Chapter Forty-Five

LOCAL AGENCY
PAVEMENT PRESERVATION

BUREAU OF LOCAL ROADS AND STREETS MANUAL

Chapter Forty-five

LOCAL AGENCY PAVEMENT PRESERVATION

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LOCAL AGENCY PAVEMENT PRESERVATION

45-1 INTRODUCTION

This chapter provides information regarding the use of pavement preservation strategies for maintaining pavement condition. The Department's policies and procedures regarding the use of pavement preservation techniques are also presented. The use of pavement preservation is an elective policy. However, proper adherence to the preservation policy and procedures specified in this chapter can provide an agency with the opportunity to use federal funding for preservation activities.

45-1.01 Pavement Preservation Definition

Many transportation agencies are using pavement preservation programs to more cost-effectively manage their pavement assets. Pavement preservation procedures have been in use for many years, but often agencies use the same pavement preservation terminology in different manners. Therefore, the Federal Highway Administration (FHWA) Office of Asset Management provided the following guidance regarding pavement preservation definitions in a Memorandum dated September 12, 2005.

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

The memorandum also defined several pavement preservation related terms including: pavement preservation, preventive maintenance, minor rehabilitation (non-structural), and routine maintenance. These terms are described in more detail in the following sections.

45-1.01(a) Pavement Preservation

Pavement preservation is a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement service life, improve safety and meet motorist expectations (FHWA 2005). Pavement preservation includes work conducted on a pavement prior to major rehabilitation, restoration, or reconstruction. Pavements with significant structural deterioration are not candidates for pavement preservation treatments.

45-1.01(b) Preventive Maintenance

The main component of pavement preservation is preventive maintenance. As defined by the FHWA in 2005, preventive maintenance is a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity). The general philosophy of the use of preventive maintenance treatments is to *"apply the right treatment, to the right pavement, at the right time."* These practices result in an outcome of *"keeping good roads in good condition."*

When activities such as crack sealing and filling and the application of seal coats are placed on the pavement at the right time they are examples of preventive maintenance treatments.

45-1.01(c) Minor Rehabilitation

Minor rehabilitation consists of non-structural enhancements made to the existing pavement section to eliminate age-related, top-down surface cracking that develop in flexible pavements due to environmental exposure or to restore functionality of concrete pavements. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation (FHWA 2005).

The placement of thin overlays or the conduct of recycling techniques such as hot in-place or cold recycling to correct significant surface cracking can be considered minor rehabilitation activities.

45-1.02 Purpose

The intended purpose of a pavement preservation program is to maintain or restore the surface characteristics of a pavement and to extend service life of the pavement assets being managed. However, the improvements are such that there is no increase in capacity or strength but they can have a positive impact on the structural capacity. As a means of improving the functional condition of the network and reducing the overall rate of deterioration of the pavement asset, preventive maintenance treatments are used in the pavement preservation program. Since they are relatively inexpensive in comparison to resurfacing or reconstruction projects, the preventive maintenance treatments are an effective means to preserve the investment in the pavement asset.

An effective pavement preservation program has two main objectives:

- Preserve the pavement investment. *This objective involves minimizing the structural failures and extending the structural life of the pavement to preserve the investment the agency has made in the pavement asset.*
- Maintain high level of service (LOS). *This objective involves maintaining acceptable smoothness and surface friction in order to provide a high LOS for the roadway customers.*

The implementation of a pavement preservation program is good practice, as it focuses on maximizing the condition and life of a network of pavements while minimizing the network's life-cycle cost. The noted benefits of the use of a pavement preservation program vary from agency to agency, but have been documented as including:

- Improved pavement performance—preservation activities extend the performance of the pavement and help to improve the overall condition of the network.

- Higher customer satisfaction—use of preservation activities can lead to smoother roads and fewer construction delays.
- Cost savings—less expensive treatments and the extension of service lives of pavements help to lower or stabilize operating costs.
- Increased safety—preventive maintenance treatments are designed to provide safer surfaces in terms of improved pavement texture and correction of safety related defects such as ruts and improving surface drainage.

A successful pavement preservation program relies on proper treatment selection and timing of the treatment to be successful. In order to select the right treatment for the right pavement at the right time, the following should be known (Peshkin et al. 2004):

- What is the structure and condition of the existing pavement?
- What is the expected performance of the pavement?
- How will different treatments affect their performance?
- What other factors affect how the treatments will perform?

These questions can often be answered by information that is available from a pavement management system (PMS). A pavement management system is a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in serviceable condition over a period of time (AASHTO 1993). Pavement management, in the broad sense, includes all the activities involved in the planning, programming, design, construction, maintenance, and rehabilitation of the pavement portion of a public works program (Haas et al. 1994).

In order to have an effective pavement preservation program, it is imperative to have some type of pavement management system in place, whether it is proprietary software, public domain software, or a simple spreadsheet. Details of pavement management requirements are provided in the next section.

45-2 PAVEMENT PRESERVATION PROCESS

45-2.01 General

The information and procedures outlined in this chapter allow agencies to conduct pavement preservation with all sources of funding (including MFT, state, or federal funds). Section 4-1 should be consulted to determine highways eligible for federal funds.

In order to understand the outlined pavement preservation processes, a general description of pavement management and some related details is provided. A pavement management system, as defined earlier, is a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in serviceable condition over a period of time (AASHTO 1993). A pavement management system can take the form of proprietary software, nonproprietary software, or a simple spreadsheet tool. Whether it is a pavement management system or a spreadsheet tool, it must contain the following information for each pavement section included in the pavement preservation program:

- Route ID
- Location designations (beginning/ending locations)
- Surface type
- Pavement surface age
- Condition rating
- Condition rating type used
- Condition survey date
- Prominent distress type
- Average Daily Traffic (ADT)

The information will be used to track the performance of the pavement sections over time and to support pavement preservation funding requests submitted to the District BLRS office.

Pavement condition surveys should be conducted at least every 3 years on all roadways included in the pavement preservation program. Ideally, all roadways maintained by the agency, not just those included in the pavement preservation program, will be included in the survey so the pavement conditions can be tracked over time and used in making treatment selections as additional sections are added to the pavement preservation program.

The highways eligible for pavement preservation and the pavement management system used by the agency shall be submitted with the agency's approval request. The following steps shall be followed for the department to approve the agency's pavement preservation program.

45-2.02 Pavement Preservation Plan Development

The agency will develop a 10-year pavement preservation plan. Agencies using a pavement management system will be able to use their software to customize a preservation plan, while those using a spreadsheet tool will need to use the available condition rating data to create the pavement preservation plan. The first 2 years of the 10-year plan should provide detail on specific pavement preservation projects proposed for funding. The remaining 8 years of the plan should include a summary of the proposed total miles of preservation projects that are planned in each year. Because preservation projects are based upon selecting "the right treatment at the right time," it is difficult to schedule long-range preservation projects. Therefore, it is more appropriate to note the number of miles proposed for each type of treatment during the remaining 8 years of the pavement preservation plan.

45-2.03 Pavement Preservation Plan Approval

The pavement preservation plan shall be submit to the District BLRS for approval.

1. An agency interested in participating in the pavement preservation program must submit Form BLR 45300 and Form BLR 45310 to the District BLRS.
2. The District BLRS will review the request and recommend approval to the Central BLRS. If the District BLRS does not approve the agency as a participant, the agency will be notified in writing of the reasons why they are not approved.
3. The District will forward 3 original copies of Form BLR 45300, Form BLR 45310, and all required supporting documentation to the Central BLRS for review and approval. If approved by the Central BLRS, Central BLRS will sign Form BLR 45300. Two copies of Form BLR 45300 will be returned to the District BLRS and 1 copy will be retained by Central BLRS for the file. If the request is denied, the agency will be notified in writing.

45-2.04 Pavement Preservation Plan Updates

Each year, the agency should update the list of projects included in the first 2 years of the pavement preservation project plan. On even number years, the number of miles of pavement preservation projects planned for the last 8 years of the 10-year plan should be updated. The revised plan shall be submitted to the District BLRS for approval.

1. Form BLR 45310 should be submitted to the District BLRS by October 1 of each year.
2. The District BLRS will review the revised plan. If the District BLRS does not approve, the agency will be notified in writing detailing needed revisions.
3. Upon approval by the District BLRS, funding may be allocated for use on the preservation treatments specified in the pavement preservation plan.
4. For federal day labor and federal local let projects, the approved Form BLR 45310 shall be included with the request to the Central BLRS. For state let projects, the approved Form BLR 45310 shall be included with the plans, specifications and estimates submittal to the Central BLRS

45-2.05 Pavement Preservation Treatment Project Submittal

The section number for all projects approved under the pavement preservation plan should use the PP section number.

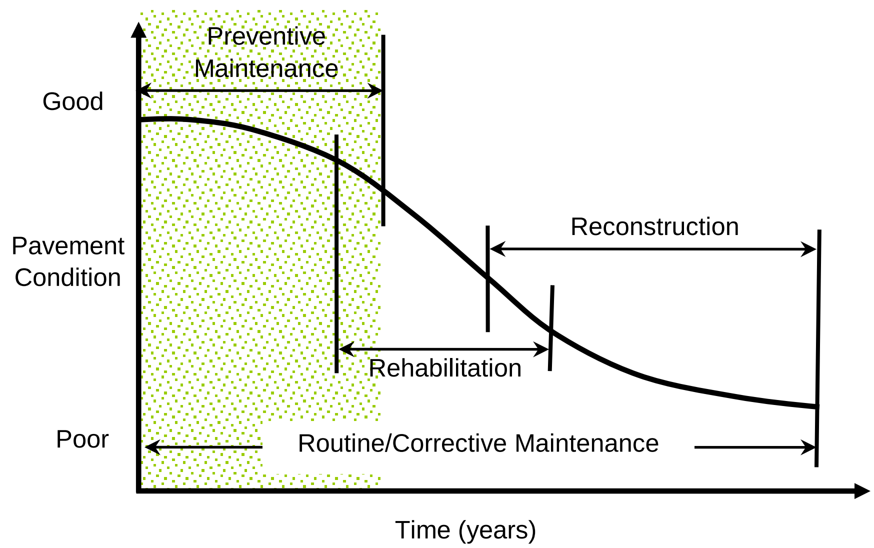
All pavement preservation projects are considered as Categorical Exclusion Group I. Form BLR 46300, a location map, and a typical section shall be submitted for all pavement preservation projects regardless of funding. For pavement preservation projects that involve a structure, the Form BLR 46300 will be forwarded to the Local Bridge Unit for the approval of the Engineer of Bridges and Structures.

If the bridge cannot safely carry the additional dead load resulting from resurfacing, gap the bridge. For structures greater than 20.0 feet (6.1 m) in length that are not being gapped, Form BLR 10220 “Asbestos Determination Certification” will be required. All structure condition ratings of these structures must be a “5” or greater. The Bureau of Bridges & Structures (BBS) will evaluate the structural adequacy of the structure, and record the status of the asbestos Form BLR 10220, before approval of the pavement preservation project.

45-3 PAVEMENT PERFORMANCE

45-3.01 General

One of the keys to an effective pavement preservation program is to understand how pavements perform. Figure 45-3A illustrates the typical life cycle of a pavement and the categories of treatments that are appropriate at different times of the life of the pavement. The application of these treatments is also based upon the condition of the pavement, as preventive maintenance treatments are used early on in the life of a pavement while a pavement is still in relatively good condition. There is also a time when preventive maintenance is no longer appropriate (because the pavement has deteriorated to a point that more extensive cracking and other distresses are present), but it is too soon to trigger the pavement for major rehabilitation. Pavements at this condition level would receive minor rehabilitation treatments such as thin overlays or pavement recycling. Together, the use of preventive maintenance treatments and minor rehabilitation techniques along with routine maintenance provide pavement preservation options for a pavement that is still in relatively good condition.



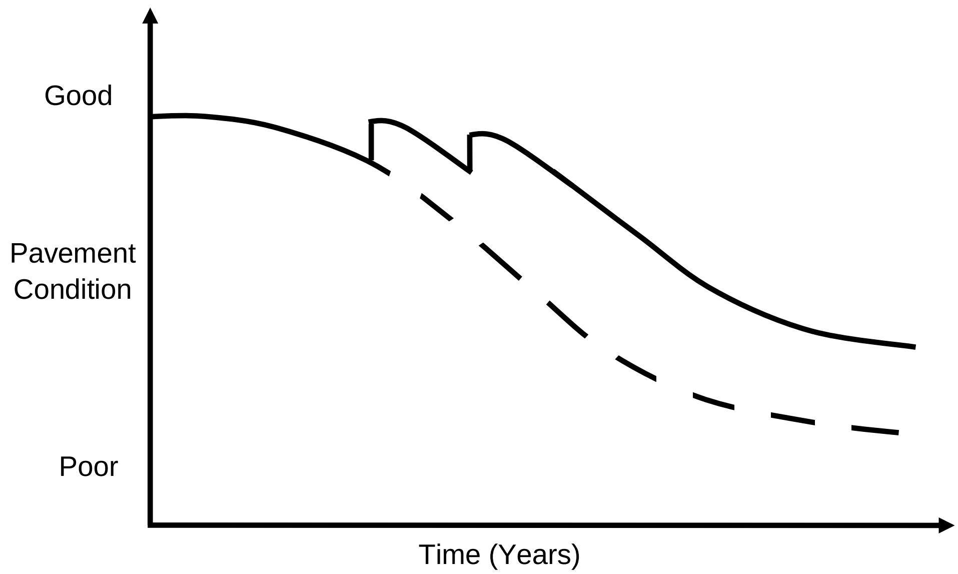
RELATIONSHIP BETWEEN PAVEMENT CONDITION AND TYPICAL TYPES OF TREATMENT

Figure 45-3A

If preventive maintenance or minor rehabilitation is not used during the life of the pavement, the pavement will deteriorate to the point that major rehabilitation (structural restoration, such as full-depth repairs or thick overlays, or even reconstruction) is necessary. When a pavement develops significant levels of distress, pavement preservation activities are no longer viable treatment options. If preventive maintenance or minor rehabilitation is used on a pavement that is highly deteriorated, the life of the chosen treatment can be greatly reduced.

Figure 45-3A depicts a generic pavement performance curve; there can be significant differences in the shape of the performance curve for different pavements due to differences such as environment, design, and construction.

The philosophy of pavement preservation is to address pavements while they are still in good condition and without any serious structural damage. A preventive maintenance treatment applied at the right time can restore the pavement almost to its original condition. Systematic, successive preservation treatments applied correctly help prolong the service life of the asset and delay the more expensive major rehabilitation treatments and reconstruction. Figure 45-3B depicts how the application of successive preventive maintenance treatments (shown as the solid line) can help maintain the pavement in good condition for a longer period of time as compared to a pavement without treatments (depicted by the dashed line performance curve). Additionally, performing a series of successive pavement preservation treatments during the life of a pavement is less disruptive to traffic than the long closures normally associated with reconstruction projects.



PAVEMENT PERFORMANCE EXTENDED BY PREVENTIVE MAINTENANCE

Figure 45-3B

To apply pavement preservation techniques at the optimal time, it is imperative to understand the causes of pavement deterioration for the various types of pavements.

45-3.02 Causes of Pavement Deterioration

Understanding the distress mechanisms that cause pavement deterioration is essential in properly identifying preservation strategies and treatments for pavements. The causes of deterioration can lead to a variety of distresses. Typical pavement distresses are discussed in section 45-3.03.

45-3.02(a) Flexible Pavement Deterioration

For flexible pavements, which are hot-mix asphalt (HMA) or other bituminous surfaces, the general causes of primary deterioration include traffic, environment/aging, and material problems. A secondary cause of deterioration is due to moisture infiltration. These causes of deterioration influence the performance of the pavement in various ways.

- Traffic can lead to load-related distress such as plastic deformation that manifests as rutting, or structural fatigue cracking that occurs in the wheelpaths of the pavement. Fatigue cracking can lead to the occurrence of potholes. Additional traffic-related distress includes polishing of the pavement surface due to surface wear, which leads to friction loss.
- Environment and aging can cause oxidation of the asphalt and lead to block cracking and weathering/raveling. Environmental forces can also cause thermal cracking, which typically is seen as regularly spaced transverse cracks.
- Material problems include bleeding (contributing to loss of friction), shoving and surface deformation, and stripping.
- Moisture infiltration, while a secondary cause of deterioration, can lead to further breakdown of existing cracks and cause increased roughness. The infiltration of moisture will also soften the subgrade and can lead to the occurrence of longitudinal cracking at the edge of the pavement or potholes.

45-3.02(b) Rigid Pavement Deterioration

For rigid pavements, which are portland cement concrete (PCC) surfaced, the general causes of primary deterioration include traffic loadings, environment and material problems, and poor construction quality. Secondary causes of deterioration are due to incompressibles in joints and moisture infiltration. These causes of deterioration influence the performance of the pavement in various ways.

- Traffic can lead to load-related distress in the slab such as mid-slab cracking. Pumping, faulting, and corner breaks are also load-related distresses. Traffic-related distress includes polishing of the pavement surface due to surface wear, which leads to friction loss.
- Environment and material problems include D-cracking (durability cracking) and alkali-silica reactivity. The environment can also cause oxidation of the joint seal which will allow moisture infiltration into the pavement structure.
- Poor construction quality can cause issues such as longitudinal cracking or surface distress in the form of map cracking and scaling.
- Incompressible materials lodged in a joint a secondary cause of deterioration can cause the occurrence of joint spalls.
- Moisture infiltration to sub-surface layers, while a secondary cause of deterioration, can lead to further breakdown of existing cracks and spalls and cause increased roughness. The infiltration of moisture will also soften the subgrade and can lead to the occurrence of pumping, transverse joint faulting, and corner breaks.

45-3.03 Distress Identification

Distress is defined as pavement deterioration that reduces serviceability or leads to a reduction in serviceability. The following discussion will help users recognize the types and severity levels of some of the most common distresses in flexible and rigid pavements. A short description of each distress type is provided along with a photograph of typical light, moderate, and severe cases.

The lists of flexible and rigid distress types described in the following two sub-sections are not comprehensive. This discussion is meant to provide the user with a general understanding of some of the most common distresses, especially in regards to applying pavement preservation treatments. Additional distress types that are not as common are introduced in less detail in section 45-3.03(c).

45-3.03(a) Flexible Pavement Distresses

Flexible pavement surface distresses include a variety of pavement defects as follows:

1. Alligator/Fatigue Cracking

Alligator or fatigue cracking is a bottom-up type of cracking that indicates fatigue failure (caused by repetitive stress) and is considered a structural distress. Because the cracks generally extend through all asphalt layers, water is allowed to penetrate into the subgrade, leading to increased deterioration.

Alligator cracking is a series of cracks that, when severe, forms a pattern resembling chicken wire. This type of cracking is usually found in the wheel path or along the edge of the pavement (also sometimes called edge cracking). Cracking initially develops as a series of longitudinal cracks that become interconnected as further fatigue damage occurs.

Severity levels are defined by how interconnected the cracking pattern is and the stability of the piece as shown in Figure 45-4C.

Light Alligator Cracking - A longitudinal crack or a series of parallel longitudinal cracks with little or no interconnection.

Moderate Alligator Cracking - Cracks are interconnected and may be slightly spalled, but are stable.

Severe Alligator Cracking - Cracks are wider and pieces are spalled and show movement under traffic loads.

ALLIGATOR CRACKING SEVERITY LEVELS

Figure 45-4C

2. Bleeding

Bleeding occurs when a film of excess asphalt material pools on the pavement surface. Bituminous material saturates the aggregate voids during hot weather or traffic compaction, then expands onto the pavement surface. This can contribute to a considerable safety threat by reduction in the skid resistance of the pavement surface.

Bleeding usually creates a shiny, glass-like reflecting surface that can become sticky when hot and dry and slippery when wet. It is often found in the wheel paths. The severity of bleeding is defined by the amount and extent of asphalt binder visible at the surface of the pavement as shown in Figure 45-3D.

Light Bleeding – Small or isolated areas where asphalt material has pooled on the pavement surface.

Moderate Bleeding – Bleeding is apparent over large or continuous areas of the pavement surface.

Severe Bleeding – Bleeding covers much of the pavement surface and is relatively thick.

BLEEDING SEVERITY LEVELS

Figure 45-3D

3. Block Cracking

Block cracking is a functional distress caused by environmental conditions which lead to hardening and shrinkage of the asphalt. This is not a load-related distress. However, the cracks may allow water to enter the pavement causing further deterioration.

Block cracking occurs as a pattern of cracks that divide the pavement into approximately square (or block shaped) pieces. The blocks generally range from 1 ft by 1 ft to 10 ft by 10 ft (0.3 m by 0.3 m to 3 m by 3 m) and cover a large area. Patterns smaller than this often are a sign of alligator cracking; blocks larger than this usually are measured as longitudinal and transverse cracks.

Block cracking is measured by the area containing the block-cracking pattern. The severity of block cracking is defined by the cracks, in the same manner that severity levels for longitudinal and transverse cracking shown in Figure 45-3E.

Light Block Cracking – Tight cracks or sealed cracks with the filler in good condition.

Moderate Block Cracking – Cracks have opened up, exhibit a small amount of spalling, or have adjacent random light cracking.

Severe Block Cracking – Cracks are wide, have significant spalling, or are accompanied by adjacent moderate severity random cracking.

BLOCK CRACKING SEVERITY LEVELS

Figure 45-3E

4. Longitudinal and Transverse (L&T) Cracking

By definition, longitudinal cracks run parallel to the centerline and transverse cracks run perpendicular.

Similar to block cracking, longitudinal and transverse (L&T) cracking is caused by environmental factors (thermal expansion and contraction). These cracks may be located anywhere on the pavement surface, including along paving lane joints. L&T cracks can also form in areas with swelling or settlement because of additional strain on the pavement in these specific areas.

Joint reflective cracking in composite pavements can also be categorized as L&T cracking. In this case, the cracks form when joints in the underlying PCC reflect through to the HMA surface.

L&T cracking is not a load-related distress; however, the cracks can allow water to enter the pavement and eventually weaken the structure, leading to load-related deterioration.

Severity levels are determined based upon the width and depth of cracking, stability/movement of the pavement material adjacent to the cracks, and the extent of spalling and secondary cracking (adjacent random cracking). Some rating procedures record longitudinal and transverse cracking separately, or have a different distress for cracking due to joint reflection of composite pavements (see Figure 45-3F).

Light L&T Cracking - Tight cracks or sealed cracks with the filler in good condition.

Moderate L&T Cracking - Cracks have opened up, exhibit a small amount of spalling, or have adjacent random light cracking.

L & T

Severe L&T Cracking - Cracks are wide, have significant spalling, or are accompanied by adjacent moderate severity random cracking.

SEVERITY LEVELS

Figure 45-3F

5. Rutting

A rut is a longitudinal surface depression in the wheel path. Rutting can pose a potential safety threat when water collects in the depressed area as hydroplaning can occur. There are two types of rutting: rutting in the HMA layer, and rutting in the subgrade.

Rutting occurs in the HMA layer due to poor mix design properties (which can sometimes cause transverse material displacement) or secondary compaction of the mix under a concentration of heavy wheel loads.

Subgrade rutting occurs when the subgrade (and hence the overlying asphalt concrete) exhibits wheel path depressions due to loading. Subgrade rutting is a load-related distress, generally indicating that the pavement structure is not adequate for the applied loads.

Rutting can be measured using a transverse profiler, or simply by measuring the depth of the lowest point in the rut relative to the pavement surface. Severity levels are based on rut depth and may vary by the condition rating procedure used. The depths listed for light, moderate, and severe rutting to the right are typical, but are based on the measured depth at a given location. When rut data is collected using automated means, an average depth is often reported (see Figure 45-3G).

Light Rutting - Rut depth visible, approximately less than ½ inch (12.7 mm) in a given location.

Moderate Rutting - Rut depth approximately between ½ inch and 1 inch (12.7 mm and 25.4 mm) in a given location.

Severe Rutting - Rut depth greater than approximately 1 inch (25.4 mm) in a given location.

RUTTING SEVERITY LEVELS

Figure 45-3G

6. Weathering/Raveling

Weathering/raveling occurs when aggregate particles and asphalt binder are worn away from the HMA surface. This can occur when the surface has oxidized and hardened, or from poor mix quality. Aggregate is eroded from the surface, leaving a rough and sometimes pitted texture. Other factors that can contribute to weathering/raveling include oil spillage, which softens the asphalt and allows aggregate to become dislodged, and mechanical abrasion, such as snow-plow blades or studded tires.

Severity levels are based upon the extent of lost aggregate and visibility of aging in the pavement (see Figure 45-3H).

Light Weathering/Raveling - Some aggregate loss from the pavement surface with little or no pitting.

Moderate Weathering/Raveling - Some aggregate loss resulting in an overall rough pavement surface with some localized pitting.

Severe Weathering/Raveling - Considerable aggregate loss resulting in an overall rough pavement surface with pitted/eroded areas.

WEATHERING/RAVELING SEVERITY LEVELS

Figure 45-3H

45-3.03(b) Rigid Pavement Distresses

The most significant and commonly observed distresses in rigid pavements are as follows:

1. Corner Breaks

Corner breaks are created in PCC pavements by cracks located within a single quadrant of the slab, resulting in an approximately 45-degree angle to the direction of traffic. A corner break extends vertically through the entire depth of the slab and is caused by high corner stresses. The high corner stresses can develop from overloading and thermal curling or as a loss of support under the slab, including poor initial compaction. Corner breaks are considered a load-related distress.

The number of corner breaks is to be recorded at each severity level within each section (see Figure 45-3I).


Light Corner Breaks - Crack is hairline and unspalled; the resulting corner piece is not cracked or shows no movement under load.


Moderate Corner Breaks - Crack has some spalling and the corner piece is intact and has little or no movement under load.


Severe Corner Breaks - Crack is heavily spalled; corner is broken into two or more pieces, is faulted, or moves under load.

CORNER BREAK SEVERITY LEVELS

Figure 45-3I

2. Durability (D) Cracking

D-Cracking is a series of closely spaced, crescent-shaped hairline cracks near a joint, corner or crack. There is often dark staining around the cracks that can help distinguish this distress from others (especially other material-related distresses).

D-cracks are caused by freeze-thaw expansion of the coarse aggregate within the PCC slab. This distress requires a susceptible coarse aggregate (which can be controlled when selecting the appropriate mix design), moisture, and a climate with freeze-thaw conditions. The deterioration commonly starts from the bottom of the slab where the saturation levels are higher.

D-cracking is considered a material- and climate-related problem and is not caused by load. However, this can be a very destructive distress that eventually affects the load-carrying ability of the pavement structure.

The severity level is determined by the extent of the break-up of the pavement due to D-cracking. Also, the extent of cracking that covers the slab surface can help define the severity of D-cracking (see Figure 45-3J).

Light D-Cracking - Tight cracks with no loose or missing pieces and no patching in the affected area.

Moderate D-Cracking - Well defined cracks, with a few small loose pieces.

Severe D-Cracking - A well defined cracking pattern with a significant amount of loose or missing material.

D-CRACKING SEVERITY LEVELS

Figure 45-3J

3. Faulting

A difference in elevation across a joint (between two slabs) or crack (within a slab) is referred to as faulting.

Faulting is often an indicator of poor load transfer (especially in un-doweled jointed-plain concrete pavements). In this case, fines are pumped from beneath the far slab to beneath the near slab (in reference to the direction of travel) causing the difference in elevation. Faulting can also be caused by uneven settlement of adjacent slabs or by frost heave.

Severity levels are based upon the measured difference in surface elevation across the joint or crack and vary by the condition rating procedure used. The measurements listed for light, moderate, and severe faulting shown in the photos to the right are provided as examples. Some rating procedures do not record faulting across cracks (only across joints), incorporating faulting into the crack's severity level. Automated data collection can also be used to assess faulting (see Figure 45-3K).

Light Faulting - Faulting is visible and measures approximately less than ¼ inch (6.4 mm) at a given location.

Moderate Faulting - Faulting measures approximately ¼ inch to ½ inch (6.4 mm and 12.7 mm) at a given location.

Severe Faulting - Faulting is greater than approximately ½ inch (12.7 mm) at a given location.

FAULTING SEVERITY LEVELS

Figure 45-3K

4. Joint Seal Damage

Joint sealant in good condition keeps both incompressible material and water out of the joints. When incompressible materials collect in joints, the pavement cannot expand and contract as needed resulting in distresses such as spalling or blowups. Keeping water out of the pavement structure is important for preventing other distresses, such as faulting and pumping. To be effective, joint sealant should be intact, pliable, and bonded to both sides of the joint.

Severity levels should be determined by the ability of the joint sealant to adequately protect the joint from deterioration and keep water from entering the pavement structure. The performance of the sealant is usually judged over a large area and categorized by the overall performance (see Figure 45-3L).

Light Joint Seal Damage - Only localized areas of the sealant are damaged.

Moderate Joint Seal Damage - Portions of the sealant are missing, oxidized (no longer pliable), split, or have lost adherence.

Severe Joint Seal Damage - Sealant is mostly missing, oxidized (no longer pliable), split, or is lost all adherence; sealant is no longer performing its intended function.

JOINT SEAL DAMAGE SEVERITY LEVELS

Figure 45-3L

5. Longitudinal Cracking

Longitudinal cracking is used to describe cracks that predominately run parallel to the pavement centerline. These cracks usually extend through the entire depth of the slab.

Longitudinal cracks are the result of internal stresses caused by temperature and moisture gradients (curling and warping), late or inadequate sawcutting, excessively wide slabs, or poor base/subgrade support conditions.

Severity is defined by the deterioration along the crack (crack width and amount of spalling). Some rating procedures consider shattered slabs (slabs divided into multiple pieces) as a separate distress while others simply record the number of cracks (see Figure 45-3M).

Light Longitudinal Cracking - Tight cracks with little or no spalling.

Moderate Longitudinal Cracking - Wider cracks with some spalling.

Severe Longitudinal Cracking - Cracks that exhibit movement accompanied by discernable spalling.

LONGITUDINAL CRACKING SEVERITY LEVELS

Figure 45-3M

6. Map Cracking and Scaling

Map cracking and scaling develop because of material-, construction- and weather-related problems. Map cracking appears in the form of closely spaced cracks that are typically tight and shallow; scaling refers to the loss of surface material.

Over-finishing the PCC surface during construction or adding water during finishing are common causes of map cracking. Over-finishing works excess water to the surface, creating a weak layer of mortar that easily breaks off. Surface cracks can also form if the PCC surface dries out too quickly while curing; however, these are usually referred to as plastic shrinkage cracks and are generally more isolated.

Alkali silica reactivity (ASR) or other material-related problems can also cause map cracking. In some cases, the application of deicing chemicals can also cause scaling.

Severity levels are based primarily on the amount of scaling, but also consider the cracks, if present (see Figure 45-3N).

Light Surface Distress - Very clear cracking pattern on the surface, where cracks appear tight and shallow; no scaling.

Moderate Surface Distress - Cracks have opened up and/or there is some material loss (scaling) on the pavement surface.

Severe Surface Distress - Extensive material loss (scaling).

SURFACE DISTRESS SEVERITY LEVELS

Figure 45-3N

7. Pumping

Pumping occurs when fine material beneath the slab is worked up through joints and cracks under applied loads. Over time, voids can form under the corners/edges of the slabs, leading to loss of support problems. Positive load transfer, effective joint sealant, and limiting the fines in the underlying base course can minimize pavement pumping.

Pumping is likely to be occurring when stains near joints and cracks are visible. Severities of pumping are difficult to define because most of the deterioration occurs below the pavement surface (see Figure 45-3O).

Light Pumping - Small areas of staining visible.

Moderate Pumping - Visible staining on the pavement surface.

Severe Pumping - Excessive amounts of staining. Additional indications may include faulting or the erosion of shoulder pavement from applied pumping forces.

PUMPING SEVERITY LEVELS

Figure 45-3O

8. Spalling

Spalling is defined as cracking, breaking or chipping of joint edges. Spalling can occur along joints, in corners, or along cracks. Spalls extend diagonally from the pavement surface toward the joint or crack, in contrast to corner breaks or linear cracks which extend vertically through the slab. Spalling often occurs when incompressible material enters the joints or cracks and prevents normal expansion and contraction of the slab, eventually leading to deterioration around the joint or crack.

Severity levels should be determined based upon the amount and depth of deterioration and loss of material observed at the joint or crack (see Figure 45-3P).

Light Spalling - Slight wear along the joint or crack, with minimal loose or missing pieces.

Moderate Spalling - Shallow but discernable wear at the joint or crack, with loose pieces that can be removed easily or are missing.

Severe Spalling - Considerable wear and loss of material at the joint or crack; ride quality is affected.

SPALLING SEVERITY LEVELS

Figure 45-3P

9. Transverse Cracking

Transverse cracks run perpendicular to the centerline of a roadway. These cracks are similar to longitudinal (linear cracks) in that they typically extend vertically through the slab and are a structural distress. They are distinguished here from longitudinal cracks because some of the repair options differ.

Slabs often crack from overloading or because of poor base/subgrade support. As with longitudinal cracks, transverse cracks can form due to improper joint spacing, late or inadequate joint sawcutting, or from internal stresses caused by temperature and moisture gradients (curling and warping) in combination with loading.

Severity is defined by the deterioration along the crack (crack width and amount of spalling), presence of faulting, and the number of pieces the slab is divided into. Some rating procedures record longitudinal and transverse cracks separately, or have another distress type for shattered slabs (slabs divided into multiple pieces) (see Figure 45-3Q).

Light Transverse Cracking - Tight cracks with little or no spalling and no faulting.

Moderate Transverse Cracking - Wider cracks with some spalling or faulting.

Severe Transverse Cracking - Cracks that exhibit movement accompanied by discernable spalling or faulting.

TRANSVERSE CRACKING SEVERITY LEVELS

Figure 45-3Q

45-3.03(c) Additional Pavement Distresses

The following distress types may appear in some condition rating procedures, but are either less applicable to pavement preservation programs (which focus on treatments applied over large areas rather than localized repairs) or are somewhat less common than those previously discussed:

1. Depression. Depressions are often localized and can be built in during construction or develop in areas with poor base or subgrade compaction (see Figure 45-3R).

DEPRESSION

Figure 45-R

2. Blowups. Blowups occur in PCC pavements, typically during exceptionally hot weather. When PCC pavements do not have room to expand sufficiently, internal forces can become great enough to cause a localized upward movement of the slab edges resulting in buckling or shattering of the joint. If blow-ups are a common problem, some preventive activities such as regular joint resealing and, in severe cases, the installation of pressure relief joints, may be needed to control this distress.

3. Bumps and Sags. Bumps and Sags are a flexible pavement distortion that affect ride quality. Often this distress can better be classified by a more descriptive distress, such as swelling, shoving, rutting (in the HMA surface), or corrugation. This distress does appear in some distress rating procedures, though.

4. Corrugation. This distress is usually only found at intersections or areas with stopping traffic. The result is a washboard effect where there are ridges of HMA that run perpendicular to the centerline. This distress is a result of an unstable mix combined with stopping traffic, which causes the surface to slide and form ripples.

5. Lane-Shoulder Drop Off. Some condition rating procedures include a lane-shoulder drop off as a distress describing an elevation change between the edge of pavement and the adjacent shoulder, which can be a potential safety problem if a vehicle tire goes beyond the edge of pavement. In addition, pavement deterioration along a loaded edge can sometimes occur as a result of the edge not being supported (see Figure 45-3S).

LANE-SHOULDER DROP OFF

Figure 45-3S

6. Patch Deterioration. While patches are often placed to repair a pavement problem, they eventually deteriorate. To account for this, some condition rating procedures include patches as a separate distress. Alternately, the types of distress occurring within a patched area can be recorded.

7. Polished Aggregate. This distress can occur on either PCC or HMA-surfaced pavements. In both cases, frequent traffic applications (not necessarily heavy loads) can wear away the pavement surface and polish any exposed aggregate until the pavement surface is smooth. Polished aggregate results in a surface that is smooth, causing a potential safety problem. Polished aggregates can be detected using skid testing, or by visual observations (see Figure 45-3T).

POLISHED AGGREGATE

Figure 45-3T

8. Popouts. Popouts develop as a result of expansive aggregates expanding during a freeze-thaw cycle, and breaking free from the surface of a PCC pavement. This distress does not pose a safety concern, nor does it affect the structural capacity of a pavement (see Figure 45-3U).

POPOUTS

Figure 45-3U

9. Potholes. Potholes often occur as a result of severe weathering/raveling or severe alligator cracking. Typically pavements with excessive potholes are beyond the need for preventive maintenance activities; patching is typically used as a localized repair (see Figure 45-3V).

POTHOLES

Figure 45-3V

10. Punch-outs. A punch-out is a type of distress that occurs in continuously reinforced concrete pavements (CRCP). A portion of a cracked slab breaks free from the surrounding pavement and partially sinks into the base/subgrade (see Figure 45-3W).

PUNCH-OUTS

Figure 45-3W

11. Shoving. Shoving can refer to a couple of different distress types. First, shoving can occur at the interface between HMA and PCC pavements. In this case, the expansive forces of the PCC during hot weather can apply pressure to the HMA. As a result, the HMA along the interface will bulge or it will crack and break into pieces. Shoving also can refer to areas in an unstable HMA pavement where areas of the pavement move under a load – similar to rutting, but localized (see Figure 45-3X).

SHOVING

Figure 45-4X

12. Slippage Cracking. Slippage cracking occurs when the surface HMA layer is no longer bonded to the layer directly below it (another HMA layer, PCC, brick, or other non-granular material) allowing the surface layer to move when breaking or turning wheel loads are applied. Often cracking appears in a crescent shaped pattern which may open into a wide crack in only the upper-most HMA lift (see Figure 45-3Y).

SLIPPAGE CRACKING

Figure 45-3Y

13. Swelling. Upward heave of a flexible pavement, typically due to frost heave or expansive soils below the surface, is referred to as swelling. Blow-ups of underlying PCC pavement are also sometimes categorized as swelling.

45-3.03(d) Use of Pavement Preservation to Maintain Pavement Performance

Pavement preservation can address many of the various distress types discussed in the previous section. Specifically, pavement preservation techniques have two main uses: 1) prevent or slow many distresses from occurring or 2) correct some minor surface distress when applied.

Some of the pavement problems that are prevented or slowed with the use of pavement preservation for flexible and rigid pavements are detailed in Figure 45-3Z. The distresses that are corrected with the use of pavement preservation are detailed in Figure 45-3AA.

HMA or Other Bituminous Surfaces Problems	PCC Problems
Loss of fines (pumping) Crack deterioration Block cracking Edge cracking Potholes Weathering/raveling Roughness	Loss of fines Crack deterioration Corner breaks Blow-ups Joint spalling Joint faulting Roughness

PAVEMENT PROBLEMS PREVENTED OR SLOWED WITH PAVEMENT PRESERVATION

Figure 45-3Z

HMA or Other Bituminous Surfaces Problems	PCC Problems
Stable asphalt rutting Raveling Bleeding/flushing Surface friction loss Roughness	Joint seal damage Map cracking and scaling Surface friction loss Roughness

PAVEMENT PROBLEMS CORRECTED WITH PAVEMENT PRESERVATION

Figure 45-3AA

The benefits realized by the application of pavement preservation are accomplished because these techniques accomplish the following: 1) reduce water infiltration, 2) maintain drainage, 3) reduce water infiltration into cracks and joints, 4) slow aging effects of the pavement, and 5) minimize dynamic loads.

The reduction in water infiltration and the proper maintenance of drainage help protect the underlying layers of the pavement from being softened or washed away and also help reduce the effects of freeze/thaw-induced distress. The reduction of incompressible debris into the joints and cracks greatly reduces the potential for crack deterioration, joint spalling, and pavement blow-ups. The use of global preventive maintenance surface treatments can help to slow asphalt aging/hardening. The pavement preservation techniques also help preserve the pavement by reducing and/or correcting pavement roughness, which helps minimize dynamic loadings and in turn extends the life of the pavement.

There is a point in the life of the pavement when pavement preservation techniques will no longer provide an adequate treatment to the pavement. In those cases, the pavement has deteriorated to the point that preservation techniques, if used, will have shortened lives. Some indicators that the pavement section is not a viable candidate for preservation treatments are shown in Figure 45-3AB.

HMA or Other Bituminous Surfaces Problems	PCC Problems
Potholes Severely deteriorated cracks Delaminations Unstable rutting	Blow-ups Corner breaks Severely deteriorated cracks

INDICATIONS THAT IT IS TOO LATE FOR PAVEMENT PRESERVATION

Figure 45-3AB

45-4 CONDITION RATING ASSESSMENTS

45-4.01 General

Effective pavement preservation cannot be performed without an appropriate assessment of pavement condition for the pavement sections in the network. Pavement condition data are necessary to document current condition, determine future conditions, and evaluate possible future preservation strategies.

The condition of the pavement can be determined through the use a variety of methods: 1) surface condition, 2) roughness/ride quality, 3) structural capacity, and 4) surface friction. For all condition assessment procedures, the methods that provide the highest level of accuracy often cost the most in terms of time, effort, and money. Therefore, final decisions on which data to collect and methods for data collection should be carefully considered based upon available resources. For this reason many local agencies focus on conducting a surface distress condition analysis for the pavement network, as the required data can be collected using a variety of methods. The collection of roughness/ride quality, structural capacity, and surface friction information often involves the use of specialized equipment. Therefore, this testing is often only used on a project-by-project basis or when adequate funding is available.

45-4.02 Surface Condition

Pavement surface condition surveys can vary greatly. Some procedures are simple subjective assessments of the pavement surface condition while others are more detailed determinations of types, severities, and quantities of distress that is present on the pavement surface. The simple methods, which are often a subjective rating of the surface condition from the windshield of a slow moving vehicle, are quicker to perform but provide limited information for the selection of preservation projects for specific pavement sections. Detailed distress information can be collected either manually through walking surveys which can be labor intensive or through the use of semi-automated or automated data collection vans. The use of data collection vans can reduce time in the field, but depending upon the survey methodology and level of automation used, the surveys can be as time consuming as walking surveys. Nevertheless, the detailed distress surveys provide all the details necessary to select a specific preservation project for a pavement section.

Details of four different surface condition rating procedures are provided here as potential options to be used by the agency when conducting condition surveys. There are many other survey options available to agencies. Each agency should consider the complexity of the procedure along with available time and resources when deciding on the condition survey procedure that will work best for the agency long-term. The following example procedures are presented: Pavement Surface Evaluation and Rating (PASER), Condition Rating Survey (CRS), the Pavement Condition Index (PCI), and the rating procedure associated with the Transportation Asset Management System (TAMS) developed by the Utah Local Technical Assistance Program (LTAP). Additional information regarding these condition rating procedures can be obtained from the Illinois LTAP center at http://www.dot.state.il.us/blr/t2center.html.

45-4.02(a) Pavement Surface Evaluation and Rating (PASER)

The PASER system was developed by the Wisconsin Transportation Information Center to evaluate pavement surface conditions using visual evaluations. Rating guides exist for both asphalt and concrete roads.

The evaluation for asphalt pavements is focused on identifying the different types of pavement distress on the roadway and grouping that distress into four major categories: surface defects, surface deformation, cracks, and patches/potholes. For rigid pavements, the four major categories of distress are the following: surface defects, joints, pavement cracks, and pavement deformation.

For both of these procedures, the condition of the pavement is assessed and based upon documented distress present a rating on a 10-point rating scale (10–excellent condition to 1–failed condition) is assigned to the pavement as shown in figure 45-4A. If an agency is using this rating procedure to determine the condition of the pavement network, it is advised that they also note the most prominent distress type present on the pavement section so it can be utilized when making final preservation treatment selection. Figure 45-4A also provides a range of PASER conditions in which pavement preservation is feasible and not feasible.

PASER Condition Ranges			
Excellent		10 – 9	10 – 5: Feasible for pavement preservation
Very Good		8	
Good		7 – 6	
Fair		5 – 4	
Poor		3	4 – 1: Not feasible for pavement preservation
Very Poor		2	
Failed		1	

PAVEMENT PASER CONDITION RANGE CLASSIFICATIONS

Figure 45-4A

45-4.02(b) Condition Rating Survey (CRS)

The CRS procedure has been used by the Department as its standard methodology of documenting pavement condition since 1974. The CRS is based upon the visual pavement condition, in which a rating between 9.0 (excellent) and 1.0 (poor) is assigned to the pavement based upon the existing surface condition. Figure 45-4B displays the CRS Condition Ratings and also provides a range of conditions in which pavement preservation is feasible and not feasible.

CRS Condition Ranges			
Excellent		9.0 – 7.6	9.0 – 6.1: Feasible for pavement preservation
Satisfactory		7.5 – 6.1	
Fair		6.0 – 4.6	6.0 – 1.0: Not feasible for pavement preservation
Poor		4.5 – 1.0	

PAVEMENT CRS CONDITION RANGE CLASSIFICATIONS

Figure 45-4B

Procedures exist for calculating the CRS from automated surveys, but values can be assigned to a pavement section using the *Condition Rating Survey Manual for IDOT* as a basis. Further information regarding the CRS procedure can be obtained from the Office of Planning and Programming.

45-4.02(c) Pavement Condition Index (PCI)

The PCI is a numerical indicator that rates the surface condition of the pavement. The PCI procedure was developed by the U.S. Army Corps of Engineers (USACOE) to provide a systematic methodology for rating and reporting pavement condition. The procedure is described in the USACOE Construction Engineering Research Laboratroy (CERL) Technical Report M-90/05, *Pavement Maintenance Management for Roads and Streets using the PAVER System* and the *APWA PAVER Pavement Condition Index Field Manual* and adopted by ASTM as a testing standard in D 6433, *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys.*

The output of the PCI procedure is a single number providing a numerical indication of the overall pavement condition. A PCI score encompasses components of the pavement that reflect its structural integrity, environmental damage, and other associated performance factors (e.g. safety). As shown in figure 45-4C, the final calculated PCI score is a number from 0 to 100, with 100 representing a pavement in excellent condition. Figure 45-4C also provides a range of PCI conditions in which pavement preservation is feasible and not feasible.

PCI Condition Ranges			
Excellent		100-86	100 – 65: Feasible for pavement preservation
Very Good		85-71	
Good		70-56	
Fair		55-41	64 - 0: Not feasible for pavement preservation
Poor		40-26	
Very Poor		25-11	
Failed		10-0	

PAVEMENT PCI CONDITION RANGE CLASSIFICATIONS

Figure 45-4C

During the PCI survey procedure, the types of distress present on the pavement surface are quantified in terms of type, severity, and extent. This information provides valuable information on the current condition of the pavement, and is used in calculating the associated PCI value for the roadway.

45-4.02(d) Transportation Asset Management System (TAMS) Condition Rating

The Utah LTAP developed the TAMS to assist cities and counties with the management of their transportation systems. TAMS is an asset management computer program that utilizes information from a condition rating procedure to determine work strategies for the pavement network.

The distresses observed on the roadway are rated according to the Strategic Highway Research Program (SHRP) Distress Manual (Miller and Bellinger 2003). The rating forms utilize a matrix setup and classify the distresses according to low, medium, and high extents and severities. With the distress extent and severity classified, the condition information is entered into TAMS and used to determine the appropriate treatments for the pavement sections in the network.

45-4.03 Roughness/Ride Quality

Roughness information is often used to classify the ride quality of a pavement section from the users' perspective. This information can be used to characterize the condition of the roadway. Depending upon the level of detail desired for the roughness survey, data can be collected in a variety of manners. For example, if data is needed on a qualitative basis, a windshield survey where each driving lane is driven at posted speed limits and broad categories of roughness (e.g., not rough, slightly rough, moderately rough, very rough) are noted can be used. However, when detailed quantitative data is needed roughness-measuring equipment can be obtained using commercially available equipment. Further information regarding pavement roughness data is provided in section 53-1.04(b) of the IDOT *Bureau of Design Manual*.

45-4.04 Structural Capacity

Nondestructive testing can be used to measure the structural capacity of a pavement section. Often a device such as a falling weight deflectomer (FWD) is used to "backcalculate" the fundamental engineering properties of the pavement structure and underlying subgrade soil. The information can then be used to determine overly thickness for those pavements needing structural enhancement. Additional details regarding the use of the FWD are provided in Section 53-3.03 of the IDOT *Bureau of Design Manual*.

45-4.05 Surface Friction

Surface friction is another characteristic that can be used to assess the condition of the pavement. Surface friction, which is sometimes referred to as skid resistance, is directly related to the safety of the roadway. Details regarding pavement friction testing are provided in Section 53-3.04 of the IDOT *Bureau of Design Manual*.

45-5 TREATMENT SELECTION GUIDELINES

45-5.01 General

The use of pavement preservation strategies to maintain the condition of the pavement network requires that an agency address the following two questions:

- Is the pavement a good candidate for pavement preservation?
- If so, what treatment(s) can be applied?

Appropriate maintenance strategies are determined based upon a combination of the current condition of the pavement and the types of distresses present. In some cases, combinations of preservation strategies are needed to correct the combination of distress that is present on the pavement. The process of selecting the most appropriate combination of pavements and treatments for preservation activities includes the following general steps:

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

45-5.02 Gather Pavement Information

Selecting appropriate preservation techniques includes the collection of historical pavement information. The type of information needed to select the right projects and treatments include 1) pavement type, 2) pavement age and design life, 3) traffic, and 4) pavement cross section and materials. This is the type of information that can be housed in a pavement management system and accessed to make informed selection of the “right treatment at the right time on the right road”.

The pavement type dictates the choice of treatment, as different techniques are appropriate for various surface types. In addition to pavement type, the age and design life of the pavement can provide insight into how the pavement has performed over time and how it can be expected to perform in the future. If the pavement is near the end of its design life, it may be an indication that preservation is not appropriate. The traffic level information, specifically the number of heavy trucks, is a critical detail for determining treatments that cannot provide appropriate performance for the expected traffic level. Knowing the existing pavement structure and materials properties can also be very useful to determine what treatments will work well with the current structure and how the pavement section might perform in the future.

45-5.03 Assess Pavement Condition

In addition to gathering historical pavement information, the current condition of the pavement must be assessed in order to determine feasible preservation treatments. Ideally the condition would be determined in the form of a standard condition rating procedure to include details of the types, severities, and the amounts of all distresses present on the pavement. A variety of example condition rating procedures are described in section 45-4 for use in assessing the condition of the pavement. The agency also has the opportunity to use any other standard rating procedure or can use the general guidelines for detailing distress types that is provided in Section 45-4.02 to assess the types of distress present on their pavement network.

45-5.04 Evaluate Pavement Data

In order to determine whether a pavement section is a good candidate for pavement preservation treatments, the agency should consider the following:

- Is there excessive distress (large quantities and/or severe levels of distress) on the pavement section?
- Is there evidence of structural problems (e.g., any of the distresses listed in Figure 45-3AB)?
- Has the time for applying a pavement preservation treatment to the pavement while it is in "good" condition passed?
- Are there other known pavement problems (e.g., material problems or signs of construction problems) on the pavement section?
- Is there a history of pavement problems in this location?

If the answer to the majority of these questions is "no," then the pavement section is likely to be a good candidate for pavement preservation techniques. For pavement sections for which the answer to most of these questions is "yes," the agency should not consider preservation techniques and instead plan major rehabilitation or future reconstruction for the roadway.

For those sections that are good candidates for preservation treatments, figure 45-5A provides additional general guidelines for determining if the section should receive preservation treatments.

Condition Rating Procedure	Typical condition ranges for pavement preservation treatments
PASER	10 to 5
IDOT's CRS	9.0 to 6.0
PCI	100 to 65

GENERAL GUIDELINES TO DETERMINE IF THE PAVEMENT SECTION IS ELIGIBLE FOR PAVEMENT PRESERVATION TREATMENTS

Figure 45-5A

45-5.05 Identify Feasible Preservation Treatments

The appropriate treatment strategy for those pavement sections identified as candidates for pavement preservation can be determined by looking at the type and severity of pavement distresses present on the pavement. Guidelines for determining recommended and feasible treatments are provided in figures 45-5B and 45-5C for flexible and rigid pavements. Figures 45-5B and 45-5C provide guidance for treatment selection based upon attributes such as distress levels, ride, friction, traffic levels, and relative cost. These characteristics are primarily based on a relationship between a single treatment and a single distress. When multiple distresses exist, the appropriate treatment to address each distress type should be examined and the recommended treatments must be used in combination with engineering judgment to make final treatment decisions.

45-5.06 Select Most Appropriate Preservation Treatment

Of the feasible preservation treatments, the most appropriate treatment is one that can provide the best cost/benefit while meeting the constraints of the project. There are several methods to identify the treatment with the most benefit for the associated cost. This analysis is done internally within many pavement management systems. Ideally, the selection of the right treatment at the right time is governed by optimization (maximizing benefits for given constraints). However, treatment selection can be accomplished through a manual assessment of the benefits versus the projected project cost.

In addition to the benefits and costs of the feasible treatments, the selection of the most appropriate preservation treatment also includes considering the variety of project constraints that affect treatment selection. The types of project constraints that should be considered when selecting the most appropriate preservation treatment include:

- Availability of qualified contractors.
- Availability of quality materials.
- Agency practice or local preference.
- Time (of year) of construction.
- Initial costs.
- User preferences.
- Pavement noise.
- Facility downtime.
- Surface friction.

The effect of these constraints will vary from project to project and should be taken into consideration as the final projects are selected for inclusion in a pavement preservation program.

Pavement Conditions	Severity Levels	Crack Filling	Crack Sealing	Fog Seal	Sand Seal	Scrub Seal	Rejuvntr	Slurry Seal	Micro-surfacing	Chip Seal	Cape Seal	CIR	HIR	Thin HMA Overlay	Ultra-Thin Friction Course	UTW	Cold Mill	Drainage Presrvtn
Alligator/ Fatigue Cracking [1]	Light	F	F	NR	NR	NR	NR	F	F	F	F	F	F	F	F	F	NR	R
	Moderate	NR	NR	NR	NR	NR	NR	NR	NR	F	NR	NR	NR	NR	NR	NR	NR	F
	Severe	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	F
Block Cracking	Light	R	R	F	R	R	NR	R	R	R	R	R	R	R	F	R	F	NR
	Moderate	R	R	NR	NR	F	NR	F	NR	F	F	R	R	F	NR	NR	NR	NR
	Severe	F	F	NR	NR	NR	NR	NR	NR	NR	NR	F	F	NR	NR	NR	NR	NR
Bleeding	Light	NR	NR	NR	F	F	NR	F	R	R	R	R	R	R*	R	R	R	NR
	Moderate	NR	NR	NR	NR	NR	NR	NR	R	F	F	R	R	F	F	F	F	NR
	Severe	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	F	F	NR	NR	NR	F	NR
Longitudinal and Transverse Cracking [2]	Light	R	R	F	R	R	NR	R	R	R	R	R	R	R**	F	R	F	NR
	Moderate	R	R	NR	NR	NR	NR	F	F	F	F	F	F	R**	NR	F	NR	NR
	Severe	F	F	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
"Stable" Rutting [3]	Light	NR	NR	NR	NR	NR	NR	F	R	F	F	R	R	R*	F	R*	F	R
	Moderate	NR	NR	NR	NR	NR	NR	NR	R	NR	NR	R	R	R	NR	R*	F	F
	Severe	NR	NR	NR	NR	NR	NR	NR	F	NR	NR	R	R	NR	NR	R*	F	F
Weathering/ Raveling	Light	NR	NR	R	R	R	R	R	R	R	R	R	R	R	R	R	NR	NR
	Moderate	NR	NR	F	F	F	F	R	R	R	R	R	R	R	F	F	NR	NR
	Severe	NR	NR	NR	NR	NR	NR	F	F	F	F	R	R	R*	NR	NR	F	NR
Ride	Poor	NR	F	NR	F	F	NR	NR	F	NR	F	R	R	R	F	R	R	F
Friction	Poor	NR	NR	NR	R	R	NR	R	R	R	R	R	R	R	R	R	R	NR
ADT	< 2,500	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
	2,500 – 10,000	R	R	F	F	F	F	F	R	R	R	R	R	R	R	R	R	R
	> 10,000	R	R	NR	NR	NR	NR	NR	R	F	R	NR	R	R	R	R	R	R
Relative Cost	($ to $$$$)	$	$	$	$$	$$	$$	$$	$$	$$	$$	$$$	$$$	$$$	$$$	$$$$	$	Varies

R - Recommended treatment for the specified pavement condition. Engineer should ensure that all critical distress types are addressed by the selected treatment.

F - Feasible treatment, but depends upon other project constraints including other distresses.

NR - Treatment is not recommended to correct the specified pavement condition.

R* - Recommended treatment when used with milling prior to treatment.

R** - Used in combination with crack sealing.

1- Preservation treatments do not correct alligator cracking. Of the included treatments, chip seals are most effective at covering the alligator cracking.

2 - If longitudinal and transverse cracking are present without other distresses, crack filling or sealing is recommended.

3 - If stable rutting is present without other distresses, microsurfacing or mill and overlay are the recommended treatment.

TREATMENT SELECTION GUIDELINES FOR FLEXIBLE PAVEMENTS

Figure 45-5B

Pavement Conditions	Parameters	Crack Sealing	Joint Resealing	Diamond Grinding	Diamond Grooving	Full-Depth Repairs	Partial-Depth Repairs	LTR [1]	Cross Stitching	Subsealing/ Undersealing	Drainage Presrvtn
Corner Breaks	Light	R	NR	NR	NR	NR	NR	NR	NR	NR	R
	Moderate	R	NR	NR	NR	F	NR	NR	NR	NR	F
	Severe	NR	NR	NR	NR	R	NR	NR	NR	NR	NR
D-cracking	Light	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Moderate	NR	NR	NR	NR	F	R	NR	NR	NR	NR
	Severe	NR	NR	NR	NR	R	NR	NR	NR	NR	NR
Faulting	Light	NR	R	F	NR	NR	NR	NR	NR	NR	R
	Moderate	NR	F	R	NR	NR	NR	R	NR	R	F
	Severe	NR	NR	R*	NR	NR	NR	R	NR	R	NR
Joint Seal Damage	Light	NR	F	NR	NR	NR	NR	NR	NR	NR	NR
	Moderate	NR	R	NR	NR	NR	NR	NR	NR	NR	NR
	Severe	NR	R	NR	NR	NR	NR	NR	NR	NR	NR
Longitudinal Cracking	Light	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Moderate	R	NR	NR	NR	F	NR	NR	R	NR	NR
	Severe	F	NR	NR	NR	R	NR	NR	F	NR	NR
Pumping	All	NR	F	NR	NR	NR	NR	F	NR	R	R
Spalling	Light	NR	F	NR	NR	NR	F	NR	NR	NR	NR
	Moderate	NR	F	NR	NR	NR	R	NR	NR	NR	NR
	Severe	NR	NR	NR	NR	F	R	NR	NR	NR	NR
Surface Distress	Light	NR	NR	F	NR	NR	NR	NR	NR	NR	NR
	Moderate	NR	NR	F	NR	NR	F	NR	NR	NR	NR
	Severe	NR	NR	F	NR	NR	F	NR	NR	NR	NR
Transverse Cracking	Light	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Moderate	R	NR	NR	NR	F	NR	F	NR	NR	NR
	Severe	F	NR	NR	NR	R	NR	R	NR	NR	NR
Ride	Poor	NR	NR	R	NR	NR	NR	F*	NR	F	F
Skid	Poor	NR	NR	R	R	NR	NR	NR	NR	NR	NR
Relative Cost	($ to $$$$)	$	$	$$	$$	$$$$	$$$	$$$	$$$	$$	Varies

R - Recommended treatment for the specified pavement condition. Care must be examined in making sure that all critical distress types are addressed by the selected treatment.

R* - Recommended when used in conjunction with LTR and/or Subsealing/Undersealing.

F - Feasible treatment but depends upon other project constraints including other existing distresses.

F* - Feasible treatment if poor ride is a result of undoweled joints or faulted transverse (mid-slab) cracking.

NR - Treatment is not recommended to correct the specified pavement condition.

1 - LTR (Load Transfer Restoration) is normally used in combination with diamond grinding.

TREATMENT SELECTION GUIDELINES FOR RIGID PAVEMENTS

Figure 45-5C

45-6 TREATMENTS

45-6.01 General

Many different pavement preservation techniques and treatments are available. These range from localized applications to treatments that are applied to the entire pavement surface. For all preservation treatments, the purpose is to minimize the effects of pavement distress or prevent them from occurring.

Commonly used preventive maintenance treatments and minor rehabilitation techniques are described in one-page summaries in this section. Further details regarding the treatments are available in the standard and supplemental specifications and the special provisions. Each treatment summary is followed by a simple pictorial representation of the major steps of the construction sequence for the treatment. The flexible and rigid pavement treatments that are presented are summarized in Figure 45-6A. Prior to the presentation of each treatment type is a *Special Considerations* section that provides details that are applicable to a variety of treatments.

Treatments for Flexible Pavements	**Treatments for Rigid Pavements**
Crack Filling Crack Sealing Fog Seals Sand Seals Scrub Seals Rejuvenators Slurry Seals Microsurfacing Chip Seals Cape Seals Cold In-place Recycling (CIR) Hot In-Place Recycling (HIR) Thin Asphalt Concrete Overlay Ultra-Thin Bonded Wearing Course Ultra-Thin Whitetopping (UTW) Cold Milling	Crack Sealing Joint Resealing Diamond Grinding Diamond Grooving Full-Depth Repairs Partial-Depth Repairs Load Transfer Restoration (LTR) Cross Stitching Pavement Subsealing/Undersealing
Drainage Preservation	

PAVEMENT PRESERVATION TREATMENTS FOR FLEXIBLE AND RIGID PAVEMENTS

Figure 45-6A

45-6.02 Special Considerations

There are several special considerations that must be addressed prior to the construction of various pavement preservation techniques.

45-6.02(a) Raised Pavement Markers

All pavement sections should be reviewed for the presence of raised pavement markers (RPMs) prior to treatment placement for global treatments. The thickness of the treatment should be evaluated to determine if the RPMs can remain in place. If so, the lens of the marker can be removed and tape placed over the marker during treatment placement. Following treatment placement, the tape can be removed and a new lens can be installed.

If the thickness of the treatment is such that the markers must be removed, then the hole from the removal of the markers should be repaired prior to the new treatment and the new marker should be repositioned in the new surface.

45-6.02(b) Pavement Preparation

All flexible pavement sections should be evaluated for the presence of bumps greater than 0.5 inch (12 mm) using a 16-foot straightedge. For flexible treatments that do not include milling or recycling of the pavement surface, the bumps should be ground prior to treatment placement. Special attention should be given to properly cleaning all milled materials off of the pavement surface prior to treatment placement. Cleaned surfaces are imperative prior to global flexible surface treatments in order to obtain proper bonding to the underlying pavement. Crack sealing, when needed prior to preventive maintenance treatment, should be placed at least 3 months prior to the placement of the treatment to minimize difficulties in constructing the treatment.

45-6.02(c) Pavement Markings

A minimum of seven days of good drying weather is needed prior to the placement of paint striping on various flexible pavement treatments. Temporary striping of water-based paint or foil-backed tape will be until permanent markings can be applied.

45-6.02(d) Traffic Control

Proper traffic control is needed to ensure acceptable cure times for the majority of treatments. Without proper traffic control after placement, premature failure of the preservation treatment may occur. For rigid pavements, the use of conventional patch materials is usually best for the long-term performance of the pavement but requires adequate curing which may not be available in high traffic volume areas or at certain times of the year.

45-6.02(e) Treatment Sequencing

When planning preservation work on rigid pavements, consideration should be given to the proper sequencing of treatments. For rigid pavements, an appropriate treatment sequence consists of the following: full- or partial-depth repairs, load transfer restoration, diamond grinding, and joint resealing.

45-6.03 Flexible Pavement Treatment Summaries

45-6.03(a) Crack Filling

Crack filling is effective at reducing or delaying moisture damage, further crack deterioration, roughness, and rutting. However, crack filling can also have a negative impact on roughness and friction. (See Figure 45-6B)

Treatment Description: Crack filling is the process of placing material into non-working cracks to substantially reduce infiltration of water and to reinforce the adjacent pavement. Crack filling is characterized by minimal crack preparation and the use of lower quality bituminous filler materials.

Pavement Conditions Addressed: Adds no structural benefit, but does reduce moisture infiltration through cracks. Only practical if extent of cracking is minimal and if there is little to no structural cracking.

Application Limitations: These treatments are not recommended when structural failures exist (i.e., extensive fatigue cracking or high severity rutting) or if there is extensive pavement deterioration, or little remaining life. Crack filling is appropriate for cracks 0.125 to 1.0 inch wide (3.175 to 25.4 mm).

Non-working cracks narrower than 0.125 inches (3.175 mm) that do not exhibit spalling should not be filled. These cracks generally do not penetrate through the surface nor do they pose a source of pavement deterioration. The practice of filling this type of crack by the method of pouring filler on the pavement surface is seldom of value. A crack analysis should be performed to determine whether crack filler would be effective.

Construction Considerations: Placement should occur during cool, dry weather conditions. Application during cool weather will allow for expanded crack widths. Proper crack cleaning and a dry crack are essential to achieve good bond and maximum performance.

Traffic Considerations: Performance is not significantly affected by varying ADT or truck levels. However, improper installation can permit the filler to fail.

Special Considerations: Crack filling may have negative effects. Undesirable visual impacts may occur, which include tracking of filling material by tire action, obscuring lane markings, and adversely affecting friction/skid resistance. Crack filling may result in a rougher pavement surface when the filler material is forced out of the cracks during warm months.

Performance Period: 2 to 4 years.

Relative Cost ($ to $$$$): $

Step 1. Crack cleaning. The crack-filling process requires minimal crack preparation. This typically consists of using compressed air to clean the cracks.

Step 2. Application of crack filler. This photo shows the application of a crack filler using an "overbanded" configuration.

Step 3. Application of blotter. For hot-applied materials, a blotter coat of sand is often used to reduce "tracking" of the material by vehicle tires.

GENERAL CRACK FILLING STEPS

Figure 45-6B

45-6.03(b) Crack Sealing

Crack sealing is effective at reducing or delaying moisture damage, further crack deterioration, roughness, and rutting. However, crack sealing can also have a negative impact on roughness and friction. (See Figure 45-6C)

Treatment Description: Crack sealing is the process of placing higher-quality material into "working" cracks (i.e., those that open and close with changes in temperature) in order to reduce water infiltration into a pavement. In contrast to crack "filling," crack sealing requires more substantial crack preparation procedures and uses higher quality sealant materials. Thermosetting and thermoplastic materials are both used for crack sealing.

Pavement Conditions Addressed: Adds no structural benefit, but does reduce future intrusion of incompressible materials, water and soluble chemicals (e.g., salts and brines) into the cracks. It is only practical if extent of cracking is minimal and if there is little to no structural cracking.

Application Limitations: These treatments are not recommended when structural failures exist (i.e., extensive fatigue cracking or high severity rutting) or if there is extensive pavement deterioration, or little remaining life. Crack sealing is appropriate for cracks 0.125 to 1.0 inch (3.175 to 25.4 mm) wide.

Non-working cracks narrower than 0.125 inches (3.175 mm) that do not exhibit spalling should not be sealed. These cracks generally do not penetrate through the surface nor do they pose a source of pavement deterioration. The practice of filling this type of crack by the method of pouring sealant on the pavement surface is seldom of value.

Construction Considerations: Placement should occur during cool, dry weather conditions with moderate yearly temperatures. Proper crack preparation and cleaning is essential to good bond and maximum performance. Some agencies also use a hot compressed air lance prior to sealing.

Traffic Considerations: Performance is not significantly affected by varying ADT or truck levels. However, improper installation can permit the sealant to fail.

Special Considerations: Crack sealing may have negative effects. Undesirable visual impacts may occur, which include tracking of sealing material by tire action, obscuring lane markings, and adversely affecting skid resistance. Crack sealing may result in a rougher pavement surface when the sealant material is forced out of the cracks during warm months. Sealing is best accomplished several months in advance of any other preventive maintenance surface applications.

Performance Period: 2 to 8 years.

Relative Cost ($ to $$$$): $

Step 1. Crack refacing. A uniform sealant reservoir increases the probability of a neater, better performing sealant installation.

Step 2. Cleaning and drying. Cracks must be clean and dry to facilitate sealant bonding.

Step 3. Material application. This photo shows the application of sealant using a "simple band-aid" configuration.

Step 4. Application of blotter. For hot applied materials, a blotter coat of sand is often used to reduce "tracking" of the material by vehicle tires.

GENERAL CRACK SEALING STEPS

Figure 45-6C

45-6.03(c) Fog Seals

Fog seals are effective at sealing the pavement, inhibiting raveling, enriching the hardened/oxidized asphalt, and providing some pavement edge-shoulder delineation. However, fog seals can have a negative impact on friction and stripping in susceptible HMA pavements. (See Figure 45-6D)

Treatment Description: Fog seals are very light applications of a diluted asphalt emulsion placed directly on the pavement surface with no aggregate. Typical application rates range from 0.05 to 0.10 gal per yd^2 (0.23 to 0.45 liters per m^2).

Pavement Conditions Addressed: Fog seals are placed primarily to seal the pavement, inhibit raveling, slightly enrich a hardened/oxidized asphalt, and provide some pavement edge-shoulder delineation. No structural benefit is added by this treatment.

Application Limitations: This treatment is not recommended when structural failures exist (e.g., significant fatigue cracking) or if there is already flushing/bleeding, friction loss, or thermal cracking.

Construction Considerations: Typically, a slow-setting emulsion (e.g., CSS-1H, SS-1H) is used, which requires time to “break.” Because of this, the pavement is sometimes closed for 2 hours for curing before being re-opened to traffic.

Traffic Considerations: Increased ADT or truck levels can increase surface wear.

Special Considerations: Special consideration should be given to the raised pavement markers and bump grinding prior to treatment placement.

Performance Period: 1 to 3 years.

Relative Cost ($ to $$$$): $

Step 1. Surface preparation. The surface must be free of dust, dirt, and debris prior to applying the emulsion.

Step 2. Application of emulsion. The emulsion is applied using a distributor truck.

Step 3. Sand blotter and sweeping (if necessary). Sand blotters can help address a problem with delayed curing, as well as early opening to traffic. Sweeping may be required to remove excess sand.

GENERAL FOG SEAL CONSTRUCTION STEPS

Figure 45-6D

45-6.03(d) Sand Seals

Sand seals are effective at improving poor friction and reducing or preventing moisture damage, cracking, raveling, roughness, and rutting. However, they can also have a negative impact on stripping in susceptible HMA pavements. (See Figure 45-6E)

Treatment Description: A sand seal is a thin asphalt surface treatment constructed by spraying a non-diluted emulsion, spreading a thin layer of fine aggregate (i.e., sand), and rolling. Sand seals are typically 0.1 to 0.2 in (2 to 5 mm) thick. The primary purpose is to increase surface friction; however, in some cases, sand seals are used to "lock" the aggregates in a chip seal.

Pavement Conditions Addressed: Sand seals are primarily placed to improve poor friction; however, they are effective at slowing or preventing other distresses such as moisture damage, cracking, raveling, roughness, and rutting. No structural benefit is added by this treatment.

Application Limitations: This treatment is not recommended when structural failures exist (e.g., fatigue cracking or high severity rutting), or if there is extensive pavement deterioration or little remaining life.

Construction Considerations: Sand seals should be constructed when conditions are dry (i.e., the risk of rain is not likely which would hinder the proper construction of the sand seal) and when the minimum air temperature is moderate (i.e., normally 50 °F [10°C] or above). To assure good bond to the existing pavement, the surface should be clean and dry prior to emulsion placement.

Traffic Considerations: Sand seals should generally be limited to lower volume traffic conditions with a low percentage of trucks.

Special Considerations: Special consideration should be given to the raised pavement markers and bump grinding prior to treatment placement.

Performance Period: 3 to 4 years.

Relative Cost ($ to $$$$): $$

Step 1. Surface preparation. The surface must be free of dust, dirt, and debris prior to applying the emulsion.

Step 2. Application of emulsion. The non-diluted emulsion is applied using a distributor truck.

Step 3. Sand application. Sand is applied with a spreader immediately after spray emulsion.

Step 4. Rolling and brooming. After the application of sand, the surface is rolled with pneumatic-tired rollers and broomed if necessary.

GENERAL SAND SEAL CONSTRUCTION STEPS

Figure 45-6E

45-6.03(e) Scrub Seals

Scrub seals are effective at filling narrow cracks (up to 0.5 in [12 mm]) wide, rejuvenating hardened/oxidized asphalt, and improving poor friction. No structural benefit is added by this treatment. (See Figure 45-6F)

Treatment Description: A scrub seal is a thin asphalt surface treatment constructed by spraying a polymer modified rejuvenating emulsion onto an existing pavement, dragging a broom across the surface to scrub the emulsified asphalt into the surface cracks, immediately spreading a thin layer of fine aggregate (i.e. sand or screenings) over the emulsified asphalt, dragging another broom over the surface to scrub the fine aggregate into the surface cracks, and rolling the surface with a pneumatic tire roller. Thicknesses generally range from 0.2 to 0.4 inches (5 to 10 mm).

Pavement Conditions Addressed: Scrub seals are primarily placed to fill narrow cracks, rejuvenate oxidized asphalt, and improve poor friction. No structural benefit is added by this treatment.

Application Limitations: This treatment is not recommended when structural failures exist (e.g., fatigue cracking) or if there is extensive pavement deterioration, or little remaining life. Scrub seals should not be applied to pavements with ruts greater than 0.25 inch (6 mm) deep.

Construction Considerations: Scrub seals should be constructed when conditions are dry (i.e., the risk of rain is not likely which would hinder the proper construction of the scrub seal) and when the minimum air temperature is moderate (i.e., normally 50 °F [10°C] or above). To assure good bond to the existing pavement, the surface should be clean and dry prior to emulsion placement.

Traffic Considerations: Scrub seals should generally be limited to lower volume traffic conditions with a low percentage of trucks.

Special Considerations: Special consideration should be given to the raised pavement markers and bump grinding prior to treatment placement. Scrub seals are susceptible to snow plow damage.

Performance Period: 2 to 5 years.

Relative Cost ($ to $$$$): $$

Step 1. Surface preparation. The surface must be free of dust, dirt, and debris prior to applying the emulsion.

Step 2. Emulsion application and drag-brooming. Drag-brooming is used to work emulsion into cracks and surface voids.

Step 3. Sand application. A thin layer of sand is applied to the broomed emulsion.

Steps 4 & 5. Drag-brooming of sand and rolling. After the application of sand, the surface is drag-broomed again and rolled with pneumatic-tired rollers.

GENERAL SCRUB SEAL CONSTRUCTION STEPS

Figure 45-6F

45-6.03(f) Rejuvenators

Rejuvenators are effective at reducing the effects of raveling or roughness, and may also be used to slow down thermal cracking. (See Figure 45-6G)

Treatment Description: Rejuvenators are specialized emulsions that are sprayed on an existing asphalt surface with the intent of softening the existing binder, enriching the weathered pavement, and thereby, inhibiting raveling. The emulsions used as rejuvenators are typically mixtures of asphalt, polymer latex, and other additives. Rejuvenating emulsions can be used in a fog seal, sand seal, scrub seal, or any other surface seal applied directly to the pavement surface.

Pavement Conditions Addressed: While rejuvenators do not directly correct any distresses, they are effective at softening the existing binder; thereby, slowing the development of raveling, thermal cracking, and roughness.

Application Limitations: This treatment is not recommended when structural failures exist (e.g., fatigue cracking), where the surface has poor friction, or if there is extensive pavement deterioration or little remaining life.

Construction Considerations: Choosing an appropriate rejuvenating agent, and determining the correct application rate for the existing pavement's material characteristics and condition, are the most important construction-related considerations. Testing needs to be conducted to determine the correct application rate.

Traffic Considerations: Rejuvenators are effective on asphalt surfaces in all traffic conditions. However, traffic should not be allowed back on the surface until adequate friction is restored. This is often provided by the placement of manufactured sand prior to opening to traffic.

Special Considerations: When selecting a rejuvenator for a project, questions regarding available materials can be directed to the IDOT Bureau of Materials and Physical Research.

Performance Period: 3 to 5 years.

Relative Cost ($ to $$$$): $$

Step 1. Rejuvenator application. The rejuvenating emulsion is applied to the surface using a distributor truck.

Step 2. Light sanding. After the rejuvenator has been allowed to be absorbed for the recommended amount of time, a light application of sand is often applied to improve skid resistance.

GENERAL REJUVENATOR CONSTRUCTION STEPS

Figure 45-6G

45-6.03(g) Slurry Seals

Slurry seals are effective at sealing low-severity cracks, waterproofing the surface, and restoring friction. However, they can also accelerate the development of stripping in susceptible AC pavements. (See Figure 45-6H)

Treatment Description: Mixture of crushed well-graded aggregate (fine sand and mineral filler) and asphalt emulsion that is spread over the entire pavement surface with either a squeegee or spreader box attached to the back of a truck. They are effective in sealing low-severity surface cracks, waterproofing the pavement surface, and improving skid resistance at speeds below 30 mph (64 km/h). Thickness is generally <0.5 in (13 mm).

Pavement Conditions Addressed: Low-severity cracking; raveling/weathering (loose material must be removed); asphalt oxidation and hardening; friction loss; and moisture infiltration. While slurry seals add no structural capacity, they can temporarily seal cracks (if severity is low) or fill very minor rutting (if the ruts are not severe and are stable). It is strongly recommended to complete needed patching and crack sealing before slurry seal placement.

Application Limitations: Slurry seals are not recommended when structural failures exist (e.g., significant fatigue cracking and deep rutting) or if there is high-severity thermal cracking. They also can accelerate the development of stripping in susceptible AC pavements.

Construction Considerations: Surface must be clean and areas of traffic tape, thermoplastics, or new paint striping should be removed prior to placement. Aggregates must be clean, angular, durable, well-graded, and uniform. Avoid placement in hot weather (potential flushing problems) or when freezing temperatures are expected. Slurry seals should be placed between May 1 and October 15 and when the temperature is at least 50 °F (10°C) and rising and the forecast for the next 24 hours is above 40 °F (5°C). Avoid premature opening to traffic and premature placement of pavement markers and striping. Quick setting emulsions may cure in as little as 1 hour, but others may require from 2 to 4 hours depending upon the environmental conditions. Temporary pavement markings should be used until permanent markings are applied a minimum of 7 days following slurry seal placement.

Traffic Considerations: Performance in terms of surface wear is affected by increasing ADT and truck traffic levels. Slurry mix properties (i.e., aggregate quality, gradation, modifiers, and emulsion content) can be modified to accommodate the higher traffic volumes. Areas of heavy truck turning or down grade locations are best avoided as there is a high potential for early damage.

Special Considerations: The designer should use the IDOT *Special Provision for Preventive Maintenance – Slurry Seal* as a basis for use of this treatment. Special consideration should be given to the raised pavement markers and bump grinding prior to treatment placement.

Performance Period: 3 to 6 years.

Relative Cost ($ to $$$$): $$

Step 1. Repair existing distress. Any structural failures should be patched, and non-working cracks >0.25 in. (6 mm) wide should be sealed.

Step 2. Prepare surface. Surface must be clean, and striping must be removed. All other in-pavement fixtures (e.g., manholes) need to be protected prior to paving.

Step 3. Slurry placement. This photo shows the placement of material using a slurry seal spreader box.

Step 4. Hand work. Some handwork is required to smooth edges. Excessive handwork can segregate the mix as well as leave an unsatisfactory finish.

GENERAL SLURRY SEAL CONSTRUCTION STEPS

Figure 45-6H

45-6.03(h) Micro-surfacing

Micro-surfacing is effective at correcting or inhibiting raveling and oxidation of the pavement surface, improving surface friction, sealing the pavement surface, and filling minor surface irregularities and wheel ruts up to 1.25 inches (32 mm) deep. (See Figure 45-6I)

Treatment Description: Applied in a process similar to slurry seals, micro-surfacing consists of a mixture of latex-modified emulsified asphalt, mineral aggregate, mineral filler, water, and additives. Micro-surfacing material is mixed in specialized, compartmented, self-powered trucks and placed on the pavement using an augered screed box.

Pavement Conditions Addressed: Low-severity cracking; raveling/weathering (loose material must be removed); low- to medium-severity bleeding; minor roughness; friction loss; and moisture infiltration. Adds limited structural capacity. Temporarily seals fatigue cracks (if severity is low) and can serve as a rut-filler (if the existing ruts are stable). A scratch coat of the microsurfacing can be used for light profile repairs.

Application Limitations: Micro-surfacing is not recommended when the pavement contains structural failures (e.g., significant fatigue cracking), high-severity thermal cracking, or extensive pavement deterioration. This treatment can also accelerate the development of stripping in susceptible AC pavements.

Construction Considerations: Avoid placement in hot weather if there is potential for flushing problems. Placement in cool weather can lead to early raveling. Do not place when freezing temperatures are expected. Micro-surfacing should be placed between May 1 and October 15 and when the temperature is at least 50 °F (10°C) and rising and the forecast for the next 24 hours is above 40 °F (5°C). Avoid premature placement of pavement markers and striping. A minimum of 7 days of good drying weather should be allowed before placement of new markers or striping with temporary markers used prior to permanent placement. Micro-surfacing typically breaks within a few minutes of placement and can carry traffic after approximately an hour.

Traffic Considerations: Very successful on both low and high volume roadways. However, areas of heavy truck turning or down grade locations are best avoided as there is a high potential for early damage. The dusting of a blotter material can be used to allow for earlier opening of intersections and turning lanes.

Special Considerations: The designer should use the IDOT *Special Provision for Preventive Maintenance – Micro-surfacing* as a basis for use of this treatment. If micro-surfacing is being used to fill ruts, this must be specified on the plans along with appropriate gradation and application rate. Special consideration should be given to the raised pavement markers and bump grinding prior to treatment placement.

Performance Period: 4 to 7 years.

Relative Cost ($ to $$$$): $$

Step 1. Repair existing distress. Any structural failures should be patched, and non-working cracks >0.25 in. (6 mm) wide should be sealed.

Step 2. Prepare surface. Surface must be clean, and striping must be removed. All other in-pavement fixtures (e.g., manholes) need to be protected prior to paving.

Step 3. Microsurfacing placement. This photo shows the placement of material using a microsurfacing spreader box.

Step 4. Hand work. Some handwork may be required to smooth edges. Excessive handwork can segregate the mix as well as leave an unsatisfactory finish.

GENERAL MICRO-SURFACING CONSTRUCTION STEPS

Figure 45-6I

45-6.03(i) Bituminous Surface Treatments (BST)

BST, also known as chip seals, are effective at improving poor friction, inhibiting raveling, correcting minor roughness and bleeding, and sealing the pavement surface. (See Figure 45-6J)

Treatment Description: Asphalt (commonly an emulsion) is applied directly to the pavement surface (0.26 to 0.46 gal/yd^2 [1.2 to 2.1 l/m^2]) followed by the application of aggregate chips (16 to 30 lb/yd^2 [9 to 16 kg/m^2]), which are then immediately rolled to imbed chips (50 to 70 percent). Application rates depend upon aggregate gradation and maximum size. This treatment caan be applied in multiple layers (e.g., double chip seals) and in combination with other surface treatments.

Pavement Conditions Addressed: Longitudinal, transverse, and block cracking; raveling/weathering (loose material must be removed); friction loss; minor roughness; low-severity bleeding; and moisture infiltration. Adds almost no structural capacity. The flexible impermeable AC surface helps reduce cracking and is somewhat effective at sealing medium-severity fatigue cracks in comparison with other treatments.

Application Limitations: Not recommended for pavements with the following conditions: structural deficiency; cracks > 0.25 in (6 mm) wide; medium- to high-severity alligator cracking; many potholes; rutting > 1 in (25 mm) deep; very rough surface. BST can also accelerate the development of stripping in susceptible AC pavements.

Construction Considerations: Surface must be clean. Treatment should be placed during warm weather with chip spreader immediately behind asphalt distributor and rollers close behind the spreader. BST are placed from May 1 to August 31 and when the temperature in the shade is above 55 °F (13°C). Approximately 2 hours of cure time are required before roadway may be re-opened to normal speed traffic. Brooming is usually required to remove loose chips. Pilot vehicles should be used to make sure traffic does not damage the fresh surface and to reduce windshield breakage and other vehicle damage. Lightweight aggregate can be used to help minimize claims. Flaggers may be needed at crossing intersections to control traffic. Avoid premature placement of pavement markers and striping.

Traffic Considerations: With special design and proper placement, BST can perform well on high-volume roads. However, use is sometimes limited to lower-speed, lower-volume roads because of the propensity for loose chips to crack windshields.

Special Considerations: The designer should use IDOT's *Special Provision for Preventive Maintenance-- Chip Seals* as a basis for use of the treatment and must specify the gradation for the chip seal on the developed plans. The provision also includes details for extending the construction season. Special consideration should be given to the raised pavement markers and bump grinding prior to treatment placement. Additional information is available from the BLRS Technology Transfer Center (T^2) Report, *Seal Coats (Oil & Chipping)* (IDOT 2006).

Performance Period: Single seals: 4 to 6 years; double seals; 5 to 7 years.

Relative Cost ($ to $$$$): $$

Step 1. Surface preparation. Surface must be clean and dry to ensure good bond with the asphalt.

Step 2. Binder application. The asphalt binder is applied to the surface with a distributor truck.

Step 3. Aggregate application. A self-propelled, pneumatic-tired, motorized unit has a hopper on the front where the chips are dumped.

Steps 4 & 5. Rolling and brooming. After the application of the aggregate, the surface is rolled with pneumatic-tired rollers and broomed to remove excess aggregate.

GENERAL BST CONSTRUCTION STEPS

Figure 45-6J

45-6.03(j) Cape Seals

A cape seal combines a BST with slurry or micro-surfacing to provide a smooth wearing quiet surface at a lower cost than a full asphalt concrete overlay. (See Figure 45-6K)

Treatment Description: The treatment consists of a BST, followed within a few days by a micro-surfacing treatment to cover the chips and seal them in.

Pavement Conditions Addressed: Longitudinal, transverse, and block cracking; raveling/weathering (loose material must be removed); friction loss; minor roughness; low- to medium-severity bleeding; and moisture infiltration. Adds limited structural capacity. Somewhat effective at sealing medium-severity fatigue cracks in comparison with other treatments.

Application Limitations: Not recommended for pavements with the following conditions: structural deficiency; cracks > 0.25 in (6 mm) wide; medium- to high-severity alligator cracking; many potholes; rutting > 1 in (25 mm) deep; very rough surface. This treatment can also accelerate the development of stripping in susceptible AC pavements.

Construction Considerations: Construction should be done in summer months, and the micro-surfacing should follow the BST by no more than 12 days. Temperature and placement time of year details for chip seals and micro-surfacing apply to the use of this treatment. The existing surface should be cleaned and any areas requiring pavement repairs should be corrected using partial depth repairs prior to application of the BST.

Traffic Considerations: No traffic concerns, since the application of the micro-surfacing removes the hazard of loose chips on high-volume or high-speed roadways.

Special Considerations: The designer should use IDOT's *Special Provision for Preventive Maintenance – Cape Seals* as a basis for use of the treatment and must specify the gradation for the BST on the developed plans. The provision also includes details for extending the construction season of the BST. Special consideration should be given to raised pavement markers and bump grinding prior to treatment placement.

Performance Period: 4 to 7 years.

Relative Cost ($ to $$$$): $$

Step 1. Surface preparation. Surface must be clean and dry to ensure good bond with the asphalt.

Steps 2 & 3. Binder and aggregate application. The asphalt binder is applied to the surface with a distributor truck. A self-propelled, pneumatic-tired, motorized unit has a hopper on the front where the chips are dumped.

Steps 4 & 5. Rolling and brooming. After the application of the aggregate, the surface is rolled with pneumatic-tired rollers and broomed to remove excess aggregate.

Step 6. Slurry placement. This photo shows the placement of material using a microsurfacing spreader box. This material should be placed within 12 days of the placement of the chip seal.

GENERAL CAPE SEAL CONSTRUCTION STEPS

Figure 45-6K

45-6.03(k) Cold In-Place Recycling (CIR)

CIR is very effective at correcting distresses contained in the top 2 to 4 in (50 to 100 mm) of the pavement surface. Examples include poor friction and roughness, bleeding, raveling, rutting, and poor cross slope. (See Figure 45-6L)

Treatment Description: Cold in-place recycling (CIR) is an in situ process used to recycle the top 2 to 4 in (50 to 100 mm) of an existing asphalt concrete pavement to construct a new asphalt concrete layer. As the name suggests, the recycling process is conducted without the addition of heat. During the CIR process, the reclaimed asphalt pavement (RAP) is sized, mixed with additives (e.g., asphalt binder, emulsion, rejuvenator, and/or virgin aggregate), and relaid. The recycled pavement is then typically resurfaced with a surface treatment or an AC overlay.

Pavement Conditions Addressed: Cracking limited to the surface layers; profile, crown, and cross slope problems; poor ride quality and surface friction; rutting, corrugations, and bumps; raveling; and bleeding.

Application Limitations: CIR is not an appropriate treatment for pavements with major or extensive structural deficiencies (severe alligator cracking and severe structural rutting), or distresses deeper than the CIR depth. CIR may also be difficult to conduct on steep grades, tightly curved roads, or on roads with many utility appurtenances.

Construction Considerations: The CIR process uses a number of pieces of equipment including tanker trucks, milling machines, crushing and screening units, mixers, pavers, and rollers. CIR should not be performed at temperatures below 50 °F (10 °C) or when it is raining. It takes 1 to 2 weeks of good weather for the CIR material to cure.

Traffic Considerations: CIR is most often used on secondary and low volume roads.

Special Considerations: Areas of weak material should be removed and replaced with suitable patching material prior to recycling to reduce the risk of the cold planing machine or other CIR equipment breaking through the pavement.

Performance Period: 5 to 13 years.

Relative Cost ($ to $$$$): $$$

Step 1. Pulverization. In a multi-unit train, the pavement material is first milled and placed in a windrow.

Step 2. Mix recycling. Next, the milled material is crushed, sized, mixed with recycling additives.

Step 3. Laydown. Conventional paving equipment is used to place the recycled material.

Steps 4. Rolling. Steel-wheeled rollers are used for final compaction.

GENERAL COLD IN-PLACE RECYCLING CONSTRUCTION STEPS

Figure 45-6L

45-6.03(l) Hot In-Place Recycling (HIR)

HIR is effective at correcting surface distresses that are limited to the top 1 to 2 in (25 to 50 mm). Examples include rutting, corrugations, raveling, flushing, loss of surface friction, minor thermal cracking, and minor load-associated cracking. (See Figure 45-6M)

Treatment Description: A process of correcting asphalt pavement surface distress by softening the existing surface with heat, mechanically loosening the pavement surface, mixing the loosened surface material with recycling agent, aggregate, rejuvenators, or hot-mix asphalt, and relaying the recycled material without removing it from the site. Different HIR processes include: *surface recycling (heater scarification), repaving,* and *remixing*.

Pavement Conditions Addressed: HIR is effective at correcting surface distresses that are limited to the top 1 to 2 in (25 to 50 mm). Examples include rutting, corrugations, raveling, flushing, loss of surface friction, minor thermal cracking, and minor load-associated cracking.

Application Limitations: Good HIR candidates have no structural failures; limited variation in the existing AC mix; no paving fabrics or interlayers in the anticipated treatment depth plus 25 percent; no deep ruts greater than one-half of the anticipated HIR treatment depth; no large stone mixes. The presence of rubber in the surface lift, rubberized seal coats, and some crack fillers require special attention in the mix design process.

Construction Considerations: As the HIR equipment is relatively wide and long, short road sections, particularly in urban settings, are not suitable for HIR treatment. HIR should not be performed at temperatures below 50 °F (10 °C) or when it is raining.

Traffic Considerations: HIR is appropriate for Very Low to High traffic conditions. *The heater-scarification* process should be used only for low volume traffic. The *remixing* and *repaving* processes can be used on high traffic volume roads.

Special Considerations: Crack sealant should be removed prior to the HIR operation to reduce flash fires or excessive blue smoke from the treatment placement.

Performance Period: 6 to 15 years.

Relative Cost ($ to $$$$): $$$

Step 1. Heating the surface. The surface is heated to soften the existing material.

Step 2. Surface scarification. The surface is loosened with scarifying teeth.

Step 3. Addition of Rejuvenator. A rejuvenating agent is sprayed onto the loosened material and mixed.

Step 4. Laydown. Mixed material is placed with conventional equipment.

Step 5. Rolling. Steel-wheeled rollers are used to compact the final surface.

GENERAL HOT IN-PLACE RECYCLING CONSTRUCTION STEPS

Figure 45-6M

45-6.03(m) Thin HMA Overlay

The combination of cold milling and the application of a thin HMA overlay is a viable option for improving rideability and surface friction, reducing hydroplaning and tire splash (using an open graded friction course), and improving the profile, crown, and cross slope. (See Figure 45-6N)

Treatment Description: Plant-mixed combinations of asphalt cement and aggregate applied to the pavement in thicknesses between about 0.75 and 1.50 in (19 and 38 mm). Dense-graded, open-graded, and stone matrix mixes are all used. The SMART program (Surface Maintenance At the Right Time) consists of placing a 1.5 inch (38 mm) single-pass overlay on a previously resurfaced pavement that is not in need of significant repair and is in good condition. If the SMART overlay is applied at the correct time, it can delay serious distresses, extend the life of the pavement, and decrease the overall cost. A Half-SMART overlay is another treatment option, which consists of 0.75 in (19 mm) HMA level binder with a BST on top.

Pavement Conditions Addressed: Low-severity cracking; raveling/weathering (loose material must be removed); friction loss; roughness; low-severity bleeding; low-severity block cracking (may perform better with additional milling). Thin overlays may also be used to correct rutting (requires use of separate rut-fill application).

Application Limitations: Thin HMA overlays are not recommended where there are structural failures (e.g., fatigue cracking), extensive pavement deterioration, or if there is high-severity thermal cracking. Surface should be uniform to ensure uniform compaction.

Construction Considerations: Surface must be clean. A tack coat prior to overlay placement will help improve the bond to the existing surface. Thin HMA overlays dissipate heat rapidly and, therefore, depend upon minimum specified mix placement temperatures and timely compaction.

Traffic Considerations: Performance is not affected by different ADT or percent trucks. Thin AC overlays are not structural layers and as such should not be subjected to strain from loadings. Such layers may be subject to top-down cracking under certain combinations of loadings, environmental conditions, and pavement structures.

Special Considerations: The minimum lift thickness information provided in Figure 37-1A of the BLRS Manual should be followed when using a thin overlay as a treatment. Localized distressed areas should be repaired prior to the placement of the overlay. If milling is not used in conjunction with the thin HMA overlay, special consideration should be given to bump grinding prior to treatment placement.

Performance Period: 5 to 10 years depending upon thickness.

Relative Cost ($ to $$$$): $$$

Step 1. Pre-overlay repair & surface preparation. Localized areas of distress are repaired prior to overlay placement and milling may be used.

Step 2. Tack coat. A tack coat is used to promote bonding between the overlay and the existing pavement.

Step 3. AC Overlay. Material is placed with conventional equipment.

Step 4. Compaction. Steel-wheeled rollers are used to compact the overlay.

GENERAL THIN HMA OVERLAY CONSTRUCTION STEPS

Figure 45-6N

45-6.03(n) Ultra-Thin Bonded Wearing Courses

An ultra-thin bonded wearing course is an alternative to BST, micro-surfacing, or thin HMA overlays as it effectively addresses minor surface distresses and increases surface friction. (See Figure 45-6O)

Treatment Description: The treatment is formed in one pass with the application of a heavy, polymer-modified asphalt emulsion tack coat and a gap-graded, polymer-modified 0.4 to 0.8 in (10 to 20 mm) HMA layer.

Pavement Conditions Addressed: Low-severity cracking (high-severity can be addressed with cold milling); raveling/weathering (loose material must be removed); high-severity friction loss; low-severity roughness; and low-severity bleeding. Provides some increased capacity and retards fatigue cracking but is not suited for rutted pavements.

Application Limitations: Ultra-thin bonded wearing courses are not recommended when structural failures exist (e.g., significant fatigue cracking and deep rutting) or if there is high-severity thermal cracking. They also are not appropriate where there is extensive pavement deterioration or little remaining life.

Construction Considerations: Requires special paving equipment to place the mix. Localized structural problems should be repaired prior to overlay application.

Traffic Considerations: Capable of withstanding high ADT volumes and truck traffic better than other thin treatments.

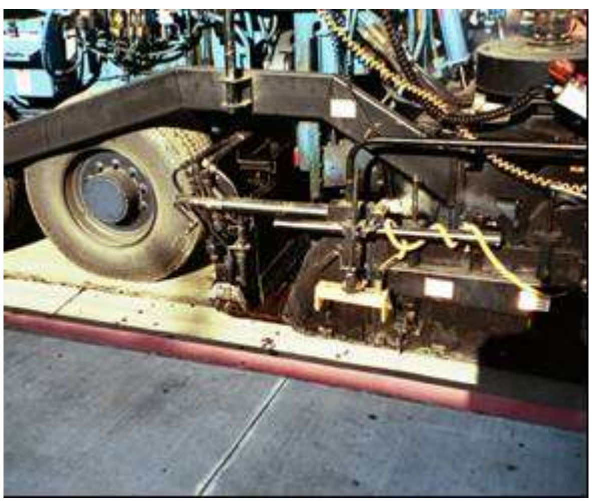
Special Considerations: Special consideration should be given to bump grinding prior to treatment placement.

Performance Period: 7 to 12 years.

Relative Cost ($ to $$$$): $$$

Step 1. Pre-overlay repair & surface preparation. Localized areas of distress are repaired prior to overlay placement.

Step 2. Milling. If necessary, milling is used to remove distress and promote bonding with the existing surface.



Step 3. Tack coat and overlay placement. Special equipment is used to apply the polymer modified emulsion and AC overlay in one pass.

Step 4. Rolling. Steel-wheeled rollers are used to compact the overlay.

GENERAL ULTRA-THIN FRICTION COURSES CONSTRUCTION STEPS

Figure 45-6O

45-6.03(o) Ultra-Thin Whitetopping (UTW)

Ultra-thin whitetopping is very effective at correcting many surface-related distresses. (See Figure 45-6P)

Treatment Description: UTW is a thin portland cement concrete (PCC) layer that is applied over an existing AC pavement. UTW is primarily characterized by its very thin slabs (2 to 4 in. [50 to 100 mm]) and short joint spacing (2 to 6 ft [0.6 to 1.8 m]). The UTW layer is bonded to the existing AC to increase load-carrying capacity.

Pavement Conditions Addressed: UTW is very effective at addressing many surface-related distresses such as rutting, washboarding, raveling, roughness, poor friction, shoving, and potholes.

Application Limitations: The existing AC must not be excessively deteriorated and must still have some load-carrying capacity. Severely deteriorated AC pavements with significant structural deterioration, inadequate base/subbase support, poor drainage conditions, or stripping of the AC layers are not candidates for UTW overlays).

Construction Considerations: Because milling is performed prior to the UTW placement, vertical overhead clearances, matching of adjacent shoulder/traffic lane elevations, and the maintenance of curb reveals is generally not a problem; however, this should be verified during the design process. Construction considerations are similar to those associated with traditional PCC paving.

Traffic Considerations: UTW performs well in all traffic conditions.

Special Considerations: This treatment is highly effective at correcting the noted distresses but is also significantly more expensive than other preventive maintenance treatments for AC pavements.

Performance Period: 5 to 15 years.

Relative Cost ($ to $$$$): $$$$

Step 1 & 2. Pre-overlay repair & milling and cleaning. Localized areas of distress are repaired prior to overlay placement. The surface is milled to remove rutting and restore profile prior to PCC placement.

Step 3. PCC placement. PCC is placed using conventional methods.

Step 4. Finishing & texturing. The PCC is finished and textured using conventional methods.

Step 5. Joint sawing & curing. Timely joint sawing is required to establish the contraction joints in the PCC pavement. Curing is important for UTW overlays due to the high surface-area-to-volume ratio.

ULTRA-THIN WHITETOPPING GENERAL CONSTRUCTION STEPS

Figure 45-6P

45-6.03(p) Cold Milling

Cold milling is effective at removing distresses in the top of the pavement, providing a smoother surface by removing vertical deformations, and improving surface friction. (See Figure 45-6Q)

Treatment Description: Cold milling involves the removal of part or all of an existing asphalt concrete surface. This treatment is frequently used to prepare an asphalt surface for an asphalt concrete overlay. It is not generally suggested as a stand alone treatment.

Pavement Conditions Addressed: Adds no structural benefit, but removes surface cracking and roughness, and restores friction. It can also be used to restore proper grades and cross-slopes on existing pavement.

Application Limitations: This treatment is not recommended for structurally deficient pavements.

Construction Considerations: The following are keys to obtaining a quality milled surface:

- Use a good working milling machine with a 12-ft (3.7-m) recommended width
- Control milling speed to achieve a smooth uniform surface (30 ft/min [9.14 m/min] or slower for deep cuts)
- Use a 30-ft (9.1-m) ski to control grade and a stringline for longitudinal guidance
- Perform pavement patching prior to milling
- Remove pavement castings and cover holes prior to milling
- Adjust casting after milling to meet final surface elevation
- If this treatment is a used as a stand alone treatment, a fine-toothed milling drum is needed to improve the smoothness and safety of the milled surface

Traffic Considerations: Cold milling can be used at all traffic levels.

Special Considerations: While not generally suggested as a stand alone treatment if the district bureaus review and agree upon the implementation plan, cold milling without applying another treatment to the milled surface may be considered. In order for the milled surface to be used as stand alone treatment, the pavement must be structurally sound with at least 3 inches of the existing asphalt concrete remaining in place and the removed material must be equal to an existing lift (at least 1 to 1.5 in [25 to 38 mm] of binder course remains). Also, the existing mixture must have a high fines content and low air voids content to avoid raveling.

Performance Period: Remaining life of the pavement (doesn't extend life).

Relative Cost ($ to $$$$): $

Step 1. Prepare surface. Patching should be completed before milling. All other in-pavement fixtures (e.g., manholes) need to be protected prior to cold milling.

Step 2. Milling. Milling is used to remove distresses such as segregation, rutting, raveling, or block cracking.

COLD MILLING GENERAL CONSTRUCTION STEPS

Figure 45-6Q

45-6.04 Rigid Pavement Treatment Summaries

45-6.04(a) Crack Sealing

Crack sealing is effective at reducing or delaying moisture damage, as well as crack deterioration and associated roughness. However, roughness can also be increased as a result of the sealing process itself, particularly if placed in an overband configuration. (See Figure 45-6R)

Treatment Description: Crack sealing is an operation involving thorough crack preparation and placement of high-quality materials into or over candidate cracks to significantly reduce moisture infiltration and to retard the rate of crack deterioration. Sealed cracks in PCC pavements deteriorate less and contribute less to the overall deterioration of the pavement. PCC cracks are typically sealed with thermosetting bituminous materials.

Pavement Conditions Addressed: Crack sealing is effective at sealing low- or medium-severity transverse or longitudinal cracks where the crack width is ≤ 0.5 in (13 mm). Full-depth working transverse cracks typically experience the same range of movement as transverse joints; therefore, it is recommended that these cracks be sealed to reduce water and incompressible infiltration.

Application Limitations: Crack sealing is most effective when performed on PCC pavements that exhibit minimal structural deterioration and in which the cracks are not showing other significant distress such as faulting or spalling.

Construction Considerations: Sealant performance is dependent on many construction factors, including material type and placement geometry, and application in a clean and dry substrate.

Traffic Considerations: Performance is not significantly affected by varying ADT or truck levels but should be allowed to cure before opening to traffic. However, improper installation can permit the sealant to fail.

Special Considerations: Crack sealing may have negative effects. Undesirable visual impacts may occur, which include tracking of sealing material by tire action, obscuring lane markings, and adversely affecting skid resistance. Crack sealing may result in a rougher pavement surface when the sealant material is forced out of the cracks during warm months.

Performance Period: 4 to 8 years.

Relative Cost ($ to $$$$): $

Step 1. Crack refacing. Small crack saws are used to reface cracks and create a reservoir for the sealant.

Step 2. Cleaning. Cracks must be clean and dry to enhance sealant bonding.

Step 3. Backer rod installation. Backer rod can be used to control the depth of the sealant in the crack.

Step 4. Application of sealant. The last step is to place the sealant in the refaced crack per governing specifications.

CRACK SEALING

Figure 45-6R

45-6.04(b) Joint Resealing

Joint resealing helps keep moisture out of the pavement layers and incompressibles out of joints, which reduces faulting, pumping, and spalling. (See Figure 45-6S)

Treatment Description: Resealing transverse joints in PCC pavements is intended to minimize the infiltration of surface water into the underlying pavement structure and to prevent the intrusion of incompressibles into the joint. A range of materials from bituminous to silicone are used in various configurations.

Pavement Conditions Addressed: Joint resealing is effective at keeping moisture out of the pavement layers, and incompressibles out of joints, which can result in less faulting, pumping, and spalling.

Application Limitations: Joint resealing is most effective when performed on PCC pavements that exhibit minimal structural deterioration. Material selection should be based on the expected time until next treatment.

Construction Considerations: Sealant performance is dependent on many construction factors, including material type and placement geometry, and application in a clean and dry substrate.

Traffic Considerations: Performance is not affected by different ADT or percent trucks. Silicone sealants which are not properly recessed are more likely to fail in the wheelpath.

Special Considerations: Joint resealing is necessary when the existing sealant has deteriorated to the point that it readily allows water and incompressibles to enter the joint. The primary cause of sealant failure is improper installation (e.g., not preparing joint sidewalls and getting bonding).

Performance Period: 4 to 8 years for hot-poured asphalt sealant; ~8 years for silicone sealant.

Relative Cost ($ to $$$$): $

Steps 1 & 2. Sealant removal & joint refacing. This photo shows the removal of existing sealant. Joints are refaced to create a uniform reservoir for the sealant.

Step 2. Cleaning. Joints must be clean and dry to enhance sealant bonding.

Step 3. Backer rod installation. Backer rod can be used to control the depth of the sealant in the joint.

Step 4. Application of sealant. The last step is to place the sealant in the refaced joint per governing specifications.

JOINT RESEALING GENERAL JOINT RESEALING STEPS

Figure 45-6S

45-6.04(c) Diamond Grinding

Diamond grinding is effective at removing joint faulting and other surface irregularities to restore a smooth-riding surface and increase pavement surface friction. (See Figure 45-6T)

Treatment Description: Diamond grinding is the removal of a thin layer of concrete (generally up to about 0.25 in [6.4 mm]) from the surface of the pavement, using special equipment outfitted with a series of closely spaced, diamond saw blades.

Pavement Conditions Addressed: Diamond grinding is used to remove joint faulting and other surface irregularities to restore a smooth-riding surface and increase pavement surface friction.

Application Limitations: If significant faulting is present, or other signs of structural failure (such as mid-panel cracks or corner breaks), diamond grinding is not appropriate. The presence of materials-related distresses may also preclude the use of diamond grinding. Soft aggregate will wear much quicker and require more frequent grinding.

Construction Considerations: Typically constructed with a moving lane closure with traffic operating in the adjacent lanes. Diamond grinding should be used in conjunction with all restoration techniques including load-transfer restoration, full- and partial depth repair, cross stitching, and subsealing/undersealing.

Traffic Considerations: Grinding may be used to remove faulting, which if the mechanism is not addressed can reoccur due to the continued application of truck traffic. If used to restore friction to a polished pavement (due to vehicle traffic), heavy volumes of traffic may cause the problem to reoccur.

Special Considerations: Note that diamond grinding is a surface repair method because it corrects the existing faulting and wear of PCC pavements. It does nothing to correct pavement distress mechanisms. Therefore, grinding usually is performed in combination with other rehabilitation methods to both repair certain pavement distresses and prevent their recurrence.

Performance Period: 8 to 15 years.

Relative Cost ($ to $$$$): $$

Diamond grinding process. Multiple passes of the grinding equipment are used to remove material from the pavement surface.

Diamond grinding depth. Generally up to about 0.25 in. (6.4 mm) of the surface is removed in a single pass.

DIAMOND GRINDING CONSTRUCTION

Figure 45-6T

45-6.04(d) Diamond Grooving

Diamond grooving is effective at increasing wet-pavement friction and reducing splash and spray in identified problem areas. (See Figure 45-6U)

Treatment Description: Diamond grooving is the process of cutting narrow, discrete grooves in the PCC surface to reduce hydroplaning and wet-pavement crashes in localized areas. Grooving can be performed in both the longitudinal and transverse directions, but is more commonly performed longitudinally.

Pavement Conditions Addressed: Grooving is conducted to increase wet-pavement friction and reduce splash and spray. Diamond grooving is conducted in localized areas of a project where wet-pavement crashes have historically been a problem (e.g., curves and intersections).

Application Limitations: In general, candidate pavements for grooving should be structurally and functionally sound.

Construction Considerations: Areas to be grooved should be clearly indicated on project plans. The grooves should be cut in accordance with recommendations of the International Grinding and Grooving Association (IGGA), which specify 0.75 in (19mm) spacing with 0.125 in (3mm) depth and width. The entire lane area should be grooved; however, allowance should be made for small areas that were not grooved because of pavement surface irregularities. Grooving is most commonly performed longitudinally due to ease of construction.

Traffic Considerations: Performance is not affected by varying ADT or truck levels.

Performance Period: Information on performance is not readily available; however, lives are expected to be greater than the 8 to 15 years.

Relative Cost ($ to $$$$): $$

Diamond Grooving. These photos show examples of longitudinal (left) and transverse diamond grooving (right).

DIAMOND GROOVING GENERAL CONSTRUCTION STEPS

Figure 45-6U

45-6.04(e) Full-Depth Repairs

Full-depth repairs are effective at correcting slab distress that extend beyond one-third the pavement depth such as longitudinal and transverse cracking, corner breaks, and joint spalling. (See Figure 45-6V)

Treatment Description: Full-depth repairs are cast-in-place concrete repairs that extend through the full thickness of the existing PCC slab. The technique involves the full-depth removal and replacement of full or half lane-width areas of an existing deteriorated PCC pavement. The minimum specified repair length is typically 6 ft (1.8 m); however, for jointed PCC pavements, in many cases it may be more cost effective and reliable to replace an entire slab.

Pavement Conditions Addressed: Full-depth repairs are used to repair localized distresses and to prepare distressed PCC pavements for a structural overlay to avoid premature failure of the overlay.

Application Limitations: Full-depth repairs are not cost effective if deterioration is widespread within a project. If the existing pavement is structurally deficient, or is nearing the end of its fatigue life, a structural enhancement (such as an overlay) is needed to prevent continued cracking of the original pavement.

Construction Considerations: During construction, it is very important to properly prepare the base, restore joint load-transfer, and finish, texture, and cure the new material per governing specifications.

Traffic Considerations: Because full-depth repairs have typically been completed using conventional PCC materials, curing time may be an issue in urban areas. High early strength concretes are used in cases where it is not desirable to close a lane overnight.

Special Considerations: It is not desirable to create the large number of closely spaced joints in a pavement that would result from placing a large number of closely spaced patches.

Performance Period: 10 to 15 years.

Relative Cost ($ to $$$$): $$$$

Step 1. Concrete sawing. Repair boundaries are cut with full-depth, diamond-bladed sawing.

Step 2. Concrete removal. Removal of slab material is best accomplished using the lift-out method or by breakout.

Step 3. Repair area preparation. It is important that the repair area be dry and properly compacted.

Step 4. Load transfer provision. Proper restoration of load transfer should be considered.

Step 5. Material placement. Conventional PCC material is most common for full-depth repairs.

Steps 6 & 7. Texturing & Curing. The final steps include texturing and providing adequate curing.

FULL-DEPTH REPAIRS

Figure 45-6V

45-6.04(f) Partial-Depth Repairs

Partial-depth repairs are primarily used to correct joint spalling. They can also be used to correct localized areas of distress that are limited to the upper 1/3 of the slab thickness. (See Figure 45-6W)

Treatment Description: Partial-depth repairs are defined as the removal of small, shallow areas of deteriorated PCC that are then replaced with a suitable repair material. These repairs restore structural integrity and improve ride quality, thereby extending the service life of pavements that have spalled or distressed joints.

Pavement Conditions Addressed: Partial-depth repairs are primarily used to correct joint spalling caused by 1) the intrusion of incompressible materials into the joints, 2) localized areas of scaling, weak concrete, clay balls, or high steel, and 3) the use of joint inserts.

Application Limitations: This treatment is not applicable for pavements with cracking and joint spalling caused by compressive stress buildup in long-jointed pavements; spalling caused by dowel bar misalignment or lockup; cracking caused by improper joint construction techniques (late sawing, inadequate saw cut depth, or inadequate insert placement depth); working cracks caused by shrinkage, fatigue, or foundation movement; and spalls caused by D-cracking or reactive aggregate.

Construction Considerations: During construction, it is very important to properly determine repair boundaries, prepare the patch area, and finish, texture, and cure the new material per governing specifications. If distress is found to extend below the upper 1/3 of the slab, or if steel is exposed, a full-depth repair is required.

Traffic Considerations: Partial-depth repairs perform under all traffic conditions. High early strength concretes are used in cases in which early opening to traffic is required or when it is not desirable to close a lane overnight.

Special Considerations: Partial-depth patches should be a minimum of 4 in (10 cm) by 12 in (30 m).

Performance Period: 5 to 15 years.

Relative Cost ($ to $$$$): $$$

Step 1. Repair boundary marking. Determine extent of unsound material, and mark repair boundaries.

Step 2. Concrete removal. Sawing the boundaries and removing deteriorated PCC.

Step 3. Repair area preparation. The repair area should be sandblasted and cleaned to promote good bonding.

Step 4. Joint preparation. It is important to maintain the existing joint reservoir during construction.

Steps 5 & 6. Bonding agent & material placement. Follow manufacturer's recommendations when placing material.

Steps 7 & 8. Curing & joint sealing. The final steps include texturing and providing adequate curing.

PARTIAL-DEPTH REPAIRS

Figure 45-6W

45-6.04(g) Load Transfer Restoration (LTR)

LTR is effective at restoring load transfer at joints and/or transverse cracks on pavements that have significant remaining structural life. (See Figure 45-6X)

Treatment Description: Load transfer restoration (LTR) is the placement of load transfer devices across joints or cracks in an existing jointed PCC pavement to restore load transfer at these locations. Poor load transfer can lead to pumping, joint faulting, and corner breaks.

Pavement Conditions Addressed: Most effective on jointed concrete pavements that have poor load transfer at joints and/or transverse cracks but also have significant remaining structural life. The optimum time to apply this technique is when the pavement is just beginning to show signs of structural distress, such as pumping and the onset of faulting.

Application Limitations: LTR is not applicable when the pavement contains significant faulting, or other signs of structural failure (such as pumping or corner breaks). Pavements with little remaining life or materials-related distresses are also not good candidates.

Construction Considerations: There are different dowel bar retrofit patterns, but three to four bars per wheelpath is typical. Careful consideration must be given in the selection of the patch material and isolation of the joint. Often performed in conjunction with diamond grinding.

Traffic Considerations: The higher the ADT and percent trucks, the greater the potential need for LTR. Low-volume jointed concrete pavements that are not doweled may not need LTR.

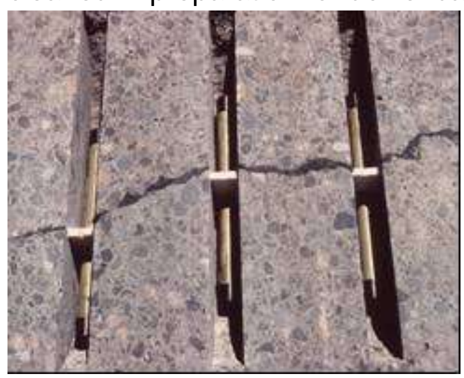
Performance Period: A minimum expected life is typically 10 to 15 years; however, many load-transfer restoration projects have been in place for more than 20 years with little or no signs of distress.

Relative Cost ($ to $$$$): $$$

Step 1 & 2. Slot creation and material removal. Slots are cut and concrete material is removed.

Step 3 & 4. Sandblasting and cleaning. Slots are sandblasted and cleaned in preparation for dowel bars.

Step 5. Caulking the joint/crack. The joint/crack edges are caulked to stop the flow of material from the slot.



Step 6. Dowel bar placement. Dowels are placed parallel to the direction of traffic and at mid-slab.

Step 7. Repair material placement. Material should be placed per governing specifications.

Steps 8 & 9. Diamond grinding & joint sealing. Final steps often consist of diamond grinding and joint sealing.

LOAD TRANSFER RESTORATION GENERAL CONSTRUCTION STEPS

Figure 45-6X

Cross Stitching

Cross stitching is effective at strengthening non-working longitudinal cracks. Preventing these crack movements helps prevent roughness and potential safety problems associated with such cracks. (See Figure 45-6Y)

Treatment Description: Cross stitching is a longitudinal crack and joint repair technique that consists of grouting tiebars in holes drilled across non-working longitudinal cracks/joints at an angle to the pavement surface. Cross stitching prevents horizontal and vertical crack movements.

Pavement Conditions Addressed: Cross stitching is effective at strengthening longitudinal cracks and preventing slab migration, mitigating the issue of tiebars being omitted from longitudinal contraction joints, tying roadway lanes or shoulders that are separating and causing a maintenance problem, and tying centerlane joints that are starting to fault.

Application Limitations: Cross stitching is not an appropriate treatment for slabs that have multiple cracks or are shattered into more than 4 to 5 pieces.

Construction Considerations: Holes should be drilled to intersect the slab/joint at mid-depth. Follow the American Concrete Pavement Association (ACPA) construction recommendations.

Traffic Considerations: Performance is not significantly affected by varying ADT or truck levels.

Special Considerations: The treatment is not recommended on transverse cracks.

Performance Period: 15 years.

Relative Cost ($ to $$$$): $$$

Step 1. Drilling of holes. Drill holes at a 35° to 45° angle to the surface so they intersect the crack/joint at mid-depth.

Step 2. Epoxy grout insertion. Clean holes with compressed air, and then insert epoxy to promote bonding.

Step 3. Bar insertion. Drive bars into holes containing epoxy.

Step 4. Final grouting. Remove excess material and finish surface of epoxy so that it is flush with the pavement surface.

CROSS STITCHING GENERAL CONSTRUCTION STEPS

Figure 45-6Y

45-6.04(h) Pavement Subsealing/Undersealing

Undersealing fills voids under slabs, thereby reducing deflections and minimizing the development of pumping, corner breaks, faulting, and roughness associated with those distresses. (See Figure 45-6Z)

Treatment Description: Undersealing is the pressure insertion of a flowable material beneath a PCC slab to fill voids between the slab and base, thereby reducing deflections and, consequently, deflection-related distresses such as pumping or faulting. It is most often performed at areas where pumping and loss of support occur, such as beneath transverse joints and deteriorated cracks. The voids being filled by this technique are generally less than 0.12 in (3 mm) thick.

Pavement Conditions Addressed: Undersealing fills voids that, if left unfilled, will lead to pumping, faulting, and other structural deterioration. This treatment performs best if performed before faulting starts to develop.

Application Limitations: Undersealing is not appropriate on pavements with significant faulting, or other signs of structural failure (such as pumping, mid-panel cracking, or corner breaks). Such distresses suggest structural failures that require more costly rehabilitation. Additional strategies, such as dowel bar retrofitting, may be required for pavements without load transfer.

Construction Considerations: Cement-fly ash grout is the most commonly used material, although asphalt and polyurethane also have been used. Slab lift must be closely monitored to avoid damaging slabs. Overfilling voids can contribute to more severe problems than leaving them unfilled.

Traffic Considerations: Performance is not known to be affected by different levels of ADT or percent trucks.

Special Considerations: Pumping (indicated by the presence of holes, depressions, and/or ejected material) is almost certain evidence of voids. If areas do not exhibit physical evidence of voids but are suspect, request nondestructive testing assistance from the Bureau of Materials and Physical Research. Pavement sections that contain voids often occur only on a portion of a project. Blanket subsealing rarely is justified. If subsealing is used on any portion of a project, bridge approaches within the project limits also should be subsealed. The use of this method requires Bureau of Design and Environment approval.

Performance Period: Performance has been variable.

Relative Cost ($ to $$$$): $$

Step 1. Locating voids. Many methods are used to locate voids, including FWD testing (shown here).

Step 2. Drilling injection holes. Holes are drilled in a selected pattern at void locations. The drill should be connected to a compressor but it is not in this photo.

Step 3. Injection of material. This photo shows an “expandable grout packer” used to inject cement grout material. Slab lift must be closely monitored during this process to avoid slab damage.

Step 4. Plugging holes. The next step is to plug each of the holes to keep grout material from flowing out through the holes. Then the plugs are removed after the grout is set and the holes are filled with mortar, and the pavement is cleaned prior to opening the road to traffic.

UNDERSEALING GENERAL CONSTRUCTION STEPS

Figure 45-6Z

45-6.05 Drainage Preservation

45-6.05(a) Drainage Preservation

Improvement of subsurface drainage characteristics for pavement systems that show water-related damage or distresses can significantly increase the serviceability and life of the pavement. (See Figure 45-AA)

Treatment Description: The improvement of subsurface drainage characteristics through the use of 1) ditch maintenance to prevent obstructed flow and provide proper cross section, 2) maintenance of existing drainage systems, or 3) the installation of localized drainage, specifically in low-lying areas.

Pavement Conditions Addressed: Stripping and structural distresses (such as fatigue cracking and rutting) related to loss of support under the bound layers.

Application Limitations: Use of drainage preservation will not restore structurally inadequate pavements or repair existing distresses, but should reduce worsening or appearance of new distresses. The installation of new drainage is only helpful if the existing pavement has a horizontally drainable layer. Otherwise, only the water between the shoulder and the pavement will be removed, instead of removing the water between the base and the bound layers.

Construction Considerations: Underdrain installation should occur prior to patching, unless there is a valid reason to do otherwise.

Traffic Considerations: Since the use of drainage preservation will improve the base and subgrade engineering properties, the treatment might help improve the load-carrying capacity of the pavement.

Special Considerations: Drainage preservation is a very worthwhile preservation activity. However, the conduct of ditch maintenance is often considered routine maintenance instead of preventive maintenance. Special justification for the use of federal funds for ditch maintenance is necessary including District and Central BLRS approval.

Performance Period: Varies.

Relative Cost ($ to $$$$): Varies

Drainage Preservation. This photo shows an example of a ditch with obstructed flow.

DRAINAGE PRESERVATION GENERAL CONSTRUCTION STEPS

Figure 45-6AA

45-7 REFERENCES

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

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3. Miller, J. S. and W. Y. Bellinger. 2003. *Distress Identification Manual for the Long-Term Pavement Performance Program.* FHWA-RD-03-031. Federal Highway Administration, Washington, D.C.

4. Peshkin, D. G., T. E. Hoerner, K. D. Smith, J. E. Bruinsma, and S. B. Seeds. 2004. *Pavement Preservation: Design and Construction of Quality Preventive Maintenance Treatments.* NHI Course 131103, Reference Manual. FHWA-NHI-04-171. National Highway Institute. Federal Highway Administration, Washington, D.C.