CP Tech Center Concrete
Overlay Technology Deployment

Intersections

Rural secondary roads

Urban freeway/interstate

Urban arterial

Rural primary/interstate

ASCE Transportation Engineering Conference
Ames, Iowa
November 5, 2014
New Concrete Overlay Guide
Update 2008 Overlay Guide - May 2014

Contents
1. Introduction
2. Evaluations
3. Applications
4. Design
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7. Construction

New Items
- Synthetic Fibers
- Evaluation Flow Chart
- Geotextile Interlayer
- 3D Survey
- Stringless Paving
- Plate Dowels
Guide for Concrete Pavement Joint Rehabilitation with Thin Concrete Overlays

- Guide demonstrates potential applicability of thin concrete overlays as a longer term solution (15 years and greater).
- Previous US experiences with thin concrete overlays are highlighted along with adapted practices to provide solutions for pavements with joint deterioration.
Performance History of Concrete Overlays in the U.S.

- Document concrete overlay history and performance
- Concrete overlay demographics and statistics
- Twelve in-depth case studies
### Case History #1

**Overlay Type:** Bonded concrete overlay on asphalt pavement

**Overlay Thickness:**

- **Location:** US 69 southbound lanes in Pittsburg County, Oklahoma
- **Year Constructed:** 2001

**Current Traffic:**
- ADT – 16,000 (two directional movements)
- 30% trucks (discuss if there is any unusual loading like in a heavy industry, etc.)
- Year – 2011; Estimated ESALs since construction through 2013 (assumed 2% growth, 50% directional, 75% design lane and a truck factor of 1.4 – 10,120,178

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**Contractor:**

**Engineer:**

**Owner:**

**Project Length:**

- **Overlay Joints:**
  - Spacing –
  - Dowel bars – N/A
  - Tie bars –
  - Joint spacing –
  - Subdrains –

**Comments:**

- Causes of deterioration in asphalt were thought to be?
- Status of stripping?

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**Subbase Type**

<table>
<thead>
<tr>
<th>Design Procedure</th>
<th>Unknown</th>
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<tbody>
<tr>
<td>Design Details</td>
<td>Transverse joints sawed T/3 x 1\frac{1}{8}&quot; at 6' c/c; unsealed joints</td>
</tr>
<tr>
<td>Fibers Used/Type/Dosage</td>
<td>Yes/Macro/3 lb per yd²</td>
</tr>
<tr>
<td>Construction Details</td>
<td>Constructed one lane at a time with traffic adjacent to the paving operation</td>
</tr>
<tr>
<td>Pre-Overlay Repairs</td>
<td>None</td>
</tr>
<tr>
<td>Approximate Cost per Mile</td>
<td>$600,000</td>
</tr>
</tbody>
</table>

**Observed Distress(es):**

- 38 slabs (less than 1%) with visible cracks and joint spalling at Centerline

**Repairs to Date:**

- 0

**Bid Tabulations:**

- Click here for a digital plan set (example)
- Click here for specifications (example)
Specifications for PCC Overlays

- Develop a draft specification
- Easily modified for use with local PCC specs
- Encourage use of PCC overlays by more state and local governments
A Solution for all Existing Pavements!

Concrete Overlays on Asphalt Pavements

Concrete Overlays on Concrete Pavements

Concrete Overlays on Composite Pavements
The When is Important...

- Maintenance
- Resurfacing
- Reconstruction
Percentage of Each Type of Concrete Overlay

- Bonded: 22%
- Unbonded: 78%
Percentage of Concrete Overlays by Existing Pavement Type

- On Concrete: 55%
- On Asphalt: 40%
- On Composite: 5%
Expectations...

• How much will it cost?
  – Why? Because our budget is fixed
  – How long do you need it to last?

• Thickness, cost and service life are interrelated
Bonding Effects on Thickness

**Bonded**

- Concrete
- NA
- Comp.
- Asphalt
- Tension

**Unbonded**

- Concrete
- NA
- Comp.
- Asphalt
- Tension
# Current State-of-the-Practice Overlay Methodologies

<table>
<thead>
<tr>
<th>Bonded concrete overlay of concrete pavements</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 1993 AASHTO Guide</td>
</tr>
<tr>
<td>• M-E PDG</td>
</tr>
<tr>
<td><strong>Bonded concrete overlay of HMA and composite pavements</strong></td>
</tr>
<tr>
<td>• BCOA Thickness Designer (ACPA 2012)</td>
</tr>
<tr>
<td>• BCOA ME Design Guide (Vandenbossche 2013)</td>
</tr>
<tr>
<td><strong>Unbonded concrete overlay of all types</strong></td>
</tr>
<tr>
<td>• 1993 AASHTO Guide</td>
</tr>
<tr>
<td>• M-E PDG</td>
</tr>
<tr>
<td>• StreetPave (ACPA 2012)</td>
</tr>
</tbody>
</table>
2010 Overlay Cost Survey

- Based on 33 projects in 6 states in 2009
- Includes concrete, placing overlay, and jointing
- Excludes pre-overlay repair and separate layer (if used)
Evaluation of Existing Pavement

- Evaluation of existing pavement is paramount
- Premature overlay failure often traceable to “picking the wrong project” to overlay
- Bond – Good to fair condition of existing pavement
- Unbond – Can be in poor condition but uniform support
What is the Condition of the Pavement We are Putting Overlays On?

- Age of Different Thickness Layers
- Estimate Remaining Life
- Mixture materials,
- Design & construction date and method,
- Performance Grades of Lifts (records)
- Type and Amount of Traffic Now and in the Future
- Pavement Management Records
- Desired Design Life
- Elevations and Grade Restrictions
Coring

- Layer confirmation
- Layer thicknesses
  - Variability
  - Minimum requirements for thin overlays
- Subsurface conditions
  - Stripping
  - Delaminations
- Samples for laboratory testing
  - Material properties
Identify and Quantify Constraints

• Vertical and horizontal constraints need to be identified in the pavement evaluation
  – Existing structures
  – Overhead clearances – overpasses, signs and utilities
  – Barrier rails
  – Existing cross-slope variability
  – Drainage structures
  – Existing foreslopes
  – Intersections, driveways and field entrances
Concrete Overlay Over Composite Design and Construction Elements
How Do Bonded Overlays over Asphalt Work?

• Concrete bonds to the asphalt
  – Lowers the neutral axis
  – Decreases stresses in the concrete

• Short joint spacing
  – Controls cracking
  – Slabs act as paver-blocks

• Fibers improve concrete toughness
Effects of Joint Spacing

3.0 ft  3.0 ft  3.0 ft

Short Slabs Deflect
Very little flexural stress

10.0 ft

Standard Slabs Bend
Higher flexural stress
Structural Fibers Considerations

- Does not increase the concrete’s strength
- Increases toughness
- Increases post-crack integrity
  - Helps control plastic shrinkage cracking
  - Steel fibers not recommended where deicing salts may be used.
Structural Fibers

Residual strength ratio = 24%

Straight synthetic: Strux 90/40

Crimped synthetic: Enduro 600
Over Milling

• Minimize milling to retain structural support for the overlay.

• Minimum of 3” asphalt should remain after milling

• Potential for delamination between lifts.

• Minimize cross slope corrections in the asphalt to help prevent crossing lift lines.

Excessive milling of existing asphalt beyond asphalt lifts (tack line)

Remaining HMA severely damaged from trucks hauling away millings
Pre Overlay Repairs

- Inspect the asphalt surface for isolated areas or spot repairs may be required.

- New asphalt patches do not bond well with the concrete overlay due to its higher bituminous content.

- Utilize concrete patches for larger areas and isolate the concrete overlay over the patch.
Surface Cleaning

Power Sweeping

Air Blasting

Water Blasting
Not normally required
PCC Placement and Finishing

• Same as conventional PCC paving
• Avoid surface contamination
• Keep ACC temperature below 120°F
• Twice curing compound rate
PCC Joint Sawing

CRITICAL
• Effective curing
• Timely joint sawing
Bonded over Asphalt/Composite
Keys to Success

• Bonding is critical
• Small square panels reduce curling, warping, & shear stresses in bond (1.5 times thickness).
• Mill to remove surface distresses, or improve bonding.
• Be sure to leave at least 3” of HMA after milling.
• HMA surface temperature below 120 F before paving.
• Joints in the overlay should not be placed in wheel paths, if possible
• Application of curing compound is critical
Bonded Concrete Overlay of Concrete Design and Construction Elements

2”–5” thickness

Before Overlay

Overlay After 19 years service
Coefficient of Thermal Expansion (CTE)

- Overlay CTE should be similar to underlying pavement
- If not near the same, the overlay CTE should be lower than existing pavement
- Key similar coarse aggregate type
Joint Design—Full Depth Cut & Width of Cut

- Overlay joint
- New overlay transverse joint
- Concrete overlay
- Sawcut in existing slab
- Crack in existing slab

Diagram showing a joint design with full depth cut and width of cut.
Pre-Overlay Repairs

Partial Depth Repairs

Full Depth Repairs

Crack cage over concrete pavement
Surface Preparation for Bonded Overlay
Bonding is Critical

Shotblaster

Shot Blasted Pavement
Cleaning the Surface to Prepare for Bonding

• Sweeping surface followed by compressed air cleaning in front of the paver.

• Air blasting or water blasting is only necessary to remove material that cannot be removed any other way.

• No standing water should not be on the surface prior to paving or de-bonding can occur.
Bonded Overlay on Concrete: Keys to Success

- Concrete Bonding is important
- Concrete aggregate used in overlay should have thermal properties similar to that of existing pavement
- Matching joints with underlying pavement allows structure to move monolithically.
- Existing joints must be in fair condition or be repaired
- Timing of joint sawing is important
- Cut transverse joints full depth +1/2” and longitudinal joints at T/2.
- Width of transverse joint of overlay to be equal to or greater than underlying crack width of the existing pavement.
- Curing should be timely and adequate
Concrete Unbonded Overlay of HMA or Composites

Figure 32 illustrates an asphalt pavement that may be a candidate for an unbonded concrete overlay, along with the kinds of roadway repairs that may be appropriate.

Before

After
Concrete Unbonded Overlay of HMA or Composites

- Use when existing pavement is poor or deteriorated condition.
  - severe rutting,
  - potholes,
  - alligator cracking,
  - shoving, and pumping
  - exhibits past D-cracking and ASR
- stripped asphalt should be removed
- Need 3” to 4” HMA remaining
Semi-Uniform Platform

Remaining HMA severely damaged from trucks hauling away millings

Removed 6-in. of existing 9-in HMA Pavement
Joint Spacing and Reinforcement

- Overlays ≤ 6 inches thick, the maximum joint spacing in feet is 1.5 the slab thickness in inches.

- Overlays > 6 inches thick, the maximum joint spacing in feet is 2 the slab thickness in inches.

- Dowels in overlays < 7 inches and tie bars in overlays < 5 inches are not typically used.
Concrete Placement & Finishing

- Sweep asphalt surface
- Mist spray to lower asphalt surface below 120° F.
- No standing water
- Utilize conventional concrete paving practices
- Use twice the rate of occurring compound if the unbonded overlay is 6 inches or less
- Where rutting has occurred in asphalt pavement, adjust the saw cut depth to account for distortions
Unbonded Over Asphalt/Composite
Keys to Success

• Milling to eliminate surface distortions of 2 in. or more
• Complete repairs at isolated spots where structural integrity needs restoring
• Concrete patches in the existing pavement should be separated from the overlay
• Surface temperature of existing asphalt pavement should be maintained below 120°F (48.9°C) when placing overlay
• Partial bonding between the overlay and the existing asphalt pavement is acceptable and may even improve load-carrying capacity
Concrete Unbonded Overlay of Concrete

Bonded Concrete Overlays of Concrete Pavements
(Overlay and existing concrete pavement act as one monolithic pavement)

- Excellent
- Good
- Fair
- Poor
- Deteriorated
- Failed

Condition vs. Time

Existing concrete pavement with surface distresses
Deteriorated partial-depth patch
Random cracking
Spalling
Transverse cracking
Scaling
Monolithic pavement with new concrete surface
Prepared surface
Cleaning
Full-depth patch

Tech Center
Unbonded Overlays Can Be Placed Over Poor Concrete Pavements

- Requires very little repairs to serve as a base for new concrete surface.

- Existing pavement must provide a stable and uniform subbase.

- Essentially designed as a new concrete pavement on existing base with a separation layer in between.

- Pavements with freeze-thaw, D-cracking and ASR, are more likely to be candidates for thicker unbonded concrete overly and would fit as rehabilitation strategy.
Milling Existing Concrete

Milling the existing concrete on Little Mack Avenue (Photo courtesy of Dan DeGraaf, Michigan Concrete Paving Association)
Spot Repairs for Unbonded Overlays of Concrete

Joint Patching
Separation Layer

• Required for good performance
  – Isolate overlay from existing distress
    ▪ Prevent reflective cracking
    ▪ Prevent bonding/mechanical interlocking
  – Provides a bidding cushion for the unbonded overlay
  – A good drainage system to drain the interlayer

• Recommended separation layer material:
  – 1 in HMA
  – Geotextile fabric
Why An Adequate Interlayer?

OVERLAY

OLD PAVEMENT

"KEY"

THICKER INTERLAYER (1"

SMOOTHER SLIP PLANE
Separation Layer

• Asphalt separation layer
  – Serves as a good cushion for the overlay
  – Can help prevent keying of the interlayer in faulted concrete pavements
  – Stripping of the asphalt binder can occur due to poor drainage of the interlayer and heavy truck traffic.

• Nonwoven geotextile fabric
  – Easy to place interlayer at less than half the cost of asphalt.
  – Improved drainage but must have outlet
  – Faulting must be minimal to prevent keying of the overlay
Placement of Geotextile

No Wrinkles
Unbonded Overlay of Concrete Pavements: Keys to Success

• Full-depth repairs - only where structural integrity is lost at isolated spots.

• Separator layer (normally 1” asphalt or geotextile fabric)

• Use to restore structural capacity of the existing pavement and increase pavement life equivalent to full-depth pavement.

• Faulting of 3/8 in. or less in the existing concrete pavement

• Shorter joint spacing helps minimize curling and warping stresses.

• To not match joints with those of the underlying concrete pavement.
WORTH COUNTY

- 6 bidders
  - 4 concrete (4”)
  - 2 asphalt (3” on 3” CIP)

- Cost
  - $165,000 per mile

- Concrete cost was 8% more than asphalt
  - Included 20% overrun in plan quantity (CY)
  - Actual was 12%
    - Negating the difference
WRIGHT COUNTY

- 6 bidders
  - 5 concrete (5”)
  - 2 asphalt (4” on 3” CIP)
- Concrete 13% below the low asphalt bid
- Cost
  - $189,874 per mile
- Preparation
  - No milling
  - Plans assumed 10% overrun
  - Actual overrun was 11%