

PAVEMENT REHABILITATION OPTIONS IN INDIANA FOR INDOT

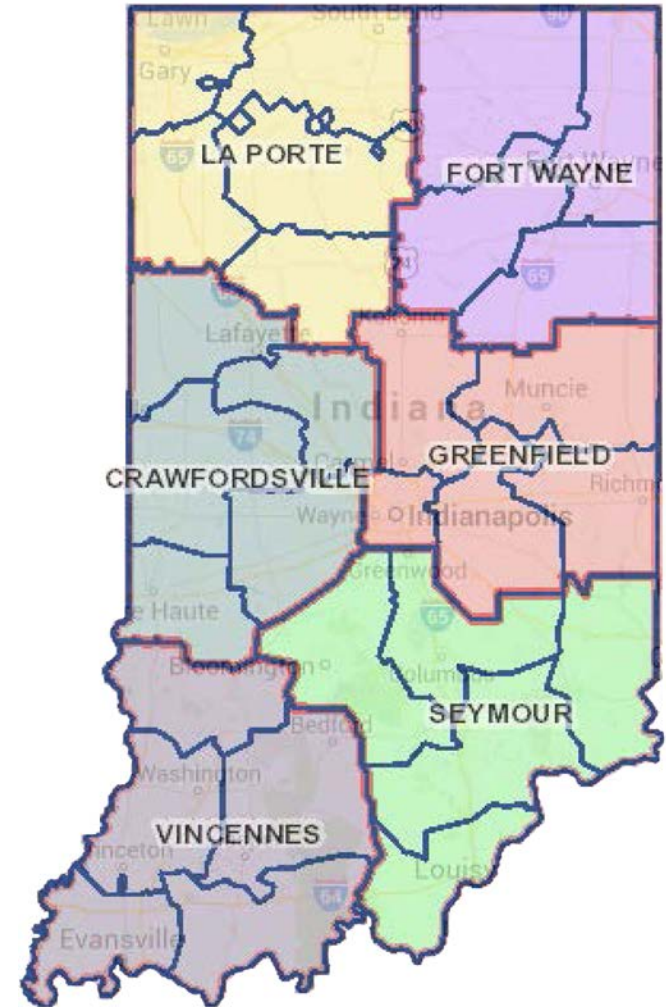
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2015 Purdue Road School



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.



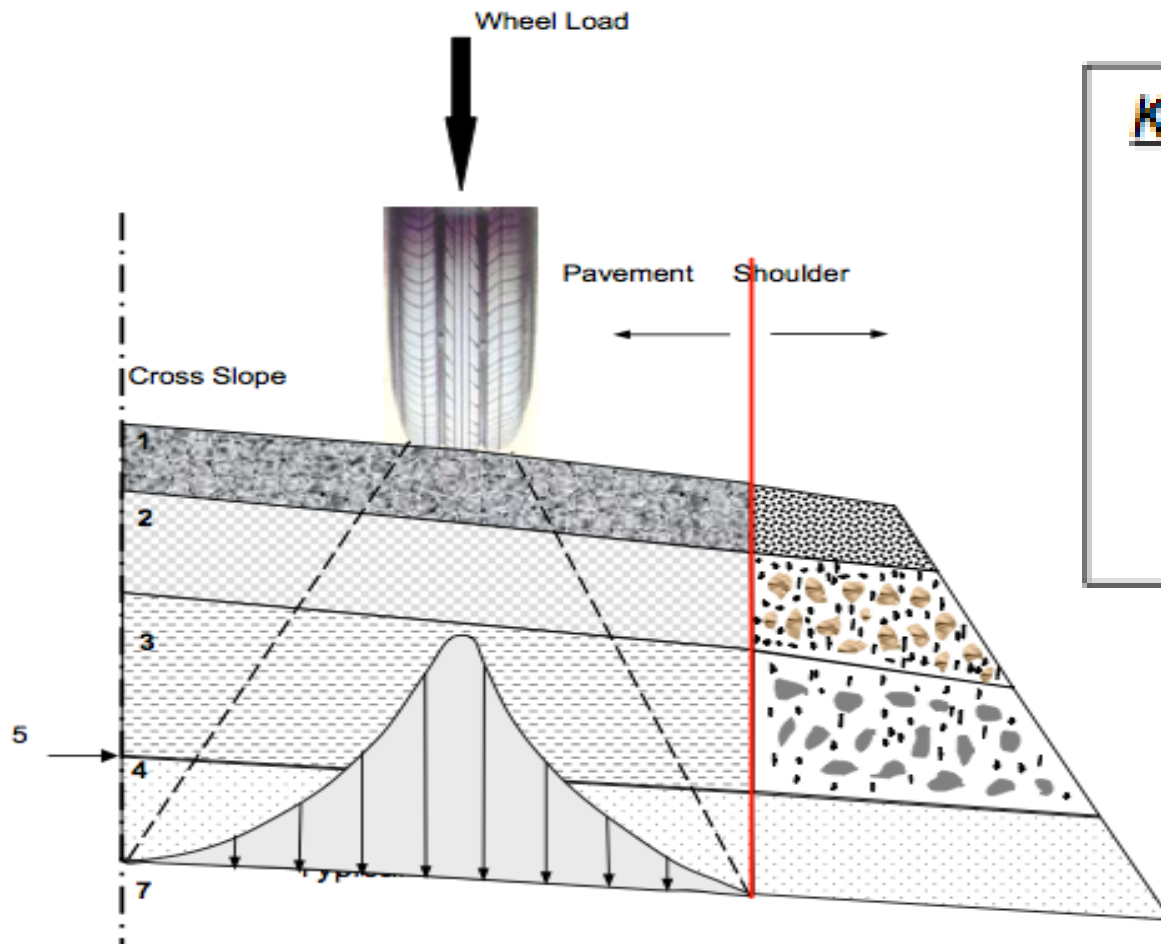
The Stage

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, ...

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



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



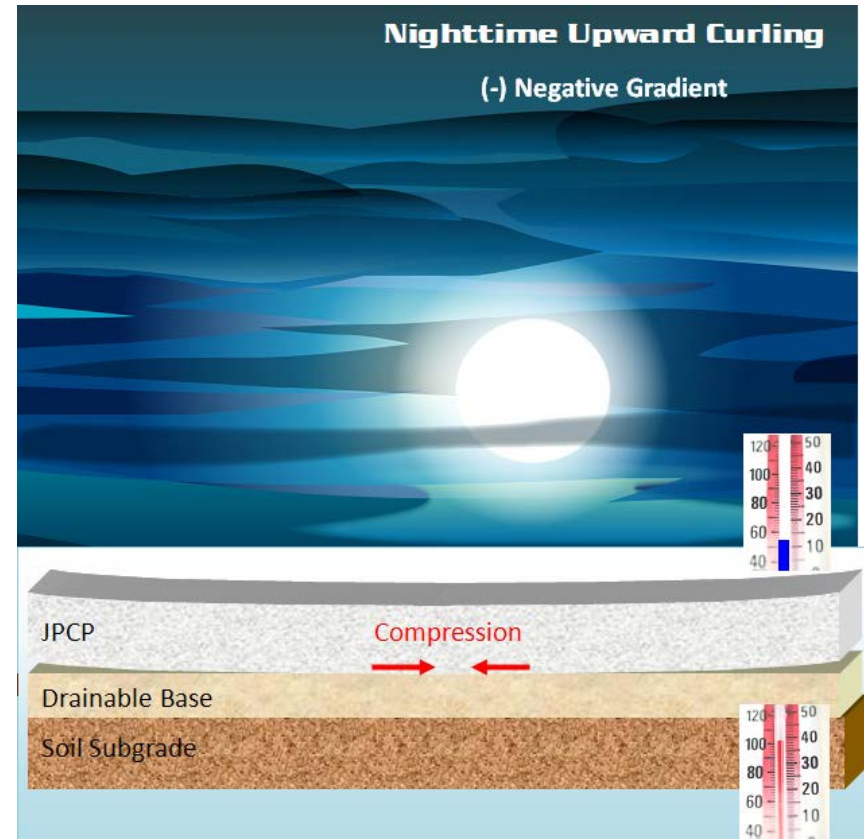
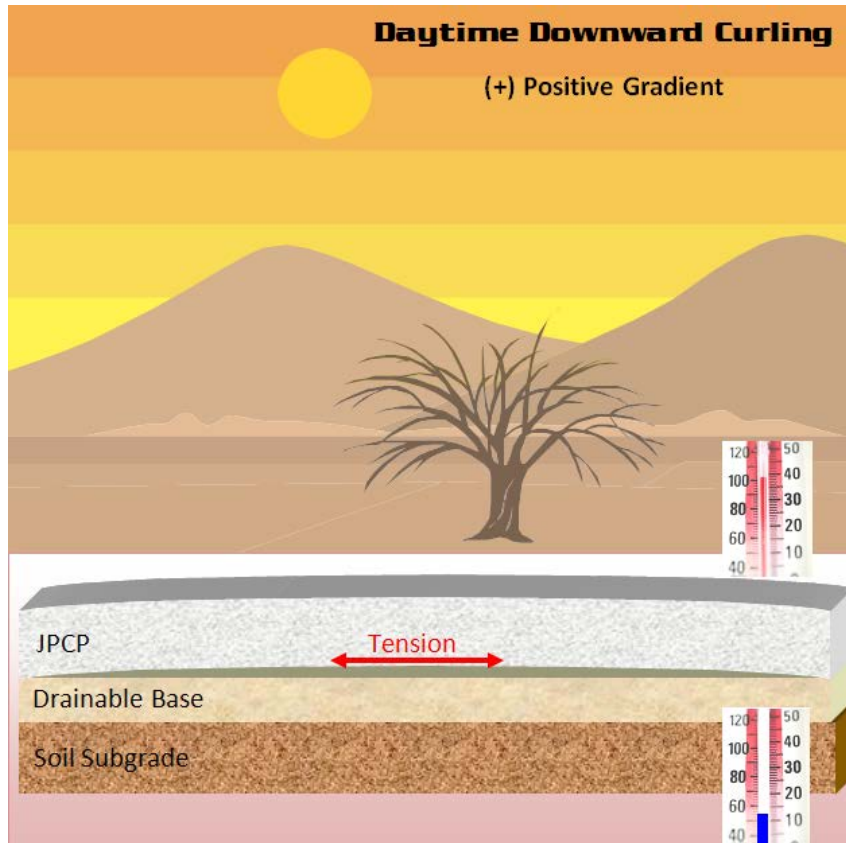
- ← 1.5" Surface
- ← 2.5" Intermediate
- ← 3"+ Dense graded base
- ← 3" Open graded base
- ← 3" Dense graded base

- ← 14" Soil treatment

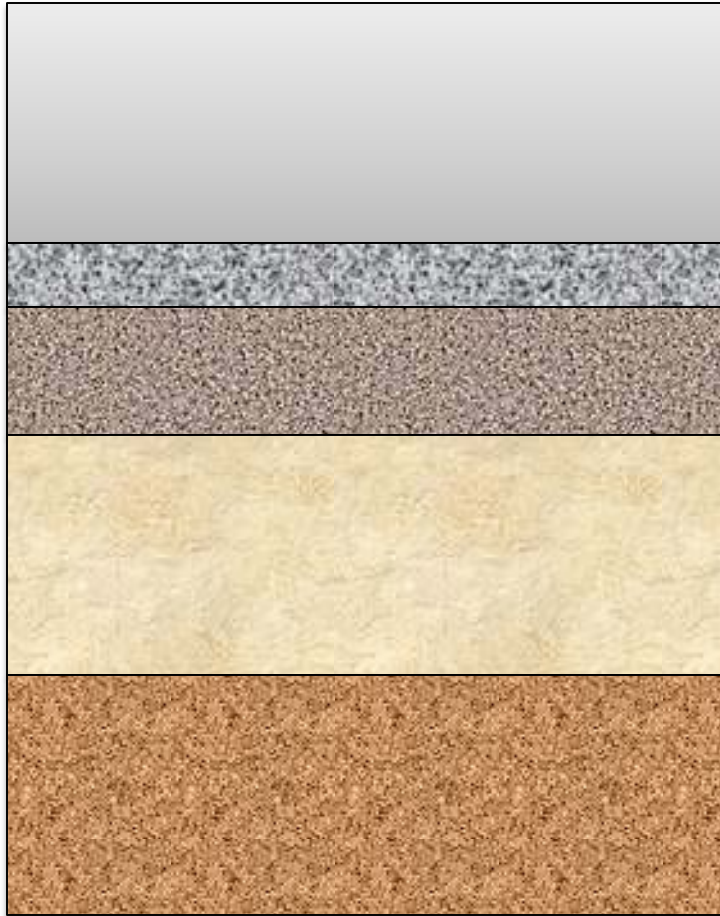
- ← Soil subgrade

- ← 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







Main project screen

Design Guide 2002 - Untitled

File Edit View Tools Help

Project [C:\DG2002\Projects\Project1.dgp]

- General Information
- Site/Project Identification
- Analysis Parameters

General Information

Analysis Status:

| Analysis | % Complete |
|----------|------------|
| | |

Status and Summary

General Project Information:

| Parameter | Value |
|-------------|----------|
| Type | |
| Design Life | 20 Years |
| Location | |

Properties

| Setting | Value |
|---------------|---------------|
| Units | US Customary |
| Analysis Type | Deterministic |
| Default Input | Level 3 |

Run Analysis

Run Analysis

Inputs

View Results and Outputs

For Help, press F1



Color-coded status icons

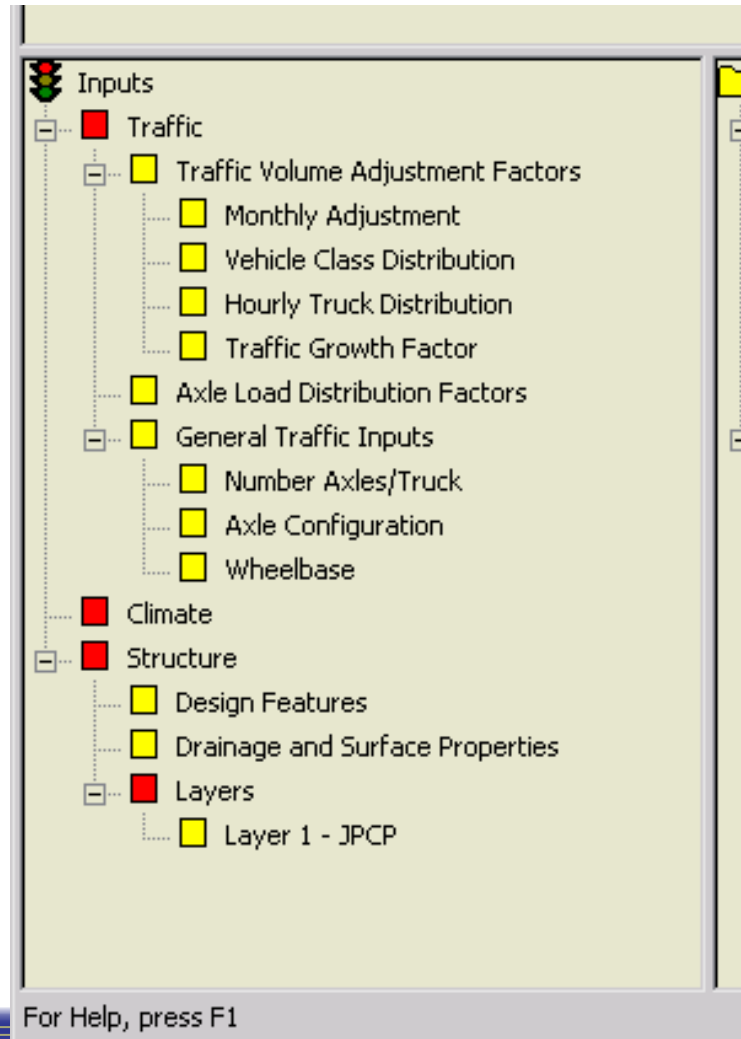
The screenshot shows the 'Design Guide 2002 - Untitled' application window. The interface is divided into several panes. The top-left pane shows a project tree with three main categories: 'General Information' (green), 'Site/Project Identification' (green), and 'Analysis Parameters' (yellow). The bottom-left pane, titled 'Inputs', lists various design parameters with color-coded status icons: 'Traffic' (red), 'Traffic Volume Adjustment Factors' (yellow), 'Monthly Adjustment' (yellow), 'Vehicle Class Distribution' (yellow), 'Hourly Truck Distribution' (yellow), 'Traffic Growth Factor' (yellow), 'Axle Load Distribution Factors' (yellow), 'General Traffic Inputs' (yellow), 'Number Axles/Truck' (yellow), 'Axle Configuration' (yellow), 'Wheelbase' (yellow), 'Climate' (red), 'Structure' (red), 'Design Features' (yellow), 'Drainage and Surface Property' (yellow), 'Layers' (red), and 'Layer 1 - JPCP' (yellow). The right pane, titled 'Analysis Status', contains a table with columns 'Analysis' and '% Compl'. The table lists: 'Traffic' (0%), 'Climatic' (0%), 'Modulus' (0%), 'Faulting JPCP' (0%), and 'Cracking JPCP' (0%). Below this is 'General Project Information' with a table: 'Type' (New JPCP), 'Design Life' (20 Years), and 'Location'. At the bottom of the right pane is a 'Properties' table: 'Units' (US Customary), 'Analysis Type' (Deterministic), and 'Default Input' (Level 3). A 'Run Analysis' button is located at the bottom of the right pane. Three callout boxes are overlaid on the image: a green box pointing to the 'General Information' and 'Site/Project Identification' categories with the text 'Green indicates completed inputs'; a yellow box pointing to the 'Traffic Volume Adjustment Factors' and 'General Traffic Inputs' categories with the text 'Yellow indicates that default values will be used for the design'; and a red box pointing to the 'Traffic', 'Climate', and 'Structure' categories with the text 'Red indicates that these inputs are still required by the program to execute the design process'.

Green indicates completed inputs

Yellow indicates that default values will be used for the design

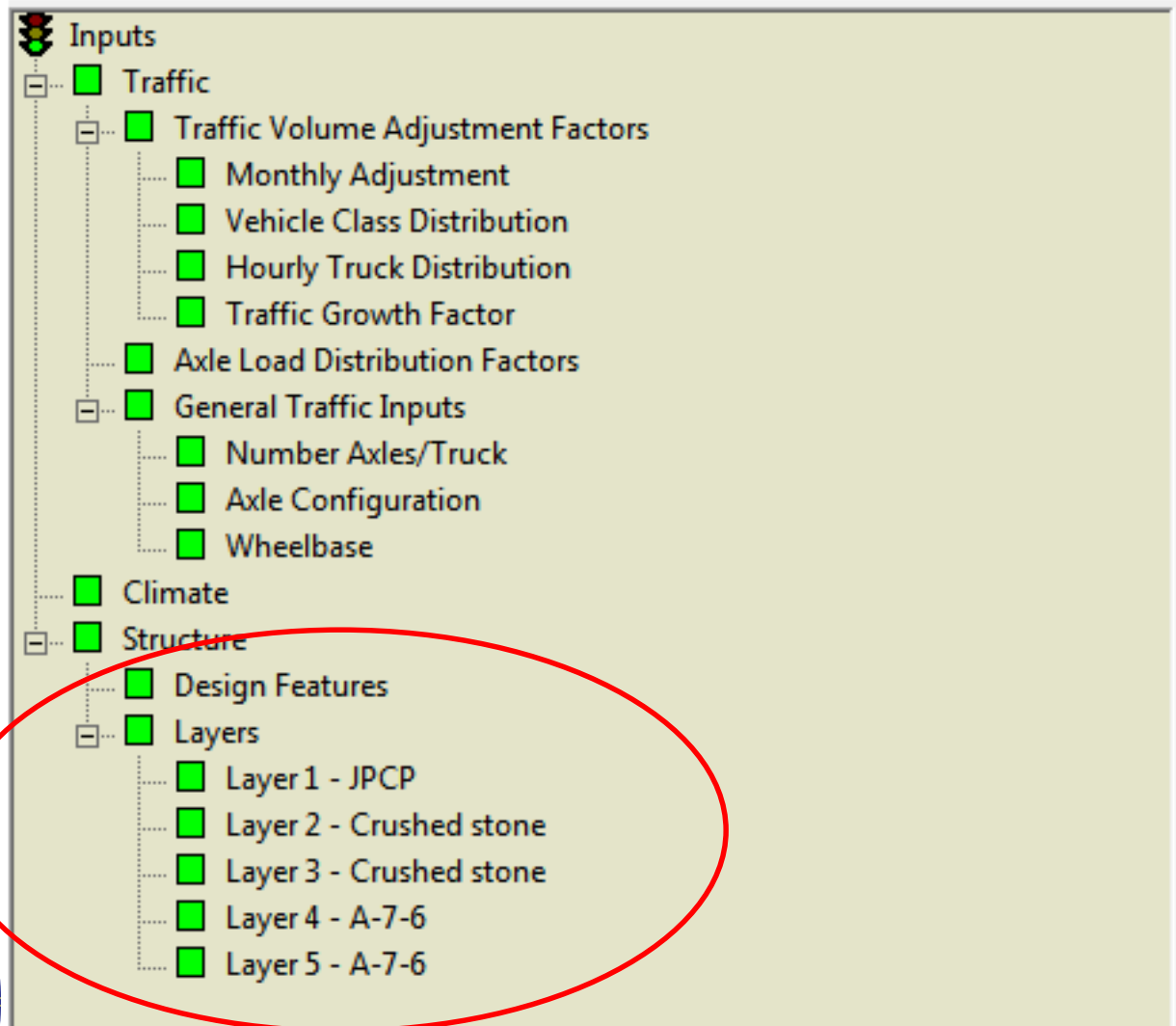
Red indicates that these inputs are still required by the program to execute the design process

Design inputs

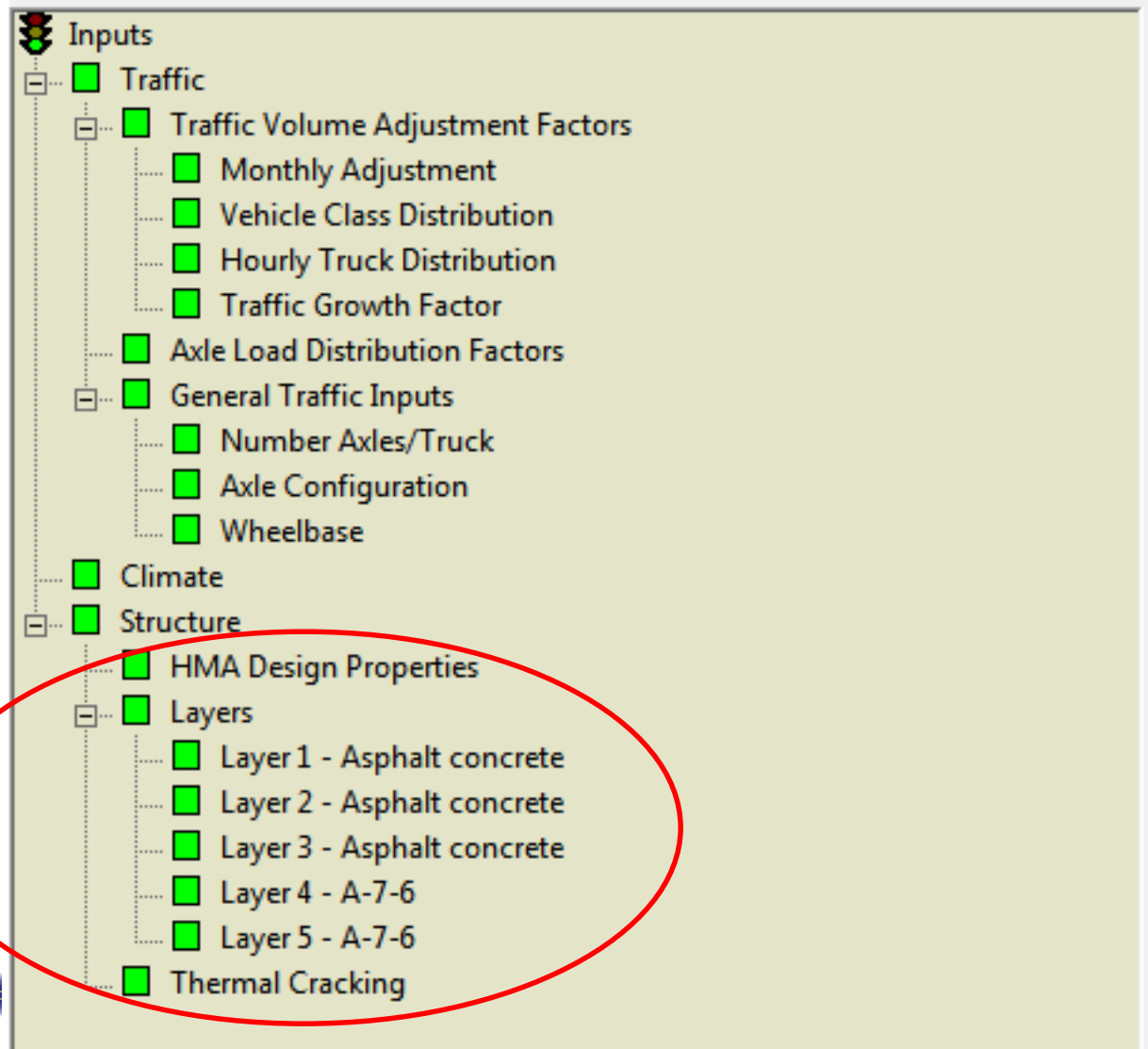


- Traffic
- Climate
- Structure

JPCP design feature, layers, and material properties



HMA design properties, layers, and thermal cracking





Run analysis

Design Guide 2002 - AC-Ex1.dgp

File Edit View Tools Help

Project [C:\DG2002\Projects\AC-Ex1.dgp]

- General Information
- Site/Project Identification
- Analysis Parameters

Inputs

- Traffic
 - Traffic Volume Adjustment Factors
 - Monthly Adjustment
 - Vehicle Class Distribution
 - Hourly Truck Distribution
 - Traffic Growth Factor
 - Axle Load Distribution Factors
 - General Traffic Inputs
 - Number Axles/Truck
 - Axle Configuration
 - Wheelbase
- Climate
- Structure
 - Thermal Cracking
 - Drainage and Surface Properties
- Layers
 - Layer 1 - Asphalt concrete
 - Layer 2 - Asphalt concrete
 - Layer 3 - A-1-a
 - Layer 4 - A-3
 - Layer 5 - Massive and Continuous

Results

- Input Summary
 - Project
 - Traffic
 - Climatic
 - Design
 - Layer
- Output Summary
- Flexible Summary
 - Layer Modulus
 - AC Modulus (plot)
 - Fatigue Cracking
 - Surface Down Damage (plot)
 - Surface Down Cracking (plot)
 - Bottom Up Damage (plot)
 - Bottom Up Cracking (plot)
 - Thermal Cracking
 - Crack Depth (plot)
 - Thermal (C-h) (plot)
 - Crack Length (plot)
 - Crack Spacing (plot)
 - Rutting
 - Rutting (plot)
 - IRI (plot)

Analysis Status:

| Analysis | % Complete |
|------------------|------------|
| Traffic | 0% |
| Climatic | 0% |
| Thermal Cracking | 0% |
| AC Analysis | 0% |
| Summary | 0% |

General Project Information:

| Parameter | Value |
|-------------|--------------|
| Type | New Flexible |
| Design Life | 20 Years |
| Location | |

Properties

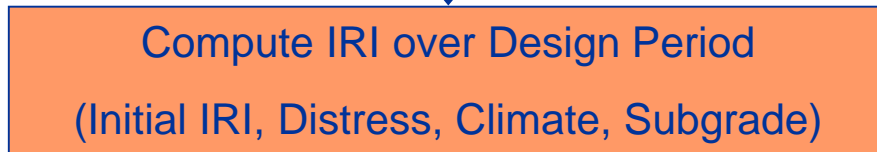
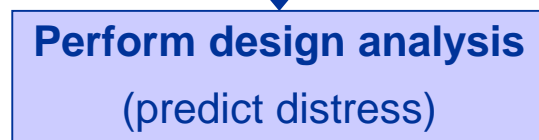
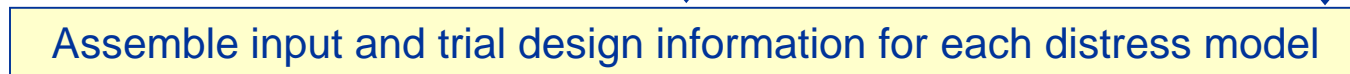
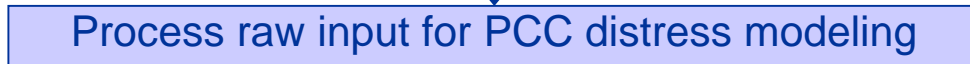
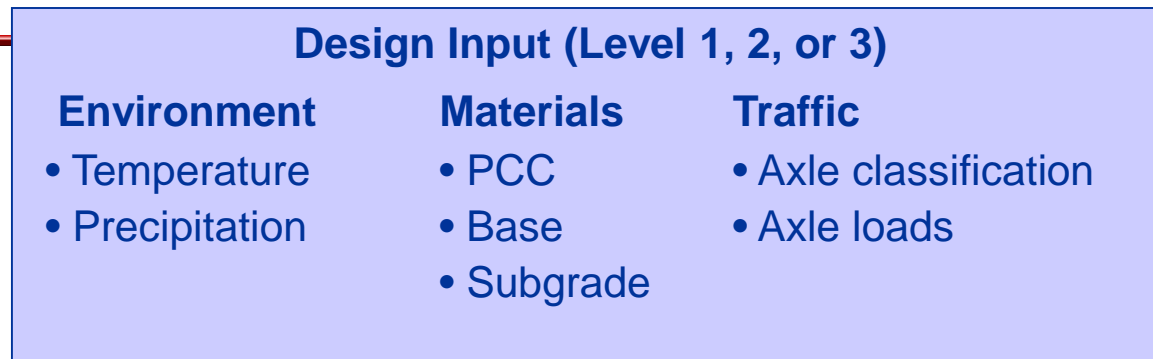
| Setting | Value |
|---------------|---------------|
| Units | US Customary |
| Analysis Type | Deterministic |
| Default Input | Level 3 |

Run Analysis

For Help, press F1

NUM





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-yr 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” inoculation

■ 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/ln-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

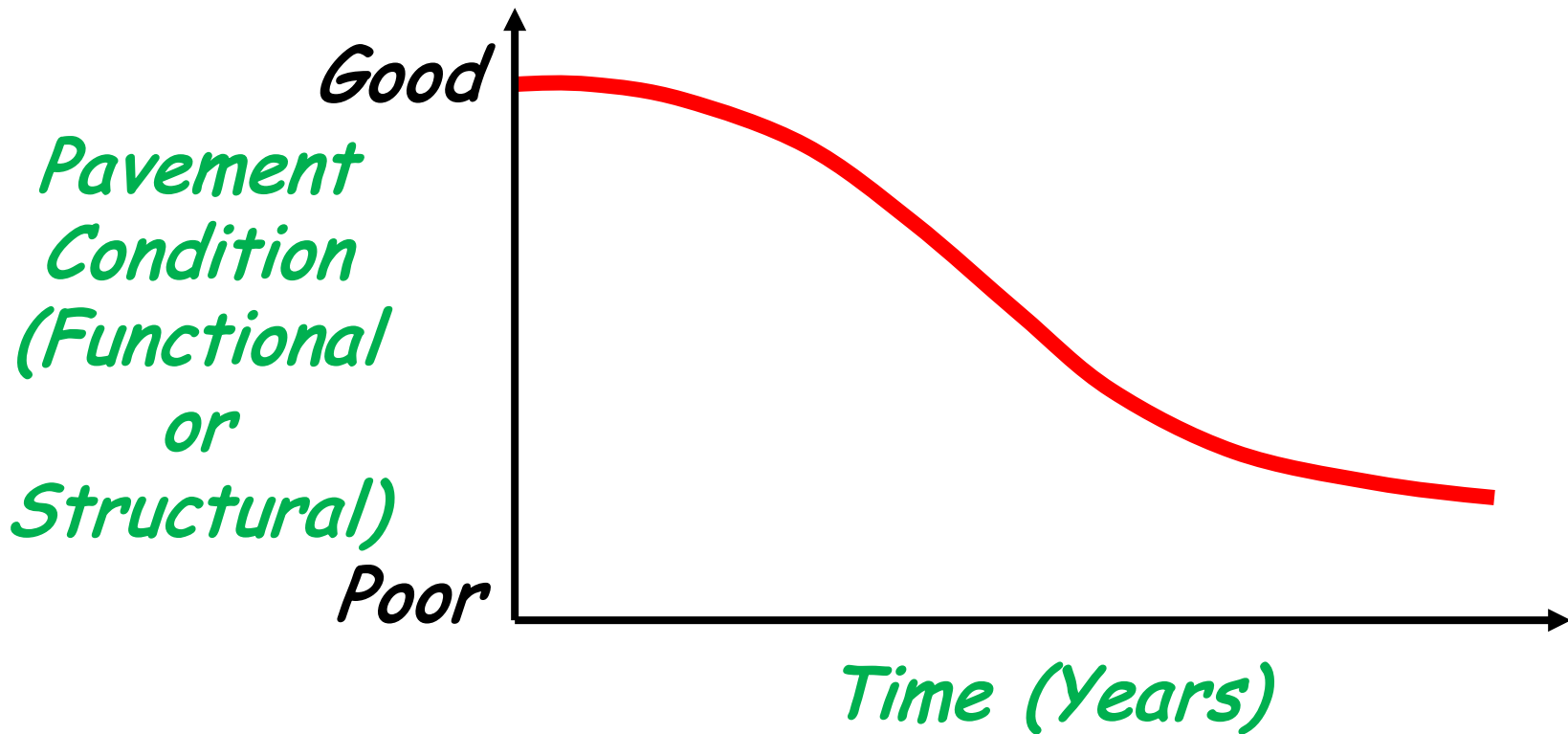


Treatment Timing Issues

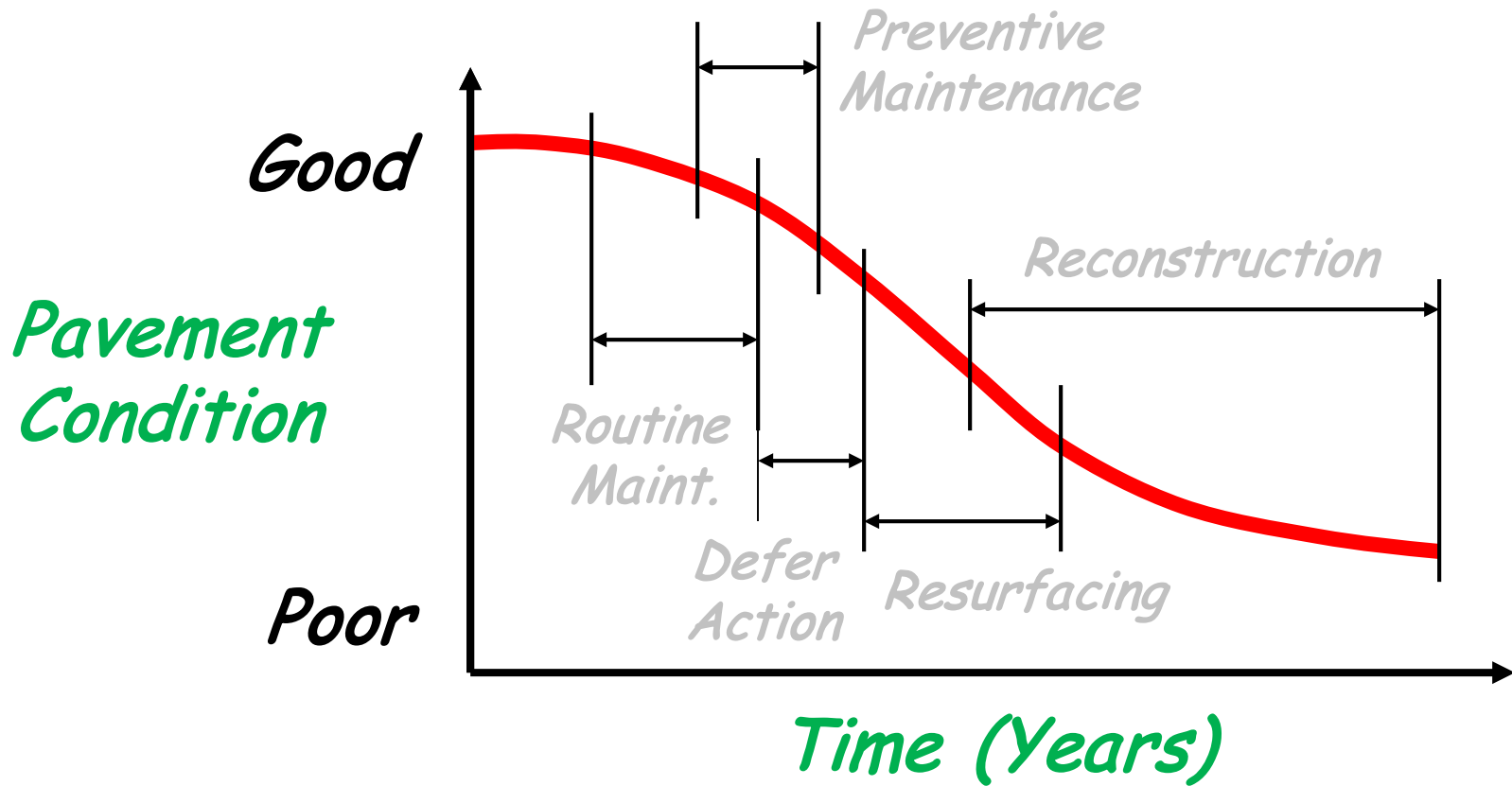
- **What factors affect treatment timing?**
- **When is too soon?**
- **Too late?**



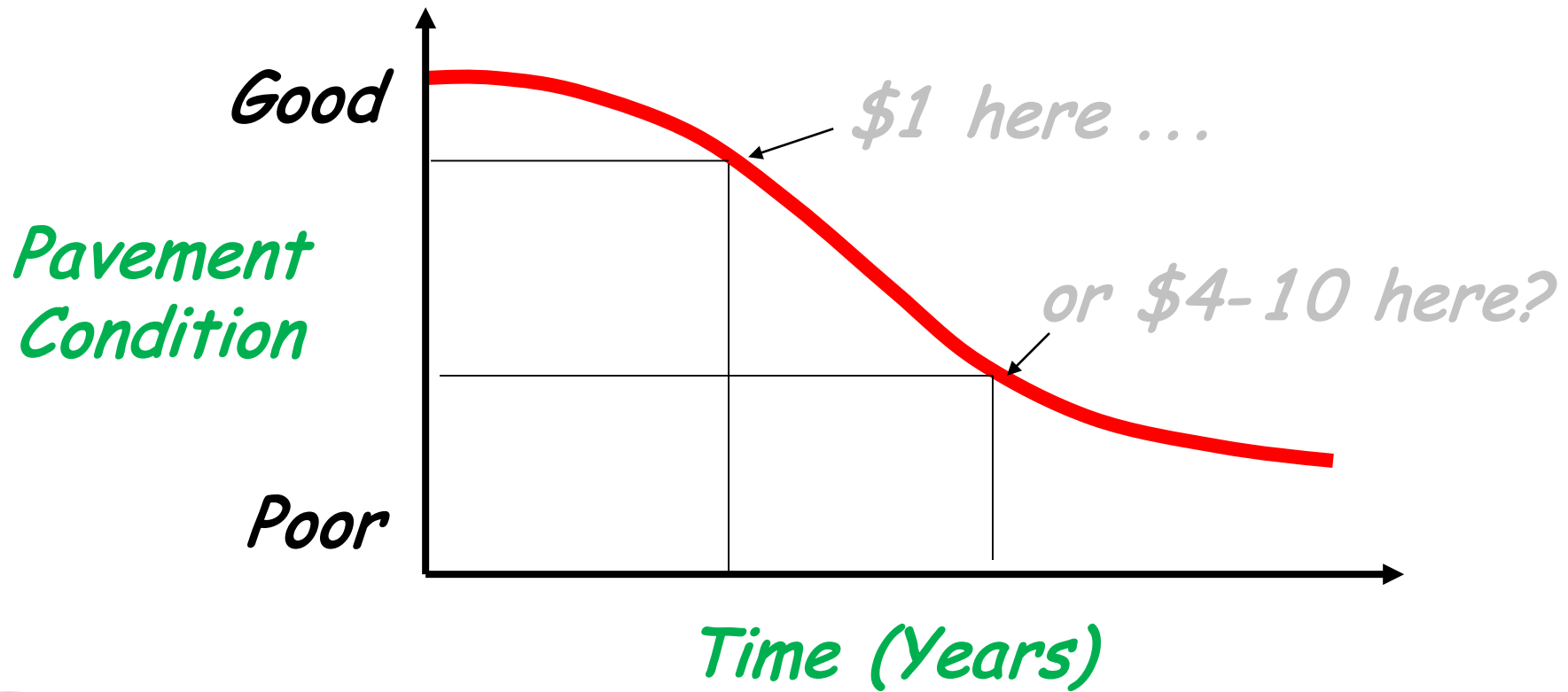
Typical Pavement Performance Curve



Typical Pavement Performance Curve



Cost Effects

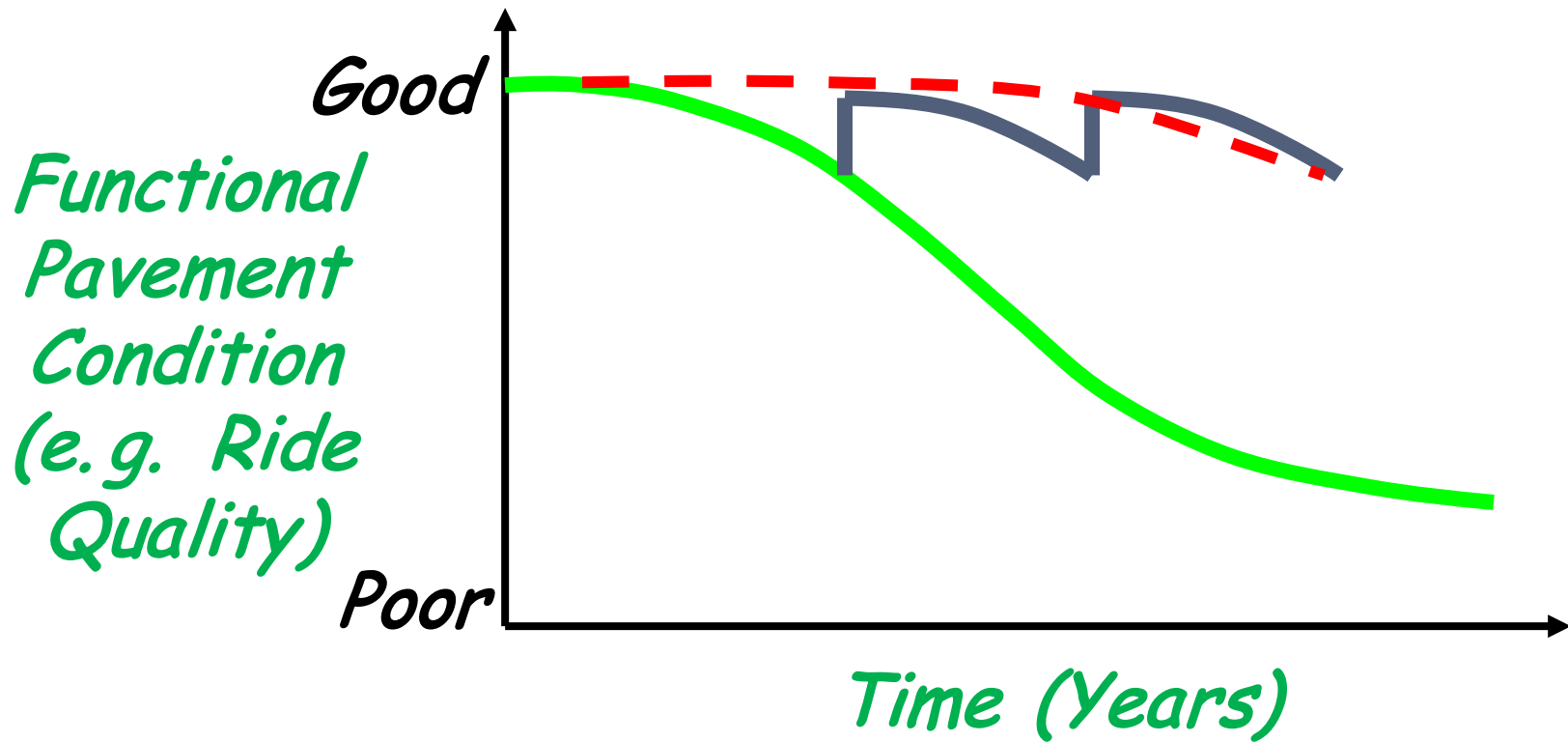


Preventive Maintenance

- **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



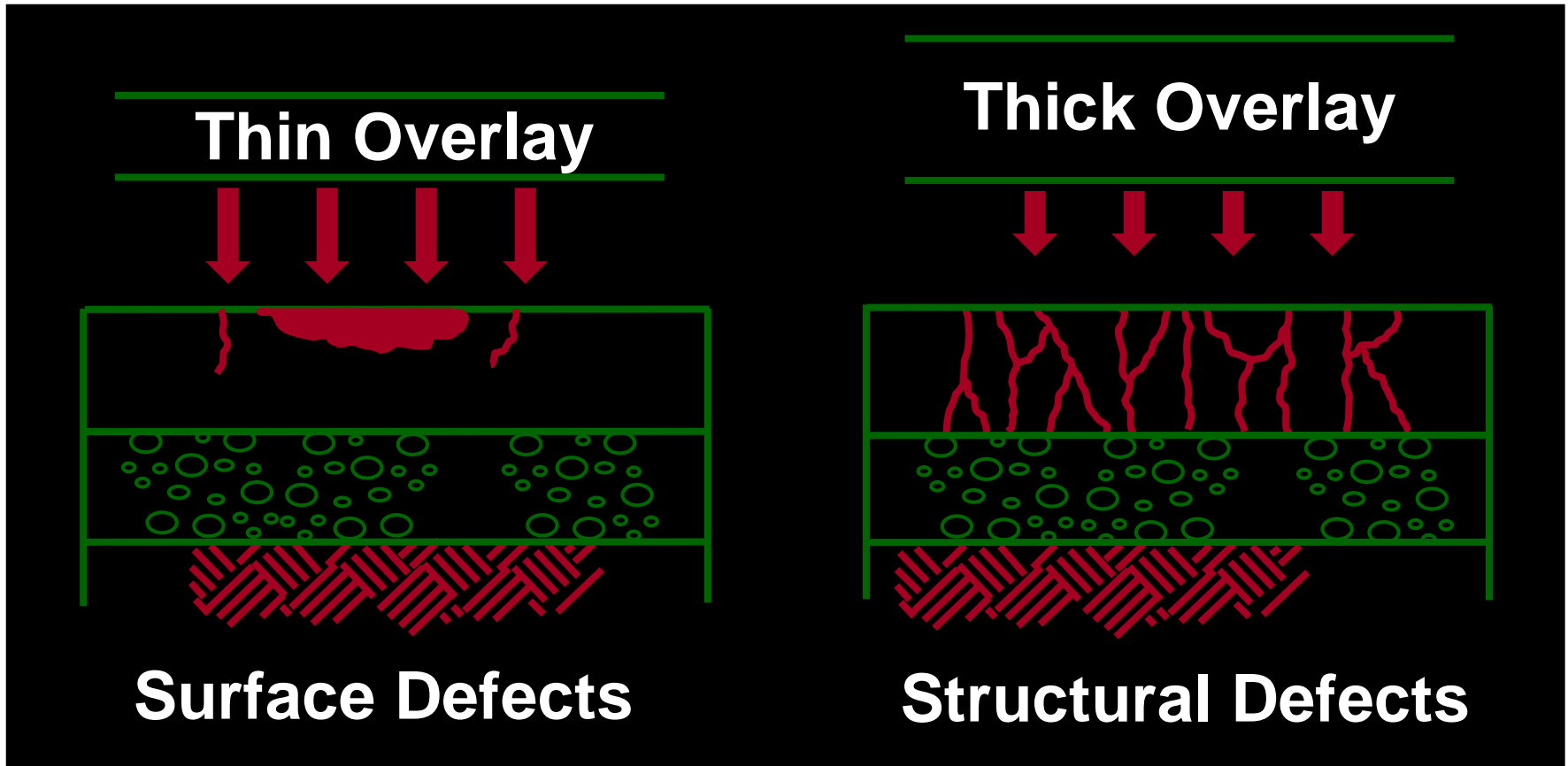
Limitations and Effectiveness

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

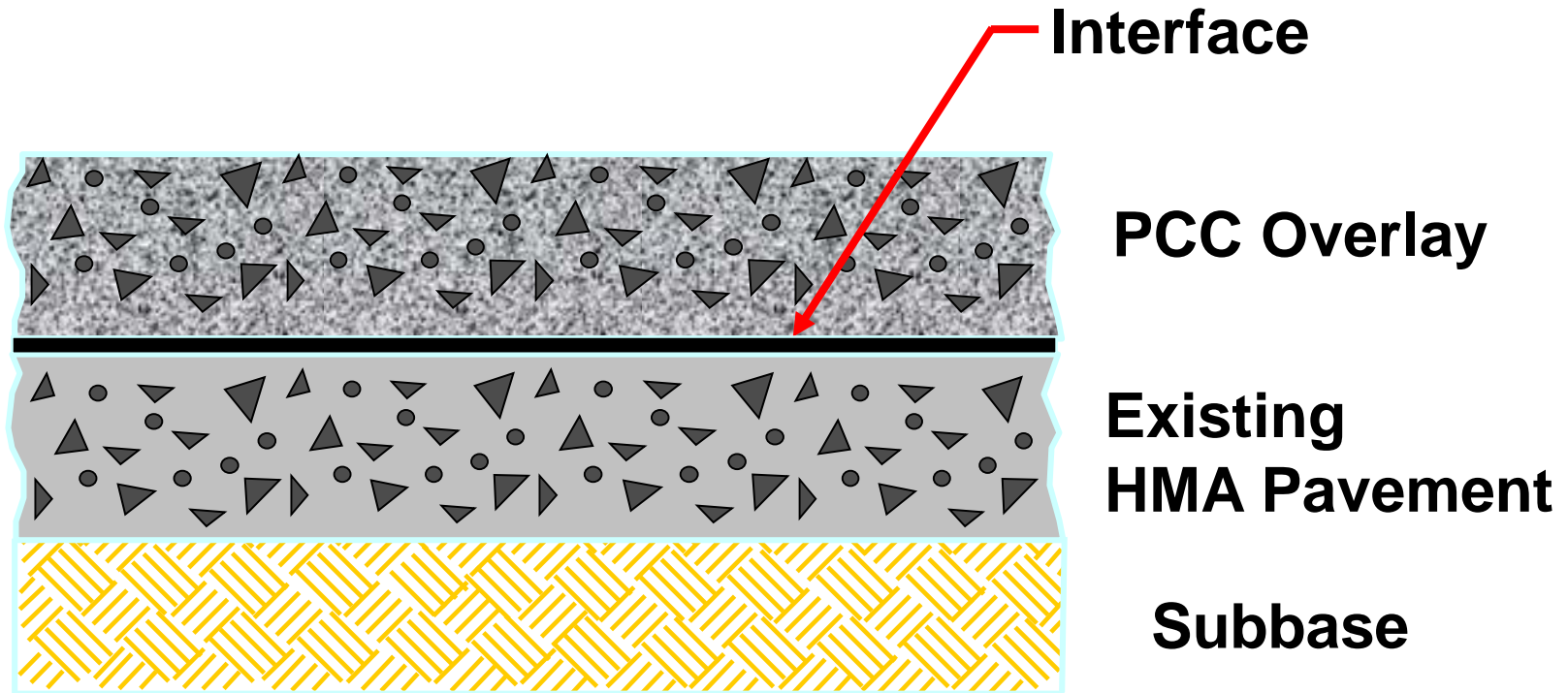
- Slabs greater than 100 mm (4 in.) thick
- Placed directly on HMA pavement (little preoverlay repair)

■ 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



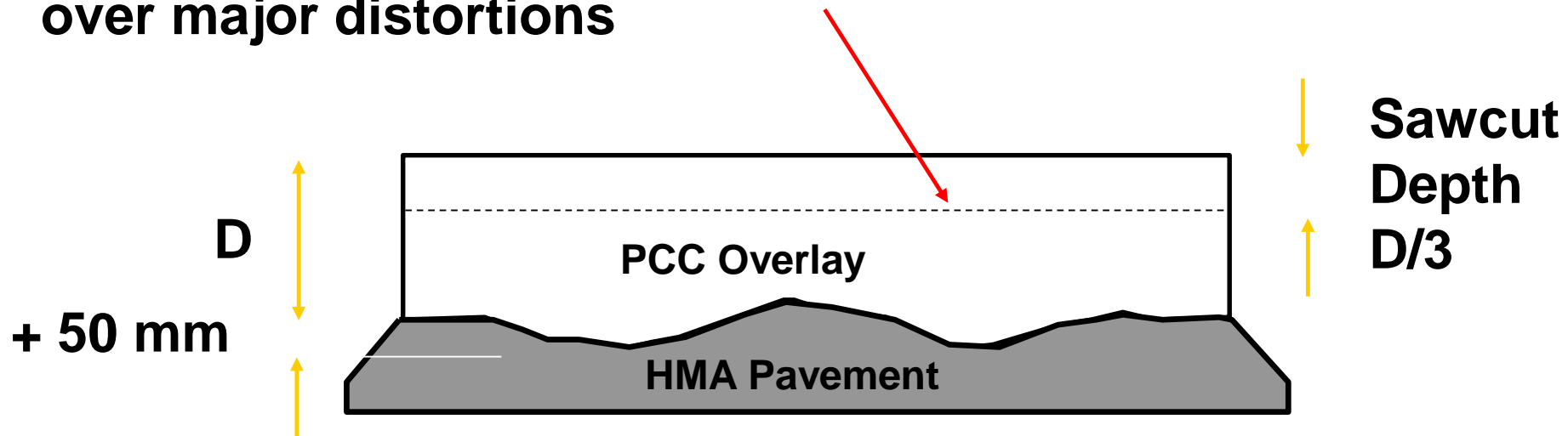
Construction —Whitetopping Overlays—

- **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



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

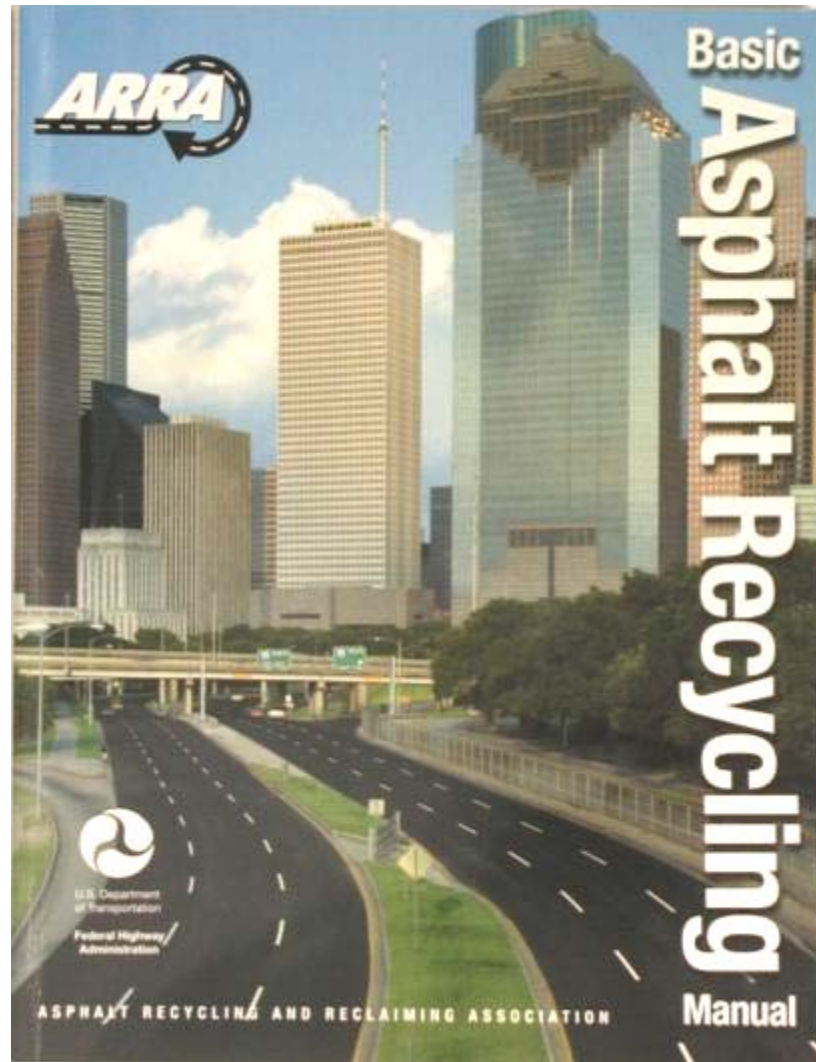


Overlay Preparation

- The CIR is tacked prior to the HMA overlay
- Paving commences
 - US-40 had a 165 lb/sy 9.5 mm surface atop the CIR base



Basic Asphalt Recycling Manual



In-Place Recycling

Measure of Effectiveness

Corrects

Poor friction
Roughness
Bleeding
Raveling
Rutting
Poor cross slope

Slows/Reduces Severity

Cracking
Moisture damage

Prevents/Delays

Cracking
Raveling
Roughness

Negatively Affects

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.**



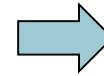
Types of Reclamation Methods

- **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



Advantages of the FDR Process

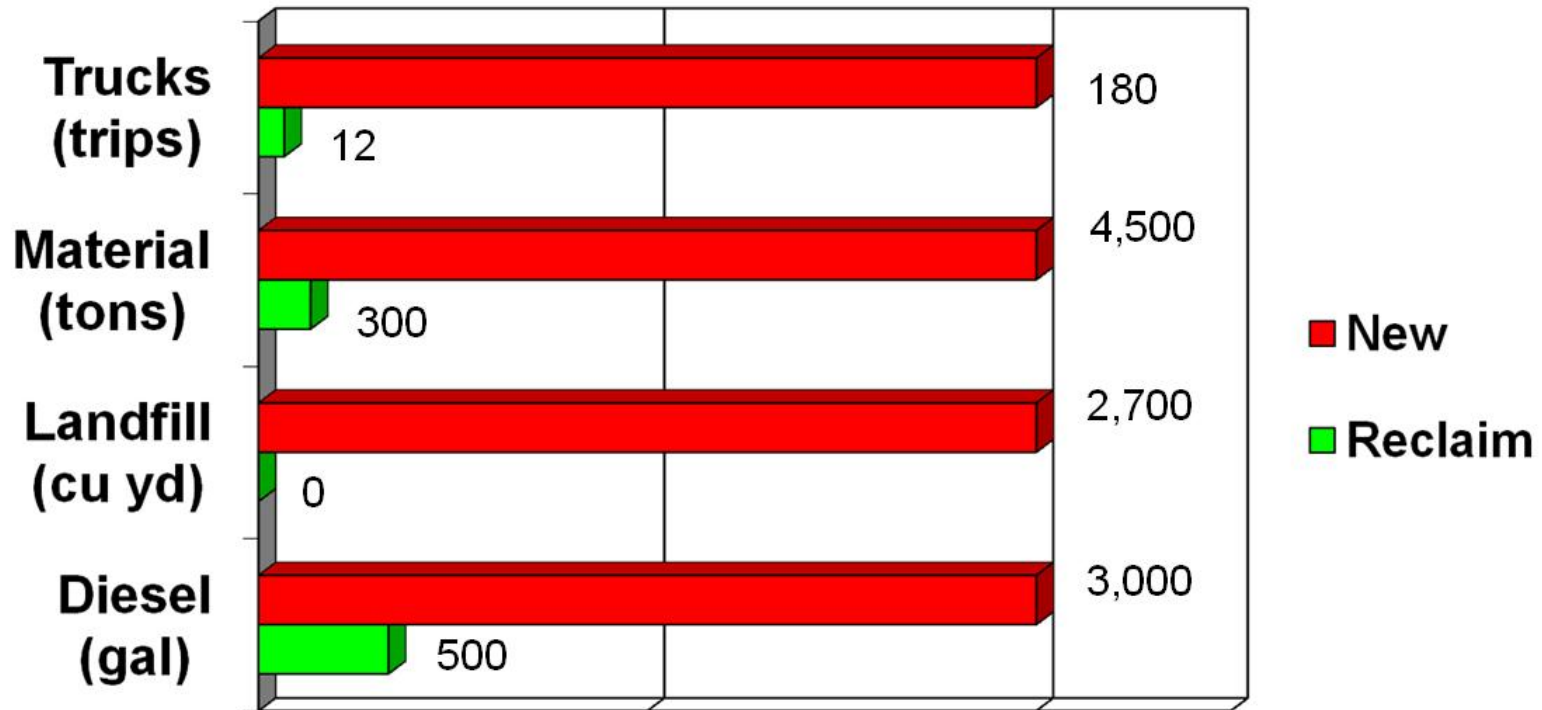
- Use of in-place materials
- Little or no material hauled off and dumped
- Maintains or improves existing grade
- Conserves virgin material
- Saves cost by using in-place “investment”
- Saves energy by reducing mining and hauls
- Very sustainable process



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

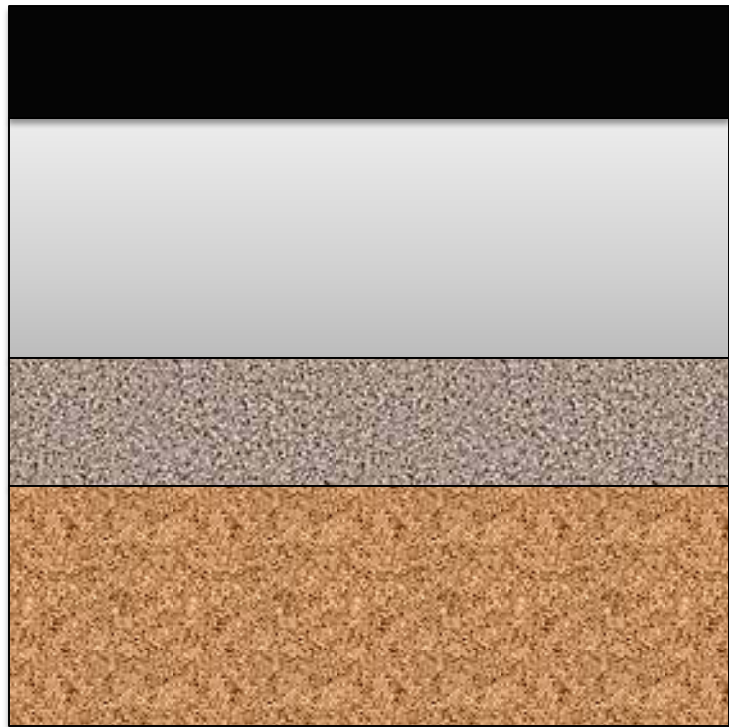


Design Issue

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 overlays: '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:**
 - 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 (Right Panel):** A list of tasks for '0400228 - US 31 (HMA. Overlay)' with a completion percentage of 100% for each:
 - 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 at the bottom 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

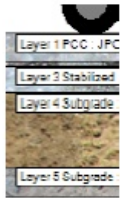
| | Use | Property | Rules | Criteria |
|---|--------------------------|----------------------|-------|----------|
| ▶ | <input type="checkbox"/> | Dowel Diameter (in.) | | |
| * | <input type="checkbox"/> | | | |

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

Explorer

- 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

1200700_I70FullDepthHMA:Project

General Information

Design type: New Pavement

Pavement type: Flexible Pavement


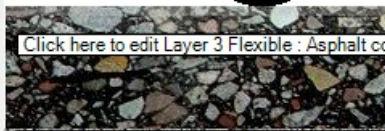

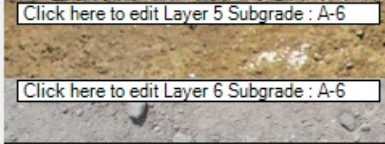
Design life (years): 25

Base construction: May 2012

Pavement construction: July 2012

Traffic opening: Septen 2012

+ Add Layer x Remove Layer

Click here to edit Layer 3 Flexible : Asphalt co

Click here to edit Layer 4 Non-stabilized Base

Click here to edit Layer 5 Subgrade : A-6

Click here to edit Layer 6 Subgrade : A-6

| Performance Criteria | 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 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???

