Concrete Overlays for Pavement Resurfacing and Rehabilitation

Ohio Transportation Engineering Conference
Session 18
October 27, 2015

Dr. Michael Ayers
Global Pavement Consultants, Inc.
The CP Tech Center

The National Concrete Pavement Technology Center (National CP Tech Center) at Iowa State University is a national hub for concrete pavement research and TECHNOLOGY TRANSFER.

MISSION:

• Help street and road agencies find answers to their concrete pavement-related questions.

• Identify critical concrete pavement research needs and discover sustainable solutions.

• Help agencies, industry, and businesses incorporate advanced, sustainable solutions and new technologies into their day-to-day practices.
Concrete Overlay Tech Support

• Tasked by FHWA to support state and local agencies with implementation of concrete overlays
• Involved in 30+ states since 2008
• Tech support for project scoping, PS&E and through construction

We do not promote or sell concrete overlays, our job is to provide unbiased technical support to agencies
CP Tech Center Overlay Program

• Each participating state agency will have an opportunity to develop in-house expertise on overlays.

• Services (each one is optional depending on what the state desires):
  – Meetings with state DOT upper management regarding the benefits of concrete overlays and to answer state DOT’s questions on issues.
  – An initial workshop on concrete overlay best practices (length of workshop depends on each state’s needs and objectives).
  – Presentation at a state or industry seminar based on the Guide to Concrete Overlay Solutions (2013 edition).

• Topics (typical but not all inclusive)
  – How do we select a project as a candidate for a concrete overlay?
  – How do we decide on what repairs are needed prior to an overlay?
  – What design method options are available & how do they work?
  – What are key construction items in a concrete overlay project?
CP Tech Center Overlay Program

Expert Team Approach

An expert team consisting of a state DOT, CP Tech Center, and when possible, an industry member and FHWA member, will be assigned to each state to share their knowledge and experiences about:

- Overlay technology
- Project evaluation and selection
- Design details
- Construction traffic control suggestions
- Constructability issues
CP Tech Center Overlay Program

Sharing Experiences
Following the site visit, the team will provide a written summary with recommendations. The findings of each site visit, as they occur, will be sent to each of the NC² state DOTs for their records and to share with other 27 states.

New documents for 2014 include:
• Concrete Overlays Guide
• Specifications Guide
• Example Overlay Plan Set & Up-To-Date Costs
• Performance History of Concrete Overlays

Who to Contact
If you have interest in holding a training event, please contact:
Dale S. Harrington P.E.; 515-290-4014; dharrington@snyder-associates.com or Melisse Leopold; 515-964-2020 mleopold@snyder-associates.com.
Concrete Overlay Guide, *Third Edition*

Contents (145 pages)
- Overview of Overlays
- Overlay types and uses
- Evaluations & Selections
- Six Overlay Summaries
- Design Section
- Misc. Design Details
- Overlay Materials Section
- Work Zones under Traffic
- Overlay Construction
- Accelerated Construction
- Specification Considerations
- Repairs of Overlays

Concrete Overlays - Introduction

• 1,152 concrete overlays in the U.S., dating from 1901 through 2012 (the database is continuing to grow)
• Concrete overlays have been successfully constructed in 45 different states
Why Concrete Overlays?

- Benefits of Concrete Overlays
  - Provides cost effective solutions – to extend service life of existing pavements
  - Can be constructed rapidly and with effective construction traffic management
  - Can be applied to a wide variety of existing pavements exhibiting a range of performance issues
  - Most importantly: long-term service.
    - Can be designed and constructed to achieve a service life of 15 to 40 years (or more).
Overlays Comprise ~14% of Concrete Surfacing Construction, Annually

Square Yards in '09 and '10

[Source: Oman and ACPA]
Historically, Mostly on Concrete

- On Concrete: 55%
- On Composite: 5%
- On Asphalt: 40%
... But More and More on Asphalt

![Bar chart showing the percentage of bonded and unbonded materials over different decades.](chart.png)
Bonded vs. Unbonded

Based on over 1,000 concrete overlays from NCHRP Synthesis 99, NCHRP Synthesis 204, and ACPA's National Overlay Explorer
Concrete Overlays – Service Life Expectations

• Thickness of 2 to 6 in. – 15+ years
• Thickness > 6 in. – 20 to 40+ years

Overlay service life is dependent upon:
• Sound overlay structural design - compatible with expected traffic and site conditions, and
• Good construction practices
System of Concrete Overlays

Concrete Overlays

Bonded Overlay System
- Thinner
- Bond is integral to design

Over Concrete Pavements

Over Asphalt Pavements

Unbonded Overlay System
- Old Pavement is base
- Thicker

Over Concrete Pavements

Over Asphalt Pavements

Over Composite Pavements

Over Composite Pavements
Bonded vs. Unbonded

Bonded

Unbonded
The “When” is Important ...

Restoration

Resurfacing

Reconstruction

<table>
<thead>
<tr>
<th>Existing pavement condition before treatment</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Deteriorated</td>
<td></td>
</tr>
<tr>
<td>Failed</td>
<td></td>
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</table>
Selecting the Appropriate Concrete Overlay Solution

1. Design Objectives
   • Desired pavement life?
   • Desired level of service?

2. Condition of the Existing Pavement

3. Budget Objectives

4. What overlay will achieve these objectives?
General Feasibility - Bonded PCC Overlays

• Bonded Concrete of Concrete
  – “Good” PCC pavements with need for:
    • Increased structural capacity
    • Improved surface characteristics

• Bonded Concrete of HMA & Composite
  – “Good” to “fair” HMA pavements with:
    • Limited structural (fatigue) cracking
    • No stripping/raveling in HMA layers
    • HMA thick > 3-5 inches (after milling)
General Feasibility - Unbonded PCC Overlays

• **Unbonded Concrete of Concrete**
  - PCC pavements in “fair” to “deteriorated” condition
  - Any traffic level

• **Unbonded Concrete of HMA & Composite**
  - HMA pavements in “fair” to “deteriorated” condition
  - Any traffic level
Bonded Concrete Overlay of Asphalt
The bonded concrete overlays of asphalt mechanistic-empirical design procedure (BCOA-ME) was developed at the University of Pittsburgh under the FHWA Pooled Fund Study TPF 5-165. This pavement structure has been referred to as thin and ultra-thin whitetopping. This site is a repository for all information relating to the BCOA-ME. The information has been sorted based on its intended use and can be retrieved by clicking on the appropriate tab below. The BCOA-ME can be run directly from this site by clicking on the “Design Guide” tab below.

http://www.engineering.pitt.edu/Vandenbossche/BCOA-ME/
Performance

• Long history of successful use given:
  – Sufficient bond is established between concrete overlay and existing asphalt
  – The existing asphalt provides adequate structural support
Keys to Success

• Milling may be needed to remove surface distortion (that greater than 2 inches)
• Minimal spot repairs may be required
• Be sure to leave a minimum of 3 inches of asphalt after milling
• Asphalt surface temperature below 120 F before paving
• The asphalt surface must be clean prior to overlay application
Keys to Success

• Small square panels reduce curling, warping, and shear stress at bond interface
  – Maximum spacing in feet is 1.5 times the thickness in inches

• Transverse joints must be sawed T/3 – pay attention to non-uniform sections

• As much as possible, joints in the overlay should not be placed in wheel paths

• Application of curing compound is critical
  – Twice the standard rate
# Possible Pre-overlay Repair

<table>
<thead>
<tr>
<th>Existing Pavement Distress</th>
<th>Spot Repairs to Consider</th>
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<tbody>
<tr>
<td>Rutting $\geq$ 2 in. (50 mm)</td>
<td>Mill</td>
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<td>Rutting $&lt;$ 2 in. (50 mm)</td>
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<td>Crack width $\geq$ maximum coarse aggregate size used in the concrete overlay mixture</td>
<td>Fill with flowable fill.</td>
</tr>
<tr>
<td>Crack width $&lt;$ maximum coarse aggregate size used in the concrete overlay mixture</td>
<td>None</td>
</tr>
<tr>
<td>Low- to medium-severity pothole</td>
<td>Remove loose material and fill integrally with the concrete overlay.</td>
</tr>
<tr>
<td>High-severity pothole and/or areas needing full-depth repair</td>
<td>To prevent a single overlay panel from bonding to both asphalt and concrete, make full-depth repairs across a full lane width with concrete and adjust the transverse joint spacing in the concrete overlay to match the location of the underlying patch. The full lane width prevents trying to match a longitudinal joint for a partial lane patch.</td>
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Milling Considerations

- Milling should be minimized to retain structural support of pavement
  - Minimum 3 inches
- Preferable to mill to depth that will minimize the potential for delamination between lifts
- Grade corrections should be made in the thickness of the concrete overlay

Excessive milling of existing asphalt beyond asphalt lifts
Bonded Concrete on Asphalt: Joint Design

• Maximum spacing of 3 to 8 ft
  – Limit in feet is 1.5 times thickness in inches
  – Some agencies include tie bars at longitudinal joints for slabs greater than 5 in
  – No dowels (aggregate interlock relied upon)
Keep Longitudinal Joints Out of Wheel Paths
Other Key Features

• Conventional concrete mixtures have been used successfully
  – Use of high-modulus synthetic structural fibers can improve toughness and postcracking behavior

• Filling joints with hot pour (no backer rod) has been found to improve performance

• Milling should be used to correct surface distortions, remove high spots, and match existing structures
  – No need to mill for bonding
Bonded Concrete Overlay of Composite Pavements
Keys to Success

• All three layers of the pavement system are effectively bonded together
• All of the considerations for bonded concrete overlays on asphalt also apply here
## Possible Pre-overlay Repairs

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Other Key Issues

• Caution should be exercised if existing PCC has some type of materials-related distress (e.g. ASR, F-T distress, etc.)
Unbonded Concrete Overlay of Asphalt
Can Be Used on Deteriorated Asphalt Pavement
Performance

• Long history of performance going back 30 years or more

• Requires little preoverlay repair – only spot repair of areas that are structural failed

• Does not rely on bonding between overlay and existing asphalt
  – Some bonding is beneficial
Keys to Success

• Milling may be needed to remove surface distortion (that greater than 2 inches)
• Full-depth repairs only in isolated locations suffering structural failure
• Existing concrete patches should be isolated from overlay with bond breaker (fabric)
• Short joint spacing can reduce stresses due to curling/warping
  – Some states have gone to 6 x 6 system
• Existing asphalt must not be stripping
## Possible Pre-overlay Repairs

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<td>Area of subgrade/subbase failure</td>
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<td>Severe distress that results in variation in strength of asphalt</td>
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<td>Potholes</td>
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Other Factors

- Existing asphalt is acting as a base and thus must support construction traffic and provided relatively uniform support
- For 7 inch or thicker overlays, traditional load transfer is used
  - Thinner overlays can use plate dowels or macro synthetic fiber reinforcement
  - Tie bars typically used at longitudinal joints
Jointing
Sawcut Depth Considerations

Consider increased saw-cut depth over low spots at areas of thicker overlay.

Design thickness

Unbonded overlay

Existing asphalt pavement with rutting

$T/3$ (typical saw-cut depth)
Unbonded Concrete Overlay of Composite
Performance

- Have good historical performance
- Uniform support from existing concrete pavement and asphalt overlay is critical
- Partial bonding between overlay and asphalt is beneficial
- Spot repairs only required in areas of structural failure
Suitable for Deteriorated Pavements
Keys to Success

• Identify instability/vertical distortion in underlying concrete pavement
  – Be wary of materials-related distress causing blow ups at joints

• Can use an interlayer if considerable stripping exists
# Possible Pre-overlay Repairs

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<td>Remove and replace with stable material (i.e., select borrow, granular subbase, etc.); correct water problems.</td>
</tr>
<tr>
<td>Severe distress that results in variation in strength of asphalt</td>
<td>Remove and replace with asphalt material or concrete patch with slurry seal or geotextile separation layer; correct water problems.</td>
</tr>
<tr>
<td>Reflective faulting or panel tenting</td>
<td>Full-depth repair with concrete and use asphalt or geotextile separation layer as bond breaker.</td>
</tr>
<tr>
<td>Potholes</td>
<td>Fill with asphalt.</td>
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</tr>
<tr>
<td>Crack width $\geq$ maximum coarse aggregate size used in the overlay mixture</td>
<td>Fill with asphalt or flowable fill.</td>
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Unbonded Concrete Overlays of Concrete
Suitable for Deteriorated Pavements
Performance

• Low history of excellent performance for more than 30 years

• Critical factors include separating the overlay from the underlying slab
  – Either asphalt of geotextile separation layer
  – No need to match joints

• Existing concrete must provide uniform support
Keys to Success

• Full-depth repairs only in isolated locations suffering structural failure

• Separation layer is critical
  – Trend is towards fabric but asphalt more effective if greater than ¼ inch faulting is present
## Possible Pre-overlay Repairs

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<td>Faulting; $\leq 0.25$ in. for geotextile interlayer;</td>
<td>None</td>
</tr>
<tr>
<td>$\leq 0.38$ in. for 1-in. asphalt interlayer</td>
<td></td>
</tr>
<tr>
<td>Faulting; $&gt; 0.25$ in. for geotextile interlayer;</td>
<td>Grind pavement to remove faulting for geotextile or thicker asphalt separation layer.</td>
</tr>
<tr>
<td>$&gt; 0.38$ in. for 1-in. asphalt interlayer</td>
<td></td>
</tr>
<tr>
<td>Significant tenting</td>
<td>Full-depth repair</td>
</tr>
<tr>
<td>Badly shattered slabs</td>
<td>Full-depth repair</td>
</tr>
<tr>
<td>Significant pumping</td>
<td>Full-depth spot repair and drainage improvements</td>
</tr>
<tr>
<td>Severe joint spalling</td>
<td>Clean</td>
</tr>
<tr>
<td>CRCP with punchouts or other severe damage</td>
<td>Full-depth repair</td>
</tr>
</tbody>
</table>
Unbonded Concrete on Concrete: Separator Layer

• Required for good performance
  – Isolate overlay from existing distress
  – Provide level surface for overlay construction

• Recommended interlayer material:
  – 1-2 in HMA
  – Geotextile
## Typical Joint Spacing

<table>
<thead>
<tr>
<th>Unbonded Resurfacing Thickness</th>
<th>Maximum Transverse Joint Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 6 in. (125 mm)</td>
<td>6 x 6 ft (1.8 x 1.8 m) panels (not to exceed 1.5 times thickness in inches)</td>
</tr>
<tr>
<td>&gt; 6 in.</td>
<td>Spacing in feet = 2 times thickness in inches, not to exceed 15-foot joint spacing</td>
</tr>
</tbody>
</table>
Work Zones under Traffic
Traffic Management - Concrete Overlays

- Objectives of work zone management
  - Safety
  - Traffic flow
  - Cost effectiveness
  - Pavement performance

- Considerations
  - Work zone space considerations
  - Paving clearances
  - Traffic control for contractor & public
  - Concrete overlay staging – set criteria and let contractor propose solution
Traffic Management - Concrete Overlays

Top 20 Elements

1. Traffic congestion-capacity analyses-lanes required, length of queues anticipated, large trucks, construction speed, etc

2. Time restrictions—peak hours, seasonal peaks

3. Limits to work areas & local access

4. Detour routes and their capacity

5. Work vehicle access and worker parking

6. Bicycle and pedestrian traffic (urban)

7. Warning sign locations—detours, long queues, intersecting roads

8. Nighttime restrictions, delineation and illumination

9. Signals, turning lanes, bus stops

10. Traffic service—residential/business
Traffic Management - Concrete Overlays

Top 20 Elements (continued)

11. Opening to traffic—maturity, strength requirements, cure time
12. Off-peak traffic hours for increased production
13. Phasing of work—length of work zone, project limits
14. Special conditions such as dropoffs, bridge installation
15. Pre-paving and paving restrictions
16. Short duration closures anticipated
17. Emergency planning
18. Public information—public meetings with landowners, media,
19. Local officials—police, fire, hospitals, schools, railroads, airports
20. Special events
Thank You!

National Concrete Pavement Technology Center

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