolis, Md., 2001.

Additional information includes:

U.S. Department of Transportation, *Pavement Preservation Compendium II*, Publication FHWA-IF-06-049, Sep. 2006.

InfraGuide 2005: Preservation of Bituminous Pavement Using Thin Surface Restoration Techniques, 2005 [Online]. Available: http://gmf.fcm.ca/Infraguide/Roads_and_Sidewalks.asp.

Purpose and Selection Criteria

Spray patching is used to slow down pavement deterioration of vulnerable localized areas or to repair localized pavement distresses such as ravelling, flushing, and block cracking. A properly applied spray patching produces an all-weather surface that seals the pavement surface, prevents or retards propagation of surficial distresses, and can provide improved surface friction. The use of spray patching to repair or slow down the progression of transverse or longitudinal cracks is not considered to be cost-effective.

Manual spray patching is suitable for localized repairs. Machine patching is typically used to repair large areas that do not require full-width coverage.

Typical Service Life and Costs

The typical life span of spray patching is 2 to 5 years. A typical cost of spray patching is in the range of $3 to $8 per square yard, depending primarily on the quantity of work.

Materials and Construction

Manual spray patching employs a variety of bituminous products (applied hot or cold) and aggregates (chips, graded aggregate, or sand). Typically, bituminous products used for spray patching are emulsions heated to less than 185°F. Aggregate used for mechanized spray patching is typically open-graded (chips). Aggregate used for manual patching can be dense or open-graded with a typical maximum aggregate size of approximately 1⁄2 in. Sand is also used.

Manual application of emulsion is done with a hand wand or a spray bar. Cover aggregate is applied immediately after spraying emulsion. Compaction with truck tires or rubber-tired rollers follows. Generally, after compaction, 75% of the height of the aggregate particles is imbedded in the emulsion.

The procedure for manual spray patching typically consists of the following steps:

• Removal of all loose material and debris.

- Spraying of an emulsion in a uniform manner.
- Application of aggregate to obtain even coverage.
- Compaction; wheels of the truck used to supply the cover aggregate can be used for compaction.
- Sweeping off loose aggregate around and over the patch.

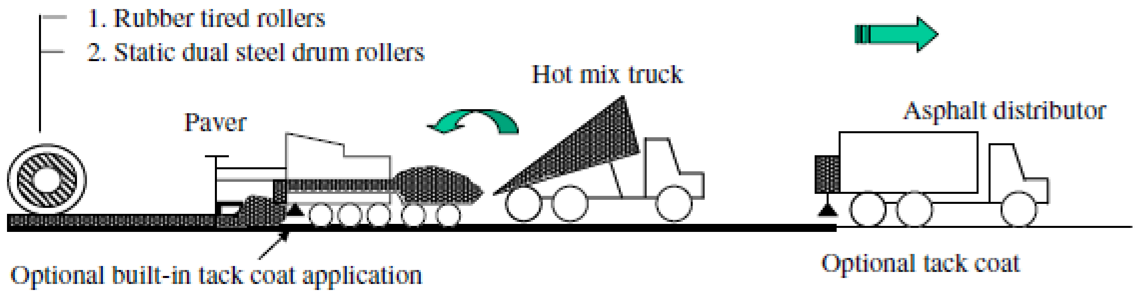
Spray patching is generally carried out only during the warmer, dryer months. Cooler temperatures and wetter conditions prolong setting (hardening) of the emulsion and the time the repairs are susceptible to damage by traffic.

Airport Experience

Spray patching used to be one of the key maintenance treatments for AC pavements. However, the usage of manual spray patching has been declining. Only a few airports surveyed routinely use spray patching or have tried it.

Fact Sheet 7—Machine Patching of AC Pavement Using Bituminous Materials

(from ACRP Synthesis 22)



Schematic of Machine Patching Operation

Machine patching of AC pavements is a maintenance technique that involves placing and spreading of premixed bituminous materials (hot or cold mix) using a mechanical paver or a grader on parts of a pavement section. As shown in the illustration, machine patching includes the application of tack coat, placement of the patching material, and compaction.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Additional resources includes:

SHRP H 348: Asphalt Pavement Repair Manuals of Practice, Materials, and Procedures for the Repair of Potholes in Asphalt-Surfaced Pavements, Strategic Highway Research Program, Transportation Research Board, National Research Council, Washington, D.C., 1993.

Purpose and Selection Criteria

Typical applications of machine patching include repairs of localized areas of ravelling and segregation, alligator cracking, potholing, rutting, frost heaving, and subgrade settlement. The areas selected for patching are expected to be well-defined and separated by areas that are in good condition. If the areas requiring patching are closely spaced, it may be more cost-effective to resurface the entire section.

Machine patching repairs can be divided into permanent and semi-permanent repairs:

Permanent repairs—Permanent patching repairs can be used on pavements that are in good condition to bring the life span of the repaired area in line with that of the rest of the pavement. For example, if it is expected that the pavement being repaired will require resurfacing in 8 years, the patching repair could be done to also last approximately 8 years.

Semi-permanent repairs—Semi-permanent repairs have a limited life expectancy and are used typically when it is anticipated that the entire pavement will be resurfaced within a few years. To save costs, the extent of patching is limited and the patched area may not receive a tack coat.

Typical Service Life and Costs

Permanent repairs may last 5 to 12 years or more; semi-permanent repairs may last approximately 5 years or less. A typical cost of machine patching is $10 to $25 per square yard.

Materials and Construction

For permanent repairs, the same type of hot mix may be used for patching as that used for the surface of the existing asphalt pavement.

Typically, permanent machine patching includes the following steps:

• *Structural repairs*—If the patch is over an area exhibiting structural weakness (e.g., alligator cracking, rutting, or depression and settlement) it may be necessary to remove some or all of the underlying base and subbase material. The granular base is restored and re-compacted. The additional pavement strength, if required, is achieved by replacing some part of the granular material with AC to avoid increasing the overall thickness of the pavement structure.
• *Removal of the deteriorated AC layer by milling*—Milling may be required to maintain pavement elevation or to provide a smooth transition between the original pavement and the patch. Figure B6 shows a construction detail for the start of a long patch.

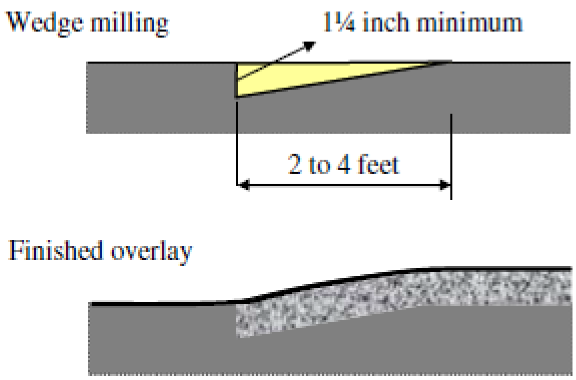


FIGURE B6 Wedge milling to key in a 1¼-in.-thick AC patch.

• Application of a tack coat at the sides of the patch and over the entire patched area to improve the bond between the original pavement and the patch, and to minimize water infiltration.
• Placing of the mix. The placement is done by a paver. The material is placed in layers not exceeding 3 in. The minimum thickness of a permanent machine-placed patch is typically 1 1⁄4 in.
• Compaction of the patch area using rollers.
• Application of a sealant at the joint of the patch and the existing pavement. Resealing the joint if it opens in a few years.

Airport Experience
About one-half of all survey respondents routinely use or have tried using machine patching. A large majority of respondents reported very good or good performance.

Fact Sheet 8—Restorative Seals (from ACRP Synthesis 22)

Schematic of Restorative Sealing Operation

Restorative seals consist of an application of a bituminous or coal-tar material, typically emulsion-based, to the surface of AC pavement as illustrated by the schematic. Restorative seals are also called rejuvenators or fog seals. Some agencies or suppliers recommend light sanding of fog seals (approximately 1 lb of sand per square yard).

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Minnesota Department of Transportation, *Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements*, Report MN/RC-2009-18, Office of Materials and Road Research, Maplewood, May 2009.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

Shoenberger, J.E., "Skid Resistance of Rejuvenated Airfield Pavements," *Proceedings of the 27th International Air Transportation Conference, Advancing Airfield Pavements,* American Society of Civil Engineers, Reston, Va., 2007.

Engineering Technical Letter 03-8, *Rejuvenation of Hot-Mix Asphalt* (*HMA*) *Pavements,* Dec. 2003.

Boyer, R. and D.I. Hanson, *Non-Coal-Tar Fuel Resistant Sealers and HMA Systems: State-of-the-Practice,* prepared for Airfield Asphalt Technology Program Project 05-02, May 2008.

Purpose and Selection Criteria

Restorative seals can serve one or more of following three purposes:

To seal the surface—Restorative seals can reduce penetration of water by sealing small cracks and porous pavement surfaces.

Restorative seals can slow the progression of raveling and coarse aggregate loss, and have been used shortly after paving to seal areas with low to moderate segregation. The sealing can also slow down oxidation and hardening of AC.

To rejuvenate oxidized and hardened asphalt binder—Restorative seals used primarily to revitalize the surface of the AC pavement are called rejuvenators. Rejuvenators are intended to penetrate the surface of the AC pavement and reverse the oxidation and hardening process in the AC. The depth of penetration is usually only 0.1 to 0.2 in. Rejuvenators do not leave much residual material on the surface and can be re-applied.

To provide protection against fuel spills and oil leak—Aircraft fuels and lubricants are chemically compatible with AC, can dissolve it, and degrade the surface of AC pavements. Restorative seals that are not compatible with AC can provide protection from the damaging effects of fuel spills and oil leaks.

Typical Service Life and Costs

A restorative seal is a temporary fix generally lasting 1 to 3 years. The cost can range from $0.5 to $2 per square yard.

Materials and Constructions

Restorative seals designed to seal the pavement surface use slow or medium setting asphalt emulsion further diluted with water.

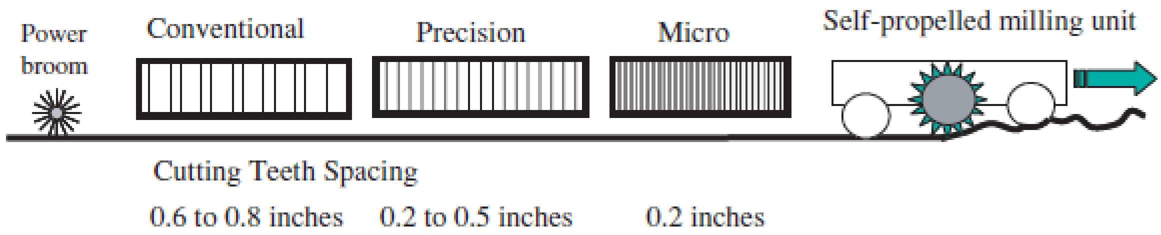
Aggregate, if applied to provide better pavement friction, is typically medium to fine sand with the particle size of less than 0.05 in.

Restorative seals designed to function as rejuvenators or as rejuvenators/sealers contain proprietary materials that may contain solvents.
Restorative seals for the protection against fuel spills and oil leaks are typically coal-tar sealers—an emulsion of coal tar stabilized with clay. Acrylic-modified bituminous emulsions can also increase protection against fuel spills.

Restorative seals are sprayed on the pavement surface by distributors. Asphalt emulsion is typically heated to about 175□F before the application to pavement that is in good condition and has been broomed before the restorative seals are applied. With correct application rates, and in some instances the use of sand, restorative seals can generally provide satisfactory levels of pavement friction.

Airport Experience
About one-half of the airports surveyed routinely use or have used restorative seals, and a large majority of the users reported very good or good performance.

Fact Sheet 9—Texturization Using Fine Milling (from ACRP Synthesis 22)



Schematic of Milling Operation

Texturization techniques using milling include conventional milling, precision milling, and fine milling. Milling is done by a cylindrical milling drum with closely spaced carbide-tipped tools (teeth). The techniques differ by the spacing of the cutting teeth, as shown on the above illustration, and by the degree of control over the profile of the milled surface. Fine milling, also called micromilling, removes unevenness from the pavement surface or improves its texture, and leaves an abraded surface that can be used as a driving surface.

Sources of Information and Additional Resources

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

The *Basic Asphalt Recycling Manual* by the Asphalt Recycling and Reclaiming Association provides guidelines for milling and other texturization techniques.

Hall, K.L., J.W. Smith, and P. Littleton, *NCHRP Report 634: Texturing of Concrete Pavements*, Final Report, Nov. 2008, Transportation Research Board of the National Academies, Washington, D.C., Nov. 2008, 97 pp.

Purpose and Selection Criteria

Fine milling can improve pavement smoothness and pavement friction. Smoothness is improved by milling of protruding pavement features such as bumps, stepping (faulting) at transverse cracks, and rutting. If the pavement has sufficient structural capacity, the reduction in thickness is not of concern.

Figure B7 shows an example of pavement surface where micromilling was used to reduce rutting and roughness.

Typical Service Life and Costs

The expected service life of texturization using fine milling is 1 to 7 years. A typical cost is approximately \$4 to \$12 per square yard.

Materials and Construction

Milling is a general term used to describe the removal of the surface of AC or PCC materials from pavements by a self-propelled unit having a cutting drum equipped with closely spaced carbide-tipped tools. Micromilling and precision-milling are types of milling that strive to provide a more even platform for an overlay and/or a finished pavement surface. Micromilling and precision-milling operations are also called fine milling. The following definitions of micromilling and precision milling are not universally accepted and are provided for orientation purposes only.

Micromilling—Typically, the depth of micromilling is up to 0.6 in. and results in a surface texture depth of about 0.04 in. with the groove-to-groove spacing of 0.2 in. Such surface does not need an overlay.

Precision milling—Typically, the depth of precision milling is up to 1 in. and results in a surface texture depth of approximately 0.2 in. A precision-milled surface is usually overlaid.

Airport Use

A small minority of airports surveyed routinely use or have used fine milling. In addition, one responding airport reported using transverse grooving of the AC surface to improve pavement friction.

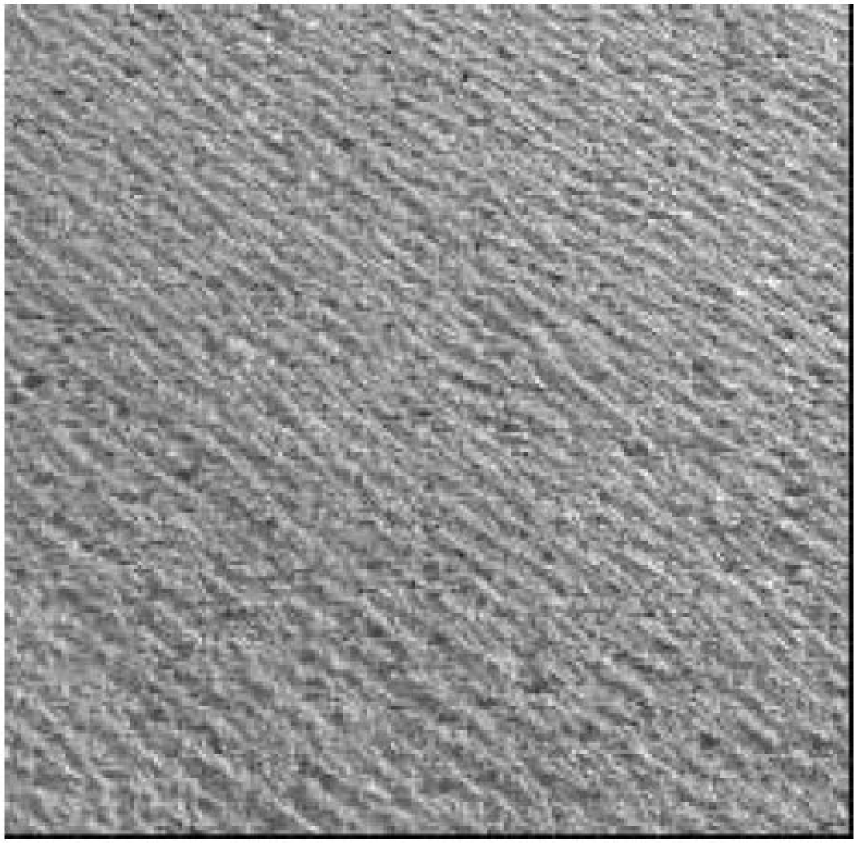
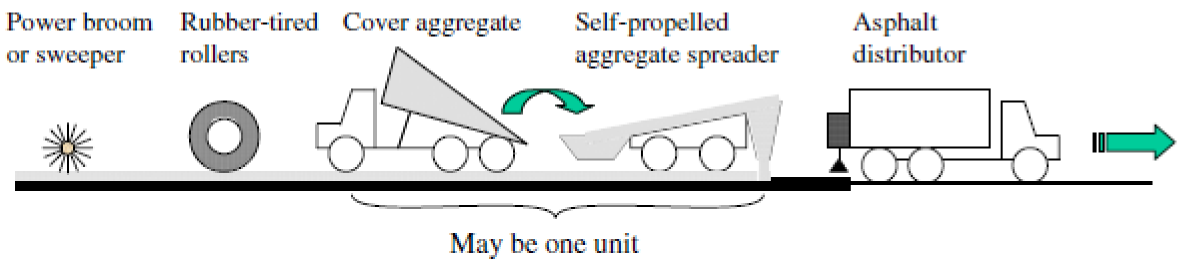


FIGURE B7 The milled surface has grooves with the peak-to-peak distance of approximately 0.6 in.

Fact Sheet 10 - Surface Treatment (Chip Seal, Chip Seal Coat) (from ACRP Synthesis 22)



Schematic of Surface Treatment Construction Process

Surface treatment (also known as surface seal, seal, and chip seal) is the application of asphalt binder, immediately followed by an application of cover aggregate, to any type of pavement surface. A typical construction process is shown in the schematic. If the aggregate is of uniform size, the treatment is usually called chip seal. Typically, surface treatments are applied on top of a granular base producing surface-treated pavement. Surface treatments can be also applied to AC pavements as a preventive or corrective maintenance treatment.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines*, Office of Pavement Engineering, Columbus, May 2001.

Minnesota Department of Transportation, *Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements*, Report MN/RC-2009-18, Office of Materials and Road Research, Maplewood, May 2009.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

Several agencies have published guidelines for the design and construction of surface treatments including the Minnesota Department of Transportation (Janish, D.W. and F.S. Gaillard, *Minnesota Seal Coat Handbook,* Office of Research Services, St. Paul, 1998).

A recent NCHRP Synthesis of Highway Practice provides practical guidelines for the construction of surface treatments (Gransberg, D. and D.M.B. James, *NCHRP Synthesis of Highway Practice 342: Chip Seal Best Practices,* Transportation Research Board of the National Academies, Washington, D.C., 2005).

Purpose and Selection Criteria

Surface treatments applied on top of AC pavements can be used as preventive or corrective treatments. As a preventive measure, surface treatment is primarily used to seal the surface showing non-traffic-load associated cracks and ravelling. As a corrective measure, surface treatment is used to restore frictional resistance and to maintain wearing surface on AC pavements. Surface treatments using polymer-modified emulsions have been used as crack relief layers between the existing AC surface and an AC overlay, or as stress relief layers between the existing PCC surface and an overlay.

Typical Service Life and Costs

When used to protect the existing pavement structure as a preventive maintenance treatment, surface treatment can prolong pavement life span by 4 to 6 years. When used to restore or improve pavement surface; for example, to restore pavement friction, surface treatment can last 5 to 8 years. The cost of a single surface treatment is approximately $2 to $4 per square yard.

Materials and Construction
The surface on which surface treatment is applied is expected to have a uniform capacity to absorb emulsion. Active cracks, such as transverse and longitudinal cracks, can be sealed prior to application of the surface treatment.
Typically, the asphalt binder used for surface treatment is asphalt emulsion applied at an elevated temperature (120°F to 180°F) using an asphalt distributor. The cover aggregate can be either chips (open-graded aggregate) or dense-graded as shown in Figure B8.

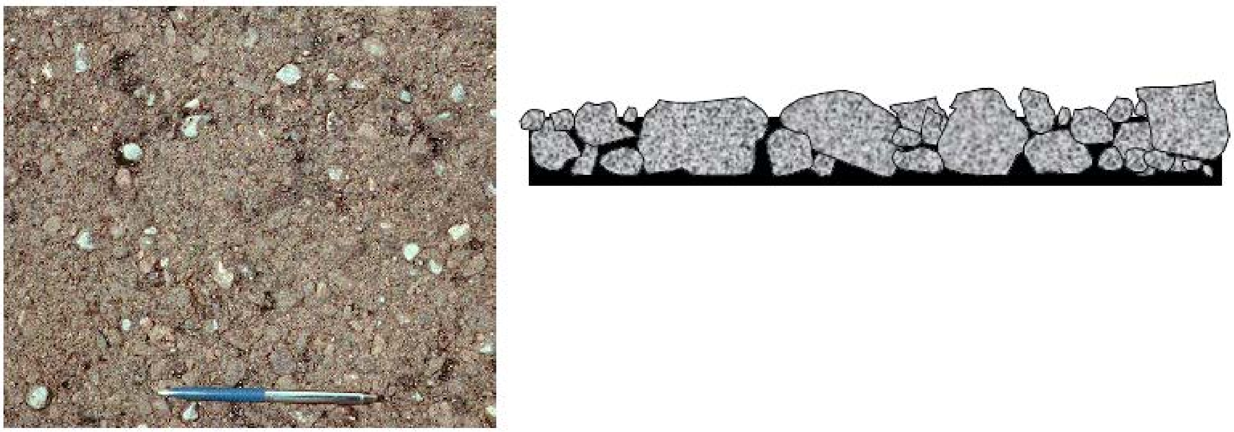
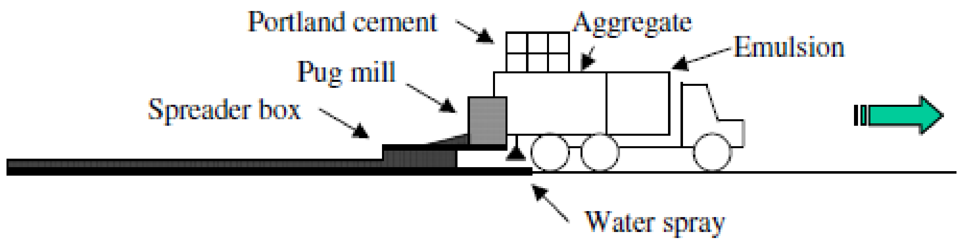


FIGURE B8 Surface of a newly constructed surface treatment using 5/8-in.-dense-graded aggregate and high-float emulsion.

About 70% of the aggregate is typically imbedded or surrounded by the binder. The need for accurate application of the binder and aggregate cover is facilitated by modern asphalt distributors, which can automatically maintain selected application rates regardless of the distributor speed. Newly constructed surface treatments need to be protected from traffic for several hours after construction.
Emulsion application rates for seal coats typically range from 0.2 to 0.4 gallon per square yard depending on the existing surface (granular, seal coat, or AC) and aircraft operations, and are further adjusted during construction according to weather conditions and other factors.

Airport Use
A small number of the surveyed airports indicated routine use of surface treatments, or have tried them. However, the majority of responding airports that routinely use or have used surface treatment rated its performance as good. Some of the reasons reported for low usage of surface treatments by airports are probably concerns about loose aggregate, dust, and rougher surface texture.

Fact Sheet 11—Slurry Seal (from ACRP Synthesis 22)



Schematic of Slurry Seal Construction

Slurry seal is an unheated mixture of asphalt emulsion, graded fine aggregate, mineral filler, water, and other additives, mixed and uniformly spread over the pavement surface as slurry. The construction of slurry seal using a self-propelled truck-mounted mixing machine is illustrated by the above schematic. Slurry seal systems are formulated with the objective of creating a bitumen-rich mortar.

They are similar to microsurfacing, but the mineral skeleton is typically not very strong and has limited interlocking of the aggregate particles. Consequently, slurry seals are applied in thin lifts to avoid permanent deformation by traffic.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication No. FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

The ISSA maintains a website, www.slurry.org, that contains recommended specifications for slurry seal [International Slurry Surfacing Association, *Recommended Performance Guidelines for Microsurfacing,* Document ISSA A143 (revised), 2005].

Engineering Brief No. 35A, SEP 27 1994, *Thermoplastic Coal-Tar Emulsion Slurry Seal,* Amended Interim Specification, Federal Aviation Administration, Washington, D.C.

Purpose and Selection Criteria

Slurry seals are used to correct surficial distresses such as raveling and coarse aggregate loss, seal slight cracking, and improve pavement friction. They are also used as a preventive maintenance treatment to seal pavement surfaces from intrusion of water and slow surface oxidation and ravelling. Slurry seals are best placed on structurally sound pavements that are in good condition with little or no cracking or rutting.

Slurry seals perform best on surfaces with uniform characteristics. If defects such as moderate or severe ravelling, cracking, or rutting occur frequently, the section is probably not a good candidate for slurry sealing. Working cracks, such as transverse cracks, can be sealed either before or after the slurry seal application.

Typical Service Life and Costs

When used as a preventive maintenance treatment, slurry seal can prolong pavement life span by 3 to 6 years. When used to restore or improve pavement surface characteristics, for example to restore pavement friction, slurry seals can last 3 to 7 years. The cost of slurry seal is approximately $2 to $4 per square yard, typically less than half of the cost of a hot-mix overlay.

Materials and Construction

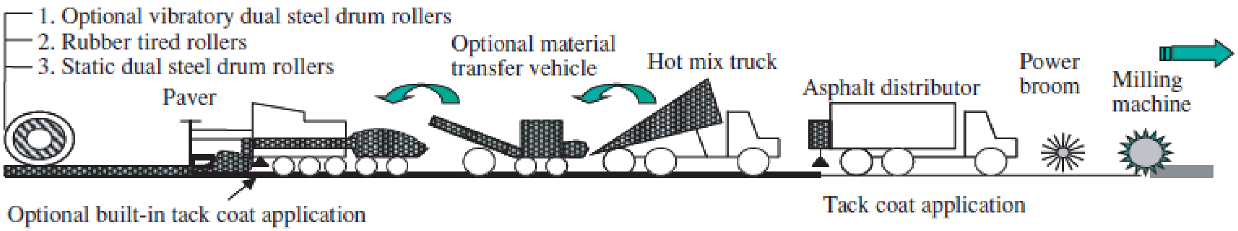
Asphalt emulsion used in slurry seals is typically cationic and contains about 60% to 65% of residual AC. The slurry mix contains 9% to 10% of AC. Coal tar-based emulsions that provide protection against fuel spills and oil leaks are also available in some markets.

Aggregate used for slurry seals is crushed high-quality dense-graded aggregate. Its gradation generally follows one of the three gradation types, Type I, II, or III, recommended by the ISSA. Type II gradation can be used for aprons and low-volume taxiways and Type III gradation for runways. Type III gradation has 70% to 90% of aggregate passing No. 4 sieve.
Mineral filler, typically Portland cement or hydrated lime, is used to control curing time of the mix (break time of the emulsion).
The amount of mineral filler is typically less than 1% of the total dry mix weight. The thickness of a slurry seal application is slightly more than the thickness of the largest aggregate particle in the mix, typically approximately 0.4 in.
Some proprietary slurry seal mixes contain crushed aggregate particles and polymer-modified emulsion and may have strength and durability characteristics that are closer to a microsurfacing than to a traditional slurry seal.

The slurry seal mixture is supplied using a specialized equipment that carries all of the components of the mixture, accurately measures and mixes them in a pug mill, and spreads the mixture (by means of a spreader box linked to the mixing unit) in a strip 10 to 12 ft wide as a thin, homogeneous coat of slurry mix.
Slurry seals are typically carried out only during the warmer, dryer months. After the slurry seal application, traffic can use the pavement without restrictions (except 360 degree turns by aircraft) in approximately 45 to 120 min, depending on setting time of the asphalt emulsion, weather condition, and traffic conditions. Cooler temperatures and wetter conditions can result in long curing times during which the slurry seal can be damaged by traffic.

Airport Experience
A small number of surveyed airports reported the use of slurry seals routinely, or have tried using them. The majority of responding airports that use slurry seals reported very good or good performance.

Fact Sheet 12—Hot-mix Overlay of AC Pavement (from ACRP Synthesis 22)



Schematic of Hot-Mix Overlay Construction Process

Hot-mix overlay of AC pavement consists of placing a layer or layers of hot mix over the existing AC surface. The above illustration shows the construction of an overlay including milling of the pavement surface, application of a tack coat, and the use of a material transfer vehicle.

Conventional AC overlays are usually constructed with a minimum thickness of 1 1⁄2 in. Overlays that are less than 1 1⁄2 in. thick are called thin overlays and typically require special construction provisions.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide,* 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance,* 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines,* Office of Pavement Engineering, May 2001.

Minnesota Department of Transportation, *Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements,* Report MN/RC-2009-18, Office of Materials and Road Research, Maplewood, May 2009.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication No. FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Another useful manual on the construction of asphalt overlays is from the Asphalt Institute (*Asphalt Overlays for Highway and Street Rehabilitation,* Manual Series No. 17, Lexington, Ky., 1998).

Purpose and Selection Criteria

Overlays are used to restore pavement serviceability by improving ride quality and providing a new waterproof surface that covers cracking, ravelling, rutting, polished pavement surface, and other pavement defects. Overlays are also used as a preventive maintenance treatment to seal pavement surfaces from intrusion of water, slow surface ravelling, seal small cracks, and improve surface friction.

Overlays can be used to strengthen the pavement structure to accommodate increased pavement loads. In this case, overlay thickness
is determined by appropriate pavement design procedures.

Single overlays are typically constructed over structurally sound pavements. Areas that exhibit weakness (e.g., settlement, alligator cracking, and rutting) can be strengthened by patching or even by full-depth repairs. Some agencies rout and seal cracks in the existing AC pavement before placing an overlay, and carry out full-depth repairs of deteriorated transverse cracks.

Typical Service Life and Costs

Hot-mix overlays have an expected service life of 7 to 12 years depending on overlay thickness, traffic loads, existing pavement condition, environment, and material and construction quality. A typical cost of constructing an AC overlay is in the range of $60 to $90 per ton of material placed. For a 2-in.-thick single overlay, the corresponding cost is approximately $6 to $9 per square yard.

Materials and Construction

There are many variations in the material of hot mix. Some of the common variations are outlined in the following.

Dense-graded and open-graded mixes—The two main types of hot mix used for overlays are dense-graded and open-graded mixes. Dense-graded mixes have aggregate particles that are fairly uniformly distributed. Open-graded mixes contain a large percentage of one-size coarse aggregate resulting in a mix with interconnected voids and high permeability. Open-graded mixes provide good pavement friction and reduce the potential for hydroplaning (Figure B9).

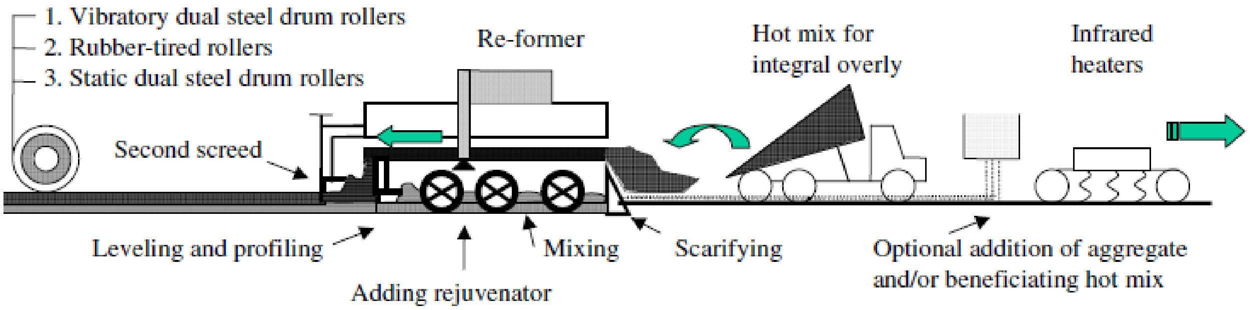
FIGURE B9 (*Left*) Thin open-graded hot-mix overlay surface; (*Right*) Dense-graded overlay surface. Diameter of the coins is 0.7 in.

Virgin or recycled mixes—The use of recycled material in hot mix is common, particularly for a binder course. For surface courses on runways, the use of virgin materials is usually specified.
Superpave—Introduced in 1992 to the highway industry, the Superpave system represented a new system for designing AC mixes.
The Superpave system includes the use of performance-graded asphalt binder specifications and Superpave mix design procedures.
Fuel resistant mixes—There are currently two proprietary hot mixes on the U.S. market that are designed to resist degradation caused by aircraft fuel spills and leaks of lubricants and hydraulic oils. In general, lower air voids and stiffer AC increase the fuel resistance of the mix.

The existence of distresses such as ravelling, segregation, and cracking may dictate partial-depth removal (cold milling) of the AC prior to resurfacing. Partial-depth removal is normally accomplished using cold milling equipment. Grade-controlled precision milling may also be used to restore longitudinal and cross-sectional pavement profile and to improve smoothness of the subsequent overlay. The reclaimed asphalt pavement material may be reused as hot or cold mix or mixed with granular material. A tack coat is typically used before placing an overlay. A tack coat is a typically slow or medium setting asphalt emulsion diluted with water.

Airport Experience
A majority of surveyed airports routinely use or have tried using hot-mix overlays with or without prior milling, and nearly all surveyed airports reported very good or good performance. No responding airports reported using thin overlay (with thickness of less than 1 1⁄2 in.).

Fact Sheet 13—Hot In-Place Recycling of AC Pavement (from ACRP Synthesis 22)



Schematic of Hot In-Place Recycling Process

Hot in-place recycling (HIR) is a pavement rehabilitation method that involves reprocessing of the existing AC material in-place at temperatures normally associated with hot-mix AC paving. The illustration above shows the construction of HIR with an integral overlay using a reformer.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

The 1997 FHWA publication *Pavement Recycling Guidelines for State and Local Governments* (Report FHWA-SA-98-042, National Technical Information Service, Springfield, Va.) describes all aspects of recycling of asphalt pavement materials to produce new pavement materials.

Button, J.W., D.N. Little, and C.K. Estakhri, *Synthesis of Highway Practice 193: Hot In-Place Recycling of Asphalt Concrete*, Transportation Research Board, National Research Council, Washington, D.C., 1994.

Taylor, M. and E. Dillman, "Airport Saves with Hot-in-place Recycling," *Public Works*, Vol. 19, No. 10, 1999.

Purpose and Selection Criteria

HIR is suitable for structurally sound pavements with surface defects, such as raveling and segregation, cracking, and rutting that affect mainly the top pavement surface layer. An additional requirement is that the AC surface layer is suitable for recycling, has a uniform composition (aggregate gradation, asphalt content, and thickness), and materials of good quality (aggregate and asphalt binder). Material properties of pavements considered for HIR are thoroughly evaluated. Because of the size of a recycling train, HIR is suitable for large projects with room to maneuver.

Typical Service Life and Costs

The success of HIR depends on the properties of the existing materials, quality and quantity of new materials added, quality of construction, and the thickness and type of the surface layer placed on top of the HIR mix. Consequently, the expected service life can range from about 5 to 12 years. Overall, HIR pavements can perform comparably to conventional asphalt surfaces.

A typical cost of a hot-in-place recycling layer is in the range of $5 to $10 per square yard.

Materials and Construction

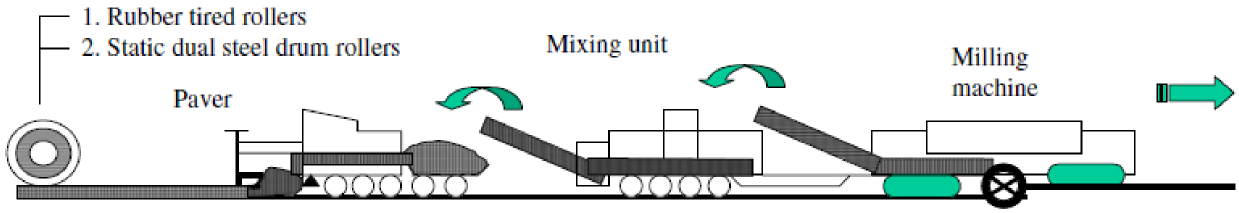
There are other types of HIR processes and equipment in addition to the process illustrated above. Typical HIR construction consists
of the following steps:

- *Heating of the existing AC surface*—Several methods are available including infrared heating panels, flame burners, and microwave heating.
- *Pavement scarification*—The depth of scarification is usually limited (by the capacity of the heaters) to the top 2 1⁄4 in. of the AC surface.
- *Adding new materials and mixing*—Depending on the properties of the existing AC material, the added new materials may include a combination of rejuvenating agents and (hot) aggregate, or the addition of a beneficiating hot mix. The objective is to compensate for deficiencies in the asphalt material to be recycled.
- *Levelling and reprofiling of the recycled mix*—Some improvement can be made to the pavement profile. Addition of new AC overlay is necessary to make significant corrections to profile.
- *Placement of a thin hot-mix layer* (*optional*)—Some HIR recycling equipment can add new hot-mix material on top of the recycled mix as an integral overlay. The thickness of the integral overlay is typically 1 1⁄4 in. The total thickness of the recycled and new mix is typically up to 3 in.
- *Compaction*—Standard compaction procedures utilizing vibratory steel drum rollers, rubber tired rollers, and static steel drum rollers are employed.

The resulting recycled layer can be used as a wearing surface or can be protected by a slurry seal, surface treatment, or a hot-mix overlay.
If an integral overlay is used, the overlay serves as the wearing surface.
HIR is typically carried out only during the warmer, dryer months. Cooler temperatures and wetter conditions can result in longer
heating times leading to the overheating and burning of the pavement surface, and creating smoke and vapors. Cooler ambient temperatures
can also result in lower mix temperatures leading to an insufficient depth of scarification, fracturing aggregate during scarification,
and poor compaction of the mix.

Airport Experience
None of the airports surveyed used hot-in-place recycling. However, hot-in-place recycling has been used for the rehabilitation of runways.

Fact Sheet 14—Cold In-Place Recycling of AC Pavement (from ACRP Synthesis 22)



Schematic of Cold Recycling Process

Cold in-place recycling (CIR) is a pavement rehabilitation method that involves reprocessing of an existing hot-mix asphalt pavement at ambient temperatures, either in-place or in an off-site processing plant, and laying it back down. The illustration above shows the construction of CIR. The recycled AC layer is typically covered by a hot-mix overlay.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

The 1997 FHWA publication *Pavement Recycling Guidelines for State and Local Governments* (Report FHWA-SA-98-042, National Technical Information Service, Springfield, Va.) describes all aspects of recycling of asphalt pavement materials.

The FHWA also maintains a web page on “Cold In-place Recycling State of Practice Review” at: http://www.fhwa.dot.gov/Pavement/recycling/cir/.

Purpose and Selection Criteria

CIR is a suitable pavement rehabilitation treatment for thick AC pavements in poor condition exhibiting extensive severe cracking, rutting, or other distresses. CIR mix helps to retard reflection cracking. CIR can also be used for pavements that require increased structural strength. In this case, the additional strength is achieved primarily by an overlay atop the CIR layer.

Candidate pavements for cold-in place recycling are thoroughly evaluated and the properties of the existing AC determined.

Because of the size of a recycling train, CIR is suitable for large projects with room to maneuver.

Typical Service Life and Costs

CIR with an appropriate hot-mix overlay provides a service life of 10 years or more. In situations where the surface layer atop the CIR mix is a surface treatment, the expected service life is lower. A typical cost of a 4-in.-thick cold recycled AC pavement is about $9 to $16 per square yard.

Materials and Construction

Cold recycling can be classified by the location where the recycling takes place as:

• *Cold in-place recycling* (*CIR*)—All asphalt pavement material processing is completed in situ. CIR is faster and environmentally preferable because of the reduced need to transport materials.

• *Cold central plant recycling* (*CCPR*)—Reclaimed asphalt pavement is hauled to a plant site and stockpiled. Subsequently, it is processed (crushed, screened, and mixed with additives), transported to the job site, and placed and compacted.

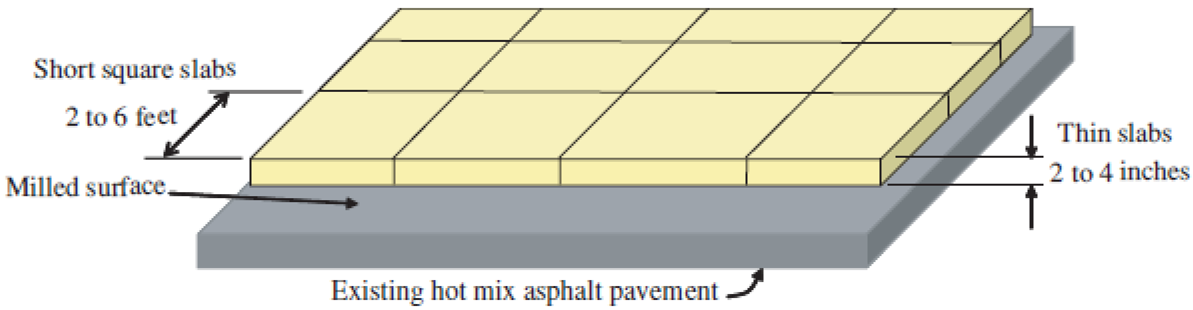
CIR can also be classified by the type of the asphalt added to the recycled mix:

• *Addition of emulsified asphalt*—Traditionally, asphalt emulsion is used to bind the mix. Polymer-modified asphalt emulsions or polymer-modified high-float emulsions are also used. The total amount of emulsion and water is approximately 4%, the emulsion alone being approximately 1.5%. Because of the added water, the resulting mix requires a minimum 14 days of curing before the mix can be sealed (overlaid). During this time, the exposed CIR mix can be damaged by traffic. CIR using emulsified asphalt is typically carried out only during the warmer, dryer months. Cooler temperatures and wetter conditions can result in long curing time during which the cold mix is susceptible to moisture intrusion and abrasion by traffic.
• *Addition of expanded* (*foamed*) *asphalt*—Although the addition of expanded asphalt can be done in-place or off-site, it is typically done in-place. The resulting material is called cold in-place recycled expanded asphalt mix (CIREAM). CIREAM allows a hot-mix surface course to be placed after only two days of curing. Expanded asphalt mix is less susceptible to environmental conditions than emulsion mix.

Airport Experience

Only one surveyed airport reported a routine use of cold-in-place recycling. However, the use of CIR is relatively frequent for the rehabilitation of runways and taxiways on small airports.

Fact Sheet 15—Ultra-thin Whitetopping of AC Pavement (from ACRP Synthesis 22)



Ultra-thin Whitetopping Pavement Rehabilitation Method

Ultra-thin whitetopping (UTW) of AC pavements is a rehabilitation method where a thin layer of PCC (2 to 4 in. thick) is bonded to the milled AC pavement to form a composite pavement structure with a new wearing surface. UTW uses short square slabs, typically from 2 and 6 ft, as shown in the above illustration.

If the thickness of the PCC overlay is more than 4 and less than 8 in., whitetopping is usually called thin whitetopping; if the thickness exceeds 8 in., it is called conventional whitetopping.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Additional resources include:

ACPA-issued, comprehensive *Construction Specification Guidelines for Ultra-thin Whitetopping* (IS120).

Rasmussen, R.O. and D.K. Rozycki, *NCHRP Synthesis of Highway Practice 338: Thin and Ultra-Thin Whitetopping*, Transportation Research Board of the National Academies, Washington, D.C., 2004.

Saeed, A., M.I. Hammons, and J.W. Hall, "Design, Construction, and Performance Monitoring of Ultra-Thin Whitetopping at a General Aviation Airport," *Proceedings of the 27th International Air Transportation Conference*, 2007.

Purpose and Selection Criteria

UTW can be used to rehabilitate AC runways, taxiways, and aprons. It has also been successfully used to mitigate rutting of AC pavements, block cracking, and fuel spill damage, and to increase structural capacity of pavements.

The surface of the existing pavement is cold milled to remove the deteriorated AC pavement. The milled surface also enhances the bond between the new PCC overlay and the existing AC pavement. The objective is to provide a sound platform for the PCC slab with a minimum thickness of AC pavement after milling of at least 4 in. A thorough engineering analysis is performed to ensure the suitability of a UTW overlay. Severe distresses (such as frost heaving and subgrade settlement) are repaired full depth prior to the placement of UTW. UTW placed on a thick cracked AC layer may result in reflection cracking of PCC slabs.

Typical Service Life and Costs

Preliminary results suggest life spans of 10 years or more. The typical cost of a UTW is estimated to be in the range of $12 to $18 per square yard.

Materials and Construction

PCC mixes used in UTW overlays are typically high early-strength mixes and generally contain fibers such as polyolefin and polypropylene. Fibers are expected to increase tensile strength of the mix and improve its resistance to shrinkage and fatigue cracking.

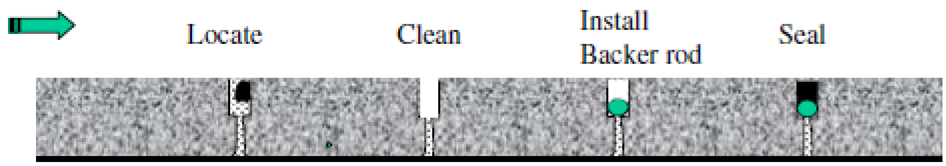
The construction of UTW consists of the following steps:

Pre-overlay repair—Localized repairs may be required to obtain uniform support for UTW.
Surface preparation—Milling of the existing AC is essential for the good performance of the UTW overlay. Milling removes deteriorated AC and provides a roughened surface that enhances the bond between the remaining AC and the new PCC surface, thereby creating an integrated pavement layer. Milling is followed by cleaning to remove all debris and any slurry resulting from milling. The typical predominant defect of UTW overlays is corner cracking attributed to the loss of bond between the PCC slab and the underlying hot-mix asphalt.

PCC placement—Conventional paving practices are used. Ambient temperatures are considered to ensure that UTW concrete is not placed on an overly hot AC surface. The hot surface could cause the PCC slab to crack when it cools down at night. It could also reduce the available water (for the chemical hardening process) at the interface of the two materials, thereby reducing the strength of the PCC at the interface. The AC surface is moistened before the PCC placement to minimize absorption of water from the PCC mix by AC and to promote bonding.
Texturing—Conventional texturing methods, such as tining, are used.
Curing—Curing is important for all PCC pavements. It is especially important for UTW overlays because of their small thickness (and large exposure area relative to the volume). Curing compound is placed on all exposed surfaces immediately after texturing and at twice the normal rate.
Joint sawing and sealing—Joint sawing starts as soon as it can be done without significant chipping of the joint edges. Typical joints are 1 in. deep and 1⁄8 in. wide, and are spaced 2 to 6 ft apart depending on thickness. Joints are not sealed.

Airport Experience
Only a few surveyed airports reported routine use of whitetopping. The Spirit of Saint Louis Airport in Missouri was the first general aviation airport in the United States to receive an ultra-thin whitetopping in 1995. Since then, whitetopping has been used on both small and large airports, including the George Bush Intercontinental Airport in Houston.

Fact Sheet 16—Joint/Crack Sealing of PCC Pavement (from ACRP Synthesis 22)



Sequence of Sealing Joints and Cracks in PCC Pavements

Sealing of joints and cracks in PCC pavements is a maintenance treatment that re-seals joints that have missing or poorly performing sealants, and seals major cracks. The sequence of the operation is shown on the above illustration.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance,* 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

Evans, L.D., K.L. Smith, and A.R. Romine, *Materials and Procedures for the Repair of Joint Seals in Portland Cement Concrete Pavements—Manual of Practice*, FHWA-RD-99-146, Federal Highway Administration, McLean, Va., 1999.

A comprehensive *Concrete Pavement Repair Manual* issued by the ACPA in 2003 is available from www.pavement.com.

Engineering Technical Letter 02-8, *Silicone Joint Sealant Specification for Airfield Pavements*, 2002.

Purpose and Selection Criteria

The purpose of joint and crack sealing is to prevent incompressible materials from getting into joints, and to prevent infiltration of water and de-icing chemicals into the pavement structure. The presence of incompressible material in the joints can cause spalling and raveling when the joints close in the summer months. Excess water in the pavement structure can lead to erosion of the base support, and de-icing chemicals can corrode dowels and tie bars.

The objective of resealing is to keep all joints sealed. Typically, only working cracks with the opening (at moderate temperatures) between 1⁄4 and 1⁄2 in. are sealed. Working cracks are typically transverse and longitudinal cracks. Re-sealing operations are carried out as scheduled maintenance when more than 50% of transverse joints start to show adhesion failures. Typically, pavements requiring joint resealing and crack sealing also require other maintenance treatments, such as partial-depth repairs.

Typical Service Life and Costs

There are three main categories of sealants for PCC pavements on the market: hot-poured bituminous sealants, silicone sealants, and compression seals (preformed or neoprene). Hot-pour sealants have a service life of 8 or more years, silicone sealants 10 years, and compression seals 12 or more years. The performance of sealants can differ significantly depending on the material and workmanship.

The typical cost of resealing operation is in the range of \$3 to \$4 per yard for hot-poured rubberized sealant, \$4 to \$5 per yard for silicone sealant, and \$6 to \$7 per yard for compression seals.

Materials and Construction

Typical joint and crack resealing operation consists of the following steps.

Removal of existing sealant—Damaged and underperforming sealant is removed. This may be accomplished by a mechanical device mounted on a garden-type tractor.

Preparation of sealant reservoir—Typical as-constructed transverse joints have sufficient reservoir at the top of the joint for hotpoured sealant. If the slab faces at the top of the joint do not have sufficient reservoir, the joint may be refaced by diamond saw cutting. Preformed compression seals require that joint sidewalls are perpendicular and without spalling. In the case of cracks, the reservoir is created by using a saw equipped with a special crack-sawing blade, rather than by using impact or rotary routers (e.g., those used for routing AC pavements) that can chip away at the crack face.

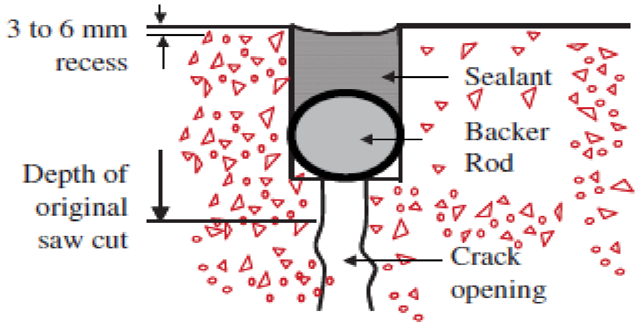
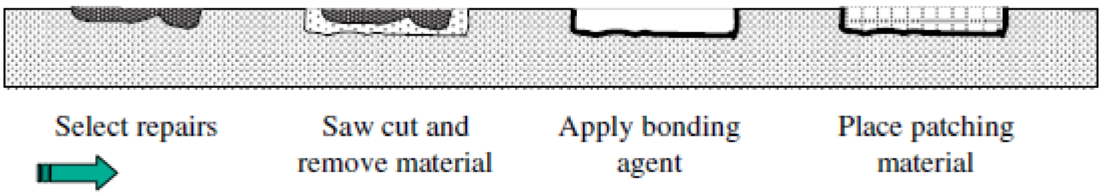


FIGURE B10 Resealed transverse contraction joint with bituminous sealant and a backer road.

Cleaning—All debris are cleaned by sand blasting or water blasting to remove all loose and weakened material, and to remove slurry residue from saw cutting. If sand blasting is used it is followed by air blasting to clean the joint. Joints must be dry before installing sealant.
Insertion of backer rod—Bituminous sealants may require a device that would prevent a liquid sealant from seeping deep inside the joint. One such device is a backer rod (Figure B10). The backer rod keeps the sealant in place near the surface of the pavement and prevents bituminous sealant from seeping into the widened crack opening.
Sealant application—The application of hot-poured sealant is similar to the application used for sealing AC pavements. Sealing operation with compression seals requires the application of a lubricant/adhesive to the joint sidewalls before the insertion of the seal. Compression seals are typically applied by a specialized machine and primarily used on new pavements. High-modulus silicone sealants are leveled (tooled) to force the sealant into a full contact with the joint sidewalls and to produce the correct shape of the sealant on top.

Airport Experience
A majority of surveyed airports reported routine use of silicone sealants, half of the responding airports have used bituminous sealants, and a minority of responding airports has used neoprene sealants. The silicone sealants as reported by survey respondents performed best, with all airports reporting very good or good performance. A majority of surveyed airports reported very good or good performance using bituminous sealants or compression sealants.

Fact Sheet 17—Partial-depth (Patch) Repairs of PCC Pavement (from ACRP Synthesis 22)



Construction Steps of Partial-depth Repair of PCC Pavement

Partial-depth patch repair of PCC pavements is a maintenance activity that includes removal of damaged material from shallow areas and replacing it with new PCC material or AC material. The key construction steps involved are shown in the above illustration.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines,* Office of Pavement Engineering, Columbus, May 2001.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

A comprehensive manual of practice, *Concrete Pavement Repair Manual*, issued by the ACPA in 2003, is available from www.pavement.com.

Fowler, D., D. Zollinger, and D. Whitney, *Implementing Best Concrete Pavement Spall Repairs*, FHWA/TX-08/5-5110-01-1, National Technical Information Service, Springfield, Va. [Online]. Available: www.ntis.gov.

UFC 3-270-03, *Concrete Crack and Partial-Depth Spall Repair,* U.S. Department of Defense, Washington, D.C., 2006, 68 pp.

Purpose and Selection Criteria

The purpose of partial-depth repairs is to repair localized shallow areas of damaged pavement, such as joint and corner spalling (joint chipping, cracking, and breaking), and any loss of material caused by weak concrete. The objective is to prevent further deterioration, restore pavement smoothness, remove the potential for loose material coming off the pavement, and facilitate joint resealing.

Partial-depth repairs are typically done only for surface distresses that affect up to one-half of the slab thickness. Partial-depth repairs are not suitable for slabs with poor load transfer and areas where reinforcing steel or load transfer devices are exposed. Partial depth repairs cannot effectively address spalls caused by durability (D) cracking or alkali silica reaction (ASR) damage. If there are several moderate or severe spalls present along one joint, it may be necessary and more economical to repair the joint using a full depth repair.

Partial-depth repairs are often done in combination with full-depth repairs, joint re-sealing and diamond grinding as part of a pavement rehabilitation project.

Typical Service Life and Costs

A partial-depth repair can last as long as the slab itself, typically 10 years or more. A typical cost of a partial-depth repair operation is in the range of $160 to $220 per square yard.

Materials and Construction

The selection of repair material depends on a number of factors including time constraints, climate, repair size and configuration, experience with local materials, and future maintenance and rehabilitation plans. Ideal repair materials have similar physical properties, such as elastic modulus, strength, and thermal expansion, as the original concrete. PCC repair materials can be general-use hydraulic cement or high early-strength hydraulic cement. There are also rapid-set proprietary patching materials on the market.
Bonding agents, if used, are typically sand–cement slurries or epoxy-modified cement slurries. AC material is typically used for temporary repairs only.

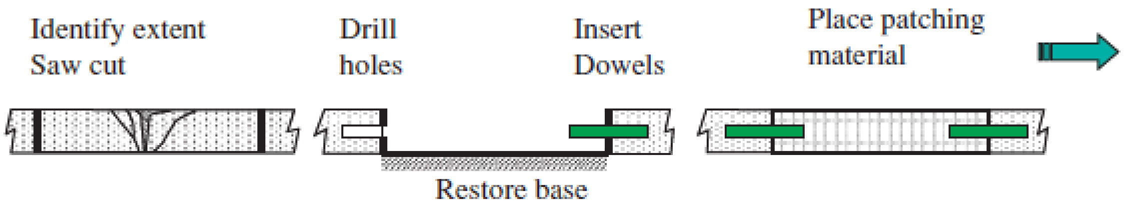
FIGURE B11 Prepared repair area; the insert, separating the repair area from the joint, extends beyond the saw cut into the existing longitudinal joint.

The patching procedure using PCC materials consists of the following steps:
1. Marking the boundaries of deteriorated and/or delaminated concrete.
2. Removal of existing concrete by saw cutting and chipping, or by milling, to create vertical surfaces of the sides of the excavated area.
3. Cleaning of the excavated area by sand blasting or water blasting.
4. Installation of a joint breaker, if the repairs are adjacent to joints, as shown in Figure B11.
5. Application of bonding agent (if used).
6. Placement of the patch material and its consolidation.
7. Finishing and texturing to match surrounding surface.
8. Application of a curing compound to retain moisture.
9. Joint resealing if the patch is adjacent to a joint.

The use of AC material for patching of PCC pavements is considered to be a temporary repair. For this reason, the excavated area is typically not saw cut and a joint breaker is not installed.

Airport Experience
About one-half of the airports surveyed routinely used or have tried partial-depth repairs with PCC material, a majority of surveyed airports have used AC material, and a large minority of surveyed airports has used proprietary materials. Overall, the performance of PCC materials was reported to be better than the performance of AC or proprietary materials.

Fact Sheet 18—Full-depth (Patch) Repairs of PCC Pavements (from ACRP Synthesis 22)



Sequence of Operation of Full-depth Repair of PCC Pavements

Full-depth patch repair of PCC pavements is a rehabilitation method that involves the full-depth removal of an entire slab or a substantial portion of the entire slab, the installation of load transfer devices (and other reinforcement if applicable), and the replacement of PCC material. The sequence of the operation is shown on the above illustration.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Ohio Department of Transportation, *Pavement Preventive Maintenance Guidelines*, Office of Pavement Engineering, Columbus, May 2001.

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

A comprehensive manual of practice, *Concrete Pavement Repair Manual*, was issued by the ACPA in 2003 and is available from www.pavement.com.

Concrete Pavement Rehabilitation—Guide for Full-depth Repairs, Report FHWA-RC Atlanta 1/10-03, Resource Center, Federal Highway Administration, Atlanta, Ga.

Purpose and Selection Criteria

The purpose of full-depth repairs is to repair slabs that can no longer be repaired using partial-depth repairs. This includes slabs with deteriorated concrete (particularly near joints), corner breaks, mid-slab cracking, slabs damaged by frost heaving and subgrade settlement, slabs with poor load transfer, and slabs where dowels are exposed. The objective of the repair is to restore the smoothness and structural integrity of the pavement, and to arrest further deterioration.

Full-depth repairs are often done together with other maintenance treatments, such as partial-depth repairs, load transfer restoration, and crack and joint sealing, as part of a pavement rehabilitation project. Full-depth repairs using PCC are also done before overlays.

Typical Service Life and Costs

The full-depth repairs are designed to last as long as the adjacent un-repaired slabs, typically 10 years or more. The typical cost of a full-depth repair using PCC material is in the range of $160 to $240 per square yard.

Materials and Construction

Full-depth repairs can be done using PCC or AC materials. Patching with AC materials is not considered a permanent repair. When using PCC materials, depending on the need to open the area to traffic, PCC repair materials can be a conventional PCC paving concrete or a "fast-track" high early-strength mix. Cement mixes modified with the addition of accelerating admixtures, polymers, or proprietary cement materials are also used. If timing is critical, the use of pre-cast slabs can be considered.

Typical full-depth cast-in-place repair of jointed PCC pavement with dowels consists of the following steps:
Selection of repair boundaries—Full-depth repairs are typically done on the full width of the lane and have the minimum length of approximately 6 ft. Detailed engineering investigation is required to properly identify the areas requiring full-depth repairs.
Visual examination is not sufficient (Figure B12).

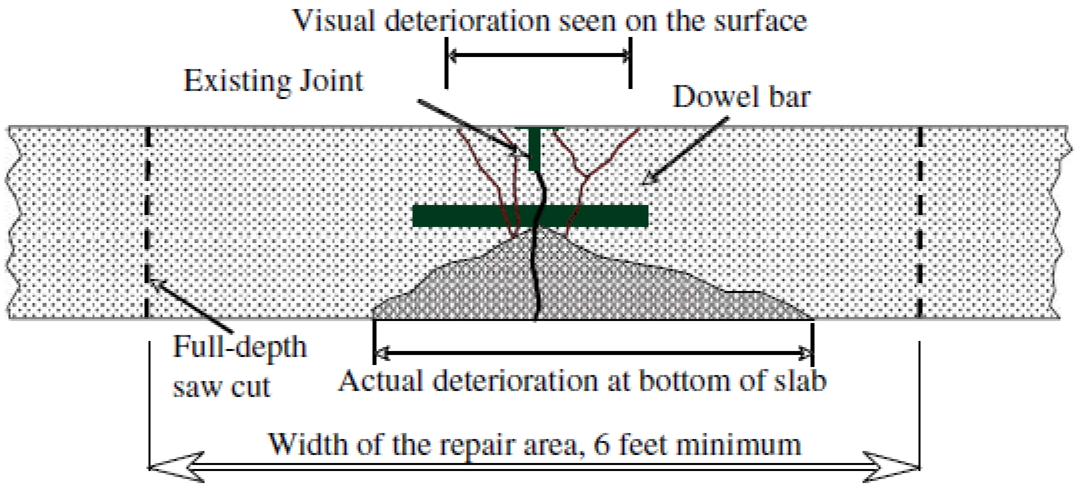


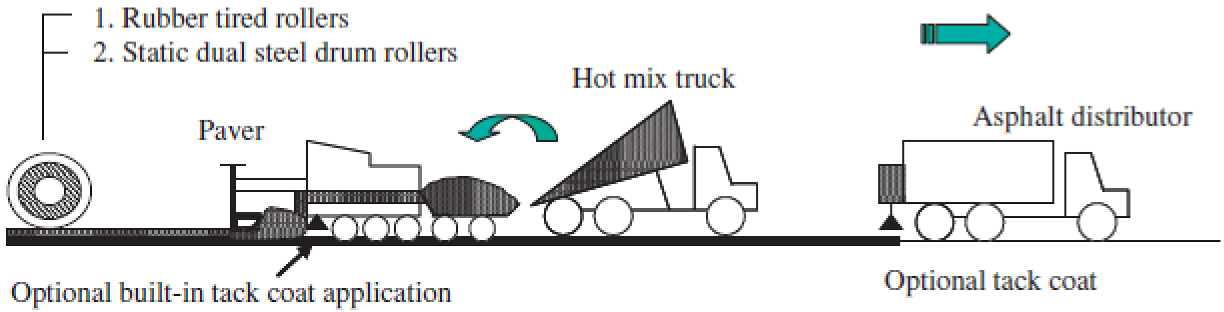
FIGURE B12 Cross section of deteriorated transverse joint.

Base preparation—After the removal of the deteriorated concrete, the base course, subgrade, and subdrains are restored. Any disturbed base material is re-compacted.
Dowel and tie bar placement—Load transfer across the transverse repair joints is re-established. The illustration at the beginning of this Fact Sheet shows the sequence of operations for installing dowels. Tie bars may be installed into the side of the PCC repair area using epoxy; these tie bars will hold the patch to the existing concrete.
Placement of concrete—Before placing concrete, the exposed portion of the dowel bars is coated with a bond breaker. Tie bars are not coated as it is important for the concrete to bond to the tie bar to prevent separation at the interface between the patch and the existing concrete.
Finishing and texturing—Unless a grinding operation or an overlay placement is to follow, the patch is textured to resemble the finish on the rest of the pavement.
Curing—Curing compound is placed as soon as the texturing is completed.
Joint cutting and sealing—All longitudinal and transverse joints are cut and sealed, or resealed.

Pre-Cast Repairs
Pre-cast repairs can provide a good alternative to cast-in-place repairs when it is necessary to minimize the duration of repairs. A new pre-fabricated concrete slab is placed into the prepared repair area in one piece. The restoration of the load transfer is accomplished by installing the dowels before or after the slab placement.

Airport Experience
A majority of surveyed airports routinely used or have tried full-depth repairs using PCC or AC materials. A large minority of surveyed airports used proprietary materials. The frequent use of AC materials is surprising and may be the result of the temporary nature of the repairs and to the low priority for restoring load transfer between PCC slabs on aprons and taxiways. Performance of both AC and PCC materials was similar, with the majority of surveyed airports reporting very good or good performance. None of the surveyed airports reported using precast panels.

Fact Sheet 19—Machine Patching of PCC Pavement with AC Material (from ACRP Synthesis 22)



Schematic of Machine Patching Operation of PCC Pavement

Machine patching of PCC pavements is a maintenance technique that involves placing and spreading of AC mix using a paver on parts of a pavement section. Machine patching includes the preparation of the patching area, addition of the patching material, and compaction as shown on the illustration above.

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Additional resources include:
A comprehensive manual of practice, *Concrete Pavement Repair Manual*, was issued by the ACPA in 2003 and is available from www.pavement.com.

Purpose and Selection Criteria

Hot-mix patching of PCC pavements does not substantially improve their structural capacity. Machine patching is most suitable for repairing surface defects such as map cracking, scaling, loss of pavement friction, and durability cracking. The areas selected for patching are expected to be well-defined and separated by areas that are in good condition. If the areas requiring patching are closely spaced, it may be more cost-effective to resurface the entire section.
Machine patching repairs can be divided into permanent and semi-permanent repairs:
Permanent repairs—Permanent patching repairs are used on pavements that are in good condition to improve surface characteristics and extend the life span. For example, if it is expected that the pavement being repaired will require resurfacing in 6 years, the patching repair lasting approximately 6 years will be appropriate.
Semi-permanent repairs—Semi-permanent repairs have a limited life expectancy and are typically used when it is anticipated that the entire pavement will be resurfaced/reconstructed within a few years.

Typical Service Life and Costs

Permanent repairs may last 6 to 10 years or more; semi-permanent repairs may last about 3 to 5 years. A typical cost of machine patching repairs is in the range of $10 to $30 per square yard.

Materials and Construction

Typically, permanent machine patching includes the following steps:
• Removal of the deteriorated PCC material by milling or chipping. Milling may be required to provide a smooth transition between the original pavement and the patch. Figure B13 shows a construction detail for the start of a long patch applied over a full width of a facility.
• Application of a tack coat at the sides of the patch and over the entire patched area to improve the bond between the original pavement and the patch, and to minimize water infiltration.
• Placing of the mix. The placement is done by a paver, and typically in layers not exceeding 3 in. The minimum thickness of a permanent machine-placed patch is approximately 2 in.
• Compaction of the patch area using rollers.

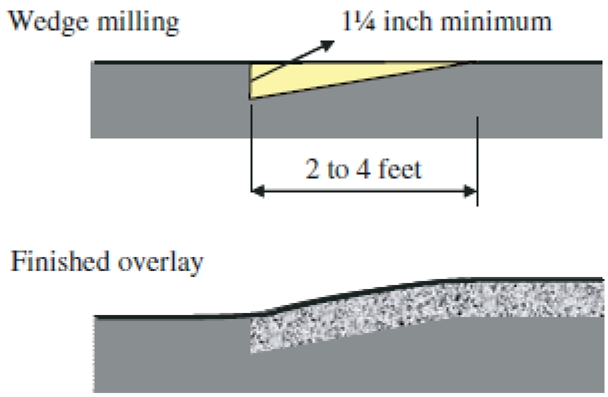


FIGURE B13 Wedge milling to key-in a 2-in.-thick AC patch.

Airport Experience
A few surveyed airports reported on the use of machine patching of PCC pavements with AC routinely; other surveyed airports reported that they have tried it. Performance data from the survey are incomplete.

Fact Sheet 20—Slab Stabilization and Slabjacking (from ACRP Synthesis 22)

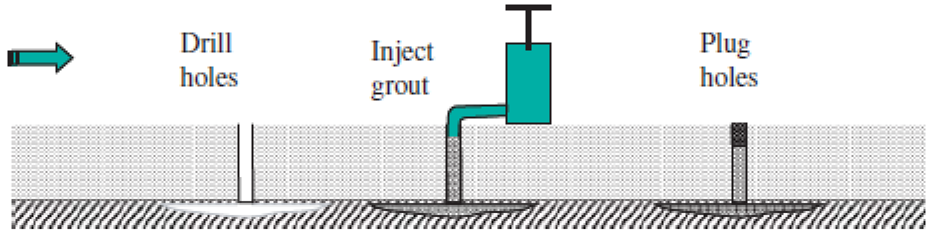


Illustration of Slab Stabilization Procedure

Slab stabilization is a rehabilitation technique that fills voids underneath PCC slabs with grout, but does not raise slabs. Slab stabilization is also called slab subsealing and under-slab grouting. Slabjacking fills voids underneath PCC slabs *and* raises the grade of the slabs. The construction sequence is shown on the above illustration

Sources of Information and Additional Resources
Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:
A comprehensive manual of practice, *Concrete Pavement Repair Manual*, was issued by the ACPA in 2003 and is available from www.pavement.com.

Purpose and Selection Criteria
The purpose of *slab stabilization* is to stabilize a pavement slab by pressurized injection of grout underneath the slab. The objective is to fill existing voids and restore full slab support, particularly at transverse joints and cracks. The main benefit of subsealing is slowing down the erosion of base and subgrade materials caused by excessive pavement deflections. Slab stabilization is typically carried out at the first signs of pumping (wetness and discoloration at transverse cracks during wet weather) and before the onset of visible signs of pavement damage such as corner cracks. Slab stabilization is typically done only for joints and working cracks that exhibit loss of support.
The purpose of *slabjacking* is to raise pavement slabs, which have settled over time, back to their original grade by pressurized injection of grout underneath the slab. At the same time, slabjacking will also stabilize the slab. The objective is to improve pavement smoothness and to fill voids underneath the pavement. Slabjacking can raise PCC slabs by over 2 in.
Slab stabilization and slabjacking are typically carried out concurrently with other rehabilitation techniques such as partial- and full-depth repairs, diamond grinding, and joint resealing. Slab stabilization is also used to achieve uniform foundation for overlays and as part of the installation of precast PCC panels.

Typical Service Life and Costs
The expected service life of slab stabilization and slabjacking is 5 to 10 years. The typical cost of slab stabilization is in the range of $80 to $180 per square yard.

Materials and Construction
Grouting materials used for slab stabilization include portland cement, fly ash-cement, polyurethane, and proprietary products. Typical slab stabilization material consists of a mixture of three parts fly ash and one part Type 10 cement, and water. Important properties of the grout material include the ability to flow into small voids, sufficient strength to support the slab and the load, and long-term resistance to erosion and deterioration.
Typical slab stabilization operation consists of the following steps:
Location of injection and observation holes—The number of holes depends on the size of the slab. Figure B14 shows an example pattern of injection and observation holes for the stabilization of transverse joints of a small slab (approximately 15 ft by 20 ft).

Drilling holes—Holes are typically 2 in. in diameter or smaller, and penetrate 2 to 6 in. below the concrete slab. Injection holes are grouted the same day.

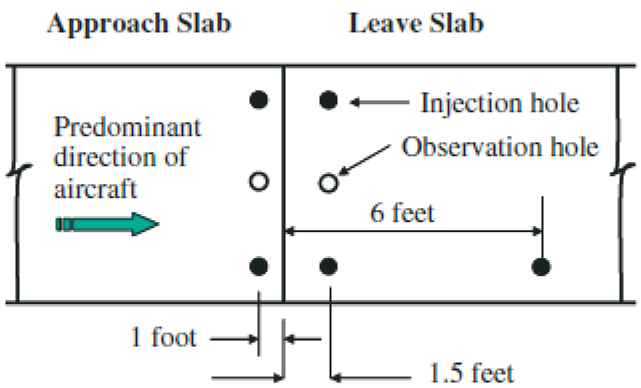
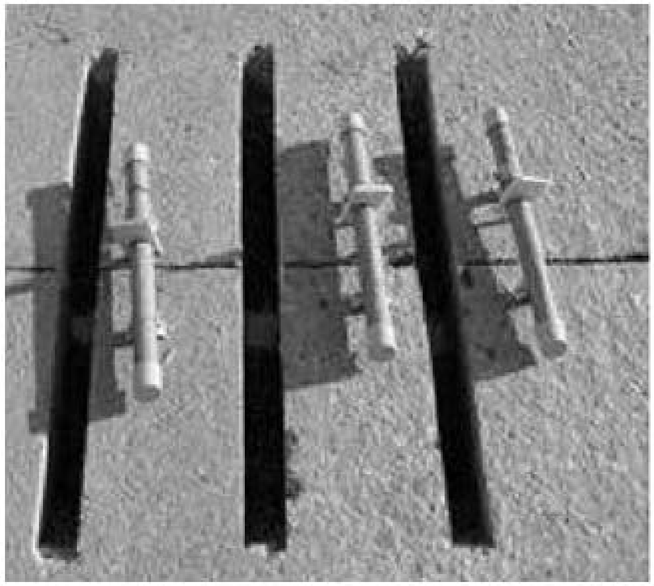


FIGURE B14 Typical location of injection and observation holes for the stabilization of a transverse joint; altogether there are five injection holes and two observation holes per slab.

Grout injection—During the grout injection process, vertical movement of the slabs is continuously monitored. The injection process is complete when grout undiluted with water appears in the observation holes, when the slab begins to rise, or when no grout material is injected at the maximum allowable pressure (typically 100 psi).
Plugging and cleanup—After injecting one hole, the hole is immediately temporarily plugged. After all holes are injected, the temporary plugs are removed and the holes are filled flush with cement grout.
Verification testing—After a minimum of 24 h, slabs are retested for the presence of voids and load transfer efficiency. It is possible to repeat the slab stabilization operation if the first attempt is insufficient. In this case, a new set of injection and observation holes is used.
Slabjacking process is similar to the slab stabilization process. However, the injection of grout continues until the slab reaches the desired grade.

Airport Experience
One surveyed airport reported routine use of slab sub-sealing. A small minority of surveyed airports has tried slab sub-sealing. Performance data from the survey are insufficient.

Fact Sheet 21—Load Transfer Restoration (from ACRP Synthesis 22)



Slots with Dowel Bars for Load Transfer Restoration

Load transfer restoration is a rehabilitation method that restores the ability of the concrete slabs to transfer wheel loads across transverse joints. The illustration above shows three slots with dowel bars prior to grouting (*Source:* Pierce et al. 2009).

Sources of Information and Additional Resources

California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Michigan Department of Transportation, *Capital Preventive Maintenance*, 2003 ed., Construction and Technology Division, Lansing, Apr. 2010.

Additional resources include:

The FHWA in conjunction with the ACPA has issued a useful publication entitled *Guide for Load Transfer Restoration.* ACPA also issued as a useful guide *Stitching Concrete Pavement Cracks and Joints*, Special Report SR903P [Online]. Available: www.pavement.com.

Pierce, L.M., J. Weston, and J.S. Uhlmeyer, *Dowel Bar Retrofit—Do's and Don'ts*, Report No. WA-RD 576.2, Washington State Department of Transportation, Olympia, Mar. 2009.

Purpose and Selection Criteria

Load transfer restoration (also called dowel bar retrofit) is achieved by inserting tie bars across the transverse joints of jointed PCC pavements. The objective is to increase load transfer across joints.

Load transfer restoration is suitable for pavements with the load transfer efficiency of 60% or less, early signs of faulting (typically more than 0.1 inch but less than 0.4 inch), and with adequate slab thickness. To ensure proper selection of transverse joints that would benefit from load transfer restoration, evaluation of the load transfer efficiency is typically carried out using Falling Weight Deflectometer (FWD) testing. Load transfer restoration is typically done concurrently with other rehabilitation treatments such as full-depth repairs and resealing of joints. It is also used prior to overlays.

Typical Service Life and Costs

The estimated service life for load transfer restoration is between 5 and 15 years. The typical cost of a load transfer restoration or crack stitching is on the order of $50 to $100 per dowel bar or tie bar.

Materials and Construction

The procedure of load transfer restoration includes the following steps:

Selecting joints—The selection is normally based on FWD testing. Some joints may not require any repairs, and some joints may require full-depth repair rather than load transfer restoration.

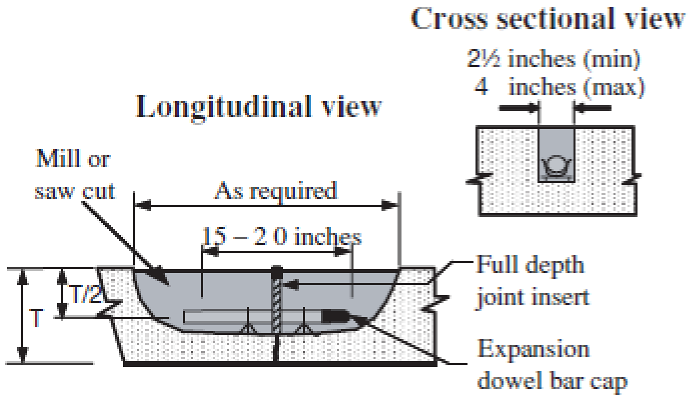


FIGURE B15 Placement of a dowel in the slots. Dowel is placed on a support chair and is approximately ½ in. above the bottom of the slot.

Slot cutting—A diamond-tipped slot cutting saw has become the most common equipment for slot cutting, although modified milling machines have been also used. It is important that the slots are perpendicular to the transverse joint, are large enough to place the dowel at mid-depth of the slab and allow for the backfill material to flow under and around the dowel, and are properly cleaned by sand blasting followed by air blasting.

Insertion of dowels—The most common type of load transfer device is a smooth epoxy-coated dowel bar. The size of the dowel bars depends on the slab thickness and anticipated loads. Typically, dowel bars have the diameter of 1 to 3⁄4 in. and a length of 15 to 20 in. (Figure B15). One-half of the dowel bar is coated with a bond-breaking agent.

Backfilling the slots—It is important that backfill materials do not exhibit excessive shrinkage. For some installations, emphasis is placed on backfill materials that develop early strength to facilitate timely opening of the pavement to traffic. Polymer concretes and high early-strength PCC materials have been used in most installations to date.

Airport Experience

About one-quarter of surveyed airports report routine use or have tried dowel retrofit. Performance data from the survey are insufficient.

Fact Sheet 22—Crack and Joint Stitching (from ACRP Synthesis 22)

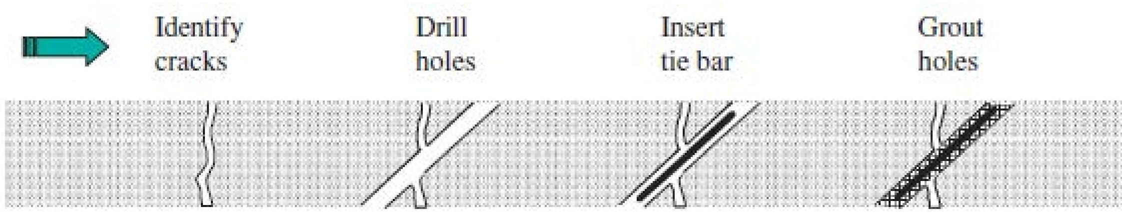


Illustration of Steps in Crack and Joint Stitching

Crack stitching is a rehabilitation method that repairs longitudinal and meandering cracks, and nonworking transverse cracks. Joint stitching strengthens longitudinal joints. There are two crack stitching methods: cross stitching and slot stitching. The illustration above shows an operational sequence of cross stitching of a longitudinal crack.

Sources of Information and Additional Resources

Gransberg, D.D., "Life-Cycle Cost Analysis of Surface Retexturing with Shotblasting as an Asphalt Pavement Preservation Tool," *Transportation Research Record: Journal of the Transportation Research Board, No. 2108,* Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 46–52.

Additional resources include:

The FHWA in conjunction with the ACPA has issued a useful publication entitled *Guide for Load Transfer Restoration.* ACPA has also issued *Stitching Concrete Pavement Cracks and Joints*, Special Report SR903P, which is available at: www.pavement.com.

Pierce, L.M., J. Weston, and J.S. Uhlmeyer, *Dowel Bar Retrofit—Do's and Don'ts,* Report No. WA-RD 576.2, Washington State Department of Transportation, Olympia, Mar. 2009.

Purpose and Selection Criteria

Crack and joint stitching is done by inserting tie bars across cracks or joints. This prevents widening of cracks and joints (slab migration).

Narrow cracks maintain aggregate interlock, reduce the potential for faulting, and are easier to seal. Good candidates for crack stitching are pavements in good condition where longitudinal cracks and joints show signs of slab migration. If longitudinal cracks and joints perform well simply by sealing them, crack and joint stitching may not be necessary.

Typical Service Life and Costs

The estimated service life for crack stitching is 5 to 15 years. A pioneering crack stitching application on a highway pavement was still performing well after 15 years. A typical cost of crack stitching is in the order of $60 to $120 per dowel bar or tie bar.

Stitching of Cracks and Joints

Stitching of cracks using *slot stitching* is very similar to load transfer restoration with the following main exceptions:

- Stitching is done to repair longitudinal and meandering cracks, nonworking transverse cracks, and longitudinal joints.
- Deformed tie bars with a smaller diameter are used instead of smooth dowel bars and are placed further apart than dowel bars.
- Tie bars are not coated with a bond-breaking agent.

Cross stitching includes the following steps:

- Drilling holes at a 35° to 45° angle so that they intersect the longitudinal crack or joint at about the slab mid-depth (Figure B16).
- Cleaning of holes by air blasting.
- Injecting epoxy into the hole in a sufficient amount to fill all the available space after a tie bar is inserted.
- Inserting a tie bar into the hole, leaving approximately 1 in. between the pavement surface and the end of the tie bar.
- Removing excess epoxy and finishing it flush with the pavement.

Airport Experience

A small minority of surveyed airports reported routine or trial use of crack and joint stitching. Performance data from the survey are insufficient.

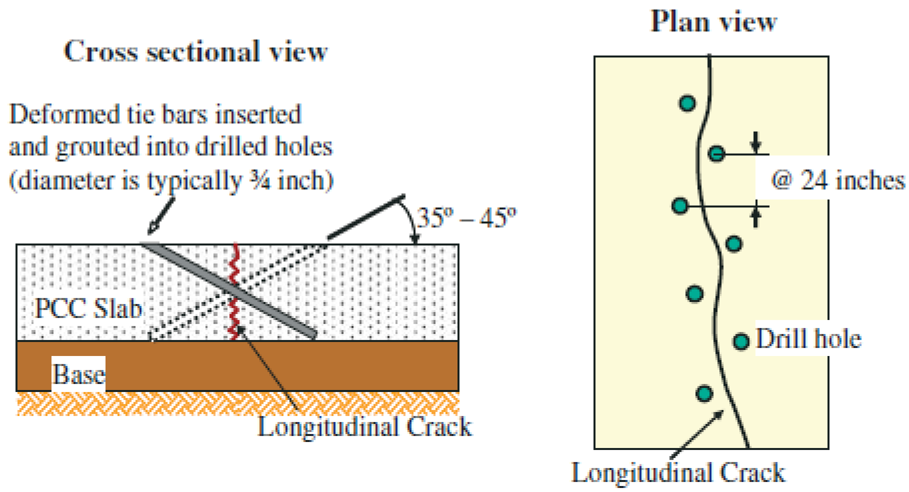
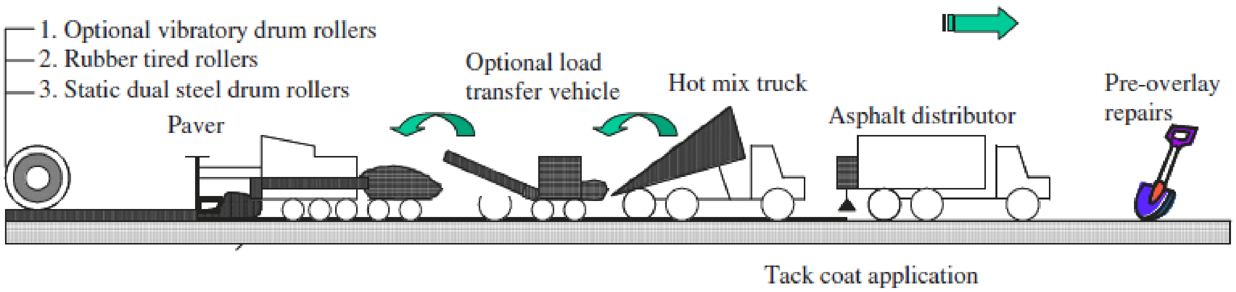


FIGURE B16 Stitched longitudinal crack.

Fact Sheet 23—AC Overlays of PCC Pavements (from ACRP Synthesis 22)



Schematic of Paving Operation for Asphalt Overlay of PCC Pavement

AC overlay of PCC pavements is a rehabilitation technique that includes repairs of structural deficiencies in the existing PCC slab, application of a bonding agent (tack coat) and/or a layer intended to mitigate the propagation of reflection cracking, and placement of a hot-mix asphalt overlay. The construction sequence is illustrated above.

Sources of Information and Additional Resources
California Department of Transportation, *Maintenance Technical Advisory Guide*, 2nd ed., Office of Pavement Preservation, Division of Maintenance, Sacramento, 2008.

Additional resources include:
The Asphalt Institute has issued a useful publication entitled *Asphalt Overlays for Highway and Street Rehabilitation*, Manual Series No. 17, Lexington, Ky., 1998.

Purpose and Selection Criteria
AC overlays of PCC pavements can be classified as functional overlays and structural overlays.
Functional overlays—The purpose of functional overlays is to improve functional deficiencies of the PCC pavement such as low pavement surface friction, inadequate cross-slope, and roughness. However, if roughness is caused primarily by slab stepping (faulting), a functional overlay may not be a cost-effective solution. The thickness of functional overlays ranges from 2 to about 3 in. Functional overlays are suitable for pavements in good structural condition without progressive faulting or for pavements that can be effectively brought to good structural condition by a limited amount of load transfer restoration, slab stabilization, and full-depth patching.
Structural overlays—The purpose of structural overlays is not only to improve the functional deficiencies, but also to improve the structural capacity of the entire pavement. The improvement in the structural strength of the pavement may be required because the structural capacity has been inadequate or is expected to be inadequate considering future aircraft operations.

Typical Service Life and Costs
The typical service life of AC overlays over PCC pavement is 8 to 15 years. Cost can range widely depending on the overlay thickness and on the treatment of the existing PCC pavement. Considering that a typical cost of hot mix is \$60 to \$90 per ton, a 4-in.-thick overlay will cost \$12 to \$18 per square yard. However, this cost does not include any rehabilitation of the underlying PCC pavement that may be required before placing the overlay.

Materials and Construction
Materials used for hot-mix overlay of PCC pavements are similar to those used for hot-mix overlay of AC pavements and are described in Fact Sheet 12, *Hot Mix Overlay of AC Pavement.*
The main challenge in constructing hot-mix overlay of jointed PCC pavements is the prevention or reduction of reflection cracking and the subsequent deterioration of reflection cracks. Over the years, many methods and materials have been developed and field tested. Some of these methods, arranged in the order of increasing costs, include:
Tack coat—Tack coat will not significantly affect reflection cracking, but will improve the bond of hot mix with the PCC surface and thus will reduce the potential for delaminating near the reflection cracks.

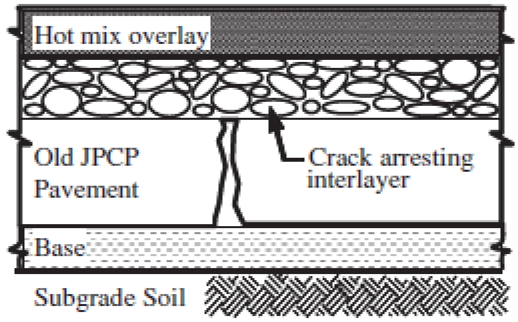


FIGURE B17 Crack arresting granular interlayer.

Sawing and sealing of joints in the overlay—Sawing is done directly above the joints in the underlying PCC pavement and the saw cuts are sealed with liquid asphalt or joint sealant material. This technique prevents uncontrolled reflective cracking and provides joints that can be maintained.
Stress relieving interlayers—A number of products designed to reduce stress in the overlays caused by joint movements have been tested. These products include geotextile fabrics and rubber or polymer-modified tack coats (with or without cover aggregate) and surface treatments used singly or in various combinations.
Crack arresting interlayers—Crack arresting interlayers are typically bound and unbound aggregate layers containing large aggregate particles. The thickness of the interlayer is typically more than 4 in., and the layer contains crushed open-graded aggregate with large numbers of voids (see Figure B17).
Increased overlay thickness—The increased overlay thickness delays the appearance of reflection cracks on the pavement surface.
Typically, cracks propagate through the overlay at the rate of approximately 1⁄2 to 3⁄4 in. per year.
Pre-overlay repairs—Repairs include slab repairs (slab stabilization, load transfer restoration, full-depth repairs) and improving drainage (retrofit subdrains).
Fracturing the PCC slabs—The methods include crack-and-seat and rubblization.

Airport Experience

Nearly one-half of the surveyed airports reported using AC overlays of PCC pavements routinely or have tried them. All surveyed airports that have used AC overlays rated their performance as very good or good.

Fact Sheet 24—Bonded PCC Overlay of PCC Pavements (from ACRP Synthesis 22)

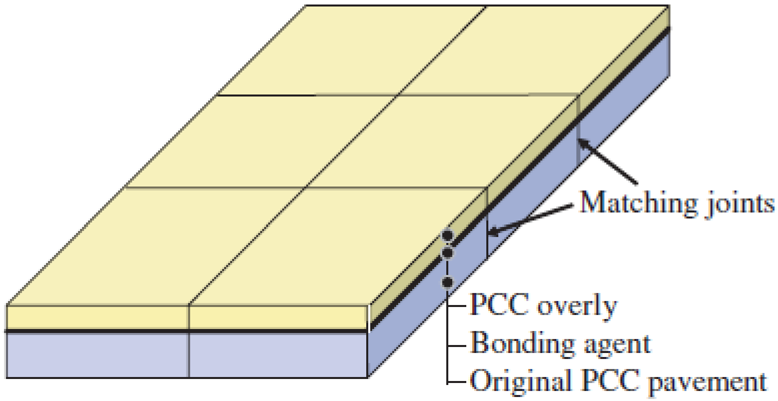


Illustration of Bonded PCC Overlay

Bonded PCC overlay of PCC pavements is a rehabilitation technique that features the placement of a thin PCC overlay directly on the surface of the existing PCC pavement with the overlay bonded to the existing pavement. Bonded overlays are typically 2 to 5 in. thick and are constructed as jointed plain concrete pavements with transverse and longitudinal joints matching those in the underlying pavement as shown in the illustration above.

Sources of Information and Additional Resources

Hicks, R.G., S.B. Seeds, and D.G. Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements,* Publication FHWA-IF-00-027, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2000.

Additional resources include:

Up-to-date information on design, construction, and performance of PCCP overlays is summarized in *Portland Cement Concrete Overlays, State of the Art Technology Synthesis,* Publication FHWA-IF-02-045, U.S. Department of Transportation, Federal Highway Administration, Apr. 2002.

ACPA document TB-007 P, *Guidelines for Bonded Concrete Overlays,* provides useful practical guidelines.

Saeed, A., M.I. Hammons, and J.W. Hall, "Design, Construction, and Performance Monitoring of Ultra-Thin Whitetopping at a General Aviation Airport," *Proceedings of the 27th International Air Transportation Conference, Advancing Airfield Pavements,* American Society of Civil Engineers, Reston, Va., 2007.

Purpose and Selection Criteria

The purpose of the bonded PCC overlay is to improve pavement smoothness and pavement surface friction and to provide increased structural strength of the pavement. Most bonded PCC overlays are placed on jointed plain concrete pavements, and such placement is assumed herein.

A bonded overlay is an appropriate rehabilitation method if the structural strength of the pavement needs to be increased, and the existing PCC pavement is in a condition conducive to such a treatment. The need for the overlay is based on an anticipated increase in aircraft loads (more and/or heavier aircraft). If load-associated pavement defects are already visible, a bonded overlay is not an appropriate rehabilitation technique. Even though bonded overlays increase structural capacity of the pavement, they are unable to arrest progression of faulting. A bonded overlay is also inappropriate if durability-related defects are present, such as scaling and D-cracking. These defects limit the ability of the overlay to bond with its base.

Typical Service Life and Costs

The expected service life of bonded overlays is approximately 10 to 20 years, and their cost is approximately $15 to $25 per square yard for a 4-in.-thick overlay.

Materials and Construction
Bonded overlays usually use conventional PCCP paving mixes. Bonded overlays may also utilize high early-strength PCCP mixes and mixes containing polypropylene and other fibers. The construction of a bonded overlay consists of the following construction tasks:
Pre-overlay repairs—Bonded overlay is placed over pavements in good structural condition. However, some *localized* repairs may be required such as partial-depth repairs, full-depth patching, and load transfer restoration. All cracks (corner, longitudinal, or transverse) in the underlying pavement are repaired.

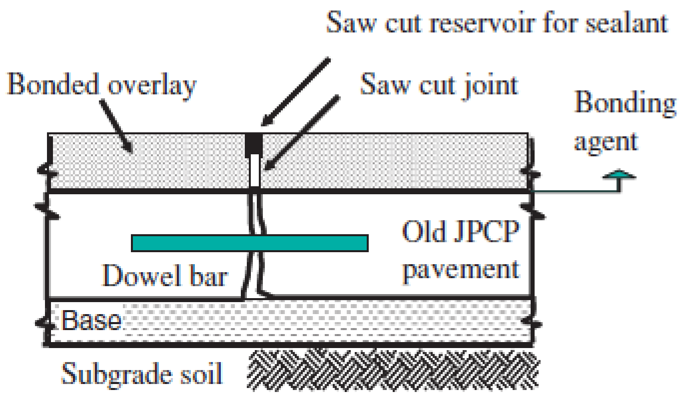


FIGURE B18 Cross section of bonded overlay of jointed plain concrete pavement

Surface preparation—It is essential to ensure that the bonded overlay slab and the slab underneath act as one monolithic slab. The existing concrete surface is cleaned and roughened through a mechanical process that removes a thin layer of concrete. The most commonly used procedures are shot blasting or micromilling followed by air blasting. A bonding agent is applied just prior to paving; a commonly used bonding agent is a mixture of cement and water; this slurry is placed immediately in front of the paver.
PCC placement, finishing, texturing, and curing—The placement of a bonded overlay and texturing uses conventional procedures.
It is very important that the bonding agent not dry out prior to placement of new concrete. Proper curing is also important because of the large surface area of the overlay relative to its thickness. A higher than usual application rate of a curing compound is typically used.
Joint construction and sealing—It is important to locate the transverse and longitudinal joints of the bonded overlay directly above those in the underlying pavement, with the deviation not exceeding 1 in. Transverse joints are sawn through the entire slab thickness plus additional 1⁄2 in. to ensure a complete slab separation. Longitudinal joints are sawed to one-half of the slab thickness.
Sawing is done as soon as possible and the joints are sealed. Sealing requires additional saw cutting to create a reservoir on the top of the pavement and filling the reservoir with sealant (Figure B18).

Airport Experience
A few surveyed airports reported the use of bonded overlays routinely or have tried them. Performance data from the survey are incomplete.

APPENDIX D – ASPHALT PAVEMENT DECISION TREES

Table D1. National Category- Wet Freeze Zone

	National Category- Wet Freeze Zone	
Ques	Accept	Best
Starting to weather (losing fines)	Do Nothing	Rejuvenator, or Fog/Coal Tar Seal
Definitely Weathering (losing fines)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Definitely raveling and losing rock	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack seal/ fill
Few longitudinal cracks or joints Med severity	Crack seal/fill	Crack seal/ fill
Few longitudinal cracks or joints- High severity	Crack seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack seal/ fill
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Crack seal/ fill
Many longitudinal cracks- High severity	Asphalt Overlay/Mill+overlay	Rehab or Reconstruct
A few edge cracks- Low severity	Crack seal/ fill	Do Nothing
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack seal/ fill
A few edge cracks- High severity	Crack seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack seal/ fill
Transverse cracks spaced 50 ft apart Med sev	Crack seal/fill	Crack seal/ fill
Transverse cracks spaced 50 ft apart High sev	Crack seal/ fill	Patch/Reconstruct area
Transverse cracks spaced 20 ft apart-Low sev	Do Nothing	Crack seal/ fill
Transverse cracks spaced 20 ft apart Med sev	Asphalt Overlay/Mill+overlay	Crack seal/ fill
Transverse cracks spaced 20 ft apart High sev	Crack seal/ fill,or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing, Chip/Cape seal	Crack seal/ fill
Block cracking Medium severity	Chip/Cape seal, or Asphalt	Crack seal/ fill
Block cracking High severity	Chip/Cape seal, or Asphalt	Rehab or Reconstruct
Reflection cracking Low severity	Do Nothing	Crack seal/ fill
Reflection cracking Medium severity	Crack seal/fill	Crack seal/ fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab or Reconstruct
Fatigue cracking- 10% Low severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low sev	Patch/Reconstruct area	Rehab or Reconstruct
Fatigue cracking- 30% Medium sev	Patch/Reconstruct area	Rehab or Reconstruct
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab or Reconstruct
Patching- 10% Low severity	Crack seal/fill	Do Nothing
Patching- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Slurry/Micro, or Chip/Cape seal	Do Nothing
Patching- 30% Medium severity	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt overlay/Mill+ overlay, or	Rehab or Reconstruct
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Asphalt overlay/Mill+ overlay, or
Roughness- Many Long Wavelength Swells	Rehab or Reconstruct	Asphalt Overlay/Mill+overlay
Roughness- No Swells, Many Short Wave Bump	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area

Table D2. National Category- Dry Freeze Zone

	National Category- Dry Freeze Zone	
Ques	Accept	Best
Starting to weather (losing fines)	Slurry/Micro	Rejuvenator, or Fog/Coal Tar seal
Definitely Weathering (losing fines)	Slurry/Micro	Rejuvenator, or Fog/Coal Tar seal
Starting to ravel (larger rock start to pop out)	Rejuvenator, or Fog/Coal Tar seal	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack seal/fill
Few longitudinal cracks or joints Med severity	Crack seal/fill	Crack seal/fill
Few longitudinal cracks or joints- High severity	Crack seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack seal/fill
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Crack seal/fill
Many longitudinal cracks- High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
A few edge cracks- Low severity	Crack seal/fill	Do Nothing
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack seal/fill
A few edge cracks- High severity	Crack seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack seal/fill
Transverse cracks spaced 50 ft apart Med sev	Crack seal/fill	Crack seal/fill
Transverse cracks spaced 50 ft apart High sev	Crack seal/fill	Patch/Reconstruct area
Transverse cracks spaced 20 ft apart- Low sev	Do Nothing	Crack seal/fill
Transverse cracks spaced 20 ft apart Med sev	Asphalt Overlay/Mill+overlay	Crack seal/fill
Transverse cracks spaced 20 ft apart High sev	Crack seal/ fill,or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack seal/fill
Block cracking Medium severity	Crack seal/fill	Chip/Cape seal
Block cracking High severity	Chip/Cape seal	Rehab/Reconstruct
Reflection cracking Low severity	Do Nothing	Crack seal/fill
Reflection cracking Medium severity	Chip/Cape seal, or Asphalt Overlay	Crack seal/fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 10% Low severity	Patch/Reconstruct area	Crack seal/fill
Fatigue cracking- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue crack Low sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Medium sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack seal/fill	Do Nothing
Patching- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Crack seal/fill	Do Nothing
Patching- 30% Medium severity	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Roughness, Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness- No Swell, Many Short Wave	Patch/Reconstruct area	Patch/Reconstruct area

Table D3. National Category- Dry No Freeze Zone

	National Category- Dry No Freeze Zone	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal tar Seal, or Slurry/Micro	Rejuvenator
Definitely Weathering (losing fines)	Fog/Coal tar Seal	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Slurry/Micro	Fog/Coal tar Seal
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Crack seal/fill	Do Nothing
Few longitudinal cracks or joints Med severity	Crack seal/fill	Crack seal/fill
Few longitudinal cracks or joints- High severity	Crack seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Crack seal/fill	Do Nothing
Many longitudinal cracks- Medium sev	Crack seal/fill	Asphalt Overlay/Mill+overlay
Many longitudinal cracks- High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
A few edge cracks- Low severity	Rejuvenator, Fog/Coal tar Seal	Crack seal/fill
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack seal/fill
A few edge cracks- High severity	Crack seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack seal/fill
Transverse cracks spaced 50 ft apart Med sev	Crack seal/fill	Crack seal/fill
Transverse cracks spaced 50 ft apart High sev	Crack seal/fill	Patch/Reconstruct area
Transverse cracks spaced 20 ft apart-Low sev	Do Nothing	Crack seal/fill
Transverse cracks spaced 20 ft apart Med sev	Asphalt Overlay/Mill+overlay	Crack seal/fill
Transverse cracks spaced 20 ft apart High sev	Crack seal/fill	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack seal/fill
Block cracking Medium severity	Crack seal/fill	Crack seal/fill
Block cracking High severity	Rehab/Reconstruct	Patch/Reconstruct area
Reflection cracking Low severity	Do Nothing	Crack seal/fill
Reflection cracking Medium severity	Crack seal/fill, or Chip/Cape seal	Crack seal/fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 10% Low severity	Patch/Reconstruct area	Crack seal/fill
Fatigue cracking- 10% Medium severity	Patch/Reconstruct area	Crack seal/fill
Fatigue cracking- 10% High severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Medium sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% High sev	Rehab/Reconstruct	Patch/Reconstruct area
Patching- 10% Low severity	Crack seal/fill	Do Nothing
Patching- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/Fill	Do Nothing
Patching- 30% Medium severity	Chip/Cape Seal	Rehab/Reconstruct
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Roughness, Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness- No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D4. National Category- Wet No Freeze Zone

	National Category- Wet No Freeze Zone NWN	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal tar Seal	Rejuvenator
Definitely Weathering (losing fines)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Starting to ravel (larger rock start to pop out)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack seal/fill
Few longitudinal cracks or joints Med severity	Crack seal/fill	Crack seal/fill
Few longitudinal cracks or joints- High severity	Crack seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Rejuvenator, Fog/Coal tar Seal	Crack seal/fill
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Crack seal/fill
Many longitudinal cracks- High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
A few edge cracks- Low severity	Do Nothing	Crack seal/fill
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack seal/fill
A few edge cracks- High severity	Crack seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack seal/fill
Transverse cracks spaced 50 ft apart Med sev	Crack seal/fill	Crack seal/fill
Transverse cracks spaced 50 ft apart High sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Transverse cracks spaced 20 ft apart-Low sev	Do Nothing	Crack seal/fill
Transverse cracks spaced 20 ft apart Med sev	Asphalt Overlay/Mill+overlay	Crack seal/fill
Transverse cracks spaced 20 ft apart High sev	Crack seal/fill	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing, Chip/Cape seal	Crack seal/fill
Block cracking Medium severity	Asphalt Overlay/Mill+overlay	Crack seal/fill
Block cracking High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Reflection cracking Low severity	Do Nothing	Crack seal/fill
Reflection cracking Medium severity	Crack seal/fill	Crack seal/fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 10% Low severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Fatigue cracking- 30% Fatigue cracking Low sev	Asphalt Overlay/Mill+overlay, or Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 30% Medium sev	Asphalt Overlay/Mill+overlay, or Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack seal/fill	Do Nothing
Patching- 10% Medium severity	Crack seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Slurry/Micro, or Cape/Chip seal	Do Nothing
Patching- 30% Medium severity	Cape/Chip seal	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Roughness, Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness, Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness,No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D5. Regional Category- Wet Freeze Zone

	Regional Category- Wet Freeze Zone RWF	
Ques	Accept	Best
Starting to weather (losing fines)	Slurry/Micro, Fog/Coal tar Seal	Rejuvenator
Definitely Weathering (losing fines)	Fog/Coal Tar Seal, or Rejuvenator	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Fog/Coal Tar Seal, or Rejuvenator	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints, Med severity	Crack Seal/fill	Crack Seal/fill
Few longitudinal cracks or joints, High severity	Crack Seal/fill, or Asphalt Overlay/Mill+Overlay	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Many longitudinal cracks- High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
A few edge cracks- Low severity	Do Nothing	Crack Seal/fill
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart Med sev	Rejuvenator, Fog/Coal tar Seal	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 20 ft apart-Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Transverse cracks spaced 20 ft apart High sev	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Chip/Cape seal	Crack Seal/fill
Block cracking High severity	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Patch/Reconstruct area	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Slurry/Micro	Do Nothing
Patching- 30% Medium severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Roughness, Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness- Many Long Wave Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness- No Swells, Many Short	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D6. Regional Category- Dry Freeze Zone

	Regional Category- Dry Freeze Zone RDF	
Ques	Accept	Best
Starting to weather (losing fines)	Do Nothing	Slurry/Micro, Fog/Coal tar Seal, Rejuvenator
Definitely Weathering (losing fines)	Slurry/Micro	Rejuvenator
Starting to ravel (large rock start to pop)	Asphalt Overlay/Mill+overlay	Slurry/Micro, or Chip/Cape seal
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few long cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few long cracks or joints Med severity	Crack Seal/fill	Crack Seal/fill
Few long cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Many longitudinal cracks- High severity	Crack Seal/fill	Rehab/Reconstruct
A few edge cracks- Low severity	Crack Seal/fill	Do Nothing
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Transverse cracks, 50 ft apart Low sev	Crack Seal/fill	Do Nothing
Transverse cracks, 50 ft apart Med sev	Do Nothing	Crack Seal/fill
Transverse cracks, 50 ft apart High sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Transverse cracks, 20 ft apart- Low sev	Do Nothing	Crack Seal/fill
Transverse cracks, 20 ft apart Med sev	Chip/Cape Seal, or Asphalt	Crack Seal/fill
Transverse cracks,20 ft apart High sev	Chip/Cape Seal, or Asphalt	Crack Seal/fill
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Chip/Cape seal	Crack Seal/fill
Block cracking High severity	Slurry/Micro, or Chip/Cape seal,	Rehab/Reconstruct
Reflection cracking Low severity	Crack Seal/fill	Do Nothing
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 10% Low severity	Patch/Reconstruct area	Crack Seal/fill
Fatigue cracking- 10% Med severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Medium sev	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Crack Seal/fill	Do Nothing
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Asphalt Overlay/Mill+overlay	Do Nothing
Patching- 30% Medium severity	Chip/Cape Seal, or Asphalt	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Roughness, Long Wavelength Swells	Do Nothing	Asphalt Overlay/Mill+overlay
Roughness- Many Long Wave Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness- No Swell, Many Short	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D7. Regional Category- Dry No Freeze Zone

	Regional Category- Dry No Freeze Zone RDN	
Ques	Accept	Best
Starting to weather (losing fines)	Slurry/Micro	Rejuvenator
Definitely Weathering (losing fines)	Chip/Cape seal	Fog/Coal tar Seal
Starting to ravel (larger rock starting to pop out)	Chip/Cape seal	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Crack Seal/fill	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- Medium sev	Crack Seal/fill	Crack Seal/fill
Many longitudinal cracks- High severity	Crack Seal/fill	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Do Nothing	Crack Seal/fill
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart Med sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 20 ft apart-Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Crack Seal/fill, or Asphalt	Crack Seal/fill
Transverse cracks spaced 20 ft apart High sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Chip/Cape seal	Crack Seal/fill
Block cracking High severity	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Do Nothing	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Do Nothing	Crack Seal/fill
Patching- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Slurry/Micro	Do Nothing
Patching- 30% Medium severity	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Roughness, Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness- No Swells, Many Short	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D8. Regional Category- Wet No Freeze Zone

	Regional Category- Wet No Freeze Zone RWN	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal tar Seal	Rejuvenator
Definitely Weathering (losing fines)	Rejuvenator	Slurry/Micro
Starting to ravel (larger rock start to pop out)	Rejuvenator	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- Med sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Many longitudinal cracks- High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Crack Seal/fill	Do Nothing
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Trans cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Trans cracks spaced 50 ft apart Medium sev	Crack Seal/fill	Crack Seal/fill
Trans cracks spaced 50 ft apart High sev	Patch/Reconstruct area	Crack Seal/fill
Trans cracks spaced 20 ft apart- Low sev	Do Nothing	Crack Seal/fill
Trans cracks spaced 20 ft apart Medium sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Trans cracks spaced 20 ft apart High sev	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Block cracking High severity	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Crack Seal/fill	Do Nothing
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Crack Seal/fill	Do Nothing
Fatigue cracking- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt overlay/mill+ overlay, or	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low sev	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct Area
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Slurry/Micro, or Chip/Cape seal	Do Nothing
Patching- 30% Medium severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Roughness, Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness- Many Long Wavelength Swells	Asphalt Overlay/Mill+overlay, or Do	Patch/Reconstruct area
Roughness- No Swell, Many Short Wave Bump	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area

Table D9. Regional Category- Wet Freeze Zone

	Local Category- Wet Freeze Zone LWF	
Ques	Accept	Best
Starting to weather (losing fines)	Rejuvenator	Do Nothing
Definitely Weathering (losing fines)	Fog/Coal tar Seal	Rejuvenator
Starting to ravel (larger rock starting to pop out)	Fog/Coal tar Seal	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Crack Seal/fill	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Rejuvenator, or Fog/Coal Tar seal	Crack Seal/fill
Many longitudinal cracks- Medium sev	Asphalt overlay/mill+ overlay	Crack Seal/fill
Many longitudinal cracks- High severity	Rehab/Reconstruct	Asphalt overlay/mill+ overlay
A few edge cracks- Low severity	Do Nothing	Crack Seal/fill
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart Med sev	Crack Seal/fill	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Transverse cracks spaced 20 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Transverse cracks spaced 20 ft apart High sev	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Rejuvenator	Crack Seal/fill
Block cracking Medium severity	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Block cracking High severity	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Do Nothing	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% High sev	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Patch/Reconstruct area	Crack Seal/fill
Patching- 10% High severity	Chip/Cape Seal	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/fill	Do Nothing
Patching- 30% Medium severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness, Long Wavelength Swells	Do Nothing	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness-No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D10. Local Category- Dry Freeze Zone

	Local Category- Dry Freeze Zone LDF	
Ques	Accept	Best
Starting to weather (losing fines)	Rejuvenator	Slurry/Micro, or Fog/Coal Tar Seal
Definitely Weathering (losing fines)	Rejuvenator	Slurry/Micro, or Fog/Coal Tar Seal
Starting to ravel (larger rock starting to pop out)	Asphalt Overlay/Mill+overlay	Slurry/Micro, or Fog/Coal tar Seal
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Rejuvenator	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Fog/Coal tar Seal	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Fog/Coal Tar Seal, or Rejuvenator	Crack Seal/fill
Many longitudinal cracks- Medium sev	Asphalt overlay/Mill+overlay	Crack Seal/fill
Many longitudinal cracks- High severity	Asphalt overlay/Mill+overlay	Rehab/Reconstruct
A few edge cracks- Low severity	Crack Seal/fill	Do Nothing
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart Med sev	Crack Seal/fill	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Transverse cracks spaced 20 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Crack Seal/fill	Crack Seal/fill
Transverse cracks spaced 20 ft apart High sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Fog/Coal Tar seal
Block cracking Medium severity	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Block cracking High severity	Asphalt Overlay/Mill+ overlay	Rehab/Reconstruct
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 10% Low severity	Fog/Coal Tar Seal, or Rejuvenator	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt overlay/Mill+ overlay	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Fog/Coal tar Seal	Asphalt overlay/Mill+ overlay
Fatigue cracking- 30% Medium sev	Patch/Reconstruct area	Asphalt overlay/Mill+ overlay
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Patch/Reconstruct area	Do Nothing
Patching- 10% High severity	Asphalt overlay/Mill+ overlay	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/fill	Do Nothing
Patching- 30% Medium severity	Patch/Reconstruct area	Chip/Cape Seal
Patching- 30% High severity	Rehab/Reconstruct	Asphalt overlay/Mill+ overlay
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness-No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D11. Local Category- Dry No Freeze Zone

	Local Category- Dry No Freeze Zone LDN	
Ques	Accept	Best
Starting to weather (losing fines)	Slurry/Micro, or Chip/Cape seal	Fog/Coal tar Seal
Definitely Weathering (losing fines)	Slurry/Micro, or Chip/Cape seal	Fog/Coal tar Seal
Starting to ravel (large rock start to pop)	Slurry/Micro, or Chip/Cape seal	Fog/Coal tar Seal
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Fog/Coal tar Seal
Few longitudinal crack/joint, Low sev	Do Nothing	Crack Seal/fill
Few longitudinal crack/joint Medium sev	Do Nothing	Crack Seal/fill
Few longitudinal crack/joint- High sev	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Fog/Coal tar Seal	Chip/Cape seal
Many longitudinal cracks- Medium sev	Slurry/Micro, or Fog/Coal tar Seal, or Crack	Chip/Cape seal
Many longitudinal cracks- High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Do Nothing	Crack Seal/fill
A few edge cracks- Medium severity	Do Nothing	Crack Seal/fill
A few edge cracks- High severity	Patch/Reconstruct area	Crack Seal/fill
Trans cracks spaced 50 ft apart Low sev	Crack Seal/fill	Do Nothing
Trans cracks spaced 50 ft apart Med sev	Do Nothing	Crack Seal/fill
Trans cracks spaced 50 ft apart High sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Trans cracks spaced 20 ft apart Low sev	Crack Seal/fill	Fog/Coal tar Seal
Trans cracks spaced 20 ft apart Med sev	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Trans cracks spaced 20 ft apart High sev	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing, or Crack Seal/Fill	Fog/Coal tar Seal
Block cracking Medium severity	Crack Seal/Fill	Chip/Cape seal
Block cracking High severity	Crack Seal/Fill	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Do Nothing	Crack Seal/fill
Reflection cracking High severity	Crack Seal/Fill	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Crack Seal/Fill	Do Nothing
Fatigue cracking- 10% Medium severity	Do Nothing, or Crack Seal/Fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Asphalt Overlay/Mill+overlay, or	Rehab/Reconstruct
Fatigue cracking- 30% High sev	Asphalt Overlay/Mill+overlay, or	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Do Nothing	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Slurry/Micro, or Chip/Cape Seal	Do Nothing
Patching- 30% Medium severity	Slurry/Micro, or Fog/Coal tar Seal	Chip/Cape Seal
Patching- 30% High severity	Patch/Reconstruct area, or	Asphalt Overlay/Mill+overlay
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness- Many Long Wave Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness-No Swell, Many Short Wave	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D12. Local Category- Wet No Freeze Zone

	Local Category- Wet No Freeze Zone LWN	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal tar Seal	Rejuvenator
Definitely Weathering (losing fines)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Rejuvenator, or Fog/Coal tar Seal	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro, or Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Rejuvenator	Chip/Cape seal
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Chip/Cape seal
Many longitudinal cracks- High severity	Crack Seal/fill	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Do Nothing	Crack Seal/fill
A few edge cracks- Medium severity	Patch/Reconstruct area	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Trans cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Trans cracks spaced 50 ft apart Medium sev	Crack Seal/fill	Crack Seal/fill
Trans cracks spaced 50 ft apart High sev	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Trans cracks spaced 20 ft apart- Low sev	Do Nothing	Crack Seal/fill
Trans cracks spaced 20 ft apart Medium sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Trans cracks spaced 20 ft apart High sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Rejuvenator	Crack Seal/fill
Block cracking High severity	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Patch/Reconstruct area	Rehab/Reconstruct
Fatigue cracking- 10% Low severity	Rejuvenator	Patch/Reconstruct area
Fatigue cracking- 10% Medium severity	Rejuvenator	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Rejuvenator	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Rejuvenator	Patch/Reconstruct area
Fatigue cracking- 30% Medium sev	Rejuvenator	Patch/Reconstruct area
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/Fill	Do Nothing
Patching- 10% Medium severity	Crack Seal/Fill	Patch/Reconstruct area
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/Fill	Do Nothing
Patching- 30% Medium severity	Slurry/Micro, or Chip/Cape seal	Patch/Reconstruct area
Patching- 30% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness-No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D13. Basic Category- Wet Freeze Zone

	Basic Category- Wet Freeze Zone BWF	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal Tar Seal, Rejuvenator	Do Nothing
Definitely Weathering (losing fines)	Do Nothing	Fog/Coal Tar Seal, Rejuvenator
Start to ravel(large rock start to pop)	Fog/Coal Tar Seal, Rejuvenator	Chip/Cape seal
Definitely raveling and losing rock	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Few long cracks or joints, Low sev	Do Nothing	Crack Seal/fill
Few long cracks or joints Med sev	Do Nothing	Crack Seal/fill
Few long cracks or joints- High sev	Crack Seal/Fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing, or Asphalt Overlay/Mill+overlay	Crack Seal/fill
Many longitudinal cracks- Med sev	Patch/Reconstruct area, or Do Nothing	Crack Seal/fill
Many longitudinal cracks- High sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
A few edge cracks- Low severity	Crack Seal/fill	Do Nothing
A few edge cracks- Medium sev	Asphalt Overlay/Mill+overlay, or Patch/Recon	Crack Seal/fill
A few edge cracks- High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Trans crack, 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Trans crack,50 ft apart Medium sev	Asphalt Overlay/Mill+overlay, or Do Nothing	Crack Seal/fill
Trans crack, 50 ft apart High sev	Crack Seal/fill	Patch/Reconstruct area
Trans crack, 20 ft apart- Low sev	Do Nothing	Crack Seal/fill
Trans crack, 20 ft apart Medium sev	Asphalt Overlay/Mill+overlay, or Do Nothing	Crack Seal/fill
Trans crack, 20 ft apart High sev	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Do Nothing	Crack Seal/fill
Block cracking High severity	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Asphalt Overlay/Mill+overlay, or Do Nothing	Crack Seal/fill
Reflection cracking High severity	Asphalt Overlay/Mill+overlay, or Rehab/Recon	Patch/Reconstruct area
Fatigue cracking- 10% Low sev	Do Nothing	Crack Seal/fill
Fatigue cracking- 10% Medium sev	Fog/Coal tar Seal	Patch/Reconstruct area
Fatigue cracking- 10% High sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Fog/Coal tar Seal	Asphalt Overlay/Mill+overlay, or Rehab/Reconstruct
Fatigue cracking- 30% Medium sev	Patch/Reconstruct area, or Rehab/Recon	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% High sev	Asphalt Overlay/Mill+overlay, or Patch/Recon	Rehab/Reconstruct
Patching- 10% Low severity	Slurry/Micro	Do Nothing
Patching- 10% Medium severity	Do Nothing	Slurry/Micro, or Patch/Reconstruct area
Patching- 10% High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Patching- 30% Low severity	Fog/Coal tar Seal	Do Nothing
Patching- 30% Medium severity	Fog/Coal tar Seal	Patch/Reconstruct area
Patching- 30% High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness, Long Wave Swells	Patch/Reconstruct area	Do Nothing
Roughness-Many Long Wave Swell	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness-No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

Table D14. Basic Category- Dry Freeze Zone

	Basic Category- Dry Freeze Zone BDF	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal tar Seal	Rejuvenator
Definitely Weathering (losing fines)	Fog/Coal tar Seal	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Slurry/Micro	Chip/Cape seal
Definitely raveling and losing rock	Slurry/Micro	Chip/Cape seal
Few longitudinal cracks or joints, Low severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Crack Seal/fill	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- Medium sev	Crack Seal/fill	Crack Seal/fill
Many longitudinal cracks- High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Do Nothing	Crack Seal/fill
A few edge cracks- Medium severity	Crack Seal/fill	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart Med sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Transverse cracks spaced 20 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Chip/Cape Seal	Crack Seal/fill
Transverse cracks spaced 20 ft apart High sev	Chip/Cape Seal	Asphalt Overlay/Mill+overlay
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Chip/Cape Seal	Crack Seal/fill
Block cracking High severity	Chip/Cape Seal	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Crack Seal/Fill, or Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Rejuvenator	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Chip/Cape Seal	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low sev	Chip/Cape seal	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Chip/Cape seal	Patch/Reconstruct area
Fatigue cracking- 30% High sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Slurry/Micro, or Fog/Coal Tar Seal	Do Nothing
Patching- 10% High severity	Slurry/Micro, or Fog/Coal Tar Seal	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/Fill	Do Nothing
Patching- 30% Medium severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness- Many Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness-No Swell, Many Short Wave Bumps	Asphalt Overlay/Mill+overlay	Do Nothing

Table D15. Basic Category- Dry No Freeze Zone

	Basic Category- Dry No Freeze Zone BDN	
Ques	Accept	Best
Starting to weather (losing fines)	Fog/Coal tar Seal	Rejuvenator
Definitely Weathering (losing fines)	Rejuvenator	Fog/Coal tar Seal
Starting to ravel (larger rock starting to pop out)	Fog/Coal tar Seal	Slurry/Micro
Definitely raveling and losing rock	Slurry/Micro	Chip/Cape seal
Few longitudinal cracks or joints, Low severity	Crack Seal/fill	Do Nothing
Few longitudinal cracks or joints Medium severity	Do Nothing	Crack Seal/fill
Few longitudinal cracks or joints- High severity	Crack Seal/fill	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Crack Seal/fill	Do Nothing
Many longitudinal cracks- Medium sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- High severity	Crack Seal/fill	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Crack Seal/fill	Do Nothing
A few edge cracks- Medium severity	Do Nothing	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/fill	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Crack Seal/fill	Do Nothing
Transverse cracks spaced 50 ft apart Med sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Patch/Reconstruct area	Crack Seal/fill
Transverse cracks spaced 20 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart High sev	Chip/Cape Seal	Crack Seal/fill
Block cracking Low severity	Crack Seal/fill	Do Nothing
Block cracking Medium severity	Do Nothing	Crack Seal/fill
Block cracking High severity	Crack Seal/fill	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Crack Seal/fill	Do Nothing
Reflection cracking Medium severity	Do Nothing	Crack Seal/fill
Reflection cracking High severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Do Nothing	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Crack Seal/fill	Patch/Reconstruct area
Fatigue cracking- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% Fatigue cracking Low sev	Rejuvenator	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Fatigue cracking- 30% High sev	Patch/Reconstruct area	Rehab/Reconstruct
Patching- 10% Low severity	Crack Seal/fill	Do Nothing
Patching- 10% Medium severity	Do Nothing	Crack Seal/fill
Patching- 10% High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/fill	Do Nothing
Patching- 30% Medium severity	Asphalt Overlay/Mill+overlay	Chip/Cape seal, or Slurry/Micro
Patching- 30% High severity	Chip/Cape seal, or Slurry/Micro	Asphalt Overlay/Mill+overlay
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness- Many Long Wavelength Swells	Asphalt Overlay/Mill+overlay	Do Nothing
Roughness-No Swell, Many Short Wave Bumps	Asphalt Overlay/Mill+overlay	Do Nothing

Table D16. Basic Category- Wet No Freeze Zone

	Basic Category- Wet No Freeze Zone BWN	
Ques	Accept	Best
Starting to weather (losing fines)	Do Nothing, or Rejuvenator	Fog/Coal tar Seal
Definitely Weathering (losing fines)	Rejuvenator, or Fog/Coal Tar Seal	Slurry/Micro
Starting to ravel (larger rock starting to pop out)	Slurry/Micro	Rejuvenator
Definitely raveling and losing rock	Chip/Cape Seal	Asphalt Overlay/Mill+overlay
Few longitudinal cracks or joints, Low severity	Do Nothing, or Rejuvenator	Crack Seal/fill
Few longitudinal cracks or joints Med severity	Do Nothing, or Rejuvenator	Crack Seal/fill
Few longitudinal cracks or joints High severity	Asphalt Overlay/Mill+overlay	Patch/Reconstruct area
Many longitudinal cracks- Low sev	Do Nothing	Crack Seal/fill
Many longitudinal cracks- Medium sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Many longitudinal cracks- High severity	Crack Seal/fill	Asphalt Overlay/Mill+overlay
A few edge cracks- Low severity	Crack Seal/fill	Do Nothing
A few edge cracks- Medium severity	Rejuvenator	Crack Seal/fill
A few edge cracks- High severity	Crack Seal/Fill, or Rejuvenator	Patch/Reconstruct area
Transverse cracks spaced 50 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart Med sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 50 ft apart High sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Transverse cracks spaced 20 ft apart Low sev	Do Nothing	Crack Seal/fill
Transverse cracks spaced 20 ft apart Med sev	Chip/Cape Seal	Crack Seal/fill
Transverse cracks spaced 20 ft apart High sev	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Block cracking Low severity	Do Nothing	Crack Seal/fill
Block cracking Medium severity	Asphalt Overlay/Mill+overlay	Crack Seal/fill
Block cracking High severity	Chip/Cape Seal	Asphalt Overlay/Mill+overlay
Reflection cracking Low severity	Do Nothing	Crack Seal/fill
Reflection cracking Medium severity	Crack Seal/fill	Crack Seal/fill
Reflection cracking High severity	Rehab/Reconstruct	Patch/Reconstruct area
Fatigue cracking- 10% Low severity	Patch/Reconstruct area	Crack Seal/fill
Fatigue cracking- 10% Medium severity	Chip/Cape Seal	Crack Seal/fill
Fatigue cracking- 10% High severity	Chip/Cape Seal	Patch/Reconstruct area
Fatigue cracking- 30% Low sev	Rejuvenator	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% Medium sev	Patch/Reconstruct Area	Asphalt Overlay/Mill+overlay
Fatigue cracking- 30% High sev	Asphalt Overlay/Mill+overlay	Rehab/Reconstruct
Patching- 10% Low severity	Do Nothing	Do Nothing
Patching- 10% Medium severity	Fog/Coal tar Seal	Do Nothing
Patching- 10% High severity	Slurry/Micro, or Chip/Cape seal	Patch/Reconstruct area
Patching- 30% Low severity	Crack Seal/Fill	Do Nothing
Patching- 30% Medium severity	Chip/Cape Seal	Asphalt Overlay/Mill+overlay
Patching- 30% High severity	Rehab/Reconstruct	Asphalt Overlay/Mill+overlay
Roughness, Long Wavelength Swells	Patch/Reconstruct area	Do Nothing
Roughness- Many Long Wavelength Swells	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay
Roughness-No Swell, Many Short Wave Bump	Patch/Reconstruct area	Asphalt Overlay/Mill+overlay

APPENDIX E – CONCRETE PAVEMENT DECISION TREES

Table E1. National Category- Wet Freeze Zone

	National Category- Wet Freeze Zone NWF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Crack/Joint Seal	Do Nothing
Joint Seal Medium sev	Crack/Joint Seal	Crack/Joint Seal
Joint Seal High sev	Crack/Joint Seal	Crack/Joint Seal
Joint and Corner Spall Lowsev	Crack/Joint Seal, or Do Nothing	Partial depth repair
Joint and Corner Spall Medium sev	Crack/Joint Seal, orPartial Depth repair	Partial depth repair
Joint and Corner Spall High sev	Partial depth repair	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint Seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair, or Full-depth repair	Crack/Joint Seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint Seal, or Partial depth repair	Full-depth repair
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Concrete/asphalt overlay
Mid-Panel Crack, 40% slabs,Med sev	Rehab/Reconstruct	Concrete/asphalt overlay
Mid-Panel Crack, 40% slabs, Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint Seal, or Full-depth repair	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair	Crack/Joint Seal
Corner Brk, 10% slab, Hi sev	Full-depth repair	Full-depth repair
Corner Brk, 30% slab, Low sev	Crack/Joint Seal	Do Nothing, or Full-depth repair
Corner Brk, 30% slab, Medium sev	Full-depth repair	Full-depth repair, or Concrete/asphalt overlay
Corner Brk, 30% slab, Hi sev	Full-depth repair	Rehab/Reconstruct
10% Shattered, Low sev	Do Nothing	Full-depth repair
10% Shattered, Medium sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Hi sev	Concrete/asphalt overlay	Full-depth repair
30% Shattered, Low sev	Rehab/Reconstruct	Concrete/asphalt overlay
30% Shattered, Medium sev	Full-depth repair	Rehab/Reconstruct
30% Shattered, Hi sev	Full-depth repair	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Partial depth repair	Full-depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair
50% slabs, Patches Low sev	Concrete/asphalt overlay	Do Nothing
50% slabs, Patches Med sev	Full-depth repair	Concrete/asphalt overlay
50% slabs, Patches Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
10% slabs Fault Low sev	Grinding/grooving	Do Nothing
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
10% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Low sev	Do Nothing	Grinding/grooving
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Rehab/Reconstruct

Table E2. National Category- Dry Freeze Zone

	National Category- Dry Freeze Zone NDF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint Seal
Joint Seal Medium sev	Crack/Joint Seal	Crack/Joint Seal
Joint Seal High sev	Crack/Joint Seal	Crack/Joint Seal
Joint and Corner Spall Lowsev	Crack/Joint Seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint Seal	Partial depth repair
Joint and Corner Spall High sev	Partial depth repair	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint Seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair	Crack/Joint Seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint Seal	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint Seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Partial depth repair	Crack/Joint Seal
Mid-Panel Crack, 40% slabs, Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint Seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair	Crack/Joint Seal
Corner Brk, 10% slab, Hi sev	Full-depth repair	Full-depth repair
Corner Brk, 30% slab, Low sev	Crack/Joint Seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Crack/Joint Seal	Full-depth repair
Corner Brk, 30% slab, Hi sev	Full-depth repair	Rehab/Reconstruct
10% Shattered, Low sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Medium sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Hi sev	Concrete/asphalt overlay	Full-depth repair
30% Shattered, Low sev	Full-depth repair	Crack/Joint Seal
30% Shattered, Medium sev	Rehab/Reconstruct	Full-depth repair
30% Shattered, Hi sev	Full-depth repair	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Full-depth repair	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Rehab/Reconstruct
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Concrete/asphalt overlay	Full-depth repair
50% slabs, Patches Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
10% slabs Fault Low sev	Crack/Joint Seal	Do Nothing
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Crack/Joint Seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal

Table E3. National Category- Dry No Freeze Zone

	National Category- Dry No Freeze Zone NDN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint Seal
Joint Seal Medium sev	Crack/Joint Seal	Crack/Joint Seal
Joint Seal High sev	Crack/Joint Seal	Crack/Joint Seal
Joint and Corner Spall Lowsev	Crack/Joint Seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint Seal	Partial depth repair
Joint and Corner Spall High sev	Partial depth repair	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint Seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair	Crack/Joint Seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint Seal	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint Seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Partial depth repair	Crack/Joint Seal
Mid-Panel Crack, 40% slabs, Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint Seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair	Crack/Joint Seal
Corner Brk, 10% slab, Hi sev	Full-depth repair	Full-depth repair
Corner Brk, 30% slab, Low sev	Crack/Joint Seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Crack/Joint Seal	Full-depth repair
Corner Brk, 30% slab, Hi sev	Full-depth repair	Rehab/Reconstruct
10% Shattered, Low sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Medium sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Hi sev	Concrete/asphalt overlay	Full-depth repair
30% Shattered, Low sev	Full-depth repair	Crack/Joint Seal
30% Shattered, Medium sev	Rehab/Reconstruct	Full-depth repair
30% Shattered, Hi sev	Full-depth repair	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Full-depth repair	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Rehab/Reconstruct
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Concrete/asphalt overlay	Full-depth repair
50% slabs, Patches Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
10% slabs Fault Low sev	Crack/Joint Seal	Do Nothing
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Crack/Joint Seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal

Table E4. National Category- Wet No Freeze Zone

	National Category- Wet No Freeze Zone	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint Seal
Joint Seal Medium sev	Crack/Joint Seal	Crack/Joint Seal
Joint Seal High sev	Crack/Joint Seal	Crack/Joint Seal
Joint and Corner Spall Lowsev	Crack/Joint Seal	Partial depth repair
Joint and Corner Spall Medium sev	Crack/Joint Seal	Partial depth repair
Joint and Corner Spall High sev	Partial depth repair	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint Seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair	Crack/Joint Seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint Seal	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint Seal	Concrete/asphalt overlay
Mid-Panel Crack, 40% slabs,Med sev	Partial depth repair	Concrete/asphalt overlay
Mid-Panel Crack, 40% slabs, Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint Seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair	Crack/Joint Seal
Corner Brk, 10% slab, Hi sev	Full-depth repair	Full-depth repair
Corner Brk, 30% slab, Low sev	Crack/Joint Seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Crack/Joint Seal	Full-depth repair
Corner Brk, 30% slab, Hi sev	Full-depth repair	Rehab/Reconstruct
10% Shattered, Low sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Medium sev	Crack/Joint Seal	Full-depth repair
10% Shattered, Hi sev	Concrete/asphalt overlay	Full-depth repair
30% Shattered, Low sev	Full-depth repair	Crack/Joint Seal
30% Shattered, Medium sev	Rehab/Reconstruct	Full-depth repair
30% Shattered, Hi sev	Full-depth repair	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Full-depth repair	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Rehab/Reconstruct
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Concrete/asphalt overlay	Full-depth repair
50% slabs, Patches Hi sev	Concrete/asphalt overlay	Rehab/Reconstruct
10% slabs Fault Low sev	Crack/Joint Seal	Do Nothing
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Crack/Joint Seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal

Table E5. Regional Category- Wet Freeze Zone

	Regional Category- Wet Freeze Zone RWF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Do Nothing, or Partial Depth repair	Crack/Joint seal
Joint and Corner Spall Medium sev	Crack/Joint seal	Partial depth repair
Joint and Corner Spall High sev	Partial depth repair	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Full-depth repair (localized)	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs,Med sev	Full-depth repair (localized)	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Hi sev	Partial depth repair	Full-depth repair (localized)
Corner Brk, 10% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
10% Shattered, Low sev	Do Nothing	Crack/Joint seal
10% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
30% Shattered, Low sev	Full-depth repair (localized)	Crack/Joint seal
30% Shattered, Medium sev	Rehab/Reconstruct	Full-depth repair (localized)
30% Shattered, Hi sev	Rehab/Reconstruct	Full-depth repair (localized)
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
10% slabs Fault Low sev	Do Nothing	Crack/Joint seal
10% slabs Fault Med sev	Crack/Joint seal	Grinding/grooving
10% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Low sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Med sev	Crossstitching/dowelbar retrofit	Grinding/grooving
30% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Rehab/Reconstruct

Table E6. Regional Category- Dry Freeze Zone

	Regional Category- Dry Freeze Zone RDF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Crack/Joint seal
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Do Nothing	Crack/Joint seal
Joint and Corner Spall Medium sev	Crack/Joint seal	Partial depth repair
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Partial depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs,Med sev	Partial depth repair, or Full-depth repair (localized)	Rehab/Reconstruct
Mid-Panel Crack, 40% slabs, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Low sev	Do Nothing	Crack/Joint seal
10% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Do Nothing	Full-depth repair (localized)
30% Shattered, Medium sev	Full-depth repair (localized)	Rehab/Reconstruct
30% Shattered, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Full-depth repair (localized)	Do Nothing
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
10% slabs Fault Low sev	Crack/Joint seal	Do Nothing
10% slabs Fault Med sev	Crack/Joint seal	Grinding/grooving
10% slabs Fault Hi sev	Crossstitching/dowelbar retrofit	Slab stabilization/ jacking/underseal
30% slabs Fault Low sev	Grinding/grooving	Do Nothing
30% slabs Fault Med sev	Grinding/grooving	Do Nothing
30% slabs Fault Hi sev	Crossstitching/dowelbar retrofit	Slab stabilization/ jacking/underseal

Table E7. Regional Category- Dry No Freeze Zone

	Regional Category- Dry No Freeze Zone ,RDN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Partial depth repair	Crack/Joint seal
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Partial depth repair, or Full-depth repair (localized)	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Low sev	Do Nothing	Crack/Joint seal
10% Shattered, Medium sev	Full-depth repair (localized)	Full-depth repair (localized)
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Do Nothing	Crack/Joint seal
30% Shattered, Medium sev	Full-depth repair (localized)	Rehab/Reconstruct
30% Shattered, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Partial depth repair	Do Nothing
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Concrete/Asphalt overlay	Rehab/Reconstruct
10% slabs Fault Low sev	Crack/Joint seal	Do Nothing
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/ jacking/underseal
30% slabs Fault Low sev	Crack/Joint seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Rehab/Reconstruct	Slab stabilization/ jacking/underseal

Table E8. Regional Category- Wet No Freeze Zone

	Regional Category- Wet No Freeze Zone ,RWN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Crack/Joint seal	Do Nothing
Joint Seal Low sev	Crack/Joint seal	Do Nothing
Joint Seal Medium sev	Crack/Joint seal	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint seal	Partial Depth repair
Joint and Corner Spall High sev	Partial Depth repair	Partial Depth repair
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Do Nothing	Full-depth repair (localized)
Mid-Panel Crack, 20% slabs, Hi sev	Partial Depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Partial Depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs,Med sev	Partial Depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Hi sev	Full-depth repair (localized)	Concrete/Asphalt overlay
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	full-depth repair (localized) or Rehab/Reconstruct
10% Shattered, Low sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Medium sev	Full-depth repair (localized)	Full-depth repair (localized)
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Crack/Joint seal	Full-depth repair (localized)
30% Shattered, Medium sev	Full-depth repair (localized)	Rehab/Reconstruct
30% Shattered, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Crack/Joint seal	Do Nothing, or Partial Depth repair
30% slabs, Patches Hi sev	Partial Depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Concrete/Asphalt overlay	Full-depth repair (localized)
50% slabs, Patches Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
10% slabs Fault Low sev	Crack/Joint seal	Do Nothing
10% slabs Fault Med sev	Crack/Joint seal	Slab stabilization/jacking/underseal
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Slab stabilization/jacking/underseal	Do Nothing
30% slabs Fault Med sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Rehab/Reconstruct

Table E9. Local Category- Wet Freeze Zone

	Local Category- Wet Freeze Zone ,LWF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Partial depth repair, or Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Partial depth repair	Crack/Joint seal
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Hi sev	Full-depth repair (localized)	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs,Med sev	Concrete/Asphalt overlay, or Partial Depth repair	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Hi sev	Full-depth repair (localized)	Partial depth repair
Corner Brk, 10% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing, or Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
10% Shattered, Low sev	Do Nothing	Crack/Joint seal
10% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Do Nothing	Crack/Joint seal
30% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
30% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
10% slabs Fault Low sev	Do Nothing	Do Nothing
10% slabs Fault Med sev	Do Nothing	Slab stabilization/ jacking/underseal
10% slabs Fault Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% slabs Fault Low sev	Do Nothing	Do Nothing
30% slabs Fault Med sev	Do Nothing	Slab stabilization/ jacking/underseal
30% slabs Fault Hi sev	Full-depth repair (localized)	Rehab/Reconstruct

Table E10. Local Category- Dry Freeze Zone

	Local Category- Dry Freeze Zone ,LDF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Partial depth repair, or Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint seal	Partial depth repair
Joint and Corner Spall High sev	Partial Depth repair	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Partial depth repair, or Full-depth repair (localized)	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Concrete/Asphalt overlay	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Partial depth repair	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
10% Shattered, Low sev	Crack/Joint seal	Do Nothing
10% Shattered, Medium sev	Crack/Joint seal	Do Nothing
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Crack/Joint seal	Do Nothing
30% Shattered, Medium sev	Concrete/Asphalt overlay	Full-depth repair (localized)
30% Shattered, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial Depth repair
30% slabs, Patches Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Concrete/Asphalt overlay
50% slabs, Patches Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
10% slabs Fault Low sev	Crack/Joint seal	Do Nothing
10% slabs Fault Med sev	Grinding/grooving	Partial depth repair
10% slabs Fault Hi sev	Concrete/Asphalt overlay	Partial depth repair
30% slabs Fault Low sev	Full-depth repair (localized)	Do Nothing
30% slabs Fault Med sev	Concrete/Asphalt overlay, or Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Concrete/Asphalt overlay, or Slab stabilization/jacking/underseal, or Grind/Groove	Rehab/Reconstruct

Table E11. Local Category- Dry No Freeze Zone

	Local Category- Dry No Freeze Zone ,LDN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Partial depth repair, or Do Nothing	Crack/Joint seal
Joint and Corner Spall Medium sev	Crack/Joint seal, or Do Nothing	Partial depth repair
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs,Med sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Hi sev	Crack/Joint seal	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Full-depth repair, or Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
10% Shattered, Low sev	Do Nothing	Crack/Joint seal
10% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
30% Shattered, Low sev	Do Nothing	Crack/Joint seal
30% Shattered, Medium sev	Full-depth repair, or Rehab/Reconstruct	Concrete/Asphalt overlay
30% Shattered, Hi sev	Concrete/Asphalt overlay	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Concrete/Asphalt overlay	Do Nothing
50% slabs, Patches Med sev	Concrete/Asphalt overlay, or Partial Depth repair	Full-depth repair (localized)
50% slabs, Patches Hi sev	Rehab/Reconstruct	Concrete/Asphalt overlay
10% slabs Fault Low sev	Crack/Joint seal	Do Nothing
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Do Nothing
10% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Crossstitching/dowelbar retrofit
30% slabs Fault Low sev	Full-depth repair (localized)	Do Nothing
30% slabs Fault Med sev	Grinding/grooving	Concrete/Asphalt overlay
30% slabs Fault Hi sev	Concrete/Asphalt overlay	Rehab/Reconstruct

Table E12. Local Category- Wet No Freeze Zone

	Local Category- Wet No Freeze Zone ,LWN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Crack/Joint seal	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint seal, or Do Nothing	Partial depth repair
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs,Med sev	Partial Depth repair	Crack/Joint seal
Mid-Panel Crack, 40% slabs, Hi sev	Crack/Joint seal	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Full-depth repair (localized)	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Full-depth repair, or Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	Rehab/Reconstruct
10% Shattered, Low sev	Full-depth repair, or Do Nothing	Crack/Joint seal
10% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
30% Shattered, Low sev	Do Nothing	Crack/Joint seal
30% Shattered, Medium sev	Rehab/Reconstruct	Full-depth repair (localized)
30% Shattered, Hi sev	Concrete/Asphalt overlay	Rehab/Reconstruct
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Partial depth repair, or Do Nothing	Do Nothing
30% slabs, Patches Hi sev	Partial depth repair, or Do Nothing	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Concrete/Asphalt overlay, or Do Nothing	Partial depth repair
50% slabs, Patches Hi sev	Rehab/Reconstruct	Concrete/Asphalt overlay
10% slabs Fault Low sev	Do Nothing	Partial depth repair
10% slabs Fault Med sev	Slab stabilization/jacking/underseal, or Do Nothing	Partial depth repair
10% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Crossstitching/dowelbar retrofit
30% slabs Fault Low sev	Full-depth repair (localized)	Concrete/Asphalt overlay
30% slabs Fault Med sev	Rehab/Reconstruct	Concrete/Asphalt overlay
30% slabs Fault Hi sev	Concrete/Asphalt overlay	Rehab/Reconstruct

Table E13. Basic Category- Wet Freeze Zone

	Basic Category- Wet Freeze Zone ,BWF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Do Nothing
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint seal	Do Nothing
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Hi sev	Partial depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Crack/Joint seal	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Hi sev	Rehab/Reconstruct	Full-depth repair (localized)
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Full-depth repair	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Low sev	Crack/Joint seal	Do Nothing
10% Shattered, Medium sev	Full-depth repair (localized)	Crack/Joint seal
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Crack/Joint seal	Do Nothing
30% Shattered, Medium sev	Full-depth repair (localized)	Crack/Joint seal
30% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Full-depth repair (localized)	Partial depth repair
10% slabs Fault Low sev	Do Nothing	Do Nothing
10% slabs Fault Med sev	Do Nothing	Crack/Joint seal
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Crack/Joint seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Grinding/grooving	Rehab/Reconstruct

Table E14. Basic Category- Dry Freeze Zone

	Basic Category- Dry Freeze Zone BDF	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Do Nothing
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint seal	Do Nothing
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Hi sev	Partial depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Crack/Joint seal	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Hi sev	Rehab/Reconstruct	Full-depth repair (localized)
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Full-depth repair	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Low sev	Crack/Joint seal	Do Nothing
10% Shattered, Medium sev	Full-depth repair (localized)	Crack/Joint seal
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Crack/Joint seal	Do Nothing
30% Shattered, Medium sev	Full-depth repair (localized)	Crack/Joint seal
30% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Full-depth repair (localized)	Partial depth repair
10% slabs Fault Low sev	Do Nothing	Do Nothing
10% slabs Fault Med sev	Do Nothing	Crack/Joint seal
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Crack/Joint seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Grinding/grooving	Rehab/Reconstruct

Table E15. Basic Category- Dry No Freeze Zone

	Basic Category- Dry No Freeze Zone BDN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Do Nothing
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Crack/Joint seal	Do Nothing
Joint and Corner Spall Medium sev	Crack/Joint seal	Do Nothing
Joint and Corner Spall High sev	Crack/Joint seal	Partial depth repair
Mid-Panel Crack, 20% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Med sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 20% slabs, Hi sev	Partial depth repair	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Crack/Joint seal	Do Nothing
Mid-Panel Crack, 40% slabs,Med sev	Crack/Joint seal	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Hi sev	Rehab/Reconstruct	Full-depth repair (localized)
Corner Brk, 10% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 10% slab, Medium sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Crack/Joint seal	Do Nothing
Corner Brk, 30% slab, Medium sev	Full-depth repair	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Low sev	Crack/Joint seal	Do Nothing
10% Shattered, Medium sev	Full-depth repair (localized)	Crack/Joint seal
10% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% Shattered, Low sev	Crack/Joint seal	Do Nothing
30% Shattered, Medium sev	Full-depth repair (localized)	Crack/Joint seal
30% Shattered, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Full-depth repair (localized)	Partial depth repair
50% slabs, Patches Hi sev	Full-depth repair (localized)	Partial depth repair
10% slabs Fault Low sev	Do Nothing	Do Nothing
10% slabs Fault Med sev	Do Nothing	Crack/Joint seal
10% slabs Fault Hi sev	Grinding/grooving	Slab stabilization/jacking/underseal
30% slabs Fault Low sev	Crack/Joint seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Hi sev	Grinding/grooving	Rehab/Reconstruct

Table E16. Basic Category- Wet No Freeze Zone

	Basic Category- Wet No Freeze Zone ,BWN	
Ques	Accept	Best
Joint seal 5 years, still GOOD	Do Nothing	Do Nothing
Joint Seal Low sev	Do Nothing	Crack/Joint seal
Joint Seal Medium sev	Do Nothing	Crack/Joint seal
Joint Seal High sev	Crack/Joint seal	Crack/Joint seal
Joint and Corner Spall Lowsev	Do Nothing	Crack/Joint seal
Joint and Corner Spall Medium sev	Do Nothing	Crack/Joint seal
Joint and Corner Spall High sev	Partial depth repair	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Med sev	Crack/Joint seal	Crack/Joint seal
Mid-Panel Crack, 20% slabs, Hi sev	Crack/Joint seal	Full-depth repair (localized)
Mid-Panel Crack, 40% slabs, Low sev	Do Nothing	Crack/Joint seal
Mid-Panel Crack, 40% slabs,Medsev	Crack/Joint seal, or Full-depth repair	Rehab/Reconstruct
Mid-Panel Crack, 40% slabs, Hi sev	Full-depth repair	Rehab/Reconstruct
Corner Brk, 10% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Medium sev	Do Nothing	Crack/Joint seal
Corner Brk, 10% slab, Hi sev	Crack/Joint seal	Full-depth repair (localized)
Corner Brk, 30% slab, Low sev	Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Medium sev	Full-depth repair, or Do Nothing	Crack/Joint seal
Corner Brk, 30% slab, Hi sev	Full-depth repair (localized)	Full-depth repair (localized)
10% Shattered, Low sev	Crack/Joint seal	Crack/Joint seal
10% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
10% Shattered, Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
30% Shattered, Low sev	Do Nothing	Crack/Joint seal
30% Shattered, Medium sev	Crack/Joint seal	Full-depth repair (localized)
30% Shattered, Hi sev	Concrete/Asphalt overlay	Full-depth repair (localized)
30% slabs, Patches Low sev	Do Nothing	Do Nothing
30% slabs, Patches Med sev	Do Nothing	Partial depth repair
30% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Low sev	Do Nothing	Do Nothing
50% slabs, Patches Med sev	Partial depth repair	Full-depth repair (localized)
50% slabs, Patches Hi sev	Partial depth repair	Full-depth repair (localized)
10% slabs Fault Low sev	Do Nothing	Crack/Joint seal
10% slabs Fault Med sev	Slab stabilization/jacking/underseal	Crack/Joint seal
10% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Grinding/grooving
30% slabs Fault Low sev	Slab stabilization/jacking/underseal, or Crack/Joint seal	Do Nothing
30% slabs Fault Med sev	Slab stabilization/jacking/underseal, or Crack/Joint seal	Grinding/grooving
30% slabs Fault Hi sev	Slab stabilization/jacking/underseal	Grinding/grooving

APPENDIX F – ASPHALT PAVEMENT REPAIR QUANTITIES AND COST TABLES

Table F-1. Repair Quantities and Costs for Crack Seal/Fill.

Distress Description	DC	Sev	Quan	Cost	LF	$/LF	Basis for Quantities
Starting to weather	57	L	5000				Not used
Definitely Weathering	57	M	5000				
Starting to ravel	52	L	5000				
Definitely raveling	52	M	5000				
Few longitudinal cracks, Low	48	L	150	$75	150	$0.50	Cracks sealed
Few longitudinal cracks, Medium	48	M	150	$113	150	$0.75	
A few longitudinal cracks, High	48	H	150	$150	150	$1.00	
Many longitudinal cracks, Low	48	L	400	$200	400	$0.50	Cracks sealed
Many longitudinal cracks, Medium	48	M	400	$300	400	$0.75	
Many longitudinal cracks, High	48	H	400	$400	400	$1.00	
Few edge cracks, Low	48	L	150	$75	150	$0.50	Cracks sealed
Few edge cracks, Medium	48	M	150	$113	150	$0.75	
Few edge cracks, High	48	H	150	$150	150	$1.00	
Transverse cracks, 50 ft apart, Low	48	L	100	$50	100	$0.50	2 cracks @ 50 foot
Transverse cracks, 50 ft apart, Medium	48	M	100	$75	100	$0.75	
Transverse cracks, 50 ft apart, High	48	H	100	$100	100	$1.00	
Transverse cracks, 20 ft apart, Low	48	L	500	$125	250	$0.50	5 cracks @ 50 foot
Transverse cracks, 20 ft apart, Medium	48	M	500	$188	250	$0.75	
Transverse cracks, 20 ft apart, High	48	H	500	$250	250	$1.00	
Block cracking Low	43	L	5000	$625	1250	$0.50	6 long cracks@100, 13 trans@50, based on 7.5x7.5 block
Block cracking Medium	43	M	5000	$938	1250	$0.75	
Block cracking High	43	H	5000	$1,250	1250	$1.00	
Reflection cracking Low	47	L	200	$100	200	$0.50	Cracks sealed
Reflection cracking Medium	47	M	200	$150	200	$0.75	
Reflection cracking High	47	H	200	$200	200	$1.00	
Fatigue crack, 10% of area, Low	41	L	500	$250	500	$0.50	Cracks sealed
Fatigue crack, 10% of area, Medium	41	M	500	$750	1000	$0.75	
Fatigue crack, 10% of area, High	41	H	500	$2,000	2000	$1.00	
Fatigue crack, 30% of area, Low	41	L	1500				Not used
Fatigue crack, 30% of area, Medium	41	M	1500				
Fatigue crack, 30% of area, High	41	H	1500				
Patching, 10% area, Low	50	L	500	$200	400	$0.50	500 sf =20@ 5'x5' =400 lf perimeter
Patching, 10% area, Medium	50	M	500	$300	400	$0.75	
Patching, 10% area, High	50	H	500				
Patching, 30% area, Low	50	L	1500	$600	1200	$0.50	3 times 10% amount
Patching, 30% area, Medium	50	M	1500				Not used
Patching, 30% area, High	50	H	1500				
Rough, Long wave swells	56	M	1000				
Rough, Many long wave swells	56	M	3000				
Rough, Many short wave bumps	44	M	2500				

Table F-2. Repair Quantities and Costs for Rejuvenator.

Distress Description	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Starting to weather	57	L	5000	$206	556	$0.37	Whole area
Definitely Weathering	57	M	5000	$206	556	$0.37	
Starting to ravel	52	L	5000	$206	556	$0.37	
Definitely raveling	52	M	5000				Not used
Few longitudinal cracks, Low	48	L	150	$206	556	$0.37	Whole area
Few longitudinal cracks, Medium	48	M	150				Not used
A few longitudinal cracks, High	48	H	150				
Many longitudinal cracks, Low	48	L	400	$206	556	$0.37	Whole area
Many longitudinal cracks, Medium	48	M	400				Not used
Many longitudinal cracks, High	48	H	400				
Few edge cracks, Low	48	L	150	$206	556	$0.37	Whole area
Few edge cracks, Medium	48	M	150				Not used
Few edge cracks, High	48	H	150	$206	556	$0.37	Whole area
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100	$206	556	$0.37	Whole area
Transverse cracks, 50 ft apart, High	48	H	100				Not used
Transverse cracks, 20 ft apart, Low	48	L	500				Not used
Transverse cracks, 20 ft apart, Medium	48	M	500				
Transverse cracks, 20 ft apart, High	48	H	500				
Block cracking Low	43	L	5000				Not used
Block cracking Medium	43	M	5000	$206	556	$0.37	Whole area
Block cracking High	43	H	5000				Not used
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200				
Reflection cracking High	47	H	200				
Fatigue crack, 10% of area, Low	41	L	500	$206	556	$0.37	Whole area
Fatigue crack, 10% of area, Medium	41	M	500	$206	556	$0.37	
Fatigue crack, 10% of area, High	41	H	500	$206	556	$0.37	
Fatigue crack, 30% of area, Low	41	L	1500	$206	556	$0.37	Whole area
Fatigue crack, 30% of area, Medium	41	M	1500				Not used
Fatigue crack, 30% of area, High	41	H	1500				
Patching, 10% area, Low	50	L	500				Not used
Patching, 10% area, Medium	50	M	500				
Patching, 10% area, High	50	H	500				
Patching, 30% area, Low	50	L	1500				Not used
Patching, 30% area, Medium	50	M	1500				
Patching, 30% area, High	50	H	1500				
Rough, Long wave swells	56	M	1000				Not used
Rough, Many long wave swells	56	M	3000				
Rough, Many short wave bumps	44	M	2500				

Table F-3. Repair Quantities and Costs for Fog/Coal Tar Seal.

Distress Description	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Starting to weather	57	L	5000	$206	556	$0.37	Whole area
Definitely Weathering	57	M	5000	$206	556	$0.37	
Starting to ravel	52	L	5000	$206	556	$0.37	
Definitely raveling	52	M	5000	$206	556	$0.37	
Few longitudinal cracks, Low	48	L	150				Not used
Few longitudinal cracks, Medium	48	M	150				
A few longitudinal cracks, High	48	H	150				
Many longitudinal cracks, Low	48	L	400	$206	556	$0.37	Whole area
Many longitudinal cracks, Medium	48	M	400	$206	556	$0.37	
Many longitudinal cracks, High	48	H	400				Not used
Few edge cracks, Low	48	L	150	$206	556	$0.37	Whole area
Few edge cracks, Medium	48	M	150				Not used
Few edge cracks, High	48	H	150				
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100	$206	556	$0.37	Whole area
Transverse cracks, 50 ft apart, High	48	H	100				Not used
Transverse cracks, 20 ft apart, Low	48	L	500	$206	556	$0.37	Whole area
Transverse cracks, 20 ft apart, Medium	48	M	500				Not used
Transverse cracks, 20 ft apart, High	48	H	500				
Block cracking Low	43	L	5000	$206	556	$0.37	Whole area
Block cracking Medium	43	M	5000				Not used
Block cracking High	43	H	5000				
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200				
Reflection cracking High	47	H	200				
Fatigue crack, 10% of area, Low	41	L	500	$206	556	$0.37	Whole area
Fatigue crack, 10% of area, Medium	41	M	500	$206	556	$0.37	
Fatigue crack, 10% of area, High	41	H	500				Not used
Fatigue crack, 30% of area, Low	41	L	1500	$206	556	$0.37	Whole area
Fatigue crack, 30% of area, Medium	41	M	1500				Not used
Fatigue crack, 30% of area, High	41	H	1500				
Patching, 10% area, Low	50	L	500				Not used
Patching, 10% area, Medium	50	M	500	$206	556	$0.37	Whole area
Patching, 10% area, High	50	H	500	$206	556	$0.37	
Patching, 30% area, Low	50	L	1500	$206	556	$0.37	Whole area
Patching, 30% area, Medium	50	M	1500	$206	556	$0.37	
Patching, 30% area, High	50	H	1500				Not used
Rough, Long wave swells	56	M	1000				Not used
Rough, Many long wave swells	56	M	3000				
Rough, Many short wave bumps	44	M	2500				

Table F-4. Repair Quantities and Costs for Slurry/Micro.

Distress Description	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Starting to weather	57	L	5000	$1,111	556	$2.00	Whole area
Definitely Weathering	57	M	5000	$1,389	556	$2.50	
Starting to ravel	52	L	5000	$1,111	556	$2.00	
Definitely raveling	52	M	5000	$1,389	556	$2.50	
Few longitudinal cracks, Low	48	L	150				Not used
Few longitudinal cracks, Medium	48	M	150				
A few longitudinal cracks, High	48	H	150				
Many longitudinal cracks, Low	48	L	400				Not used
Many longitudinal cracks, Medium	48	M	400	$1,389	556	$2.50	Whole area
Many longitudinal cracks, High	48	H	400				Not used
Few edge cracks, Low	48	L	150				Not used
Few edge cracks, Medium	48	M	150				
Few edge cracks, High	48	H	150				
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100				
Transverse cracks, 50 ft apart, High	48	H	100				
Transverse cracks, 20 ft apart, Low	48	L	500				Not used
Transverse cracks, 20 ft apart, Medium	48	M	500				
Transverse cracks, 20 ft apart, High	48	H	500				
Block cracking Low	43	L	5000				Not used
Block cracking Medium	43	M	5000				
Block cracking High	43	H	5000				
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200				
Reflection cracking High	47	H	200				
Fatigue crack, 10% of area, Low	41	L	500				Not used
Fatigue crack, 10% of area, Medium	41	M	500				
Fatigue crack, 10% of area, High	41	H	500				
Fatigue crack, 30% of area, Low	41	L	1500				Not used
Fatigue crack, 30% of area, Medium	41	M	1500				
Fatigue crack, 30% of area, High	41	H	1500				
Patching, 10% area, Low	50	L	500				Not used
Patching, 10% area, Medium	50	M	500	$1,389	556	$2.50	Whole area
Patching, 10% area, High	50	H	500	$1,667	556	$3.00	
Patching, 30% area, Low	50	L	1500	$1,111	556	$2.00	Whole area
Patching, 30% area, Medium	50	M	1500	$1,389	556	$2.50	
Patching, 30% area, High	50	H	1500	$1,667	556	$3.00	
Rough, Long wave swells	56	M	1000				Not used
Rough, Many long wave swells	56	M	3000				
Rough, Many short wave bumps	44	M	2500				

Table F-5. Repair Quantities and Costs for Chip/Cape Seal.

Distress Description	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Starting to weather	57	L	5000	$1,389	556	$2.50	Whole area
Definitely Weathering	57	M	5000	$1,528	556	$2.75	
Starting to ravel	52	L	5000	$1,389	556	$2.50	
Definitely raveling	52	M	5000	$1,528	556	$2.75	
Few longitudinal cracks, Low	48	L	150				Not used
Few longitudinal cracks, Medium	48	M	150				
A few longitudinal cracks, High	48	H	150				
Many longitudinal cracks, Low	48	L	400	$1,389	556	$2.50	Whole area
Many longitudinal cracks, Medium	48	M	400	$1,528	556	$2.75	
Many longitudinal cracks, High	48	H	400				Not used
Few edge cracks, Low	48	L	150				Not used
Few edge cracks, Medium	48	M	150				
Few edge cracks, High	48	H	150				
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100				
Transverse cracks, 50 ft apart, High	48	H	100				
Transverse cracks, 20 ft apart, Low	48	L	500				Not used
Transverse cracks, 20 ft apart, Medium	48	M	500	$1,528	556	$2.75	Whole area
Transverse cracks, 20 ft apart, High	48	H	500	$1,667	556	$3.00	
Block cracking Low	43	L	5000	$1,389	556	$2.50	Whole area
Block cracking Medium	43	M	5000	$1,528	556	$2.75	
Block cracking High	43	H	5000	$1,667	556	$3.00	
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200	$1,528	556	$2.75	Whole area
Reflection cracking High	47	H	200				Not used
Fatigue crack, 10% of area, Low	41	L	500				Not used
Fatigue crack, 10% of area, Medium	41	M	500	$1,528	556	$2.75	Whole area
Fatigue crack, 10% of area, High	41	H	500	$1,667	556	$3.00	
Fatigue crack, 30% of area, Low	41	L	1500	$1,389	556	$2.50	Whole area
Fatigue crack, 30% of area, Medium	41	M	1500	$1,528	556	$2.75	
Fatigue crack, 30% of area, High	41	H	1500				Not used
Patching, 10% area, Low	50	L	500				
Patching, 10% area, Medium	50	M	500				
Patching, 10% area, High	50	H	500	$1,667	556	$3.00	Whole area
Patching, 30% area, Low	50	L	1500	$1,389	556	$2.50	Whole area
Patching, 30% area, Medium	50	M	1500	$1,528	556	$2.75	
Patching, 30% area, High	50	H	1500	$1,667	556	$3.00	
Rough, Long wave swells	56	M	1000				Not used
Rough, Many long wave swells	56	M	3000				
Rough, Many short wave bumps	44	M	2500				

Table F-6. Repair Quantities and Costs for Overlay/Mill+Overlay.

Distress Description	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Starting to weather	57	L	5000				Not used
Definitely Weathering	57	M	5000				
Starting to ravel	52	L	5000	$1,944	556	$3.50	Whole area
Definitely raveling	52	M	5000	$2,222	556	$4.00	
Few longitudinal cracks, Low	48	L	150				Not used
Few longitudinal cracks, Medium	48	M	150				
A few longitudinal cracks, High	48	H	150	$2,500	556	$4.50	Whole area
Many longitudinal cracks, Low	48	L	400	$3,611	556	$6.50	Whole area
Many longitudinal cracks, Medium	48	M	400	$4,167	556	$7.50	
Many longitudinal cracks, High	48	H	400	$4,722	556	$8.50	
Few edge cracks, Low	48	L	150				Not used
Few edge cracks, Medium	48	M	150	$2,222	556	$4.00	Whole area
Few edge cracks, High	48	H	150	$2,500	556	$4.50	
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100	$2,222	556	$4.00	Whole area
Transverse cracks, 50 ft apart, High	48	H	100	$2,500	556	$4.50	
Transverse cracks, 20 ft apart, Low	48	L	500				Not used
Transverse cracks, 20 ft apart, Medium	48	M	500	$4,167	556	$7.50	Whole area
Transverse cracks, 20 ft apart, High	48	H	500	$4,722	556	$8.50	
Block cracking Low	43	L	5000				Not used
Block cracking Medium	43	M	5000	$4,167	556	$7.50	Whole area
Block cracking High	43	H	5000	$4,722	556	$8.50	
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200	$4,167	556	$7.50	Whole area
Reflection cracking High	47	H	200	$4,722	556	$8.50	
Fatigue crack, 10% of area, Low	41	L	500				Not used
Fatigue crack, 10% of area, Medium	41	M	500				
Fatigue crack, 10% of area, High	41	H	500	$2,500	556	$4.50	Whole area
Fatigue crack, 30% of area, Low	41	L	1500	$1,944	556	$3.50	Whole area
Fatigue crack, 30% of area, Medium	41	M	1500	$2,222	556	$4.00	
Fatigue crack, 30% of area, High	41	H	1500	$2,500	556	$4.50	
Patching, 10% area, Low	50	L	500				Not used
Patching, 10% area, Medium	50	M	500				
Patching, 10% area, High	50	H	500	$2,500	556	$4.50	Whole area
Patching, 30% area, Low	50	L	1500	$1,944	556	$3.50	Whole area
Patching, 30% area, Medium	50	M	1500	$2,222	556	$4.00	
Patching, 30% area, High	50	H	1500	$2,500	556	$4.50	
Rough, Long wave swells	56	M	1000	$4,167	556	$7.50	Whole area
Rough, Many long wave swells	56	M	3000	$4,167	556	$7.50	
Rough, Many short wave bumps	44	M	2500	$4,167	556	$7.50	

Table F-7. Repair Quantities and Costs for Patch/Reconstruct Area.

Distress Description	DC	Sev	Quan	Cost	SF	$/SF	Basis for Quantities
Starting to weather	57	L	5000				Not used
Definitely Weathering	57	M	5000				
Starting to ravel	52	L	5000				
Definitely raveling	52	M	5000				
Few longitudinal cracks, Low	48	L	150				Not used
Few longitudinal cracks, Medium	48	M	150				
A few longitudinal cracks, High	48	H	150	$7,500	150	$50	1’x150’=150SF
Many longitudinal cracks, Low	48	L	400				Not used
Many longitudinal cracks, Medium	48	M	400	$20,000	400	$50	1’x400’=400SF
Many longitudinal cracks, High	48	H	400	$20,000	400	$50	
Few edge cracks, Low	48	L	150				Not used
Few edge cracks, Medium	48	M	150	$7,500	150	$50	1’x150’=150SF
Few edge cracks, High	48	H	150	$7,500	150	$50	
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100				
Transverse cracks, 50 ft apart, High	48	H	100	$5,000	100	$50	2 cracks @ 50 footx1’=100SF
Transverse cracks, 20 ft apart, Low	48	L	500				Not used
Transverse cracks, 20 ft apart, Medium	48	M	500				
Transverse cracks, 20 ft apart, High	48	H	500				
Block cracking Low	43	L	5000				Not used
Block cracking Medium	43	M	5000				
Block cracking High	43	H	5000	$62,500	1250	$50	6 long cracks@100, 13 trans@ 50, based on 7.5x7.5 blockx1SF
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200				
Reflection cracking High	47	H	200	$10,000	200	$50	1’x200’=200SF
Fatigue crack, 10% of area, Low	41	L	500	$25,000	500	$50	500SF
Fatigue crack, 10% of area, Medium	41	M	500	$25,000	500	$50	
Fatigue crack, 10% of area, High	41	H	500	$25,000	500	$50	
Fatigue crack, 30% of area, Low	41	L	1500	$75,000	1500	$50	1500SF
Fatigue crack, 30% of area, Medium	41	M	1500	$75,000	1500	$50	
Fatigue crack, 30% of area, High	41	H	1500	$75,000	1500	$50	
Patching, 10% area, Low	50	L	500				Not used
Patching, 10% area, Medium	50	M	500	$25,000	500	$50	500SF
Patching, 10% area, High	50	H	500	$25,000	500	$50	
Patching, 30% area, Low	50	L	1500				Not used
Patching, 30% area, Medium	50	M	1500	$75,000	1500	$50	1500SF
Patching, 30% area, High	50	H	1500	$75,000	1500	$50	
Rough, Long wave swells	56	M	1000	$50,000	1000	$50	1000SF
Rough, Many long wave swells	56	M	3000	$150,000	3000	$50	3000SF
Rough, Many short wave bumps	44	M	2500	$125,000	2500	$50	2500SF

Table F-8. Repair Quantities and Costs for Rehab/Reconstruct Area.

Distress Description	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Starting to weather	57	L	5000				Not used
Definitely Weathering	57	M	5000				
Starting to ravel	52	L	5000				
Definitely raveling	52	M	5000				
Few longitudinal cracks, Low	48	L	150				Not used
Few longitudinal cracks, Medium	48	M	150				
A few longitudinal cracks, High	48	H	150	$41,670	556	$75	Whole area
Many longitudinal cracks, Low	48	L	400				Not used
Many longitudinal cracks, Medium	48	M	400				
Many longitudinal cracks, High	48	H	400	$41,670	556	$75	Whole area
Few edge cracks, Low	48	L	150				Not used
Few edge cracks, Medium	48	M	150				
Few edge cracks, High	48	H	150				
Transverse cracks, 50 ft apart, Low	48	L	100				Not used
Transverse cracks, 50 ft apart, Medium	48	M	100				
Transverse cracks, 50 ft apart, High	48	H	100				
Transverse cracks, 20 ft apart, Low	48	L	500				Not used
Transverse cracks, 20 ft apart, Medium	48	M	500				
Transverse cracks, 20 ft apart, High	48	H	500				
Block cracking Low	43	L	5000				Not used
Block cracking Medium	43	M	5000				
Block cracking High	43	H	5000	$41,670	556	$75	Whole area
Reflection cracking Low	47	L	200				Not used
Reflection cracking Medium	47	M	200				
Reflection cracking High	47	H	200	$41,670	556	$75	Whole area
Fatigue crack, 10% of area, Low	41	L	500				Not used
Fatigue crack, 10% of area, Medium	41	M	500				
Fatigue crack, 10% of area, High	41	H	500	$41,670	556	$75	Whole area
Fatigue crack, 30% of area, Low	41	L	1500	$41,670	556	$75	Whole area
Fatigue crack, 30% of area, Medium	41	M	1500	$41,670	556	$75	
Fatigue crack, 30% of area, High	41	H	1500	$41,670	556	$75	
Patching, 10% area, Low	50	L	500				Not used
Patching, 10% area, Medium	50	M	500				
Patching, 10% area, High	50	H	500				
Patching, 30% area, Low	50	L	1500				Not used
Patching, 30% area, Medium	50	M	1500	$41,670	556	$75	Whole area
Patching, 30% area, High	50	H	1500	$41,670	556	$75	
Rough, Long wave swells	56	M	1000				Not used
Rough, Many long wave swells	56	M	3000	$41,670	556	$75	Whole area
Rough, Many short wave bumps	44	M	2500				Not used

APPENDIX G – CONCRETE PAVEMENT REPAIR QUANTITIES AND COST TABLES

Table G-1. Repair Quantities and Costs for Crack Seal/Fill.

Distress	DC	Sev	Quan	Cost	LF	$/LF	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-	$1,200	800	$1.50	'20x20 slabs, Jt length = 4x100 + 5x80=800LF
Joint seal damage Low sev	65	L	20	$1,200	800	$1.50	
Joint seal damage Medium sev	65	M	20	$1,400	800	$1.75	
Joint seal damage High sev	65	H	20	$1,600	800	$2.00	
Joint/corner spall Low sev	74	L	5	$15	10	$1.50	5sl@2'/spall=10LF
Joint/corner spall Medium sev	74	M	5	$26	15	$1.75	5sl@3'/spall=15LF
Joint/corner spall High sev	74	H	5	$50	25	$2.00	5sl@5'/spall=25LF
Mid-panel crack 20% slabs Low sev	63	L	4	$120	80	$1.50	4sl@20'=80LF
Mid-panel crack 20% slabs Medium sev	63	M	4	$140	80	$1.75	
Mid-panel crack 20% slab High sev	63	H	4	$160	80	$2.00	
Mid-panel crack 40% slab Low sev	63	L	8	$240	160	$1.50	8sl@20'=160LF
Mid-panel crack 40% slabs Medium sev	63	M	8	$280	160	$1.75	
Mid-panel crack 40% slab High sev	63	H	8	$320	160	$2.00	
Corner break 10% slabs Low sev	62	L	2	$30	20	$1.50	2sl@(5'+5')=20LF
Corner break 10% slabs Medium sev	62	M	2	$35	20	$1.75	
Corner break 10% slabs High sev	62	H	2	$40	20	$2.00	
Corner break 30% slabs Low sev	62	L	6	$90	60	$1.50	6sl@(5'+5')=60LF
Corner break 30% slabs Medium sev	62	M	6	$105	60	$1.75	
Corner break 30% slabs High sev	62	H	6	$120	60	$2.00	
10% Shatter slab Low sev	72	L	2	$120	80	$1.50	2sl@(20'+20')=80LF
10% Shatter slab Medium sev	72	M	2	$210	120	$1.75	2sl@(20'+20+20')=120LF
10% Shatter slab High sev	72	H	2				Not used
30% Shatter slab Low sev	72	L	6	$360	240	$1.50	6sl@(20'+20')=240LF
30% Shatter slab Medium sev	72	M	6	$630	360	$1.75	6sl@(20'+20+20')=360LF
30% Shatter slab High sev	72	H	6				Not used
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6	$105	60	$1.75	6sl@(5'+5')=60LF
30% Patch High sev	67	H	6				Not used
50% Patch Low sev	67	L	10				Not used
50% Patch Medium sev	67	M	10				
50% Patch High sev	67	H	10				
10% slabs Fault Low sev	71	L	2	$60	40	$1.50	2sl@20'=40LF
10% slabs Fault Medium sev	71	M	2	$70	40	$1.75	
10% slabs Fault High sev	71	H	2				Not used
30% slabs Fault Low sev	71	L	6	$210	120	$1.75	
30% slabs Fault Medium sev	71	M	6				Not used
30% slabs Fault High sev	71	H	6				

Table G-2. Repair Quantities and Costs for Partial Depth Repair.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				
Joint seal damage Low sev	65	L	20				Not used
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5	$60	0.6	$100	5sl@2'x6"=5sf /9sf/sy=0.6SY
Joint/corner spall Medium sev	74	M	5	$80	0.8	$100	5sl@3'x6"=7.5sf/9sf/sy=0.8SY
Joint/corner spall High sev	74	H	5	$280	2.8	$100	5sl@5'x1"=25sf/9sf/sy=2.8SY
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4	$889	8.9	$100	
Mid-panel crack 20% slab High sev	63	H	4	$889	8.9	$100	4sl@20'x1'/9sf/sy=8.88SY
Mid-panel crack 40% slab Low sev	63	L	8	$889	8.9	$100	
Mid-panel crack 40% slabs Medium sev	63	M	8	$1,778	17.8	$100	8sl@20'x1'/9sf/sy=17.8SY
Mid-panel crack 40% slab High sev	63	H	8	$1,778	17.8	$100	
Corner break 10% slabs Low sev	62	L	2				
Corner break 10% slabs Medium sev	62	M	2				Not used
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				
Corner break 30% slabs Medium sev	62	M	6				Not used
Corner break 30% slabs High sev	62	H	6				
10% Shatter slab Low sev	72	L	2				
10% Shatter slab Medium sev	72	M	2				Not used
10% Shatter slab High sev	72	H	2				
30% Shatter slab Low sev	72	L	6				
30% Shatter slab Medium sev	72	M	6				Not used
30% Shatter slab High sev	72	H	6				
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6	$600	6	$100	6sl@(3’x3’)/9sf/sy=6SY
30% Patch High sev	67	H	6	$600	6	$100	
50% Patch Low sev	67	L	10				Not used
50% Patch Medium sev	67	M	10	$1,000	10	$100	10sl@(3’x3’)/9sf/sy=10SY
50% Patch High sev	67	H	10	$1,000	10	$100	
10% slabs Fault Low sev	71	L	2	$444	4.4	$100	
10% slabs Fault Medium sev	71	M	2	$444	4.4	$100	2sl@20’x1’=40sf/9sf/sy=4.4SY
10% slabs Fault High sev	71	H	2	$444	4.4	$100	
30% slabs Fault Low sev	71	L	6	$1,333	13.3	$100	6sl@20’x1’=120sf/9sf/sy=13.3SY
30% slabs Fault Medium sev	71	M	6				Not used
30% slabs Fault High sev	71	H	6				

Table G-3. Repair Quantities and Costs for Full- Depth Repair.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4	$889	8.9	$100	4sl@20'x1'/9sf/sy=8.88SY
Mid-panel crack 20% slab High sev	63	H	4	$889	8.9	$100	
Mid-panel crack 40% slab Low sev	63	L	8	$1,778	17.8	$100	8sl@20'x1'/9sf/sy=17.8SY
Mid-panel crack 40% slabs Medium sev	63	M	8	$1,778	17.8	$100	
Mid-panel crack 40% slab High sev	63	H	8	$1,778	17.8	$100	
Corner break 10% slabs Low sev	62	L	2	$556	5.6	$100	2sl@(5'x5')/9sf/sy=5.56SY
Corner break 10% slabs Medium sev	62	M	2	$556	5.6	$100	
Corner break 10% slabs High sev	62	H	2	$556	5.6	$100	
Corner break 30% slabs Low sev	62	L	6	$1,667	16.7	$100	6sl@(5'x5')/9sf/sy=16.7SY
Corner break 30% slabs Medium sev	62	M	6	$1,667	16.7	$100	
Corner break 30% slabs High sev	62	H	6	$1,667	16.7	$100	
10% Shatter slab Low sev	72	L	2	$8,889	88.9	$100	2sl@(20'x20')/9sf/sy=88.9SY
10% Shatter slab Medium sev	72	M	2	$8,889	88.9	$100	
10% Shatter slab High sev	72	H	2	$8,889	88.9	$100	
30% Shatter slab Low sev	72	L	6	$26,667	266.7	$100	6sl@(20'x20')/9sf/sy=266.7SY
30% Shatter slab Medium sev	72	M	6	$26,667	266.7	$100	
30% Shatter slab High sev	72	H	6	$26,667	266.7	$100	
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6	$600	6	$100	
30% Patch High sev	67	H	6	$600	6	$100	
50% Patch Low sev	67	L	10				Not used
50% Patch Medium sev	67	M	10	$1,000	10	$100	6sl@(3'x3')/9sf/sy=6SY
50% Patch High sev	67	H	10	$1,000	10	$100	
10% slabs Fault Low sev	71	L	2				Not used
10% slabs Fault Medium sev	71	M	2				
10% slabs Fault High sev	71	H	2	$444	4.4	$100	2sl@20'x1'=40sf/9sf/sy=4.4SY
30% slabs Fault Low sev	71	L	6				Not used
30% slabs Fault Medium sev	71	M	6				
30% slabs Fault High sev	71	H	6	$1,333	13.3	$100	6sl@20'x1'=120sf/9sf/sy=13.3SY

Table G-4. Repair Quantities and Costs for Concrete Overlay.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4				
Mid-panel crack 20% slab High sev	63	H	4	$20,000	888.9	$22.50	Whole area
Mid-panel crack 40% slab Low sev	63	L	8	$15,556	888.9	$17.50	Whole area
Mid-panel crack 40% slabs Medium sev	63	M	8	$17,778	888.9	$20.00	
Mid-panel crack 40% slab High sev	63	H	8	$20,000	888.9	$22.50	
Corner break 10% slabs Low sev	62	L	2				Not used
Corner break 10% slabs Medium sev	62	M	2				
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				Not used
Corner break 30% slabs Medium sev	62	M	6	$17,778	888.9	$20.00	Whole area
Corner break 30% slabs High sev	62	H	6				Not used
10% Shatter slab Low sev	72	L	2				Not used
10% Shatter slab Medium sev	72	M	2				
10% Shatter slab High sev	72	H	2	$20,000	888.9	$22.50	Whole area
30% Shatter slab Low sev	72	L	6	$15,556	888.9	$17.50	Whole area
30% Shatter slab Medium sev	72	M	6	$17,778	888.9	$20.00	
30% Shatter slab High sev	72	H	6	$20,000	888.9	$22.50	
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6				
30% Patch High sev	67	H	6				
50% Patch Low sev	67	L	10	$15,556	888.9	$17.50	Whole area
50% Patch Medium sev	67	M	10	$17,778	888.9	$20.00	
50% Patch High sev	67	H	10	$20,000	888.9	$22.50	
10% slabs Fault Low sev	71	L	2				Not used
10% slabs Fault Medium sev	71	M	2				
10% slabs Fault High sev	71	H	2				
30% slabs Fault Low sev	71	L	6	$15,556	888.9	$17.50	Whole area
30% slabs Fault Medium sev	71	M	6	$17,778	888.9	$20.00	
30% slabs Fault High sev	71	H	6	$20,000	888.9	$22.50	

Table G-5. Repair Quantities and Costs for Asphalt Overlay.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4				
Mid-panel crack 20% slab High sev	63	H	4	$4,000	888.9	$4.50	Whole area
Mid-panel crack 40% slab Low sev	63	L	8	$3,111	888.9	$3.50	Whole area
Mid-panel crack 40% slabs Medium sev	63	M	8	$3,556	888.9	$4.00	
Mid-panel crack 40% slab High sev	63	H	8	$4,000	888.9	$4.50	
Corner break 10% slabs Low sev	62	L	2				Not used
Corner break 10% slabs Medium sev	62	M	2				
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				Not used
Corner break 30% slabs Medium sev	62	M	6	$3,556	888.9	$4.00	Whole area
Corner break 30% slabs High sev	62	H	6				Not used
10% Shatter slab Low sev	72	L	2				Not used
10% Shatter slab Medium sev	72	M	2				
10% Shatter slab High sev	72	H	2	$4,000	888.9	$4.50	Whole area
30% Shatter slab Low sev	72	L	6	$3,111	888.9	$3.50	Whole area
30% Shatter slab Medium sev	72	M	6	$3,556	888.9	$4.00	
30% Shatter slab High sev	72	H	6	$4,000	888.9	$4.50	
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6				
30% Patch High sev	67	H	6				
50% Patch Low sev	67	L	10	$3,111	888.9	$3.50	Whole area
50% Patch Medium sev	67	M	10	$3,556	888.9	$4.00	
50% Patch High sev	67	H	10	$4,000	888.9	$4.50	
10% slabs Fault Low sev	71	L	2				Not used
10% slabs Fault Medium sev	71	M	2				
10% slabs Fault High sev	71	H	2				
30% slabs Fault Low sev	71	L	6	$3,111	888.9	$3.50	Whole area
30% slabs Fault Medium sev	71	M	6	$3,556	888.9	$4.00	
30% slabs Fault High sev	71	H	6	$4,000	888.9	$4.50	

Table G-6. Repair Quantities and Costs for Rehab/Reconstruct.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4				
Mid-panel crack 20% slab High sev	63	H	4				
Mid-panel crack 40% slab Low sev	63	L	8				Not used
Mid-panel crack 40% slabs Medium sev	63	M	8	$88,889	888.9	$100	Whole area
Mid-panel crack 40% slab High sev	63	H	8	$88,889	888.9	$100	
Corner break 10% slabs Low sev	62	L	2				Not used
Corner break 10% slabs Medium sev	62	M	2				
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				Not used
Corner break 30% slabs Medium sev	62	M	6				
Corner break 30% slabs High sev	62	H	6	$88,889	888.9	$100	Whole area
10% Shatter slab Low sev	72	L	2				Not used
10% Shatter slab Medium sev	72	M	2				
10% Shatter slab High sev	72	H	2				
30% Shatter slab Low sev	72	L	6	$88,889	888.9	$100	Whole area
30% Shatter slab Medium sev	72	M	6	$88,889	888.9	$100	
30% Shatter slab High sev	72	H	6	$88,889	888.9	$100	
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6				
30% Patch High sev	67	H	6	$88,889	888.9	$100	Whole area
50% Patch Low sev	67	L	10				Not used
50% Patch Medium sev	67	M	10				
50% Patch High sev	67	H	10	$88,889	888.9	$100	Whole area
10% slabs Fault Low sev	71	L	2				Not used
10% slabs Fault Medium sev	71	M	2				
10% slabs Fault High sev	71	H	2				
30% slabs Fault Low sev	71	L	6				Not used
30% slabs Fault Medium sev	71	M	6	$88,889	888.9	$100	Whole area
30% slabs Fault High sev	71	H	6	$88,889	888.9	$100	

Table G-7. Repair Quantities and Costs for Grinding/Grooving.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4				
Mid-panel crack 20% slab High sev	63	H	4				
Mid-panel crack 40% slab Low sev	63	L	8				Not used
Mid-panel crack 40% slabs Medium sev	63	M	8				
Mid-panel crack 40% slab High sev	63	H	8				
Corner break 10% slabs Low sev	62	L	2				Not used
Corner break 10% slabs Medium sev	62	M	2				
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				Not used
Corner break 30% slabs Medium sev	62	M	6				
Corner break 30% slabs High sev	62	H	6				
10% Shatter slab Low sev	72	L	2				Not used
10% Shatter slab Medium sev	72	M	2				
10% Shatter slab High sev	72	H	2				
30% Shatter slab Low sev	72	L	6				Not used
30% Shatter slab Medium sev	72	M	6				
30% Shatter slab High sev	72	H	6				
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6				
30% Patch High sev	67	H	6				
50% Patch Low sev	67	L	10				
50% Patch Medium sev	67	M	10				Not used
50% Patch High sev	67	H	10				
10% slabs Fault Low sev	71	L	2	$22	8.9	$2.50	2sl@20'x2'/9sf/sy=8.8SY
10% slabs Fault Medium sev	71	M	2	$62	17.7	$3.50	2sl@20'x4'/9sf/sy=17.7SY
10% slabs Fault High sev	71	H	2	$120	26.7	$4.50	2sl@20'x6'/9sf/sy=26.7SY
30% slabs Fault Low sev	71	L	6	$67	26.7	$2.50	6sl@20'x2'/9sf/sy=26.7SY
30% slabs Fault Medium sev	71	M	6	$187	53.3	$3.50	6sl@20'x4'/9sf/sy=53.3SY
30% slabs Fault High sev	71	H	6	$360	80.0	$4.50	6sl@20'x6'/9sf/sy=80SY

Table G-8. Repair Quantities and Costs for Slab Stabilization/Jacking/Underseal.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4				
Mid-panel crack 20% slab High sev	63	H	4				
Mid-panel crack 40% slab Low sev	63	L	8				Not used
Mid-panel crack 40% slabs Medium sev	63	M	8				
Mid-panel crack 40% slab High sev	63	H	8				
Corner break 10% slabs Low sev	62	L	2				Not used
Corner break 10% slabs Medium sev	62	M	2				
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				Not used
Corner break 30% slabs Medium sev	62	M	6				
Corner break 30% slabs High sev	62	H	6				
10% Shatter slab Low sev	72	L	2				Not used
10% Shatter slab Medium sev	72	M	2				
10% Shatter slab High sev	72	H	2				
30% Shatter slab Low sev	72	L	6				Not used
30% Shatter slab Medium sev	72	M	6				
30% Shatter slab High sev	72	H	6				
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6				
30% Patch High sev	67	H	6				
50% Patch Low sev	67	L	10				Not used
50% Patch Medium sev	67	M	10				
50% Patch High sev	67	H	10				
10% slabs Fault Low sev	71	L	2				Not used
10% slabs Fault Medium sev	71	M	2	$11,556	88.9	$130	2sl@(20’*20’)/9sf/sy=88.9SY
10% slabs Fault High sev	71	H	2				Not used
30% slabs Fault Low sev	71	L	6	$29,333	266.7	$110	6sl@(20’*20’)/9sf/sy=266.7SY
30% slabs Fault Medium sev	71	M	6	$34,667	266.7	$130	
30% slabs Fault High sev	71	H	6	$40,000	266.7	$150	

Table G-9. Repair Quantities and Costs for Cross Stitching/Dowel Bar Retrofit.

Distress	DC	Sev	Quan	Cost	SY	$/SY	Basis for Quantities
Jt Seal 5 Year Old, Good Condition	-	-	-				Not used
Joint seal damage Low sev	65	L	20				
Joint seal damage Medium sev	65	M	20				
Joint seal damage High sev	65	H	20				
Joint/corner spall Low sev	74	L	5				Not used
Joint/corner spall Medium sev	74	M	5				
Joint/corner spall High sev	74	H	5				
Mid-panel crack 20% slabs Low sev	63	L	4				Not used
Mid-panel crack 20% slabs Medium sev	63	M	4				
Mid-panel crack 20% slab High sev	63	H	4				
Mid-panel crack 40% slab Low sev	63	L	8				Not used
Mid-panel crack 40% slabs Medium sev	63	M	8				
Mid-panel crack 40% slab High sev	63	H	8				
Corner break 10% slabs Low sev	62	L	2				Not used
Corner break 10% slabs Medium sev	62	M	2				
Corner break 10% slabs High sev	62	H	2				
Corner break 30% slabs Low sev	62	L	6				Not used
Corner break 30% slabs Medium sev	62	M	6				
Corner break 30% slabs High sev	62	H	6				
10% Shatter slab Low sev	72	L	2				Not used
10% Shatter slab Medium sev	72	M	2				
10% Shatter slab High sev	72	H	2				
30% Shatter slab Low sev	72	L	6				Not used
30% Shatter slab Medium sev	72	M	6				
30% Shatter slab High sev	72	H	6				
30% Patch Low sev	67	L	6				Not used
30% Patch Medium sev	67	M	6				
30% Patch High sev	67	H	6				
50% Patch Low sev	67	L	10				Not used
50% Patch Medium sev	67	M	10				
50% Patch High sev	67	H	10				
10% slabs Fault Low sev	71	L	2				Not used
10% slabs Fault Medium sev	71	M	2				
10% slabs Fault High sev	71	H	2	$600	20.0	$30	2sl@20'/2bar/ft
30% slabs Fault Low sev	71	L	6				Not used
30% slabs Fault Medium sev	71	M	6	$1,800	60.0	$30	6sl@20'/2bar/ft
30% slabs Fault High sev	71	H	6				Not used