Concrete Pavement:

Rehabilitation Applications, Options & Performance

Purdue Road School
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Concrete Pavement Basics
Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced

**Jointed Plain**

Plan

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3.5-6.0 m
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Profile

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or

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Jointed Plain

Jointed Plain
Load Transfer

- The slabs ability to share its load with its neighboring slab
  - Dowels
    - High Traffic Volumes
      - Pavements > 8 in.
  - Aggregate Interlock
    - Low Traffic Volumes
      - Pavements < 7 in.

Jointed Reinforced

Plan

Profile

7.5-9.0 m
Jointed Reinforced
Continuously Reinforced

Plan

Profile

0.6-2.0 m
Continuously Reinforced

Rehabilitation Strategies

• Three categories:
  – Restoration
  – Resurfacing
  – Reconstruction
    Together, known as CPR\(^3\)
• Which is used depends on existing condition.
Concrete Pavement Rehabilitation

- Improves structural and/or functional condition of pavement.
  - Structural condition - the ability to carry traffic.
  - Functional condition - the ability to serve the user comfortably.

Pavement Condition
Rehabilitation Timing

Structural/Functional Condition vs. Age or Traffic

- Min. Acceptable Rating
- Restoration
- Resurfacing
- Reconstruction

Optimize

Cost vs. Performance
Restoration (CPR)

- Used early when pavement has little deterioration.
- Repairs isolated areas of distress.

Restoration Techniques

Concrete Pavements

- Full-depth repair
- Partial-depth repair
- Diamond grinding
- Joint & crack resealing
- Slab stabilization
- Retrofitting dowels
- Retrofitting concrete shoulders
- Cross-stitching long. cracks/joints
Full Depth Repairs

- Repairs distresses greater than 1/3 the slab depth.
- Consists of removing and replacing at least a portion of the existing slab to the bottom of the concrete.
Use of High Early Strength Mixes

• Can design mix to meet opening need requirements
• Specify minimum requirements:
  – INDOT(506.04): Minimum cement – 658 lbs./cy
  – INDOT(506.11): Open to traffic when $M_R > 300$ psi
  – When use Calcium Chloride – use 506.11 Chart
  – Alternative – can use maturity method to open
• California 4 x 4 system
Partial Depth Repairs

- Repairs deterioration in the top 1/3 of the slab.
- Generally located at joints, but can be placed anywhere surface defects occur.

Carbide-Milling

Longitudinal Milling

Near vertical edges.

Transverse or Longitudinal Joint/Crack

Transverse Milling (Half-moon)

Transverse or Longitudinal Joint/Crack
TYPICAL SPALLS
REMOVAL

• Milling machine
MILLING IN PROGRESS

TYPICAL MILLED AREA
CURING

• Use curing compound

Supporting Research

• JTRP/Purdue research nearing completion with report due summer 2006
  – SPR – 2648: Evaluation of Rapid Setting Cement Based Materials for Patching (Ph I)
  – SPR – 2789: Dowel Bar Retrofit Mix Design & Performance

• Presentation of interim result available on 2006 PCCP Workshop CD
• Field Trial of Rapid Set Materials (Ph II)
Load Transfer Restoration

- Reestablishes load-transfer at undoweled joints or cracks
- Used to limit future faulting

\[ \Delta L = x \quad \Delta U = 0 \]  
Poor Load Transfer

\[ \Delta L = x \quad \Delta U = x \]  
Good Load Transfer
Concrete Pavement Restoration
Concrete Pavement Restoration

Diamond Grinding

- Improves ride by removing:
  - Faulting at joints
  - Slab warping
  - Surface deformations caused by studded tires
- Reestablishes skid resistance
- Corrects cross-slope
Joint and Crack Resealing

- Minimizes water & incompressibles into pavement system.
  - Reduces:
    - Subgrade softening
    - Pumping
    - Erosion of fines
    - Spalling
Restoration Performance

- Provides 10 or more years of service.
- Preliminary engineering & timing are critical.
- Overall effectiveness is highly dependent on design adequacy, construction quality, and other restoration activities.

Repairing Cracks

Alternative: Cross Stitch Crack
Recommendation: Saw & Seal Crack - Epoxy Saw Cut

- Crack Fully Penetrates Slab Depth
- Crack within 0.3 m of Joint
- Joints Not Cracked where Cracks Exist
Cross-Stitching

Cross-Stitching
Repairing Cracks

Recommendation: Cross-Stitch the Crack

- Crack Fully Penetrates Slab Depth
- Crack Relatively Parallel in Mid-slab (>1.35 m) from Joint or Edge

Repairing Cracks

Alternative: Cross-Stitch Crack
Recommendation: Replace Slabs Full-Depth

- Crack Fully Penetrates Slab Depth
- Crack Relatively Parallel in Wheelpath (0.3-1.35 m) from Joint
Resurfacing

• Used when pavement has medium to high levels of distress.
• Used when restoration is no longer effective.

Resurfacing Activities

• Concrete overlays for concrete pavements:
  – Bonded Concrete Overlays
  – Unbonded Concrete Overlays

• Concrete overlays for asphalt pavements:
  – Conventional Whitetopping
  – Ultra-Thin Whitetopping
Bonded Overlays

- Consists of a thin concrete layer (100 mm or less) on top of an existing concrete surface.
- Specific steps are taken to bond the new concrete overlay to the existing concrete.
Bonded Overlay

• The major use of Bonded Overlays is structural enhancement of the pavement.
• Cracks in the underlying pavement will reflect into the resurfacing
• Most often used where the underlying pavement is in reasonably good condition.

Bonded Overlays

Performance

• Good when:
  – Placed correctly and at the right time.
• Poor when:
  – Placed on deteriorated pavements.
• Loss of bond does not necessarily constitute failure.
Unbonded Overlay

- Consists of thick concrete layer (125 mm or greater) on top of an existing concrete.
- Uses a “separation interlayer” to separate new overlay and existing concrete.

Unbonded Overlays

Separation Interlayer:

- Allows layers to act independently.
- Prevents distresses from reflecting into overlay.
- Typical Interlayer:
  - 1-1 ½ “Asphalt layer
Unbonded Overlays

Separation Interlayer:

- "Key"
- Old Pavement
- Smooth Slip Plane
- Old Pavement
- Thick Interlayer (> 50 mm)

Advantages

- Can Place on Pavement in Bad Condition.
- Less Pre-Overlay Repair Needed Than Other Overlay Designs.
- No Future Reflective Cracking.
- Avoid Reconstruction Problems.
- Maintain Traffic.
UNBONDED CONCRETE OVERLAYS

Job-Site Considerations

- Overhead Structures.
- On-line Bridges.
- Shoulders.
- Fill for Slope Flattening.
- Traffic Control.

UNBONDED CONCRETE OVERLAYS

Payment

Cubic Yard  Square Yard

NOTE: Divided payment is the most equitable and economic.
Unbonded Overlays

Performance

• Very Good
• Can be expected to perform for 20+ years.
  – Most failures are due to the use of inadequate separation layers.

Conventional Whitetopping

• Consists of thick concrete layer (100 mm or greater) on top of an existing asphalt pavement.
• Behaves as a new pavement on a strong base.
Whitetopping Engineering Bulletin

- New for 1998
  - Conventional Whitetopping
    - Design
    - Construction
    - Performance
  - Ultra-thin Whitetopping
    - Design
    - Construction
    - Performance

Whitetopping - History

- First Whitetopping
  - South 7th street in Terre Haute, Indiana - 1918
  - 4” concrete overlay of existing asphalt pavement
- During 40’s & 50’s used to upgrade military & civilian airports
- Highway use started approx. 1960
  - Types have included JPCP, JRCP, CRCP, FRC
Whitetopping History

• Modern usage began in Iowa in 1960’s where heavy loads from farm trucks created a need for a durable pavement.
• Performance was excellent
• Over 500 miles of whitetopped roads since the 1960’s
• Now used for Interstates, highways, airports, intersections and parking lots

Typical Whitetopping Thickness

• Depends on expected traffic load.
  – City streets, county roads, and small airports
    • 100 to 175 mm (4 to 7 in.)
  – Primary roads and interstate highways
    • 175 to 280 mm (7 to 11 in.)
  – Large airports
    • 200 to 460 mm (8 to 18 in.)
Whitetopping - Advantages

**Construction**

- Can place on pavement in bad condition.
  - Little or no pre-overlay repair needed.
- Avoid reconstruction problems.
  - Minimal rain delays.
  - Maintain traffic on existing surface.

**Whitetopping - Advantages**

- Improved structural capacity.
- Maintains high level of serviceability.
- Low maintenance.
- No seasonal weakening (spring breakup).
- Concrete slabs bridge problems asphalt cannot.
- Light reflective, safe riding surface.
Whitetopping Construction

- Critical issue is uniform support
- Subgrade / base failures need repair
- Need to evaluate drainage (esp. Inlays)
- Address surface distortions
  - Direct application
  - Profile milling
  - Leveling course

Ultra-Thin Whitetopping

- Consists of thin concrete layer (4 in. or less) on top of an existing asphalt pavement.
- Specific steps are taken to bond the new concrete to the existing asphalt and to saw short joint spacing.
Ultra-Thin Whitetopping

Short joint spacing allows the slabs to deflect instead of bend. This reduces slab stresses to reasonable values.

Bonding Effects on Edge Stress

<table>
<thead>
<tr>
<th></th>
<th>Unbonded</th>
<th>Bonded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension</td>
<td>8.49 Mpa (1230 psi)</td>
<td>2.90 Mpa (420 psi)</td>
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75 mm Concrete, 100 mm AC, K=81 Mpa/m, E_c = 27,580 Mpa, E_{ac} = 2,758 MPa
Known Design Considerations

- Bond is critical.
- Slab size (Jointing) is important.
- Underlying asphalt thickness is important.
Indiana Overlays

• I – 69 North of SR 18 – 11” 1986
• I – 65 North of SR 114 – 10.5” 1994
• I – 94 West of SR 39 – 13” 1998
• I – 70 at US 27 – Richmond – 12” 2000
• Harding Street – Indianapolis – 6” 1985
• 121st Street – Fishers – 9” 1992
• Indianapolis Bus Lanes – 3.5” 1997
• Allisonville Rd – N. of 96th – 7” 1999
• 56th Street – Brownsburg – 5” 2001
• Market & Columbia – Warsaw – 3.5” 2002
I-69 UNBONDED PCC OVERLAY

• OPENED TO TRAFFIC 1964
• RESURFACED (Bituminous) 1975
• NBL RESURFACED (Bituminous) 1978
• UNBONDED OVERLAY 1986
I-65 UNBONDED PCC OVERLAY

Harding Street - Indianapolis

- Old concrete street with patches
- PCC Unbonded overlay placed 1985
- 6” thick over old street
- Widened 6’ with 8” PCCP
- Skewed non-doweled transverse joints
- Tied longitudinal joint provided at section thickness change
- Still in excellent condition
Harding Street - Indianapolis
121st Street - Fishers
Allisonville Road
96th Street to Eller Road

Project Information

• Traffic: 26,360 vpd
• Existing 24’ asphalt pavement
• Scope:
  – widen to outside
  – maintain traffic
  – mill & overlay existing
Allisonville Road Cross Section

Allisonville Road
56th Street - Brownsburg

- Commercial and Residential traffic
- 44’ wide, 3500’ long
- 6” concrete overlay with variable depth to 9” as needed
- Center line realignment
- Drainage
- Texture: Turf Drag and Random Tining

56th Street Brownsburg
PLACING CONCRETE

PERFORMANCE

- All three sections are performing well
Market & Columbia Streets - Warsaw

3 ½” Concrete overlay over milled HMA
Joints sawed at maximum spacing – 5’ 0”
Joints sawed at 1/3 depth of overlay
Market & Columbia Streets - Warsaw
Market & Columbia Streets - Warsaw

Madison, IN Airport Apron

3 ½ “ Concrete overlay over existing HMA
Joints sawed at 4’ x 4’ spacing
Madison, IN Airport Apron

Reconstruction

- Used when the pavement has high levels of distress.
- Used after overlays are no longer effective.
Reconstruction Activities

• Final stage of rehabilitation.
• Involves removing and replacing existing pavement with a new pavement.
  – Complete removal & replacement
  – Partial removal & replacement (Inlay).
• Can correct:
  – Subgrade / subbase deficiencies, Roadway geometrics, Roadside safety features, Drainage

Reconstruction Activities

• Controls the final elevation
  – Minimizes roadside appurtenances adjustments.
• Can recycle the old pavement
Summary

• CPR³ repairs structural / functional deficiencies.
• Improves pavement condition to an acceptable level.
• Appropriate activity depends on the existing pavement condition.
  – As condition declines, the optimum activity changes.
  – Applying correct activity at correct time is essential.

Summary

• Restoration
  – Repairs isolated areas of deterioration.
• Resurfacing
  – Repairs a pavement with medium to high severity levels of distress.
• Reconstruction
  – Used at the end of the pavement’s life, when it has very high severity levels of distress.
YOU HAVE OPTIONS.

Questions?

www.pavement.com