Pavement Rehabilitation Options in Indiana

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Decision to select treatment options

Rehabilitation Treatment Overview
Objectives

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

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

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

- Definitions
- Purpose and Applications
- Limitations and Effectiveness
- Design Considerations
- Pavement Surveys
- Cost Considerations
- Construction Considerations
- Equipment
Identification of Candidate Treatments

- Specific Distresses Present
- Condition
  - Functional
  - Structural
- Loadings and Environment
- Available Tools
  - Decision trees
  - Decision matrices
Treatment Timing Issues

- What factors affect treatment timing?
- When is too soon?
- Too late?
Typical Pavement Performance Curve

Pavement Condition
(Functional or Structural)

Good

Poor

Time (Years)
Typical Pavement Performance Curve

- Preventive Maintenance
- Routine Maintenance
- Defer Action
- Resurfacing
- Reconstruction

Pavement Condition:
- Good
- Poor

Time (Years)
Cost Effects

**Pavement Condition**

- **Good**
- **Poor**

**Time (Years)**

$1$ here ...

or $4-10$ here?
Preventive Maintenance

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

- Functional Pavement Condition (e.g. Ride Quality)

- Good

- Poor

Time (Years)
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
To Repair or Not to Repair?
Types of Preoverlay Treatments

- Localized repair (patching)
- Surface leveling
- Controlling reflection cracking
- Drainage improvements
Conventional Rehabilitation Treatment

Concrete Pavement Overlay
Types of Whitetopping Overlays

- **Conventional Whitetopping**
  - Slabs greater than 100 mm thick
  - Placed directly on HMA pavement (little preoverlay repair)

- **Ultra-Thin Whitetopping**
  - Thin slabs (50 to 100 mm thick)
  - Short joint spacing (0.6 to 1.8 m)
  - Bonded to existing HMA to increase load-carrying capacity
Conventional Whitetopping

- 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
Whitetopping Feasibility—Constructibility

Conventional

Vertical Clearance: Can be a problem

Traffic Control: May be difficult to construct under traffic

Construction: No special equipment
<table>
<thead>
<tr>
<th>Whitetopping Feasibility—Performance Period</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<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
- 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

Sawcut Depth

D/3

D + 50 mm

PCC Overlay

HMA Pavement
SR-161 Whitetopping
Rehabilitation Option

Hot In-Place Recycling
Hot In-Place Recycling Description

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

Cold In-Place Recycling
Cold In-Place Recycling Description

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

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

<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>
Sustainable Element of FDR Process

1 mile of 24-foot wide, 2-lane road, with a 6-inch base
FDR in Indiana
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 Station</th>
<th>Station</th>
<th>Modulus Subgrade Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>NB</td>
<td>260</td>
</tr>
<tr>
<td>✔️</td>
<td>SB</td>
<td>276</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
J PCP optimization
### JPCP optimization result

#### 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) 15.0</td>
</tr>
<tr>
<td>Flexible</td>
<td>Asphalt concrete</td>
<td>2.0</td>
<td>Dowel diameter (in.) 1.25</td>
</tr>
<tr>
<td>Stabilized</td>
<td>JPCP (existing)</td>
<td>8.5</td>
<td>Slab width (ft) 12.0</td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-4</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-4</td>
<td></td>
<td>Semi-Infinite</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>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>190.00</td>
<td>120.37</td>
<td>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>
HMA optimization

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>Layer 1 Flexible : Asp.</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>
</tr>
<tr>
<td></td>
<td>Binder Content (%)</td>
<td>Layer 1 Flexible : Asp.</td>
<td>11.61</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Air voids (%)</td>
<td>Layer 1 Flexible : Asp.</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness (in.)</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>Binder Content (%)</td>
<td>Layer 2 Flexible : Asp.</td>
<td>10.66</td>
<td></td>
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<tr>
<td></td>
<td>Air voids (%)</td>
<td>Layer 2 Flexible : Asp.</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness (in.)</td>
<td>Layer 3 PCC : JPCP (...)</td>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness (in.)</td>
<td>Layer 4 Subgrade : A4</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unbound Modulus</td>
<td>Layer 4 Subgrade : A4</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>PCC joint spacing (ft)</td>
<td></td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slab width (ft)</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PCC coefficient of th.</td>
<td></td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28-Day modulus of nu.</td>
<td></td>
<td>350</td>
<td></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>
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</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>
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<th>Reliability (%)</th>
<th>Criterion Satisfied?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal IRI (in./mile)</td>
<td>Target: 172.00</td>
<td>Predicted: 105.11</td>
<td>Target: 90.00</td>
</tr>
<tr>
<td>Permanent deformation - total pavement (in.)</td>
<td>Target: 0.75</td>
<td>Predicted: 0.20</td>
<td>Target: 90.00</td>
</tr>
<tr>
<td>Total Cracking (Reflective + Alligator) (percent)</td>
<td>Target: 100.00</td>
<td>Predicted: 7.33</td>
<td>-</td>
</tr>
<tr>
<td>AC thermal fracture (ft/mile)</td>
<td>Target: 250.00</td>
<td>Predicted: 217.40</td>
<td>Target: 90.00</td>
</tr>
<tr>
<td>JPCP transverse cracking (percent slabs)</td>
<td>Target: 15.00</td>
<td>Predicted: 19.72</td>
<td>Target: 90.00</td>
</tr>
<tr>
<td>AC bottom-up fatigue cracking (percent)</td>
<td>Target: 25.00</td>
<td>Predicted: 1.45</td>
<td>Target: 90.00</td>
</tr>
<tr>
<td>AC top-down fatigue cracking (ft/mile)</td>
<td>Target: 2000.00</td>
<td>Predicted: 257.71</td>
<td>Target: 90.00</td>
</tr>
<tr>
<td>Permanent deformation - AC only (in.)</td>
<td>Target: 0.25</td>
<td>Predicted: 0.20</td>
<td>Target: 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>
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</tr>
</tbody>
</table>
Questions???