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
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, ...
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

Daytime Downward Curling
(+ Positive Gradient)

Nighttime Upward Curling
(- Negative Gradient)

JPCP
Drainable Base
Soil Subgrade

Tension

Compression
JPCP cross section

11” – 13” JPCP
3” Open graded stone
6” – 12” Dense graded stone
14” Soil treatment
Soil subgrade
Foundation Soil
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 ASL
Main project screen

- General Information
- Status and Summary
- View Results and Outputs
- Inputs
- Run Analysis

For Help, press F1
Color-coded status icons

- **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
  - 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
  - Design Features
  - Drainage and Surface Properties
  - Layers
    - Layer 1 - JPCP
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

Assemble input and trial design information for each distress model

Perform design analysis
(predict distress)

Compute IRI over Design Period
(Initial IRI, Distress, Climate, Subgrade)

Requirements satisfied?

Yes
- Design completed

No
- Revise trial design
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
    - Reactive maintenance
    - Preventative maintenance
    - Functional/smoothness treatments
    - Structural minor rehab treatments
    - Structural major rehab treatments
    - Structural pavement replacement

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine maintenance</td>
<td>&lt;$1K/ln-mi/svc yr?</td>
</tr>
<tr>
<td>Reactive maintenance</td>
<td>? / TBD</td>
</tr>
<tr>
<td>Preventative maintenance</td>
<td>$5K/ln-mi/svc yr?</td>
</tr>
<tr>
<td>Functional/smoothness treatments</td>
<td>$7-20K/ln-mi/svc yr?</td>
</tr>
<tr>
<td>Structural minor rehab treatments</td>
<td>$10-25K/lm-mi/svc yr(?)</td>
</tr>
<tr>
<td>Structural major rehab treatments</td>
<td>$25-35K/ln-mi/svc yr(?)</td>
</tr>
<tr>
<td>Structural pavement replacement</td>
<td>$1Mil/ln-mi/svc yr(+) (?)</td>
</tr>
</tbody>
</table>
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

Pavement Condition (Functional or Structural)

Time (Years)
Typical Pavement Performance Curve

- **Good** Pavement Condition
- **Poor** Pavement Condition

- **Preventive Maintenance**
- **Routine Maint.**
- **Defer Action**
- **Resurfacing**
- **Reconstruction**

**Time (Years)**
Cost Effects

Time (Years)

Pavement Condition

Good

$1 here ...

or $4-10 here?
Preventive Maintenance

- Planned strategy
- Preserves the system
- Retards future deterioration
- Maintains or improves functional condition
Anticipated PM Benefits

Graph showing the relationship between functional pavement condition (e.g., ride quality) and time (years). The graph indicates a decline in functional condition over time with antecedents for anticipated pavement management 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

Thin Overlay

Surface Defects

Thick Overlay

Structural Defects
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
Types of Preoverlay Treatments

- Localized repair (patching)
- Surface leveling
- Controlling reflection cracking
- Drainage improvements
Concrete Pavement Overlay

Conventional Rehabilitation Treatment
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

- Interface
- PCC Overlay
- Existing HMA Pavement
- Subbase
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
Conventional

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Clearance</td>
<td>Can be a problem</td>
</tr>
<tr>
<td>Traffic Control</td>
<td>May be difficult to construct</td>
</tr>
<tr>
<td></td>
<td>under traffic</td>
</tr>
<tr>
<td>Construction</td>
<td>No special equipment</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td><strong>Existing Condition</strong></td>
<td>Very deteriorated HMA pavements</td>
</tr>
<tr>
<td><strong>Extent of Repair</strong></td>
<td>Limited to very severe areas</td>
</tr>
<tr>
<td><strong>Future Traffic</strong></td>
<td>Any traffic level</td>
</tr>
<tr>
<td><strong>Historical Reliability</strong></td>
<td>Very good</td>
</tr>
</tbody>
</table>
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.
Consider increased saw depth over major distortions

\[ \text{Sawcut Depth} = \frac{D}{3} + 50 \text{ mm} \]

PCC Overlay

HMA Pavement

Whitetopping — Joint Sawing—
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
Pavement Condition

08/2012

06/2014
Rehabilitation Option

Cold In-Place Recycling
Cold In-Place Recycling Description

- 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

Asphalt Stabilized using emulsified asphalt or expanded (foamed) asphalt.
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
## In-Place Recycling

### Measure of Effectiveness

<table>
<thead>
<tr>
<th>Corrects</th>
<th>Slows/Reduces Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor friction</td>
<td>Cracking</td>
</tr>
<tr>
<td>Roughness</td>
<td>Moisture damage</td>
</tr>
<tr>
<td>Bleeding</td>
<td></td>
</tr>
<tr>
<td>Raveling</td>
<td></td>
</tr>
<tr>
<td>Rutting</td>
<td></td>
</tr>
<tr>
<td>Poor cross slope</td>
<td></td>
</tr>
<tr>
<td>Prevents/Delays</td>
<td>Negatively Affects</td>
</tr>
<tr>
<td>Cracking</td>
<td>None</td>
</tr>
<tr>
<td>Raveling</td>
<td></td>
</tr>
<tr>
<td>Roughness</td>
<td></td>
</tr>
</tbody>
</table>
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
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Rehabilitation Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FDR</td>
</tr>
<tr>
<td>New pavement structure</td>
<td>✓</td>
</tr>
<tr>
<td>Fast construction</td>
<td>✓</td>
</tr>
<tr>
<td>Minimal traffic disruption</td>
<td>✓</td>
</tr>
<tr>
<td>Minimal material in/out</td>
<td>✓</td>
</tr>
<tr>
<td>Conserves resources</td>
<td>✓</td>
</tr>
<tr>
<td>Maintains existing elevation</td>
<td>✓</td>
</tr>
<tr>
<td>Low cost</td>
<td>✓</td>
</tr>
</tbody>
</table>
1 mile of 24-foot wide, 2-lane road, with a 6-inch base

Sustainable Element of FDR Process
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
### Backcalculation inputs

<table>
<thead>
<tr>
<th>Select</th>
<th>Station</th>
<th>Modulus Subgrade Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ NB</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>✔️ SB</td>
<td>276</td>
<td></td>
</tr>
</tbody>
</table>

**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
### Design Structure

<table>
<thead>
<tr>
<th>Layer type</th>
<th>Material Type</th>
<th>Thickness (in.)</th>
<th>Joint Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC</td>
<td>JPCP</td>
<td>9.0 (Optimized)</td>
<td>Joint spacing (ft)</td>
</tr>
<tr>
<td>Flexible</td>
<td>Asphalt concrete</td>
<td>2.0</td>
<td>Dowel diameter (in.)</td>
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<tr>
<td>Stabilized</td>
<td>JPCP (existing)</td>
<td>8.5</td>
<td>Slab width (ft)</td>
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<tr>
<td>Subgrade</td>
<td>A-4</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-4</td>
<td>Semi-Infinite</td>
<td></td>
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</tbody>
</table>

### Traffic

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>Heavy Trucks (cumulative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 (initial)</td>
<td>6,000</td>
</tr>
<tr>
<td>2024 (12 years)</td>
<td>14,273,700</td>
</tr>
<tr>
<td>2037 (25 years)</td>
<td>31,794,300</td>
</tr>
</tbody>
</table>

### Design Outputs

#### Distress Prediction Summary

<table>
<thead>
<tr>
<th>Distress Type</th>
<th>Distress @ Specified Reliability</th>
<th>Reliability (%)</th>
<th>Criterion Satisfied?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal IRI (in./mile)</td>
<td>Target: 190.00</td>
<td>Predicted: 120.37</td>
<td>Target: 85.00</td>
</tr>
<tr>
<td>Mean joint faulting (in.)</td>
<td>0.20</td>
<td>0.07</td>
<td>85.00</td>
</tr>
<tr>
<td>JPCP transverse cracking (percent slabs)</td>
<td>12.00</td>
<td>9.49</td>
<td>85.00</td>
</tr>
</tbody>
</table>
Adding a base layer is more appropriate.
### HMA Sensitivity

<table>
<thead>
<tr>
<th>Use</th>
<th>Property</th>
<th>Layer</th>
<th>Default</th>
<th>Minimum</th>
<th>Maximum</th>
<th># of Increments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two-way AADTT</td>
<td></td>
<td>6000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness (in.)</td>
<td>Layer 1 Flexible : Asp...</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Layer 2 Flexible : Asp...</td>
<td>2.5</td>
<td>2.5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Layer 3 PCC : JPCP</td>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Layer 4 Subgrade : A-4</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unbound Modulus</td>
<td>Layer 4 Subgrade : A-4</td>
<td>6000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dowel diameter (in.)</td>
<td></td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Layer 3 PCC : JPCP</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Layer 3 PCC : JPCP</td>
<td>350</td>
<td></td>
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</tr>
</tbody>
</table>
### Design Structure

<table>
<thead>
<tr>
<th>Layer type</th>
<th>Material Type</th>
<th>Thickness (in.)</th>
<th>Volumetric at Construction:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible</td>
<td>Asphalt concrete</td>
<td>1.5</td>
<td>Effective binder content (%)</td>
</tr>
<tr>
<td>Flexible</td>
<td>Asphalt concrete</td>
<td>2.5</td>
<td>Air voids (%)</td>
</tr>
<tr>
<td>PCC</td>
<td>JPCP (existing)</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-4</td>
<td>24.0</td>
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</tr>
<tr>
<td>Subgrade</td>
<td>A-4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Traffic

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>Heavy Trucks (cumulative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 (initial)</td>
<td>6,000</td>
</tr>
<tr>
<td>2018 (6 years)</td>
<td>6,461,420</td>
</tr>
<tr>
<td>2024 (12 years)</td>
<td>13,661,300</td>
</tr>
</tbody>
</table>

### Design Outputs

### Distress Prediction Summary

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

<table>
<thead>
<tr>
<th>Weight</th>
<th>Decision Factor 1</th>
<th>Decision Factor 2</th>
<th>Decision Factor 3</th>
<th>Decision Factor 4</th>
<th>TOTAL SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alt 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alt 3</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Alt 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions???