

Pavement Rehabilitation Options in Indiana

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Decision to select treatment options

Rehabilitation Treatment Overview



Objectives

- **Identify maintenance/rehabilitation treatments.**
- **Benefits of good timing.**
- **Preventive maintenance and its principles.**



Introduction

- **How do PCC pavements typically deteriorate?**
- **When is functional performance impaired?**
- **What about structural performance?**
- **What treatments are commonly used?**



PCC Rehabilitation Treatments

- **PCC Overlays**
- **HMA Overlays**
- **PCC Pavement Recycling**
- **Accelerated Rigid Paving Techniques**
- **Feasible Treatment Identification**



Treatment Information

- **Definitions**
- **Purpose and Applications**
- **Limitations and Effectiveness**
- **Design Considerations**
- **Pavement Surveys**
- **Cost Considerations**
- **Construction Considerations**
- **Equipment**



Identification of Candidate Treatments

- **Specific Distresses Present**
- **Condition**
 - Functional
 - Structural
- **Loadings and Environment**
- **Available Tools**
 - Decision trees
 - Decision matrices

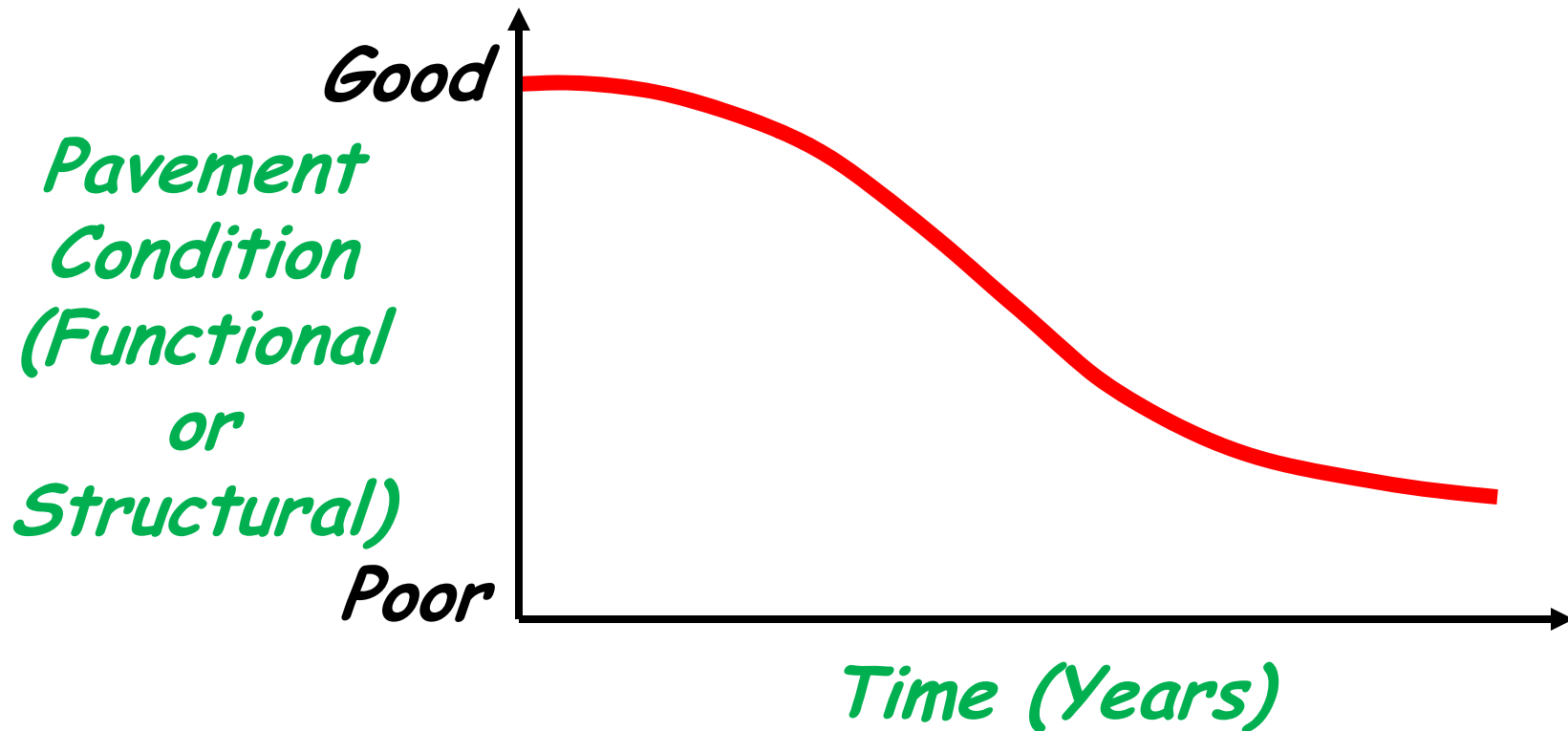


Treatment Timing Issues

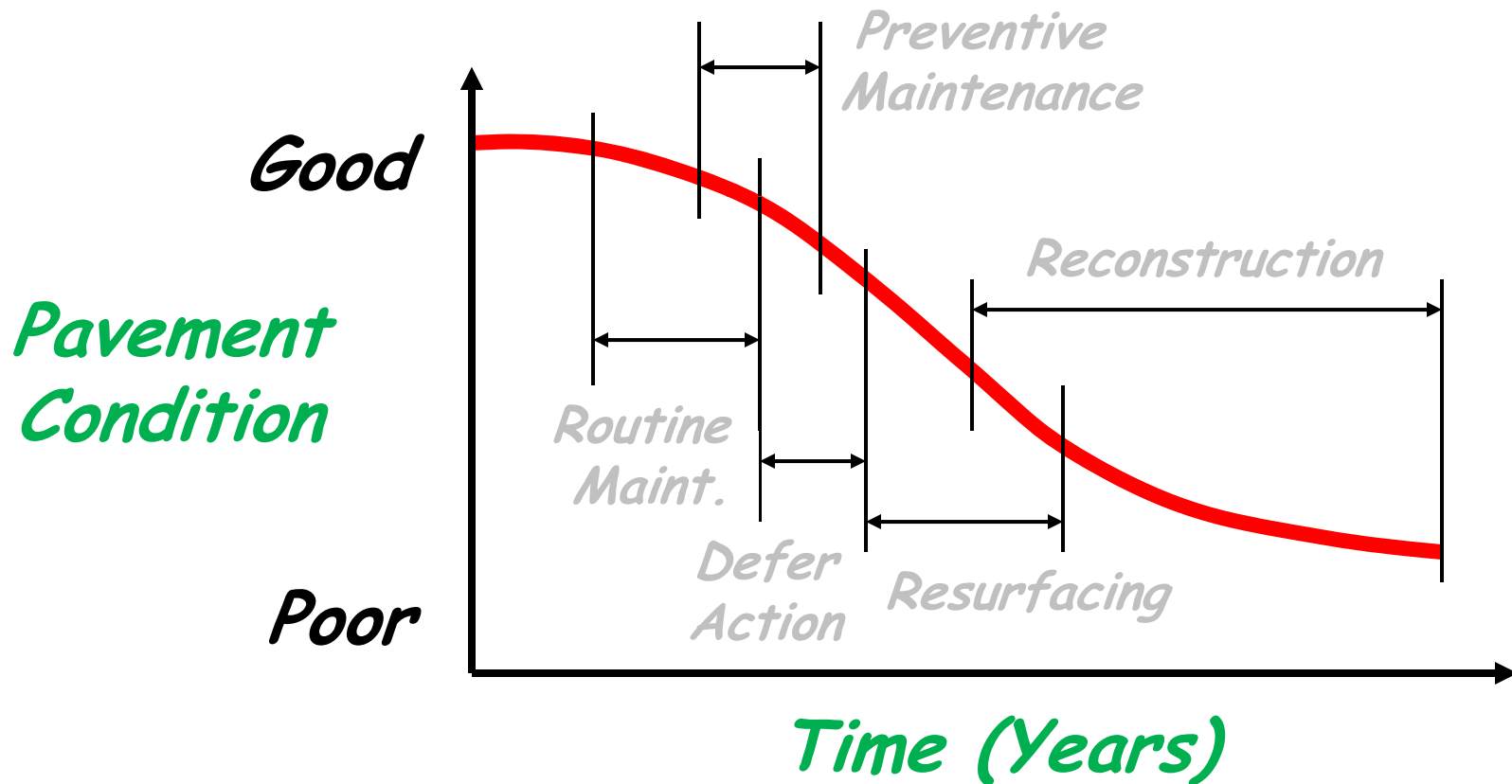
- **What factors affect treatment timing?**
- **When is too soon?**
- **Too late?**



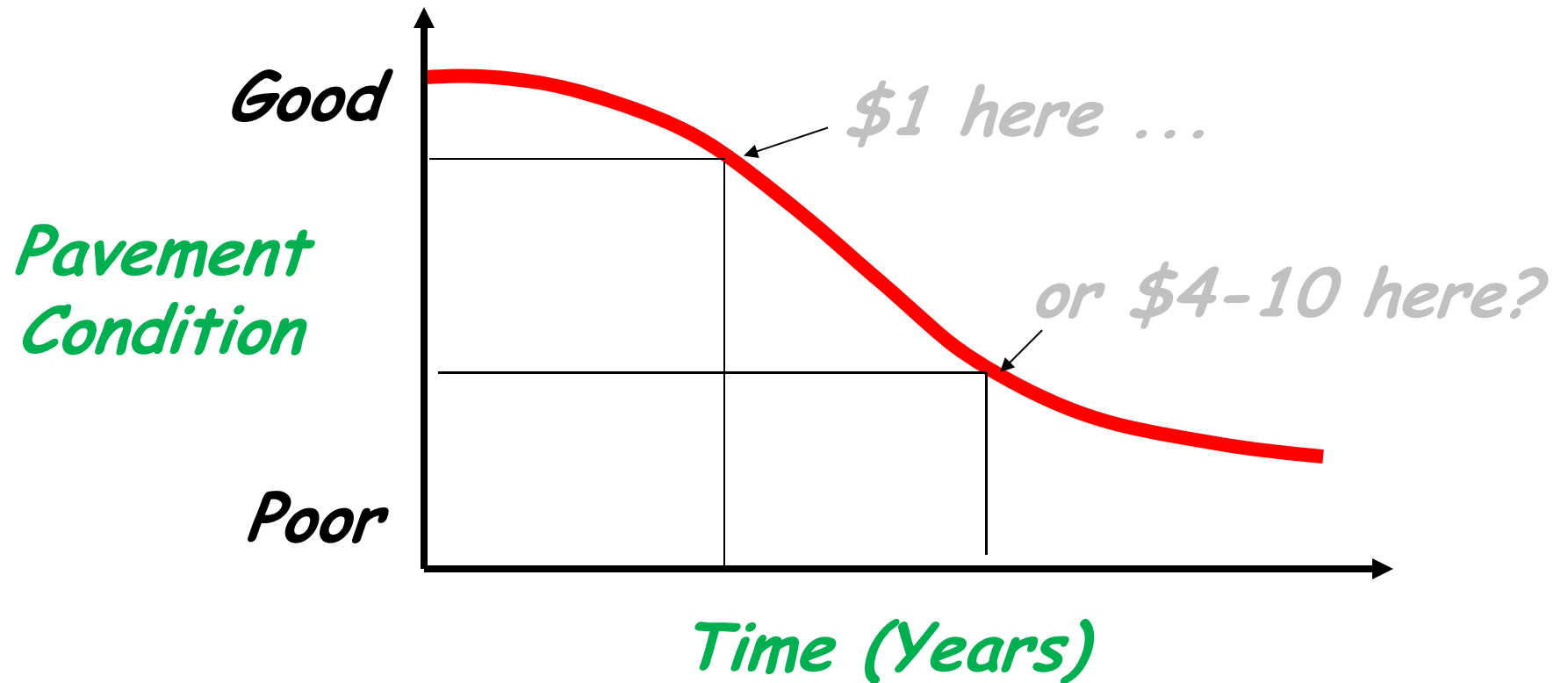
Typical Pavement Performance Curve



Typical Pavement Performance Curve



Cost Effects

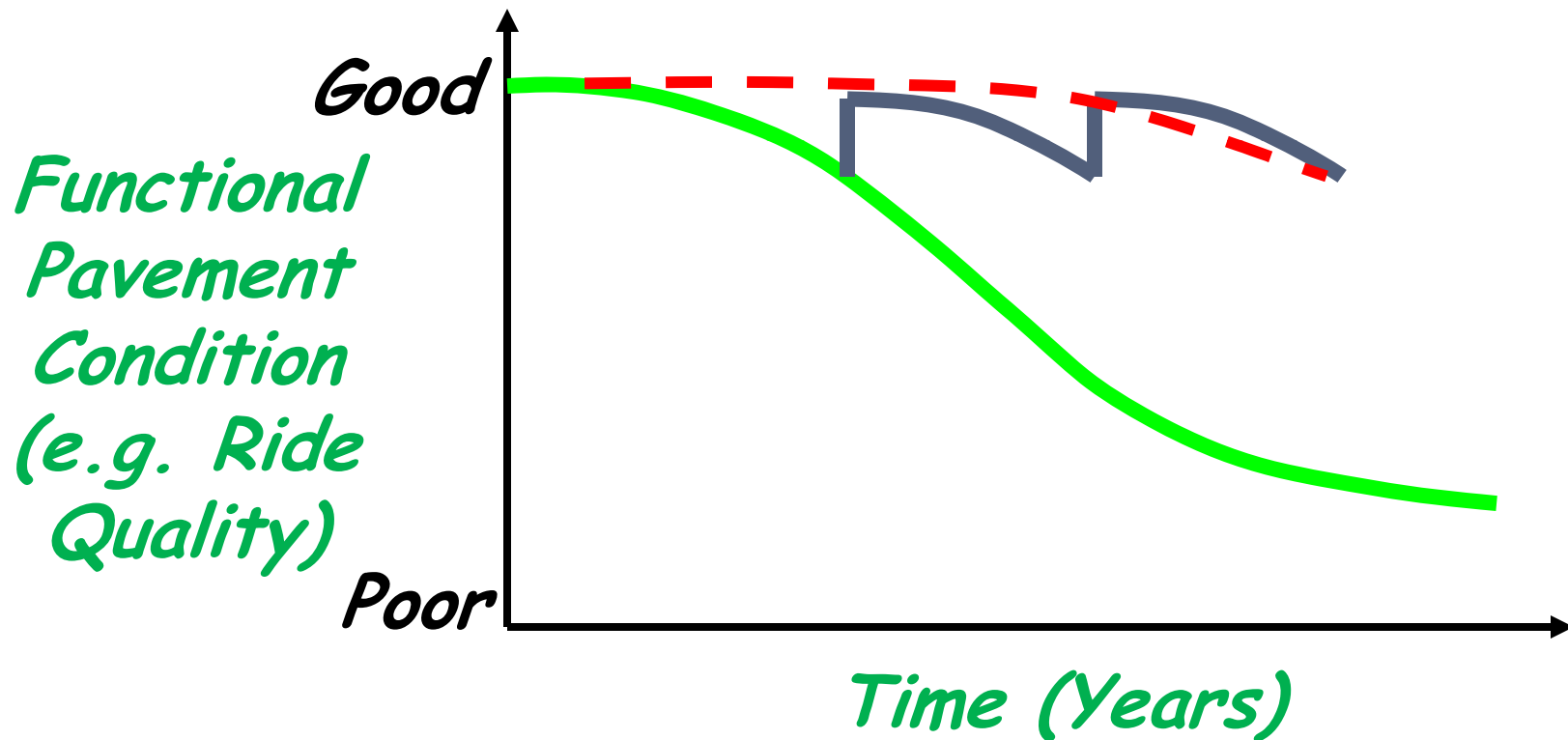


Preventive Maintenance

- **Planned strategy**
- **Preserves the system**
- **Retards future deterioration**
- **Maintains or improves functional condition**



Anticipated PM Benefits



Anticipated PM Benefits

- **Functional Performance?**
- **Structural Performance?**
- **Costs:**
 - To the agency?
 - To the user?



Conventional Rehabilitation Treatment

HMA Pavement Overlay



Introduction

- **Most popular method**
- **Relatively fast and cost-effective means for:**
 - Correcting deficiencies
 - Restoring user satisfaction
 - Adding structural capacity
- **Poor performance is NOT uncommon**



Definitions

- **Functional performance - Ability to provide a safe, smooth riding surface**
- **Structural performance - Ability to carry traffic without distress**
- **Empirical - Design based on past experience or observation**
- **Mechanistic - Design based upon engineering mechanics**



Purpose and Applications

- **Improve functional and/or structural characteristics**
- **Wide range of applications**
 - Road surface categories
 - Climate and support conditions



Characteristics of Typical HMA Overlay

- **Dense graded HMA**
- **Flexible or rigid surface**
- **25 to 200 mm (1 to 8 in) thickness**
- **Mill and Fill**



Limitations and Effectiveness

Why do we have premature failures?

- Improper selection
- Wrong type
- Inadequate design
- Insufficient preoverlay repair
- Lack of consideration of reflection cracking



Limitations and Effectiveness

What limits the effectiveness of HMA overlays?

- **Distress exhibited in HMA**
- **Intended design life of the overlay**
- **Availability of quality materials**



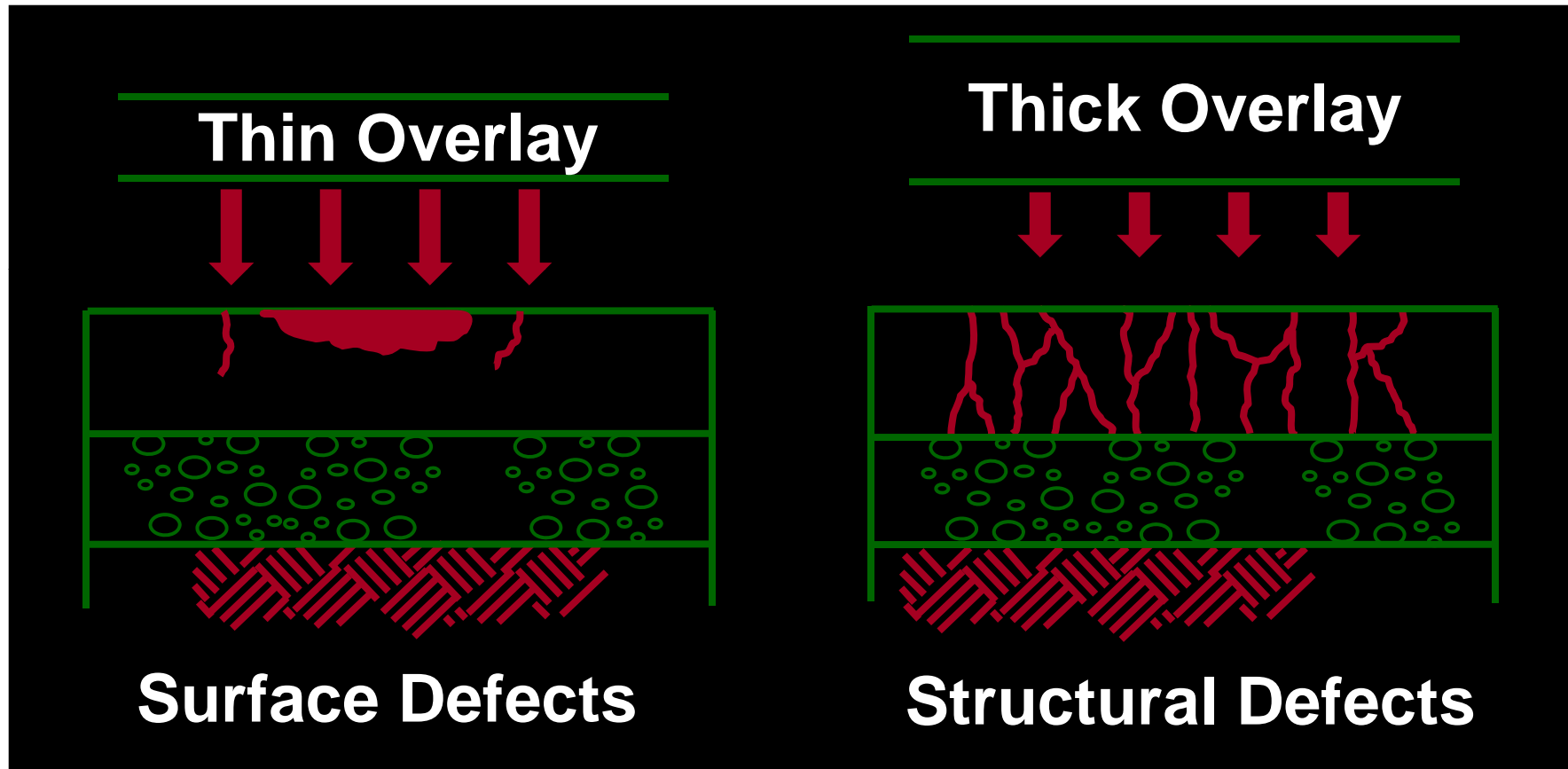
Limitations and Effectiveness

How can we improve our overlays?

- **Preoverlay treatments**
- **Better materials and practices**
- **Sound engineering judgment**



Overlay Selection to Correct Deficiencies



What Are Considerations in Overlay Selection?

- **Construction feasibility**
 - Traffic control
 - Constructibility
 - Vertical clearances
 - Utilities
- **Performance period**
- **Funding**



Preoverlay Treatment and Repair

- **Dependent upon:**
 - Type of overlay
 - Structural adequacy of existing pavement
 - Existing types of distress
 - Future traffic
 - Physical constraints
 - Cost



To Repair or Not to Repair?



Types of Preoverlay Treatments

- **Localized repair (patching)**
- **Surface leveling**
- **Controlling reflection cracking**
- **Drainage improvements**



Conventional Rehabilitation Treatment

Concrete Pavement Overlay

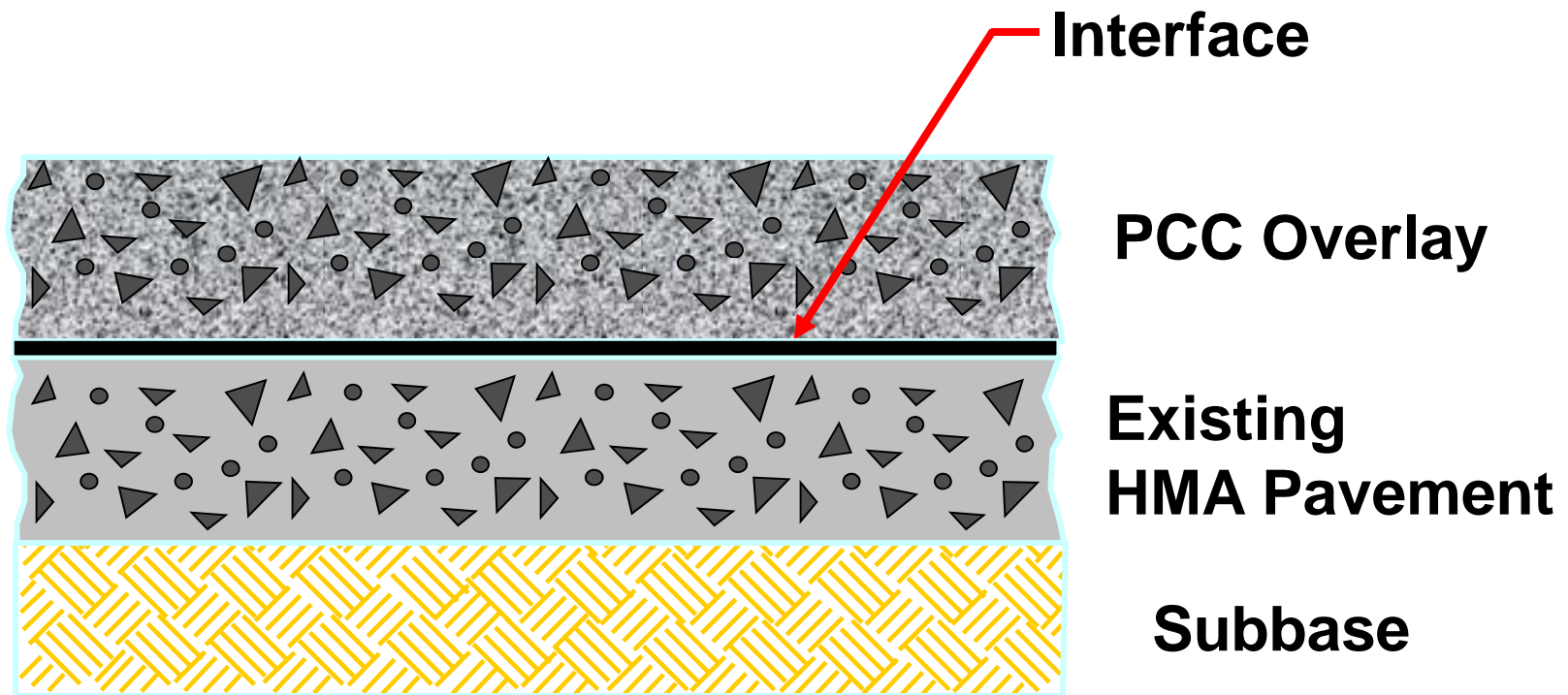


Types of Whitetopping Overlays

- **Conventional Whitetopping**
 - Slabs greater than 100 mm thick
 - Placed directly on HMA pavement (little preoverlay repair)
- **Ultra-Thin Whitetopping**
 - Thin slabs (50 to 100 mm thick)
 - Short joint spacing (0.6 to 1.8 m)
 - Bonded to existing HMA to increase load-carrying capacity



Conventional Whitetopping



Applicability

- **Conventional Whitetopping**
 - Badly deteriorated HMA pavements
 - Most any traffic volume
- **Ultra-Thin Whitetopping**
 - Low volume roads exhibiting rutting, shoving, potholing
 - Urban intersections where recurrent rutting/washboarding has been a problem



Overlay Selection

- Detailed pavement evaluation (distress, FWD, coring)
- Construction feasibility
- Performance period
- Cost effectiveness



Whitetopping Feasibility—Constructibility

Conventional

Vertical
Clearance

Can be a problem

Traffic
Control

May be difficult to
construct under
traffic

Construction

No special
equipment



Whitetopping Feasibility—Performance Period

Conventional

Existing Condition

Very deteriorated HMA pavements

Extent of Repair

Limited to very severe areas

Future Traffic

Any traffic level

Historical Reliability

Very good



Design Considerations

- **Slab thickness**
- **Joint design**
- **Drainage design**
- **Reinforcement design**
- **PCC mix design**
- **Preoverlay repair and surface preparation**



Preoverlay Repairs Whitetopping Overlays

- Localized repair of failed areas
- Filling of potholes
- Milling if rutting greater than 50 mm
- Repair of severe alligator cracking if poor support would otherwise result

Goal: Uniform support



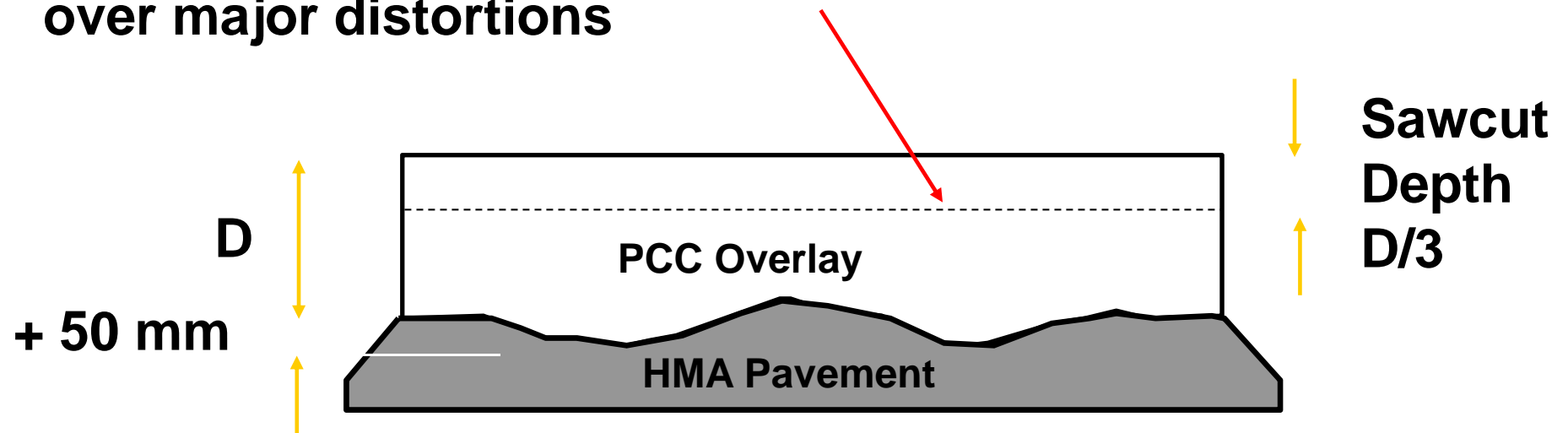
Construction —Whitetopping Overlays—

- **Conventional PCC paving equipment and construction practices are used**
- **PCC may be placed directly on HMA or on milled or leveled HMA surface**
- **Whitewashing of HMA surface may be required on hot days**

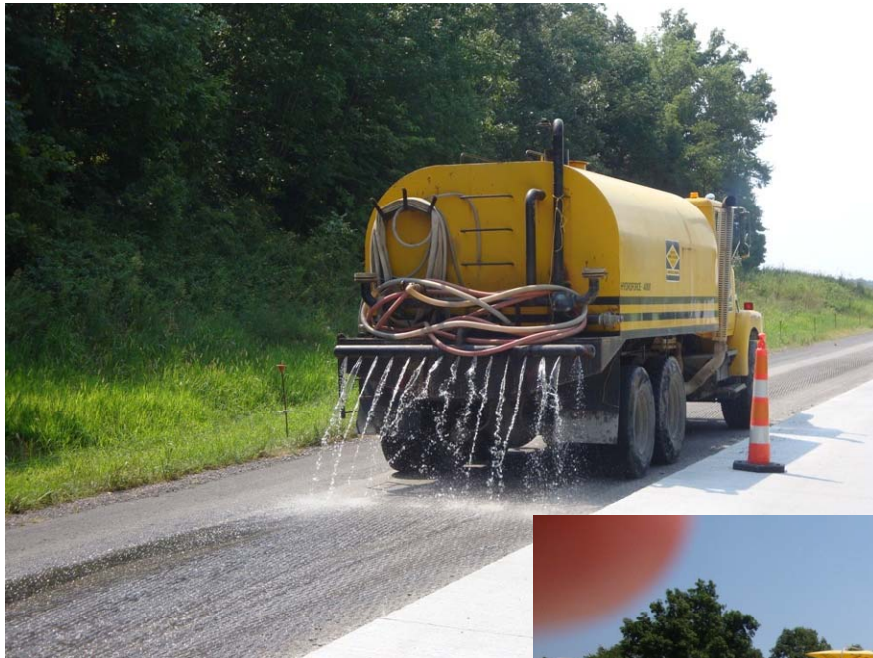


Whitetopping —Joint Sawing—

Consider increased saw depth
over major distortions



SR-161 Whitetopping



SR-161 Whitetopping



Rehabilitation Option

Hot In-Place Recycling



Hot In-Place Recycling Description

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



Rehabilitation Option

Cold In-Place Recycling



Cold In-Place Recycling Description



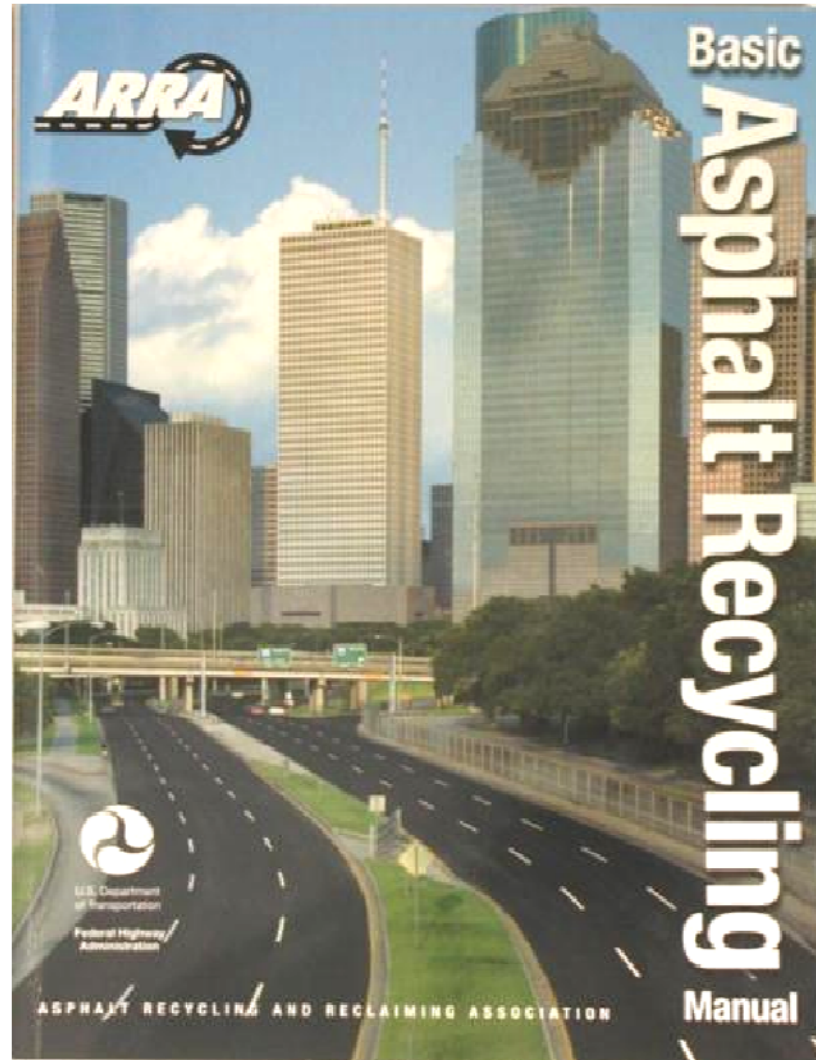
- Cold process
- Milling depth: 50 mm - 100 mm (2 in to 4 in)
- RAP mixed with additives and relaid
- Resurfacing is typically required
- Most commonly used on secondary and low-volume roads

Benefits

- **Conserves energy and materials**
- **Preserves geometrics**
- **Many surface distresses eliminated**
- **Improves profile**
- **Modifies material characteristics**
- **Relatively inexpensive**



Basic Asphalt Recycling Manual



In-Place Recycling

Measure of Effectiveness

Corrects	Slows/Reduces Severity
Poor friction Roughness Bleeding Raveling Rutting Poor cross slope	Cracking Moisture damage
Prevents/Delays	Negatively Affects
Cracking Raveling Roughness	None

Rehabilitation Option

Full Depth Reclamation (FDR)



Definition of Full-Depth Reclamation

- **Method of flexible pavement reconstruction that utilizes the existing asphalt, base, and subgrade material to produce a new stabilized base course for a chip seal, asphalt, or concrete wearing surface.**



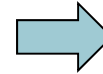
Types of Reclamation Methods

- **Mechanical Stabilization**
- **Bituminous Stabilization**
 - emulsified asphalt
 - expanded (foamed) asphalt
- **Chemical Stabilization**
 - Portland cement, slag cement, lime, fly ash, other



Challenges Facing Our Roadways

- **Continuing growth**
- **Rising expectations from users**
- **A heavily used, aging system**
- **Environmental compatibility**
- **Changes in the workforce**
- **Funding limitations**



Combined with large increases in traffic volumes and/or allowable loads often leads to serious roadway base failures!



**How do you
know if you
have
a base problem
and not just
a surface
deficiency?**



Examples of Pavement Distress

- Alligator cracking
- Rutting
- Excessive patching
- Base failures
- Potholes
- Soil stains on surface



Advantages of the FDR Process

- Use of in-place materials
- Little or no material hauled off and dumped
- Maintains or improves existing grade
- Conserves virgin material
- Saves cost by using in-place “investment”
- Saves energy by reducing mining and hauls
- Very sustainable process

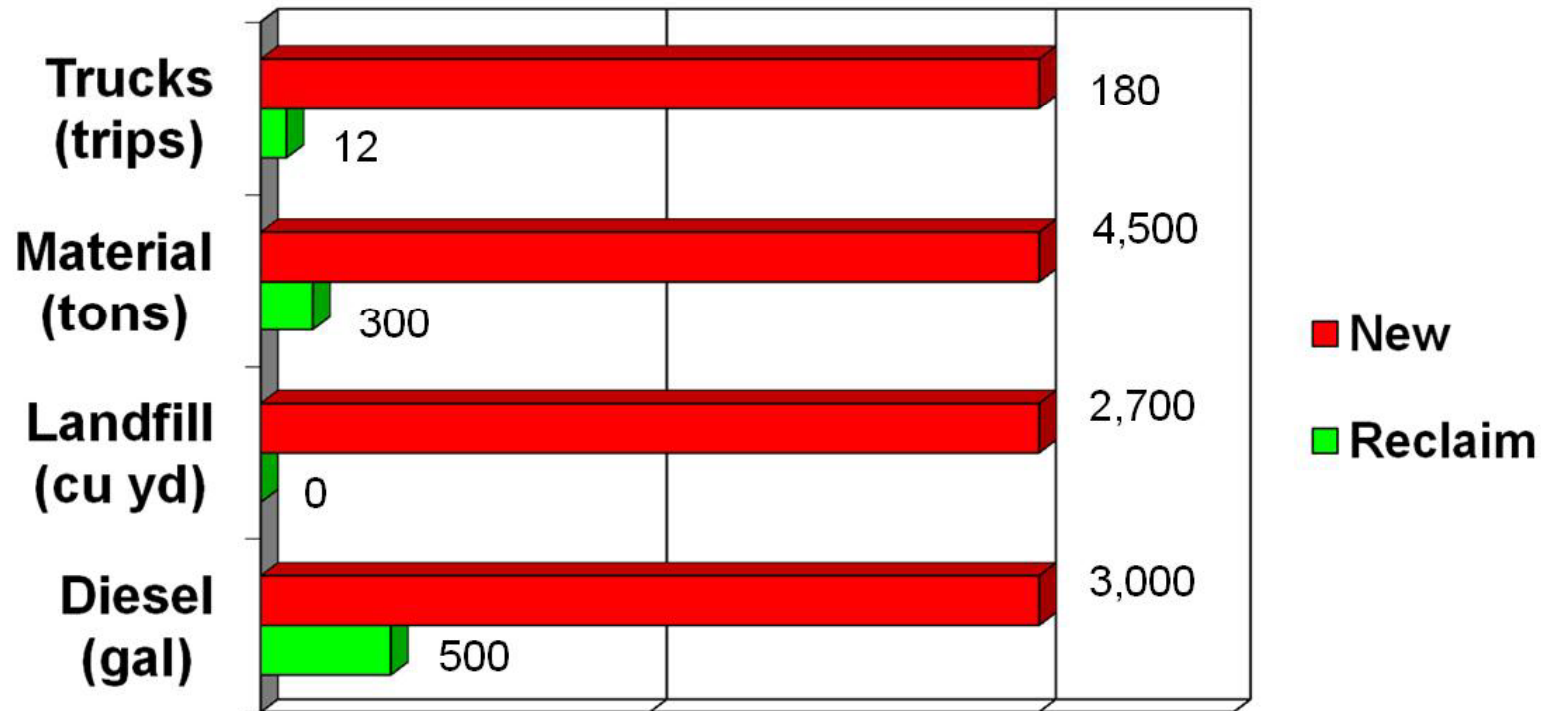


Rehabilitation Strategies

Attribute	Rehabilitation Strategy		
	FDR	Structural Overlay	Removal and Replacement
New pavement structure	√	√	√
Fast construction	√	√	X
Minimal traffic disruption	√	X	X
Minimal material in/out	√	X	X
Conserves resources	√	X	X
Maintains existing elevation	√	X	√
Low cost	√	X	X



Sustainable Element of FDR Process



1 mile of 24-foot wide, 2-lane road, with a 6-inch base



FDR in Indiana



Other Options for FDR

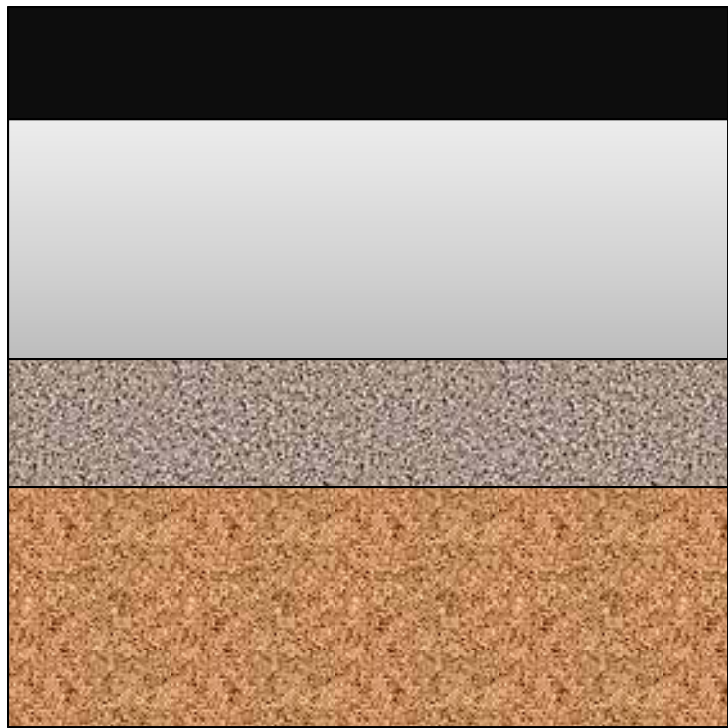


Design Issue

Pavement Rehabilitation Design



Existing pavement section



← 4" HMA overlay

← 8.5" JPCP

← 3" Dense sand

← Soil subgrade

Proposed rehabilitation



12 year LCCA

- ← HMA overlay
- ← 8.5" JPCP
- ← 3" Dense sand
- ← Soil subgrade

25 year LCCA



- ← Concrete overlay
- ← 8.5" JPCP
- ← 3" Dense sand
- ← Soil subgrade

Design alternatives

The screenshot displays a pavement design software interface with the following components:

- Explorer:** A tree view on the left showing project structure for two alternatives: '0400228 - US 31 (Conc. Overlay)' and '0400228 - US 31 (HMA. Overlay)'. It includes categories like Traffic, FoundationSupport, JPCP Design Properties, Climate, Pavement Structure, Backcalculation, and Project Specific Calibration Factors.
- General Information:** Design type: Overlay; Pavement type: JPCP over JPCP (unbc); Design life (years): 25; Existing construction: July 1975; Pavement construction: July 2012; Traffic opening: Septen 2012.
- Performance Criteria:**

Performance Criteria	Limit	Reliability
Initial IRI (in./mile)	70	
Terminal IRI (in./mile)	190	85
JPCP transverse cracking (percent slabs)	12	85
Mean joint faulting (in.)	0.2	85
- Calibration Factors:** DarwinME.RigidPavementUnbondedCalibrationGridObject.

PCC IRI J4	25.24
PCC IRI JPCP Std.Dev.	5.4
PCC Punchout	
PCC CRCP C1	2
PCC CRCP C2	1.22
PCC CRCP C3	216.842
PCC CRCP C4	33.1579
PCC CRCP C5	-0.58947
PCC CRCP Crack	1
PCC Reliability PD Standard Deviation	2+2.2593*POW(PO,0.4882)
Identifiers	
Display name/identifier	
Display name/identifier	
Display name of object/material/project for outputs and graphical interface	
- Task List:** A list of tasks with progress indicators (green circles) and percentages.

Task	Progress (%)
Running Integrated Climatic...	100
Extending climate solution	100
Calculating modulus subgra...	100
Calculating Effective Thick...	100
Preparing PCC Inputs	100
Preparing thermal gradient file	100
Calculating Faulting	100
Calculating Cracking	100
Calculating JPCP IRI	100
- Error List:** A table with columns: Project, Object, Property, Description.



Backcalculation inputs

0400228 - US 31 (Conc. O...:Project | 0400228 - US 31 (HMA. O...:Project | 0400228 - US ...:Back Calculation

New Back Calculation ~~X~~ Delete Create Projects from Back Calculation

Select Station	Station	Modulus Subgrade Reaction
<input checked="" type="checkbox"/>	NB	260
<input checked="" type="checkbox"/>	SB	276

FWD

- Backcalculation data by layer: **2 back calculation layers**
- Identifiers**
 - Display name/identifier: **NB**
 - Description of object: **FWD testing**
 - Author: **YJ**
 - Date created: **8/8/2011**
 - Approver: **TEN**
 - Date approved: **8/8/2011**
 - State: **IN**
 - District: **LaPorte**
 - County: **St. Joseph**
 - Highway: **US-31**
 - Direction of travel: **NB and SB**
 - From station (miles): **253+74**
 - To station (miles): **255+43**
 - User defined field 1:
 - User defined field 2:
 - User defined field 3:
 - Revision Number: **0**
 - Item Locked?: **False**



JPCP optimization

0400228 - US 31 (HMA. O...:Project) 0400228 - US 31 ...:Optimization 0400228 - US 31 (Conc. O...:Project) X

Last Optimized Thickness **9**

Layer Thickness	Results
6	Failed
12	Passed
9	Passed
7.5	Failed
8	Failed
8.5	Failed

Design Layers

Use	Layer	Default Thickness	Minimum Thickness	Maximum Thickness
<input checked="" type="checkbox"/>	Layer 1 PCC : JPCP	9	6	12

Optimization Rules

	Use	Property	Rules	Criteria
▶	<input type="checkbox"/>	Dowel Diameter (in.)		
*	<input type="checkbox"/>			

Optimize Thickness



JPCP optimization result

Design Structure



Layer type	Material Type	Thickness (in.):
PCC	JPCP	9.0 (Optimized)
Flexible	Asphalt concrete	2.0
Stabilized	JPCP (existing)	8.5
Subgrade	A-4	24.0
Subgrade	A-4	Semi-infinite

Joint Design:

Joint spacing (ft)	15.0
Dowel diameter (in.)	1.25
Slab width (ft)	12.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2012 (initial)	6,000
2024 (12 years)	14,273,700
2037 (25 years)	31,794,300

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in./mile)	190.00	120.37	85.00	99.96	Pass
Mean joint faulting (in.)	0.20	0.07	85.00	100.00	Pass
JPCP transverse cracking (percent slabs)	12.00	9.49	85.00	92.70	Pass



HMA optimization

0400228 - US 31 (Conc. O...:Project) 0400228 - US 31 (HMA. O...:Project) 0400228 - US 31 ...:Optimization

Last Optimized Thickness

Layer Thickness	Results
-----------------	---------

Design Layers

Use	Layer	Default Thickness	Minimum Thickness	Maximum Thickness
<input type="checkbox"/>	Layer 1 Flexible : As...	1.5	1.5	3.0
<input checked="" type="checkbox"/>	Layer 2 Flexible : As...	2.5	2.5	5

Optimization Rules

Optimization rules are currently available only for JPCP analyses.

Adding a base layer is more appropriate

Optimize Thickness



HMA sensitivity

0400228 - US 31 (H...Sensitivity) 0400228 - US 31 (Conc. O...Project) 0400228 - US 31 (HMA. O...Project) ▼ ×

Run Factorial Create Sensitivity Run Sensitivity View Summary

Use	Property	Layer	Default	Minimum	Maximum	# of Increments
<input type="checkbox"/>	Two-way AADTT		6000			
<input type="checkbox"/>	Thickness (in.):	Layer 1 Flexible : Asp...	1.5			
<input type="checkbox"/>	Binder Content (%)	Layer 1 Flexible : Asp...	11.61			
<input type="checkbox"/>	Air voids (%)	Layer 1 Flexible : Asp...	8			
<input checked="" type="checkbox"/>	Thickness (in.):	Layer 2 Flexible : Asp...	2.5	2.5	5	5
<input type="checkbox"/>	Binder Content (%)	Layer 2 Flexible : Asp...	10.66			
<input type="checkbox"/>	Air voids (%)	Layer 2 Flexible : Asp...	8			
<input type="checkbox"/>	Thickness (in.):	Layer 3 PCC : JPCP (...)	8.5			
<input type="checkbox"/>	Thickness (in.):	Layer 4 Subgrade : A-4	24			
<input type="checkbox"/>	Unbound Modulus	Layer 4 Subgrade : A-4	6000			
<input type="checkbox"/>	Dowel diameter (in.)		1.25			
<input type="checkbox"/>	PCC joint spacing (ft)		15			
<input type="checkbox"/>	Slab width (ft)		12			
<input type="checkbox"/>	PCC coefficient of th...	Layer 3 PCC : JPCP (...)	5.4			
<input type="checkbox"/>	28-Day modulus of ru...	Layer 3 PCC : JPCP (...)	350			



HMA Sensitivity result

Design Structure



Layer type	Material Type	Thickness (in.):
Flexible	Asphalt concrete	1.5
Flexible	Asphalt concrete	2.5
PCC	JPCP (existing)	8.5
Subgrade	A-4	24.0
Subgrade	A-4	Semi-infinite

Volumetric at Construction:

Effective binder content (%)	11.6
Air voids (%)	8.0

Traffic

Age (year)	Heavy Trucks (cumulative)
2012 (initial)	6,000
2018 (6 years)	6,461,420
2024 (12 years)	13,661,300

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in./mile)	172.00	105.11	90.00	100.00	Pass
Permanent deformation - total pavement (in.)	0.75	0.20	90.00	100.00	Pass
Total Cracking (Reflective + Alligator) (percent)	100.00	7.33	-	-	-
AC thermal fracture (ft/mile)	250.00	217.40	90.00	95.93	Pass
JPCP transverse cracking (percent slabs)	15.00	19.72	90.00	74.75	Fail
AC bottom-up fatigue cracking (percent)	25.00	1.45	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	2000.00	257.71	90.00	100.00	Pass
Permanent deformation - AC only (in.)	0.25	0.20	90.00	98.85	Pass



FDR and New HMA design inputs

The screenshot displays a software interface for pavement design, titled "1200700_I70FullDepthHMA:Project".

Explorer Panel (Left):

- Projects
 - 0200700_I70FullDepthHMA
 - Traffic
 - Single Axle Distribution
 - Tandem Axle Distribution
 - Tridem Axle Distribution
 - Quad Axle Distribution
 - Climate
 - AC Layer Properties
 - Pavement Structure
 - Layer 1 Flexible : Asphalt concrete
 - Layer 2 Flexible : Asphalt concrete
 - Layer 3 Flexible : Asphalt concrete
 - Layer 4 Non-stabilized Base : Crushed stone
 - Layer 5 Subgrade : A-6
 - Layer 6 Subgrade : A-6
 - Project Specific Calibration Factors
 - New Flexible
 - Rehabilitation Flexible
 - New Rigid
 - Restore Rigid
 - Bonded Rigid
 - Unbonded Rigid
 - Sensitivity
 - Optimization
 - PDF Output Report
 - Multiple Project Summary
 - Batch Run
 - Tools
 - DARWin-ME Calibration Factors

General Information (Top Left):

- Design type: New Pavement
- Pavement type: Flexible Pavement
- Design life (years): 25
- Base construction: May 2012
- Pavement construction: July 2012
- Traffic opening: Septen 2012

Performance Criteria (Top Right Table):

	Limit	Reliability
Terminal IRI (in./mile)	160	90
AC top-down fatigue cracking (ft/mile)	2000	90
AC bottom-up fatigue cracking (percent)	10	90
AC thermal fracture (ft/mile)	50	90
Permanent deformation - total pavement (in.)	0.75	90
Permanent deformation - AC only (in.)	0.4	90
Reflective cracking (percent)	10	50

Layer Properties (Bottom Right):

Layer 1 Asphalt Concrete: Asphalt concrete

- Asphalt Layer**
 - Thickness (in.) 1.5
- Mixture Volumetrics**
 - Unit weight (pcf) 173.5 *Warning: Value is greater than*
 - Effective binder content (%) 13.4
 - Air voids (%) 7
- Poisson's ratio** (calculated)
- Mechanical Properties**
 - Dynamic modulus Input level: 1
 - Select HMA Estar predictive model Use Viscosity based model (nationally c
 - Reference temperature (deg F) 70
 - Asphalt binder Level 1 - SuperPave:

Thickness (in.)
Thickness of the asphalt concrete layer.
Minimum: 1
Maximum: 20



Decision making process

Treatment Selection



Treatment Selection Factors

- **Available Funds**
- **Staged Construction**
- **Traffic Control**
- **Lane Closure**
- **Minimum Desired Life**
- **Future Maintenance**
- **Geometric Issues**



Treatment Selection Factors (continued)

- **Present and Future Utilities**
- **Right-of-Way Restrictions**
- **Regulatory Restrictions**
- **Available Materials and Equipment**
- **Contractor Expertise and Manpower**
- **Agency Policies**



Selection Process

- **Develop feasible alternatives for evaluation**
- **Identify key decision factors important to agency (e.g., cost, service life, traffic control, duration of construction, etc.)**
- **Assign weighting values for each decision factor**
- **Assign scoring values for each alternative**
- **Add scores and rank alternatives**



Selection Worksheet

	Decision Factor 1	Decision Factor 2	Decision Factor 3	Decision Factor 4	TOTAL SCORE
Weight	Weight 1	Weight 2	Weight 3	Weight 4	
Alt 1					
Alt 2					
Alt 3					
Alt 4					



Questions???

