How to Select the Appropriate Pavement Rehabilitation Option

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Pavement Rehabilitation Selection
Understanding the Problem
Pavement Assessment

- Pavement assessment is the first step in making good decisions.
- The condition of the existing pavement is assessed through:
  - Pavement History
  - Pavement Condition/Distress Survey
  - Pavement Strength Evaluation
  - Surface, Base and Subgrade Analysis
  - Surface and Subsurface Drainage Review
  - Others?
Pavement Assessment
Pavement History

- Historic or existing information for the pavement should be gathered and assessed, including:
  - Original design information
  - As-built/constructed data
  - Quality Control/Quality Assurance construction data
  - Pavement Management System (PMS) data
  - Maintenance activity records
Pavement Assessment
Pavement Condition/Distress Survey

• What is a pavement condition survey?
  – A detailed visual inspection which rates all of the surface irregularities, flaws and imperfections found in a given area
  – A link to key insights into the causes of deterioration
  – Project level versus network level
Pavement Assessment
Pavement Condition/Distress Survey

Bituminous Pavement Distresses
Concrete Pavement Distresses
Evaluation of the structural capacity of an existing pavement can be determined by destructive or non-destructive methods

- Non-destructive testing methods include Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR) and Dynamic Cone Penetrometer (DCP)
- Proof-rolling – granular surfaces only
- Destructive testing methods include soil borings, probe holes, test pits and coring
Pavement Assessment
Pavement Strength Evaluation

• FWD Testing
  – Data used to calculate pavement strength, capacity and remaining life
Pavement Assessment
Pavement Strength Evaluation

- **Ground Penetrating Radar (GPR) Data**
  - Provides a “picture” of pavement structure
  - Used for FWD Analysis
Pavement Assessment
Pavement Strength Evaluation
Pavement Assessment
Pavement Strength Evaluation

- Coring Data
  - Pavement layers (surface, base and sub-base) are measured, classified and photographed
  - Asphalt cores are measured and analyzed for stripping/segregation
  - Data used to calibrate GPR data
Pavement Assessment
Surface, Base and Subgrade Analysis

• Coring
  – Determination of pavement thickness, layering, condition of each layer, bonding between layers, presence of materials related to distress and strength

• Soil Borings/GPR
  – Thickness, type or classification, moisture content, contamination, strength determination
Pavement Assessment
Surface and Subsurface Drainage Review

• Visual inspection for presence of:
  – Curb and gutter
  – Ditches
  – Subsurface drainage installed
    • Is it working?

• Soil borings:
  – Base material type
  – Subgrade material type
Pavement and Materials Assessment Approximate Costs

- Coring - $1,000 to $1,500 (per project < 2 miles)
- Soil / pavement borings ~$1,000 (per mile)
- FWD w/ analysis - $1,000 to $3,000 (per project < 2 miles)
- Sampling & subgrade testing - $1,500 (per project < 2 miles)
- DCP - equipment costs $1,500 (per project < 2 miles)

Costs will vary depending on many factors, especially mobilization and traffic control
Pavement Rehabilitation Selection
Choosing Rehabilitation Techniques
Bituminous Pavement Rehabilitation Techniques

- **Overlays**
  - Bituminous
  - Concrete
  - Mill and Overlay
  - Mill and Inlay

- **Recycling Options**
  - Cold In-place Recycling
  - Full-Depth Reclamation
    - Pulverization
    - Stabilization – including subgrade stabilization
Overlays

- Subgrade – Fill or Natural Soil
- Subbase
- Base
- Wearing Surface Layers
- Overlay
Overlays
What is an Overlay?

- Placement of a new course of pavement on the remaining pavement structure
  - Bituminous or Concrete
  - Mill and Overlay/Inlay
What is a BOB Overlay?

- A new bituminous surface is paved over an existing bituminous pavement.
- Can be a non-structural or structural overlay:
  - Non-structural overlay
    - Generally used as a short-term fix
  - Structural overlay
    - Thicker mat that will increase pavement strength
• **Direct Placement or Milling**
  - Direct placement when all the following are true:
    • Additional structure is necessary
    • No issues with existing pavement materials
    • No vertical limitations
  - Mill when one or more of the following is true:
    • Adequate structure in existing pavement
    • Problems with existing pavement materials
    • Vertical limitations exist
Bituminous over Bituminous Overlays
Applications for Non-structural BOB Overlays

• Good Candidates include pavements with:
  – Good subgrade, base and cross-section
  – Adequate strength
  – Where a short term fix is acceptable

• Poor Candidates include pavements with:
  – Poor subgrade and/or base support
  – Significant surface distresses
Bituminous over Bituminous Overlays
Applications for Structural BOB Overlays

- **Good Candidates** include pavements with:
  - Good subgrade and base, but inadequate thickness
  - Marginal structure, but cannot be closed to traffic

- **Poor Candidates** include pavements with:
  - Poor subgrade and/or base support that cannot be overcome with a thick overlay
  - Frost issues
Concrete over Bituminous Overlays

What is a COB Overlay?

- A new concrete surface is paved over an existing bituminous pavement
- Typically used as an unbonded overlay (≥4”)
- Can be bonded or unbonded
  - For unbonded overlays, degree of bond is not considered in design
Concrete over Bituminous Overlays
Fundamentals of COB Overlays

1. Pavement Evaluation
2. Resurfacing Design
   • Resurfacing Thickness
     • Typically 6 – 11 inches on high volume roads
     • Minimum of 4 inches on low volume roads
   • Mixture Design
   • Joint Design
   • Drainage Design
   • Edge support considerations

<table>
<thead>
<tr>
<th>Unbonded resurfacing thickness</th>
<th>Maximum transverse joint spacing</th>
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<tbody>
<tr>
<td>&lt; 5 in. (12.7 cm)</td>
<td>6 x 6 ft (1.8 x 1.8 m) panels</td>
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<tr>
<td>5–7 in. (12.7–17.8 cm)</td>
<td>Spacing in feet = 2 times thickness in inches</td>
</tr>
<tr>
<td>&gt; 7 in. (17.8 cm)</td>
<td>15 ft (4.6 m)</td>
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Concrete over Bituminous Overlays
Considerations for COB Overlays

- Original roadway width
- Vertical clearance
- Number of culverts and bridges
- Drainage
- Materials
- Schedule
- Traffic
Concrete over Bituminous Overlays
Applications for COB Overlays

- Good Candidates include pavements with:
  - Adequate subgrade support, but inadequate pavement structure
- Poor Candidates include pavements with:
  - Vertical geometry restrictions
  - Significant frost issues
  - Cannot be closed to traffic
Mill and Overlay

- Generally used with vertical restrictions or to correct severe surface defects
- Mill and overlay may increase the overall pavement height slightly – i.e. Mill 3”, Overlay 4”
Mill and Inlay

- Also used with vertical restrictions or to correct severe surface defects
- Maintains the same overall pavement height – i.e. Mill 3”, Overlay 3”
- Keep existing shoulders and/or curb
Recycling
FHWA - 2002 Recycled Materials Policy

- Recycled materials should get first consideration in materials selection
  - Recycling ⇒ engineering, economic & environmental benefits
  - Review engineering & environmental suitability
  - Assess economic benefits
  - Remove restrictions prohibiting use of recycled materials without technical basis
Recycling
Why Recycle?

- Improve serviceability of aged, deteriorated pavements
- Reduce raw material costs
- Level deformations & re-establish crowns
- Retain overhead clearances
Recycling
Why Recycle (Cont)?

- Minimize lane closure time, user delays
- Public acceptance of recycling
- Recycled pavement can be recycled itself
Recycling
When to Recycle?

- Pavement at end of its serviceable life
  - Fatigue (alligator) cracking
- Oxidized
- Raveling of thermal cracks - potholes
- Low clearances under bridges
Recycling Options
Bituminous

- Mill, haul and recycle at HMA plant
- Cold In-place Recycle (CIR)
  - Conventional
  - Engineered
- Hot In-place Recycle (HIR)
- Full Depth Reclamation (FDR)
  - Pulverization
  - Stabilization
In-place Recycling
Bituminous Recycling Options

Cold In-Place Recycling

Full Depth Reclamation
Cold In-place Recycling (CIR)
Cold In-place Recycling (CIR)
What is Cold In-place Recycling?

• CIR is the on-site rehabilitation of asphalt pavements without the application of heat during recycling.
• CIR interrupts the existing crack pattern and produces a crack-free layer for the new wearing course.
Cold In-place Recycling (CIR)
The Train Machine Concept

Used when the Engineer’s design requires milled material needs to be screened, be of a uniform size and fully mixed in a pugmill.
Cold In-place Recycling (CIR)
Fundamentals of CIR

• Analyze existing structure & conditions
  – Understand causes for distress
• Correct any drainage or base problems
• Two options:
  – Conventional
  – Engineered design process
Cold In-place Recycling (CIR) Fundamentals of CIR

Comparison of Conventional and Engineered CIR

- **Conventional**
  - No mix design
  - 2% Emulsion
  - QC requirements
    - Two gradations per day
    - 100% passing 1-1/2"
    - 90-100% passing 1"
    - Control strip

- **Engineered**
  - Defined sampling protocol
  - Engineered design
  - Performance-related specs
  - Early strength & long term durability
Cold In-place Recycling (CIR) Fundamentals of CIR

- Mix design
  - Reclaimed Asphalt Pavement (RAP) crushed to defined gradations
  - Emulsion formulated
  - Superpave Gyratory Compactor (SGC) mixes at field moisture content
- Performance-related tests
Cold In-place Recycling (CIR)
Mix Design

RAP/Base Analysis

- Foamed Asphalt, Engineered Emulsion and Fly Ash
  - Field cores crushed to 3 gradation bands
  - A design made for at least 2 gradations

![Graph showing gradation analysis](image-url)
Cold In-place Recycling (CIR)

Environmental Benefits of CIR

- No heat is used during the process thereby reducing the use of fossil fuels and also reducing air pollution.
- Since the existing aggregate and asphalt cement is reused, the need for virgin aggregate and asphalt cement are reduced or eliminated.
- 40% to 50% energy savings can be achieved using this process versus conventional approaches.
Cold In-place Recycling (CIR)
Applications for CIR

• Good candidates include pavement with:
  – At least 4” of hot mix
  – Adequate base and subgrade
  – Severe pavement distresses

• Poor candidates include pavements with:
  – Inadequate base or subgrade support
  – Inadequate drainage
  – Paving fabrics or inter-layers
Full Depth Reclamation (FDR)
Full Depth Reclamation (FDR)
What is FDR?

- The full thickness of the asphalt pavement and a predetermined portion of the base, subbase and/or subgrade is uniformly pulverized and blended to provide a homogeneous material.
- If new material is not a sufficient base for a new surface course, the reclaimed materials are stabilized by mechanical, chemical or bituminous means.
Full Depth Reclamation (FDR)
What is FDR?

- Bituminous pavement needing repair

FDR Example
- Overlay
- 6-10 inches stabilized material
- Granular base
- Soil

LRRB Pavement Rehabilitation Selection
Full Depth Reclamation (FDR)

Types of FDR

- **Mechanical stabilization** - FDR without addition of binder (Pulverization)
- **Chemical stabilization** - FDR with chemical additive (Calcium or Magnesium Chloride, Lime, Fly Ash, Kiln Dust, Portland Cement, etc.)
- **Bituminous stabilization** - FDR with asphalt emulsion, emulsified recycling agent, or foamed/expanded asphalt additive
Full Depth Reclamation (FDR)
Types of FDR

Additives Used in Recycling

- Foam: 2%
- Fly Ash: 5%
- Other (Kiln dust/CaCl2): 6%
- Lime: 11%
- Emulsion: 16%
- Cement: 20%
- None (dry): 40%
Full Depth Reclamation (FDR) Keys to Success

Stabilization Considerations

Prone to Rutting → Flexible ⏏ Granular ⏏ Organic Clay ⏏ Subbase/Subgrade ⏏ Stiff ⏏ Surface ⏏ Prone to Cracking

Granular

Flexible

Stiff

Organic Clay

Subbase/Subgrade

LRRB Pavement Rehabilitation Selection
Full Depth Reclamation (FDR)
Keys to Success

Stabilization Considerations

- Cutbacks or Road Mix: Prone to Rutting
- Proprietary Products
- Emulsion
- Foam Asphalt or Lime
- Fly Ash or Cement: Prone to Cracking

Flexible (left) to Stiff (right)
Granular (bottom) to Organic Clay (top)
Stabilization Considerations

- Fly Ash or Cement Stabilization
  - Mill to 3”- material
  - Can incorporate some plastic subgrade soils
  - Cement addition rate of 2-4% by weight, fly ash addition rate of 6-10% by weight
    - Short working time due to hydration
    - Specific design for each project
    - Higher stiffness, lower flexibility
Full Depth Reclamation (FDR) Applications for FDR

- Good Candidates include pavements with:
  - Need for upgrading, widening or rehabilitation
  - Bituminous surface on compacted base that:
    - Has sufficient depth to accommodate reclamation process (at least 2" greater than reclamation depth)
    - Exception: Compatible native materials meeting P200 & SE requirements
  - Generally has up to 20% fines (P200)
Full Depth Reclamation (FDR) Applications for FDR

- Good Candidates (Continued):
  - High severity distresses
    - Ruts
    - Base problems
    - Cracks
    - Edge failures
    - Potholes
  - Good drainage or drainage to be corrected
Full Depth Reclamtion (FDR)
Applications for FDR

- Poor Candidates include pavements with:
  - Clay-like native soils
    • Exception - can be stabilized with fly ash or lime/cement
  - Doesn’t meet P200 criteria & can’t or won’t accept added rock
  - Drainage problems
    • Including ditch & regional flooding problems
Full Depth Reclamation (FDR) Summary

- Builds structure down into pavement
  - Site assessment, sampling & mix design key to success
  - Performance-related design tests & specs improve reliability & performance
    - Early Strength
    - Cured Strength
    - Cracking Resistance
    - Moisture Resistance
    - QA / QC
CIR and FDR Considerations:

- What is the depth of my existing pavement?
  - CIR is best for pavements at least 5” thick
  - FDR is for any depth
- Is the pavement thickness consistent or variable?
  - FDR is better for variable thickness pavements
CIR and FDR Considerations (Continued):

- What is the condition and strength of the pavement base and subbase?
  - CIR requires base support for the heavy train equipment
  - FDR will break up cracking patterns in the base
- What is the required ease of construction?
  - CIR is all done at once
  - FDR has greater difficulty in getting material placed