PAVEMENT REHABILITATION OPTIONS IN INDIANA FOR INDOT

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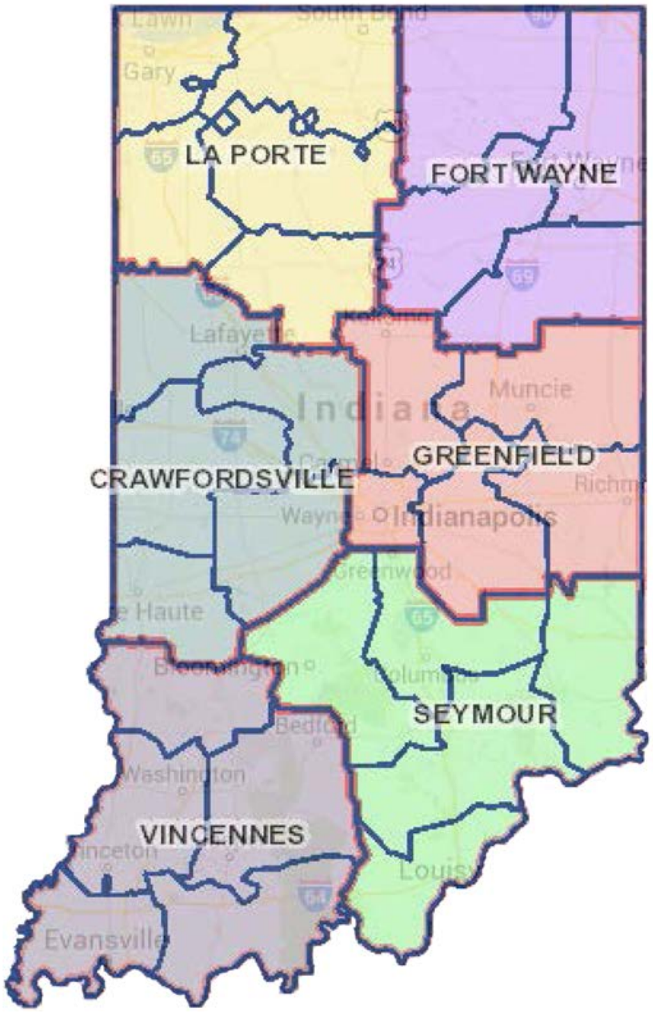
2015 Purdue Road School

INDOT Profile

- Six district offices
- 3,404 employees
- $1 billion/annual capital expenditures
- 28,400 total roadway lane miles
- 5,300 INDOT-owned bridges
- Assists 42 railroads in planning & development of more than 3,880 miles of active rail lines
- Supports 69 Indiana State Aviation System Plan airports



The Stage

In 1818 the Institution of Civil Engineers was founded in London, and in 1820 the eminent engineer Thomas Telford became its first president. The institution received a Royal Charter in 1828, formally recognizing civil engineering as a profession. Its charter defined civil engineering as:

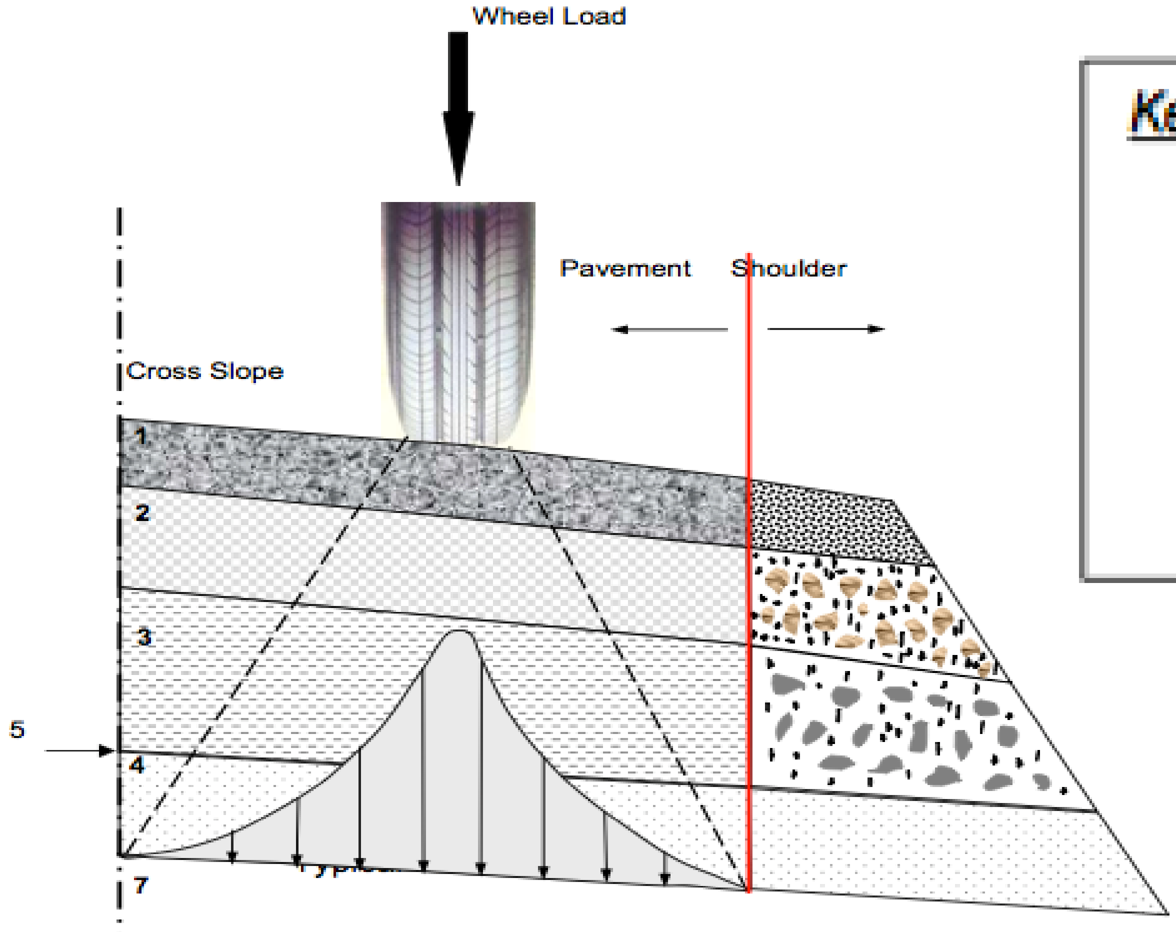
> The art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the construction of ports, harbors, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and application of machinery, and in the drainage of cities and towns.

Institution of Civil Engineers, 1 Great George Str, Westminster, London

The Stage

The art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, …

Definitions – Flexible Pavement



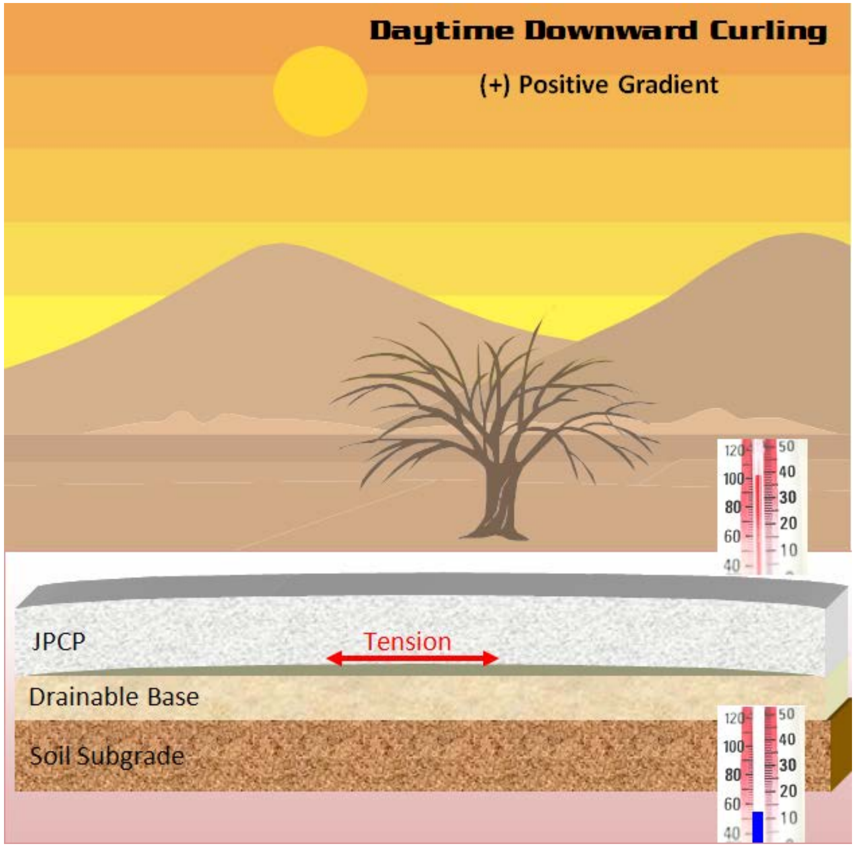
Key:

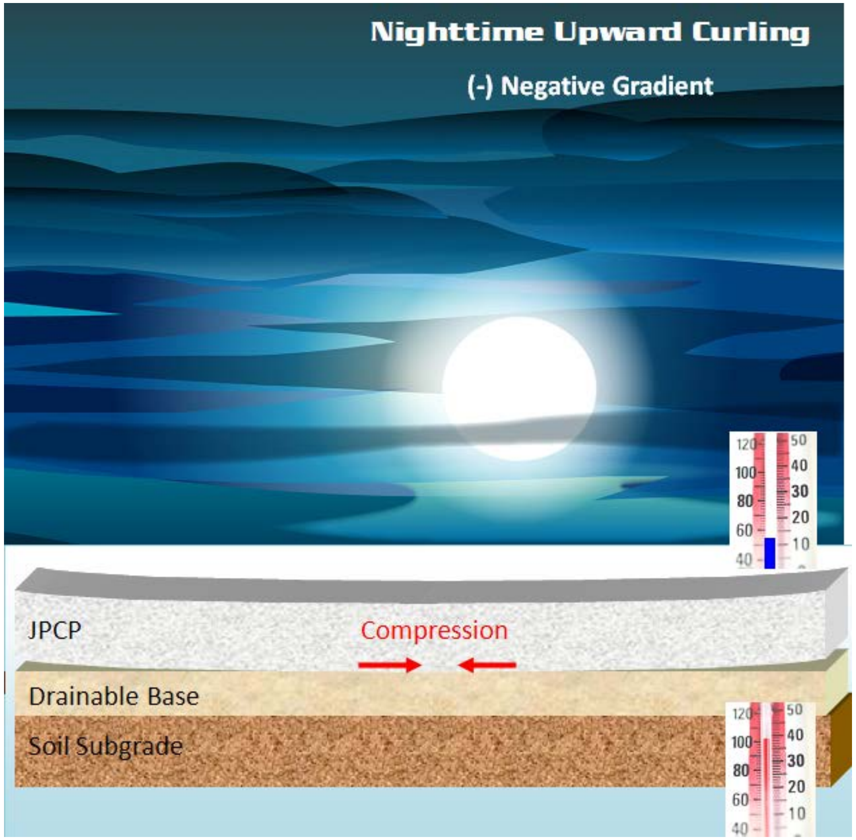
1: A.C. surface course
2: base
3: sub base
4: compacted road
5: subgrade
6: concrete surface
7: roadbed

HMA pavement cross section

- 1.5” Surface
- 2.5” Intermediate
- 3”+ Dense graded base
- 3” Open graded base
- 3” Dense graded base
- 14” Soil treatment
- Soil subgrade
- Foundation Soil

Stress and strain in rigid pavement





JPCP cross section

11” – 13” JPCP

3” Open graded stone

6” - 12” Dense graded stone

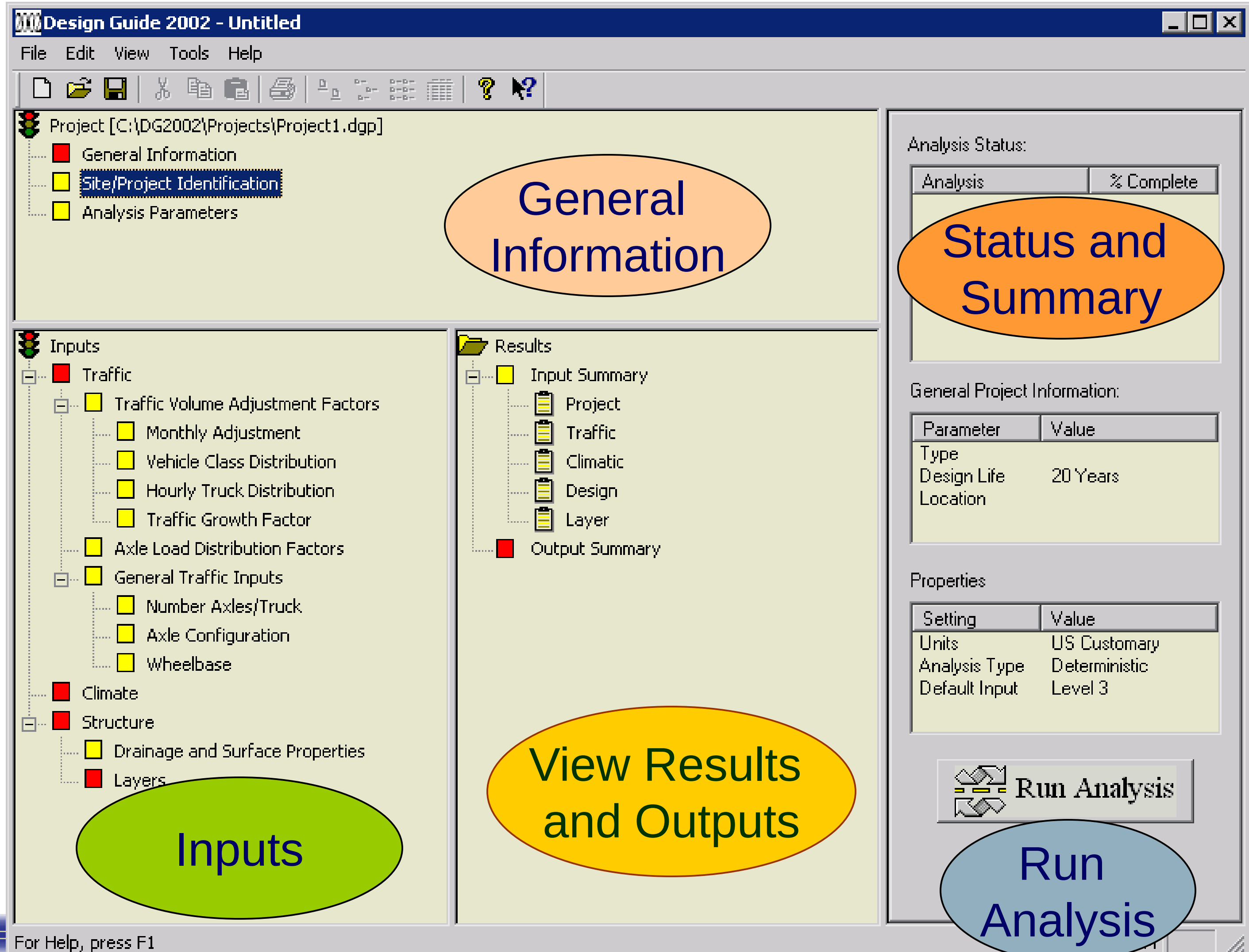
14” Soil treatment

Soil subgrade

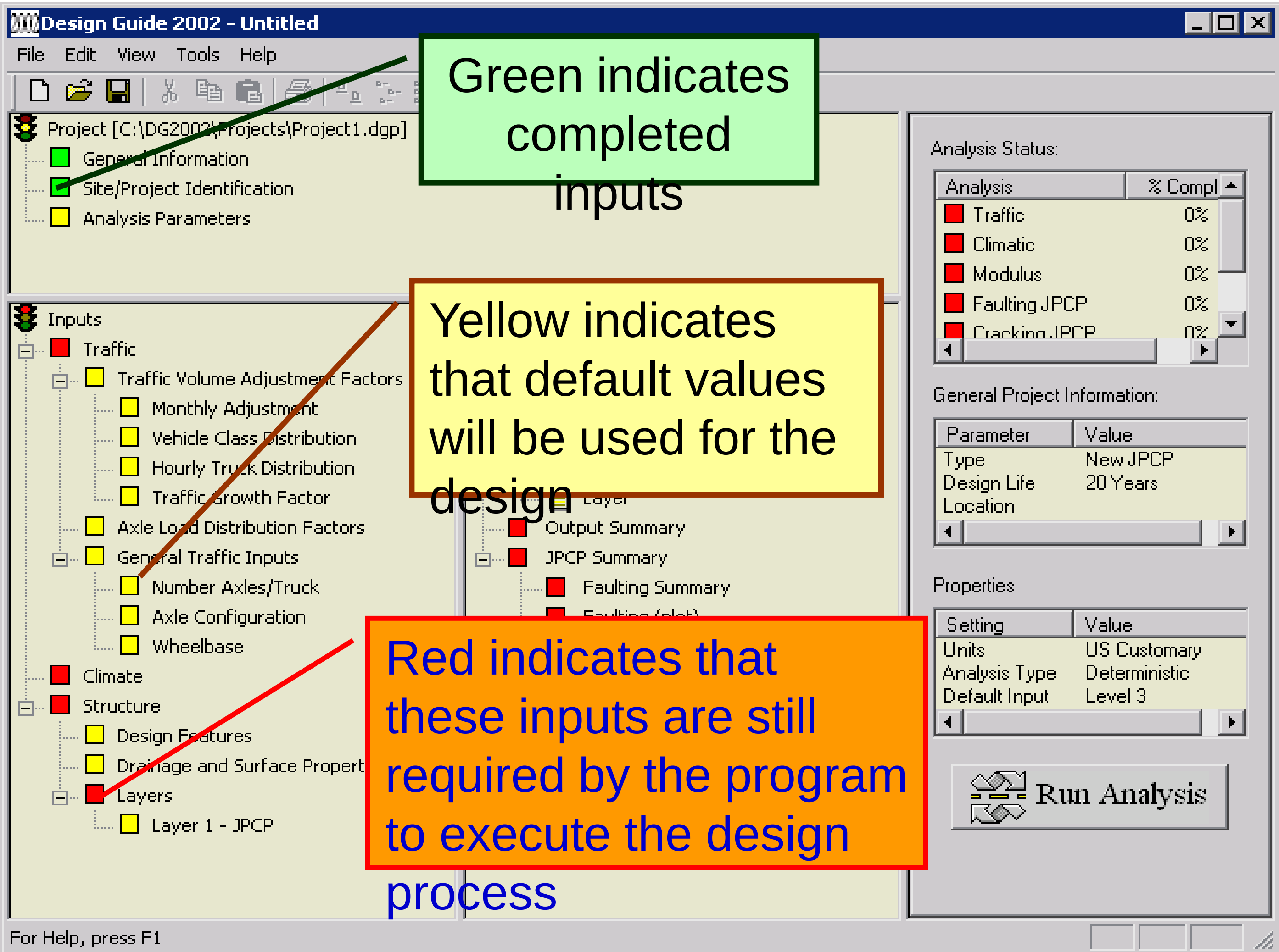
Foundation Soil


NCHRP
M-E PDG
Mechanistic-Empirical Pavement Design Guide
This software is for review only and should not be used for design.
This software was developed under NCHRP 1-37A and 1-40D.
Distribution of this software must be approved by NCHRP.
developed by
APPLIED RESEARCH ASSOCIATES, INC
TRANSPORTATION
ASU

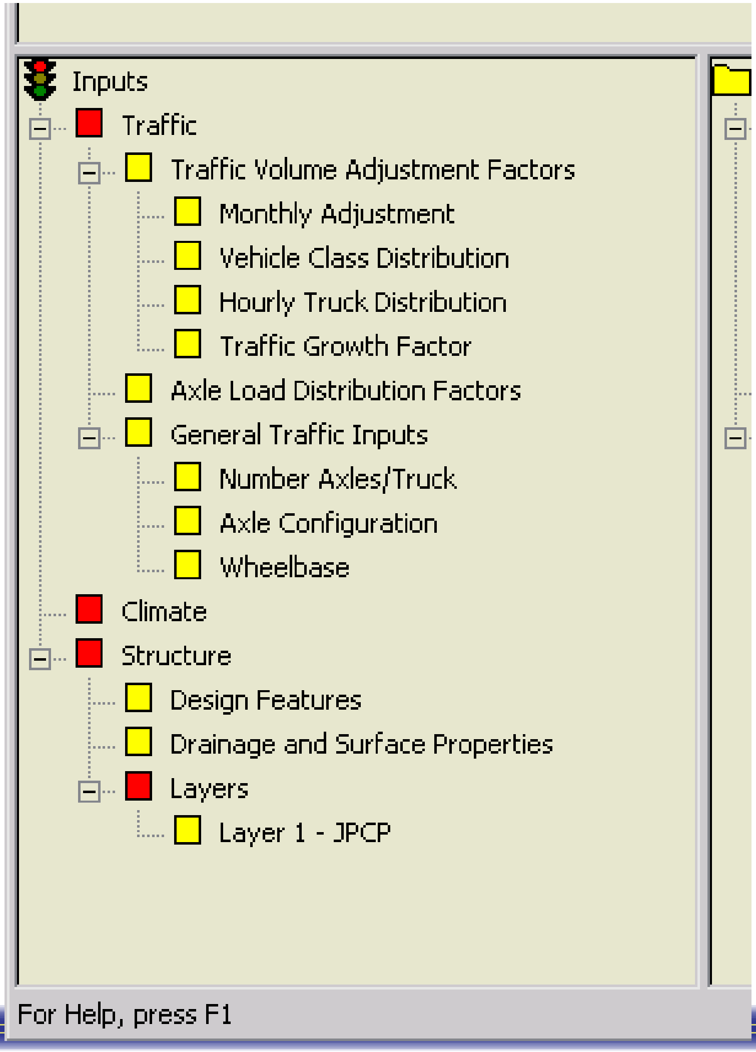
Main project screen



Color-coded status icons

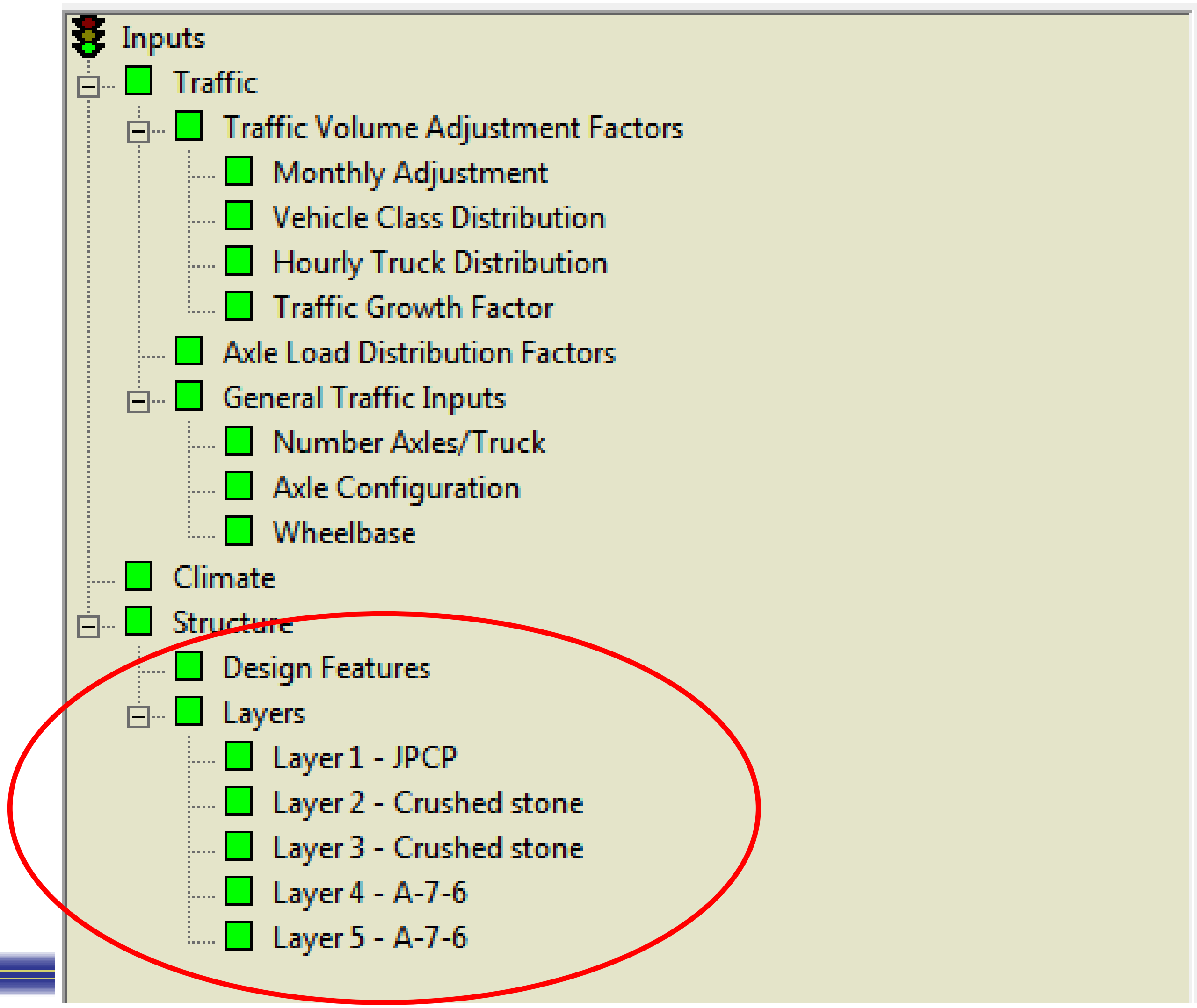


Design inputs

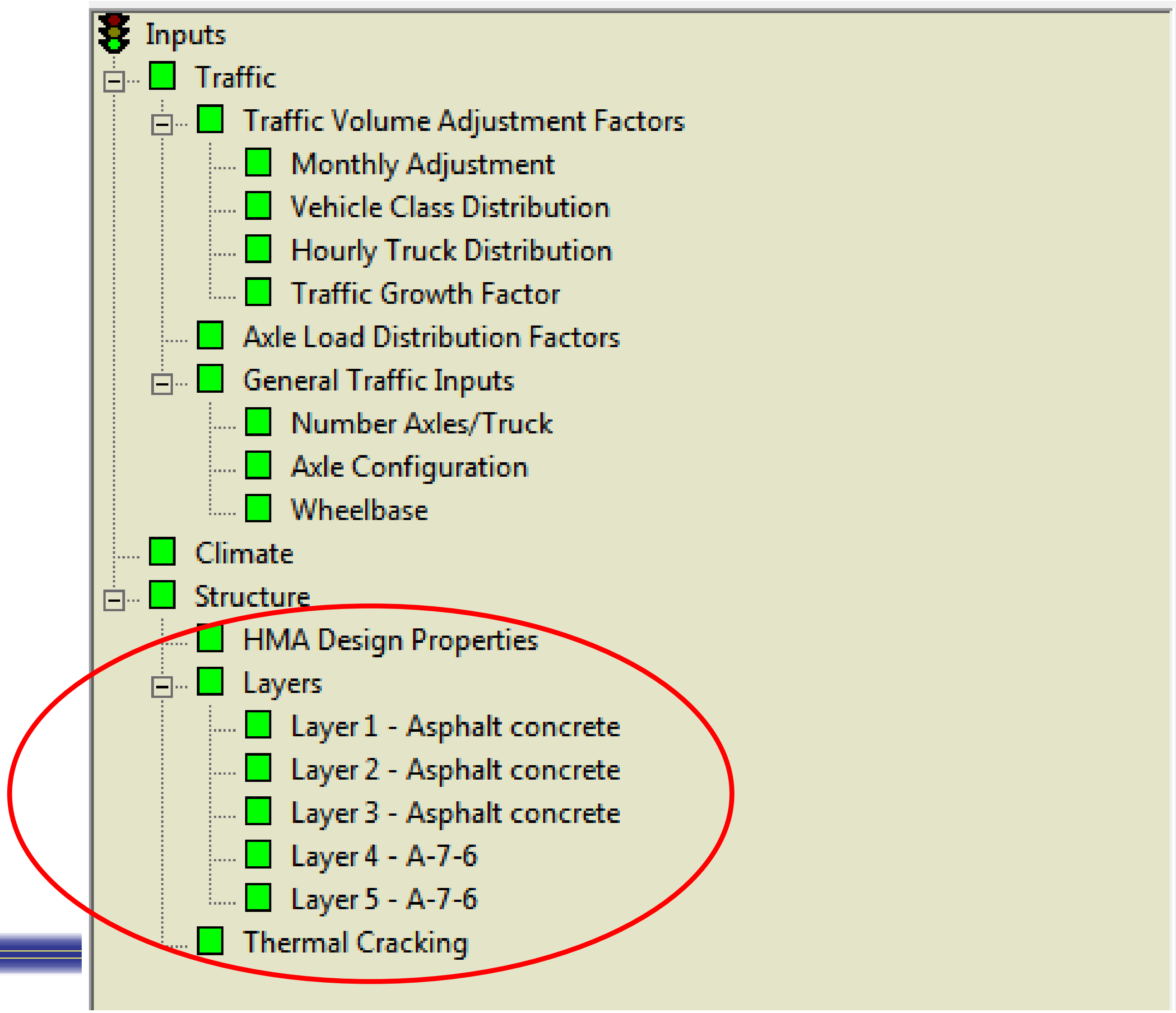


- Traffic
- Climate
- Structure

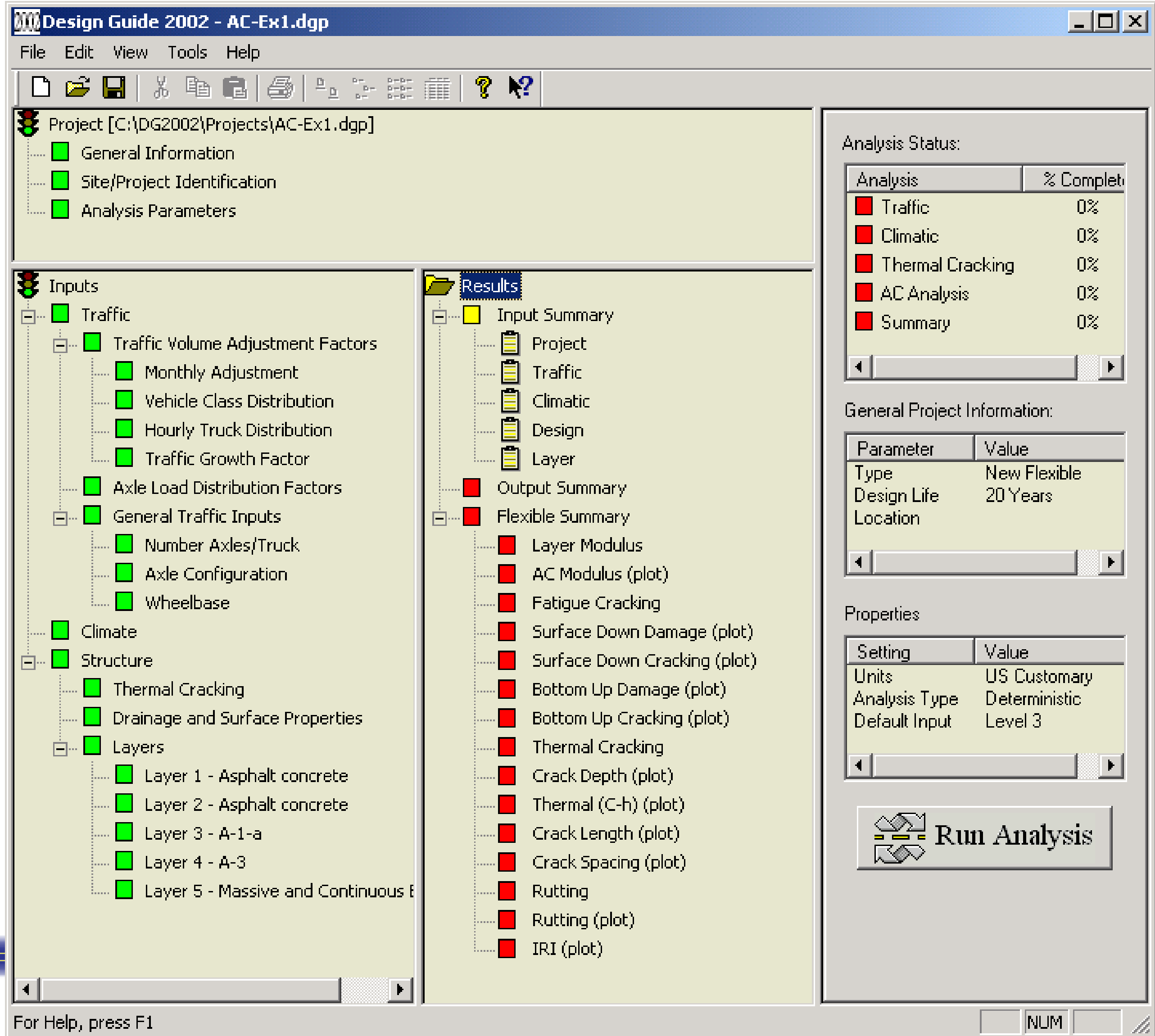
JPCP design feature, layers, and material properties

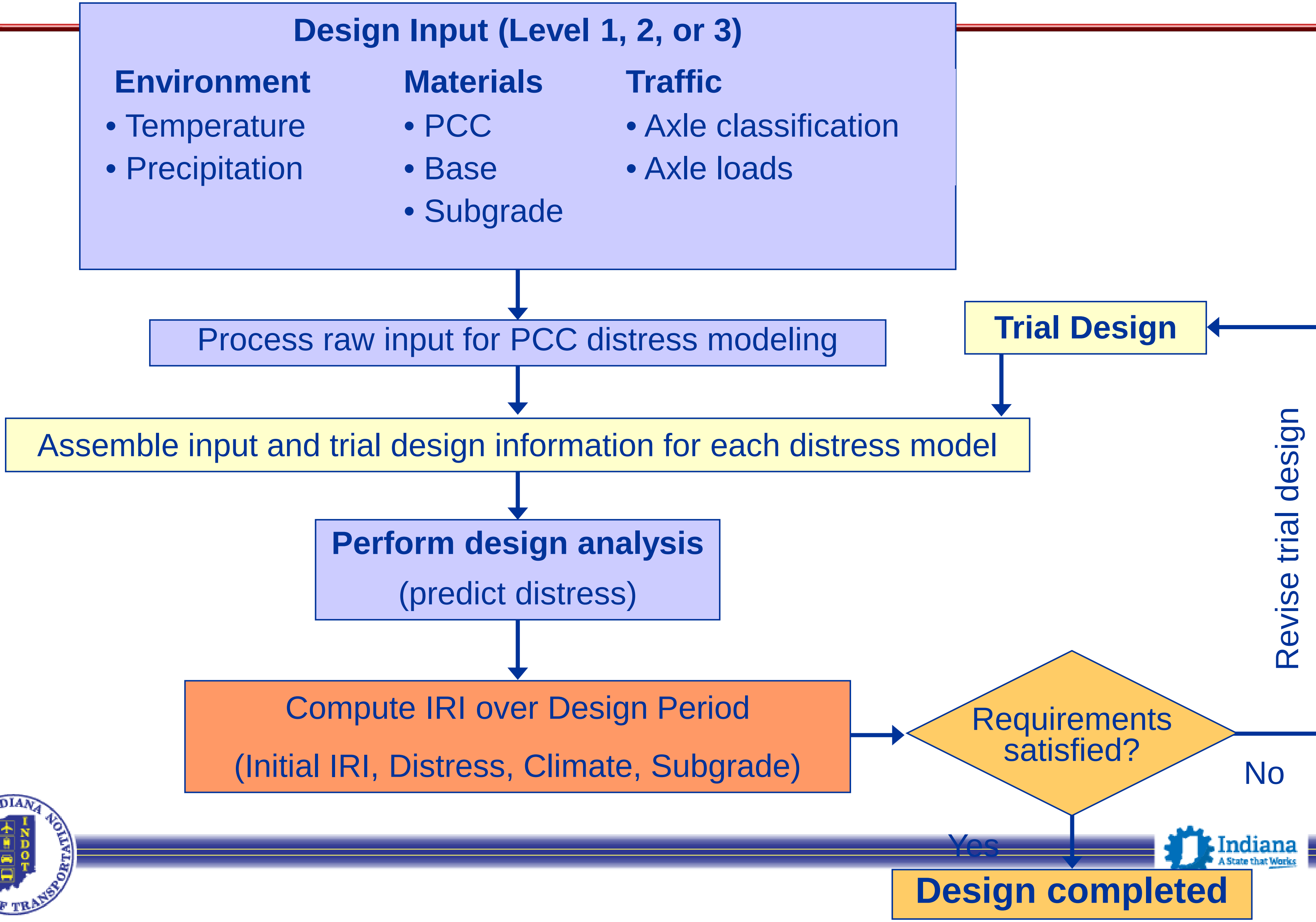


HMA design properties, layers, and thermal cracking



Run analysis




Design Input (Level 1, 2, or 3)
Environment
• Temperature
• Precipitation
Materials
• PCC
• Base
• Subgrade
Traffic
• Axle classification
• Axle loads
Process raw input for PCC distress modeling
Trial Design
Assemble input and trial design information for each distress model
Perform design analysis
(predict distress)
Revise trial design
Compute IRI over Design Period
(Initial IRI, Distress, Climate, Subgrade)
Requirements satisfied?
No
Yes
Design completed

Historical Project Selection

- **Historical pavement AM – Pre 1970s**
  - We’ve been managing pavements since there have been roads!
  - AASHTO Road Test (1950s-60s)
    - Limited loading weights and cycles compared to today
    - Now 50-yrs old data
    - Truck weights and age vastly different
  - BEST WE HAD AT THE TIME!

Historical Project Selection

- **Historical pavement AM - 1970s/80s**
  - Subject matter expert based project selection
  - Case-by-case
  - Informal network analysis
  - Professional memory based

  - Developing objective theory
  - Establishing some objective measures
    - IRI, roughness, etc.

Historical Project Selection

- **Historical pavement AM - 1990s**
  - Initially interstate only (‘91-’92)
    - INDOT interstate program centrally managed
    - Van trips post-data analysis, SME input
    - dTIMS AM software obtained
    - Limited models !
    - Data limitations !
      - IRI / Rut / PCR (10% sampling)

Historical Project Selection

- **Historical pavement AM - 1990s**
  - Non-interstate model developed ‘96-’97
    - Limited models
    - Data limitations
    - IRI / Rut / PCR (10% sampling)
  - Computer processing improvements

Current Project Selection

- **Decision-Support Information needed:**
  - Traffic: AADTT, truck volumes
  - Condition: IRI, rut, cracking type & severity, friction, structural adequacy, drainage,
  - Inventory: location, geometrics
  - Materials: soils, HMA mix, PCC mix
  - History: maintenance, construction, jurisdictional

Current Project Selection

- **How is the road?**
  - Condition adequacy
- **What do you need to do?**
  - Engineering perspective
  - Business perspective

Current Project Selection

- **Initial engineering perspective**
  - No problems
  - Minor flaws
  - Major flaws
  - REAL MAJOR PROBLEMS

Current Project Selection

- **Engineering problem - AM perspective**
  - No problems
  - Lack of maintenance
  - Rough ride
  - Beginning of structural deterioration
  - Advanced structural deterioration
  - Structurally failed
  - Roadside / drainage problems

Current Project Selection

- **Business owner perspective**
  - It is about money
  - Is the pavement unacceptable or not?
  - How much is it going to cost to address?
  - How long will it not be a problem?
  - Different managerial approaches depending on the previous question's answer

Current Project Selection

- **Pavement is unacceptable now**
  - Do something now!
  - WORST FIRST maybe

  - Priority of effort
  - Not necessarily a strategic fix
  - GET IT OUT OF UNACCEPTABLE category
  - Maybe least bad solution?

Current Project Selection

- **Pavement is acceptable**
  - Least cost of ownership approach
    - $/lane-mile year of service purchased
  - Optimized cost-effective right-treatment at right time for right cost approach
  - Or bridging strategy or approach

Current Project Selection

- **Possible fixes**
  - Do nothing
  - Routine maintenance
  - Reactive maintenance
  - Preventative maintenance or PPI (pavement preservation initiative) treatment
  - Structural treatments
  - Each approach has several optional treatments
  - Options have cost, time & benefit ranges

Current Project Selection

- **Comprehensive list of *NEEDS!***
- **Process this list through business guidance**
  - Priority of resourcing / effort
  - Effectiveness of relative improvements
  - Priority of relative improvements
  - Funding

Current Project Selection

- **Problem assessment and statement**
- **Possible solutions**
  - Treatment options
- **COA screening and evaluation**
  - Worst first worst, but necessary
  - Engineering economics intervention point optimization
  - Temporary bridging strategy or approach

Current Project Selection

- **COA screening and evaluation**
  - Delineated factors & considerations
    - Your successor might need to know
    - I call it the “dumb bunny’ innoculation
  - FAS-DC
  - Recorded
    - Where did you use ____________ logic
      - worst first worst, but necessary
      - engineering economics intervention point optimization
      - temporary bridging strategy or approach

Current Project Selection

- **COA screening and evaluation**
  - Engineering economics intervention point optimization
    - Echelons of treatments
      - Routine maintenance <$1K/ln-mi/svc yr?
      - Reactive maintenance ? / TBD
      - Preventative maintenance $5K/ln-mi/svc yr?
      - Functional/smoothness treatments $7-20K/ln-mi/svc yr?
      - Structural minor rehab treatments $10-25K/lm-mi/svc yr(?)
      - Structural major rehab treatments $25-35K/ln-mi/svc yr(?)
      - Structural pavement replacement $1Mil/ln-mi/svc yr(+)(?)

Current Project Selection

- speaker note - talk about:
  - $33 vs. $9 Million
  - Last Friday
  - Repeated internal/external examples

  - That which you inspect gets done well

Current Project Selection

- **Requirements for Treatment Selection**
  - What are my Options?
  - Which One is Best Value?
  - Prove It, and I'll Spend Taxpayer Dollars!
  - What is the menu of choices?

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

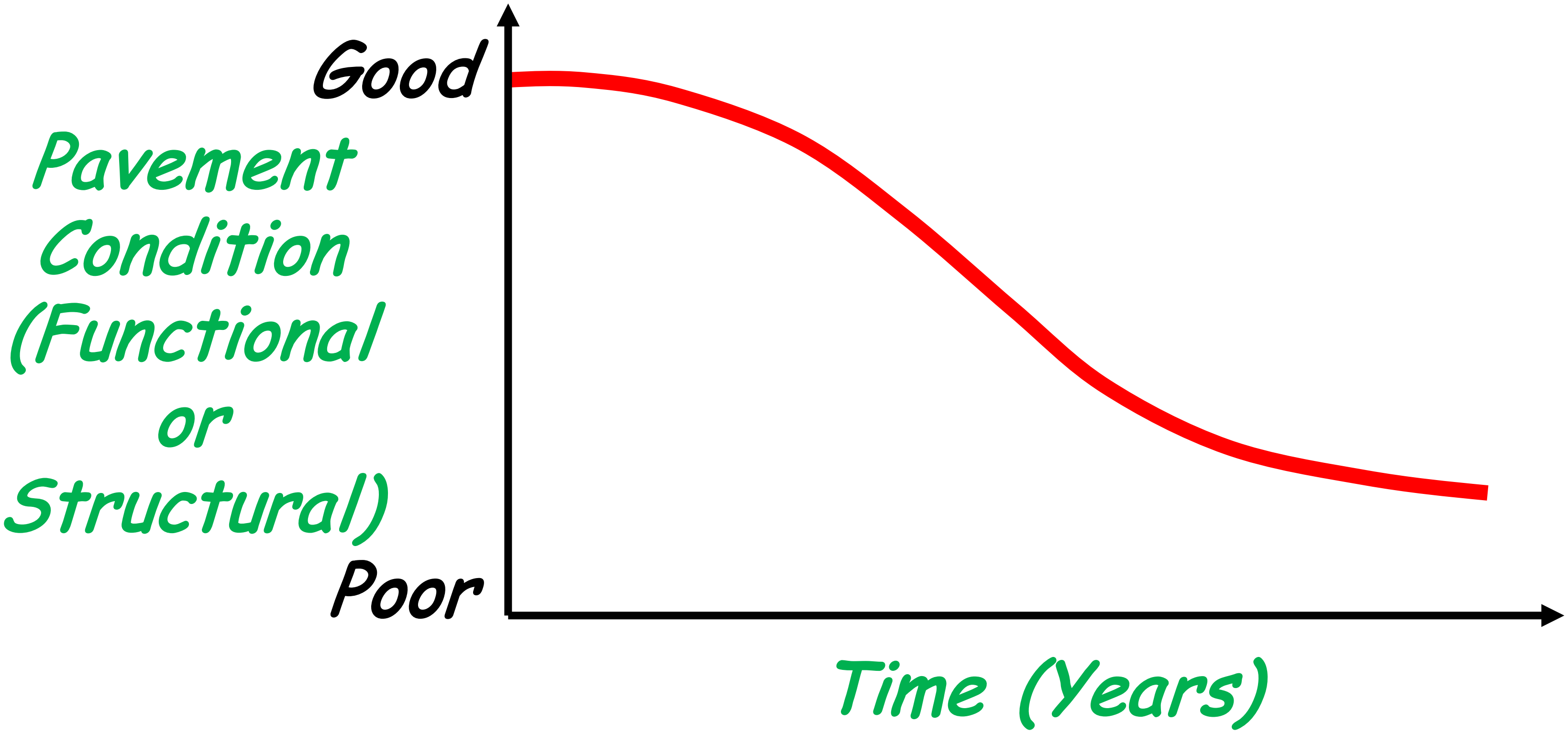
Identification of Candidate Treatments

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

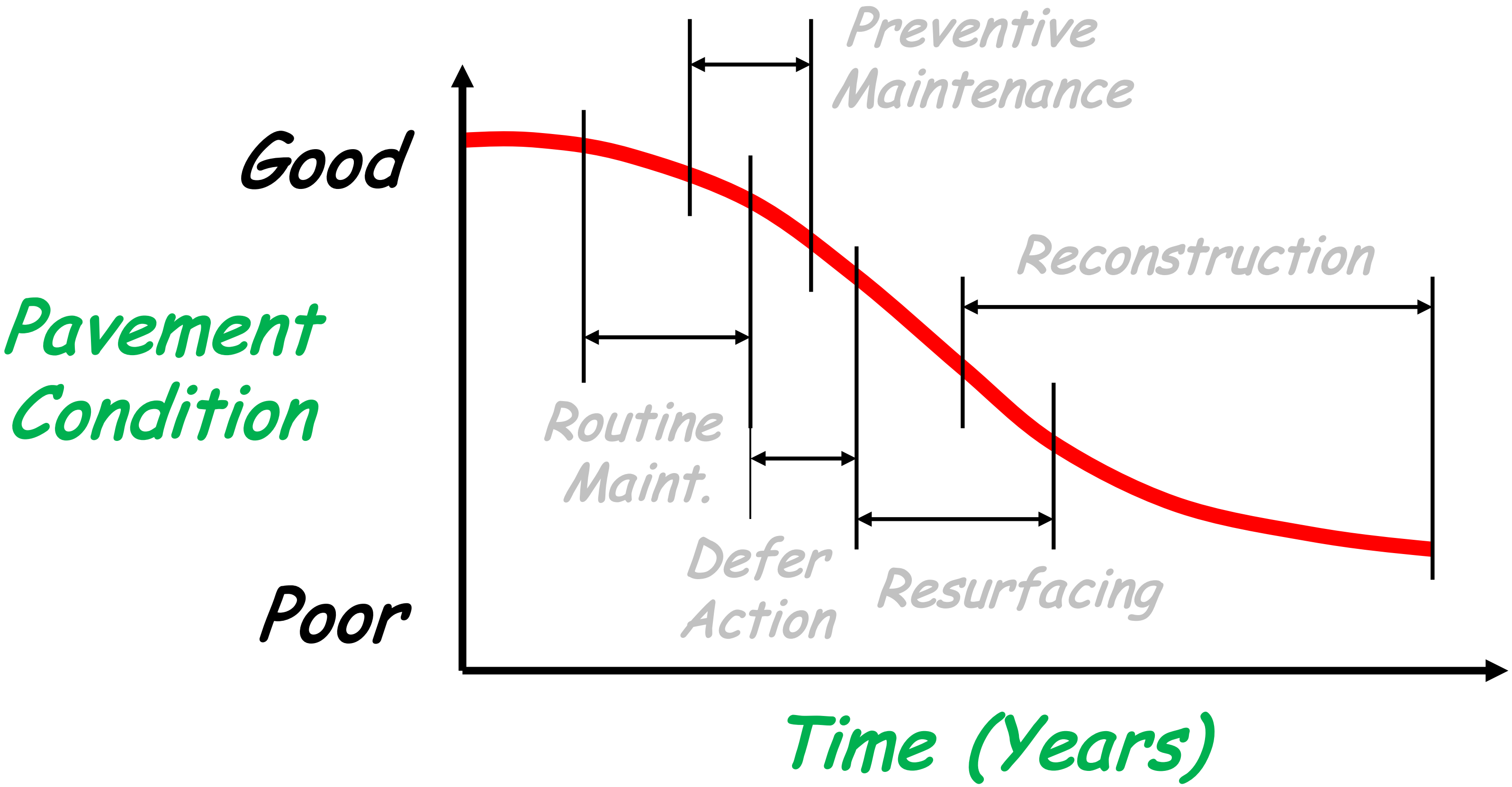
Treatment Timing Issues

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

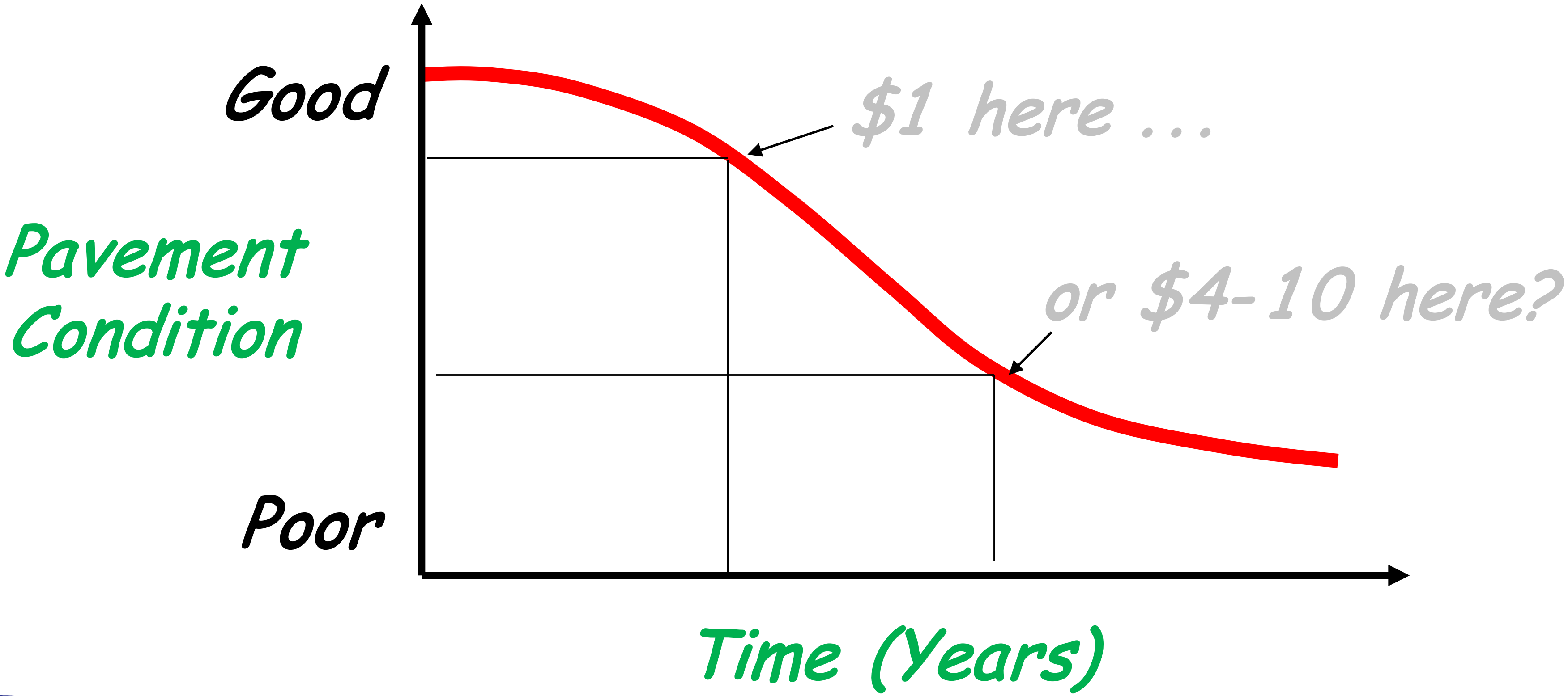
Typical Pavement Performance Curve



Typical Pavement Performance Curve



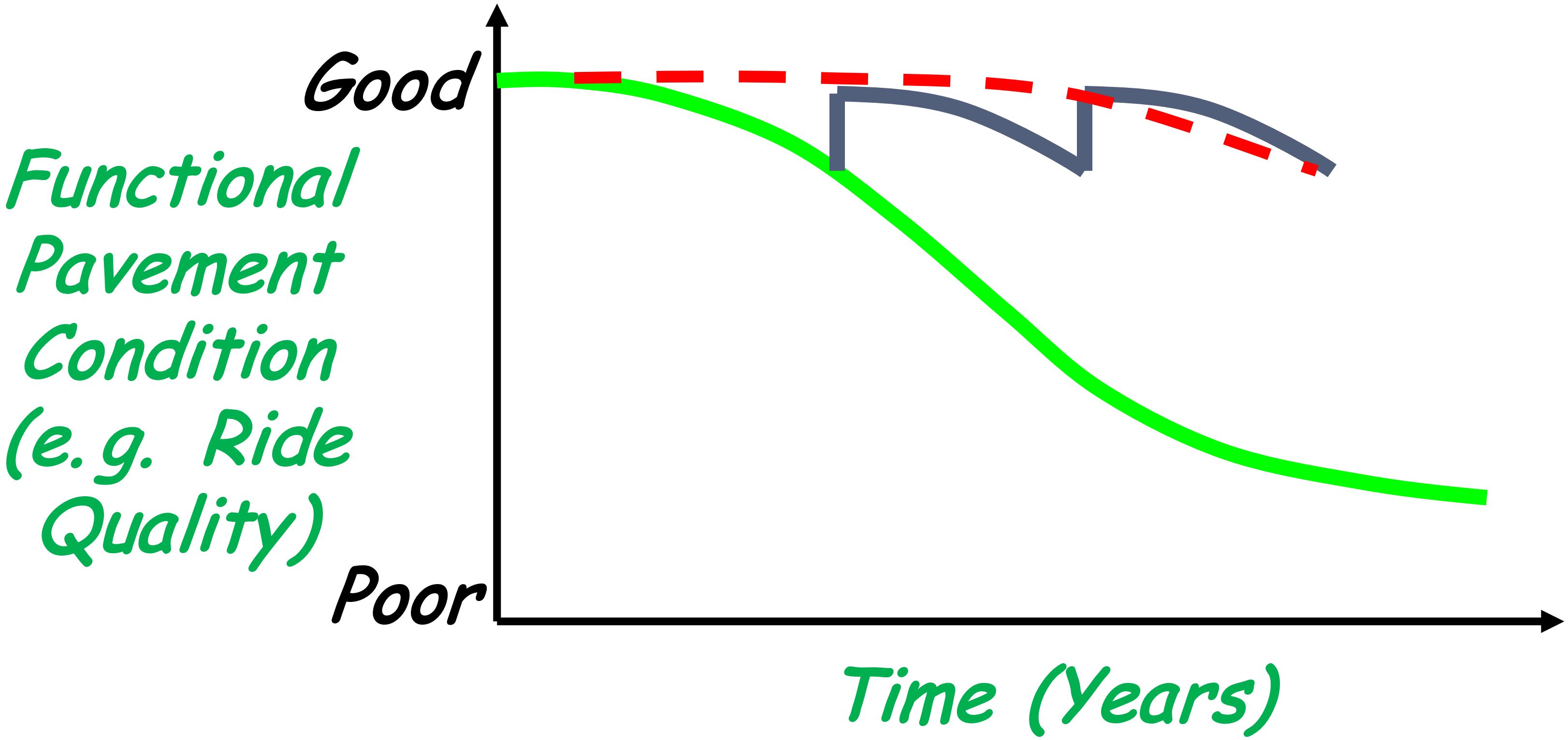
Cost Effects



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?

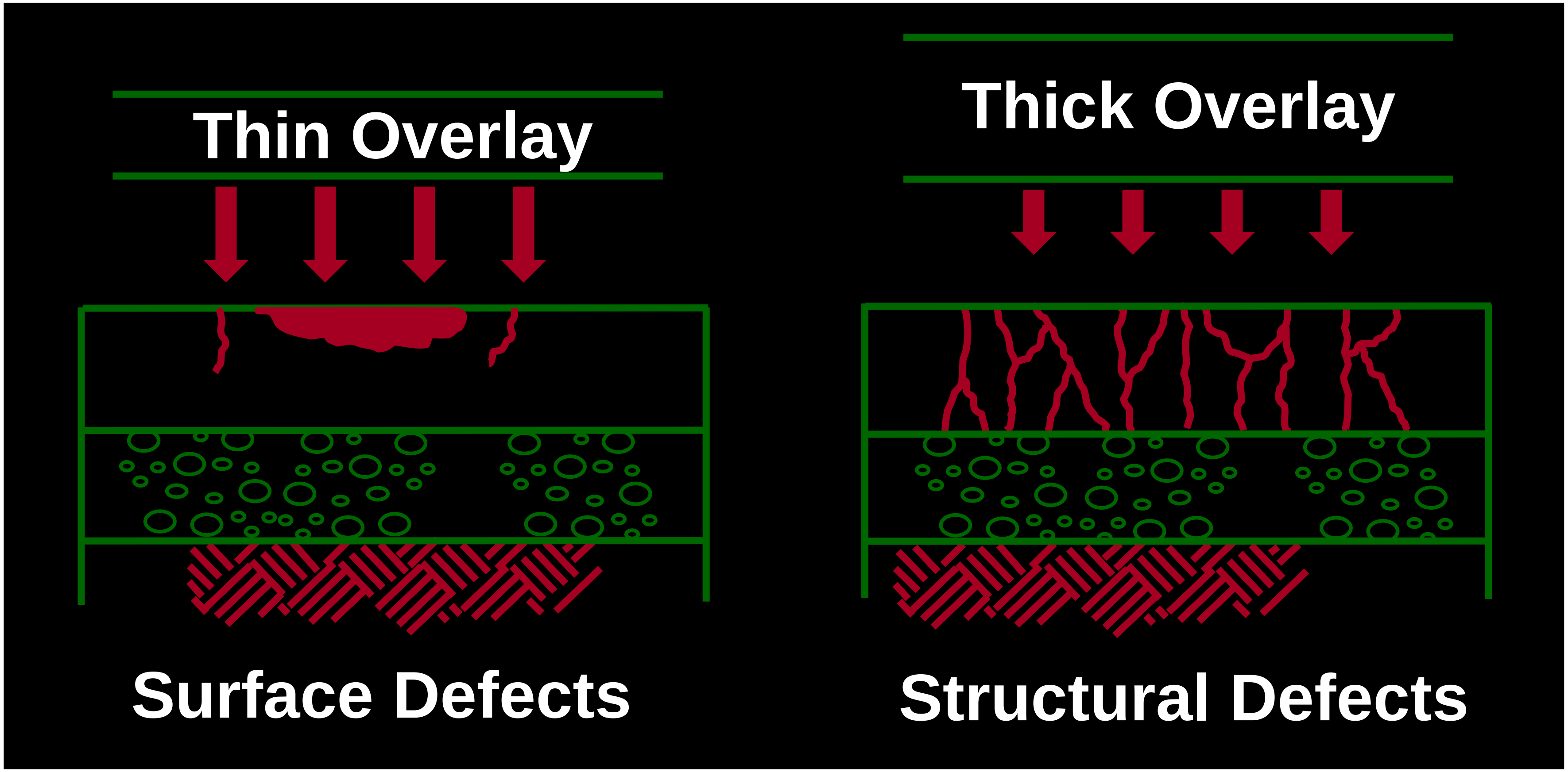
- **Distress exhibited in HMA**
- **Intended design life of the overlay**
- **Availability of quality materials**

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

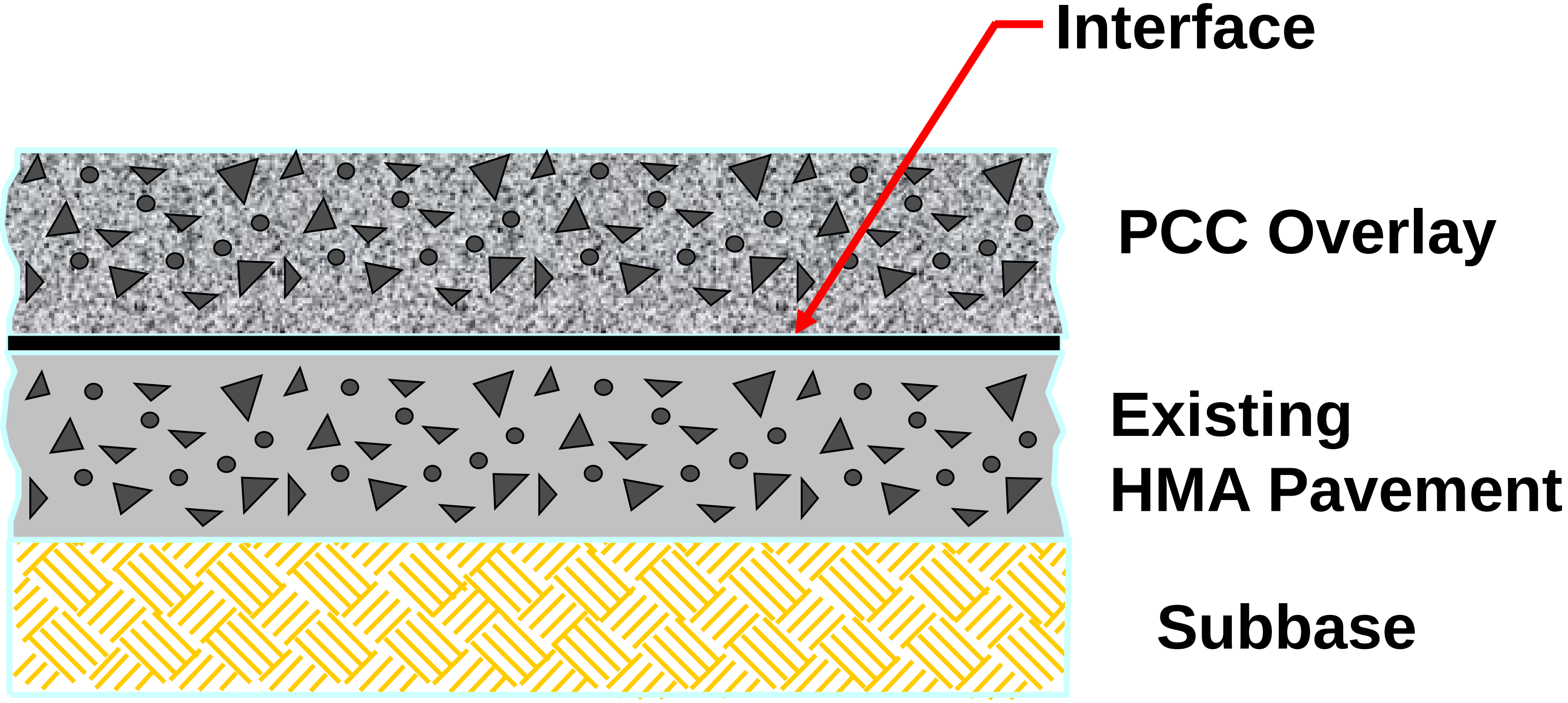
Conventional Rehabilitation Treatment

Concrete Pavement Overlay

Types of Whitetopping Overlays

- **Conventional Whitetopping**
  - Slabs greater than 100 mm (4 in.) thick
  - Placed directly on HMA pavement (little preoverlay repair)
- **Ultra-Thin Whitetopping**
  - Thin slabs (50 to 100 mm thick) (2 to 4 in.)
  - Short joint spacing (0.6 to 1.8 m) (2 to 6 ft)
  - 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 (2 in.)**
- **Repair of severe alligator cracking if poor support would otherwise result**

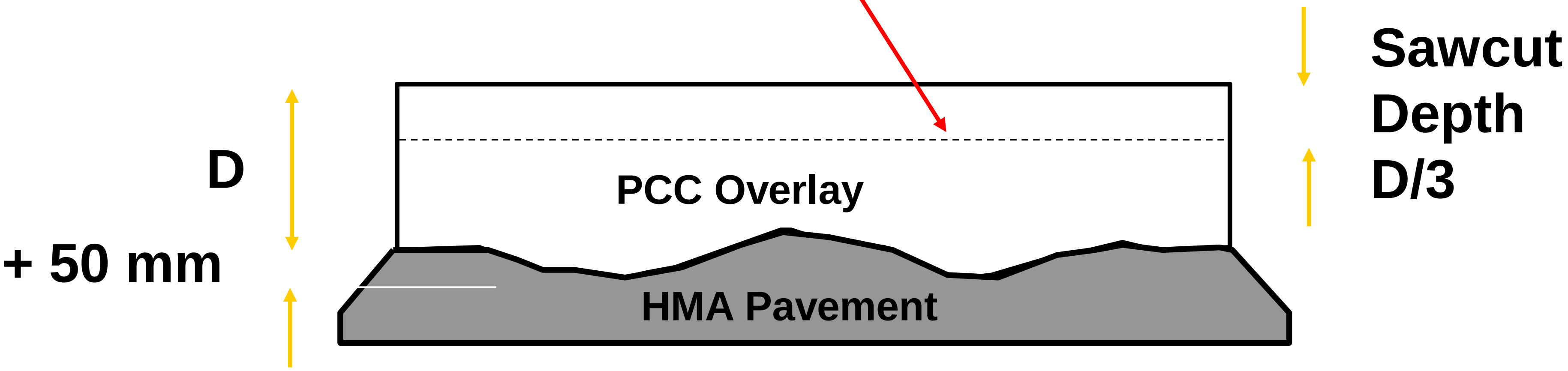
Goal: Uniform support

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 - 2.0 in)
- RAP mixed with additives and relaid
- Immediate opening to traffic
- Applicable for all traffic levels
- Resurfacing usually required.

Pavement Condition

Before 08/2012

After 08/2012


08/29/2012


08/29/2012


08/29/2012

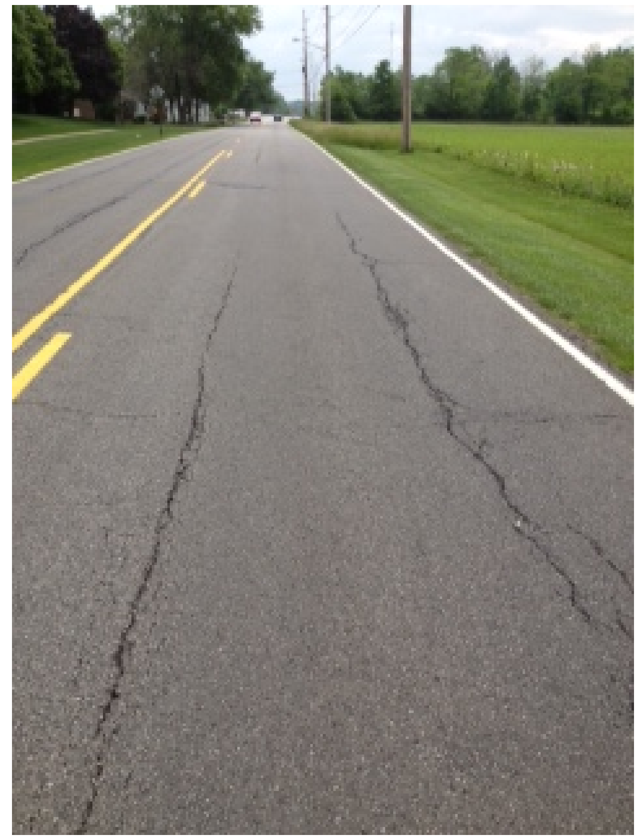

08/29/2012

08/29/2012

Pavement Condition

08/2012

06/2014



Rehabilitation Option

Cold In-Place Recycling

Cold In-Place Recycling Description

Asphalt Stabilized using emulsified asphalt or expanded (foamed) asphalt.

- Cold process
- Milling depth: 50 mm - 100 mm (2 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

Pavement Condition

- US 40 condition
  - Aged surface
  - Minor rutting
  - Heavy patching due to stripped HMA layer

Pavement Milling

- Milling operation will cut up to 4” depth and windrow material
- Can incorporate virgin aggregate during milling operation

Stabilization

- Water, additives and stabilizing materials are incorporated into the windrow material
- The windrow is re-milled to mix the materials

Spreading

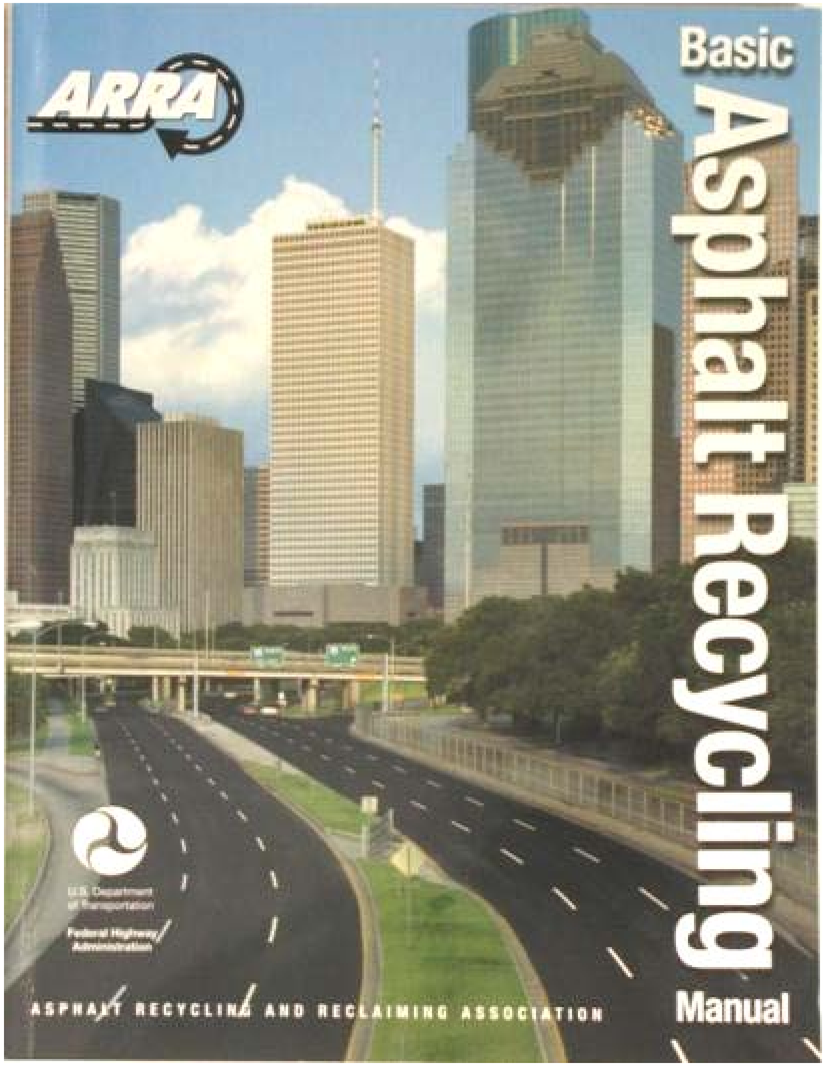
- The stabilized material is picked up by a windrow elevator
- The paver spreads the material
- Compaction is achieved using steel drum and pneumatic tire rollers

Overlay Preparation

- The CIR is tacked prior to the HMA overlay
- Paving commences

  US-40 had a 165 lb/sys 9.5 mm surface atop the CIR base

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
- Maximum pavement depth of ~14”

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

INDIANA DEPARTMENT OF TRANSPORTATION INDOT

Indiana A State that Works

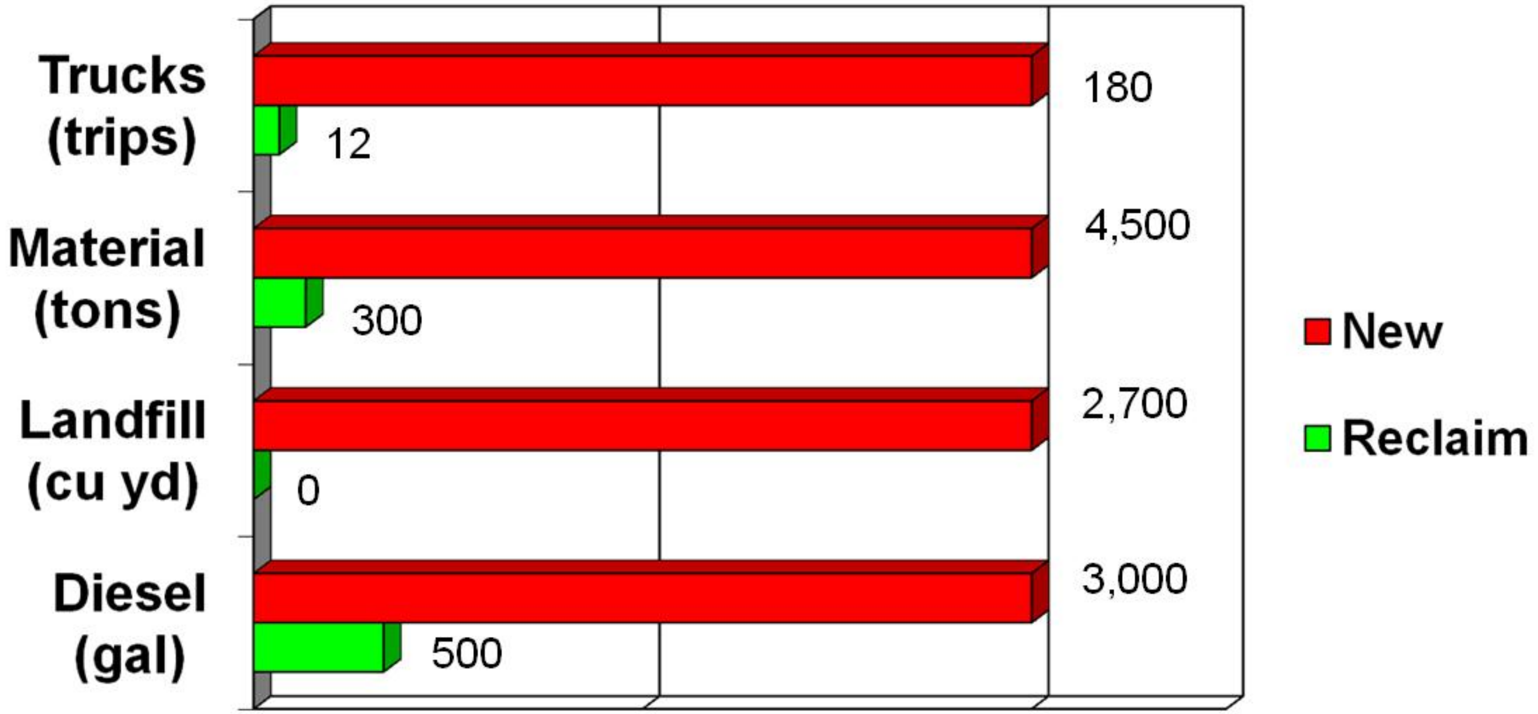
Advantages of the FDR Process

- 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

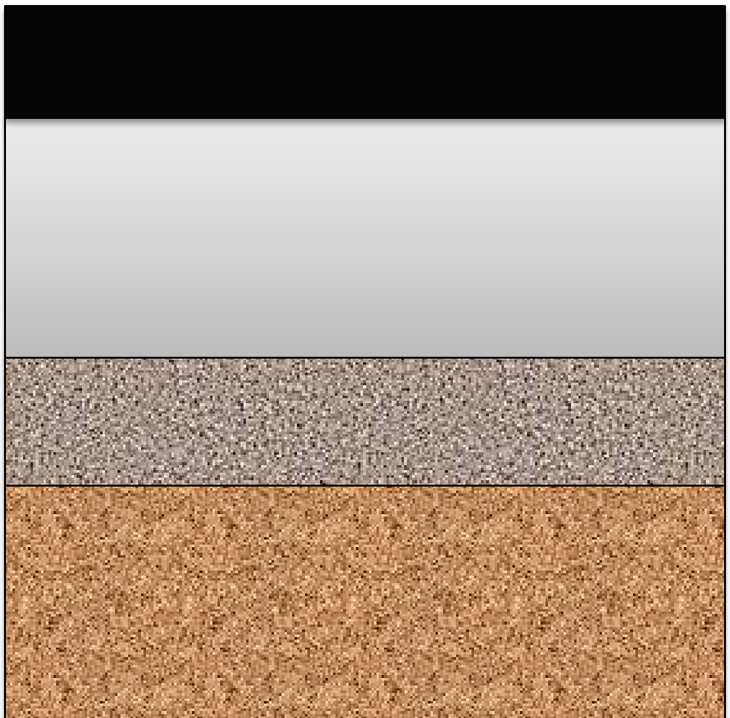
FDR in Indiana

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

HMA overlay

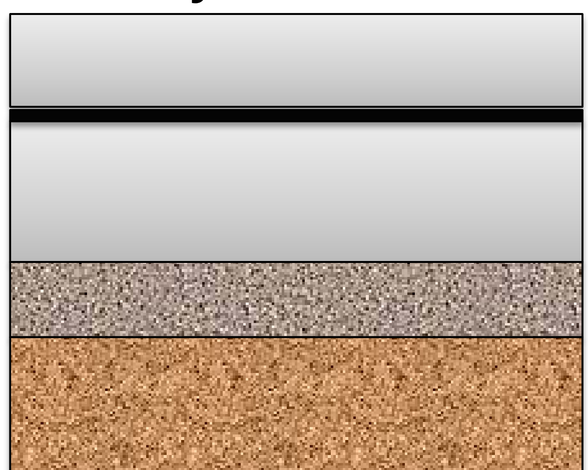
8.5” JPCP

3” Dense sand

Soil subgrade

12 year LCCA

25 year LCCA



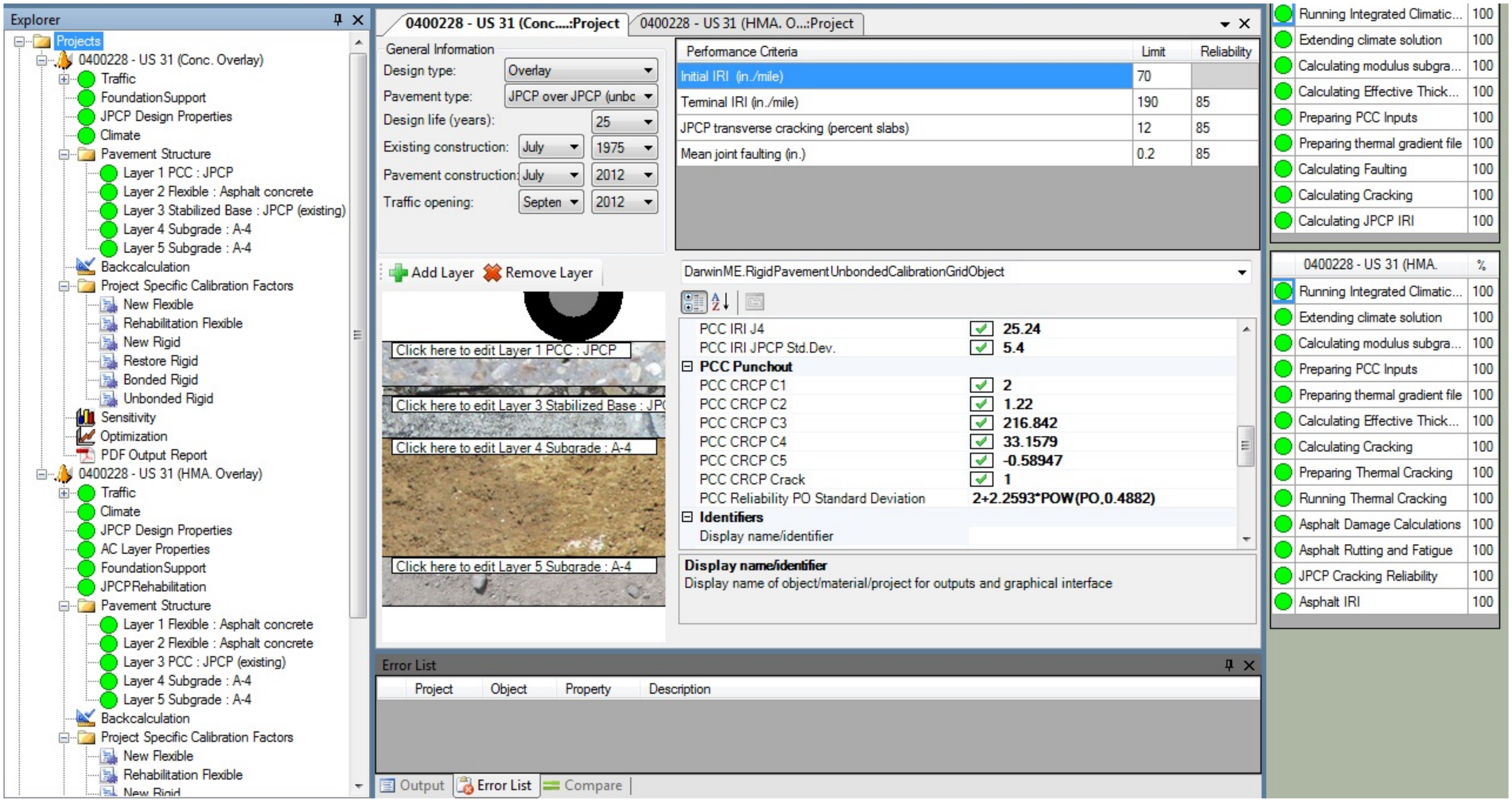
Concrete overlay

8.5” JPCP

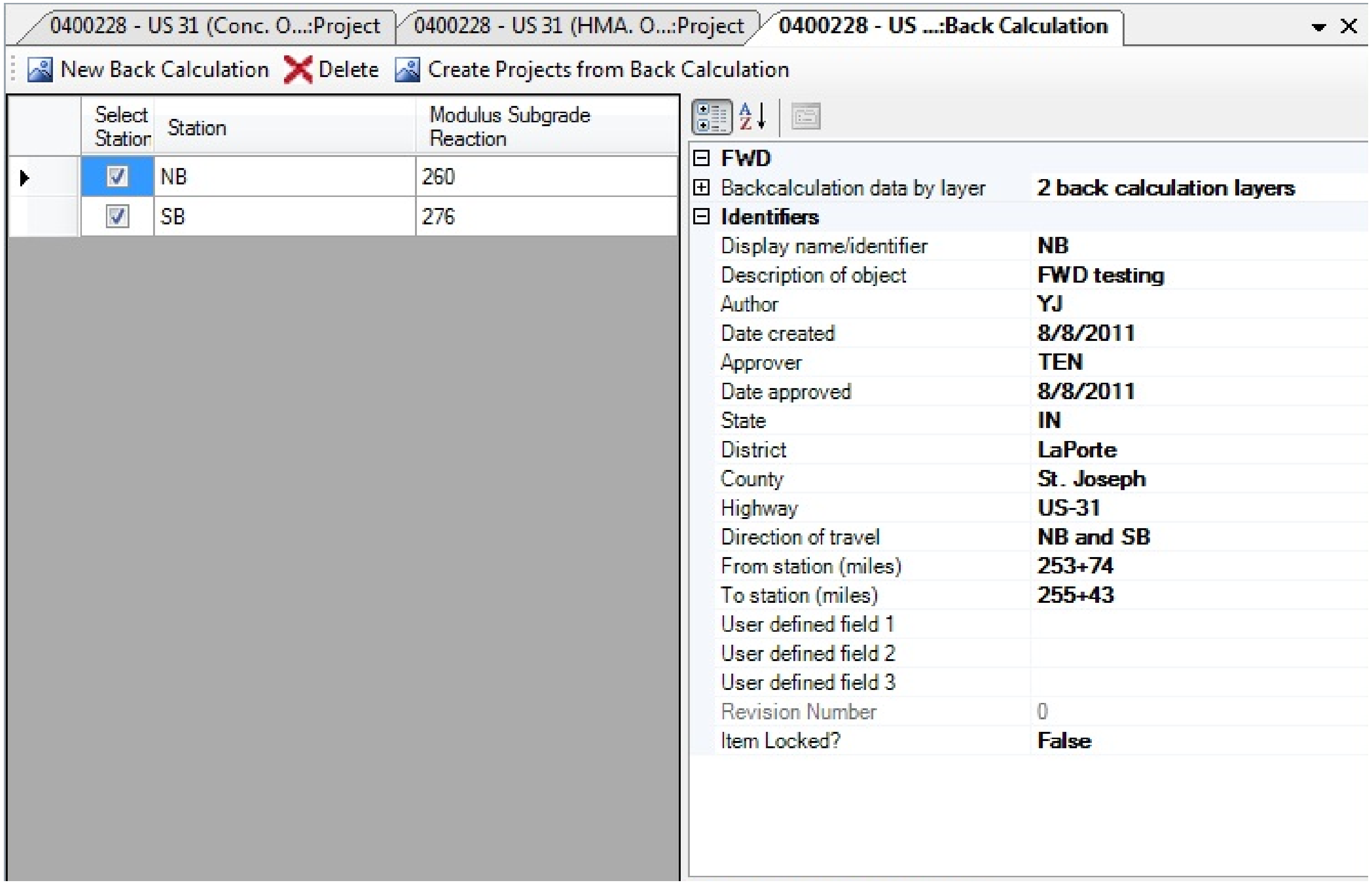
3” Dense sand

Soil subgrade

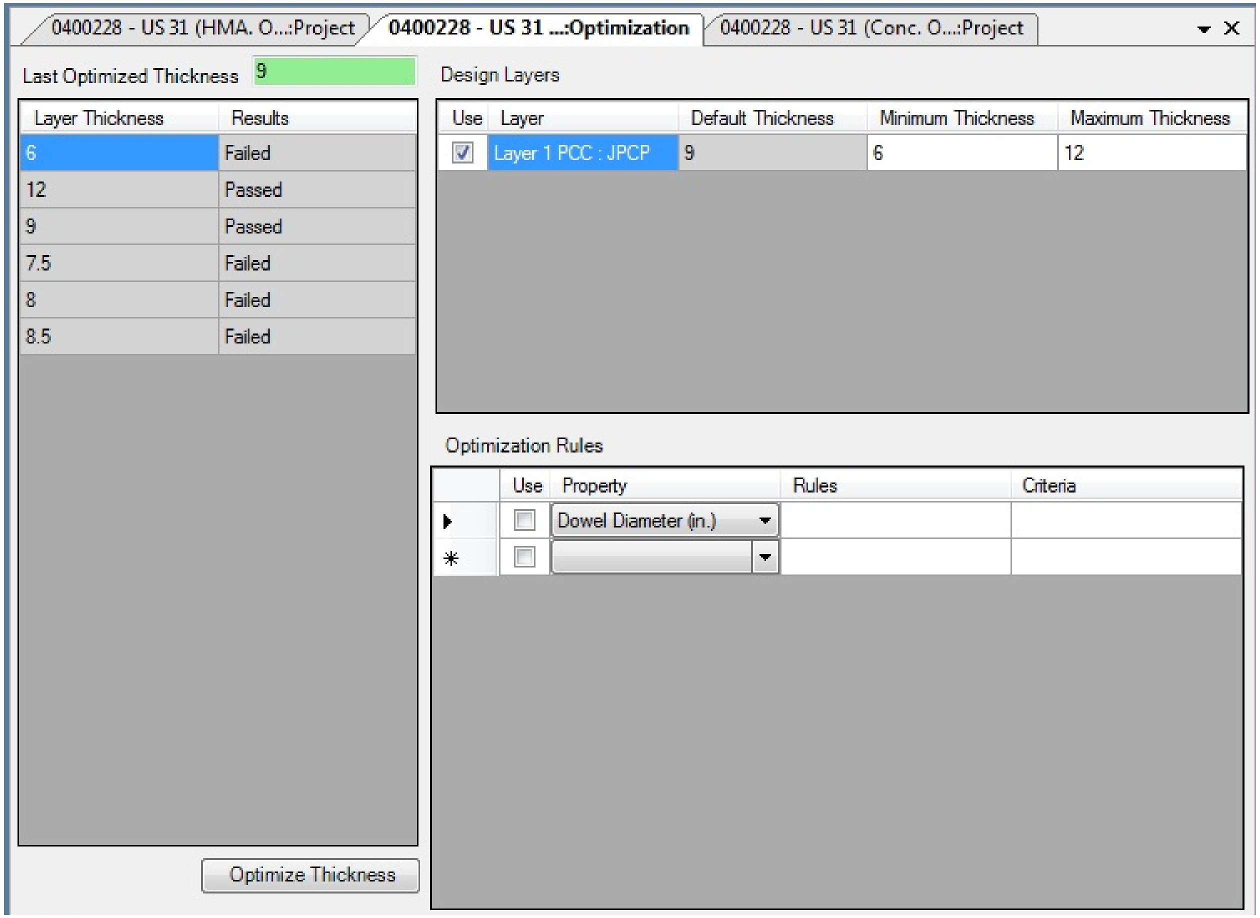
Design alternatives



Backcalculation inputs

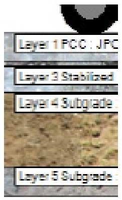


JPCP optimization



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

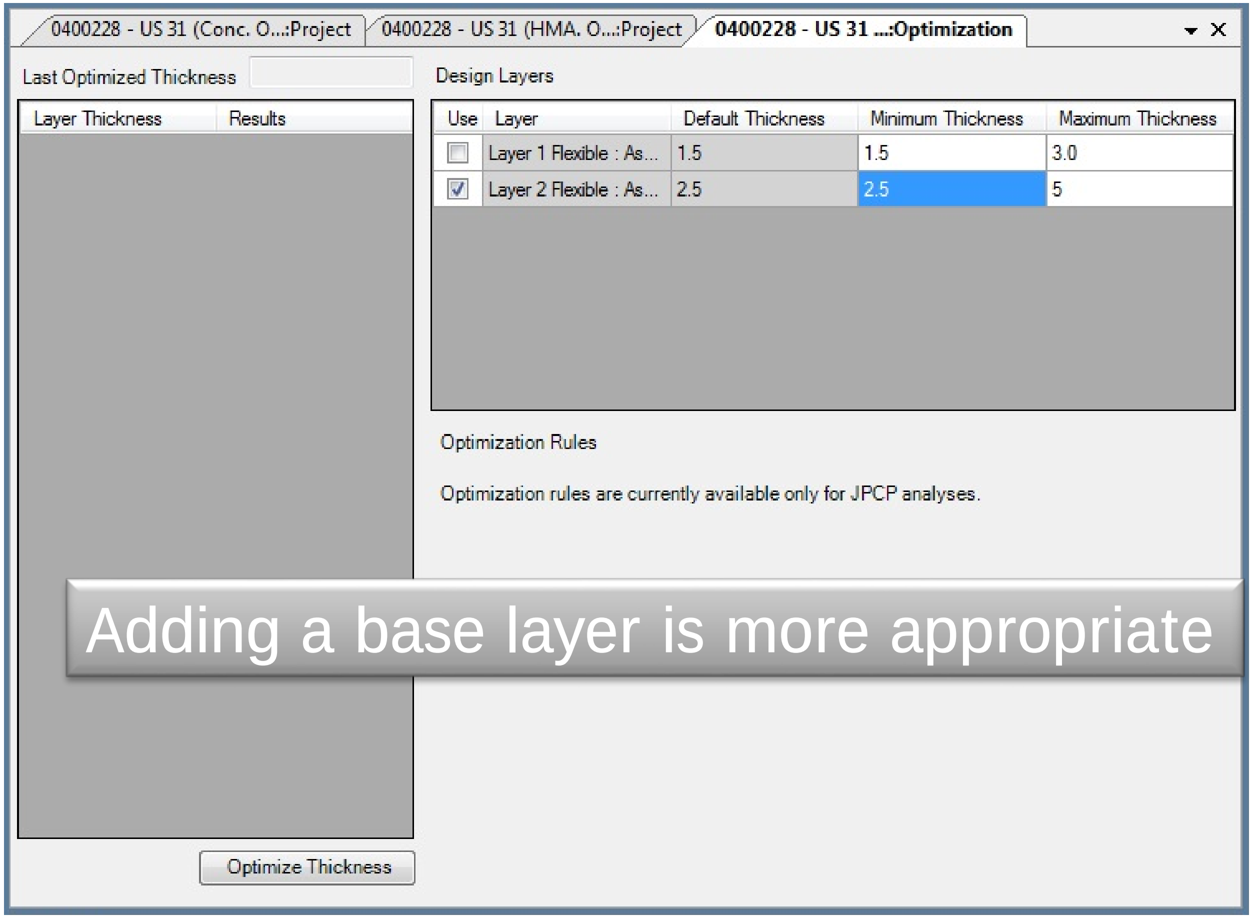
Age (year)	Heavy Trucks (cumulative)
2012 (initial)	6,000
2024 (12 years)	14,273,700
2037 (25 years)	31,794,300

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



Adding a base layer is more appropriate

HMA sensitivity

0400228 - US 31 (H...:Sensitivity | 0400228 - US 31 (Conc. O...:Project | 0400228 - US 31 (HMA. O...:Project

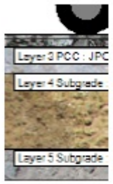
Run Factorial

Create Sensitivity | Run Sensitivity | View Summary

Use	Property	Layer	Default	Minimum	Maximum	# of Increments
☐	Two-way AADTT		6000			
☐	Thickness (in.):	Layer 1 Flexible : Asp...	1.5			
☐	Binder Content (%)	Layer 1 Flexible : Asp...	11.61			
☐	Air voids (%)	Layer 1 Flexible : Asp...	8			
☑	Thickness (in.):	Layer 2 Flexible : Asp...	2.5	2.5	5	5
☐	Binder Content (%)	Layer 2 Flexible : Asp...	10.66			
☐	Air voids (%)	Layer 2 Flexible : Asp...	8			
☐	Thickness (in.):	Layer 3 PCC : JPCP (...	8.5			
☐	Thickness (in.):	Layer 4 Subgrade : A-4	24			
☐	Unbound Modulus	Layer 4 Subgrade : A-4	6000			
☐	Dowel diameter (in.)		1.25			
☐	PCC joint spacing (ft)		15			
☐	Slab width (ft)		12			
☐	PCC coefficient of th...	Layer 3 PCC : JPCP (...	5.4			
☐	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

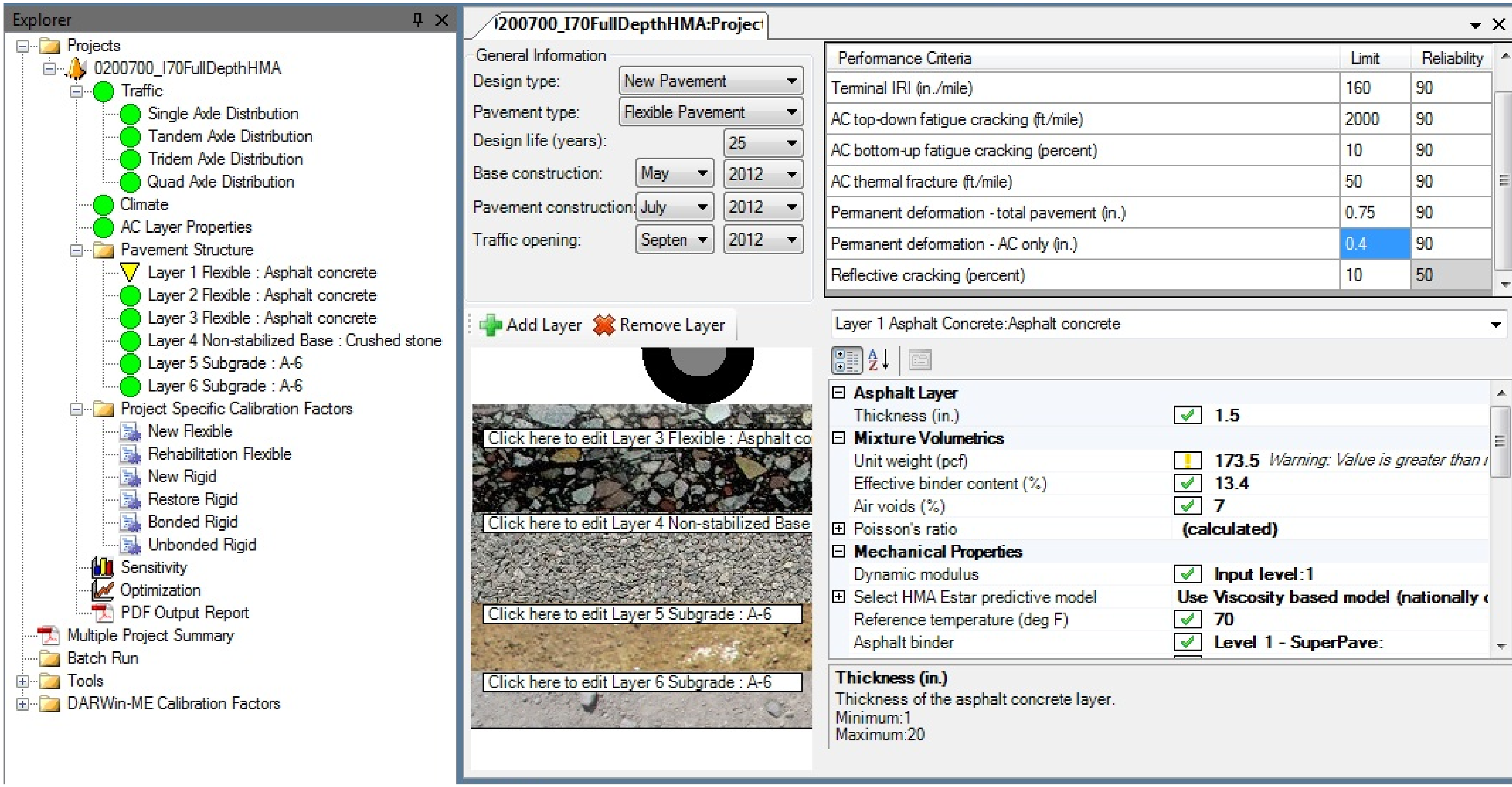
Age (year)	Heavy Trucks (cumulative)
2012 (initial)	6,000
2018 (6 years)	6,461,420
2024 (12 years)	13,661,300

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



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???