# Designing and Maintaining Long-Life Asphalt Pavements

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applied pavement TECHNOLOGY

providing engineering solutions to improve pavement performance

# What are Long-Life Pavements?

# Why Do We Need Long-Life Pavements?

# Characteristics of Long-Life Pavements

- 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 Design Characteristics

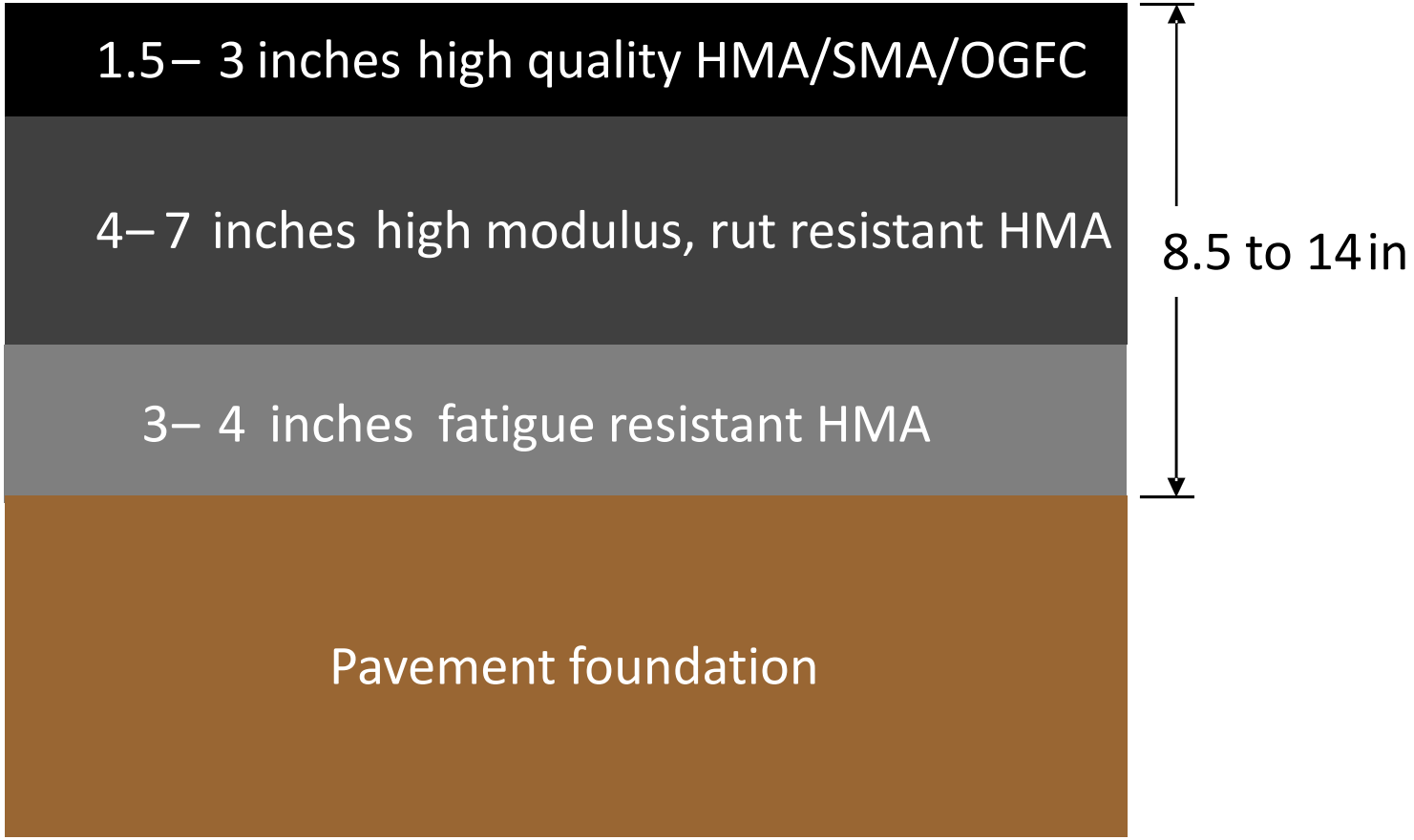
- HMA base layer that will resist bottom up cracking
- Intermediate HMA layer that provides additional structural support and is resistant to cracking and rutting
- A rut-resistant HMA surface layer
- Subgrade with a minimum CBR of 5 percent, or roughly a $M_R$ of 7,500 psi

# Perpetual Pavement Mix Types

| Layer | Mix Type | Trucks per day | | |
|---|---|---|---|---|
| | | < 20 | 20 – 700 | > 700 |
| Surface | Dense-graded (fine) | ✓✓ | ✓✓ | ✓ |
| | Dense-graded (coarse) | | | ✓✓ |
| | Stone Mastic Asphalt | | ✓ | ✓✓ |
| | Open-graded Friction Course | | | ✓✓ |
| Intermediate | Dense-graded (fine or coarse) | ✓✓ | ✓✓ | ✓✓ |
| Base | Dense-graded (fine or coarse) | ✓✓ | ✓✓ | ✓✓ |
| | Asphalt Treated Permeable | | | ✓✓ |

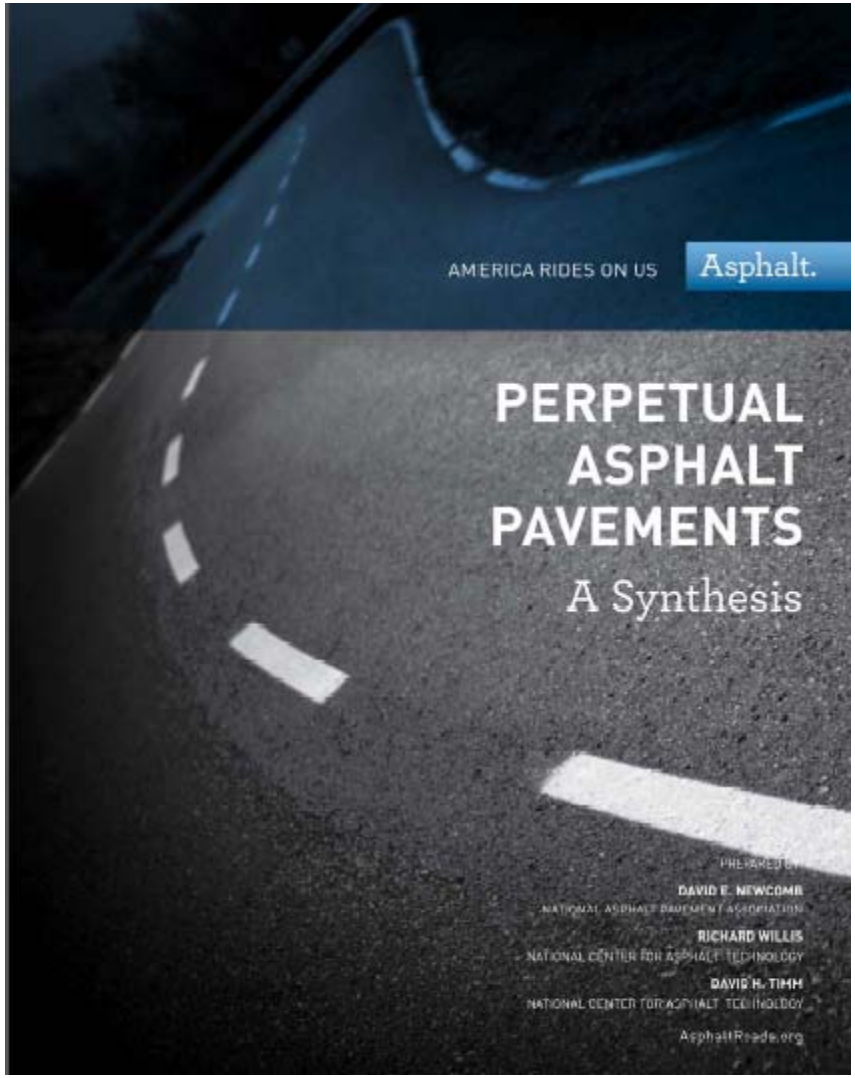
(✓) recommended and (✓✓) strongly recommended.

# Perpetual Pavement Cross-Section



# Additional Information

http://asphaltroads.org



# Other Long-Life Pavement Characteristics

Typically, bottom-up fatigue cracking can be minimized if the total asphalt layer is greater than about 6 – 8 inches

- 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 Design Approach

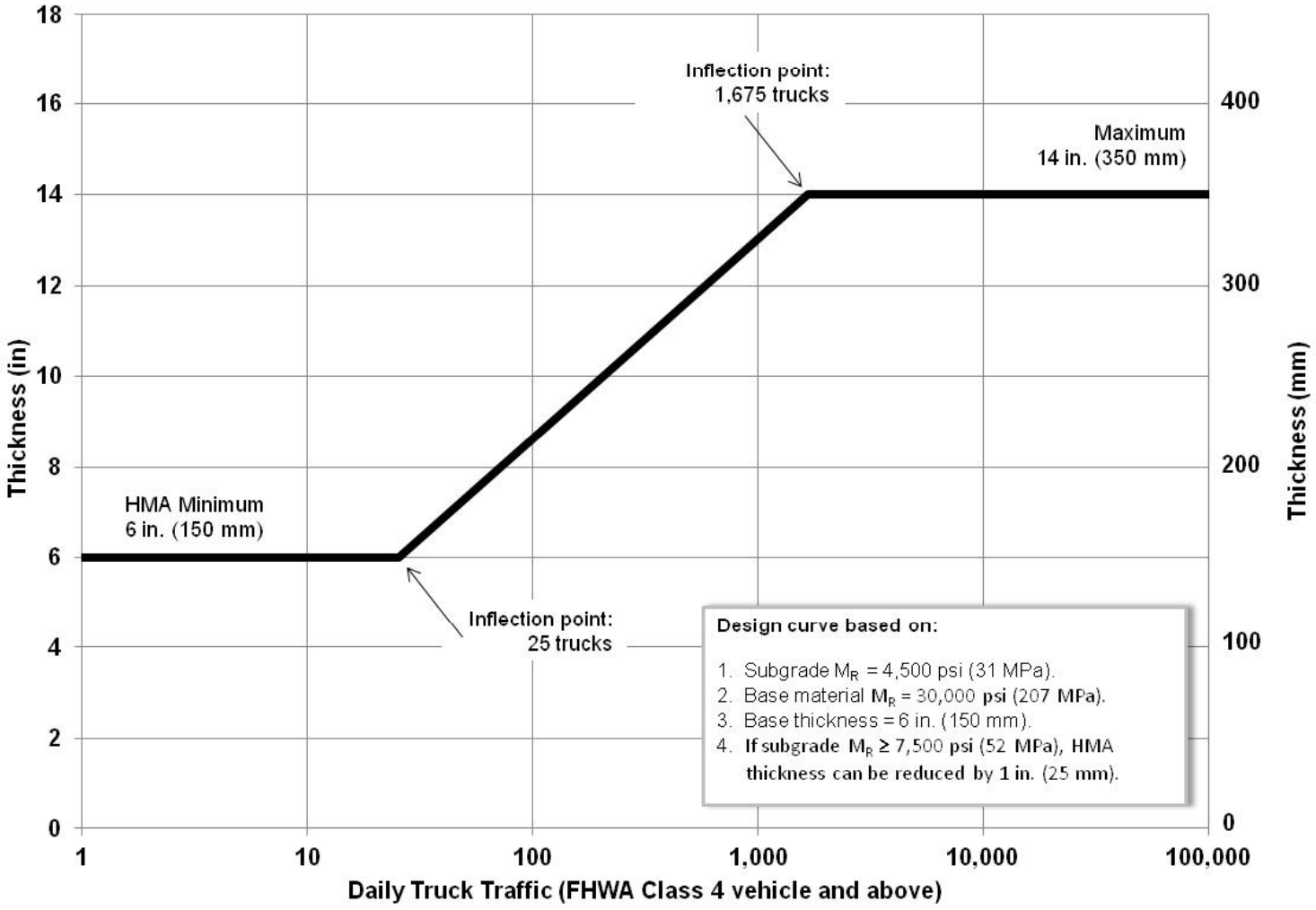



**Chart modified from GreenRoads Long-Life Pavement Design Chart**

# Foundation Layers

Regardless of thickness design procedure…

- Stable base and subgrade are essential
- Well constructed layer(s) will improve support and minimize rutting
- Freeze-thaw effects need to be minimized

# Pavement Performance Will Depend On…

- Traffic
- Environment

**Addressed in pavement design**

- Materials selection
- Good construction practice

**It is more than just thickness!**

# Long-Life Pavement Construction Features (cont.)

- 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

# Long-Life Pavement Construction Features (cont.)

- 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

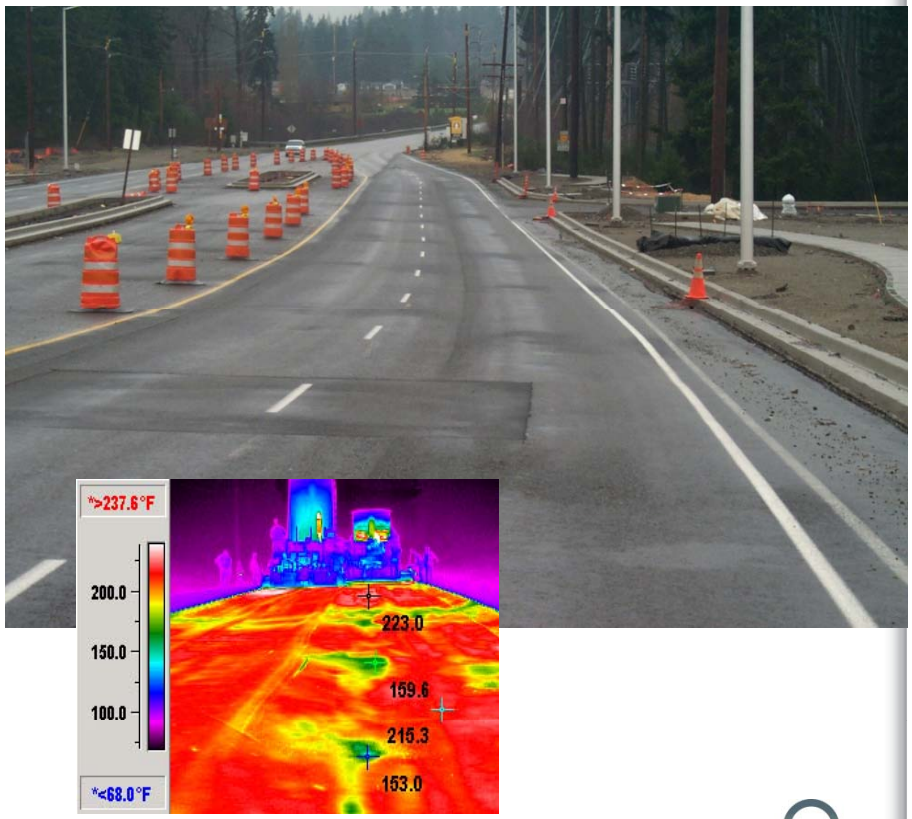
# Tack Coat Application

# Mix Production

- Job mix formula
  - Asphalt content
  - Gradation

# Mix Placement Concerns: Temperature

- Must control temperature differentials
- Cooling of mix during delivery is problematic
- Difficulty in obtaining adequate density on cooler mix contributes to segregation



# Mix Placement: End-of-Day's Paving

- Improper joint construction
- Difficulty in obtaining density at low temperatures

# Mix Placement: Longitudinal Streak

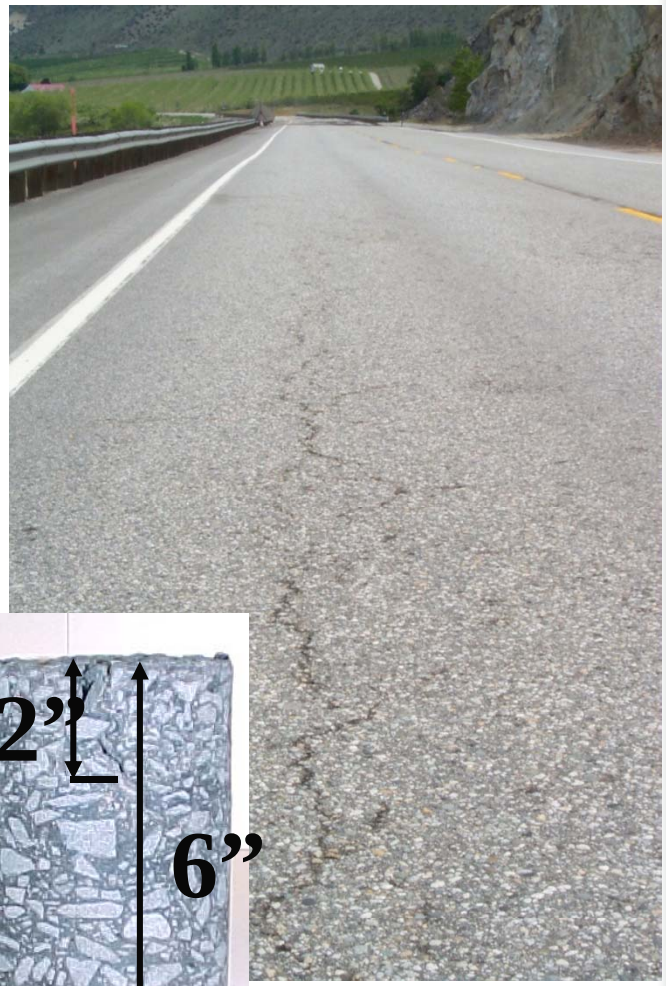
- Occurs during placement
- “Starving” the auger of mix
- Worn equipment
- Results in low density

# Mix Placement: Longitudinal Paving Joint

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

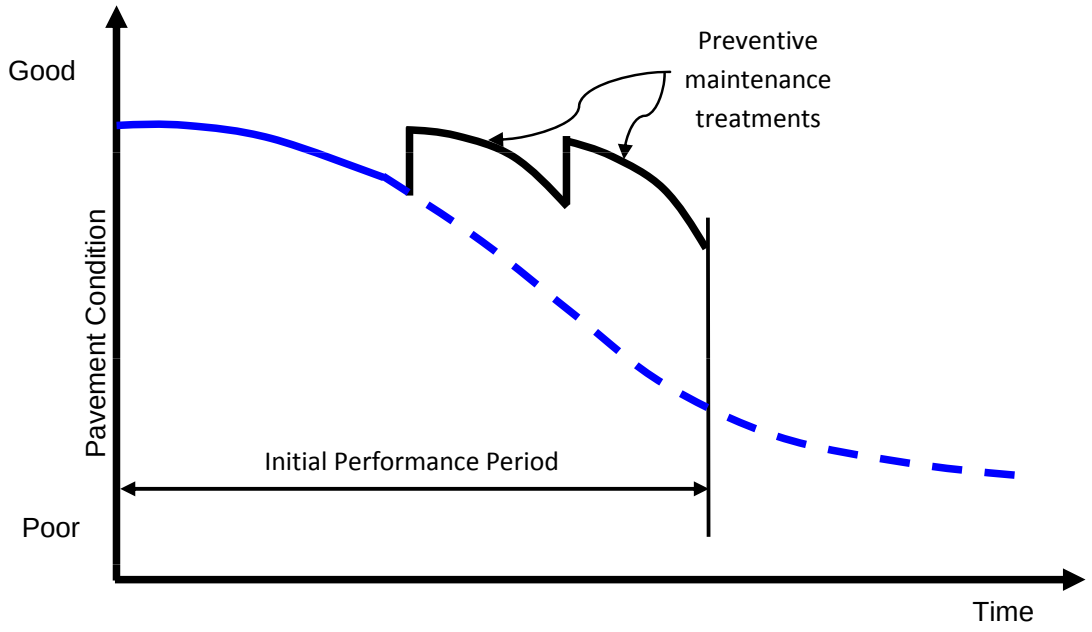
# Top Down Cracking

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



# Maintaining Long-Life Pavements

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



# 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/Filling

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Longitudinal cracking<br>▪ Transverse cracking<br>▪ Minor block cracking<br><br>**Structural**<br>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)<br>▪ Extensive pavement deterioration, little remaining life | + Non-load-related transverse and longitudinal cracking<br><br>+ Reflection cracking in HMA overlays<br><br>– Smoothness (filler material may bulge during warmer months) |
| **Expected Life** | 2 to 6 years | |

# Fog Seal/Rejuvenators

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Longitudinal cracking<br>▪ Transverse cracking<br>▪ Low and medium block cracking<br>▪ Raveling/weathering<br>▪ Asphalt aging, oxidation, and hardening<br>▪ Moisture infiltration<br><br>**Structural**<br>Adds no structural benefit, but can reduce moisture infiltration through low severity fatigue cracks. | ▪ Structural failure (i.e., extensive fatigue cracking)<br>▪ Medium flushing/bleeding<br>▪ Medium/high friction loss<br>▪ High severity thermal cracking<br>▪ Extensive pavement deterioration, little remaining life<br>▪ Very dense pavement surface<br>▪ Pavement with poor surface friction | + Non-load-related transverse and longitudinal cracking<br><br>+ Load-related alligator cracking<br><br>+ Smoothness (potentially to the detriment of friction)<br><br>– Friction |

| | |
|---|---|
| **Expected Life** | Fog seals: 1 to 2 years<br>Rejuvenators: 3 to 5 years |

# Slurry Seal/Microsurfacing

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Longitudinal cracking<br>▪ Transverse cracking<br>▪ Raveling/weathering<br>▪ Friction loss<br>▪ Moisture infiltration<br>▪ Bleeding<br>▪ Roughness<br>▪ Asphalt aging, oxidation, and hardening<br>▪ Rutting (microsurfacing)<br><br>**Structural**<br>Neither microsurfacing nor slurry seals add structural capacity. Both treatments can seal low severity cracks (including initial fatigue cracks) | ▪ Structural failure (i.e., extensive fatigue cracking)<br>▪ High severity thermal cracking<br>▪ Stripping-susceptible HMA pavements<br>▪ Extensive pavement deterioration, little remaining life | + Non-load-related transverse, longitudinal cracking<br><br>+ Load-related alligator cracking until they reflect through<br><br>+ HMA rutting (microsurfacing)<br><br>+ Friction<br><br>▪ Can accelerate the development of stripping in susceptible pavements, negatively affecting cracking, rutting.<br>▪ 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<br>Microsurfacing: 4 to 7 years | |

# Chip Seal

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Longitudinal cracking<br>▪ Transverse cracking<br>▪ Block cracking<br>▪ Friction loss<br>▪ Bleeding<br>▪ Roughness<br>▪ Moisture infiltration<br><br>**Structural**<br>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)<br>▪ High severity thermal cracking<br>▪ Extensive pavement deterioration, little remaining life<br>▪ Pavement susceptible to stripping | + Load-related alligator cracking<br><br>– Smoothness<br><br>+ Friction<br><br>– Can accelerate the development of stripping in susceptible pavements, negatively affecting cracking, rutting. |
| **Expected Life** | 4 to 7 years | |

# Thin HMA Overlays

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Longitudinal cracking<br>▪ Transverse cracking<br>▪ Raveling/weathering<br>▪ Block cracking<br>▪ Friction loss<br>▪ Bleeding<br>▪ Roughness<br><br>**Structural**<br>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)<br>▪ High severity thermal cracking<br>▪ Extensive pavement deterioration, little remaining life | + Non-load-related transverse and longitudinal cracking<br><br>+ Load-related alligator cracking<br><br>+ Smoothness<br><br>+ Friction<br><br>+ Total rut depth (requires separate rut-fill treatment) |
| **Expected Life** | 5 to 10 years | |

# Ultra-Thin Friction Course

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Longitudinal cracking*<br>▪ Transverse cracking*<br>▪ Block cracking*<br>▪ Raveling/weathering<br>▪ Friction loss<br>▪ Bleeding<br>▪ Roughness<br><br>* High severity cracking can be better addressed with cold milling.<br><br>**Structural**<br>Multiple applications may add structural benefit, and retard fatigue cracking. | ▪ Structural failure (i.e., extensive fatigue cracking and deep rutting)<br>▪ High severity thermal cracking<br>▪ Extensive pavement deterioration, little remaining life<br>▪ Not suited for deeply rutted pavements. | + Non-load-related transverse and longitudinal cracking<br><br>+ Load-related alligator cracking<br><br>+ Smoothness<br><br>+ Friction |
| **Expected Life** | 7 to 10 years | |

# In-Place Recycling

| Conditions Addressed | Contraindications | Pavement Performance Indicators Affected |
|---|---|---|
| **Functional/Other**<br>▪ Alligator, thermal, and surface cracking<br>▪ Raveling/weathering<br>▪ Friction loss<br>▪ Bleeding<br>▪ Roughness<br>▪ Corrugation<br>▪ Rutting<br><br>**Structural**<br>Adds some structural benefit. | ▪ Structural failure (i.e., extensive fatigue cracking and/or structural rutting)<br>▪ Distresses deeper than range of treatment effectiveness<br>▪ High traffic volumes (CIR)<br>▪ Urban road sections (HIR) | + Non-load-related transverse cracking<br>+ Load-related alligator cracking<br>+ Load-related, surface initiated cracking<br>+ HMA rutting<br>+ Smoothness<br>+ Friction |
| **Expected Life** | 5 to 15 years | |

# Rehabilitation Strategies

- Patching
  - Full-depth
  - Partial-depth
- Cold milling
- HMA overlay

# 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
- Construction techniques
  - 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
  - Controlling depth of milling is essential for obtaining 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

# Questions/Discussion

**Thank you!**

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