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

- Good Pavement Condition (Functional or Structural)
- Poor

Time (Years)
Typical Pavement Performance Curve

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

**Pavement Condition**

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

**Time (Years)**
Cost Effects

Graph showing the relationship between pavement condition and cost over time. The graph indicates that maintenance costs decrease over time, with a suggestion to choose between $1 here or $4-10 here.
Preventive Maintenance

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

Time (Years)

Functional Pavement Condition (e.g. Ride Quality)

Good

Poor
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
Whitetopping Feasibility—Performance Period

**Conventional**

**Existing Condition**
- Very deteriorated HMA pavements

**Extent of Repair**
- Limited to very severe areas

**Future Traffic**
- Any traffic level

**Historical Reliability**
- Very good
Design Considerations

- Slab thickness
- Joint design
- Drainage design
- Reinforcement design
- PCC mix design
- Preoverlay repair and surface preparation
Preoverlay Repairs Whitetopping Overlays

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

**Goal: Uniform support**
Construction — Whitetopping Overlays —

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

Consider increased saw depth over major distortions

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></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>
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<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
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

### General Information
- **Design type:** Overlay
- **Pavement type:** JPCP over JPCP
- **Design life (years):** 25
- **Terminal IRI (in/mile):** 70
- **Initial IRI (in/mile):** 150
- **JPCP transverse cracking (percent slope):** 12
- **Mean joint faulting (in):** 0.2

### Performance Criteria

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Limit</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI (in/mile)</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>Terminal IRI (in/mile)</td>
<td>150</td>
<td>85</td>
</tr>
<tr>
<td>JPCP transverse cracking (percent slope)</td>
<td>12</td>
<td>85</td>
</tr>
<tr>
<td>Mean joint faulting (in)</td>
<td>0.2</td>
<td>85</td>
</tr>
</tbody>
</table>

### Layer Details

- **Layer 1:** PCC - JPCP
- **Layer 2:** Flexible - Asphalt concrete
- **Layer 3:** Flexible - Asphalt concrete
- **Layer 4:** Reinforced - JPCP (existing)
- **Layer 5:** Subgrade - A-4
- **Layer 6:** Subgrade - A-4

### Error List

<table>
<thead>
<tr>
<th>Project</th>
<th>Object</th>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Object</td>
<td>Property</td>
<td>Description</td>
</tr>
</tbody>
</table>

### Additional Details

- **PCC IRI I4:** 25.24
- **PCC IRI JPCP Std Dev.:** 5.4
- **PCC Punchout:** 2
- **PCC CRCP C1:** 1.22
- **PCC CRCP C2:** 3.16
- **PCC CRCP C4:** 33.15
- **PCC CRCP C5:** 5.82
- **PCC CRCP Crack:** 1

### Identifiers
- **Display name/identifier:** Display name of object/material/project for outputs and graphical interface.
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
JPCP optimization

Layer Thickness | Results
--- | ---
6 | Passed
12 | Passed
9 | Passed
7.5 | Failed
3 | Failed
3.5 | Failed

Optimization Rules

Use | Property | Rule | Criteria
--- | --- | --- | ---
| Dowel Diameter (in.) | | |
**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>Semi-Infinite</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>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 99.96</td>
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<tr>
<td>Mean joint faulting (in.)</td>
<td>0.20</td>
<td>0.07</td>
<td>85.00 100.00</td>
</tr>
<tr>
<td>JPCP transverse cracking (percent slabs)</td>
<td>12.00</td>
<td>9.49</td>
<td>85.00 92.70</td>
</tr>
</tbody>
</table>
HMA optimization

Adding a base layer is more appropriate
### HMA sensitivity

![HMA sensitivity](image)

<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>
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</thead>
<tbody>
<tr>
<td>Two-way AADTT</td>
<td>Thickness (in.)</td>
<td>Layer 1 Flexible : Asp...</td>
<td>6000</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Thickness (in.)</td>
<td>Layer 1 Flexible : Asp...</td>
<td>1.5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Binder Content (%)</td>
<td>Layer 1 Flexible : Asp...</td>
<td>11.61</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Air-voids (%)</td>
<td>Layer 1 Flexible : Asp...</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness (in.)</td>
<td>Layer 2 Flexible : Asp...</td>
<td>2.5</td>
<td>2.5</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Binder Content (%)</td>
<td>Layer 2 Flexible : Asp...</td>
<td>10.66</td>
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<tr>
<td>Air-voids (%)</td>
<td>Layer 2 Flexible : Asp...</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Thickness (in.)</td>
<td>Layer 3 PCC : JCPA (...</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness (in.)</td>
<td>Layer 4 Subgrade : A-4</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unbound Modulus</td>
<td>Layer 4 Subgrade : A-4</td>
<td>6000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dowel diameter (in.)</td>
<td>Layer 3 PCC : JCPA (...</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCC joint spacing (ft)</td>
<td>Layer 3 PCC : JCPA (...</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel width (ft)</td>
<td>Layer 3 PCC : JCPA (...</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCC coefficient of th...</td>
<td>Layer 3 PCC : JCPA (...</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28-Day modulus of ru...</td>
<td>Layer 3 PCC : JCPA (...</td>
<td>350</td>
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<td></td>
<td></td>
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</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>
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<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>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-4</td>
<td></td>
<td>Semi-infinite</td>
</tr>
</tbody>
</table>

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<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>Terminal IRI (in./mile)</td>
<td>172.00</td>
<td>106.11</td>
<td>100.00</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>
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<tr>
<td>Alt 3</td>
<td></td>
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<tr>
<td>Alt 4</td>
<td></td>
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</tbody>
</table>
Questions???