Designing and Maintaining Long-Life Asphalt Pavements

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applied pavement TECHNOLOGY

providing engineering solutions to improve pavement performance

Why Do We Need Long-Life Pavements?

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- Potentially higher initial costs
- Lower future preservation and rehabilitation costs
- Lower impact to the traveling public during preservation and rehabilitation activities
- Longer lived pavements result in lower total life cycle costs

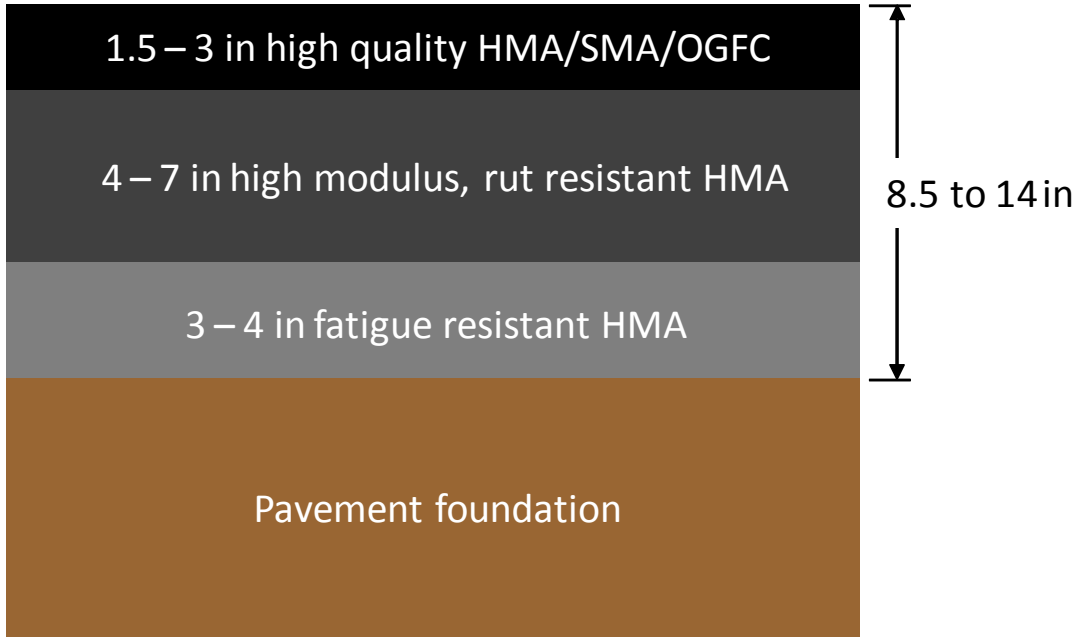
Perpetual Asphalt Pavement

"an asphalt pavement designed and built to last longer than 50 years without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement"

- Newcomb, Willis, and Timm

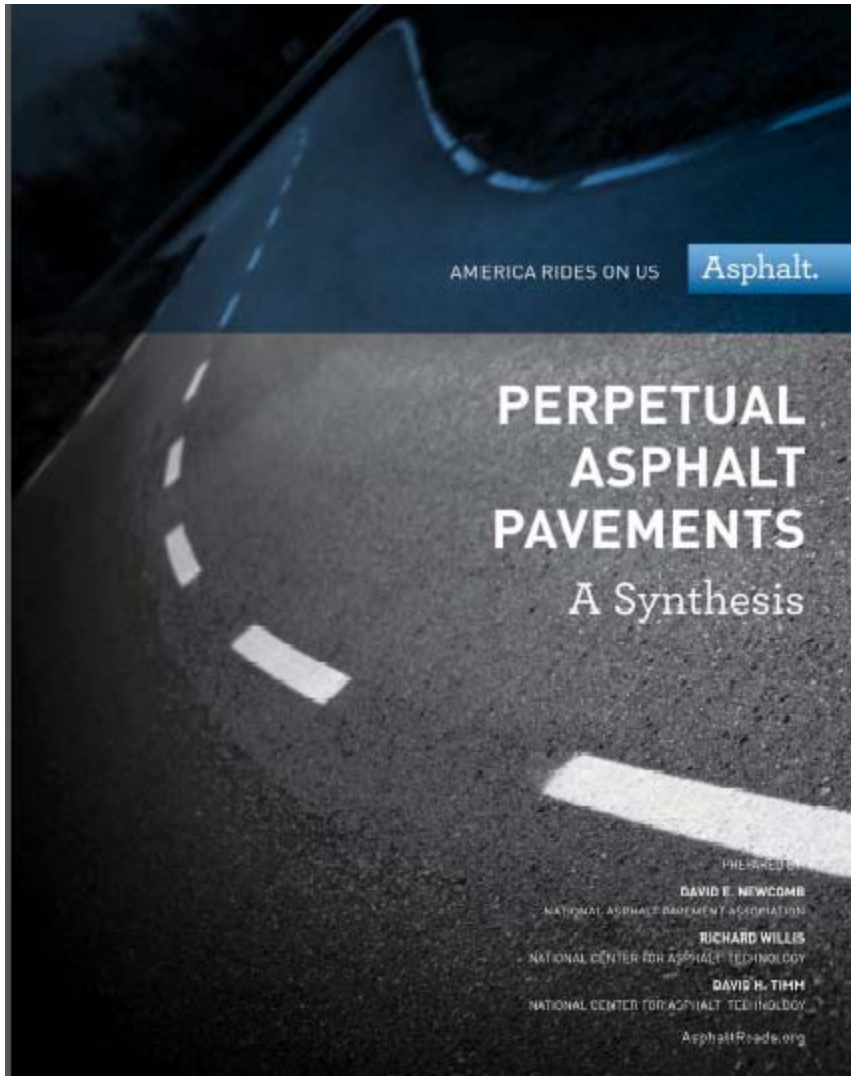
Perpetual Pavement Key Features

- Resist bottom up cracking
- Structural support and resists cracking and rutting
- Rut-resistant surface
- Subgrade (minimum CBR of 5 percent or M_R of 7,500 psi)



Additional Information

http://asphaltroads.org



Other Long-Life Alternatives

- Typically, bottom-up fatigue cracking can be minimized if the total asphalt layer is greater than about 6 – 8 in.
  - Placed in the same construction season (excludes staged construction or multiple overlays of an existing pavement)
  - Requires surface renewal over the life of the pavement

Other Long-Life Alternatives

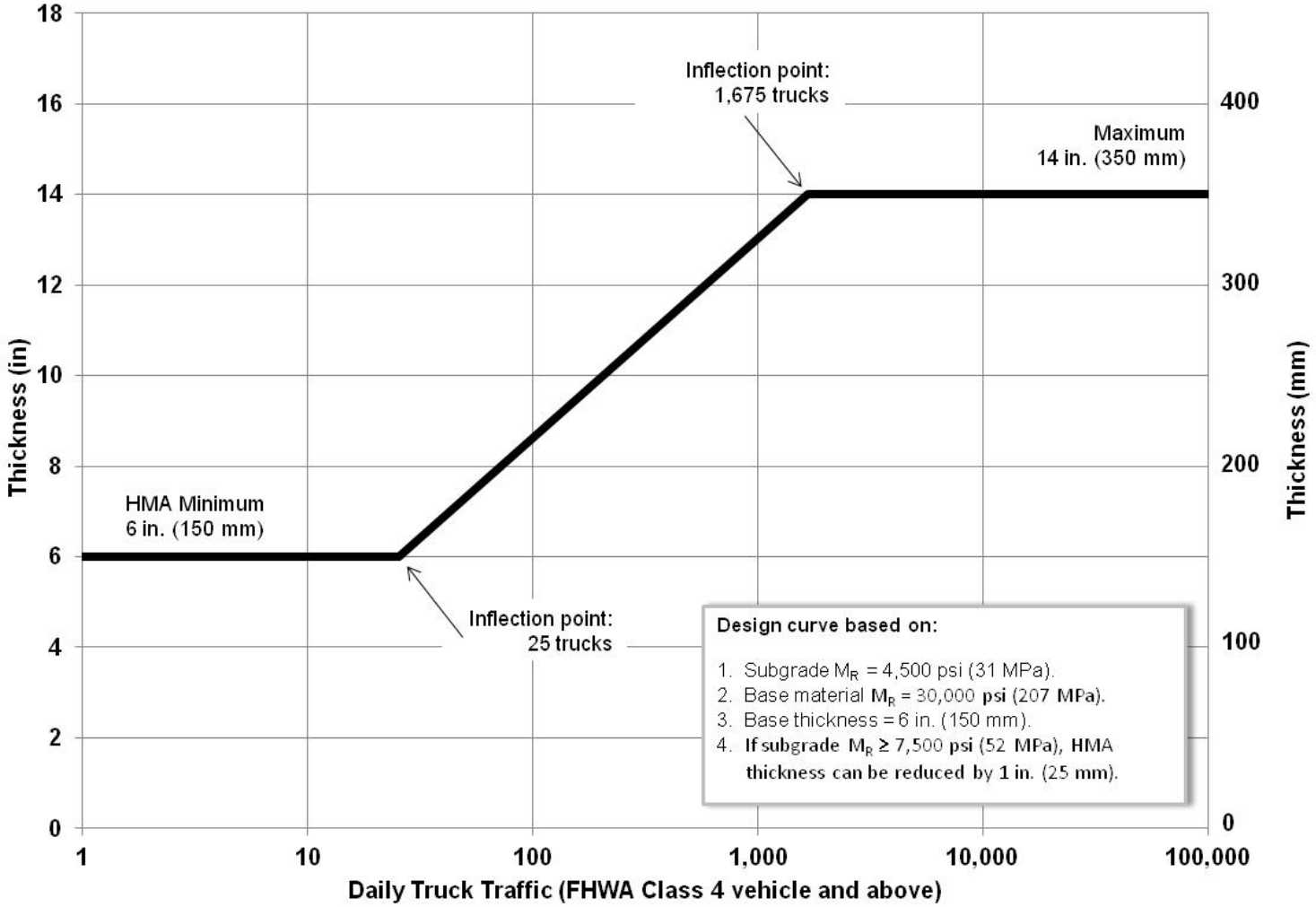


Chart modified from GreenRoads Long-Life Pavement Design Chart

Foundation Layers

- Regardless of thickness design procedure
  - Stable base and subgrade are essential
  - Provide well constructed layer(s) to improve support and minimize rutting
  - Minimize freeze-thaw effects

Pavement Performance Will Depend On…

- Traffic
- Environment

} **Addressed in pavement design**

- Materials selection
- Good construction practice

It is more than just thickness!

Construction Requirements

- Adequate density
  - Minimizes cracking of the lower HMA layers
  - Minimizes rutting in the upper HMA layers
- Eliminate the potential for aggregate segregation during production
- Eliminate the potential of temperature differentials during mix transport and paving

Construction Requirements (continued)

- Adequate density at joints to minimize water infiltration
- Good bond between each HMA lift
- Quality control during mixture production and placement

Tack Coat Application

- Apply between all lifts (no matter what)!
- Ensures adequate bond
- Minimizes future damage due to delamination

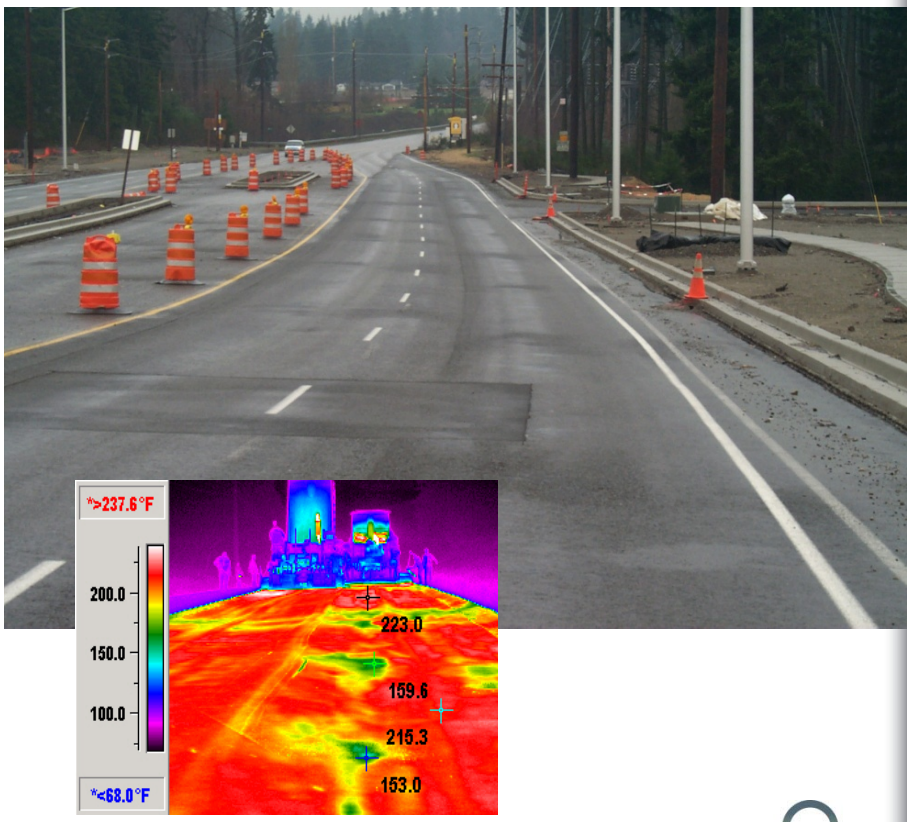
Tack Coat Application

Mix Production

- Job mix formula
  - Asphalt content
  - Gradation

Mix Placement

- Temperature differentials
  - Cooling of mix during delivery
  - Difficulty in obtaining adequate density on cooler mix



Mix Placement

- End of day's paving
  - Improper joint construction
  - Difficulty in obtaining density at low temperatures

Mix Placement

- Longitudinal streak
  - Occurs during placement
  - “Starving” the auger of mix
  - Worn equipment
  - Results in low density

Mix Placement

- Longitudinal joint
  - Improper rolling technique
  - Material not adequately compacted on either side of the joint

Mix Placement

- Longitudinal joint

Mix Placement

- Longitudinal joint

Mix Placement

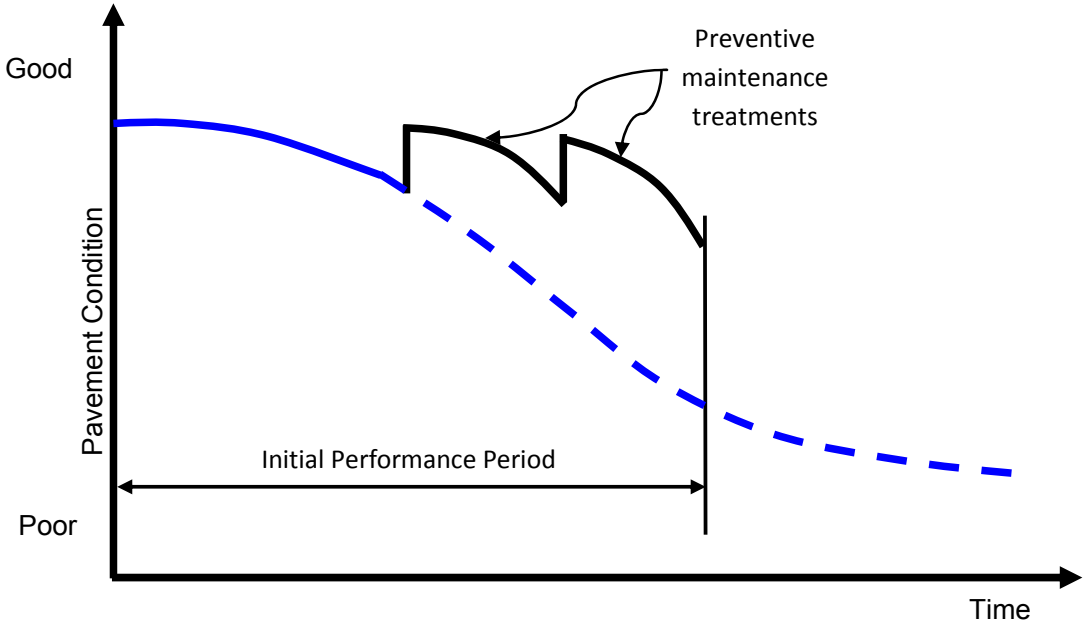
- Longitudinal joint

Top Down Cracking

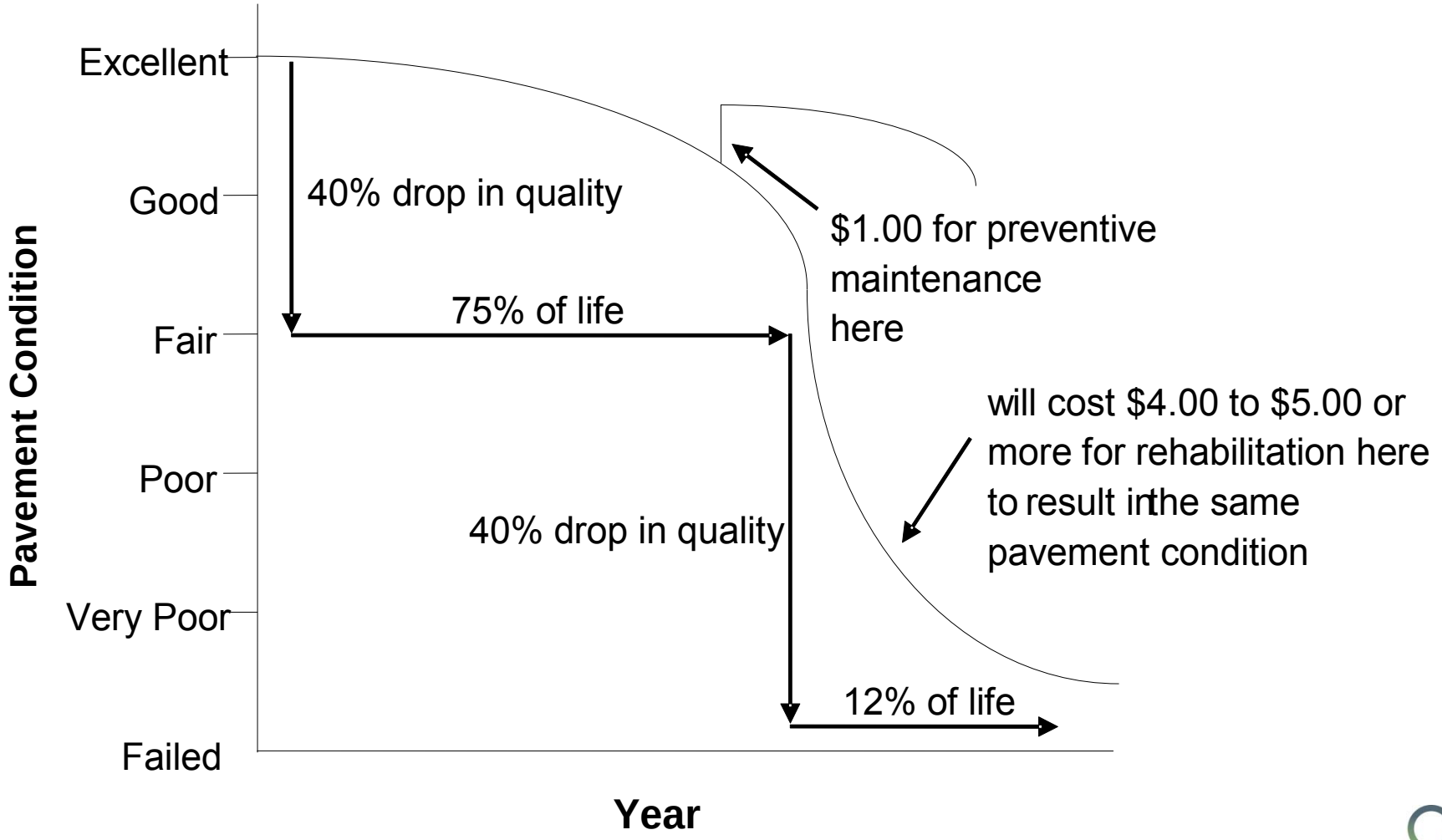
- Cause
  - High surface stresses due to truck tires
  - Asphalt binder hardening
  - Low stiffness in upper layers
- Minimal occurrence when initial asphalt layer > 6-8 in.

Maintaining Long-Life Pavements

- Requires timely application of the right treatment(s)
- Minimize extensive distress
- Keep distress in upper surface layer



Benefits of Pavement Preservation



Preservation Treatments

- Crack sealing/filling
- Fog seal/rejuvenators
- Slurry seal/microsurfacing
- Chip seals (bituminous surface treatments)
- Thin hot-mix asphalt (HMA) overlays
- Ultra-thin friction course
- In-place surface recycling

Preservation Treatments and Distress

Treatment	Rutting	Transverse Cracking	Alligator Cracking	Longitudinal Cracking	Reflection Cracking	Smoothness (IRI)
Crack sealing/filling		+			+	(−)
Fog seal/rejuvenators		+	(+)	(+)		
Slurry seal/ microsurfacing	+	+	(+)	(+)	−	+
Chip seals	(+)		+	+		+/−
Thin HMA overlays	+	(+)	+	+	(+)	+
Ultra-thin HMA overlays, ultra-thin bonded wearing course	(+)		(+)	(+)		+
In-place surface recycling	+	+	+	+	(+)	+

+ Positive impact. − Negative impact. (+) or (−) Marginally positive or negative impact.

Crack Sealing versus Crack Filling

Crack Sealing	Crack Filling
• Applicable for use on working cracks. • Appropriate for cracks 0.2 to 0.75 in. wide, preferably less than 0.5 in. • Requires crack preparation. • Higher quality material. • Wide range of performance depending on material, climate, construction quality, and so on.	• Applicable for use on non-working cracks (i.e., longitudinal reflective cracking, cold joint, edge cracks, and distantly spaced block cracks). • Appropriate for cracks 0.2 to 1.0 in. wide. • Little crack preparation is needed, generally only blowing out debris. • Can use lower quality sealant material. • Often used as a stop-gap activity. • Short-term performance.

Crack Sealing/Filling

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Longitudinal cracking. • Transverse cracking. • Minor block cracking. **Structural** • Adds no structural benefit and does not address structural deterioration. • Does minimize moisture infiltration through cracks to base and subgrade and may slow progression of structural cracking exacerbated by moisture infiltration.	• Structural failure (i.e., extensive fatigue cracking or high severity rutting). • Extensive pavement deterioration, little remaining life.	+ Non-load-related transverse and longitudinal cracking. + Reflection cracking in asphalt overlays. – Smoothness (filler material may bulge during warmer months).
Expected Life	2 to 6 years.	

Fog Seal/Rejuvenators

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Longitudinal cracking. • Transverse cracking. • Low and medium block cracking. • Raveling/weathering. • Asphalt aging, oxidation, and hardening. • Moisture infiltration. **Structural** • Adds no structural benefit.	• Structural failure. • Medium flushing/bleeding. • Medium/high friction loss. • High severity thermal cracking. • Extensive deterioration, little remaining life. • Very dense pavement surface. • Pavement with poor surface friction.	+ Non-load-related transverse and longitudinal cracking. + Smoothness (potentially to the detriment of friction). – Friction.
Expected Life	Fog seal: 1 to 2 years. Rejuvenators: 3 to 5 years.	

Slurry Seal/Microsurfacing

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Longitudinal cracking. • Transverse cracking. • Raveling/weathering. • Friction loss. • Moisture infiltration. • Bleeding. • Roughness. • Asphalt aging, oxidation, and hardening. • Rutting (microsurfacing). **Structural** • No addition to structural capacity. • Both treatments can seal low severity cracks (including initial fatigue cracks).	• Structural failure (i.e., extensive fatigue cracking). • High severity thermal cracking. • Stripping-susceptible asphalt pavements. • Extensive pavement deterioration, little remaining life.	+ Non-load-related cracking. + Load-related alligator cracking until they reflect through. + Asphalt rutting (microsurfacing). + Friction. • Can accelerate the development of stripping in susceptible pavements, negatively affecting cracking, rutting. • If placed over working cracks (e.g., fatigue cracks and wide thermal cracks), cracks will reflect through and may cause localized delamination (roughness).
Expected Life	Slurry seals: 3 to 5 years. Microsurfacing: 4 to 7 years.	

Chip Seal

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Longitudinal cracking. • Transverse cracking. • Block cracking. • Friction loss. • Bleeding. • Roughness. • Moisture infiltration. **Structural** • Adds no structural benefit, but can be effective at sealing medium severity fatigue cracks in comparison with other treatments.	• Structural failure (i.e., extensive fatigue cracking). • High severity thermal cracking. • Extensive pavement deterioration, little remaining life. • Pavement susceptible to stripping.	+ Load-related alligator cracking. – Smoothness. + Friction. – Can accelerate the development of stripping in susceptible pavements, negatively affecting cracking, rutting.
Expected Life	4 to 7 years.	

Thin HMA Overlays

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Longitudinal cracking. • Transverse cracking. • Raveling/weathering. • Block cracking. • Friction loss. • Bleeding. • Roughness. **Structural** • Rutting (requires separate rut-fill treatment). • Also, although intended as a functional treatment, load-carrying capability may be improved, depending on thickness.	• Structural failure (i.e., extensive fatigue cracking). • High severity thermal cracking. • Extensive pavement deterioration, little remaining life.	+ Non-load-related transverse and longitudinal cracking. + Load-related alligator cracking. + Smoothness. + Friction. + Total rut depth (requires separate rut-fill treatment).
Expected Life	5 to 10 years.	

Ultra-Thin Friction Course

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Longitudinal cracking.* • Transverse cracking.* • Block cracking.* • Raveling/weathering. • Friction loss. • Bleeding. • Roughness. **Structural** • Multiple applications may add structural benefit, and retard fatigue cracking.	• Structural failure (i.e., extensive fatigue cracking and deep rutting). • High severity thermal cracking. • Extensive pavement deterioration, little remaining life. • Not suited for deeply rutted pavements.	+ Non-load-related transverse and longitudinal cracking. + Load-related alligator cracking. + Smoothness. + Friction.
Expected Life	7 to 10 years.	

In-Place Recycling

Conditions Addressed	Should Not Be Used For	Pavement Performance Indicators Affected
Functional/Other • Thermal and surface cracking. • Raveling/weathering. • Friction loss. • Bleeding. • Roughness. • Corrugation. • Rutting. **Structural** • Low severity top-down cracking. • Adds some structural benefit.	• Structural failure (i.e., extensive fatigue cracking and/or structural rutting). • Distresses deeper than range of treatment effectiveness. • Urban road sections.	+ Non-load-related transverse cracking. + Load-related alligator cracking. + Load-related, surface initiated cracking. + Asphalt rutting. + Smoothness. + Friction.
Expected Life	5 to 15 years.	

Rehabilitation Strategies and Distress

Distress Type	Full-Depth Patching	Partial-Depth Patching	Cold Milling	HMA Overlay
Fatigue cracking	✓	✓	✓	✓
Block cracking		✓	✓	✓
Thermal cracking	✓		✓	✓
Longitudinal cracking	✓			✓
Bleeding	✓	✓	✓	✓
Rutting			✓	✓
Shoving			✓	
Weathering		✓	✓	✓
Raveling		✓	✓	✓
Pothole	✓	✓		
Bumps, settlement, heaves	✓		✓	✓

Full- and Partial-Depth Patching

- Full-depth: Remove to intact base layer or subgrade
- Partial-depth: Remove partial depth of HMA layer
- Patch area should extend at least 1 foot beyond the visible surface distress
- Obtaining adequate density is essential

Cold Milling

- Removal of material from the HMA surface
- Carbide bits mounted on a rotating drum
- Full- or partial-roadway width
- Construction
  - Control depth of milling to obtain adequate smoothness

HMA Overlay

- Provide sufficient thickness to address future traffic loading
- Construction requirements
  - Tack coat application
  - Density
  - Smoothness

Summary

- Long life asphalt pavements require:
  - Stable and sufficiently strong platform
  - Pavement design that takes into account future traffic and environmental conditions
  - Quality materials
  - Quality construction
  - Timely preservation and rehabilitation application