Concrete Overlay Thickness Design

Mark B. Snyder, Ph.D., P.E.
Vice-President, ACPA Pennsylvania Chapter

Prepared for Workshop:
Extending System Performance with Concrete Overlays
November 13, 2014 – Fort Wayne, Indiana
The Principal Factors of Concrete (Overlay) Pavement Design

- Geometrics
- Thickness
- Joint Systems
- Materials (and bonding between layers of material)
The Principal Factors of Concrete (Overlay) Pavement Design

- Geometrics
- Thickness
- Joint Systems
- Materials

Most Often Influence Cost & Selection of Projects
The Principal Factors of Concrete (Overlay) Pavement Design

- Geometrics
- Thickness
- Joint Systems
- Materials

Most Often Influence Real-world Performance
MnROAD Whitetopping Distress (Mainline - Feb 2002)

<table>
<thead>
<tr>
<th>Cell</th>
<th>Panels</th>
<th>Corner</th>
</tr>
</thead>
<tbody>
<tr>
<td>4”-4’x4’ (93)</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3”-4’x4’ (94)</td>
<td>40</td>
<td>165</td>
</tr>
<tr>
<td>3”-5’x6”*(95)</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>6”-5’x6’ (96)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6”-10’x12’(97U)</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>6”-10’x12’ (92D)</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

4’x4’ Panels - Corner Breaks due to Wheel Loadings
Longitudinal Joint Layout

2 ft x 2 ft

3 ft x 3 ft

4 ft x 4 ft

6 ft x 6 ft

Outer Shoulder

Traffic

12 ft
How Are Pavements (and Overlays) Designed

• Today, we have data-driven methods to design major elements of concrete pavements

  – Thickness
  – Joint Spacing
  – Edge Support
  – Load Transfer
  – Flexural Strength
  – Subgrade Support
  – Subbase
  – And more
Pavement Evaluation for Overlay Design

Functional Evaluation of Existing Pavement

- Surface Friction Problems/Polishing
  - Use Diamond Grinding or Grooving to Restore Skid Resistance
- Surface Roughness
  - Use CPR and Diamond Grinding or Thin Bonded Overlay to Restore Structure

*Overlay Designs Must Address the Causes of Functional Problems and Prevent Recurrence*
Important Considerations in Overlay Design

- Required Future Design Life of the Overlay
- Traffic Loading (ESALs)
- Pre-overlay Repair
- Reflective Crack Control
- Subdrainage
- Structural vs Functional Overlays
- Recycling Existing Pavement (PCC & AC)
- Durability of aggregate for new concrete
Important Considerations in Overlay Design (cont.)

- Shoulders
- Existing PCC Slab Durability
- PCC Overlay Joints
- PCC Overlay Reinforcement
- PCC Overlays Bonding / Separation Layers
- Overlay Design Reliability Level & Overall Standard Deviation
- Pavement Widening
- Traffic Disruptions and User Delay Costs
Design Balances Several Factors

- Desired service life, load-carrying capacity
- Costs
- Existing pavement condition, preoverlay repairs
- Design (thickness, etc.)
Thicknes Design Procedures

- Empirical Design Procedures
  - Based on observed performance
    - ‘72, ‘86/’93 AASHTO Design Procedures

- Mechanistic-Empirical Design Procedures
  - Based on mathematically calculated pavement responses
    - Pavement-ME (MEPDG)
    - PCA Design Procedure (PCAPAV)
    - ACPA Ultrathin Whitetopping Design Procedure
    - StreetPave (ACPA Design Method)
    - BCOA-ME (Univ. of Pittsburgh, 2013)
1993 AASHTO Guide

- Based on mathematical models derived from empirical data collected during the AASHO Road Test in the late 1950’s.
- Procedure provides suitable bonded and unbonded concrete overlay designs.
- The AASHTO computer software for implementation of the 1993 AASHTO Guide is called DARWin. In addition, a number of agencies and State Departments of Transportation have developed custom software and spreadsheets to apply this procedure.
Structural Deficiency Approach to Overlay Design

- Original Capacity
- Capacity after Rehabilitation
- Effective Capacity of Existing Pavement
- Capacity of Overlay

Loads
1993 AASHTO Guide

- Uses the concepts of structural deficiency and effective structural capacity for the evaluation and characterization of the existing pavement to be overlaid.
- The structural capacity (SC) of a pavement section will decrease with traffic and time.
- Structural capacity of an overlay (SCoverlay) will restore the structural capacity of the existing pavement (SCeffective) to meet the requirements to carry the predicted future traffic (SCfuture traffic).
Overlay Design - Basic Steps
1993 AASHTO

1. Determine Existing Pavement Information
2. Predict Future Traffic / ESALs
3. Determine Required Future Structural Capacity
4. Perform Condition Survey
5. Perform Deflection Testing
6. Perform Coring / Materials Testing
7. Determine Existing Structural Capacity
8. Determine Overlay Structural Capacity and Thicknesses

Overlay Designs Must Address the Causes of Functional & Structural Problems and Prevent Recurrence

Limitations?
Mechanistic-Empirical Design

• The Mechanistic Part:
  ➢ Structural models predict responses of pavement (stresses, strains, deflections) to loads and environment

• The Empirical Part:
  ➢ Data-based models predict pavement performance (IRI, cracking, faulting, etc.) for given pavement stress/strain/deflection

Allows consideration of new designs and design features — INNOVATION!

Examples:
  smaller panels or widened lanes (w/reduced slab thickness)
• MEPDG provides models and design tools for JPCP & CRCP overlays of existing HMA, JPCP & CRCP
• MEPDG used to analyze impact of existing pavement condition on performance and design of concrete overlay.
M-E PDG

• M-E PDG combines a mechanistic-based analysis approach with field performance data in order to enable the engineer to confidently predict the performance of pavement systems.

• Method adopts an integrated pavement design approach which allows:
  - Designer to determine the overlay thickness based on the interaction between the pavement geometry (slab size, shoulder type, load transfer, steel reinforcement).
  - Support conditions, local climatic factors, and concrete material and support layer properties.
Family of Concrete Overlays

- **Bonded Family**
  - Bonded Concrete Overlay of Concrete Pavements
  - Bonded Concrete Overlay of Asphalt Pavements
  - Bonded Concrete Overlay of Composite Pavements

- **Unbonded Family**
  - Unbonded Concrete Overlay of Concrete Pavements
  - Unbonded Concrete Overlay of Asphalt Pavements
  - Unbonded Concrete Overlay of Composite Pavements

**Thinner**

**Thicker**

**Bond is integral to design**

**Old pavement is base**
Typical PCC Overlay Service Lives

<table>
<thead>
<tr>
<th>Concrete Overlay Type</th>
<th>Typical Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonded on Concrete</td>
<td>15-25 years</td>
</tr>
<tr>
<td>Unbonded on Concrete</td>
<td>20-30 years</td>
</tr>
<tr>
<td>Bonded on Asphalt/Composite</td>
<td>5-15 years</td>
</tr>
<tr>
<td>Unbonded on Asphalt/Composite</td>
<td>20-30 years</td>
</tr>
</tbody>
</table>

Based on FHWA’s “Portland Cement Concrete Overlays – State of the Technology Synthesis” (FHWA-IF-02-045)
Bonded versus Unbonded (intent)

- **Bonded**: Use to eliminate surface defects; increase structural capacity; and improve surface friction, noise, and rideability.

- **Unbonded**: Use to restore structural capacity and increase pavement life equivalent to full-depth pavement. Also results in improved surface friction, noise, and rideability.
Jointing Patterns Vary

• Joint spacing depends on bond, stiffness of support, etc.

Match Existing Joint Spacing/Location

Joint Spacing based on Thickness; Shorter Panels = Less Curl/Warp

Bonded Concrete Overlay of Concrete Pavements

Bonded Concrete Overlay of Asphalt Pavements

Bonded Concrete Overlay of Composite Pavements

Unbonded Concrete Overlay of Concrete Pavements

Unbonded Concrete Overlay of Asphalt Pavements

Unbonded Concrete Overlay of Composite Pavements

Joint Spacing is Similar to New Concrete Pavement; Shorter Might be Used, Especially for Unbonded over Concrete
Unbonded Concrete Overlays

Unbonded Concrete Overlays of Concrete Pavements
—previously called unbonded overlays—

Unbonded Concrete Overlays of Asphalt Pavements
—previously called conventional whitetopping—

Unbonded Concrete Overlays of Composite Pavements
Unbonded on Concrete / Composite
1993 AASHTO

• Slab Thickness Design

Unbonded overlay design equation:

\[ D_{ol} = \sqrt{D_f^2 - D_{eff}^2} \]

where:

- \( D_{ol} \) = Required PCC overlay thickness
- \( D_f \) = Thickness of new PCC pavement for design conditions
- \( D_{eff} \) = Effective thickness of existing PCC
Determination Of Effective Slab Thickness ($D_{\text{eff}}$)

$$D_{\text{eff}} = F_{\text{jcu}} \times D$$

Where

- $F_{\text{jcu}}$ = Joints and Cracks Adjustment Factor
- $D$ = Thickness of Existing Slab, in.
Unbonded Concrete Overlay
Joints & Cracks Adjustment Factor, \( (F_{jcu}) \)

Adjusts for PSI loss due to unrepaired joints, cracks, and other discontinuities

- Number of deteriorated transverse joints per mile
- Number of deteriorated transverse cracks per mile
- Number of existing expansion joints, exceptionally wide joints (>1 in.), or AC full-depth patches

Very little reflective cracking has been observed in unbonded overlays

Can use thicker interlayer instead of repairs
Unbonded Concrete Overlay
Joints & Cracks Adjustment Factor, \( (F_{jcu}) \)

Figure 5.13. \( F_{jcu} \) Adjustment Factor for Unbonded JPCP, JRCP, and CRCP Overlays
Unbonded on Concrete: 1993 AASHTO

- Separator layer (interlayer)
  - Can significantly affect performance
  - Functions
    - Isolate overlay from underlying pavement
    - Allow differential horizontal movement
    - Provide a level surface for the overlay construction
  - Types
    - Dense- or open-graded HMA, typ. 1-2 in.
    - Nonwoven Geotextile
    - Other materials have been used with varying success
Nonwoven Geotextile Fabrics are now being used as the Separator/Interlayer

“Non-woven fabrics are defined as a web or sheet of fibers bonded together by entangling fiber or filaments mechanically, thermally or chemically. They are flat, porous sheets that are made directly from separate fibers.

Missouri DOT
• Completed about 25 projects utilizing the fabric to include interstate highways, state routes, lower volume roads, and airports
• All fabrics have been placed between existing old concrete and the new unbonded overlay
• The existing concrete was bare or was milled to remove asphalt overlays
• To date, no issues have arisen with performance, and the first project (2007) is performing well
• Missouri DOT currently has three approved fabrics (see Missouri DOT website for specifications)

Core from Germany showing non-woven geotextile interlayer between surface concrete and cement-treated base. Fabric bonds to PCC but not CTB or LCB.
# Proposed Interim Specifications for Geotextile Interlayer Material

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirements</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geotextile Type</td>
<td>Nonwoven, needle-punched, no thermal treatment to include calendaring</td>
<td>EN 13249, Annex F (Certification)</td>
</tr>
<tr>
<td>Color</td>
<td>Uniform/nominally same color fibers</td>
<td>(Visual Inspection)</td>
</tr>
<tr>
<td>Mass per unit area</td>
<td>( \geq 500 \text{ g/m}^2 ) (14.7 oz/sq.yd) ( \leq 550 \text{ g/m}^2 ) (16.2 oz/sq.yd)</td>
<td>ISO 9864 (ASTM D 5261)</td>
</tr>
<tr>
<td>Thickness under load (pressure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[a] At 2 kPa (0.29 psi): ( \geq 3.0 \text{ mm} ) (0.12 in.)</td>
<td>ISO 9863-1 (ASTM D 5199)</td>
<td></td>
</tr>
<tr>
<td>[b] At 20 kPa (2.9 psi): ( \geq 2.5 \text{ mm} ) (0.10 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[c] At 200 kPa (29 psi): ( \geq 1.0 \text{ mm} ) (0.04 in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wide-width tensile strength</td>
<td>( \geq 10 \text{ kN/m} ) (685 lb/ft)</td>
<td>ISO 10319 (ASTM D 4595)</td>
</tr>
<tr>
<td>Wide-width maximum elongation</td>
<td>( \leq 130% )</td>
<td>ISO 10319 (ASTM D 4595)</td>
</tr>
<tr>
<td>Water permeability in normal direction under load (pressure)</td>
<td>( \geq 1 \times 10^{-4} \text{ m/s} ) at 20 kPa (2.9 psi)</td>
<td>DIN 60500-4 (modified ASTM D 5493)</td>
</tr>
<tr>
<td>[a] ( \geq 5 \times 10^{-4} \text{ m/s} ) at 20 kPa (2.9 psi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[b] ( \geq 2 \times 10^{-4} \text{ m/s} ) at 200 kPa (2.9 psi)</td>
<td>ISO 12958 (modified ASTM D 4716)</td>
<td></td>
</tr>
<tr>
<td>In-plane water permeability (transmissivity) under load (pressure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[b] ( \geq 2 \times 10^{-4} \text{ m/s} ) at 200 kPa (2.9 psi)</td>
<td>EN 12224 (ASTM D 4355 @ 500 hrs. exposure)</td>
<td></td>
</tr>
<tr>
<td>Weather resistance</td>
<td>% Retained Strength ( \geq 80% )</td>
<td></td>
</tr>
</tbody>
</table>
Unbonded on Concrete: 1993 AASHTO

- Nonwoven Geotextile Interlayer

www.ConcreteOnTop.com

It is recommended that the design thickness calculated using the 1993 AASHTO Guide be increased by 0.5 in. when a nonwoven geotextile interlayer is used in lieu of HMA.
Pavement-ME Unbonded Concrete Overlays
(Uses the same process as new pavements...)

- Determine basic design parameters (traffic, soil conditions, etc.)
- Develop preliminary designs (thickness, base designs, joint spacing, and other design features)
- Evaluate the predicted performance from Pavement-ME over the analysis period (e.g., 50 years) to determine the life-cycle activity profiles describing “when” and “what” rehabilitation activates will be performed.
- Calculate the Initial and Life Cycle Costs for each pavement design over the analysis period.
- Evaluate designs and modify as needed to develop a pavement section that meets or exceed the required initial performance period and has the lowest life cycle cost.
Unbonded Concrete Overlay of Asphalt
1993 AASHTO

- **Thickness**
  - Designed as new pavement on asphalt base
    - Need to adjust “k-value” in design procedure
  - Assumes no bonding to the existing asphalt

- **Jointing**
  - Spacing - same as new concrete pavement
  - Depth - adjust for AC distortion
  - Reinforcing & dowels - same as new pavement
Unbonded Overlay of Asphalt AASHTO 93 Design

- Figure 3.3 - nomograph for determining k-value using
  - Roadbed soil modulus
  - Subbase modulus-use AC modulus
  - Subbase thickness-use AC thickness
- Typical Value
  - $k = 300 - 400$ psi/in

Figure 3.3. Chart for Estimating Composite Modulus of Subgrade Reaction, $k_x$, Assuming a Semi-Infinite Subgrade Depth. (For practical purposes, a semi-infinite depth is considered to be greater than 10 feet below the surface of the subgrade.)
<table>
<thead>
<tr>
<th>Design Method</th>
<th>Design Assumptions, Deficiencies / Strengths and/or Items to Note</th>
</tr>
</thead>
</table>
| 1993 AASHTO Guide     | • This procedure assumes no friction between the concrete overlay and the existing HMA pavement or interlayer, uses a composite k-value, and consequently yields conservative thickness designs.  
• The effective structural capacity of existing concrete and composite pavements is based on the condition survey or the remaining life methods. These two methods have different limitations and may yield inconsistent or unreasonable results. |
| M-E PDG               | • Integrates slab geometry, climatic factors, concrete material and support layer properties compared to the 1993 AASHTO Guide.  
• The HMA and concrete are treated as unbonded structural layers without any frictional consideration with the concrete overlay.  
• This method is still under evaluation, calibration, and implementation by State Highway Agencies.                                                                                                                                                                                                                       |
Lots of Guidance Available...
Bonded Concrete Overlays

Bonded Concrete Overlays of Concrete Pavements
-previously called bonded overlays-

Bonded Concrete Overlays of Asphalt Pavements
-previously called ultra-thin whitetopping-

Bonded Concrete Overlays of Composite Pavements
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
Bonding Effects on Edge Stress

Unbonded

Bonded
Effects of AC Thickness

Concrete
Tension
Comp. Asphalt

Concrete
Comp. Asphalt
Tension

NA

x

2x
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
Short Panels Improve Performance By Decreasing Curling And Warping

Effect of Slab Length on Shrinkage Force

- Curling & warping is produced by the shrinkage force at the slab surface.
  - Due to drying and thermal differential shrinkage on the surface of the concrete.
- The magnitude of this force is dependent on the length of the surface.
  - Shorter slabs have less length, which means that shorter slabs have reduced curling

Effect of Slab Length on Curling/Warping

- All concrete slabs curl / warp so that approximately 1/4 of the slab length is lifted of the subgrade / subbase support
- By reducing slab length, the amount lifted, and the height of the lift is greatly reduced

Cantilever = 1/4 L

Length 12 to 15 ft., cantilever = 3 to 3.75 ft

Cantilever = 1/4 L

Length 6 ft., cantilever = 1.5 ft
Bonded on HMA/Composite: Original ACPA Method

- Web-based
- Mechanistic-empirical
  - Fatigue failure (corner loading)
  - New fatigue model with reliability input
  - Better fatigue characterization of HMA
- Fibers - Improved flexural ductility, toughness, fatigue capacity
- Models bond failure

**American Concrete Pavement Association**

**Unit of Measure**

- Select unit of measure for inputs and outputs.

**Axle-Load Category**

- Category A

**Portland Cement Concrete Inputs**

- Thickness (inches, mm): 2
- Joint Spacing (feet, meters): 2
- Flexural Strength (psi, MPa): 700

**Asphalt Concrete Inputs**

- Thickness (inches, mm): 3

**Other Inputs**

- k-value (pci, MPa/m): 100

[Calculate Allowable Trucks Per Lane]
Bonded on HMA/Composite: Modified ACPA Method

• Improved by:
  – Randell Riley, Illinois Chapter, ACPA
  – Dr. Jeff Roesler, University of Illinois (sponsored by Illinois DOT)

• Improvements made to modified include:
  – New fatigue model with reliability input
  – Better fatigue characterization of HMA

• Fibers – Improved flexural ductility, toughness, fatigue capacity

• Models bond failure
Bonded Overlay on Asphalt/Composite: Bonded Concrete Overlay on Asphalt (BCOA)

- Web-based
- Mechanistic-empirical
  - Fatigue model with reliability input (corner loading)
  - Better fatigue characterization of HMA
  - Fibers - Improved flexural ductility, toughness, fatigue capacity
- Models bond failure

**Bonded On Asphalt/Composite (BCOA) Inputs**

### General Design Details

- **Design Lane ESALs**: [Estimate ESALs] 0
- **Slabs Cracked at End of Design Life (%):** 20%
- **Reliability (%):** 85%
- **Effective Temperature Gradient (°F/in.):** -1.4
- **Time at Effective Temperature Gradient (%):** 58%

### Existing Pavement Structure Details

- **Remaining Asphalt Thickness (in.):** 4
- **Asphalt Modulus of Elasticity (psi):** 700,000
- **Modulus of Subgrade Reaction (pci):** 150

### Concrete Material Details

- **28-Day Flexural Strength (psi):** 750
- **Fibers Used In Concrete:** No Fibers
- **Concrete Modulus of Elasticity (psi):** 3,600,000
- **Coefficient of Thermal Expansion (10^{-6}/°F):** 5.5

### Concrete Overlay Details

- **Joint Spacing (in.):** 72
- **Preoverlay Surface Preparation:** Old Asphalt, Cleared
Bonded On Asphalt/Composite (BCOA) Inputs

- BCOA is a thickness calculator, but you can adjust design thickness and joint spacing to determine allowable trucks.
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/
Project Goal

• Rational mechanistic-empirical design procedure
  – Stand alone design procedure
  – Easily incorporated into Pavement ME
  – Address actual failure modes
  – Account for climatic effects
## BCOA-ME Design

**General Information**
- Latitude (degree): 44.5
- Longitude (degree): 93.1
- Elevation (ft): 874
- Estimated Design Lane ESALs: 200,000
- Maximum Allowable Percent Slabs Cracked (%): 25%
- Desired Reliability against Slab Cracking (%): 85%

**Climate**
- AMDAT Region ID: 5
- Sunshine Zone: 2

**Existing Structure**
- Post-milling HMA Thickness (in): 6
- HMA Condition: Adequate
- Composite Modulus of Subgrade Reaction, k-value (psi/in): 250
- Does the existing HMA pavement have temperature cracks? Yes

**PCC Overlay**
- Average 28-day Flexural Strength (psi): 650
- Estimated PCC Elastic Modulus (psi): 3,930,000
- Coefficient of Thermal Expansion (10^-4 in/°F/in): 5.5
- Fiber Type: No Fibers
- Fiber Content (lb/cu yd) (Only used when a fiber type is selected): 0

**Joint Design**
- Joint Spacing (ft): 6

### Performance Analysis
- Calculated PCC Overlay Thickness (in): 3.26
- Design PCC Overlay Thickness (in): 3.5
- Is there potential for reflective cracking? Yes

*Solved.*
**Debonding Model**

Split wedge: Material property at the interface = f(load rate, temp., surface texture)

ALF testing: Energy required for delamination

FEM: Evaluation of actual BCOA designs

Area of delamination as a function of load applications
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

Straight synthetic: Strux 90/40

Crimped synthetic: Enduro 600

Residual strength ratio = 24%
Structural Fibers

(a) Flange of base I-beam
(b) Fabcel
(c) Top I-beam
(d) Restraining rod
(e) Brace plate
(f) Horizontal load plates
(g) Vertical load plates
(h) Calibrated spring
(1) LVDT and its holder

Beam ALF

Full scale ALF
Guide for the Design of Concrete Overlays using Existing Methodologies

- Background of recommended overlay design techniques
  - 1992 AASHTO Overlay procedure
  - Pavement-ME/MEPDG
  - ACPA Bonded Concrete Overlay of Asphalt pavements
  - (BCOA-ME background on host website)

- Detailed examples of how to use the existing design methodology

- Learn by example – then apply for your situation!
Design Methods Recommended

AASHTO, Guide for Design of Pavement Structures 1993

Windows Pavement Analysis Software (WinPAS) Guide
Based on the 1993 AASHTO Guide for Design of Pavement Structures

DARWin
Mechanistic Empirical Pavement Design

University of Pittsburgh

WinPAS 11
Based on the 1993 AASHTO Guide for the Design of Pavement Structures

ACPA
Bonded Concrete Overlay on Asphalt (BCOA) Thickness Designer

Background
The bonded concrete overlay of Pittsburgh under the FHPA this white topping. This site is on its intended use and can be

apps.acpa.org
Guide for the Design of Concrete Overlays using Existing Methodologies

- Tech Summary
  - Interim Guidance
  - Background of recommended overlay design techniques

- Available online:
  - http://www.cptechcenter.org/
Thank You For Your Attention!