TECHNICAL MEMORANDUM TASK 5

A Guide for Pavement Repair Before Preventive Maintenance

TxDOT Project 0-7175, Develop Best Practices for Flexible Pavement Repairs

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TASK REPORT 5: A Guide—Best Practices for Flexible Pavement Repairs

This memorandum contains a proposed best practices booklet for your review.

TEXAS DEPARTMENT OF TRANSPORTATION

A Guide for Pavement Repair Before Preventive Maintenance

Texas A&M Transportation Institute

Research Project 0-7175: Develop Best Practices for Flexible Pavement Repairs

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CHAPTER 1. INTRODUCTION

This chapter summarizes the key aspects of asphalt pavement repair before preventive maintenance (PM). It outlines the workflow and includes a series of tables detailing the benefits and drawbacks of different repair options, recommended repair options based on distresses (failure mechanisms), and recommended materials and equipment types based on the repair options.

Workflow

Best practices for asphalt pavement repair before PM include performing proper planning, identifying distress types (structural or functional), determining failure sources and mechanisms, and preparing the repair area before applying the appropriate material. Identifying distress can begin with a review of project management information system (PMIS) data to flag areas with poor ratings, followed by visual inspection and nondestructive testing (NDT) to evaluate whether the damage is structural in nature. Flexible pavement damage (e.g., cracking, potholes, etc.) that extends more than 2 inches deep is generally considered structural, which threatens the pavement's integrity for its intended service. If the maintenance supervisor cannot identify the source of damage and it recurs, they should consult the district pavement engineer, who can assist with NDT to locate the source of the problem. Figure 1 outlines the steps for effective asphalt pavement repair strategies before PM.

Repair Options and Their Benefits and Drawbacks

For agencies like the Texas Department of Transportation (TxDOT) that oversee extensive roadway networks, understanding the advantages and limitations of different repair methods is essential for optimizing performance and resource utilization. Effective repairs can extend pavement life, enhance ride quality, and lower lifecycle costs, whereas poor or incorrect methods may lead to early failures and higher maintenance costs. Table 1 summarizes the benefits and drawbacks of various asphalt pavement repair strategies before PM.

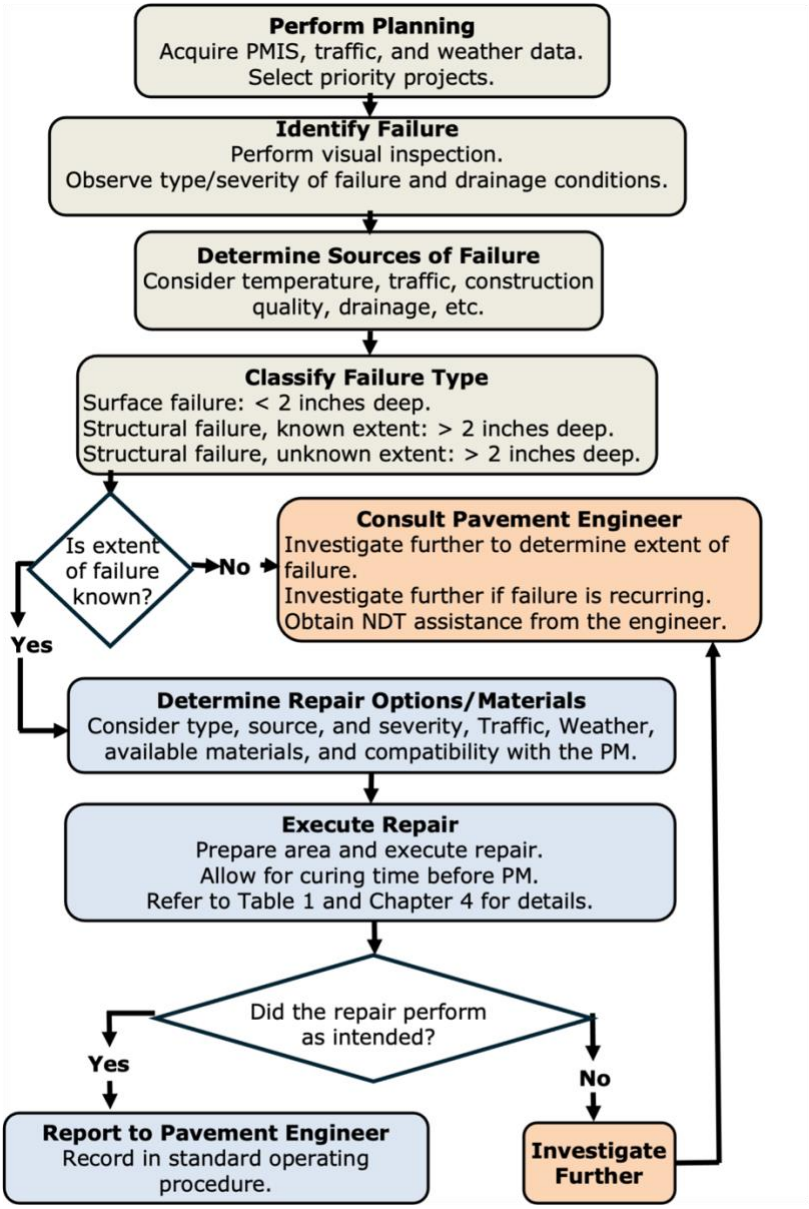


Figure 1. Flowchart of Effective Repair Strategies before PM.

Table 1. Benefits and Drawbacks of Various Repair Options.

Repair Option	Benefits	Drawbacks
Nonstructural Repair		
Crack seal	Cost-effective, prevents water infiltration, slows progression of load-related cracking.	Requires frequent reapplication, less effective on high-severity distress, excessive crack seals can negatively affect ride quality.
Fog seal	Inexpensive; seals minor cracks; reduces asphalt aging, oxidation, and hardening; prevents moisture infiltration; helps hold coat surface aggregates (i.e., reduces raveling/aggregate loss).	Less effective on high-severity distresses, can reduce skid when applied heavily.
Scrub seal	Cost-effective, can be applied quickly, seals cracks better than traditional chip seal.	Not ideal for high-traffic/speed roads; does not fix structural problems; requires dry, warm conditions for proper curing.
Microsurfacing/ slurry seal	Restores surface texture, improves skid resistance, extends pavement life.	Higher initial cost, requires skilled labor, does not fix deep structural issues.
Seal coat	Cost-effective, protects pavement from oxidation, improves appearance/texture.	Requires frequent reapplication, less effective in high-severity distresses, loose aggregate can become a windshield hazard, typically noisy relative to traditional asphalt.
Level up and overlay	Improves ride quality, extends pavement life, is cost-effective.	Does not fix deep structural issues, requires skilled labor.
Level up and seal coat	Improves ride quality, extends pavement life, is cost-effective.	Does not fix deep structural issues, requires skilled labor, may complicate the uniform application of asphalt binder when PM is seal coat.
Mill and overlay	Restores ride quality, extends pavement life, recycles existing materials.	Higher initial cost, requires skilled labor, may not fix deep structural issues.
Spot seal	Targets localized distress, can be applied quickly, is cost-effective.	Temporary solution, requires frequent reapplication, not effective on high-severity distresses.
Ultra-high-pressure water retexturing	Restores surface texture, improves skid resistance, can be applied quickly.	Temporary solution, requires frequent reapplication.
Pothole: Throw-and-roll	Provides fast/inexpensive fix, requires minimal equipment, can be done at any time of year.	Temporary solution with very short life span, poor preparation leads to poor bonding, unstable/cannot be under the PM surface (e.g., seal coat).

Repair Option	Benefits	Drawbacks
Pothole: Spray injection	Material is self-compacting, can be applied quickly.	Requires specialized equipment/ skilled labor, less effective in wet/cold conditions, relatively more expensive than throw-and-roll.
Pothole: Semipermanent repair	Provides good bonding with existing pavement.	Requires dry conditions, more time, traffic control.
Structural Repair		
Edge repair and overlay	Improves edge stability, extends pavement life, is cost-effective.	Does not fix deep structural issues, requires skilled labor.
Cement stabilized base	Improves load-bearing capacity, extends pavement life, addresses structural issues.	Higher initial cost, requires skilled labor.
Full-depth patching	Addresses structural issues, is most durable/permanent option.	Expensive, time-consuming, requires traffic control.
Base repair and seal	Addresses structural issues, extends pavement life, improves load-bearing capacity.	Expensive; requires traffic detours, skilled labor, and equipment.
Full-depth reclamation	Renews pavement structure, extends service life, allows for design upgrades.	Most expensive, significantly disrupts traffic, requires extensive planning/resources.

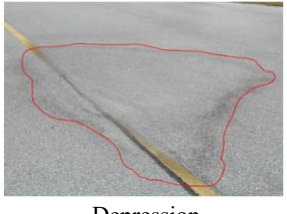
Repair Options Based on Distress (Failure Mechanism)

The identification of the specific failure mechanisms is essential for selecting repair strategies that target the root causes rather than merely the symptoms. By aligning repair options with the type and severity of damage, agencies can use resources more effectively, extend pavement life, and improve overall performance. Table 2 displays various distresses (failure mechanisms), their likely source, and potential repair options. Table 2 includes visual illustrations of each failure mechanism to clearly show how each distress appears (Ahmad & Khawaja, 2018; California Department of Transportation, 2003; Canestrari & Ingrassia, 2020; Dong et al., 2013; Federal Highway Administration [FHWA], 2014; Indiana Department of Transportation, 2023; Pavement Interactive, n.d.; Pavement Management Services, 2021; RDC Paving, 2021; Renolith, 2023; TxDOT, 2010, 2021).

Table 2. Distresses (Failure Mechanisms), Sources, and Repair Options.

Failure Mechanism	Source	Repair Option
Block cracking	Block cracking is due to temperature changes that cause the pavement to expand and contract. It is often limited to the surface layer (< 2 inches deep) and forms as interconnected rectangular sections (varying in size from 1 ft × 1 ft up to 10 ft × 10 ft). It occurs over a large portion of the pavement area, and its severity can be low, medium, or high based on crack width.	Low severity: For infrequent cracks < 0.5 inches wide, choose *crack seal* or *seal coat*. High severity: For frequent cracks > 0.5 inches wide, choose *level up and overlay*.
Fatigue (or alligator) cracking	Fatigue (or alligator) cracking occurs due to repeated traffic loading on the pavement surface in the wheel path (excessive deflection) and may cause pavement structure failure. This type of cracking initiates at the bottom of a hot mix asphalt layer, where tensile stress and strain are highest under traffic loading. Inadequate pavement thickness and subgrade weakening from excessive moisture can cause fatigue cracking.	Small, localized cracking: For a few connecting cracks, remove the cracked pavement area and choose *base repair, spot seal, edge repair, and overlay*. Large cracked areas: For severely spalled interconnected cracks, choose *full-depth reclamation (pulverization and resurfacing)*.
Longitudinal cracking	Longitudinal cracking may be caused by poor joint construction, thermal expansion and contraction of the asphalt material, or differential movement of pavement layers due to changes in moisture or traffic loading. This type of cracking (at least 0.125 inches in size) is approximately parallel to the pavement's centerline.	Low severity: For cracks < 0.5 inches, choose *crack seal* or *seal coat*. High severity: For cracks > 0.5 inches, replace cracked pavement and choose *level up and overlay*.

Failure Mechanism	Source	Repair Option
Transverse cracking	Transverse cracks are predominantly perpendicular to the pavement centerline (or traffic flow) and are typically caused by temperature fluctuations. Transverse cracking (at least 0.125 inches in size) may also reflect cracks from underlying layers.	Low severity: For cracks < 0.5 inches, choose *crack seal*. High severity: For cracks < 0.5 inches, replace cracked pavement and choose *level up and overlay*.
Potholes	Potholes can be caused by water, poor drainage, traffic loading, and/or a weak layer(s). Extreme cases of other failures, such as raveling or cracking, can also cause potholes. Potholes may extend down to the base course.	Low/moderate severity: For potholes < 2 inches deep, choose *spray injection or semipermanent repair* to repair the pavement surface. High severity: For potholes > 2 inches deep, choose *full-depth patching* or *base repair and seal coat/overlay*.
Excessive patching	Excessive patching occurs when significant repaving of the pavement layer fails. It may be caused by excessive distress and delamination. High-severity distress shows faulting or settlement beyond 0.25 inches.	Remove existing patching and choose *base repair, spot seal, edge repair, and overlay*.

Failure Mechanism	Source	Repair Option
Bleeding/flushing	Bleeding/flushing can be caused by excess binder or low air voids in asphalt mixes. Bleeding/flushing can also be caused by a loss of aggregates (exposing the asphalt to the surface) or over-compaction. This type of failure mechanism is limited to the asphalt surface.	Low/moderate severity: Choose *seal coat*. Moderate/high severity: *Use the ultra-high-pressure water jets to remove excess asphalt binder and improve pavement surface texture*.
Shoving	Shoving can be caused by subgrade failure, an unstable mix design, poor bond between pavement layers, vehicle braking or turning, inadequate compaction, lack of edge support, inadequate pavement thickness, etc.	Moderate severity: For pavements with a ≤ 0.75-inch height differential, choose *mill and overlay*. High severity: For pavements with a ≥ 1.5-inch differential and structural failure, choose *full-depth patching/repair*.
 Depression	Depression is a localized pavement surface settlement compared to the surrounding pavement. It can be caused by a volume change in the subgrade material, settlement of foundation soil, or construction activities, resulting in pavement surface roughness.	Saw cut and replace the affected pavement area then choose *base repair, spot seal, edge repair, and overlay*.

Failure Mechanism	Source	Repair Option
Rutting	Rutting is a type of surface depression in the wheel path, and pavement may uplift along the sides of the rut. Rutting is caused by deformation of any pavement layer under traffic loads. Shallow rutting is defined as 0.25–0.5 inches, and deep rutting is defined as > 0.5 inches.	Deep rutting: For ruts > 0.5 inches, choose *mill and overlay* or *scrub seal*. Rutting at lower hot mix asphalt layer: Choose *base repair and seal*. Rutting at base layer: Choose *full-depth reclamation (pulverization and resurfacing)*.
Raveling	Raveling can be caused by the dislodging of aggregate particles and loss of asphalt binder. Raveling indicates potential mixture-related issues.	Low severity: For a small, affected area, choose *seal coat* and *fog seal*. High severity: Choose *mill the surface, if necessary, then place a thin hot mix asphalt overlay*.
Top-down cracking	Top-down cracking begins at the pavement surface. It tends to be longitudinal, often within or near the vehicle wheel paths. These cracks may be caused by heavy vehicles, thermal stress (high surface temperature), and/or hardening of the asphalt binder due to age (making it susceptible to cracking under stress).	Low severity: For cracks ≤ 0.25 inches wide, choose *crack seal*. Moderate severity: For cracks 0.25–0.75 inches wide, replace the pavement layers at a little more depth than the top-down cracks then choose *mill and overlay*. High severity: For cracks ≥ 0.75 inches wide, choose *full-depth reclamation (pulverization and resurfacing).*

Recommended Materials Based on Repair Option

Table 3 presents a recommended list of commonly used materials for preparatory repairs to asphalt pavements before PM, aligned with specific repair methods. This linkage between each material and its suitable application is intended to aid informed decision-making in pavement maintenance planning. Factors like local availability may prevent certain recommended materials from being used; in such cases, other materials not listed in Table 3 may be used, provided they meet requirements and are approved by TxDOT.

In Table 3, a bolded *R* indicates that a material is recommended/allowed for the repair method, and *NA* indicates that a material is not usually required for the repair method.

Recommended Equipment Based on Repair Option

Choosing the right equipment is essential for performing high-quality repairs that address surface and structural problems before applying treatments such as seal coats, slurry seals, or thin overlays. Table 4 presents a recommended list of commonly used equipment types for preparatory repairs to asphalt pavements before PM, aligned with specific repair methods. This linkage between each equipment type and its suitable application is intended to improve planning and resource management for pavement maintenance activities.

In Table 4, a bolded *R* indicates that a particular equipment type is recommended/allowed for the repair method, and *NA* indicates that a particular equipment type is not usually required for the repair method.

Table 3. Recommended Materials Based on Repair Option.

Materials	Item/ DMS	Crack Seal	Fog Seal	Scrub Seal	Micro-surfacing	Seal Coat/ Spot Seal	Level Up/ Overlay	Base Repair	Edge Repair[a]	Full-Depth Patching[a]	Pothole Repair[a]
Item/special specification		712/–	315/–	–/3005	350/–	316/–	341, 344/–	351/–	Various[a]	Various[a]	Various[a]
Cold-applied sealant	300/–	**R**	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hot-applied sealants	300/–	**R**	NA	NA	NA	NA	NA	NA	NA	NA	NA
Asphalt cement	300/–	NA	NA	NA	NA	**R**	**R**	**R**	NA	NA	NA
Emulsion	300/–	NA	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
Cutback asphalt	300/–	NA	NA	NA	NA	**R**	NA	**R**	NA	NA	NA
Aggregates	302/–	NA	NA	**R**	**R**	**R**	NA	**R**	NA	NA	NA
Hot mix asphalt	341, 344/–	NA	NA	NA	NA	NA	**R**	NA	**R**	**R**	NA
RAP/rejuvenated RAP	–/9202	NA	NA	NA	NA	NA	**R**	NA	**R**	NA	NA
Flexible base	247/–	NA	NA	NA	NA	NA	NA	**R**	**R**	NA	NA
Cement	–/4600	NA	NA	NA	**R**	NA	NA	**R**	**R**	NA	NA
Limestone rock asphalt	330/9210	NA	NA	NA	NA	NA	**R**	**R**	NA	NA	**R**
Cold mix asphalt with emulsion	–/9202	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**
Cold mix asphalt with cutback	–/9202	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**
Hot mix cold-laid asphalt	334/–	NA	NA	NA	NA	NA	NA	NA	NA	**R**	**R**
Asphalt concrete patching (stockpile storage, bagged)	–/9202, 9203	NA	NA	NA	NA	NA	NA	NA	NA	**R**	**R**

[a]Several specifications and materials may apply/be used; see material specification based on repair details.
DMS = departmental material specifications; NA = not applicable; R = recommended; RAP = reclaimed asphalt pavement.

Table 4. Recommended Equipment Based on Repair Option.

Equipment Type	Crack Seal	Fog Seal	Scrub Seal	Micro-surfacing	Seal Coat	Level Up/ Overlay	Mill/ Inlay	Base Repair	Spot Seal	Edge Repair	UHP Water Retexturing	Pothole Repair	Full-Depth Reclamation Patching
Router	**R**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hot air lance	**R**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Melter-applicator	**R**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wand	NA	**R**	**R**	**R**	**R**	NA	NA	NA	**R**	NA	NA	**R**	NA
Broom/sweeper	NA	**R**	**R**	**R**	**R**	**R**	**R**	NA	NA	NA	**R**	**R**	**R**
Distributor truck with spray bar	NA	**R**	**R**	NA	**R**	NA	NA	**R**	NA	NA	NA	NA	**R**
Paver	NA	NA	NA	**R**	NA	**R**	NA	**R**	NA	**R**	NA	NA	NA
Aggregate spreader	NA	NA	NA	**R**	**R**	**R**	**R**	NA	NA	NA	NA	NA	NA
Steel wheel roller	NA	NA	NA	**R**	**R**	**R**	**R**	**R**	NA	NA	NA	NA	NA
Vibratory roller	NA	NA	NA	NA	NA	NA	NA	**R**	**R**	NA	NA	NA	**R**
Pneumatic roller	NA	NA	NA	NA	NA	**R**	NA	NA	NA	NA	NA	NA	NA
Sheep foot roller	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**	NA	**R**	NA
Milling machine	NA	NA	NA	NA	NA	NA	**R**	NA	NA	NA	NA	NA	NA
Sweeper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**
Excavator	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**	NA	NA	NA
Air blower	NA	NA	NA	NA	NA	NA	NA	NA	**R**	NA	NA	**R**	NA
Tack sprayer	NA	NA	NA	NA	NA	**R**	NA	NA	**R**	NA	NA	NA	**R**
Small distributor	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Grader	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**	NA	NA	**R**
Pulverizing mixer	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**R**
Saw	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**R**	NA
UHP water jet system	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**R**	NA	NA

Equipment Type	Crack Seal	Fog Seal	Scrub Seal	Micro-surfacing	Seal Coat	Level Up/ Overlay	Mill/ Inlay	Base Repair	Spot Seal	Edge Repair	UHP Water Retexturing	Pothole Repair	Full-Depth Reclamation Patching
Water truck	NA	NA	NA	NA	NA	NA	NA	**R**	NA	**R**	NA	NA	NA
Gradall	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**R**	**R**
Haul truck	NA	NA	NA	**R**	**R**	**R**	**R**	**R**	NA	**R**	NA	**R**	**R**

NA = not applicable; R = recommended; UHP = ultra-high-pressure.

CHAPTER 2. GENERAL GUIDANCE FOR PAVEMENT EVALUATION TOOLS

Pavement evaluation tools measure both the functional and structural properties of pavements. Structural properties describe the pavement/subgrade stiffness, pavement layer thickness and condition, and load transfer (for concrete pavements). Functional properties describe roughness, rut depth, geometry, skid resistance, and noise. Together, these properties provide crucial information for pavement design and evaluation.

The chapter outlines specific tools available to TxDOT that address many of these properties.

Structural Properties

Pavement Stiffness

Vehicle-mounted, nondestructive devices that can be used for measuring pavement stiffness include a falling weight deflectometer (FWD) and dynamic cone penetrometer (DCP).

FWD. The FWD measures pavement deflection by dropping a weight onto its surface to assess the pavement's structural integrity (see Figure 2). The deflection data are then converted into stiffness measurements (i.e., moduli) using the Modulus software (Liu and Scullion, 2001).

DCP. The pointed DCP tool measures the in-situ resistance to penetration of a pavement material (see Figure 3). Correlations have been established to connect the penetration testing data with stiffness. DCP testing typically accompanies FWD testing to verify the moduli of the base/subbase and subgrade. The DCP evaluates the in-situ strength of undisturbed soil or compacted materials by using the penetration depth of each blow.

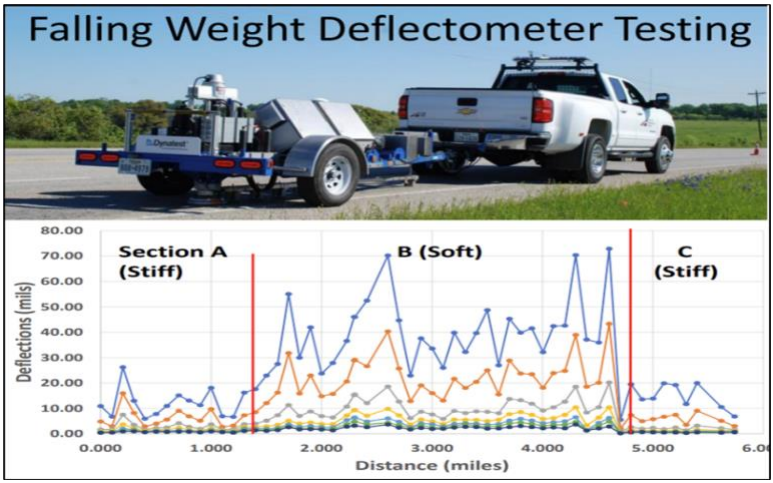


Figure 2. FWD Testing and Report.

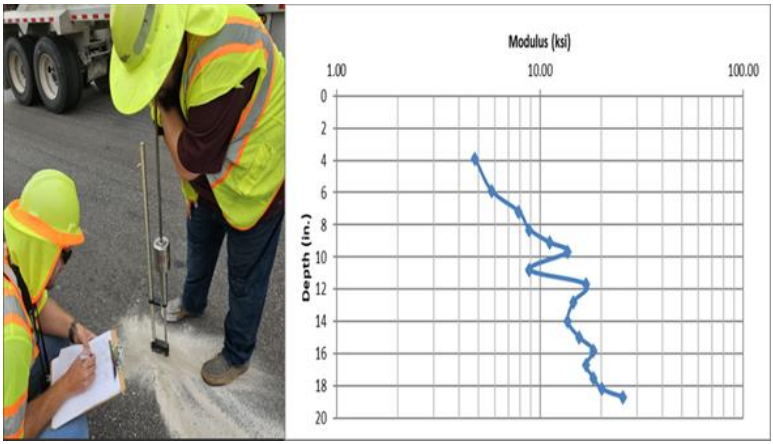


Figure 3. DCP Testing and Report.

Pavement Layer Thickness and Deterioration

Devices and methods used to verify layer thickness and identify deterioration under the pavement layers include ground penetrating radar (GPR), core drilling, and ball penetration testing.

GPR. GPR is a nondestructive device used to identify pavement layer thicknesses, potential deterioration areas, and defect limits (see Figure 4). GPR can estimate hot mix asphalt (HMA) layer densities

and detect defects, such as stripping and segregation (TxDOT, 2021). The PaveCheck software can relay GPR data, as combined videos and color waveform plots, to the engineers. Using GPR data, engineers can pinpoint poor pavement sections along the road to target FWD testing and coring at specific locations (Scullion, 2020).

Core Drilling. The coring device used for pavement/subgrade sampling is typically mounted on the back of a truck for support, enabling heavy-duty coring (see Figure 5). Pavement cores are often extracted to assess damage extent or verify NDT (e.g., GPR) results. Core drilling/inspection can reveal the extent and size of cracks and determine the composition of the pavement layers and materials.

Ball Penetration Testing. Ball penetration tests are modified DCP tests used to assess the stability of seal coat surfaces (when multiple existing seal coat layers exist) and determine excess or deficient binder on a road surface before applying a new seal coat (see Figure 6). The test involves dropping a DCP hammer to push a 0.75-inch-diameter steel ball into the seal coat surface. The ball penetration test correlates with the potential embedment of seal aggregate and is used to adjust the application rates of asphalt for surface treatments. Asphalt application rates are typically reduced when the ball penetration test shows high embedment.

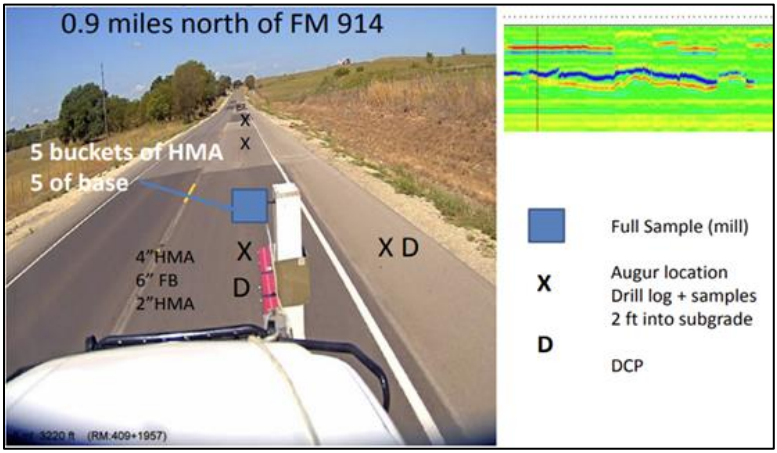
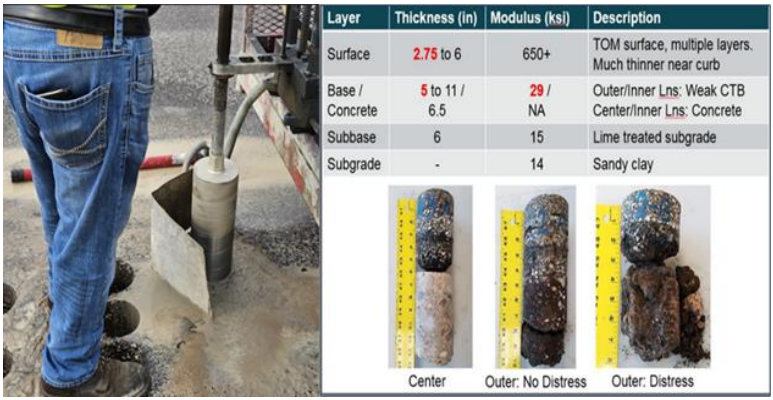


Figure 4. GPR Testing and Report.



Layer	Thickness (in)	Modulus (ksi)	Description
Surface	2.75 to 6	650+	TOM surface, multiple layers. Much thinner near curb
Base / Concrete	5 to 11 / 6.5	29 / NA	Outer/Inner Lns: Weak CTB Center/Inner Lns: Concrete
Subbase	6	15	Lime treated subgrade
Subgrade	-	14	Sandy clay

Figure 5. Core Drilling Process and Report.

Ball Penetration Test Result	Corresponding Action
< = 0.039 inches (1 mm)	0.039 inches (1 mm) adjustment to mat thickness for application rate on new seal coat.
> 0.039 inches (2 mm) to 0.118 inches (3 mm)	No adjustment.
0.118 inches (3mm) to 0.157 inches (4 mm)	-0.039 inches (-1 mm) adjustment to mat thickness for application rate on new seal coat.
> 0.197 inches (5 mm)	Repair pavement instead of seal coat.

Figure 6. Ball Penetration Testing and Report.

Functional Properties

Roughness

An inertial profiler and the Grind Diagnostics software are used to quantify the ride quality of the pavement surface.

Inertial Profiler. An inertial profiler assesses the functional properties of pavement by measuring longitudinal and transverse roughness at highway speeds (see Figure 7). These measurements are collected in real time and quantified as two indices—the serviceability index and the international roughness index. This equipment also detects

localized roughness, bumps, and dips. The serviceability index serves as an input in TxDOT's flexible pavement design system software (FPS 23).

Grind Diagnostics Software. The inertial profiler data can be used in the Grind Diagnostics software to identify milling limits and level ups (i.e., rut sections). The software organizes dips and bumps across both wheel paths to create a defect correction index (DCI), which correlates with the need to address localized roughness that affects ride quality. A DCI > 0.7 indicates that defects require correction. Furthermore, the Grind Diagnostics software can determine the types of defects identified for correction and match them with appropriate repair options (TxDOT, 2021). For example, if a bump is the only defect detected, the software will recommend "grind only" as the best option. If the defect type is a dip, the software will recommend "spot overlay" as the best option. If the defect type is a dip and a bump, the software will recommend "mill and fill" as the best option. The Grind Diagnostics software can additionally estimate material quantities and total costs, which is vital for budgeting.

Figure 7. Inertial Profiler and Grind Diagnostics DCI Analysis Map.

Geometry

Lidar Technology. Lidar technology can be used to gather geometry data. Lidar employs lasers to measure distances and create three-dimensional maps of the pavement geometry (see Figure 8). The data generated can be utilized for various geometric applications including rut mapping and cross-slope estimation. In addition to pavement geometry, the side road geometry can also be measured to provide information for drainage or other design requirements.

Figure 8. Lidar Scanning Technology.

Subgrade Properties

Web Soil Survey. The Web Soil Survey is a free online tool (https://websoilsurvey.nrcs.usda.gov) that offers U.S. soil characteristic information. The U.S. Department of Agriculture's Natural Resources Conservation Service manages the information and website access. Engineers can use this data to support construction or identify potential areas of concern. They can make timely decisions regarding field sampling locations due to the data availability and analysis simplicity, deducing soil chemical/physical properties, underground water levels, and other characteristics.

Pavement Testing and Technical Support

The TxDOT Maintenance Division, Pavement Analysis and Design Branch, provides statewide testing and technical support.

CHAPTER 3. REPAIR BEST PRACTICES

This chapter discusses typical asphalt pavement repair options, which include the following:

- Crack seal.
- Fog seal.
- Microsurfacing.
- Seal coat.
- Scrub seal.
- Level up and overlay (or seal coat).
- Mill and overlay.
- Base repair and seal.
- Spot seal (or strip seal).
- Edge repair and overlay.
- Full-depth reclamation (pulverization and resurfacing).
- Cement stabilized base.
- Ultra-high-pressure (UHP) water cutting.
- Pothole repair, including throw-and-roll, spray injection, semipermanent repair, and full-depth patching.

The subsequent sections describe each of these repair options and detail their conditions for use.

Crack Seal

Description

Crack seals involve placing adhesive material into and/or over working cracks (i.e., those that open and close with temperature changes, such as transverse thermal and reflective cracks, diagonal cracks, and certain longitudinal reflective cracks) at the pavement surface to prevent moisture from infiltrating the pavement structure (see Figure 9). Cracks should first be cleaned using air blasting or other acceptable method (if using a hot air lance for cleaning/drying cracks, avoid overheating to prevent burning the surrounding asphalt). When required, cracks should be routed or sawed to provide

a reservoir over the crack. Cracks 0.125–1.5 inches in width are filled with standard sealant, per manufacturer recommendations and in accordance with TxDOT Item 712; cracks wider than 1.5 inches are filled with fiber-reinforced polymer patching materials (TxDOT, 2024a).

Tip: Use a wand with a squeegee for a smooth, flush finish.

Figure 9. Crack Seal.

Conditions for Use

Main Distresses. Crack seals can address longitudinal, transverse, reflection, and block cracking.

Limits of Repair. All longitudinal or transverse cracks > 0.125 inches and ≤ 1.5 inches wide can be sealed (TxDOT, 2024a).

Traffic. Crack seals are appropriate for both low- and high-traffic roads; however, slow-moving traffic may pick up fresh crack sealant.

Climate. Crack seals perform well in all climatic regions; however, appropriate materials should be chosen based on anticipated temperatures. Sealing should occur during the coldest months of the year, when the cracks are at their widest opening, to allow the crack sealant time to age and cure before the hot weather.

Restrictions. Extensive crack sealing may require blotting sand to maintain the pavement's skid resistance. A blotting stone can also help mitigate the fresh sealant's "tracking" (TxDOT, 2024a).

Advantages. A crack seal is an inexpensive PM treatment. It is effective at keeping water out of the pavement structure and may slow the progression of load-related cracking.

Limitations. Excessive cracking may be better addressed with a blanket treatment such as a seal coat. Excessive crack seals can negatively impact ride quality if too much material is applied. Additionally, applying a thin hot mix overlay may cause the sealant to expand, resulting in a bump.

Expected Performance. A crack seal treatment is expected to be effective for 3–8 years.

Fog Seal

Description

Fog seals involve very light applications of slow-setting, water-diluted asphalt emulsion applied directly to the pavement surface without any aggregate. Typically, an asphalt distributor is used to apply the treatment. As a best practice, calibrate the spray bar for uniform coverage (see Figure 10). Specifically, set the nozzle spacing at usually 4–6 inches apart, adjust the bar height for uniform overlap, and maintain a consistent travel speed for the target application rate. Fog seal application rates over seal coats depend on aggregate size. For seal coats with aggregates < 0.5 inches, a typical fog seal rate is 0.09–0.11 gal/sq yd (50:50 diluted). For seal coats with aggregates > 0.5 inches, the rate increases to 0.11–0.13 gal/sq yd (50:50 diluted).

Tip: Use a fine-spray nozzle (fan cone or hollow cone) for even distribution, and check for clogging and wear before use.

Figure 10. Fog Seal.

Conditions for Use

Main Distresses. Fog seals can be used to treat low-severity longitudinal, transverse, and block cracking. Furthermore, it will mitigate low-severity raveling and fatigue cracking.

Traffic. Treated roads can range from very low to high traffic, but the average daily traffic (ADT) is typically below 4,000 vehicles/day (Abdallah and Nazarian, 2011). As ADT or truck percentages rise, surface wear increases. On high-traffic roads, skid resistance may also become a factor.

Climate. Fog seals function effectively in all climate zones. The treatment should ideally be applied when temperatures reach 60°F or higher and conditions are dry (TxDOT, 2024b). At lower temperatures, longer curing times are necessary before opening to traffic.

Restrictions. Pavements with significant fatigue cracking or severe thermal cracking are unsuitable for fog seals. This treatment should not be used if moderate-severity flushing or bleeding is present or if rutting exists. Furthermore, the pavement must be sufficiently porous to absorb a significant amount of the emulsion when applying the fog seal.

Advantages. A fog seal is an inexpensive PM treatment. It also offers some pavement edge delineation. Fog seals can be applied to seal coats that show signs of aggregate shelling. Aggregate shelling occurs after the first cold spell following seal coat placement. The treatment reduces asphalt aging, oxidation, and hardening and prevents moisture infiltration.

Limitations. The treatment has a short lifespan and does not enhance structural value. Because of the slow-setting emulsion, the road must remain closed to traffic for a minimum of 2 hours. It does not impact the ride quality of a road but may reduce skid resistance (Illinois Department of Transportation, 2010).

Expected Performance. A fog seal treatment is anticipated to last 1–3 years (Maher et al., 2005).

Microsurfacing

Description

Microsurfacing consists of polymer-modified emulsified asphalt cement, well-graded crushed fine aggregate (with a maximum size of < 0.5 inches), mineral filler, water, and additives, which are mixed in specialized, compartmentalized, self-powered trucks (Lenz, 2011). Although the components of microsurfacing are similar to HMA, microsurfacing is placed at ambient temperatures, typically without requiring compaction, which allows for the application of much thinner layers than is possible with standard HMA. Also, microsurfacing is more stable than slurry seals and can be applied at thicknesses up to three times the size of the largest aggregate in the mix.

Tip: Select the proper application rate based on distress type and desired thickness.

Conditions for Use

Main Distresses. This treatment can address low- to moderate-severity transverse, longitudinal, and block cracking. Moreover, it will stop raveling/weathering, low- to moderate-severity bleeding, shallow rutting, and low-severity alligator cracking.

Limits of Repair. Microsurfacing is not effective against unstable rutting, ruts > 1.5 inches deep, or cracks > 0.25 inches wide (Maher et al., 2005).

Traffic. Microsurfacing has been successful on both low- and high-traffic roads. It is typically applied on roads with an ADT > 400 vehicles/day (Maher et al., 2005).

Climate. This treatment is effective in all climates, but it performs better in warm temperatures with low daily fluctuations. Placement in hot weather should be avoided if a potential for flushing exists. Construction should not be commenced if freezing temperatures are expected within 24 hours because it can lead to early raveling (Maher et al., 2005).

Restrictions. Pavements with structural failures and high-severity thermal cracking are not good candidates for microsurfacing. Other remedial activities may be necessary prior to treatment.

Advantages. Microsurfacing corrects pavement surface oxidation and surface friction. It also seals the pavement while filling minor surface irregularities, improving riding quality. The road can be opened to traffic after just 1 hour. Microsurfacing performs better than seal coats in turning and stopping movements (i.e., high shear environments). A tack coat is usually not required unless the surface is extremely dry or raveled.

Limitations. Microsurfacing does not improve structural capacity. The potential exists for early damage in areas of heavy truck turning and downgrading locations due to insufficient curing times.

Expected Performance: Microsurfacing treatments are expected to last 5–8 years.

Seal Coat

Description

A seal coat, also known as chip seal, is a thin surface treatment applied by spraying a layer of asphalt binder (e.g., emulsified

asphalt, cutback asphalt, or asphalt cement) directly onto the pavement surface, followed by a pneumatically rolled aggregate cover (see Figure 11). The aggregate can be precoated or uncoated. Precoated aggregates improve adhesion and reduce early aggregate loss. Rolling the single-sized crushed aggregate (50–70 percent) is essential for enhancing chip retention. The maximum chip size dictates the thickness of the seal layer, which is typically 0.25–0.375 inches, although larger chips have been successfully used on roads with heavy truck traffic.

Tip: Use temperature-controlled tanks to maintain binder quality, avoid overlapping passes to prevent excess aggregate, and roll immediately after spreading aggregate for a uniform surface finish.

Figure 11. Seal Coat.

Conditions for Use

Main Distresses. Seal coats have been successful in treating light to moderate non-load-related longitudinal, transverse, and block cracking. The treatment can also address low- to moderate-severity raveling and flushing. The seal coat may also serve as a temporary solution for low-severity alligator cracking.

Limits of Repair. Seal coats cannot effectively bridge cracks > 0.25 inches wide (South Dakota Department of Transportation, 2010).

Traffic. Although seal coats have been used to treat roads with ADTs > 10,000 vehicles/day, they are typically used when ADTs are < 1,000 vehicles/day, when placed over an aggregate base, or < 2,000 vehicles/day, when placed over an existing asphalt layer (Maher et al., 2005). Commonly, seal coats are placed on roads with a truck percentage of < 15 percent or 250 trucks/day (annual average) (Abdallah and Nazarian, 2011). Alternatively, roads with truck percentages of up to 45 percent have been successfully treated in the past (Wu et al., 2010).

Climate. Seal coats perform well in all climatic conditions, but special attention should be given during placement. Seal coats should be applied in warm, low-humidity, wind-free weather; rainy, cold conditions should be avoided.

Restrictions. Avoid using seal coats on structurally failed pavements with extensive fatigue cracking, severe longitudinal and transverse cracking or ruts > 0.5 inches deep (Maher et al., 2005). Cracks > 0.125 inches wide should be sealed before a seal coat is applied (TxDOT, 2024b). This treatment is not recommended for areas of frequent truck turning, braking, accelerating, or snowplowing. Patch severe distress in the existing pavement as required, and use transverse-variable asphalt shot rates when wheel paths are already bleeding.

Advantages. This treatment creates a waterproof membrane that protects the underlying materials from moisture and erosion, thus retaining their strength and reducing surface oxidation and bleeding. It also improves surface friction and texture, corrects minor deformations, and provides a temporary cover for a base course until the rest of the asphalt course is placed.

Limitations. Seal coats result in prolonged traffic disruptions due to their curing requirements. This treatment does not improve structural capacity or ride quality. The roughness of the underlying layer mainly determines ride quality. Loose chips that are not embedded can become windshield hazards.

Expected Performance. Seal coat treatments are expected to last 3–8 years (Wu et al., 2010). Seal coats applied over aggregate bases generally have shorter service lives.

Scrub Seal

Description

Scrub seals are similar to seal coats (or chip seals). Polymer-modified asphalt is applied to an asphalt pavement surface with a broom before a layer of aggregate is applied (see Figure 12). The aim is to restore pavement surface texture and weatherproofing (Pavement Preservation and Recycling Alliance, 2025; TxDOT, 2021).

Tip: Use a drag/scrub broom with angled bristles and ensure complete contact with the surface to push emulsion into cracks.

Figure 12. Scrub Seal.

Conditions for Use

Main Distresses. Scrub seals can be applied to existing, structurally sound pavements with low to excessive amounts of fine cracks on the surface.

Limits of Repair. Scrub seals can consist of one or more applications that are scrubbed into cracks and/or voids on the pavement surface. This treatment is recommended for roads with a low percentage of trucks. Scrub seals are effective for nonstructural cracking (< 0.5 inches wide), but FHWA suggests limiting their use on existing ruts > 0.375 inches deep.

Traffic. This treatment can be applied on both low- and high-traffic roads.

Climate. This treatment is effective in all climates, but it performs better in warm temperatures with low daily fluctuations. Placement in hot weather should be avoided if a potential for flushing exists. Construction should not commence if freezing temperatures are expected within 24 hours. In general, scrub seals should be applied during dry, warm weather to allow for proper curing.

Restrictions. Scrub seals are not suitable for pavement with structural failures or high-severity cracking on the pavement surface. This treatment is also not recommended for pavements with bleeding or flushing.

Advantages. Scrub seals can seal pavements while filling minor surface irregularities, provide protection from oxidation, and potentially improve surface friction (TxDOT, 2021). The road can be opened to traffic after just 1 hour.

Limitations. Scrub seals are ineffective for potholes, severe rutting, or rough surfaces. Generally, this treatment does not improve the structural capacity of the pavement or ride quality.

Expected Performance. Depending on pavement conditions, the lifespan of a scrub seal treatment is 1–10 years. If applied correctly, seal coats can last 6–7 years on average (Pavement Preservation and Recycling Alliance, 2025).

Level Up and Overlay (or Seal Coat)

Description

Level-up patching involves laying down (blade or laydown) a 1–1.5-inch asphalt mix layer over existing ruts or profile/cross-slope anomalies in the pavement. The patch size may extend across two full-width lanes and 50 ft or more in length (Dessouky & Papagiannakis, 2012). Typical materials include hot mix hot-laid asphalt concrete, limestone rock asphalt, and special reclaimed pavement mixes. After level-up patching, a PM treatment, such as an overlay or seal coat, can be applied. A preferred combination is a level up with an overlay (> 2 inches), especially when high-volume traffic prevails. An overlay layer of plant-mixed asphalt cement is applied over the level up and existing surface (see Figure 13). The mix can be stone matrix, dense-graded, or open-graded. A tack coat is required before the overlay placement to improve the bond to the existing surface and level up.

Tip: Allow the tack coat to break before the PM treatment.

Conditions for Use

Main Distresses. Level up treatments can treat extensive patching in good condition and shallow rutting caused by traffic loading. It can also fix depressions due to subgrade failure, utility cuts, and minor dips affecting ride quality. This treatment could also be used to treat edge drop-off.

Limits of Repair. A level up treatment can be used to fill ruts < 2 inches deep, but it is not suitable for widespread structural failures.

Traffic. A level up with a seal coat is suitable for low- to moderate-traffic roads with low speeds (< 45 mph), where ride quality is less critical. A level up with an overlay is suitable for moderate- to high-traffic roads. Unlike a seal coat, an overlay can be designed to improve the pavement's structural capacity (TxDOT, 2024b).

Figure 13. Level Up and Overlay.

Climate. This treatment performs well in all weather. During placement, the air temperature should be above 40°F (TxDOT, 2024a, 2024b), and rain should be avoided.

Restrictions. This treatment is not recommended for pavements with significant fatigue cracking or pavements that have structurally failed. Candidate roads should feature a stable pavement with a solid base. If severe surface distresses are present, milling of the asphalt layer should be included. The overlay should be applied immediately after the level up.

Advantages. Performing a level-up repair before a PM treatment ensures a uniform surface and improves ride quality. This treatment delays severe distress and extends the pavement life. It provides a protective waterproof membrane and corrects surface irregularities.

Limitations. A level up treatment does not correct deep structural failures in the base or subgrade. Additionally, it is not ideal for high-traffic roads or heavy truck routes unless a more robust treatment, such as an overlay, is applied.

Expected Performance. The service life of the level up is dependent upon the applied PM treatment. The life expectancy of a level up alone (temporary fix) is 1–3 years. A level up with a seal coat has an expected life of 3–7 years compared to 3–17 years for a level up with an overlay (Oregon Department of Transportation [ODOT], 2011). A typical TxDOT overlay is expected to last 8 years (Lenz, 2011).

Mill and Overlay

Description

In a mill and overlay treatment, the pavement is first milled to remove part of the existing asphalt surface. Then, a layer of plant-mixed asphalt cement and aggregate (≥ 2 inches thick) is applied to the current surface (see Figure 14). The mix can be stone matrix, dense-graded, or open-graded. A tack coat is necessary before placing the overlay to improve bonding with the existing surface. Some pavement repair may be needed after milling if severe delamination or other distress has occurred.

Tip: For best results, use automated grade control for consistent milling and regularly check the milling machine (cold planer) drum teeth and conveyor belt.

Conditions for Use

Main Distresses. Asphalt overlays effectively fix medium- to high-severity transverse, longitudinal, and block cracking. This treatment also addresses moderate-severity raveling and alligator cracking. Cold milling allows for the repair of more severe surface issues, including stable shallow rutting and deteriorated patches.

Figure 14. Mill and Overlay.

Traffic. When an overlay is utilized for additional structural capacity, its thickness is contingent upon traffic loading. The pavement design methods utilized by the respective state transportation agencies should be applied.

Climate. This treatment performs well in all weather. During placement, the air temperature should be above 40°F (TxDOT, 2024a), and rain should be avoided.

Restrictions. This treatment is not recommended for pavements that have structurally failed. Candidate roads should have a stable pavement with a good base. When extensive deep rutting is present, separate rut-filling applications are needed. Patching of localized deep distresses must be completed before milling.

Advantages. The mill and overlay treatment enhances ride quality and surface friction while reducing hydroplaning and tire splash (when using an open-graded friction course). This treatment delays severe distress and extends the pavement life. It provides a protective waterproof membrane and corrects surface irregularities. It adds structural capacity and is less susceptible to reflective cracking. Cold milling restores proper grades and cross slopes.

Limitations. This treatment requires a high initial cost and specialty contractors. Curb and bridge clearances may be an issue. Open friction courses should not be resurfaced. Millings must be disposed of or recycled.

Expected Performance. Mill and overlay treatments are expected to last 3–17 years (ODOT, 2011; Peshkin, 2004). Milling ensures that the overlay does not fail prematurely. A typical TxDOT overlay is expected to last 8 years (Lenz, 2011).

Base Repair and Seal

Description

This two-step treatment involves repairing the pavement structure and restoring the surface condition of damaged asphalt pavement. Base repair aims to enhance the pavement's structural integrity before the application of a PM treatment, such as a seal coat. The repair procedure entails marking the repair limits, cutting the pavement, removing unsuitable base material without disturbing the subgrade, replacing it with suitable material (e.g., crushed stone or stabilized base), and ensuring proper compaction (see Figure 15). The remaining area of the removed pavement is filled with asphalt concrete and compacted to match the surrounding pavement. The surface can be restored with a seal coat; however, the repaired section needs time to cure before its application (see Chapter 6). The seal coat is applied by spraying a layer of asphalt binder (e.g., emulsified asphalt, cutback asphalt, or asphalt cement) onto the pavement surface, followed by a pneumatically rolled aggregate cover.

Tip: For best results, compact the base in layers and use a vibratory plate for tight corners.

Conditions for Use

Main Distresses. Base repair addresses areas with repeated cracking or deformation, where surface treatment alone is not adequate. It also targets localized structural distresses such as alligator cracking and rutting.

Figure 15. Base Repair.

Limits of Repair. Base repair is generally confined to specific areas that show structural failure (e.g., potholes and alligator cracking). It may involve only the surface and base layers (e.g., 4–8 inches deep). Full-depth reconstruction may be more suitable if the pavement has significant base or subgrade failure.

Traffic. Base repair is designed to carry the expected traffic. Surface treatments, such as seal coats, are typically used when ADTs are < 1,000 vehicles/day, when placed over an aggregate base, or < 2,000 vehicles/day, when placed over an existing asphalt layer (Maher et al., 2005). Commonly, they are applied on roads with a truck percentage of < 15 percent or 250 trucks/day (annual average) (Abdallah and Nazarian, 2011). Alternatively, roads with truck percentages of up to 45 percent have been successfully treated in the past (Wu et al., 2010).

Climate. This treatment is susceptible to moisture and rainfall. Moisture in the base layer can prevent proper bonding with the seal coat and compromise the pavement's structural integrity. Additionally, in wet conditions, water can infiltrate the pavement if base repairs are not adequately compacted and sealed, leading to early failure. Seal coats should be applied in warm, low-humidity, wind-free weather; rainy or cold conditions should be avoided. Application of this treatment is not recommended from September to April or when freezing is anticipated within 48 hours (Maher et al., 2005).

Restrictions. If the structural distress is widespread, the localized base repair will not be effective.

Advantages. This treatment creates a waterproof membrane that safeguards the underlying materials from moisture and erosion, helping to retain their strength while minimizing surface oxidation and bleeding. It enhances surface friction and texture, corrects minor deformations, and provides temporary coverage for a base course until the remaining asphalt layer is applied. It is durable, lower in initial cost, and widely accessible.

Limitations. Base repairs cause extended traffic disruptions due to their curing requirements. This treatment does not enhance structural capacity or ride quality. Chip seals are prone to stripping. The roughness of the underlying layer primarily influences ride quality.

Expected Performance. Base repairs ensure that the PM treatment (e.g., seal coat) does not encounter premature failures. The expected lifespan of base repair and seal is 3–8 years (ODOT, 2011).

Spot Seal (or Strip Seal)

Description

Spot seals (or strip seals) are localized surface treatments for issues such as oxidation, minor cracking, raveling, or surface finish related to local base repairs or edge repairs that involve applying a protective sealant like a seal coat, fog seal, or slurry seal (FHWA,

2019; TxDOT, 2024a). As a first step, clean the surface and ensure it is dry and free of contaminants. After cleaning, apply a light tack coat, as needed, to enhance bonding (see Figure 16). The next steps depend upon the type of sealant applied. For a seal coat, spray the asphalt emulsion, then immediately spread the aggregate. For a fog seal, spray diluted asphalt emulsion directly onto the surface. For a slurry seal, apply a mix of emulsion, fine aggregate, and additives. Compact the aggregate and embed it into the binder. Allow the spot seal to cure before opening the road to traffic (a few hours) or before applying a PM treatment, such as an overlay (> 2 inches) or a seal coat.

Tip: When spraying the binder using a hand sprayer, use a low-pressure setting to prevent overspray.

Figure 16. Spot Seal.

Conditions for Use

Main Distresses. Spot seals effectively treat transverse, longitudinal, and block cracking. Additionally, this treatment addresses moderate raveling and alligator cracking. Extensive patching in good condition and shallow rutting may also be treated. Localized failed areas, including fatigue cracking and rutting, can also be fixed.

Traffic. Spot seals are suitable for all traffic levels, depending on materials and the type of PM treatment (a seal coat is suitable for low- to moderate-traffic roads; an overlay is suitable for moderate- to high-traffic roads).

Climate. This treatment performs well in all weather. During placement, the air temperature should be above 40°F and rain should be avoided (ODOT, 2011).

Restrictions. This treatment is not recommended for pavements with extensive fatigue cracking or that have structurally failed. Candidate roads should have a stable pavement with a good base. If structural distress is widespread, this combination of treatments may not be cost-effective.

Advantages. A spot seal enhances ride quality, offers a protective waterproof membrane, and addresses surface irregularities. Furthermore, it extends pavement life by sealing cracks and preventing water infiltration. It can also serve as part of a broader PM strategy.

Limitations. No structural improvement may be needed in high-traffic or high-stress areas.

Expected Performance. Spot seals are expected to last 3–7 years, depending on traffic, materials, and surface preparation (Lenz, 2011; TxDOT, 2024a).

Edge Repair

Description

Edge repair restores the structural integrity and shape of deteriorated pavement edges, often caused by erosion, traffic loading, or poor drainage. It is the same as localized base repair on the edge of the pavement. The repair procedure includes marking the repair limits, cutting the pavement, removing unsuitable base material without disturbing the subgrade, replacing it with suitable material (e.g., crushed stone or stabilized base), and ensuring proper compaction (see Figure 17). The section of removed pavement is filled with

asphalt concrete and compacted to align with the surrounding pavement. The localized surface may be finished with a spot seal before applying a PM treatment. Sufficient curing time is required before applying the PM treatment; in Texas, this curing time often exceeds 8 months (TxDOT, 2024a).

Figure 17. Edge Repair.

Conditions for Use

Main Distresses. The edge repair process effectively addresses edge cracking, shoulder drop-off, pavement edge raveling or crumbling, and loss of lateral support.

Traffic. The edge repair treatment is suitable for low- to moderate-traffic roads.

Climate. Edge repair should occur in dry, warm weather; moist or rainy conditions should be avoided. Poor drainage or freeze-thaw cycles can accelerate edge failure (ODOT, 2011).

Restrictions. This treatment is ineffective if the subgrade is unstable or saturated. Instead, opt for full-depth reconstruction.

Advantages. Edge repair restores edge support and prevents further cracking. It enhances safety by eliminating edge drop-offs. It prepares the pavement for surface treatments like seal coats by addressing the underlying cause of the problem.

Limitations. Edge repair requires a high initial cost and specialized contractors. Curb and bridge clearances may be an issue. Frequent maintenance may be necessary in areas with high moisture or heavy traffic.

Expected Performance. The life expectancies of edge repairs can vary greatly. Without a PM treatment, edge repairs could last 2–5 years. With different PM treatments, edge repairs could last 3–17 years (Wu et al., 2010).

Full-Depth Reclamation

Description

Full-depth reclamation is a technique where the entire asphalt pavement depth and a portion of the base (maximum depth is typically 12 inches) are pulverized and blended to create a stabilized base. The materials are blended with stabilization agents, including cement, lime, fly ash, foamed asphalt, or emulsions (see Figure 18). The new base is then compacted and resurfaced.

Tip: Use a calibrated spreader to uniformly blend stabilized agents, compact in layers, frequently verify density, and keep equipment moving to avoid segregation.

Conditions for Use

Main Distresses. Full-depth reclamation eliminates all existing distresses.

Traffic. This treatment is suitable for low- to high-traffic roads. The designed base thickness is dependent upon the traffic loading. The use of lime should be restricted to lower-traffic roads.

Figure 18. Full-Depth Reclamation.

Climate. For this treatment option, care should be taken when using cement to stabilize the mix in frost heave areas. Similarly, the use of asphalt as the stabilization agent is not attractive for areas of high humidity (> 80 percent) or high rainfall (Scullion et al., 2003). Construction must not occur during heavy rain or snowfall or when the surface is frozen. Warm temperatures are required for the stabilization reaction to occur.

Restrictions. If the desired stabilization depth exceeds that of the existing materials above the subgrade or if the resulting material blend is of poor quality, additional aggregates, reclaimed asphalt pavement, or crushed Portland cement concrete may need to be added. Cutting into the subgrade should be avoided because it may introduce excessive fines into the blend, making the recycled layer susceptible to moisture. When using cement as the stabilization agent, it is essential to avoid excessive strength to mitigate shrinkage cracking and to incorporate microcracking in the stabilized layer. Areas with severe localized alligator cracking or structural rutting may require a full-depth patch.

Advantages. Full-depth reclamation recycles existing road materials to create a stronger road foundation. It restores ride quality and

structural capacity, significantly reducing the risk of reflective cracking. The addition of lime enhances base soil strength and stiffness. The addition of cement can stabilize any soil except for highly organic ones.

Limitations. Increased stiffness can lead to shrinkage cracking. Chemical stabilization may require up to 1 week to cure before surfacing can be applied (Scullion et al., 2003). Asphalt emulsions have not demonstrated satisfactory performance in moist environments or in thicker lifts (> 6 inches). Truck traffic is not permitted until the riding surface is installed.

Expected Performance. The expected life of full-depth reclamation with a surface treatment is 7–10 years, compared to 15–20 years with an asphalt overlay (Maher et al., 2005).

Cement Stabilized Base

Description

In the cement stabilized base treatment, the pavement is first cold-milled to remove the existing asphalt surface. The base layer is then stabilized to enhance relevant soil properties by adding a stabilizing agent, in this case, cement (see Figure 19).

Tip: Use a calibrated spreader to spread the cement evenly, maintain proper moisture for hydration, and avoid windy conditions to reduce dust loss.

Conditions for Use

Main Distresses. Cold-milling allows for moderate to severe surface load and thermal-induced distresses to be fixed. Rutting and deteriorated patches are also eliminated.

Traffic. This treatment is suitable for low- to high-traffic roads. The thickness of the designed base is dependent upon the traffic load. The pavement design methods utilized by the respective state transportation agencies should be applied.

Figure 19. Cement Stabilized Base.

Climate. For this treatment option, care should be taken when using cement to stabilize the base in frost heave areas. Construction must not occur during heavy rain or snowfall or when the surface is frozen. Stabilization should be completed at least 1 month before the first freeze (Scullion et al., 2003).

Restrictions. The subgrade must provide adequate support or differential movement may lead to reflective cracking. Cutting into the subgrade should be avoided because it may introduce excessive fines into the blend, resulting in moisture susceptibility of the recycled layer. Excessive strength should be avoided. Areas with significant alligator cracking or severe structural rutting may require a full-depth patch. Typically, > 3 percent cement is required to achieve the recommended unconfined compressive strength of 300–500 psi at 7 days (Sebesta, 2002; TxDOT, 2024a). The base must consist of high-quality materials with < 25 percent passing the No. 200 sieve, and the plasticity index must remain below 12 (TxDOT, 2005, 2024a). For specific materials, such as a flexible base, refer to the requirements in TxDOT's specification item 247.

Advantages. Cold-milling restores proper grades and cross slopes and allows for restored surface friction, ride, and texture. It

eliminates serious distresses and extends the life of the pavement. The cement stabilized base increases base soil strength and stiffness and adds structural capacity. Cement can be used to stabilize any base layer except highly organic soils.

Limitations. The limitations of a cement stabilized base treatment are somewhat similar to concrete and include cracking, sensitivity to moisture (during the curing period), etc. Until sufficient strength is achieved within the cement base layer, traffic should be restricted.

Expected Performance. If the roadway has a proper structural design, the life expectancy of a cement stabilized base is about 20–30 years (Maher et al., 2005).

UHP Water Cutting

Description

The UHP water cutting treatment is a nondestructive pavement treatment that uses high-pressure water jets to remove excess asphalt binder and improve pavement surface texture. UHP water cutting can be used to shave off excess binder on large leveled-up sections before application of a seal coat (see Figure 20). The UHP water cutting device can deliver at least 16 gal/min while operating at 36,000 psi. Potable water is typically used for this operation. Water used by this equipment must be free from industrial waste, oils, acids, or other debris; it is not advisable to use water directly from lakes or rivers (TxDOT, 2024a; Waters, 2004).

Tip: For best results, maintain a forward speed within ± 0.1 mph for uniform texture and keep the vacuum system active to remove debris and water.

Conditions for Use

Main Distresses. This treatment addresses flushed pavements with excess asphalt binder on the surface and polished aggregate surfaces that result in a loss of microtexture and skid resistance.

Figure 20. UHP Water Cutting.

Limits of Repair. If the surface is severely deteriorated (i.e., has extensive cracking, raveling, or structural damage), UHP water cutting can exacerbate the condition by removing thin layers such as slurry seals or microsurfacing, by harming the internal structure, or by blocking the pores in porous asphalt.

Traffic. UHP water cutting is appropriate for both low- and high-traffic roads because it causes minimal disruption. Additionally, treated roadway surfaces can be reopened to traffic quickly.

Climate. This treatment performs relatively well in all climatic regions, although preferred application temperatures are 35°F–85°F. During cold weather, freezing temperatures can cause the water to freeze on the surface, creating safety hazards.

Restrictions. This treatment requires access to clean water (no lake or river water).

Advantages. UHP water cutting is a nonintrusive and cost-effective method of restoring the pavement's microtexture and macrotexture. It is also environmentally friendly (no chemicals or abrasive materials are used). It is quickly applied and allows early opening of the roadway to traffic.

Limitations. UHP water cutting is not effective on surfaces with deep rutting or cracking. It is a temporary solution and requires reapplication.

Expected Performance. This treatment will likely last 1–3 years, depending on traffic volumes and environmental conditions (Waters, 2004).

Pothole Repair

Description

Pothole repair generally involves square cutting the repair area, removing any loose/foreign materials, removing any water, drying the area, and applying a tack coat to the surface of the repair area (see Figure 21). Next, repair materials are placed in horizontal lifts ≤ 3 inches thick. Materials used for the repair can include limestone rock asphalt, hot mix cold-laid asphalt concrete, dense-graded HMA, asphaltic concrete patching materials (stockpiled or bagged), or rapid-curing asphalt concrete patching materials (TxDOT, 2024a). To ensure proper repair, the limits are typically extended into a structurally sound section of the pavement, usually by 12 inches. Specific pothole repair options can be categorized as throw-and-roll, semipermanent repair, spray injection, and full-depth patching. Only permanent repairs are suitable under a PM treatment (e.g., seal coat).

Throw-and-Roll. The throw-and-roll option involves filling the pothole with patching material and compacting it using a truck tire. A tamper or plate compactor can also be used to create a more even and solid surface. It is a temporary, quick fix suitable for low-traffic roads.

Tip: For best results, slightly crown the mix above the surface.

Semipermanent Repair. The semipermanent repair option involves removing water/debris, squaring the pothole edges, placing patching material, and compacting it. It is more durable than the throw-and-roll option.

Tip: For best results, compact in lifts for deep patches.

Figure 21. Pothole Repair.

Spray Injection. The spray injection option uses specialized equipment to blow out debris, spray a tack coat, and inject asphalt/aggregate. It is fast, efficient, and suitable for moderate-traffic roads.

Tip: Finish with a dry aggregate cover to prevent tracking.

Full-Depth Patching. Full-depth patching involves excavating the pothole and surrounding area and placing/compacting new HMA. This option is ideal for long-term structural repairs.

Tip: For optimal results, layer the mix, compact each layer, and verify density. Also, match grade and cross slope to prevent water ponding.

Conditions for Use

Main Distresses. Pothole repair addresses potholes caused by fatigue cracking, water infiltration, and freeze-thaw cycles.

Limits of Repair. In Texas, the throw-and-roll, semipermanent repair, and spray injection options are restricted to the top 2 inches of the pavement, while full-depth patching extends to the pavement's structural bottom layers. Also, cold mixes cannot be used at depths > 2 inches because they are not designed to offer structural capacity (Dailey et al., 2017).

Traffic. The throw-and-roll option is suitable for low- to moderate-traffic roads, while the spray injection and semipermanent repair options are suitable for moderate- to high-traffic roads. Full-depth patching is suitable for high-traffic roads (ADT > 400 vehicles/day).

Climate. Climate has a profound effect on the materials used. Cold mix is used in the winter, hot mix is used in the warmer seasons, and spray injection works in most climates.

Restrictions. Wet or freezing conditions may limit the effectiveness of pothole repairs. All potholes must be repaired permanently before a seal coat is applied.

Advantages. Pothole repair offers quick restoration of ride quality and safety and minimizes the rate of pavement deterioration. It also provides a level platform for PM treatments (e.g., seal coats).

Limitations. Except for full-depth patching, all other pothole repair options do not improve structural capacity. A potential for early damage exists in areas with heavy trucks.

Expected Performance. The expected life of a pothole repair varies depending on the option applied. Throw-and-roll, semipermanent repair, and spry injection options are expected to last weeks to months, 6–12 months, and 1–2 years, respectively. Full-depth patching is expected to last 3–10 years.

Table 5 streamlines decision-making by matching key conditions with the most appropriate pothole repair option.

Table 5. Decision Table for Pothole Repair.

Distress Severity	Traffic Volume	Climate	Repair Urgency	Recommended Repair Option
Minor	Low/ moderate	Cold/wet	Urgent	Throw-and-roll
Moderate	Moderate/ high	Moderate	Moderate	Spray injection or semipermanent repair
Severe	High	Warm/dry	Not urgent	Full-depth patching

CHAPTER 4. WORK AND SAFETY

Pavement repair work involves hazards related to traffic, equipment, and materials. This chapter describes methods for mitigating each of these hazard types.

Traffic. Vehicles navigating a work site pose a risk to workers and other vehicles. Implementing appropriate traffic control measures is essential to ensure safe work zones. Please consult TxDOT's traffic control plans to determine the appropriate level of traffic control based on the repair work and traffic levels (TxDOT, 2022). Table 6 defines traffic levels in pavement maintenance (Chang et al., 2014).

Table 6. Matrix Traffic Level Definitions

Pavement	Traffic Level	Per Lane ADT (vehicles/day/lane)
Asphalt	Low	< 1,000
	Medium	1,000–5,000
	High	> 5,000
Jointed concrete	Low	< 7,500
	High	≥ 7,500
Continuously reinforced concrete	Low	< 7,500
	High	≥ 7,500

Equipment. Equipment such as pavers, rollers, and milling machines can pose risks to workers, including crushing, entanglement, hearing loss, or being struck. Enhancing safety around equipment requires understanding the environment, maintaining a safe distance when equipment is in operation, implementing the lockout/tagout procedure, and using spotters to guide equipment operators and manage traffic flow (Texas Department of Insurance, 2025).

Materials. Hazards from materials include burns from hot substances, inhalation of harmful fumes, and physical injury from lifting heavy objects. For guidance on material-related safety, refer to TxDOT's *Handbook of Safe Practices* (TxDOT, 2016). Additionally, consult the material safety data sheet for further information.

CHAPTER 5. CONSTRUCTION AND CURING TIME

To ensure durability, performance, and cost-effectiveness, repairs are best applied within a specific window. This chapter discusses the recommended seasonal and daily timing, weather and traffic conditions, material-specific timing, and repair materials curing time.

Seasonal Timing

Spring and early fall are generally the best times for asphalt repair because temperatures are moderate and precipitation is less likely. Avoid extreme conditions; temperatures that are too cold can cause the asphalt to cool too quickly, reducing compaction quality, while temperatures that are too hot can lead to over-compaction/bleeding.

Daily Timing

Start early in the morning/day to take advantage of cooler temperatures and allow sufficient curing time before traffic resumes. Avoid late day paving because the surface may not cure properly overnight, especially in cooler months.

Weather Conditions

Never pave on wet surfaces. Moisture can cause poor bonding and premature failure. Avoid paving if rain is expected within 24 hours.

Traffic Conditions

Schedule repairs during low-traffic periods (e.g., off-peak hours or at night) to minimize disruption and allow proper curing. Allow at least 24 hours of curing time before opening the road to traffic or follow the manufacturer's recommendations for specific materials.

Material-Specific Timing

HMA must be placed/compacted while still hot (within 30–60 min of mixing, depending on ambient temperature). Cold patch can be used in cold conditions but is typically a temporary fix.

Repair Materials Curing Time Before PM Treatment

Repair materials need time to cure before applying a PM treatment (e.g., seal coat). A general rule of thumb is to wait 6–12 months after the repair. This window could vary depending on the repair material, climate, and traffic conditions. Table 7 shows the typical curing times for different repair materials.

Table 7. Repair Material Curing Times.

Repair Option	Maintenance Treatment	Minimum Desirable Time before Sealing
Crack seal	Emulsion	2 months[a,b]
	Cutback products	6 months[a,b]
	Hot bituminous products	1 year[c,d]
Patching/ edge repair	Premixed/cold-mixed asphalt with emulsion	Minimum 4 months;[a] typical > 9 months[b]
	Premixed/cold-mixed asphalt with cutback asphalt	> 6 months[a,b,c]
	Premixed/cold-mixed asphalt with fluxing material (limestone rock asphalt)	> 9 months[b]
	Cold mix	6 months[d,e]
	HMA	Minimum 4 months[d]
	Microsurfacing	Minimum 3 months;[a] typical > 9 months[b]
Reseal	Cutback bitumen and Grade 5 aggregates	6 months[a]
	Emulsion and Grade 5 aggregates	1 month[a]
Fog seal	Base material: Slow-setting emulsions	3 months[d]
Structural repair	Cold in-place asphalt recycling	Moisture content < 2% of total material weight[e] or 9 months[d]
	Flexible base repair	Moisture content < 2% of optimum[f] or 6 months[d]
Other	Treatment of flushed areas by asphalt patching or solvent use	2–6 months[a,b]
	Maintenance of shoulders/longitudinal drain	2 weeks[a,b]
	Line marking before resealing	3–6 months[a]
	UHP water cutting	6 weeks–6 months[a,b]

[a]New Zealand Transport Agency (2005).
[b]Austroads Ltd. (2021).
[c]FHWA (2020).
[d]Texas Asphalt Pavement Association (2025).
[e]De Carteret (2009).
[f]TxDOT (2024a).

CHAPTER 6. EFFECTS OF REPAIRS ON PM

Preparing and repairing the pavement before the PM treatment are essential for long-term performance. However, if repairs are not done correctly, they can harm the PM treatment (e.g., seal coat). This chapter describes the possible negative effects on the PM treatment and outlines ways to reduce them.

Adverse Effects

Surface Irregularities. Poorly leveled patches can result in bumps or dips. These irregularities impair uniform application of a seal coat, leading to premature wear and a decreased ride score.

Inconsistent Seal Coat Bonding. A seal coat may not adhere properly if the repair materials (especially cold mix) are not fully cured or compacted, leading to peeling of the seal coat in the patched areas.

Material Incompatibility. Certain patching materials (e.g., oil-rich cold mixes) may be incompatible with seal coat emulsions, potentially leading to bleeding, tracking, or seal coat failure in those areas.

Moisture Entrapment. If repairs trap moisture or are done in damp conditions, applying a seal coat too soon can seal in moisture, leading to stripping, blistering, or early deterioration.

Excessive Repatching/Resurfacing. Excessive repatching and resurfacing (i.e., too many nonstructural layers) can destabilize the pavement and result in premature failure. Additionally, excessive patching may cause seal coat bleeding.

Bleeding/Flushing. If repair patches are not properly cured or if seal coat asphalt rates are not adjusted, the patches can absorb the seal coat asphalt, leading to rock loss, bleeding, and flushing. Similarly, large leveled-up sections or areas that have undergone multiple seal coats or patches may complicate the seal coat application due to the potential for problems related to bleeding/flushing (TxDOT, 2024a, 2016).

Best Practices to Minimize Adverse Effects

Best practices to minimize adverse effects include the following:

- Allow sufficient curing time for patches before sealing.
- Make sure to use compatible materials for repairs.
- Ensure surfaces are level and compacted.
- Thoroughly clean and dry the repair area before patching and the patch surface before applying the seal coat.
- Consider applying a fog seal or tack coat over patches to enhance bonding. For additional information, refer to the seal coat design method in TxDOT's *Seal Coat and Surface Treatment Manual* (TxDOT, 2024b).
- Consider using ball penetration testing to assess the stability of the layers.
- Consider using UHP water cutting to remove excess binder on bleeding patches or leveled-up sections.

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