

Thin Maintenance Surfaces Handbook



August 2007

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Sponsored by

the Iowa Highway Research Board
(IHRB Project TR-507)

Preparation of this handbook was financed in part
through funds provided by the Iowa Department of Transportation
through its research management agreement with the
Center for Transportation Research and Education,
CTRE Project 03-161.

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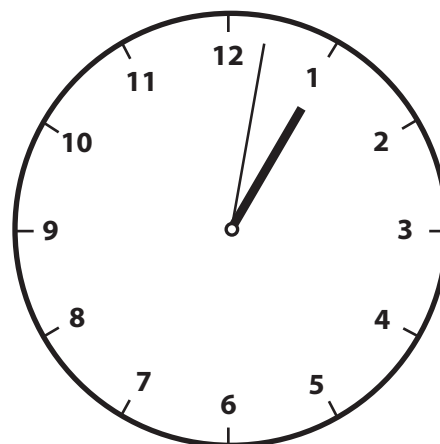
Ch 1. Philosophy of preventive maintenance

If a pavement is constructed and no maintenance is done, the pavement may not last as long as it should. Preventive maintenance is a strategy to extend the serviceable life of a pavement by applying cost-effective treatments that will slow down pavement deterioration and prevent new distresses from forming. Preventive maintenance is also intended to improve the condition of the pavement by sealing cracks or covering existing distresses such as raveling or oxidation.

Some preventive maintenance techniques for asphalt pavements include crack sealing, seal coating, slurry sealing, micro-surfacing, fog sealing, and thin hot mix asphalt (HMA) overlays. These strategies are all considered thin maintenance surfaces (TMS)—the subject of this manual.

Although it is impossible to stop a pavement from eventually failing, it is possible to slow down the aging process or to “turn back the clock” to extend the life using preventive maintenance techniques such as TMS.

However, the timing of preventive maintenance can be a bit tricky. In order to “turn back the clock” the greatest amount, the thin maintenance surface must be placed at the right time. If a TMS were placed on a newly paved road with little or no distress, little to no value would be added, and the life of the pavement would not be extended. It is harder to “turn back the clock” when only a brief period of time has passed. Likewise, if a TMS were placed on a pavement in poor condition with severe distresses, the TMS would not effectively extend the life of the pavement, because the pavement would already be too close to failure.



Why preventive maintenance?

Many highway agencies have found that every dollar spent on preventive maintenance now saves \$6–\$10 in the future, because the pavement lasts longer and rebuilding is delayed. The extended pavement life lowers the long-term costs of keeping up a road. By maintaining a favorable condition on the pavement, users experience better ride quality, increasing taxpayer satisfaction.

Stopgap approach

Some pavements have almost failed and need to be rehabilitated or reconstructed; however, the current budget may not be large enough to fund the work immediately. Sometimes TMS can be used as a stopgap that will “glue” the road together for a few years until the necessary money is available to do more costly work that will fix the problem more permanently. In this situation, the TMS will not last long because it does not add structure to the pavement, and the money spent is only to delay construction.

Ch 2. Selecting a pavement

Selecting pavements for thin maintenance surfaces is a matter of judgment, and people will have varying opinions on how to make these selections. This section describes several rules of thumb.

Pavement/road type requirements for a TMS

To qualify for a TMS, a road must be paved with

- hot mix asphalt (HMA),
- seal coat (usually several layers that have been built up over a number of years), and
- stabilized base.

It's important to know whether the road is HMA or seal coat before selecting the treatment, binder, and aggregate types. Thin maintenance surfaces are not intended for portland cement concrete (PCC) pavements.

The main thing to keep in mind when selecting a pavement is that thin maintenance surfaces do not add any structural integrity to a pavement, nor do they correct structural distress. However, an agency can repair the structural deficiencies by patching, filling, or pulverizing and re-stabilizing the base of the pavement. Seal coat roads can be scarified with a motor grader and the base stabilized if the road is experiencing high densities of severe distresses.

Good candidates for a TMS

These types of pavements are good candidates for a TMS in a preventive maintenance mode:

- Pavements with oxidation where the surface has turned from black to light grey
- Pavements suffering from light raveling, loss of fines, or pocking (when individual pieces of aggregate are removed from the surface)
- Pavements that are experiencing non-progressive rutting
- Pavements that are in good structural condition
- Pavements with joint reflection cracks

At this point in the pavement's life, the surface will begin to become more porous, allowing water into the pavement where it will accelerate deterioration. Furthermore, cracks will begin to form and allow even more water to pass beneath the surface. This makes the surface a good candidate for a waterproof seal.

Possible candidates for a TMS

The following types of pavements may benefit from a TMS:

- Pavements suffering from medium to heavy raveling, loss of fines, or pocking
- Pavements that have medium severity cracking and medium severity rutting

Since these distresses are more severe than those described above for good candidates, a TMS will not extend the pavement's life in these cases as much as it would for pavement in better condition. Nevertheless, some benefit will likely result, especially if the traffic levels are low to moderate.

TMS as a stopgap before rehabilitation or reconstruction

The following pavements require rehabilitation or reconstruction. If a TMS is used on such pavements, it will serve only as a stopgap, temporarily "gluing" the road together to delay rehabilitation or reconstruction:

- Pavements with a high density of fatigue cracking
- Pavements with progressive rutting that is already one inch deep
- Pavements with excessive cracking or high-severity cracking

When structural distresses are present, the pavement structure has been compromised. If the structural failure is of low to medium severity on a low-volume road, it is possible to use a TMS because the TMS will slow the advancement of the distress.

Occasionally, on roads with light traffic and good structure, the stopgap TMS will last a surprisingly long time.

Using a windshield survey to select pavements for treatment

A windshield survey is the process of driving around, looking at pavements, and documenting their conditions. Such a survey can be used if a pavement management system has not been developed. The survey is a way to list the roads that would benefit from treatment. It also enables staff members to set up a basic maintenance program while familiarizing themselves with their road network.

The purpose of the survey is to collect information. Decisions about which TMS to use should be made later.

Materials needed for a windshield survey

- Map of all the pavements for which the agency is responsible

- Clipboard and note paper
- Red, green, and blue markers or highlighters
- Screwdriver
- Camera
- Surveys and maps from previous years
- Information on planned maintenance or construction activities, if previously developed

Procedure of a typical windshield survey

- Begin the survey by driving around, viewing each road.
- For each road, document the type of pavement and current condition, listing the distresses. (See Chapter 3 on identifying distresses.)
 - Identify any structural distresses and their density. If possible, drive into the sun. This will cast shadows on cracks and make them much easier to identify.

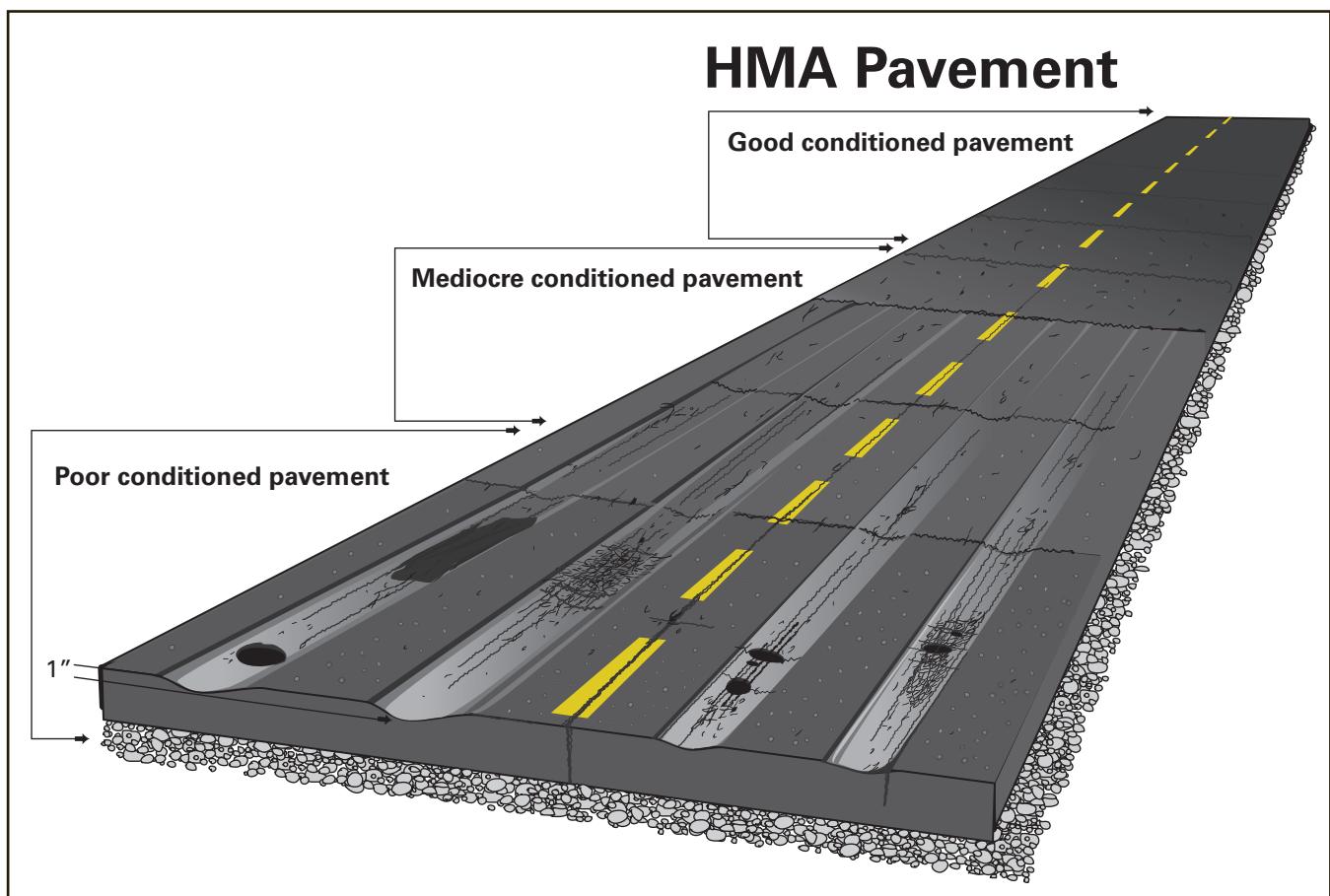


Figure 1. Good, mediocre, and poor pavement conditions.

- Use a screwdriver to try to dislodge aggregate (figure 2). This is a simple test to determine the degree of oxidation on the pavement. The easier it is to dislodge the aggregate, the more oxidized the pavement is and the more likely raveling and pocking will occur. Look at the type of traffic on the pavement. Is there a high amount of truck traffic? Is there the potential for a high amount of truck traffic due to new development nearby?
- Compare the road to the previous year's survey and map. Has the road been recently re-surfaced? How much has the condition changed? Is there going to be any work done on the pavement within five years?
- Determine whether the pavement is eligible for a TMS and mark it on the map. Use green for TMS, red for rehabilitation or reconstruction, or blue for pavements that do not currently require maintenance. Don't try to determine which type of TMS should be used. Just identify possible locations for using a TMS.
- Repeat the process on all streets/roads.



Figure 2. Use of a screwdriver to dislodge aggregate can help test the degree of oxidation on the pavement.

This process may seem slow at first, but once the staff gets used to the process and knows what to look for, the process goes faster.

Things to look for during a windshield survey

Oxidation or light raveling/pocking—good candidate for a TMS (figure 3).

These distresses are a good sign that the pavement has aged and is a suitable candidate for a new surface. At this point in the pavement's life, the surface will develop micro cracks that allow water to seep into the pavement where it will compromise the structure. This makes the surface a good candidate for a water-proof seal.

Structural failure—TMS as a possible stopgap

- If there are cracks at the bottom of the wheel paths, the pavement structure has been compromised. A TMS can be used as a stopgap procedure to “glue” the road together until reconstruction or rehabilitation can take place. However, this is only a temporary measure. The pavement's life may not be extended by much.
- The presence of alligator cracks usually indicates a soft base, insufficient pavement thick-



Figure 3. Light oxidation or pocking is a type of distress that makes a good candidate for a water-proof seal.

ness, fatiguing pavement, or a combination of all three (figure 4). Unless the road is lightly trafficked and does not pump under load, little benefit will be obtained by using a thin maintenance surface.

- If the structural failure is of low to medium severity on a low-volume road, using a TMS will slow the advancement of the distresses. Occasionally, a very low volume road will benefit from the application of a thin maintenance surface if the structure of the base is good, despite the fact that the pavement structure is poor.



Figure 4. Alligator cracking is a distress that can sometimes be slowed by using a TMS as a stopgap, depending the level of severity and volume of traffic.

Ch 3. Identifying distresses

A variety of distresses can occur on a flexible pavement. This chapter explains how to identify each distress and its various levels of severity, what causes the distress, and how to measure the distress (for a survey). The level of severity governs what treatment may be used and is defined as low (L), medium (M), or high (H).

Some distresses are referred to as structural, which means that they are caused by traffic loading rather than by environmental factors. Because thin maintenance surfaces do not add structure to a pavement, it is necessary to identify structural distresses and provide a means of repair before a TMS is applied.

Bleeding

Identification

Asphalt binder is pushed to surface of the pavement and the appearance is usually shiny and black. Bleeding can occur over the entire pavement but is more common in wheel paths.

Causes

Asphalt mix was too rich with binder or too much binder was applied on a seal coat. Traffic works aggregate into the pavement, collapses air voids, and pushes excess binder to the surface.

Measurement

Measured in square feet of surface area.

Severity rating

Low—Bleeding has occurred to a slight degree. Aggregate is still exposed on the surface. Asphalt does not stick to shoes (figure 5).

Medium—Bleeding has occurred to the extent that shoes begin to stick and leave imprints. Aggregate is marginally visible.

High—Bleeding has occurred to the extent that asphalt sticks to shoes. Shoe soles and tire treads are left in the surface. Aggregate is barely visible (figure 6).



Figure 5. Low levels of bleeding are often the result of too much asphalt binder being pushed to the surface, but aggregate is still exposed, and asphalt does not stick.



Figure 6. In high ratings of bleeding on pavements, shoes and tires stick to the surface and aggregate is barely visible.

Bumps and sags

Identification

Bumps are small, localized bulges of the pavement surface. Sags are small, abrupt depressions of the pavement surface.

Causes

Bumps and sags are caused by buckling or bulging of underlying PCC slabs or frost heave.

Measurement

Measured in lineal feet.

Severity rating

Low—Causes small problems with ride quality.

Medium—Causes moderate problems with ride quality.

High—Cause major problems with ride quality.

Cracking

Alligator cracking

Identification

Alligator cracking is a structural distress composed of interconnected cracks that have the appearance of alligator scales. Alligator cracking is typically found in wheel paths and may be accompanied by rutting.

Causes

Alligator cracks form in areas of repeated traffic loads. The traffic loads cause high stress in the bottom of the pavement. This stress cracks the pavement starting from the bottom and working up to the surface. The cracking begins with hairline longitudinal cracks in the wheel paths and, as the pavement ages, the cracks begin to interconnect and form small blocks.

Measurement

Measured in square feet of surface area.

Severity rating

Low—Longitudinal cracks have formed, but few interconnecting cracks have formed. Cracks are tight and have not spalled. Pavement does not pump under loading (figure 7).

Medium—Cracks are beginning to form small blocks. Cracks are beginning to spall. Pavement does not pump under loading.

High—A dense network of cracks has formed. Cracks have spalled. Pavement pumps when loaded (figure 8).

Block cracking

Identification

Cracks form large rectangles in the pavement. The blocks range from 1–10 square feet. Block cracking usually occurs over the entire pavement, not just in wheel paths. Block cracking is not an indication of structural failure.

Causes

Block cracking is caused by the shrinkage of the pavement due to daily temperature cycling. It most commonly appears in desert climates where there are wide differences between daytime and nighttime temperatures.

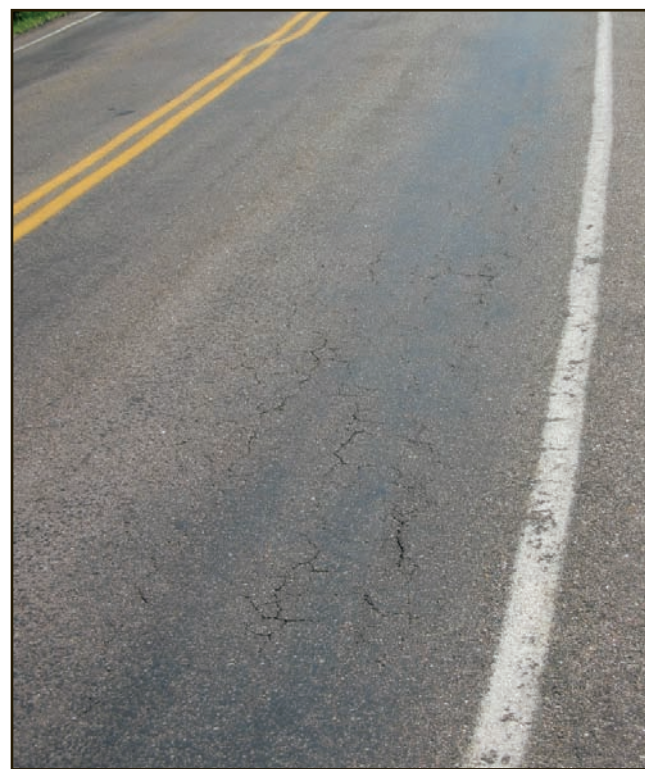


Figure 7. Low levels of alligator cracking begin with a few hairline longitudinal cracks, but pavement do not pump under loading.

Measurement

Measured in square feet of surface area.

Severity rating

Low—Cracks are less than $\frac{1}{4}$ inch wide or have been sealed (and seal is still in good condition).

Medium—Cracks are $\frac{1}{4}$ to $\frac{3}{4}$ inch wide.

High—Cracks are wider than $\frac{3}{4}$ inch and are spalling (figure 9).

Edge cracking

Identification

Cracks along the edge of the pavement near the shoulder.

Causes

Cracks can be caused by inadequate support, sub-base failure due to water intrusion, and traffic loading.

Measurement

Measured in lineal feet.



Figure 8. High alligator cracking is a network of cracks that have formed and grown into blocks. Areas where dense cracks have formed pump when loaded.

Severity rating

Low—Cracks are $\frac{1}{4}$ inch wide or less, with no breakup or raveling.

Medium—Cracks are $\frac{1}{4}$ to $\frac{3}{4}$ inch wide with some breakup and raveling.

High—Considerable breakup or raveling along the edge.

Joint reflection cracking

Identification

Cracks mirror joints in an underlying overlay or PCC pavement. Cracks are usually very straight and intersect at right angles.

Causes

When the joints in the underlying layers move, the surface layer moves and reflects the joint cracks. Movement of the underlying pavement may be vertical, caused by traffic, or horizontal, caused by shrinkage.



Figure 9. High block cracking ratings are those with cracks wider than $\frac{3}{4}$ inch that are spalling. They occur over in large rectangles over the entire pavement.

Measurement

Measured in lineal feet.

Severity rating

Low—Cracks are less than $\frac{1}{4}$ inch wide or have been sealed (and seal is still in good condition).

Medium—Cracks are $\frac{1}{4}$ to $\frac{3}{4}$ inch wide (figure 10).

High—Cracks are wider than $\frac{3}{4}$ inch and/or spalling.

Longitudinal cracking

Identification

Cracks parallel to the direction of traffic. The cracks are commonly located in wheel paths and at construction joints (figure 11). These cracks indicate structural failure.

Causes

Some cracks form at the bottom of the pavement layer under the wheel path and propagate to the surface. Other cracks are formed at construction joints and are caused by a lack of fine aggregate at the surface or poor compaction resulting in a weak bond between the two pavements. Still other longitudinal cracks are caused by paving machine–induced segregation. Sometimes paving machines place excess coarse aggregate in the middle of the screed where the augers are attached to the auger drive shaft. Longitudinal cracks sometimes appear above this coarse aggregate.

Measurement

Measured in lineal feet.

Severity rating

Low—Cracks are less than $\frac{1}{4}$ inch wide or have been sealed (and seal is still in good condition).

Medium—Cracks are $\frac{1}{4}$ to $\frac{3}{4}$ inch wide (figure 12).

High—Cracks are wider than $\frac{3}{4}$ inch and/or spalling.

Transverse/thermal cracking

Identification

Transverse cracks run perpendicular to the direction of the road. These cracks typically start at the top and move towards the bottom.



Figure 10. Medium ratings of joint reflection cracking, cracks that mirror joints, are those with cracks $\frac{1}{4}$ to $\frac{3}{4}$ inch wide.



Figure 11. Longitudinal cracking can occur down the centerline where construction joints intersect, parallel to the direction of traffic.



Figure 12. Medium ratings of longitudinal cracking, cracks that parallel the direction of traffic, are those with cracks $\frac{1}{4}$ to $\frac{3}{4}$ inch wide.

Causes

Transverse cracks are typically caused by the thermal shrinkage of the pavement.

Measurement

Measured in lineal feet.

Severity rating

Low—Cracks are of low severity. Cracks are less than $\frac{1}{4}$ inch or have been sealed (and seal is still in good condition).

Medium—Cracks are of medium severity. Cracks are between $\frac{1}{4}$ inch and $\frac{3}{4}$ inch (figure 13).

High—Cracks are of high severity. Cracks are wider than $\frac{3}{4}$ inch and are spalling (figure 14).

Oxidation

Identification

Surface of the pavement is a light gray. Surface binder is brittle. Aggregate can be easily removed from the surface (figure 15).



Figure 13. Medium ratings of transverse cracking, cracks that run perpendicular to the direction of the road, are those with cracks $\frac{1}{4}$ to $\frac{3}{4}$ inch wide.

Causes

Ultraviolet rays from the sun. Exposure to water.

Measurement

The entire surface of the pavement will be oxidized.

Severity rating

None.



Figure 14. High severity ratings of transverse cracking are wider than $\frac{3}{4}$ inch wide and are spalling.



Figure 15. Oxidation of pavement is caused by exposure to the sun and to water, causing binder to become brittle.

Patching and utility cut patching

Identification

An area of the pavement has been replaced with new material to repair the existing pavement. This includes pothole and utility patches. Patching is considered a distress because the structure of the pavement has been altered.

Measurement

Measured in square feet of surface area.

Severity rating

Low—Patch is in good condition (visual inspection). Ride quality is good.

Medium—Patch has moderately deteriorated. Ride quality is mediocre (figure 16).

High—Patch has completely deteriorated and requires replacement. Ride quality is poor.

Pocking

Identification

Individual pieces of aggregate have dislodged from the pavement surface and left small voids (figure 17).

Causes

In some cases, asphalt binder becomes hard and brittle from oxidation, allowing the stone to break away. In other cases, some pieces of aggregate may expand or prematurely deteriorate and work out of the pavement under traffic or snowplowing.

Measurement

None.

Severity rating

None.

Polished aggregate

Identification

Smooth appearance of the pavement. When touched, there is little to no friction on the surface of the pavement (figure 18).



Figure 16. Medium ratings of patching are areas moderately deteriorated that had been replaced with new material.



Figure 17. Pocking occurs when pieces of aggregate become dislodge or deteriorate prematurely.



Figure 18. Polished aggregate is smooth pavement with little or no friction. (FHWA)

Causes

Repeated traffic applications. Aggregate with poor abrasion resistance.

Measurement

Measured in square feet of surface area.

Severity rating

None.

Potholes

Identification

Bowl-shaped holes in the pavement surface. Generally, the area surrounding the pothole is alligator cracked. Growth is accelerated by water pooling inside of the hole (figure 19 and 20).

Causes

Poor surface mixtures or structural failure of the pavement.

Measurement

Measured by counting the number of low-, medium-, and high-severity occurrences.

Severity rating:

Average Diameter of Pothole		Maximum Depth of Pothole		
		½ to 1 in.	1 to 2 in.	> 2 in.
	4 to 8 in.	Low	Low	Medium
	8 to 18 in.	Low	Medium	Medium
	18 to 30 in.	Medium	High	High

Rutting

Identification

A surface depression runs parallel to traffic and is located in the wheel path.

Causes

There are three possible causes. (1) If the pavement has risen around the edges of the rut, the rut is most likely caused by an unstable mix that flows out from under the wheel and moves to the edges. (2) If there are longitudinal cracks at the bottom of the rut, it is most likely caused by structural failure



Figure 19. Potholes are a bowl-shaped hole in the pavement surface generally surrounded by alligator cracking.



Figure 20. High severity rated potholes are 1–2+ inches deep and range from 18–30 inches in diameter.

of the sub-base (figure 21). (3) If the rut has neither of these characteristics, the rut is likely the result of insufficient compaction during construction and subsequent traffic compaction of the asphalt. After a rut is fully compacted, filling it with slurry seal or micro-surfacing can provide a relatively permanent repair. Progressive rutting (rutting that continues to grow deeper and wider) is a result of a poor sub-base or an unstable mix. If rutting is progressive, filling with slurry seal or micro-surfacing will only provide a temporary solution.

Measurement

Measured in square feet of surface area (figure 22).

Severity rating

Low—Ruts are $\frac{1}{4}$ to $\frac{1}{2}$ inch deep.

Medium—Ruts are $\frac{1}{2}$ to 1 inch deep.

High—Ruts are >1 inch deep.

Shoving and corrugation

Identification

A permanent longitudinal displacement of a localized area of a pavement surface. Shoving produces a wave or bump in the asphalt. Shoving failures usually occur on hills, curves, and intersections. Shoving can also occur where an asphalt pavement abuts a concrete pavement. Corrugation is the repetition of shoving and is perpendicular to the direction of traffic (figure 23).

Causes

Shoving is caused by braking or accelerating vehicles that displace the asphalt mix. When shoving is located at the transition from a PCC to an ACC pavement, it is caused by the thermal expansion of the PCC. The expanding PCC pushes the asphalt pavement, causing the distress.

Measurement

Measured in square feet of surface area.

Severity rating

Low—Causes small problems with ride quality.

Medium—Causes moderate problems with ride quality.



Figure 21. Longitudinal cracks at the bottom of rutting are often caused by structural failure of the subbase.



Figure 22. Rutting occurs in the wheel path, and is measured in square feet of surface area.



Figure 23. Shoving or corrugation of pavement surface is a longitudinal wave or bump in the asphalt, usually on hills, curves, or intersections.

High—Cause major problems with ride quality.

Spalling

Identification

An existing crack of any type begins to form parallel satellite cracks.

Causes

Stresses from traffic cause cracks to roll down near the edges. When these stresses are too great on the pavement, new cracks begin to form parallel to the old crack.

Measurement

None.

Severity rating

None.

Weathering/raveling

Identification

The pavement surface is pitted and rough due to loss of aggregate.

Causes

Oxidation makes the binder brittle so that pieces of aggregate can break out of the mix. Tracked vehicles or studded tires can also contribute. On thin maintenance surfaces, causes of raveling usually include snow plow damage, traffic, or a poor design. Loss of aggregate may also be caused by an insufficient amount of binder or poor compatibility between the aggregate and binder.

Measurement

Measured in square feet of area.

Severity rating

Low—Aggregate or binder has started to wear away. Surface is starting to pit.

Medium—Aggregate or binder has worn away. Surface is moderately rough and pitted.

High—Aggregate or binder has worn away considerably. Surface is very rough and severely pitted.



Figure 24. Low level spalling where parallel satellite cracks are beginning to form.



Figure 25. High severity raveling of a seal coat.



Figure 26. New raveling of a pavement surface.

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Ch 4. Treatments at a glance

The following tables summarize the information presented about treatment selection in Chapter (7). These tables recommend which surfaces are suitable for the various distresses and traffic volumes. However, these tables do not break down the vari-

ous distresses by level of severity. For a more detailed breakdown, refer to the tables for individual surfaces located in Chapter (X). These tables can be taken along on a windshield survey to help start the selection process.

		Micro-surfacing *	Slurry seal**	Thin HMA overlay	NovaChip®
Rut depth					
Rut depth	Less than ¼ inch	One course	One course	One course	One course
	¼ to ½ inch	Scratch course and final surface [#]	One course	One course	One course
	½ to 1 inch	Rut box and final surface [@]	Micro-surfacing scratch course and final surface	Scratch course plus surface course	Mill surface or use another material for scratch course
	Greater than 1 inch	Multiple placements with rut box	***	Scratch course plus surface course	Mill surface or use another material for scratch course

* As recommended by International Slurry Seal Association

** Current practice in Iowa

*** Sometimes successful (anecdotal evidence)

[#] Anecdotal evidences suggests that one course may be sufficient for functionality, but apperance may be compromised

[@] Scratch course and surface course have been successfully used in Iowa according to author observations.

		Fog seal	Seal coat	Slurry seal	Micro-surfacing	Thin HMA overlay
Traffic volume:						
	AADT<2,000	✓	✓	✓	✓	✓
	2,000>AADT>5,000	✓	↔ ⁽¹⁾	↔ ⁽¹⁾	✓	✓
	AADT>5,000	✓	↔ ⁽⁴⁾	↔ ⁽¹⁾	✓	✓
Bleeding		✗	✓	✓	✓	✓
Rutting		✗	✗	✓	✓	✓
Raveling		✓	✓	✓	✓	✓
Cracking						
	Few tight cracks	✓	✓	✓	✓	✓
	Extensive cracks	✗	✓	✗	✗	✓
	Alligator cracking	✗	↔	✗	✗	✗
Low friction		May improve ⁽³⁾	May improve	May improve	May improve ⁽²⁾	May improve
Snowplow damage		Least susceptible	Most susceptible	Moderately susceptible	Least susceptible	Least susceptible



Recommended



Not recommended



Marginal

¹ There is a greater likelihood of success when used in lower speed traffic.

² Micro-surfacing reportedly retains high friction for a longer period of time.

³ Fog seal will reduce friction for the first few months until traffic wears binder of the tops of aggregate

⁴ Not used in Iowa, but other states have seen success.

Ch 5. Economics of TMS

When selecting a thin maintenance surface, it's important to compare costs. This chapter provides information on the average costs of TMS in Iowa in 2005. The information came from analyzing interviews with city engineers, contractors, and material suppliers who place these surface treatments. The wages used are Davis Bacon Wage Rates from 2005.

The cost of traffic control varies considerably, depending on the number of traffic control devices

required. Urban projects may require only a few cones or barricades to close roads. Rural projects may require renting or purchasing traffic control devices to delineate several miles of road.

Costs were obtained from Flint Hill Resources (Dan Staebell), Sta-bilt, Inc. (Rick Burchett), the City of Cedar Rapids (Denny Clift), the City of Grinnell (Glen Baker), and the City of Des Moines (Bruce Braun).

Treatment	Fog seal	Seal coat	Slurry seal	Micro-surfacing	Thin HMA overlay
Life expectancy	2–4 years	3–7 years	3–7 years	3–7 years	5–15 years
Cost per square yard	\$0.10–0.80	\$0.80	\$0.90	\$1.50	\$4.40

Ch 6. Treatment options

Following are descriptions of the various types of thin maintenance surfaces. Included in each is a brief definition, a list of the advantages and disadvantages, rules of thumb, equipment list and construction process, application rates, and a decision matrix.

Seal coat

A surface treatment in which an asphalt or seal coat pavement is sprayed with an asphalt binder and then covered with a single layer of aggregate. The type of binder that is typically used is an emulsion or a cutback. An emulsion is a mixture of asphalt binder and water. The binder is held in suspension by a chemical called a surfactant (equivalent to a very strong soap). A cutback is a mixture of asphalt binder and distillate, such as kerosene or fuel oil. Emulsions and cutbacks have the property of.... The aggregate is typically less than one-half inch. A seal coat is also known as a chip seal, tar and rock (informal description), oil and rock, and a surface seal.

Advantages

- Seals the surface of a pavement. The binder forms a waterproof barrier.
- Seals cracks.
- The aggregate becomes a new wearing surface, possibly providing more friction and increasing skid resistance.
- Seal coats are flexible and can move with a pavement without cracking.
- Seal coats are inexpensive in comparison to other alternatives.

Disadvantages

- Unbound aggregate, called flyrock, can be kicked up by traffic and cause vehicle damage, especially to a vehicle's windshield.
- Newly placed seal coats have the appearance of a gravel road and may be rough and noisy. Considerable dust may be generated, depending on the amount of fines in the aggregate.



Figure 27. Seal coat surface treatment.

- Because the treatment is one stone thick, it is not able to fill ruts or depressions.
- Depending on the color of the aggregate, a seal coat can be a poor background for pavement markings.
- After multiple lifts of a seal coat, a city street can develop a high crown, which can be troublesome for vehicles entering or exiting the road via driveways.

Rules of thumb

- Take care when selecting the emulsion. Factors such as aggregate type and quality, construction speed, cost, and expected life should be considered. See Chapter * for material selection.
- If an emulsion binder is used, it's critical to have clean aggregate. If the aggregate is dusty, the emulsion will bond to the dust, not the aggregate. The effect is similar to trying to stick duct tape to a dusty wall.
- Selecting the proper emulsion application rate is critical. Too little binder and there won't be enough to hold the aggregate. Too much binder and the seal coat will bleed. Apply enough binder so that 70 percent of the aggregate is embedded in the binder after the aggregate has been seated with a pneumatic tire roller.
- Electronically controlled distributors and chip spreaders are recommended for construction to ensure accurate application rates of the binder and aggregate.
- Many different design procedures are available to design the application rates for both binders and aggregates. The Minnesota DOT seal coat manual provides a good explanation for these procedures.
- When dust must be avoided or when the binder isn't holding the aggregate, consider using pre-coated aggregate. Pre-coated aggregate has been coated with a thin film of asphalt binder by processing it in a hot mix plant. The coating reduces dust, facilitates a strong bond between the aggregate and emulsion, and gives the seal coat a darker appearance.

Equipment

- Street sweeper
- Distributor truck
- Chip spreader
- Pneumatic tire roller
- Dump trucks for material hauling

Construction process

1. Set up traffic control in accordance with the MUTCD.
2. Sweep the pavement to remove any debris.
3. Cover any utility covers with construction paper to make sure the seal coat does not cover them.
4. Make sure all necessary equipment is onsite and properly functioning. Also ensure that the necessary materials are onsite.
5. Make sure the first dump truck is properly attached to the chip spreader.
6. Begin to spray the pavement with the binder using the distributor truck. If a slow setting emulsion is used, approaches or radii at intersections should be sprayed first.
7. The chip spreader should then begin to follow behind the distributor truck.
 - a. The following distance should be kept at a minimum, especially for rapid-setting cationic emulsions. Most emulsions and cutbacks require chip placement within two to three minutes after the emulsion has been applied or before the surface has turned black. (Emulsions have a dark brown color immediately after they are sprayed from the distributor and turn black as they set and cure.) However, with a high-float emulsion, it is preferable to wait until the surface of the emulsion has formed a skin.
 - b. A simple test for whether the binder has set is to throw chips across the binder. If the chips stick to the binder, it is okay to apply the chips. If the chips bounce along the binder, the binder has set.

8. The pneumatic tire roller should follow closely behind the chip spreader. Roll the entire width of the seal coat. Make three passes. If the roller is not able to keep up with the chip spreader, multiple rollers should be used.
9. Return to the site the next day to sweep up excess aggregate.

Application rates

Binder = 0.20–0.35 gal/yd²

The amount of binder applied to the surface can vary depending on the condition of the pavement. If the pavement is smooth with few voids or small macro-texture (area between pieces of aggregate), reduce the application rate. However, if the pavement is rough with many voids and a deep macro-texture, increase the application rate.

Aggregate = 15–30 lbs/yd²

If the aggregate is spread more than one stone thick, decrease the application rate. Applying too much aggregate leads to excessive fly rock, dust, and waste. Extra aggregate requires additional cleanup and haul costs. If large areas of binder are exposed between pieces of aggregate, apply more aggregate.

Double seal coat

Two seal coats are placed consecutively. The nominal size of the aggregate on the first seal coat is typically one and a half to two times the nominal size of the second layer.

Advantages

- Adds more waterproofing to the surface in comparison to a single seal coat.
- Seals cracks to a greater degree than a single seal coat.
- Is more robust than a single seal coat.
- Other advantages are the same as those for a single seal coat.

Disadvantages

- Has a higher risk of bleeding if the emulsion application rate is too high.
- Added cost of extra material and labor for the construction.
- Other disadvantages are the same as those for a single seal coat.

Rules of thumb

- The proper emulsion application rate is critical to success.



Figure 28. Double seal coat surface treatment.

- Other rules of thumb are the same as those for a single seal coat.





Construction process

Use the seal coat construction process.

Application rates

Use a seal coat design procedure to set the application rates for the first pass, except reduce the amount of aggregate slightly (5–10 percent) to reduce the amount of loose aggregate that will be covered by the second pass. On the second pass, use an emulsion application rate for a rough surface.

Decision matrix for seal coats

																
Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	< 2,000	2,000 < ADT < 5,000	> 5,000	Friction	Oxidation
✓	✓	**	✓	✓	**	✓			✓	**	**	✓	(1)	(2)	✓	✓



Recommended

* Seal coats are effective on roads with ADT > 2,000 but are not commonly used in Iowa.

** Permissible on very low volume roads. Double seal coats will likely be more effective.

(1) There is a greater likelihood of success when used with lower speed traffic.

(2) Not used in Iowa, but other states have seen success.

Life	Costs			Materials			
3–7 yrs.	\$0.80/yd ²	\$1070/city block*	\$11,000/mile**	Binders used in Iowa (0.20–0.35 gal/yd ²)		Aggregates used in Iowa (15–30 lb/yd ²)	
				HFE (high float emulsion)	\$0.80/gal	Limestone	\$19/ton
				CRS (rapid setting emulsion)	\$0.80/gal	Pearock	
				Cutback (asphalt dissolved in petroleum solvent)	\$1.10–1.15/gal	Quartzite	
				Polymer modified emulsion	\$0.95/gal	Pre-coated chips	Add \$10/ton
				Cost of delivery	\$0.08/gal		

* 1 block = 40 ft. wide pavement x 300 ft.

** 24 ft. wide pavement

See page 7 for source of cost information.

Slurry seal

A mixture of emulsion, aggregate, water, and mineral filler that is pre-mixed and placed as a slurry onto a pavement. The application of the slurry is only as thick as the largest-sized aggregate. The slurry has the consistency of mud and can be easily worked with hand tools.

Advantages

- Seals the surface of a pavement.
- Enhances the appearance of a pavement by providing a uniform black or gray surface, which is a good background for pavement markings.
- Provides a new wearing course, restoring friction and skid resistance. The degree of friction and skid resistance is largely dependent on the quality of the aggregate.
- Reduces raveling and further oxidation of the underlying asphalt binder.
- Fills shallow ruts (full-width pass not necessary).
- Levels rolled down cracks.
- Fills longitudinal cracks (full-width pass not necessary).

Disadvantages

- Slurry seal should not be placed on pavement that have severe cracking. Because of its brittle nature, the slurry seal will reflect all the cracks quickly and not provide a water-tight seal. On heavily trafficked roads, the cracks may spall or widen.
- The road must be closed for six to eight hours before traffic can be allowed onto the surface.

Rules of thumb

- High-quality aggregates are necessary for high-quality slurry seals.
- The thickness of the slurry seal is approximately the same as the largest aggregate size.
- Use of a rapid-setting emulsion can reduce the road closure time. Temperature and climate also affect the road closure time: the hotter and drier it is, the sooner the road can be opened to traffic.
- If the pavement is experiencing rutting and the ruts continue to deepen, filling them with slurry seal will result in only a temporary improvement.



Figure 29. Slurry seal application.

- When filling ruts, use multiple lifts on deeper ruts. Use a rut box for the best results. If the ruts are shallow, use a scratch course to level the pavement. (A scratch course is a lift of slurry seal that is placed without finishing to fill ruts. It is called a scratch course because the spreader will often “scratch” the high spots on the road.) By using a scratch course or a rut box, the final application will be smoother and have a better appearance.
- Tire noise increases immediately after construction, but after the slurry seal is trafficked, the noise levels will drop.
- Material on high spots of a pavement may ravel off due to snow plow damage.
- Wide cracks can be filled with slurry to reduce the width of the crack.

Equipment

- Street sweeper
- Slurry mixer and spreader (continuous)
- Nurse trucks

Alternatively, the slurry mixer and nurse truck can be combined into one vehicle, and the spreader can be swapped between trucks. This alternative provides more maneuverability in tight urban areas.

Construction process

Because of the high cost and specialized nature of the equipment, slurry seal construction is often

performed by a contractor. Sample specifications and quality control procedures are available from the International Slurry Seal Association.

1. Set up traffic control in accordance with the MUTCD.
2. Sweep the pavement to remove debris.
3. Remove vegetation from cracks.
4. Cover any utility covers with construction paper to make sure that the slurry seal does not cover them.
5. Make sure all necessary equipment is onsite and properly functioning. Also ensure that the necessary materials are onsite.
6. Begin by placing the slurry at intersections and radii using hand tools.
7. Place the full-width pass of the slurry on the pavement.
8. Do not allow traffic on the road until the slurry has cured and does not track.





Application rates

20–30 lbs/yd² for a Type III gradation

The application rate depends on the gradation of the aggregate. If a smaller aggregate gradation is used, fewer pounds per square yard are needed for the application.

The mix design should be performed by the contractor. Agencies will usually specify the aggregate type and gradation and the specific type of binder to be used.

Decision matrix for slurry seal

																
Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	< 2,000	2,000 < ADT < 5,000	< 5,000	Friction	Oxidation
✓	✓		✓	✓**		✓	✓		✓**			✓	*	*	✓	✓

✓ Recommended

* Slurry seal can be used on higher traffic roads, but this is not a common practice in Iowa.

** Acceptable for very low volume roads.

Life	Costs			Materials			
3–7 yrs.	\$0.90–\$1.15/ yd ²	\$1200/city block*	\$13,077/mile**	Binders used for slurry seal		Aggregates used in Iowa	
				SS-1, SS-1h, CSS-1, CQS-1h	\$0.80/gal	Limestone	\$19/ton

* 1 block = 40 ft. wide pavement x 300 ft.

** 24 ft. wide pavement

References: ISSA Slurry Seal Specifications

Micro-surfacing

Micro-surfacing is somewhat similar to a slurry seal in appearance and application but has very different properties. Micro-surfacing is a mixture of polymer-modified emulsion, 100 percent crushed aggregate, water, and mineral filler that is pre-mixed and placed as a slurry onto a pavement.

Advantages

- Seals the surface of a pavement.
- Enhances the appearance of a pavement by providing a uniform black or gray surface, which is a good background for pavement markings.
- Provides a new wearing course, restoring friction and skid resistance. The degree of friction and skid resistance is largely dependent on the quality of the aggregate.
- Reduces raveling and further oxidation of the underlying asphalt binder.
- Can be used to fill ruts up to 1.5 inches deep. Rut filling can be performed without a full-width pass.
- Can be opened to traffic within one hour after application, even in cooler temperatures or at night.

Disadvantages

- After the micro-surfacing has cured, it is brittle and will reflect cracks quickly. However, due to the presence of polymers that make the material more resilient compared to a slurry seal, the cracks will be unlikely to spall after the crack initially reflects.
- The ratios of emulsion, aggregate, water, and mineral filler must be kept in a narrow range, which can be troublesome during construction.
- Compared to slurry seal, there is less time to perform hand work.

Rules of thumb

- The higher quality the aggregate, the higher quality the micro-surfacing.
- Thickness of micro-surfacing is approximately the same as the largest aggregate size.
- Micro-surfacing should not be placed on a pavement that has severe cracking. It will reflect all the cracks quickly and not provide a watertight seal for them.
- If the pavement is experiencing rutting and the ruts continue to deepen, filling them with



Figure 30. Micro-surfacing application.

micro-surfacing will result in only a temporary improvement.

- When filling ruts, use multiple lifts on deeper ruts. Use a rut box for the best results. If the ruts are shallow, use a scratch course to level the pavement. (A scratch course is a lift of micro-surfacing that is placed without finishing to fill ruts. It is called a scratch course because the spreader will often “scratch” the high spots on the road.) By using a scratch course or a rut box, the final application will be smoother and have a better appearance.
- Tire noise increases immediately after construction, but after the micro-surfacing is trafficked, the noise levels will drop.
- Minnesota DOT requires the construction of nighttime test sections to ensure micro-surfacing quality and prevent substitution of micro-surfacing for a rapid setting slurry seal. This was specified because it was thought that a slurry seal will not cure within an hour at night but that a micro-surfacing will.
- Material on high spots of a pavement may ravel off due to snow plow damage.

Equipment

- Street sweeper
- Slurry mixer and spreader (continuous)
- Nurse trucks

Alternatively, the slurry mixer and nurse truck can be combined into one vehicle, and the spreader can be swapped between trucks. This arrangement will provide greater maneuverability, which can be desirable in urban areas.

Construction process

Because of the high cost and specialized nature of the equipment, micro-surfacing construction is performed by a contractor. Write specifications and perform quality control to ensure quality construction and materials.

1. Set up traffic control in accordance with the MUTCD.
2. Sweep the pavement to remove debris.
3. Remove vegetation from cracks.
4. Cover any utility covers with construction paper to make sure that the slurry seal does not cover them.
5. Make sure all necessary equipment is onsite and properly functioning. Also ensure that the necessary materials are onsite.
6. Begin by placing the micro-surfacing at intersections and radii using hand tools.
7. Place the full-width pass of the micro-surfacing on the pavement.
8. Do not allow any traffic until the slurry has cured and is stable enough for traffic. With micro-surfacing, this can be done within one hour.

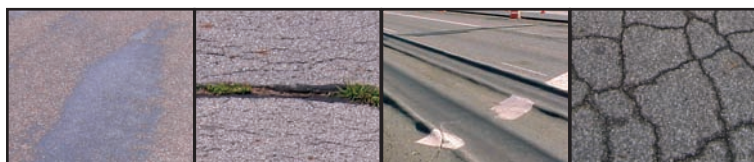
Application rates

20–30 lbs/yd² for a Type III gradation

The application rate depends on the gradation of the aggregate. If a smaller aggregate gradation is used, fewer pounds per square yard are needed for the application.

The mix design should be performed by the contractor. Agencies will usually specify the aggregate type and gradation to be used.

Decision matrix for micro-surfacing



Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med.	High	Low	Med.	High	Low	Med.	High	< 2,000	2,000 < ADT < 5,000	< 5,000	Friction	Oxidation
✓	✓		✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓

✓ **Recommended**

Life	Costs			Materials			
3–7 yrs.	\$1.50/yd ²	\$2,000/city block*	\$21,000/mile**	Binders used for micro-surfacing		Aggregates used in Iowa	
				CRS-2P	\$0.95/gal	Limestone	\$19/ton
				Ralumac [®] Portland cement (mineral filler)	\$1.30/gal	Quartzite	
				Potable water			

* 1 block = 40 ft. wide pavement x 300 ft.

** 24 ft. wide pavement

Fog seal

A light application of binder to a pavement surface without a cover aggregate. Several types of binder can be used, such as

- A diluted asphalt emulsion (50 percent water, 50 percent emulsion)
- Gilsonite sealer binder (Gilsonite is a natural asphalt ore with a high resin content) applied as an emulsion (suspended in water) or a cutback (dissolved or mixed with petroleum distillate)
- Other proprietary products such as Reclamite® and PASS®

Advantages

- Waterproofs the surface of a pavement.
- Seals low severity cracks.
- Improves the appearance of a pavement and makes a good background for pavement markings.
- Prevents oxidation of the asphalt binder and is effective in mitigating raveling.

- If a rejuvenating emulsion is used, oils are restored to an oxidized pavement, which softens the binder and reduces the risk of raveling.
- Low cost.

Disadvantages

- Skid resistance may be reduced considerably after application. However, skid resistance is restored after binder is worn off the tops of the aggregate.
- Not as effective for pavements with higher levels of distress compared to treatments that include aggregate.
- Road must be closed to traffic for two to eight hours while the binder is curing.

Rules of thumb

- Fog seals should be applied before distresses develop in order to prevent raveling and cracking from beginning.
- Regular emulsions can be used for fog seals. The emulsion should be diluted with water so that the ratio is one part emulsion and one part water.



Figure 31. Fog seal application

- Use blotting sand to increase skid resistance shortly after application.
- Rejuvenating emulsions can be used on pavements that are severely oxidized to restore oils to the surface.

Equipment

- Street sweeper
- Distributor truck

Construction process





1. Set up traffic control in accordance with the MUTCD.
2. Sweep the pavement to remove debris.
3. Cover any utility covers with construction paper to make sure the fog seal does not cover them.

4. Make sure all necessary equipment is onsite and properly functioning. Check to make sure that the nozzles are properly aligned and the spray bar is at the correct elevation to minimize streaking in the application.
5. Begin by spraying any intersections or radii.
6. Spray the entire width of the pavement. If possible, spread sand from the distributor truck to increase friction.
7. Do not allow any traffic on the fog seal until it has cured.

Application rates

As low as 0.03 gal/yd² for a pavement with a tight surface and as high as 0.22 gal/yd² for a pavement with a more porous surface. Application rate of the sand is 2 lb/yd².

Decision matrix for fog seal

																
Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med.	High	Low	Med.	High	Low	Med.	High	< 2,000	2,000 < ADT < 5,000	> 5,000	Friction	Oxidation
✓			✓									✓	✓	✓		✓

✓ Recommended

Life	Costs			Materials	
2–5 yrs.	\$0.18–0.80/yd ²	\$250–1,100/city block*	\$2,500–11,000/mile**	Binders used for fog seal	
				CRS	\$0.80/gal (before dilution)
				HFRS	\$.80/gal (before dilution)
				Rejuvenators increase the cost of the fog seal	

* 1 block = 40 ft. wide pavement x 300 ft.

** 24 ft. wide pavement

Smooth seal

A thin HMA overlay typically one to two inches thick placed over an existing seal coat road. A seal coat road that has been in place for several years and shows little distress can serve as an excellent base for this treatment. A smooth seal can also be placed over gravel roads provided that they have adequate structure.

Advantages

- Provides a surface that is similar to that of a full-depth HMA road.
- Provides a smooth, quiet surface that accommodates inline skates, skateboards, and bikes.
- Eliminates the need to place seal coats periodically.
- Although design calculations assume that smooth seal does not add structure to the pavement, in actuality, it may add a small amount of structure which may be helpful.

Disadvantages

- Initial cost of construction can be high.
- Limited to use on low-volume roads with limited truck traffic.

- Does not remove crown from the seal coat.
- Requires adjustment of utility covers.

Rules of thumb

- The overlay only needs to be one inch thick on residential pavements. Two inches or thicker should be used for any roads that experience truck traffic.
- Do routine maintenance to extend the life of the overlay. Crack sealing is especially important because the structure of the underlying seal coat will be severely compromised by moisture infiltration.
- Replace any areas of structural deficiency with a full-depth patch before constructing the smooth seal.
- Maintain or construct proper drainage to prevent moisture from saturating the sub-base.
- The thin HMA will cool quickly. This loss of temperature can make proper compaction difficult to obtain.

Equipment

- Street sweeper
- Distributor truck



Figure 32. Smooth seal overlay on existing seal coat road.

- Asphalt paver
- Pneumatic tire rollers
- Steel rollers

Construction process

HMA overlays are typically performed by contractors. Write specifications and perform quality control to ensure quality construction and materials.

1. Set up traffic control in accordance with the MUTCD. (This step may need to be repeated more than once if steps 2, 3, and 4–7 are separate operations.)
2. Address drainage problems.
3. Adjust utility covers to proposed pavement height.
4. Sweep the pavement.
5. Make sure all necessary equipment is onsite and properly functioning.
6. Apply the tack coat.
7. Place the HMA mat.





8. Use the vibratory steel rollers for the initial compaction, pneumatic tire rollers for the second stage, and static steel rollers for the final stage. Thin overlays tend to cool quickly, so the rollers must keep up with the paver. Monitor temperatures to ensure that the mix is being properly compacted.
9. Open road to traffic when the pavement has cooled.

Application rates

One inch of HMA for pavements with light residential traffic. Two inches of HMA for pavements with light truck traffic. Tack coat application is usually 0.02–0.10 gal/yd².

The contractor should design the mix. Typically, contractors will have a pre-determined mix that is suitable for this type of surface.

Decision matrix for smooth seal

																
Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med.	High	Low	Med.	High	Low	Med.	High	< 2,000	2,000 < ADT < 5,000	> 5,000	Friction	Oxidation
✓	✓	✓	✓			✓	✓	✓				✓			✓	✓

✓ Recommended

Life	Costs			Materials	
5–15 yrs.	\$3–6/yd ² *	\$1,600–2,000/city block**	\$28,000–42,000/mile***	Hot mix asphalt	Cost is dependent on the price of HMA/ton (in-place)
					To calculate cost/yd ² : Multiply \$/ton x 0.056 x depth of overlay (in.)

* Assumes \$55/ton of HMA for 1 in. and 2 in. overlays

** 1 block = 24 ft. wide pavement x 300 ft.

*** 24 ft. wide pavement

Thin HMA overlay

An application of a standard HMA mix in a lift that is 1.5 inches thick or less. Thin HMA overlays are placed over existing asphalt pavements.

Advantages

- Aesthetic appearance of an HMA.
- Smooth, quiet surface.
- Provides good background for pavement markings.

Disadvantages

- Initial cost of construction can be high.

Rules of thumb

- Routine maintenance should be planned to extend the life of the overlay.
- Any areas of structural deficiency should be replaced with a full-depth patch before constructing a thin HMA overlay.
- Maintain or construct proper drainage to prevent moisture from saturating the sub-base.
- Any cracks that are sealed before application of the overlay should be recessed and not over-banded. This prevents the crack sealant from expanding due to the high temperature of the HMA which can cause bumps in the overlay.

Equipment

- Street sweeper
- Distributor truck
- Asphalt paver
- Pneumatic tire rollers
- Steel rollers

Construction process

HMA overlays are typically performed by contractors. Write specifications and perform quality control to ensure quality construction and materials.

1. Set up traffic control according to MUTCD. (This step may need to be repeated if steps 2 and 3–7 are separate operations.)
2. Adjust utility covers to proposed pavement height.

3. Sweep the pavement.
4. Adjust utility covers to proposed pavement height.
5. Make sure all necessary equipment is onsite and properly functioning.
6. Apply the tack coat.
7. Place the HMA mat.
8. Use the vibratory steel rollers for the initial compaction, pneumatic tire rollers for the second stage, and static steel rollers for the final stage. Thin overlays tend to cool quickly so the rollers must keep up with the paver. Monitor temperatures to ensure that the mix is being properly compacted.
9. Open road to traffic.

Application rates

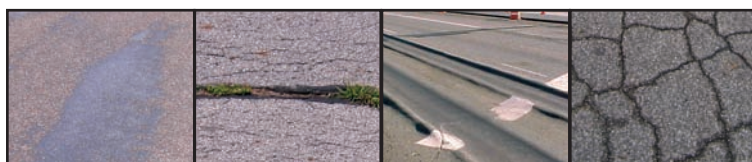
One inch of HMA for pavements with light residential traffic. Two inches of HMA for pavements with light truck traffic. Tack coat application is usually 0.02–0.10 gal/yd².

The contractor should design the mix. Typically, contractors will have a pre-determined mix that is suitable for this type of surface and locally available aggregates and binders.



Figure 33. Thin HMA overlay

Decision matrix for HMA overlay



Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med.	High	Low	Med.	High	Low	Med.	High	< 2,000	2,000 < ADT < 5,000	< 5,000	Friction	Oxidation
✓	✓		✓			✓	✓	✓				✓	✓	✓	✓	✓

✓ **Recommended**

Life	Costs			Materials	
5–15 yrs.	\$3–6/yd ² *	\$1,600–2,400/city block**	\$28,000–42,000/mile***	Hot mix asphalt	Cost is dependent on the price of HMA/ton (in-place)
					To calculate cost/yd ² : Multiply \$/ton x 0.056 x depth of overlay (in.)

* Assumes \$55/ton of HMA for 1 in. and 2 in. overlays

** 1 block = 24 ft. wide pavement x 300 ft.

*** 24 ft. wide pavement

References: CalTrans Maintenance Manual Chapter 8: Maintenance Overlays

NovaChip®

Thin course (less than 3/4 in.) open-graded aggregate hot mix asphalt over a binder membrane called NovaBond™. NovaChip® goes down with a special paver that applies both a thick tack coat and the HMA in one pass. NovaChip® is purported to provide a water resistant membrane in a manner similar to that of a seal coat without the disadvantage of fly rock. A few projects in Iowa have been constructed using this proprietary process, mostly as demonstration projects.

Advantages

- Improves the aesthetic appearance of an HMA.
- Provides smooth, quiet surface.
- Because surface is porous, water spray during rain is reduced considerably.
- Reduces headlight glare on rainy nights.
- Provides good background for pavement markings.
- Can be opened to traffic immediately after construction.

Disadvantages

- Initial cost of construction can be high.
- Possible free/thaw damage due to water getting trapped in porous surface.
- Drainage must be provided at low edge of road to allow water to exit, which may be difficult where curb and gutter are used.
- Difficulty in providing feathered edges at utility covers and construction joints.

Rules of thumb

- NovaChip® can be used to fill ruts up to 1/2 in. on the first pass. If the ruts are deeper, pavement surface should be milled down to reduce rut depth or a scratch course of slurry seal, micro-surfacing, or HMA should be placed to fill the ruts.

Equipment

- Street sweeper
- NovaChip® paver



Figure 34. NovaChip® application.

Construction process

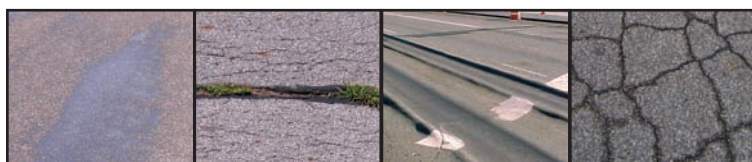
1. Set up traffic control according to MUTCD. (This step may need to be performed more than once if steps 2 and 3–7 are separate operations.)
2. Adjust utility covers to new pavement height.
3. Sweep the pavement to remove any large debris.
4. Cover any utility covers with construction paper to make sure the NovaBond™ does not cover the manholes.
5. Make sure all necessary equipment is onsite and properly functioning.
6. Place the NovaChip® over the NovaBond™ in one pass.
7. Seat and orient aggregate with one or two passes of a static-steel wheeled roller.
8. Open road to traffic.

*NovaChip® must be placed by a contractor who is licensed to place this proprietary product. However, quality control should be performed and specifications should be written so as to ensure quality construction and materials.

Application rates

The mix design will be performed by the contractor.

Decision matrix for NovaChip®



Raveling			Cracking			Rutting			Alligator cracking			Traffic (ADT)			Properties	
Low	Med	High	Low	Med.	High	Low	Med.*	High*	Low	Med.	High	< 2,000	2,000 < ADT < 5,000	< 5,000	Friction	Oxidation
✓	✓		✓			✓	✓	✓				✓	✓	✓	✓	✓

✓ **Recommended**

*Premilling or scratch course of slurry seal, micro-surfacing, or HMA is required for ruts greater than 1/2 in.

Life	Costs			Materials	
5–15 yrs.	\$3.50/yd ² *	\$2,800/city block**	\$49,000/mile***	Hot mix asphalt	Cost is dependent on the price of HMA/ton (in-place)
					To calculate cost/yd ² : Multiply \$/ton x 0.056 x depth of overlay (in.)

* Based on interview with Koch Pavement Solutions (7/15/2005)

** 1 block = 24 ft. wide pavement x 300 ft.

*** 24 ft. wide pavement

References: Koch Pavement Solutions, Cost-Effective Rut Repair Methods

Ch 7. Selecting the treatment

Often there is not a clear best choice for a TMS treatment. Each TMS has advantages and disadvantages, depending on a pavement's distresses. This can make the decision process difficult.

Multiple factors will influence the final decision of the surface to be used:

- Type of distress
- Aesthetics
- Initial cost
- Life cycle costs
- Availability of materials

Type of distress

Certain treatments are better for some distresses than others. For example, if the surface is cracked, a more flexible treatment such as a seal coat is most effective, since it can reduce water intrusion into cracks to a greater extent than a stiffer treatment such as slurry seal or micro-surfacing. However, for rut filling, stiffer treatments such as slurry seal or micro-surfacing are more effective. Therefore, the treatment must be selected to match the distress.

Aesthetics

The appearance of the road will be important to neighboring property owners, some road users, and many others in the community. Consider preferences in aggregate color and texture that stakeholders may have.

Initial costs

Most maintenance programs have to fit within an annual budget. If a certain amount of road must be maintained, this may limit the choices available to the decision maker.

Life cycle costs

Decisions about maintenance investments can have impacts on future maintenance and construction costs. It may be possible to delay a construction project and invest the funding in maintenance, thereby delaying the need for future rehabilitation and construction. On the other hand, a well-selected

reconstruction or rehabilitation project might reduce future maintenance costs. Decision makers should consider how their decisions will affect the costs for the entire life cycle of the road.

Availability of materials

Transportation of aggregates is very expensive in comparison to their value in a stockpile at the quarry. For this reason, decision makers often decide to limit their choices to locally available aggregates. Rail or barge transportation may provide opportunities to ship aggregates longer distances. In addition, asphalt suppliers provide a limited number of emulsions and, like aggregate, the cost of transportation is high in comparison to the value of the product. So, as with aggregates, decision makers will be limited in the variety of emulsions and other binders that they can specify.

Availability of contractors and equipment

Mobilization costs can be high and scheduling can be difficult for contractors who are not local to the area. Therefore, decision makers may decide to use treatments that can be applied by local contractors. If the work is performed by a government agency using their own workers and equipment, decision makers may be limited to methods and materials that can be applied using those resources.

Repetition and economics of scale

Many jurisdictions settle on a limited number of treatments that work well for them, then repeat those treatments on a regular basis (e.g., once every one to five years). Mobilizing to provide a small amount of a particular treatment that is not one of those regularly used may be uneconomical or administratively challenging. Therefore, decision makers will often rely on treatments that are in their usual repertoire as much as possible. However, by being in the habit of using a particular treatment, decision makers run the risk of misapplying that treatment or not realizing that it might be economical to use a different treatment.

Common HMA pavement conditions

The examples in this section illustrate common HMA pavement conditions and suggest possible thin maintenance surface selections. See Figure 1.

HMA No. 1: Excellent to very good condition

- Pavement is slightly to moderately oxidized and is beginning to pock or ravel in low severity.
- Thermal cracks have formed but are still thin (hairline to ¼ inch), or joints cracks from underlying pavement have reflected and are of low severity.
- There is no indication of structural failure.

In this example, because there is little distress, all thin maintenance surfaces could be considered for preventive maintenance. However, from the perspective of road users, thin maintenance surfaces other than fog seal may result in a rougher road texture that would be considered undesirable. Nevertheless, the benefits of arresting oxidation and waterproofing the surface may extend pavement life sufficiently to justify an investment in maintenance. Many of these benefits can also be obtained with a fog seal.

Preconstruction

Cracks should be sealed two to three months before construction.

Surfaces suitable for this pavement

Fog seal—Recommended if the distresses are of low severity.

Fog seal is effective for waterproofing the surface of the pavement, mitigating raveling, and sealing thin cracks. Fog seal also restores a dark color that resembles a new asphalt pavement and is a good background for pavement markings.

Note: A fog seal will reduce friction until the binder has been worn off the tops of the exposed aggregate. Applying sand can help to restore the friction. Also, the road will have to be closed until the emulsion has cured, which can take up to eight hours, depending on the weather.

Slurry seal, micro-surfacing—Recommended if pavement is moderately oxidized or pocked. Effective at sealing all of the distresses described in this exam-

ple and provides a new high-friction wearing course.

Slurry seals can be used in place of a seal coat with little added cost. The slurry seal has the advantage of a higher aesthetic value over the seal coat. Also, if the pavement has low-severity and low-density cracking, the slurry seal will perform well.

Compared to a slurry seal, micro-surfacing may have a longer service life, but the cost of micro-surfacing is higher than that of a slurry seal.

Seal coat—Recommended with caution. Although seal coat will likely extend pavement life, it may have limited acceptance by road users, neighboring property owners, and other stakeholders. High-quality application techniques, smaller aggregate, and premium materials are recommended if seal coat is applied to a pavement that is in good condition.

The seal coat will provide a new wearing course which can restore friction to an existing low-friction surface. Well-maintained surfaces can be sealed with ¼ to 3/8 aggregate. This reduces materials costs, because less binder is required to attach the smaller particles. The smaller aggregate also results in a smoother road. Avoid using uncrushed aggregate such as pea rock. The round shape makes it more likely to roll on the pavement, causing raveling of the seal coat. When lighter color aggregates are used, the seal coat gives the appearance of a gravel road, and it can be very dusty if the aggregate has excessive fines. Using pre-coated chips will prevent dust problems and give the seal coat an appearance closer to that of an HMA road. The pre-coated chips also form a stronger bond with the binder, which decreases raveling.

Surfaces not recommended for this pavement

Thin HMA overlay, smooth seal, NovaChip®—Not recommended. Given the good condition of the pavement in this example, investment in these surfaces is likely to be premature.

HMA No. 2: Good to fair condition

- The pavement surface is oxidized and is raveling or pocking.
- Areas of polished aggregate are beginning to form.
- Thermal cracks and/or joint reflection cracks are beginning to widen or spall.

- Rutting, if present, is shallow.
- A centerline crack has formed.

Treatments placed on roads in this condition are maintenance treatments, not preventive maintenance.

Preconstruction

Cracks should be sealed two to three months before construction.

Surfaces suitable for this pavement

Seal coat—Recommended if rutting does not exceed moderate severity.

Ruts between ¼ and 1 inch deep can be reduced by filling them with slurry seal (see below). After the ruts are filled, a seal coat may be placed over the entire road to provide a uniform surface.

A seal coat effectively provides a waterproof surface to mitigate raveling, and it also seals thermal, reflected, and centerline cracks. A seal coat will also restore friction to a pavement with polished aggregate or low friction. Consider using a double seal coat or a cape seal to increase the robustness of the seal coat against distresses.

Slurry seal, micro-surfacing—Recommended.

Both slurry seal and micro-surfacing will provide a waterproof seal and good friction. They also make the pavement look like an HMA pavement and provide a good background for pavement markings. A slurry seal is recommended for pavements with low severity cracks that are not spalling. Because slurry seals are brittle, the surface will quickly reflect cracks, which may widen or spall. Micro-surfacing is more resilient and less likely to widen or spall at crack locations.

For rounded-over cracks, use either the slurry seal or micro-surfacing to level and fill in the crack before the entire surface is sealed. This will mitigate crack spalling and also restore a smoother ride to the pavement.

For ruts up to one inch deep, a good slurry seal mix can fill them when carefully placed. For deeper ruts under higher traffic, micro-surfacing is more stable and a more reliable choice. However, well-designed and placed slurry seal has reportedly successfully filled ruts deeper than one inch.

Both surfaces will have a higher tire noise until the

aggregate in the seal is laid flat by traffic. The cost of a slurry seal is only slightly higher than a seal coat. The cost of micro-surfacing is one and a half to two times as expensive as a seal coat.

Thin HMA, smooth seal, NovaChip®—Recommended for the same reasons as the slurry seal and micro-surfacing.

These surfaces are effective at filling ruts. Although the design assumption is that these surfaces do not add structure, in actuality they do add a marginal amount of structure that can be helpful in life extension. Any cracking will reflect through to the new surface. These surfaces will provide a smooth ride and good appearance. In comparison to other treatments, these surfaces restore a completely “new road” look and feel and will likely last longer. The cost will be higher.

Surfaces not recommended for this pavement

Fog seal—Not recommended.

HMA No. 3: Fair to poor condition

- Pavement is oxidized and is raveling and pocking.
- The cracks in the pavement are wide and have spalled.
- Rutting is ½ to 1 inch deep, and longitudinal cracks are beginning to form in the rut.
- The centerline crack is spalling.
- Low-severity alligator cracking is beginning to form in the wheel paths.

Pavements with these conditions would need to be rehabilitated soon. Thin maintenance surfaces may be used as stopgap treatments, depending on the severity of the distresses, and may delay the need for rehabilitation. However, such use is rarely economical, and most stakeholders are disappointed by the results.

Preconstruction

Check drainage conditions and make changes if necessary. Perform full-depth patching for areas with structural failure. Cracks should be sealed two to three months before construction. High spots on the pavement can be milled down with a milling machine, and areas outside the wheel paths can be milled down

to decrease depth of ruts. Any potholes should be excavated and replaced with a full-depth patch.

Surfaces suitable for this pavement

Seal coat—Possible stopgap life extension technique.

Because seal coats are flexible and can “glue” the surface together, they can be an effective stopgap procedure. The seal coat will seal the cracks and waterproof the surface, but it is likely that the cracks will reflect quickly because the emulsion will soak into the cracks leaving little on the surface to hold the chips. This reflection can be reduced by pre-sealing the cracks before placing the seal coat. Seal coats should not be used if rut filling is desired. Seal coats can be marginally effective on alligator cracks if traffic is light and the cracks don’t pump (proof roll test) under traffic.

Thin HMA overlay, smooth seal, NovaChip®—Marginally recommended.

These surfaces will add some structure to the pavement and will also fill in the ruts. Any areas of alligator cracking should be replaced with a full-depth patch, as the cracking will reflect quickly. These surfaces are effective at smoothing out the surface. If ruts are deep or there are variations in the grade, apply a scratch course to fill low spots before the surface course is applied.

Surfaces not suitable for this pavement

Fog seal—Not recommended.

Slurry seal, micro-surfacing—Usually not recommended.

If the original pavement has few cracks but has other distresses such as rutting, raveling, or bleeding, using a slurry seal or micro-surfacing may extend the life somewhat (see the slurry seal section in the HMA No. 2 example). If the cracking is dense and severe, these surfaces are not recommended because all the cracks will reflect quickly and little improvement will result.

Common seal coat pavement conditions

The examples in this section illustrate common seal coat pavement conditions and suggest possible thin

maintenance surface selections.

The deterioration of seal coat pavements differs from that of HMA pavements because seal coats tend to have less structural capacity and more flexibility. They are therefore more prone to structural distresses such as rutting of base materials, alligator cracking, and longitudinal cracking in wheel paths. Bleeding and raveling are common when aggregate and binder application rates are not appropriate. Occasionally, seal coat pavements will develop transverse cracks.

Seal coat No. 1: Excellent condition

- Seal coat pavement displays little to no distress.
- The only distress might be light-severity raveling or loss of aggregate.

Surfaces recommended are intended for preventive maintenance.

Preconstruction

None.

Surfaces suitable for this pavement

Fog seal—Recommended.

A fog seal can mitigate light raveling and prevent more from occurring, because it is gluing the aggregate down to the base. It is possible to place a fog seal over a seal coat immediately after the seal coat has been placed to prevent raveling, mitigate dust, and improve the appearance of the pavement. The application of the fog seal should be designed so as to reduce the likelihood of bleeding. Keep in mind that a fog seal will reduce friction until the binder is worn off the tops of the exposed aggregate. This tendency can be reduced by applying sand. Also, the road will have to be closed until the emulsion has cured, which can take up to eight hours, depending on the weather.

Seal coat—Recommended every one to three years.

If the pavement is a full-depth seal coat, place a new seal coat every one to two years. Even though the seal coat may be in excellent condition, if cracks form and are not sealed, water will quickly weaken the sub-base, causing failure.

Smooth seal—Recommended.

Smooth seals are intended to be placed on seal coats that are in good structural condition. Although the cost is much higher, the smooth seal should last

for 7–15 years or more, depending on the amount of traffic and the strength of the base. It will provide a smooth, clean, and uniform surface. Consider surfacing a few blocks per summer while maintaining others with a seal coat.

Slurry seal—Recommended if the existing seal coat is thick and the structural condition is good.

Slurry seal can have better public acceptance in comparison to a seal coat, because there is less dust and fly rock and the resulting surface is more uniform. On urban streets, layers of seal coat can build up the crown of the road so high that vehicles scrape the road as they enter and exit driveways. A slurry seal provides a thinner layer and slows the buildup of the crown.

Surfaces not suitable for this pavement

Micro-surfacing—Not recommended.

The extra cost of micro-surfacing is seldom justified for seal coat pavements which generally experience low traffic and may have marginal structural characteristics.

Seal coat No. 2: Fair to good condition

- Seal coat is displaying mild bleeding or raveling.
- Some cracks have formed.
- Ruts are beginning to form.
- Alligator cracking is forming and developing into potholes.

Depending on the amount of work necessary, the surfaces recommended are considered to be maintenance or stopgap.

Preconstruction

Patch potholes and consider full-depth patches for areas of alligator cracking. If there are large areas of alligator cracking, check drainage. Consider the possibility that the structure could be improved by improving drainage.

Surfaces suitable for this pavement

Seal coat—Recommended.

If the seal coat is raveling, a new seal coat will mitigate raveling and provide friction in areas that have lost large amounts of aggregate. If the seal coat is bleeding, applying a new seal coat with special

attention to the application rates can prevent bleeding on the new seal coat. If bleeding is severe and located only in the wheel paths, consider pre-spraying the areas outside of the wheel path with binder, following immediately with a full-width pass of the emulsion. This will decrease the amount of binder in the wheel paths, preventing bleeding on the new surface.

The seal coat will effectively seal cracks; however, if the cracks are deep or wide, pre-sealing the cracks is strongly encouraged. If maintenance has been neglected for a time, applying a double seal coat will sometimes help “catch up.”

If the pavement is severely distressed and funds are available, the road should be pulverized and possibly mixed with stabilizing agents to provide a stabilized road (See appendix or SUDAS).

Surfaces not suitable for this pavement

Fog seal—Not recommended.

Smooth seal, slurry seal, micro-surfacing—Not recommended.

Any areas with structural distress must be replaced with a full-depth patch before placing the smooth seal, slurry seal, or micro-surfacing. If considerable patching is required, it may be a better investment to rebuild the road.

Treatment for specific distresses

Bleeding

- Place a new surface over the bleeding.
- If bleeding is severe and located only in the wheel paths, pre-spray the areas outside of the wheel path with binder, following immediately with another light, full-width pass of the emulsion. This will decrease the amount of binder in the wheel paths and prevent bleeding on the new surface.

Bumps and sags, shoving and corrugation

- Grind any bumps down with a pavement milling attachment. If unavailable, it may be possible to make some improvement by scraping with motor grader blades or loader buckets.

- When shoving and corrugation occurs, it usually indicates that the underlying pavement has insufficient stability to withstand traffic loads. The pavement will likely have to be removed and replaced to provide a permanent solution. Applying a TMS may delay the need for rebuilding.
- If slurry seal, micro-surfacing, or a thin HMA overlay is used, a scratch course is recommended to fill any sags or voids.

Cracking

Alligator cracking

- Removing distressed pavement and placing a full-depth patch works best.
- If the base or subgrade is soft, it should be removed and replaced or stabilized.
- Low severity alligator cracks can be seal coated or slurry sealed to slow down water penetration and “glue” the pieces together. This is most effective on low traffic roads if the alligator cracks are not pumping. A good way to test for pumping is to walk along a piece of equipment or a loaded tandem axle and watch to see if the pavement flexes under the load. This test is similar to proof rolling.

Block cracking

- Consider pre-sealing the cracks.
- For low-severity cracks, all surfaces are recommended for block cracking.
- For a pavement with a high density of cracks, seal coating may be most effective.
- As the severity or density of block cracking increases, a double seal coat becomes more desirable.
- If the block cracks are still hairline, a slurry seal or micro-surfacing will narrow the cracks. Micro-surfacing has greater resilience compared to a slurry seal, and may armor the edges of the crack for a time and prevent spalling.
- Thin overlays may be used to extend the life of the pavement. However, the cracks will reflect through to the surface, possibly two to four

years after the overlay is placed.

Edge cracking

- Patch areas where the edge has spalled off the pavement.
- Seal cracks.
- Eliminate edge drop-offs between the pavement and granular shoulders to support the pavement and increase safety.
- If the distress is located where the ditch is deep and the shoulder is narrow, the edge of the road embankment may be sliding into the ditch.

Joint reflection cracking, transverse/thermal cracking

- Pre-seal cracks before placing a thin maintenance surface.
- Joint reflection cracking seldom results in a high density of cracking, because crack locations are limited to the location of original pavement joints in underlying layers.
- If hairline cracks exist, slurry seal or micro-surfacing will narrow the cracks. Micro-surfacing tends to be more resilient and will resist spalling and crack widening better under high traffic.
- On wider cracks, seal coats or thin HMA overlays are effective. Cracks will reflect through these surfaces, but with proper mix design and maintenance, spalling can be delayed for several years.

Longitudinal cracking (load related)

- Because load-related longitudinal cracks begin at the bottom of the pavement and move up, the crack is likely to be wider at the bottom than at the top. Cracks should be sealed as soon as possible.
- Seal cracks as soon as possible to prevent water infiltration and further weakening of the road.
- The use of thin maintenance surfaces will be a stopgap measure because the road is suffering a structural failure.

Longitudinal cracking (construction joint and paver segregation)

- If distress is low-severity, a fog seal strip over the area will likely slow further deterioration.

- A slurry seal strip over the defect can also be helpful.
- Seal coats can be effective for more advanced deterioration.

Oxidation, weathering/raveling

- All surfaces protect the pavement from oxidation. If the pavement suffers only from oxidation, a fog seal will be sufficient. It has the lowest cost and inflicts the least disruption.
- As oxidation turns to weathering and raveling, more aggressive treatments are required. As distresses become more severe, thicker applications such as slurry seal or micro-surfacing are desirable. Also consider using larger-sized (half-inch) aggregate or a double seal coat. A thin HMA overlay also addresses these distresses but cost more.

Potholes, patching and utility cut patching

- Remove and replace the pavement with a full-depth patch before applying a new surface. If the subgrade or base is soft or unstable, replace it.
- All surfaces can be successfully applied to a pavement that has patches in good condition.
- If a patch is in poor condition, replace it before applying a new surface.
- Seal cracks.
- The edges of patches can reflect through thin maintenance surfaces in a manner that is similar to that of cracks. If the patch density is low, slurry seal and micro-surfacing can provide a more uniform appearance, and reflected cracks will not be overly problematic. Micro-surfacing has greater resilience compared to a slurry seal and is less likely to spall or widen at cracks.

Polished aggregate

- All surfaces except fog seal are recommended for polished aggregate.

Rutting

- Slurry seals are recommended for ruts up to one-half inch.

- Micro-surfacing and thin HMA overlays are recommended for ruts up to one and a half inches.
- For ruts that are one-half to one inch deep, micro-surfacing should be placed in two lifts: a scratch course and a finish course. The scratch course fills ruts while the spreader box is allowed to drag on high spots in the pavement.
- For ruts deeper than one inch, a rut box should be used. A rut box has augurs that sweep larger pieces of aggregate into the bottom of the rut, resulting in a more stable mixture. Using a rut box requires two passes, one for each rut. Then a finish course is usually required to provide a surface with a uniform appearance.
- If deep ruts are filled in one pass, the road will have a blotchy appearance because the aggregate tends to sink to the bottom of the rut while the binder rises. This leaves dark spots on the road that appear to be bleeding. (According to anecdotal evidence from Iowa DOT personnel, this does not result in a noticeable loss of friction during skid testing.)
- Consider milling the pavement to reduce rut depth.
- If ruts are still progressing due to an unstable mix or a failing base or subgrade, rutting will reappear after a new surface is applied.

Ch 8. Selecting materials

This section describes various materials that are commonly used for thin maintenance systems in Iowa, with an emphasis on materials for seal coating. The materials for micro-surfacing and slurry seals should be selected according to the International Slurry Seal Association specifications.

Aggregate categories

Three major categories of aggregate are commonly used for TMS in Iowa: limestone, pea rock, and quartzite. The cost will vary depending on the haul distance. Both quartzite and pea rock aggregates are much harder than the limestone aggregate.

Limestone

Advantages

- Limestones with low clay content are easily and permanently bound by most binders.
- Sharp edges promote good skid resistances until worn.
- Some limestone has a microstructure that promotes good skid resistance even after edges are worn.
- Locally available in many places in Iowa, thus lower transportation costs.
- Individual stones may shear apart during snowplowing operations preventing them from being plucked from the road.

Disadvantages

- High clay content limestone requires careful binder selection.
- Soft limestones will not be durable, losing sharp edges under traffic.
- Individual stones may shear during snowplowing, reducing macro-texture (may not occur in wheel ruts).

Pea rock

Advantages

- Round stones provide smoother road surface that may be friendlier to pedestrians, bike riders, skate boarders, and in-line skaters.
- Round stones may not catch snowplow blades.
- Inexpensive local sources reduce cost.



Figure 36. Plain limestone aggregate.



Figure 37. Pea rock aggregate.

Disadvantages

- Round particles provide less macro-texture for skid resistance.
- Round particles provide less stability; this may make them more susceptible to snowplow damage if the blade engages them.
- Particles are not from a homogeneous source, so their chemical behavior with binders is less predictable

Quartzite

Advantages

- Particles have sharp edges that provide excellent skid resistance

- High durability
- Pink coloration can be contrasted with other aggregates to delineate portions of the road

Disadvantages

- Binder must be properly formulated to mitigate stripping
- Sharp edges catch snowplow blades, causing wear on blade or plucking improper bound aggregate from road
- High transportation costs in portions of Iowa that are not close to sources

Aggregate shapes

The shape of the aggregate can play a significant role in how it interacts with traffic and the stability of the TMS. There are three categories of aggregate shape: flat, cubical, and round. The following table describes the advantages and disadvantages of each of the different shapes of aggregate. Following the table, a few figures depict the reaction of the aggregates under traffic.

Cubical

Advantages

- Greater stability in wheel tracks and areas where traffic is turning.
- Allows higher shot rate for binder, ensuring that aggregate particles are better attached.

Disadvantages

- Requires more expensive production techniques, which raise cost and limit availability, and in some cases increases volume of waste products in quarry.

Flat

Advantages

- May be more easily produced and therefore lower in cost in some areas.

Disadvantages

- Flat particles reorient under traffic to lowest possible elevation, possibly submerging in binder and causing tracking and bleeding.
- Reduces design shot rate, which may cause some particles to be less firmly bound.

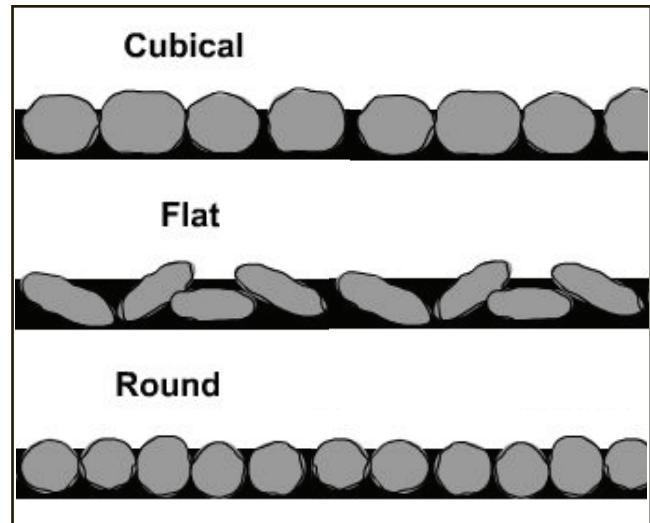


Figure 38. Aggregate shapes.

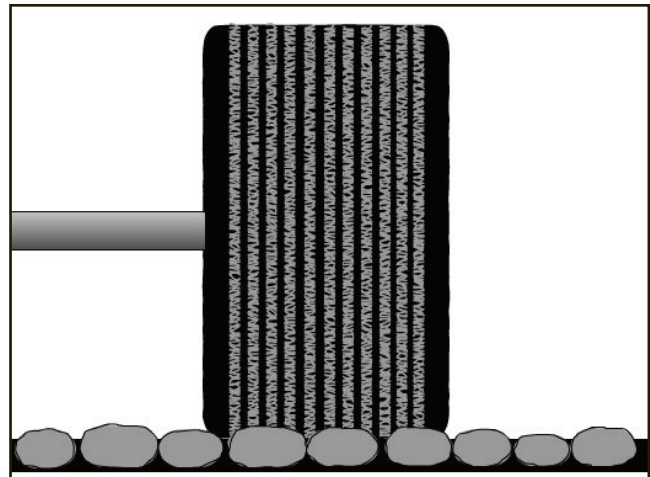


Figure 39. Cubical aggregate

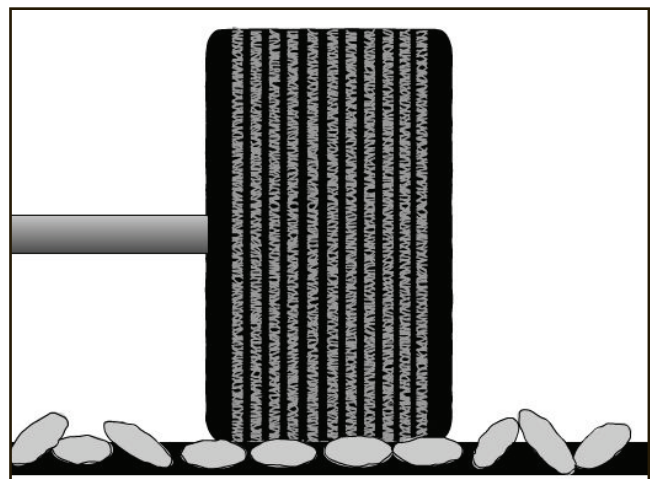


Figure 40. Flat aggregate.

Round

Advantages

- Create a smoother surface that is more comfortable to walk on.

Disadvantages

- More susceptible to rolling and displacement under starting, stopping, and turning actions of traffic.
- Does not interlock as well, unless a graded aggregate is used, thus is dislodged more easily by snowplow blades.

Aggregate gradation

The aggregate gradation can play a very important role in the success of a TMS. With micro-surfacing, slurry seals, and thin HMA overlays, a densely grade aggregate is specified in order to give the mix adequate stability. The gradations for slurry seal and micro-surfacing have been specified by the International Slurry Surfacing Association and can be found at www.slurry.org.

However, for seal coats the aggregate can be specified as a graded aggregate or a single sized aggregate. Each has advantages and disadvantages. To reduce the amount of dust, the percentage of fines in a gradation should be kept at very low regardless of whether the aggregate is a graded or single sized aggregate. A rule of thumb to tell if the chips are too dusty is to pick up a handful of aggregate, throw it down, and check to see if there is dust left on our hand. If so, it's too dusty and you should consider using a cutback or high float emulsion (described later).

Single-size aggregate

Advantages

- More void space (compared to graded aggregate) for more binder to be shot and allows more tolerance with regard to binder application rate.
- Allows spreading of aggregate in one layer so each particle is bound to the road surface, not other aggregate particles.
- Mitigates tracking by keeping tires away from binder.

- Theoretically prevents snowplow blades from catching single aggregate particles that stand above others and plucking them out.
- Requires lower application rate by weight per square are compared to graded aggregate.

Disadvantages

- Road may seem rough or noisy to occupants (though no worse than any other road with an open texture).
- May add to cost of aggregate if fine material becomes a waste product, which cannot be used in another product.
- May not be produced in certain geographic areas, thus requiring long distance transportation and more expense.
- Some aggregate may be plucked or sheared off by snowplow blades because sharp corners may stand above other aggregate pieces.

Graded aggregate

Advantages

- Provides a smooth tighter road surface.
- Uses fine material from quarry that may otherwise become a waste product.
- High availability locally in Iowa, thus low transportation costs.

Disadvantages

- Reduces macro-texture, thus increasing risk of hydroplaning.
- Lack of void space allows less binder to be shot and less tolerance in binder shot rate, com-

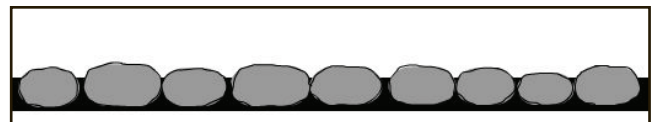


Figure 41. Single sized aggregate.

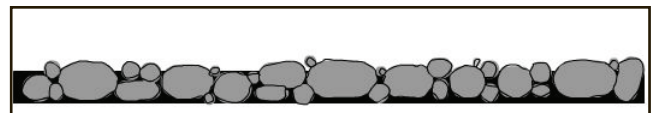


Figure 42. Graded aggregate.

pared to one-size aggregate.

- Subject to tracking because some aggregate may be submerged in binder.
- Subject to aggregate loss because some aggregate is not bound directly to the road surface.
- Requires higher application rate in weight per square area when compared to one size aggregate.

Aggregate size

The size of the aggregate chosen also plays a role in the materials used. Aggregate size has been broken down into two categories: small and large.

Small size ($\leq 3/8"$)

Advantages

- Provides a smoother, tighter road surface.
- Requires a smaller weight per square area of aggregate to be spread.
- Fly rock does less damage to vehicles.
- Design shot rate is smaller, thus lower cost.

Disadvantages

- Less room for error in the binder application rate (the distance from the top of the aggregate to the top of the binder is smaller).
- Design shot rate is smaller, thus less binder is available to seal cracks.
- The top of the aggregate may wear down more quickly allowing tire contact with the binder.
- Less macro-texture.

Large size ($> 3/8"$)

Advantages

- Less sensitive to errors in binder application rate.
- Design shot rate is larger; more binder available to seal cracks.
- Aggregate is less likely to wear sufficiently to allow tires to contact the binder.
- More macro-texture.

Disadvantages

- Like other open surfaces with high macro-texture, more road noise for vehicle occupants.

- Larger weight of aggregate per square area to be spread.
- Fly rock is heavier and more likely to damage vehicles.
- Design shot rate is higher, thus higher cost.

Pre-coated chips

It's possible to pre-coat limestone chips with asphalt binder before they are placed on a road. To pre-coat the chips, the chips are processed at an asphalt plant and a thin film of asphalt is applied to all the aggregate. This pre-coating reduces typical problems when using limestone chips. It strengthens the bond between the chips and the binder, eliminates dust, and improves the appearance of the chips. When constructing a seal coat using pre-coated chips, the binder application rate should not be adjusted.



Figure 43. Precoated limestone chips.



Figure 44. Dust comparison.

Binder

There are three different types of binders that can be used for TMS: cutback, emulsion, and hot asphalt binder. Only cutbacks and emulsions are commonly used in Iowa.

A cutback is an asphalt binder that has been liquefied for low temperature use by the addition of a cutter, typically a petroleum product such as kerosene or fuel oil. Cutbacks can be used later in the season because the curing process only involves the evaporation of the cutter. Cutbacks stay active longer, which means that they are able to penetrate and coat the dust that may be on the aggregate. Cutbacks also have a much higher percentage of binder which leads to more asphalt being left on the road surface per gallon of binder applied when compared to an emulsion.

An emulsion is a mixture of asphalt binder, water, and an emulsifying soap. It's created by grinding the asphalt binder into microscopic globules and mixing it with water and the soap. The soap prevents the globules from clumping together. This suspends them in the water. Depending on the type of surfactant used, it's possible to change the charge of the emulsion in order to improve the bond with the aggregate. In Iowa, cationic (positively charged) emulsions are used because most aggregate is negatively charged. When the emulsion is placed on the pavement, the soap is attracted to the aggregate leaving the asphalt particles behind to group together, forming an asphalt

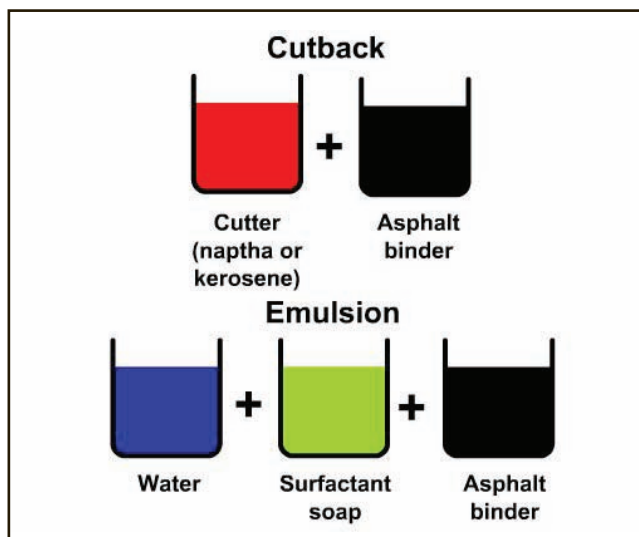


Figure 45. Three different types of binders.

skin on the aggregate. This process is called breaking and can be identified when the color of the emulsion turns from brown to black. After the emulsion has broken, the water begins to evaporate out of the emulsion—this is curing.

When selecting a binder, consider the aggregate too. The ability of the binder to bind to the aggregate is largely dependent on the aggregate's properties. For example, if the aggregate is dusty, some binders will bond with the dust and not the aggregate, which results in the aggregate raveling off due to the poor bond.

The following binders are commonly used in Iowa.

Cutback asphalt

Advantages

- Best at binding dusty aggregate.
- Some possible penetration into dry road surfaces increases bond.
- Will retain aggregate that is not spread immediately after shooting binder.

Disadvantages

- Subject to bleeding and tracking.
- Some products are flammable.
- Emits hydrocarbons during curing process.
- Curing can take considerable time.
- Aggregates must be dry.

Cationic rapid setting (CRS)

Advantages

- Binds clean aggregates with low clay content securely to road surface.
- Cures quickly.
- Works with damp aggregate.
- Commonly available and familiar to industry participants.

Disadvantages

- Ineffective for dusty aggregates or aggregates with high clay content.
- Aggregate must be spread immediately behind distributor truck.

High float

Advantages

- Binds aggregate with more dust and clay when

compared to CRS.

- Cures quickly, but not as quickly as CRS.
- Works with damp aggregate.
- May coat aggregate more thickly, yet reduce movement that causes bleeding due to “gel” structure of cured emulsion.

Disadvantages

- Does not cure as quickly as CRS (but more quickly than cutback).
- Industry participants may not be as familiar with this product as CRS, depending on geography and local experience.
- Some hydrocarbons released during curing due to the use of cutter (kerosene) in this product (much less than standard cutback).

Polymer-modified (added either to CRS or high float)

Advantages

- Greater flexibility during cold weather, mitigates cracking.

- Greater stiffness in warm weather, mitigates bleeding and retains aggregate in areas of turning, accelerating, and decelerating traffic.
- Higher early strength during curing leads to better chip retention.

Disadvantages

- Higher cost compared to non-polymer-modified binder.

Design methods

It's possible to calculate the ideal application rates of both the aggregate and binder. The Minnesota DOT Seal Coat handbook contains a good design method. The aggregate application rate depends on the aggregate gradation, shape, and specific gravity. The binder application rates depend on the aggregate gradation, absorption, shape, traffic volume, existing pavement condition, and the residual asphalt content of the binder.

Specification references:

Ch 9. Contracting

Selecting the best contracting method and specification can help an agency receive the best surface for the dollar. There are several types of contracting techniques that are used to place all of the risk on the contractor or agency and others that distribute the risk among the involved parties. However, if the agency owns its own equipment and does all the work in-house, it isn't necessary to develop a contracting method.

When deciding on the type of contract to be used, the agency must decide how much risk it's willing to bear. Each type of contract, specification, or warranty allocates the risk between the agency and the contractor in a different way. If the agency places the entire burden on the contractor, it will likely pay a premium for shedding the risk. On the other hand, if the agency takes all the risk, the contractor may be unmotivated to avoid risk on the agency's behalf.

Three typical types of contracts are let for thin maintenance surfaces: lump sum contract, a unit price for the area, and a unit price for the material. All have advantages and disadvantages.

Lump sum

In a lump sum contract, the contractor provides the agency with one price that includes materials, labor, mobilization, overhead, and profit. Lump sum projects can be risky for a contractor if more material is used than initially estimated because the extra cost of that material is absorbed by the contractor. Consequently, contractors are more likely to raise the total price of a contract to allow for contingency funds. They may also decide to save money by decreasing the amount of materials used to cut the risk of material overruns. This can result in a low quality surface.

Unit price for area

In a unit price for area contract, the agency pays a set amount per unit of area covered. This provides flexibility in case the agency wishes to add or subtract work from the contract. The adjustment is made by

simply paying for more or fewer units. If mobilization is paid as a separate item, the contractor does not have to "bury" that expense in the unit price for area, and the agency may be able to add additional work for less cost than if mobilization were not a separate item. However, with this method, the contractor's profits will increase if it uses less material. Agencies are sometimes concerned that insufficient material will be placed unless they are vigilant about the application rates. In most cases, contractors are concerned about agency satisfaction, so this is not an issue.

Unit price for materials

In a unit price for materials contract, the agency pays for each gallon of binder and each ton of aggregate used. This eliminates the incentive to skimp on materials. However, some vigilance is sometimes required to ensure that contractors do not waste materials. This tendency can be reduced if the agency and the contractor agree on a standard application rate after a few test applications are made to find the appropriate rate for the job's conditions. The final cost of the contract is more unpredictable compared to other methods since required application rates may vary according to project conditions. On the average, this method should result in the lowest overall cost because the contractor has to make up the smallest amount to cover risk.

Warranties

If the contractor is given some latitude with regard to material selection and construction methods, a warranty can be included in the specification. One-year warranties are sometimes used for thin maintenance surface construction. In general, if the surface is performing well at the end of a year, it will usually perform satisfactorily for its expected life. Note that the warranty should not include items that are beyond the scope of thin maintenance surface capabilities such as correcting structural failures or withstanding aggressive snow plowing.

Construction season

When constructing a new surface on a pavement, it's best to place the surface in the hottest and driest weather possible. Hot and dry weather helps the water in an emulsion or the cutters in a cutback evaporate quickly which speeds up the curing process. Also, avoid placing a TMS when the project is threatened with rain or cold weather.

It should be stated in a contract that the construction should be completed before a specified date to ensure that the surface is not constructed too late in the season. Additionally, the specifications should state that the construction should not take place if there is a threat of rain.

If an agency has its own crews, the maintenance department should have a policy that states that all surfacing should be performed by a specific date. A common last day in Iowa is August 15th. This allows time for crews to finish work and stripe the pavements before school starts.

Many times it's advantageous to perform maintenance such as crack sealing or patching well before the construction of the surface in order for the crack sealing material to cure or the patch to compact under traffic. If the agency wants to ensure that surface construction takes place after these other maintenance activities, this should be noted in the specifications or maintenance policy.

Ch 10. Construction

Traffic control

Traffic control is a vital part of all TMS construction. The main purpose of traffic control is to protect construction workers. It also prevents collisions between road users and construction equipment. The traffic control set up should direct traffic through the work zone and past hazards that the construction presents. Motorists should easily understand the traffic control set up.

Consult the *Manual on Uniform Traffic Control Devices* (MUTCD), Chapter 6H for proper techniques and sign placements. Published by the Federal Highway Administration, this manual is available at <http://mutcd.fhwa.dot.gov/pdfs/2003r1/pdf-index.htm>.

Quality control

The right treatment and the best materials cannot overcome poor construction. Proper construction processes must be followed. Quality control is the process of ensuring that the construction plans, agency policies, and contract specifications are being followed. This process ensures that a satisfactory product has been constructed and the likelihood of a successful, long-lasting surface is increased.

Quality control should start before the actual application begins. This includes ensuring that all necessary equipment and materials are on site before construction begins, the pavement has been cleaned, and any necessary maintenance such as crack sealing has been previously performed.

Quality control should also involve making sure that the equipment is in proper working order. The spray bar should be set at the right height. The spray nozzles should be clean and properly aligned. All of the gates should be in proper working order on a chip spreader. The equipment manuals should contain a checklist that describes a pre-construction inspection. It's wise to check on a regular basis items such as these that could hinder the construction.

Quality control also ensures that proper techniques are being followed during construction and making sure that any re-work is promptly performed. During construction make sure that all joints are straight and clean and that areas with an inadequate amount of aggregate receive a second pass by the chip spreader (a light application) or a few shovels full of aggregate are spread to prevent bleeding. It's important to ensure that the binder has not set before the aggregate is placed.

The crew applying the surface has the greatest ability to perform the quality control function. Crew members have direct control over the process and are in the best position to know what's being done well and what's being done poorly. They also can watch one another's work and communicate whether a change needs to be made. This responsibility for quality control should be communicated to the crew members and their responsibilities should be properly defined.

Following is a list of a seal coat crew members' jobs and their quality control activities:

Distributor truck drivers

Before starting, they should make sure that

- Traffic control is in place.
- Aggregate is on site.
- Their distributor truck is functioning properly with all of the nozzles properly aligned and cleaned and the spray bar at the right height.
- Pavement has been swept.
- Necessary equipment such as the chip spreader (with aggregate truck attached) and rollers are on site and prepared to begin construction.

During construction drivers should

- Maintain a proper distance in front of the chip spreader and slow down if the chip spreader is not keeping up.
- Be aware of the amount of emulsion left in the tank.

Chip spreader operators

Before starting, they should make sure that

- Gates are properly opened and aligned.
- Belts and feeds are functioning properly.

During construction operators should

- Maintain communication with the distributor truck operator.
- Tell the distributor truck operator when to stop because the chip spreader is running out of aggregate. This will prevent the chip spreader from running out of chips and prevent the binder from sitting too long without being covered.
- Watch the distributor truck's application to make sure it's consistent and there are no streaks (caused by plugged or poorly aligned nozzles or incorrect spray bar height). Let the driver know if more or less binder should be applied.

Pneumatic tire roller operators

Before starting, they should make sure that the tires are at the specified air pressure.

During construction roller operators should

- Watch the chip spreader's application to make sure the proper amount of chips is applied and that they're evenly spread over the pavement.
- Make sure the chip spreader isn't changing directions too quickly, causing the aggregate to come unbound from the binder.

Quality control should also be performed by an inspector, the foreman of an in-house construction crew, or the street superintendent to ensure that the final product is of good quality and that no rework should be performed.

A series of pamphlets called "Pavement Preservation Checklist Series," developed by the Foundation for Pavement Preservation and the Federal Highway Administration, provide useful information on the construction of crack sealing, seal coating, slurry seal/micro-surfacing, and thin HMA overlays. These pamphlets also define various quality control techniques for all types of surfaces and have a checklist of

items that can be used for quality control purposes.

These checklists can also be used to define the quality control roles of the various workers on a crew.

Construction plan

A construction plan is essential for the success of a TMS—it's the first form of quality control on the project. The team that develops the construction plan should include the engineer, maintenance superintendents, and maintenance foreman. The plan should ensure that traffic control signs and barriers are delivered and set up, all equipment is brought to the site on time and in good working condition, and all materials are delivered on time or that the necessary trucks have been reserved to deliver the materials during construction.

Although a specific plan is not necessary for each project, it's advantageous to develop one for each type of surface such as a seal coat or a slurry seal. The plan may be a short checklist of items. Specific plans for individual projects may consist of scheduling the work, ensuring that all equipment and materials are available or ordered, and traffic control rental or setup has been ordered.

The previously mentioned "Pavement Preservation Checklist Series" provide helpful insight when developing construction plans.

Documentation

Agencies should keep detailed documentation of the surfaces applied to roads. This should include application rates of the binder and aggregate, material types, costs, and any other information that might be useful in the future such as a brief description of the work performed or any problems that were encountered. This documentation is useful when looking back to discover which surfaces were successful or unsuccessful. It also helps to know what lies beneath the surface when reconstruction or rehabilitation is going to be performed. Individual agencies should develop a documentation process that's consistent with other documentation they've developed.

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