



DRAFT

MAINTENANCE TECHNICAL ADVISORY GUIDE
Volume I – Flexible Pavement Preservation
Second Edition



State of California Department of Transportation
Office of Pavement Preservation
Division of Maintenance
1120 N Street, MS-5
Sacramento, CA 95814

June 28, 2007

MTAG Overview

(Flexible Pavements)

From... Maintenance Technical
Advisory Guide (MTAG)

What is MTAG?

- A Maintenance Technical Advisory Guide developed for Caltrans and other pavement professionals
- Developed by Caltrans Division of Maintenance
- MTAG Vol. 1 for Flexible Pavements
 - First edition – 2003 (8 chapters)
 - Second edition – 2007 (13 chapters)
- MTAG Vol. 2 for Rigid Pavements
 - First edition – July 2006 (7 chapters)
 - Second edition – July 2007 (8 chapters)
- Both volumes focus on pavement preservation strategies

Chapters Covered in MTAG for Flexible Pavements

Chapter	Topic
1	Introduction
2	Materials
3	Framework for Treatment Selection
4	Crack Sealing, Crack Filling, and Joint Sealing
5	Patching and Edge Repair
6	Fog and Rejuvenating Seals
7	Chip Seals
8	Slurry Seals
9	Microsurfacing
10	Thin Maintenance Overlays
11	Bonded Wearing Courses
12	Interlayers
13	In-Place Recycling

Organization of Training Modules

- Modules on each treatment contain three sub-modules
 - Managers' overview
 - Design, materials, and specifications
 - Construction and inspection

Chapter 1

Introduction

From... Maintenance Technical
Advisory Guide (MTAG)

Purpose of Pavement Preservation

- To keep good pavements in good conditions by applying the right maintenance strategies at the right time to extend pavement life and preserve investments



FHWA Definition of Pavement Preservation

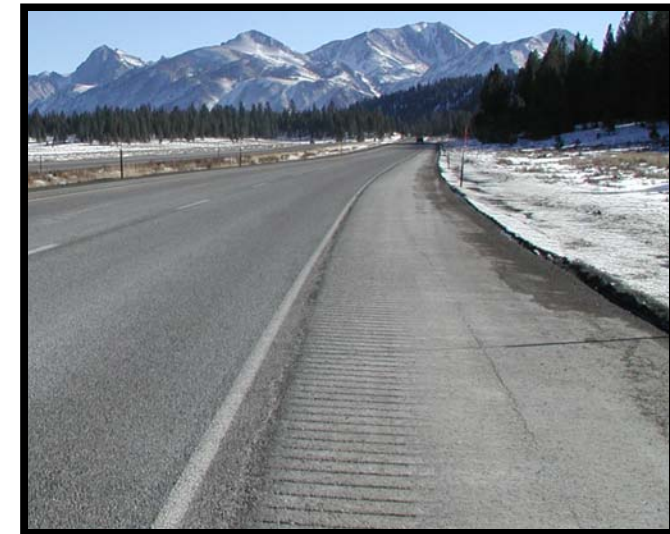
“A program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations”

Components of Pavement Preservation Program

- Consists primarily of three components:
 - preventive maintenance
 - minor rehabilitation (restoration), and
 - some routine maintenance
- Does not include new pavements or pavements that require major rehabilitation or reconstruction



Crack Seal



Chip Seal

Pavement Preservation Concept

- A proactive approach to maintaining the existing highways
- Addresses pavements while they are still in good condition and before the onset of serious damage
- Applying a cost-effective treatment at the right time to the right pavement to extend pavement life



NOT a Preservation Candidate

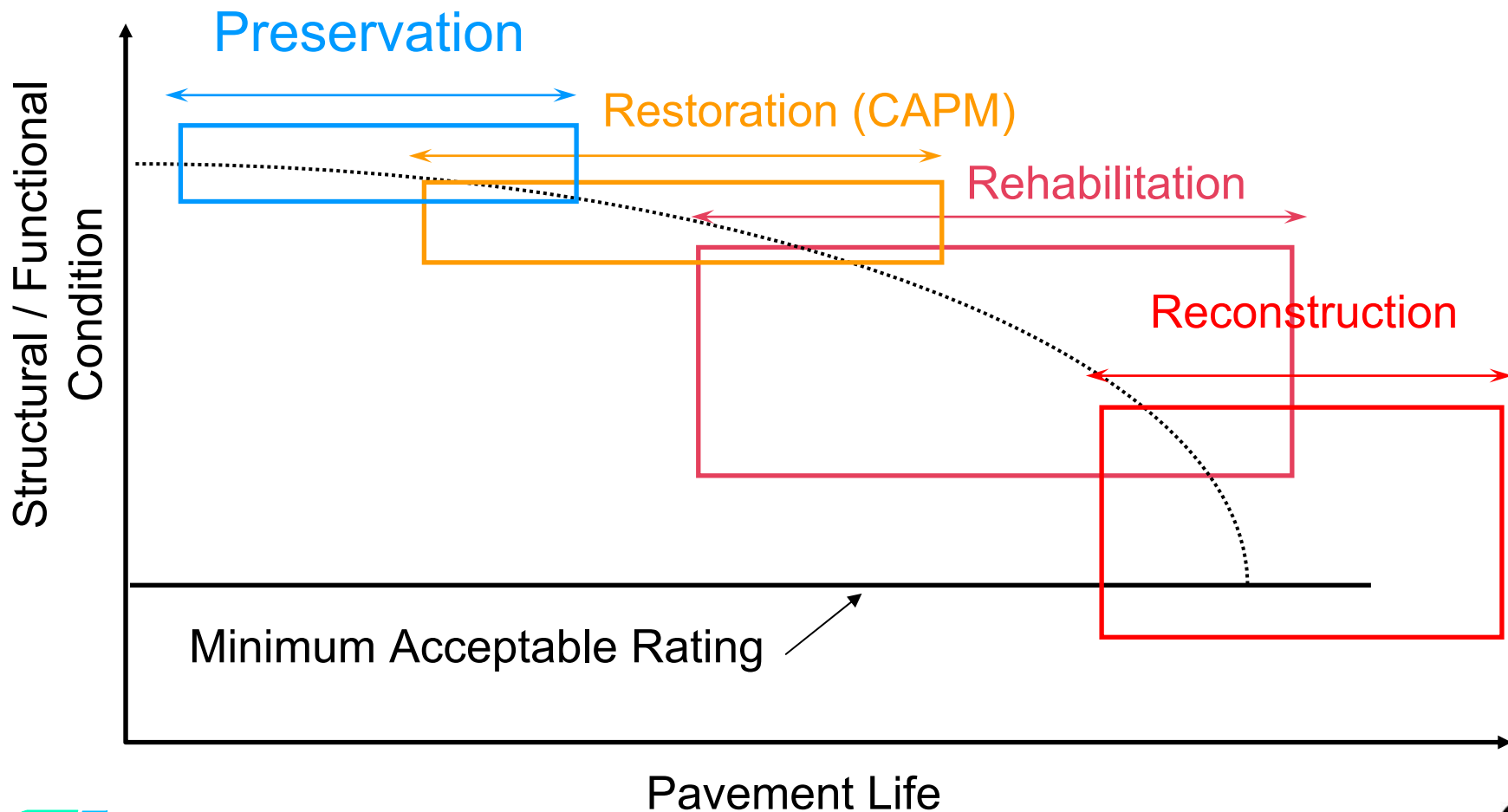
Essentials of Pavement Preservation Program

- Pavement preservation is an agency program
- An effective pavement preservation program includes agency leadership and a dedicated annual budget
- It also includes support and input from staff in planning, finance, design, construction, materials, and maintenance

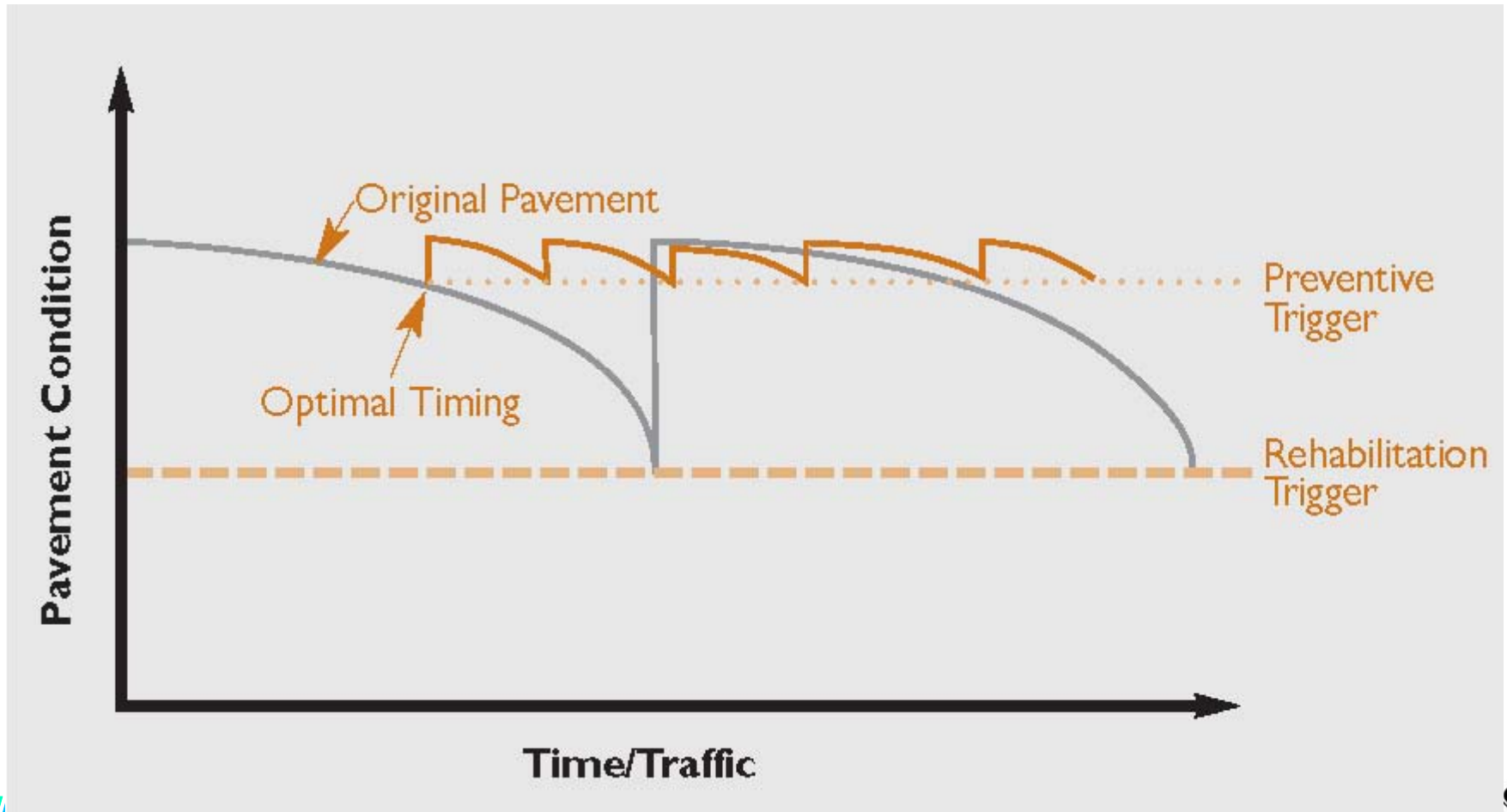
Benefits of Pavement Preservation

- Benefits of pavement preservation program:
 - preserving the roadway network
 - enhancing pavement performance
 - ensuring cost-effectiveness by extending pavement life, and
 - reducing user delays by avoiding rehabilitation or reconstruction.
- Some of these benefits may be noticed immediately and some may be realized over time

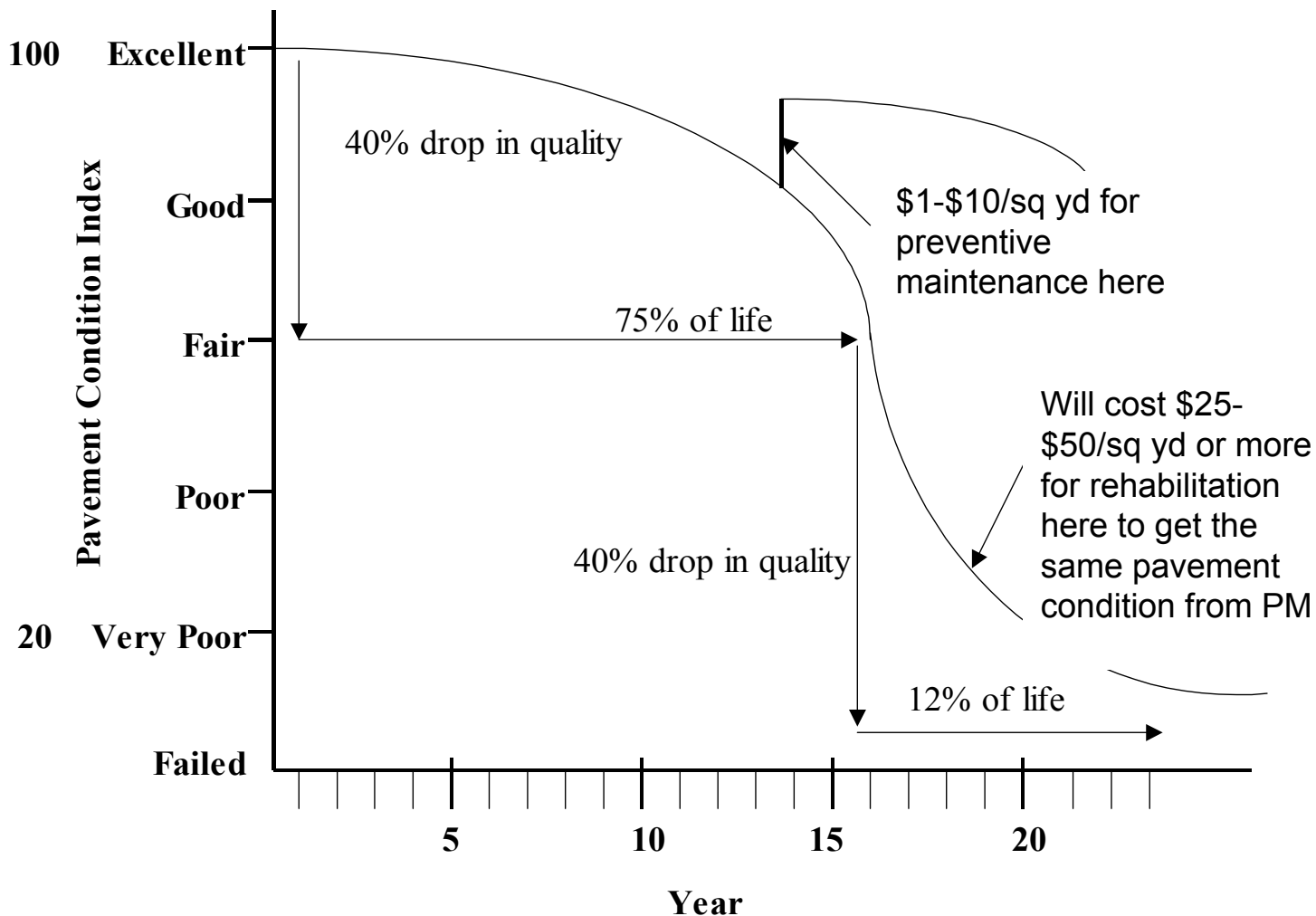
Typical Pavement Performance Curve



Importance of Timely Treatments



Cost Effects of Treatments



Fundamentals of Pavements

- Function of pavements
- Factors affecting pavement performance
 - Subgrade soil
 - Pavement materials characteristics
 - Asphalt cement
 - Aggregate
 - Modifiers for asphalt cement (e.g., rubber and polymers)
 - Additives or stabilizing agents for aggregates (e.g., lime and cement)
 - Traffic loading
 - Environment
 - Moisture; and
 - Temperature
- Common flexible pavement distresses

Chapter 2

Materials

From... Maintenance Technical
Advisory Guide (MTAG)

Asphalt Binders



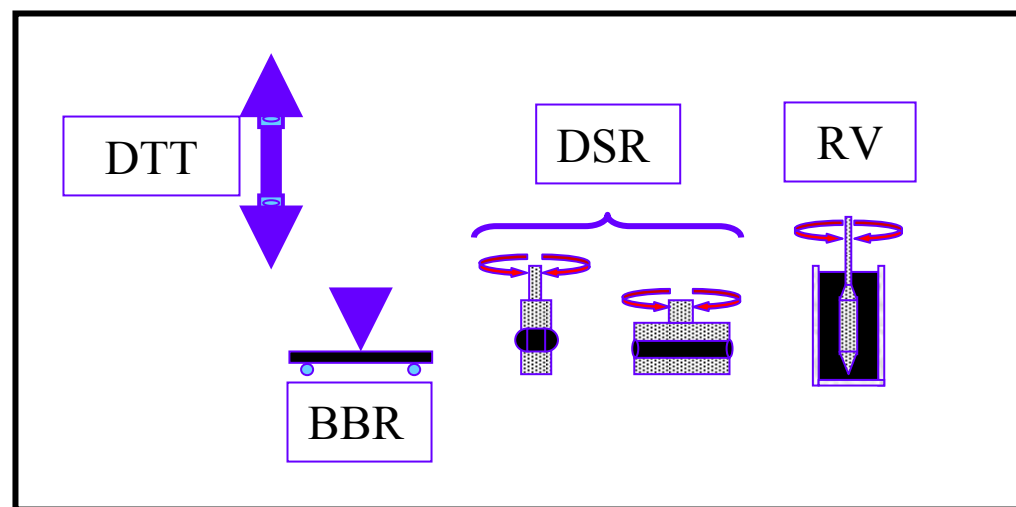
- Paving Asphalt Constituent
 - A refined material from crude oil
 - Asphalt properties depend on its chemical composition, crude source and type
 - Highly temperature dependent
- Caltrans requirements for asphalt binders – Section 92 of the Standard Specifications

Asphalt Binders – Specifications

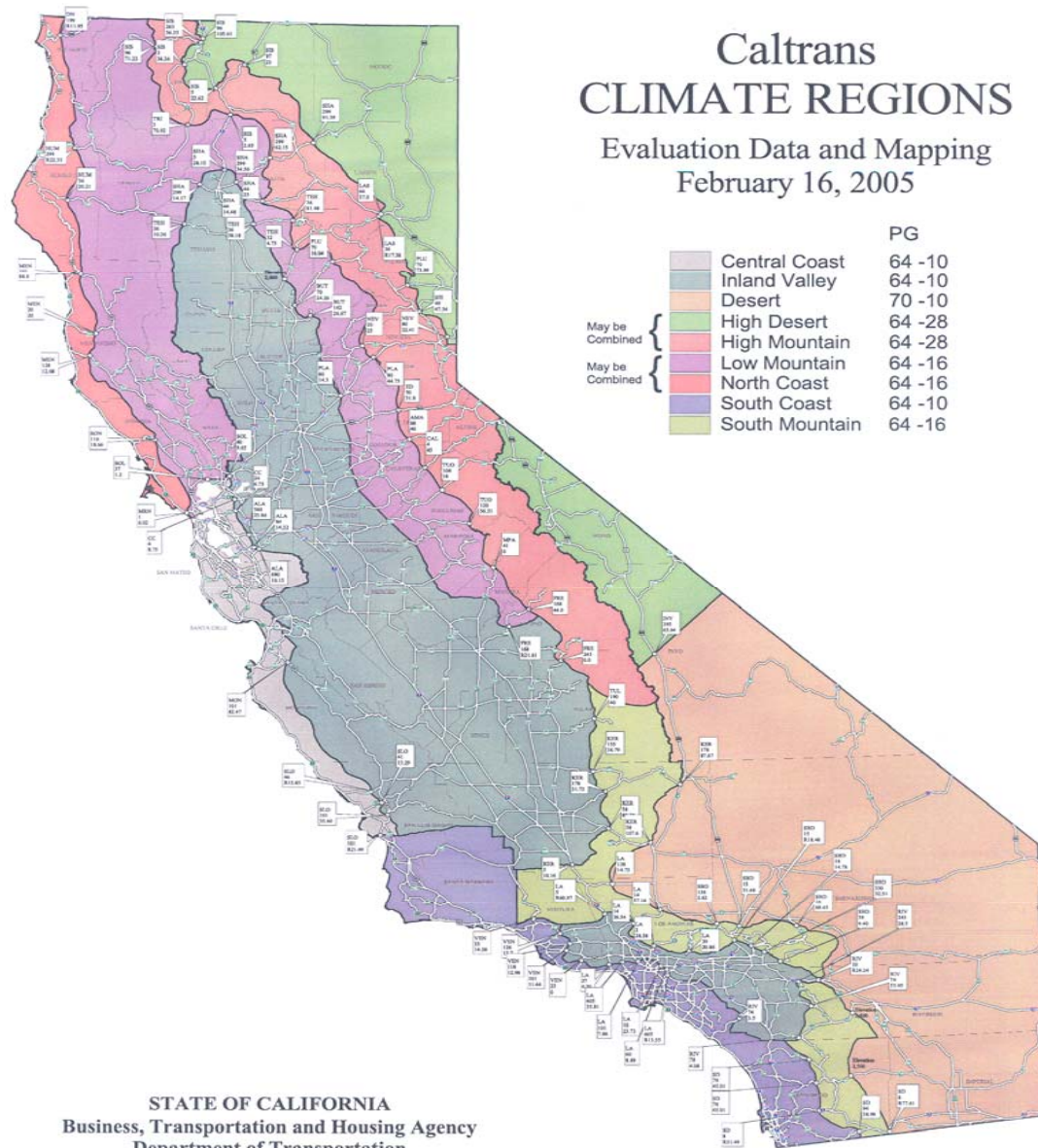
Caltrans adopted the Performance Graded (PG) system for asphalt binder since 2006 for conventional binders and 2007 for modified binders



Elastic Recovery



Asphalt Binders – Where to Use?



Asphalt Binders – Where to Use?

Binder Climatic Region	Conventional Hot Mixed Asphalt				RAC
	Dense Graded HMA		Open Graded		Base Stock for RAC-O and RAC-G
	Typical	Special ¹	Placement Temperature		
			>70°F	<70°F	
South Coast Central Coast Inland Valleys	PG 64-10	PG 70-10 PG 64-28 PM	PG 64-10	PG 58-34 PM	PG 64-16
North Coast	PG 64-16	PG 64-28 PM	PG 64-16	PG 58-34 PM	PG 64-16
Low Mountain South Mountain	PG 64-16	PG 64-28 PM	PG 64-16	PG 58-34 PM	PG 64-16
High Mountain High Desert	PG 64-28	PG 58-34 PM ²	PG 64-28	PG 58-34 PM	PG 58-22
Desert	PG 70-10	PG 64-28 PM	PG 70-10	See Note 3	PG 64-16

Notes:

- PG 76-22PM may be specified for conventional dense graded hot mixed asphalt for special conditions in all climatic region when specifically requested by the District Materials Engineer.
- PG 64-28 PM may be specified when specifically requested by the District Materials Engineer.
- Consult the District Materials Engineer for appropriate binder grade.

Asphalt Emulsions

- Emulsion Constituent
 - An asphalt dispersed in water
- Breaking
 - The process of separating the asphalt and water
- Curing
 - The process by which the asphalt expels water and dries to a film on the aggregate or surface

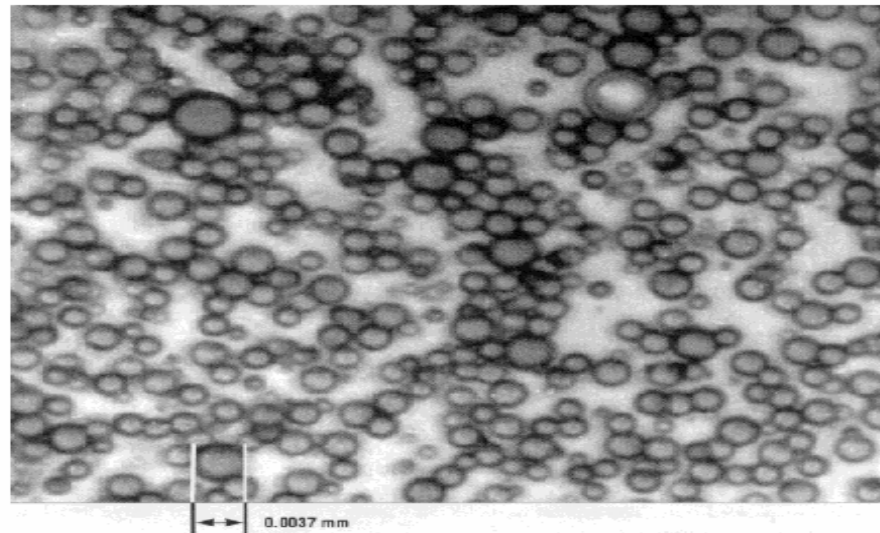
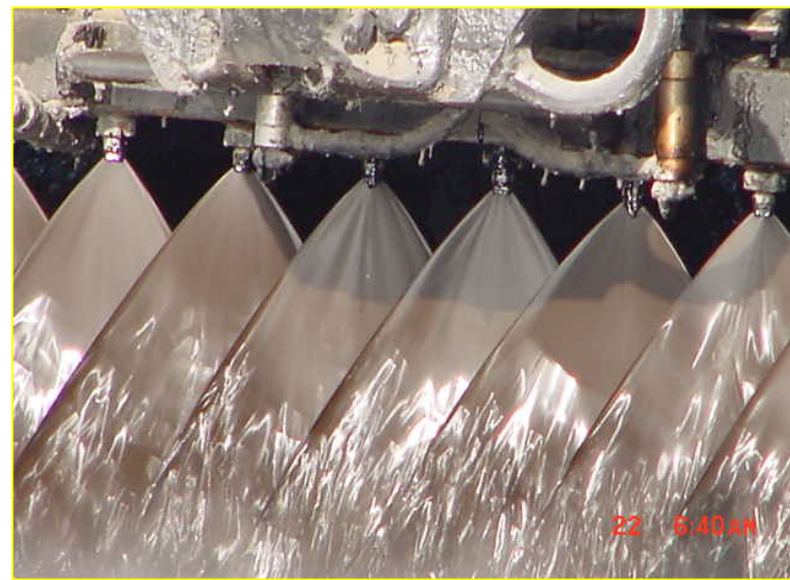


Figure 2.6-1 Relative Sizes and Distribution of Asphalt Particles in an Emulsion

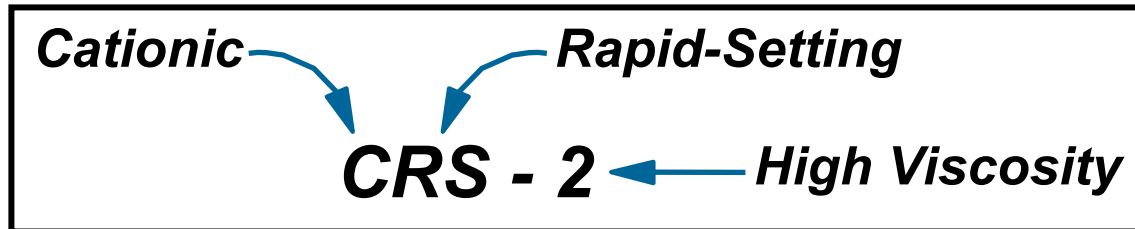
Asphalt Emulsions



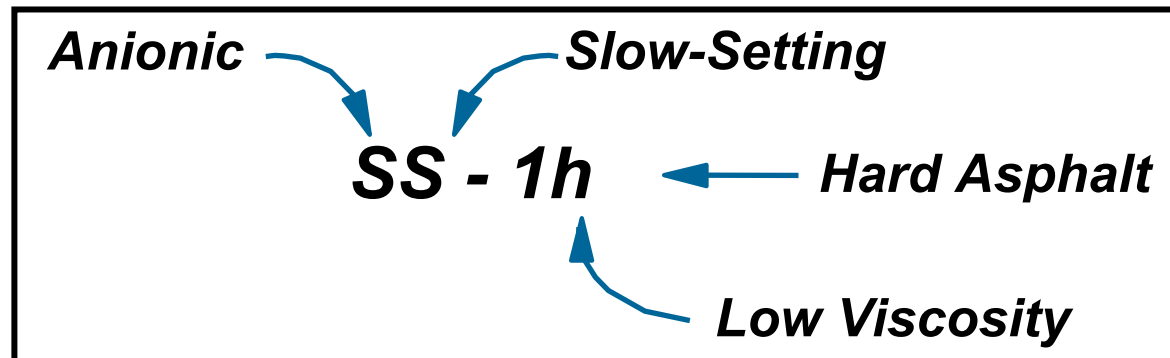
- Caltrans Specifications
 - Anionic emulsions: rapid set (RS), Medium Set (MS), and Slow Set (SS)
 - Cationic emulsions: rapid set (CRS), Medium Set (CMS), and Slow Set (CSS)
 - Polymer modified emulsions
 - Quickset slurry emulsion

Asphalt Emulsions

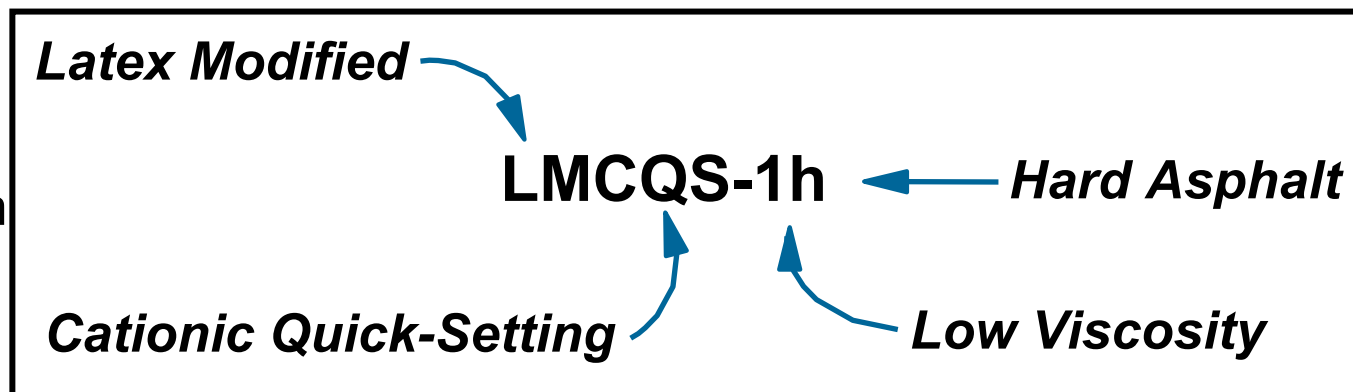
Chip Seal
Emulsion



Tack Coat



Slurry
Emulsion



Cutback Asphalts

- In California, only slow cure cutbacks are still made and used
- The main use for cutbacks is prime coats over aggregate base materials prior to placement of an asphalt-wearing course in new construction

Polymer Modified Binder

- Polymers are large molecule additives that are used to enhance the performances of asphalt cement and asphalt concrete pavement, particularly at high temperatures
- Some purposes of polymers
 - Increase serviceable temperature range
 - Improve durability at all temperatures
 - Reduce moisture damage
 - More forgiving binder

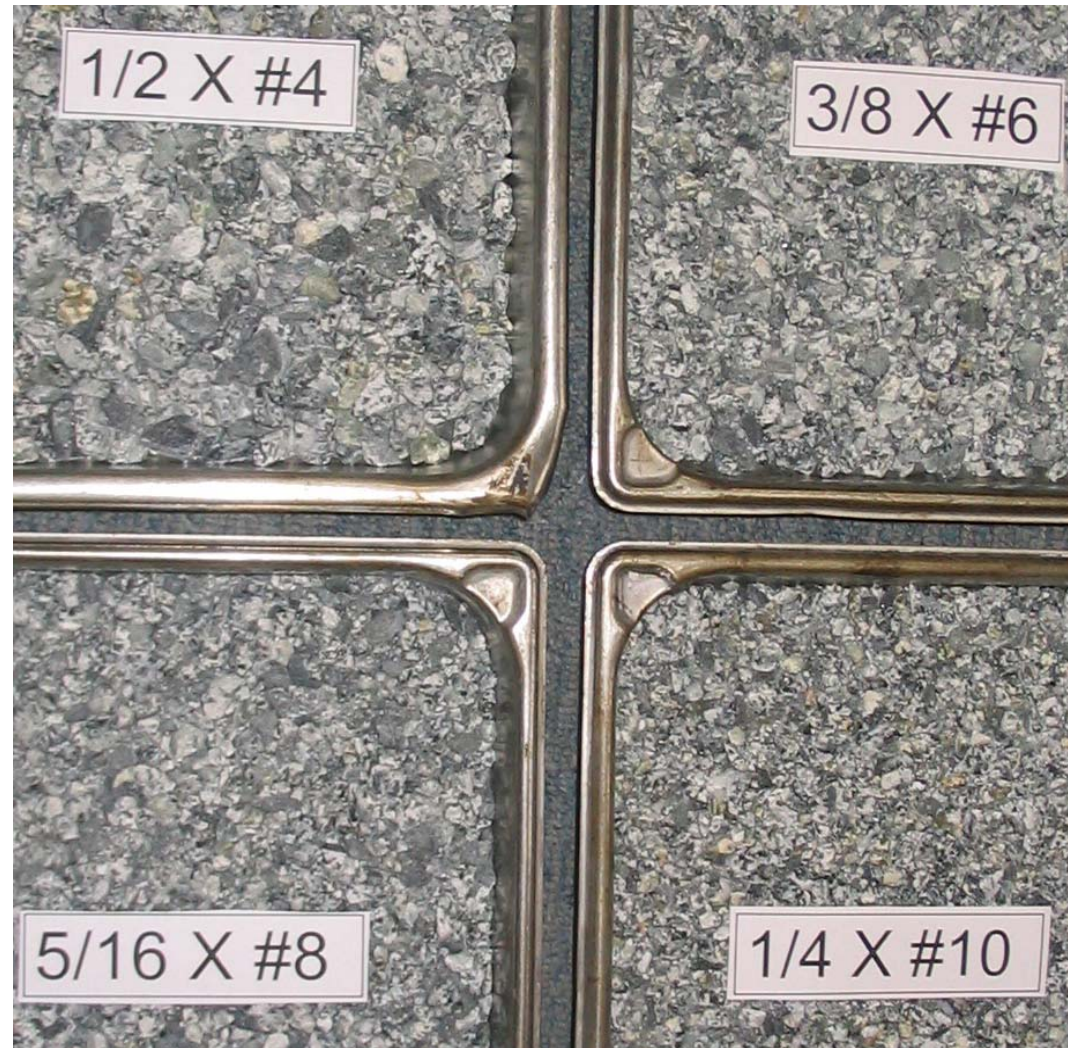
Asphalt Rubber

- Asphalt rubber constituent
 - Crumb Rubber Modifier (CRM)
 - Scrap Tire Rubber
 - High Natural Rubber Content Scrap Rubber
 - Asphalt Cement
 - Extender Oil – Caltrans
- Some purposes of AR
 - Use waste tires
 - Increase viscosity, elasticity, and resilience
 - Improve durability



Aggregates

- The major building material for pavements
- Form the structural matrix in HMA mix
- Types
 - Igneous
 - Sedimentary rocks
 - Gravel
 - Sands
 - Slag



Aggregate Properties

- Chemical
 - Affinity to asphalt
- Physical
 - Grading or particle size distribution
 - Cleanliness or presence of deleterious materials
 - Hardness or abrasion resistance
 - Durability or soundness
 - Particle shape and surface texture
 - Absorption characteristics

Chapter 3

Framework for Treatment Selection

From... Maintenance Technical
Advisory Guide (MTAG)

What is Treatment Selection?

A guide to assist maintenance personnel in making better and more informed decisions in selecting and applying maintenance treatments

In other words...

What do we do with this?



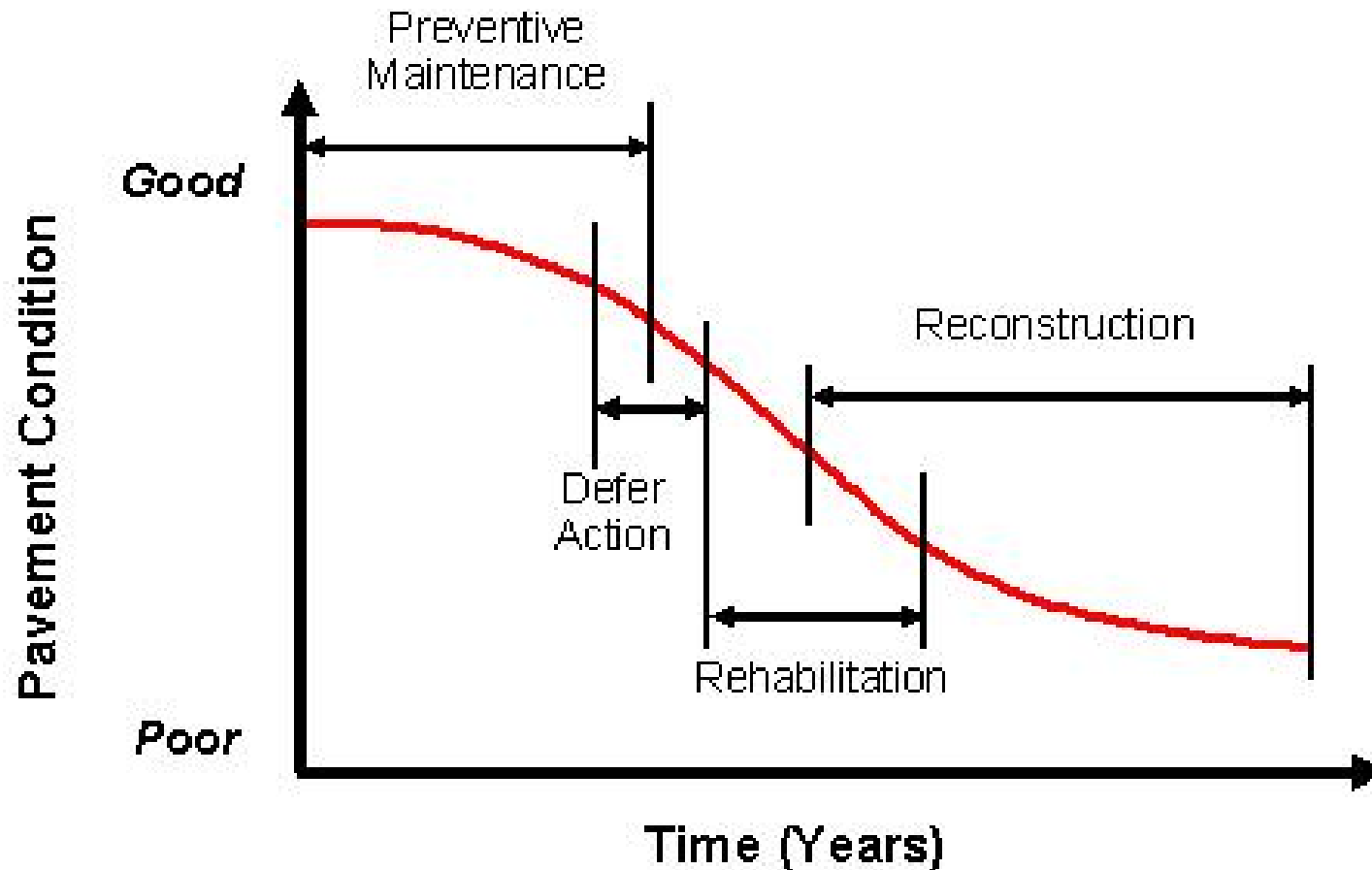
Treatment Selection Matrix

- Covers all the major treatment types currently used by Caltrans for flexible pavements and allows for inclusion of future strategies
- Treatment selection is a complex, yet important procedure to ensure a optimum pavement treatment

Factors Affecting Treatment Selection

- Pavement age, condition
- Climate
- Traffic levels, expected future plans
- Available funding
- Agency policy

Treatment Selection Based on Pavement Condition



Treatment Selection Training Modules Available

1. Treatment Selection Matrix
2. Life Cycle Cost Analysis

Chapter 4

Crack Sealing, Crack Filling, and Joint Sealing

From... Maintenance Technical
Advisory Guide (MTAG)

Why Treat Cracks?

- Prevent water from entering and weakening the base and subgrade
- Prevent debris (incompressible materials) from entering cracks/joints
- Prepare road surface for overlay or maintenance treatments
- Cost Effective – “fix the roof now so that you don’t have to fix the house later”



When to Use?

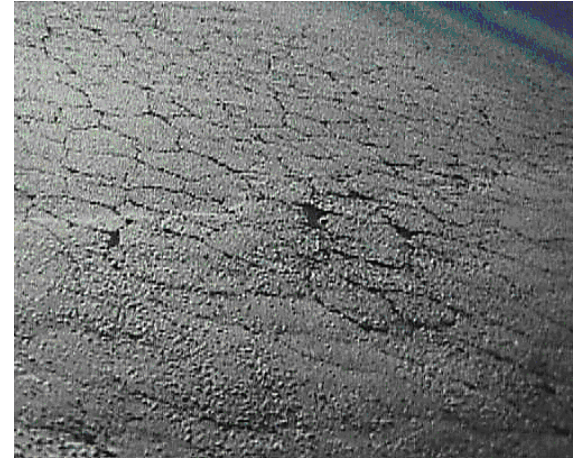
- Longitudinal Cracking
- Transverse Cracking
- Block Cracking



- Crack width should be 0.12 – 1.00 inch

When NOT to Use?

- Crack sealing/filling is not efficient on:
 - Alligator Cracking (due to poor subgrade support)
 - Fatigue Cracking (due to fatigue failure)
 - Reflective Cracking
 - Edge Cracking
 - Slippage Cracking



Performance

- Depending on sealant and method used:
 - Asphalt emulsion placed in flushed configuration, in unrouted cracks: 2 – 4 years
 - Hot-applied rubber and fiber modified asphalt placed in flush or overbanded configuration: 6 – 8 years

Chapter 5

Patching and Edge Repair

From... Maintenance Technical
Advisory Guide (MTAG)

What is Patching?

- Patching consists of removing and replacing the material in a highly distressed area, or adding additional material to cover up the distressed area



Why Use Patching?

- Restores the pavement surface to a state where other preservation treatments can be used with a good chance of success
- Often done in preparation for other forms of corrective maintenance, pavement preservation, or pre-treatment prior to an overlay

When to Use?

- Patching is not pavement preservation
- Emergency-temporary patches to reduce likelihood of vehicle damage and/or accidents which they might cause
- Before localized areas of distress become problematic
- Prior to overlays or other pavement treatments

Where to Use?

- Localized areas where even the underlying support materials have disintegrated, contaminated, or lost their load-carrying capacity
- Pavement failure along the edges due to traffic and loss of edge support



Where to Use?



***Localized High Severity
Alligator Cracking***



Pothole

Chapter 6

Fog and Rejuvenating Seals

From... Maintenance Technical
Advisory Guide (MTAG)

What is a Fog Seal?

A mixture of asphalt emulsion and water applied to the asphalt surface of a road, street or highway. The primary purpose is to seal the road surface and defer surface degradation



Why Use Fog Seal?

- An inexpensive way of arresting raveling and adding binder back to aged surfaces
- Fog seals are also useful in chip seal applications to hold chips in place in fresh seal coats to help prevent vehicle damage arising from flying chips
- improve sealing or waterproofing
- improve the surface appearance

When/Where to Use Fog Seal?

- Pavement surface condition – Dry mixes, high air voids, and surfaces showing minor and/or moderate raveling.
- When chip seals are in need to prevent aggregate loss.
- Pavement age – relatively newer pavement (not more than 2 years in service)
- Pavement surface mix – can be used on dense-, gap-, and open-graded mixes; however, the seal must penetrate.

What is a Rejuvenating Seal?

- A combination of various chemicals or a mixture of asphalt emulsion and recycling agents applied to the asphalt pavement surface
- The primary purpose is to soften the stiffness of the oxidized HMA pavement surface and to extend the life of the pavement surface by adjusting properties of the HMA mixture

A Rejuvenating Seal Job...



Why Use a Rejuvenating Seal?

- A way to soften the hardness of oxidized asphalt concrete surface, making it less brittle
- The major benefit of the rejuvenating seals is to improve the flexibility of the asphalt binder and slow down the rate of aging and oxidization

When to Use a Rejuvenating Seal?

- Old and fairly oxidized pavement surface or surface starting to oxidize or show raveling
- In addition to oxidation a pavement surface may begin to show evidence of distress cracking; if this is the case a rejuvenating scrub seal should be used
- Generally used on pavement over 2 years or more

Where to Use Rejuvenating Seal?

- Can be used on dense-, gap- and open-graded pavement surface mixes



**Heavily aged,
dense-graded HMA**



**Open-graded
HMA**

Chapter 7

Chip Seals

From... Maintenance Technical
Advisory Guide (MTAG)

What is Chip Seal?

Application of asphalt binder on existing pavement followed by a layer of aggregate chips. The treatment is then rolled to embed the aggregate into the binder.



Why to Use - Performance and Cost

- Performance
 - Typical treatment life: 5 to 10 years
 - Function of climate, existing pavement condition, traffic, type of chip seal
- Average cost
 - \$2.50 to \$5.00/yd² (depending on oil price)



Where and When to Use

- Surface for light to medium traffic (ADT<30,000)
- Waterproof layer
- Skid resistant surface
- Restore weathered surface
- Address bleeding
- Temporary base course cover
- Define shoulders



When NOT to Use!

- Structurally deficient pavements
- Cracks $>1/4$ in width unless sealed
- Large number of potholes
- Rutting $>1/2$ in
- Ride quality needs significant improvement



Chip Seal Variations

- Applications
 - Single chip seals
 - Double or triple chip seals
 - Cape seals
 - Fabric and chip seals
 - Scrub seals
- Asphalt Binder Types
 - PME
 - PMA
 - AR

Chapter 8

Slurry Seals

From... Maintenance Technical
Advisory Guide (MTAG)

What is Slurry Seal?

- A thin maintenance treatment
- A mixture of:
 - asphalt emulsion
 - graded aggregates
 - mineral filler
 - water
 - Additives



- When placed on the pavement surface the mixture breaks and cures creating a new wearing surface.

Why Use Slurry Seals?

- Cost Effective
- Benefits:
 - minimize oxidation/ageing
 - reduce water infiltration
 - provide skid resistance
 - improve aesthetics
 - correct raveling and weathering
- Average performance life: 3 to 5 years

Where to Use?

- Hot Mix Asphalt Pavements:
 - Roadways (All traffic levels)
 - Parking Lots
 - Taxiways and Runways
 - Bridges and Over-Crossings
- Geographic Regions/Climate Zones:
 - All throughout California



Cape Seal (Slurry over Chip Seal)

When to Use?

- To correct/improve:
 - raveling and weathering
 - loss of frictional properties
 - aesthetics
- To prevent/reduce:
 - ageing/oxidation of asphalt concrete
 - surface water infiltration
 - pavement degradation due to the elements



When NOT to Use?

- On pavements with structural defects:
 - Alligator Cracking
 - Rutting
 - Bumps and Depressions
 - Potholes
- Nighttime construction



Chapter 9

Microsurfacing

From... Maintenance Technical
Advisory Guide (MTAG)

What is Microsurfacing?

- A thin maintenance treatment
- A mixture of:
 - polymer modified emulsion
 - graded aggregates
 - mineral filler
 - water
 - Additives
- Instead of breaking and curing via evaporation, like slurry, a chemical reaction causes the material to set-up.



Why Use Microsurfacing?

- Cost Effective
- Benefits:
 - minimize oxidation/ageing, reduce water infiltration, correct raveling and weathering
 - provide skid resistance
 - improve aesthetics
 - correct rutting and minor surface profile irregularities
- Average performance life: 5 to 7 years

Caltrans District 11 -



Before



After

**Type III Micro Surfacing Project,
Contract No. 11-276004, 11-SD-76-30.2/52.9
Intermountain Slurry Seal**

Where to Use?

- Hot Mix Asphalt Pavements:
 - Roadways (All traffic levels)
 - Taxiways and Runways
 - Bridges and Over-Crossings
- Geographic Regions/Climate Zones:
 - All throughout California

When to Use?

- To correct/improve:
 - raveling and weathering
 - loss of frictional properties
 - aesthetics
 - rutting and surface profile irregularities
- To prevent/reduce:
 - ageing/oxidation of asphalt concrete
 - surface water infiltration
 - pavement degradation due to the elements

When NOT to Use?

- On pavements with structural defects:
 - Alligator Cracking
 - On-going Rutting
 - Bumps and Depressions
 - Potholes



Microsurfacing Vs. Slurry Seal

<i>Differences in:</i>	<i>MICROSURFACING</i>	<i>SLURRY SEAL</i>
Asphalt Emulsion	always polymer modified, quick set	could be polymer modified
Aggregate Quality/Gradation	stricter spec. for sand equivalent; use only Type II and Type III	Can use Type I, II or III
Additives/Break	chemical break largely independent of weather conditions	breaking and curing dependent on weather conditions

Microsurfacing Vs. Slurry Seal

<i>Differences in:</i>	<i>MICROSURFACING</i>	<i>SLURRY SEAL</i>
Mix Stiffness/ Equipment	stiffer mix, use augers in the spreader box and secondary strike-off	softer mix, use drag box
Applications	same as slurry seal + rut filling, night work, correction of minor surface profile irregularities	correct raveling, seal oxidized pavements, restore skid resistance

Distress Conditions

Pavement Distress

Surface cracking

Early longitudinal

X

X

Hairline

X

X

Full depth cracking

Thermal or Transverse

-

-

Fatigue or Alligator

-

-

Block

-

-

Reflective

-

-

Late longitudinal

-

-

Slippage (tack failure)

-

-

Corrugation or Shoving (wash boarding) -

X

X Recommended; - Not recommended

Distress Conditions (cont.)

Pavement Distress

Slurry Microsurfacing

Rutting

Sound base

-

X

Unsound base

-

-

Raveling

X

X

Bleeding

-

X

Polishing (loss of skid resistance)

X

X

Patched pothole

Structure unsound

-

-

Base repaired patch

X

X

Loss of profile (crown, edge, etc.)

-

X

X Recommended; - Not recommended

Chapter 10

Thin Maintenance Overlays

From... Maintenance Technical
Advisory Guide (MTAG)

What Are Thin Maintenance Overlays?

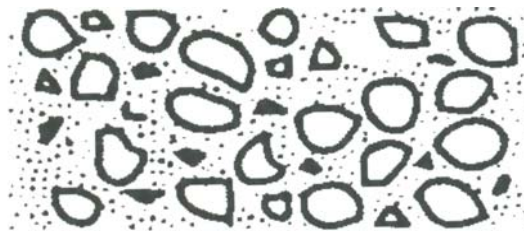
- Defined as thin treatment using a hot mix system
- Non-structural layer
- Applied as a maintenance treatment (corrective or preventive)
- Thickness:
 - Caltrans: 1¼ in
 - Nationally: less than 1½ in

Types of Thin Maintenance Overlays

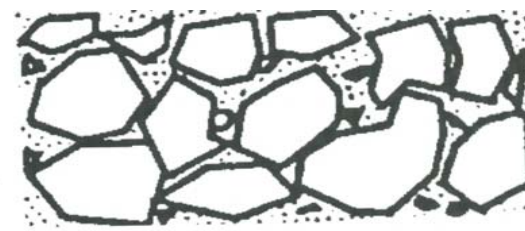
- Dense-graded: HMA Type A and B
- Open-graded: OGFC, RHMA-O and RHMA-O-HB
- Gap-graded: RHMA-G



a) Dense Graded



b) Gap Graded



c) Open Graded

Why Use Thin Overlays?

- Extends Pavement Life
- Improves Ride Quality
- Mitigates Distresses
 - Raveling
 - Oxidation
 - Cracking
 - Skid problems
 - Flushing surfaces



When to Use?

- Structurally sound pavement
- Rut depth < 1/2"
- Minor cracking
- cracking
- Minor to moderate bleeding
- Raveled surface



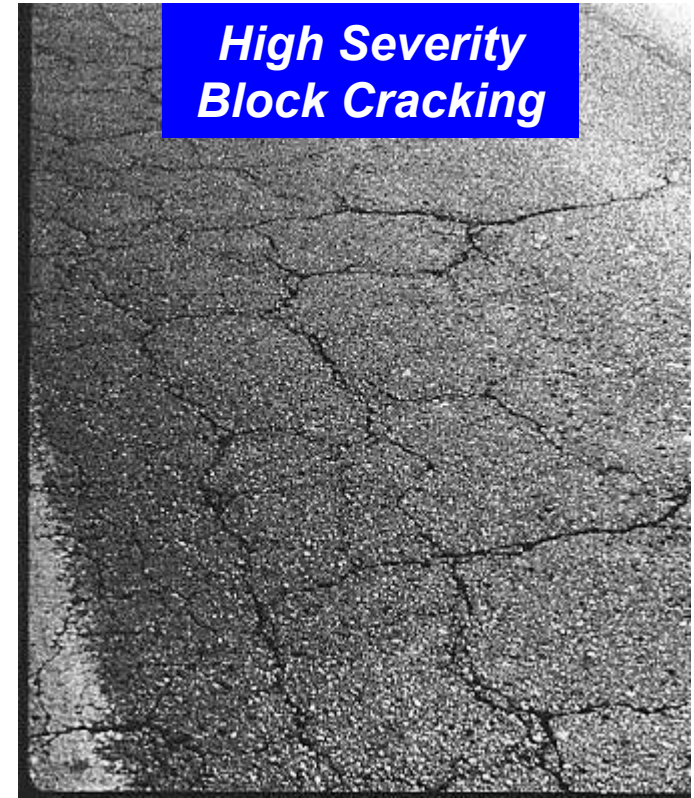
When NOT to use!

Poor Candidates

**High Severity
Alligator Cracking**



**High Severity
Block Cracking**



**Rutting
>1/2"**



**High Severity
"D" Cracking**



Where to Use?

- As a surface treatment over asphalt concrete pavements and on portland cement concrete pavements
- Over structurally sound pavements
- For reducing oxidation
- For mitigation of cracking
- For improving skid resistance

Where to Use?

Open- and Gap-Graded Overlays

- In sections with high frequency of wet weather accidents or when recommended to minimize wet weather accident occurrences
- For improving skid resistance
- For noise reduction

Chapter 11

Bonded Wearing Course

From... Maintenance Technical
Advisory Guide (MTAG)

What is BWC?



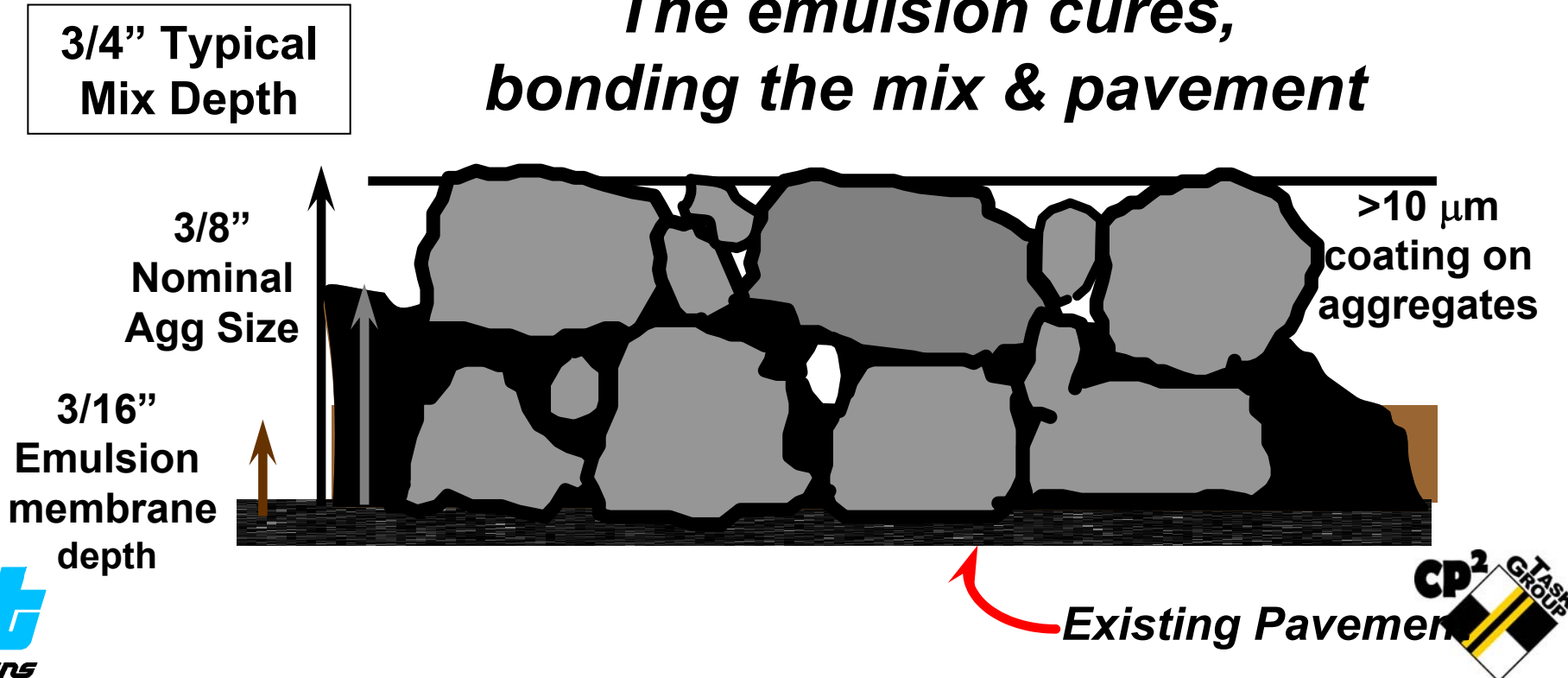
- **A thin Hot Mix Asphalt Overlay placed over a polymer modified emulsion membrane which:**
 - **seals the existing pavement**
 - **bonds the two surfaces**
- **The roadway is open to traffic very quickly**
- **This process is done in a single machine**



What is BWC?

Emulsion membrane “wicks up” around the HMA aggregates

The emulsion cures, bonding the mix & pavement



When to Use?

Site Selection Guidelines

- Structurally sound pavement
- Rut depth < 1/2"
- Minor to moderate transverse & longitudinal cracking
- Bleeding minor to moderate
- Raveled



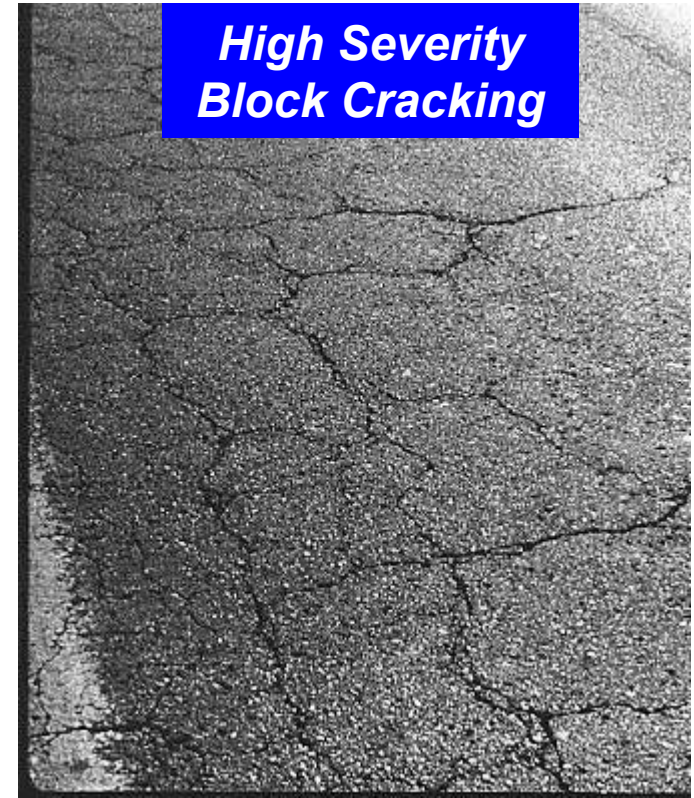
When NOT to Use!

Poor Candidates

**High Severity
Alligator Cracking**



**High Severity
Block Cracking**



**Rutting
>1/2"**



**High Severity
"D" Cracking**



Where/Why to Use (cont.)

- Quick return to traffic- Reduced Work Zone Time (*Workers' Safety*)
- Noise Reduction- Open/Gap Graded Mix
- Night Work- Min Temp 45° F (*More working days*)
- Reduced Backspray- Open/Gap Graded Mix
- High Volume Roadways- Faster Paving Process (*Get In- Get Out*)

Hwy 99 RBWC



Hwy 73 BWC



Where to Use?

Chapter 12

Interlayers

From... Maintenance Technical
Advisory Guide (MTAG)

Chapter 13

In-Place-Recycling

From... Maintenance Technical
Advisory Guide (MTAG)

Types of In-Place-Recycling

- Cold-In-Place Recycling (CIR), HMA<3”
- Hot-in-Place Recycling (HIR), HMA<3”
- Full Depth Reclamation (FDR) – this topic is not addressed in the MTAG 2nd edition for flexible pavements

Cold In-Place Recycling (CIR)

From... Maintenance Technical
Advisory Guide (MTAG)

What is Cold In-Place Recycling?

Distressed Pavement = New Pavement Using A Train of Equipment that:

- **Mills deteriorated pavement**
 - **Reclaimed asphalt pavement (RAP)**
- **Crushes RAP to gradation**
- **Mixes with recycling emulsion**
- **Re-Paves recycled mix**
- **Compacts to specified density**
- **Ready for surface treatment**



Why Use Cold In-Place Recycling?

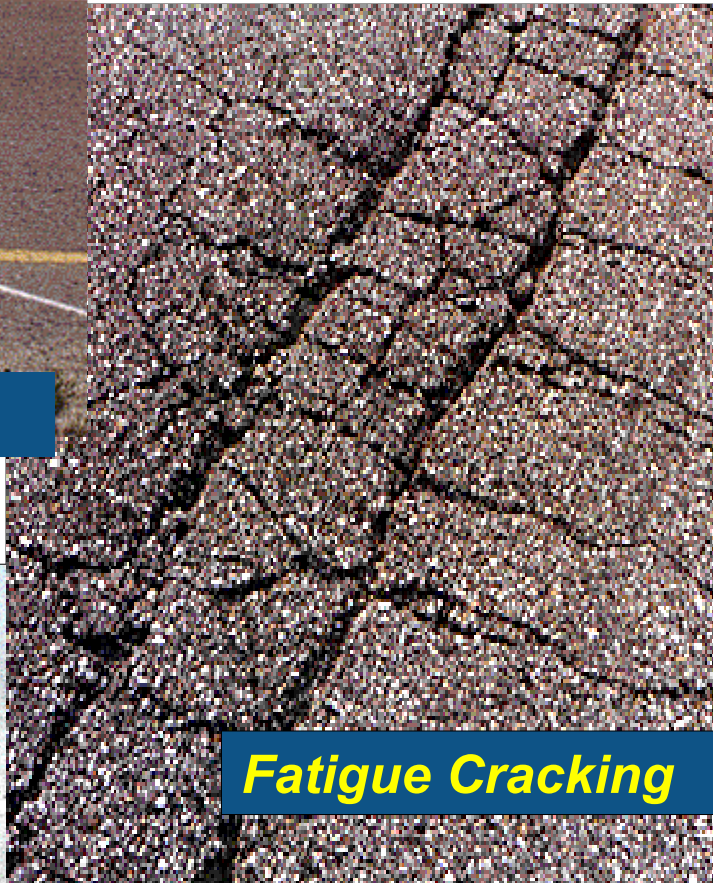
- Maintains and Restores Deteriorated Pavements
- Disrupts Reflective Cracking
- Cost Effective up to 50% Less than Traditional Method of Mill and Fill
- Up to 75% Reduction in Working Days
- Lowers User Delays
- Conserves Natural Resources & Energy
- Eliminates 98% of Construction Truck Traffic
- Recycling Credits



When to Use Cold In-Place Recycling?



Thermal Cracking



Fatigue Cracking



Poor Rideability



Patched



Dry, Raveled

Where to Use Cold In-Place Recycling?

- Anywhere mill and fill is considered
- Will handle all cracking distress provided not base related
- Where surface maintenance is no longer effective
- To repair raveling & potholes
- Where safety is a concern
- When life cycle costs dictate
- No limitation to traffic/ADT



Hot In-Place Recycling (HIR)

From... Maintenance Technical
Advisory Guide (MTAG)

What is HIR?

Distressed converted to New Pavement Using A Train of Equipment that:

- Heats deteriorated pavement surface
- Mills Reclaimed asphalt pavement (RAP)
- Mixes with recycling agent and new HMA
- Re-Paves recycled mix
- Compacts to specified density



Hot In-Place Recycling

- Three methods: surface recycling, remixing, and repaving
- Typical depth: 15 to 50 mm (0.6 to 2.0 in)
- RAP mixed with additives and relaid
- Immediate opening to traffic
- Applicable for all traffic levels

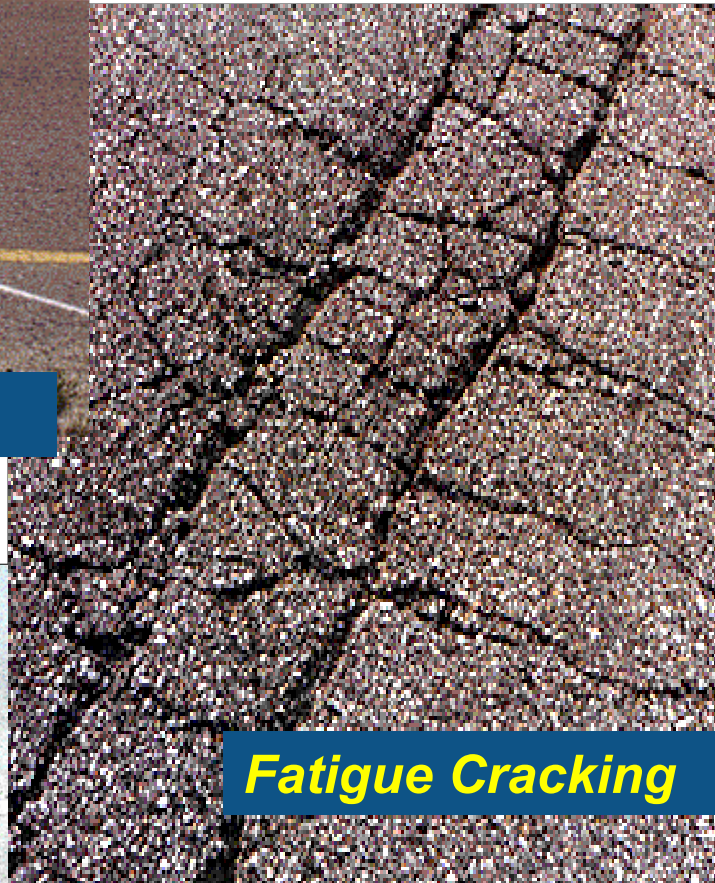
Why Use HIR?

- **Maintains and Restores Deteriorated Pavements**
- **Disrupts Reflective Cracking**
- **Cost Effective up to 50% Less than Traditional Method of Mill and Fill**
- **Up to 75% Reduction in Working Days**
- **Lowers User Delays**
- **Conserves Natural Resources & Energy**
- **Eliminates 98% of Construction Truck Traffic**
- **Recycling Credits**



After

When to Use HIR?



Where to Use HIR?

- Anywhere mill and fill is considered
- Will handle all cracking distress provided not base related
- Where surface maintenance is no longer effective
- To repair raveling & potholes
- Where safety is a concern
- When life cycle costs dictate
- No limitation to traffic/ADT



HIR - Limitations

- Influence of mix variation
- Cannot recycle fabrics or interlayers
- Problems with deep ruts
- Trouble recycling large stone mixes
- Difficulties from rubber in the mix
- Higher moisture content reduces production rate

Summary

Chapter	Topic
1	Introduction
2	Materials
3	Framework for Treatment Selection
4	Crack Sealing, Crack Filling, and Joint Sealing
5	Patching and Edge Repair
6	Fog and Rejuvenating Seals
7	Chip Seals
8	Slurry Seals
9	Microsurfacing
10	Thin Maintenance Overlays
11	Bonded Wearing Courses
12	Interlayers
13	In-Place Recycling

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MAINTENANCE TECHNICAL ADVISORY GUIDE
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Thank You

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