Concrete Overlay Design

58th Annual ICPA Workshop
February 2 – 4, 2022

Eric Ferrebee, P.E.
Director of Technical Services
ACPA
Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents
Evaluation Informs Design

Existing pavement condition before treatment

<table>
<thead>
<tr>
<th>Condition</th>
<th>Preventive maintenance</th>
<th>Bonded on Concrete</th>
<th>Unbonded on Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deteriorated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Time

Maintenance

Resurfacing

Reconstruction
Evaluation and Survey Information

- Existing Pavement History Evaluation
  - Layer materials, properties, depths, & age
  - Widening material type, depths, widths, & age
  - History of full depth patching by location, type & age
- “As Built” Plan Information
  - Vertical & horizontal alignment
  - Previous test sections in project limits
  - Previous drainage structure remains

Where are the problem areas? What maintenance has been done? Are any pre-overlay repairs required?
Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents
Overlay Type Selection

Concrete on Asphalt
Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

Concrete on Concrete
Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COA–B (Full Depth and Composite)  |  COA–U (Full Depth and Composite)
COC–B (JPCP and CRCP)  |  COC–U (JPCP and CRCP)
Overlay Type Selection

Concrete on Asphalt–Unbonded (full depth)

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

CONDITION

Concrete on Asphalt–Unbonded (composite)

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

CONDITION

Concrete on Asphalt–Bonded (full depth)

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

CONDITION

Concrete on Asphalt–Bonded (composite)

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

CONDITION
Overlay Type Selection

**Good Condition**
The pavement is structurally sound. Surface characteristics issues such as low friction or high noise may be present. Minor repairs may be needed in isolated locations to correct functional deficiencies.

**Spot Repairs**
Can spot repairs correct deficiencies or restore the surface to good or better structural condition, allowing for a bonded concrete overlay?

**Fair Condition**
The pavement may exhibit some distresses such as moderate levels of fatigue cracking.

**Milling/Minor Spot Repairs**
Can milling and minor spot repairs cost-effectively solve deficiencies?

**Poor Condition**
Concrete pavement may exhibit some distresses such as joint deterioration, working cracks, spot structural failures, faulting, and materials-related distresses.
Asphalt pavement may exhibit some distresses such as alligator cracking, rutting, shoving, and stripping.

**Milling and Patching**
Can spot structural repairs and/or milling cost-effectively solve deficiencies, meet vertical constraints, and restore the existing pavement to a condition that will provide a uniform base for an unbonded overlay?

**Deteriorated Condition**
The pavement exhibits significant surface deterioration and structural distresses. If concrete pavement exhibits severe or potentially severe joint deterioration from freeze-thaw damage or materials-related distress and exhibits deterioration below the dowel bar, the pavement may not be a good candidate for an overlay.
Asphalt pavement exhibits significant deterioration from raveling, thermal cracking, stripping, and structural distresses.

**Additional Repairs**
Can existing and/or potential unstable conditions or major deficiencies be addressed cost-effectively using preservation techniques? For composite pavements, does the asphalt need to be completely milled to remove major deficiencies such as stripping and a new interlayer placed over the underlying concrete to create an unbonded overlay on concrete?

**Concrete Overlay-Bonded**

**Concrete Overlay-Unbonded**

**Yes**

**No**

**Reconstruction**
Bond Breaker Selection

- Nonwoven Geotextile or Asphalt Interlayer

<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>≥ 450 g/m² (13.3 oz/yd²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 500 g/m² (14.7 oz/yd²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 550 g/m² (16.0 oz/yd²)</td>
<td></td>
</tr>
<tr>
<td>Thickness under load (pressure)</td>
<td>[a] At 2 kPa (0.29 psi): ≥ 3.0 mm (0.12 in.)</td>
<td>ISO 9884 (ASTM D 5261)</td>
</tr>
<tr>
<td></td>
<td>[b] At 20 kPa (2.9 psi): ≥ 2.5 mm (0.10 in.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[c] At 200 kPa (29 psi): ≥ 0.10 mm (0.04 in.)</td>
<td></td>
</tr>
<tr>
<td>Wide-width tensile strength</td>
<td>≥ 10 kN/m (685 lb/ft)</td>
<td>ISO 10319 (ASTM D 4595)</td>
</tr>
<tr>
<td>Wide-width maximum elongation</td>
<td>≤ 130 percent</td>
<td>ISO 10319 (ASTM D 4595)</td>
</tr>
<tr>
<td>Water permeability in normal direction under load (pressure)</td>
<td>≥ 1.0 x 10⁻⁶ m/s (3.3 x 10⁻⁴ ft/s) at 20 kPa (2.9 psi)</td>
<td>DIN 6850-4 (modified ASTM D 5493)</td>
</tr>
<tr>
<td>In-plane water permeability (transmissivity) under load (pressure)</td>
<td>[a] ≥ 5.0 x 10⁻⁴ m/s (1.5 x 10⁻³ ft/s) at 20 kPa (2.9 psi)</td>
<td>ISO 12958 (ASTM D 6574)* or ISO 12958 (modified ASTM D 4716)</td>
</tr>
<tr>
<td>[b] ≥ 2.0 x 10⁻⁴ m/s (6.6 x 10⁻⁵ ft/s) at 200 kPa (2.9 psi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weather resistance</td>
<td>Retained strength ≥ 80 percent</td>
<td>EN 12224 (ASTM D 4355) ≥ 500 hrs exposure for</td>
</tr>
</tbody>
</table>

Table 4. Recommended geotextile thickness

<table>
<thead>
<tr>
<th>Overlay Thickness</th>
<th>Recommended non-woven geotextile thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 in.</td>
<td>13.3 oz/yd²</td>
</tr>
<tr>
<td>≥ 5 in.</td>
<td>14.7 oz/yd²</td>
</tr>
</tbody>
</table>

• https://cptechcenter.org/geotextiles/
Design Life and Traffic

Planning Information

- Determine **Design Life**
  - Usually between 20 – 40+ years
- Current & Projected **Traffic** – ADT & ADTT
  - Directional & lane distribution
- Current & Expected Adjacent Land Use
Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents
Selecting a Pavement Design Tool

AASHTO 93
(software as ACPA WinPAS)

AASHTOWare Pavement ME
( previously known as DARWin-ME and MEPDG)

FREE Industry Developed Tool Based on PCA Method

FREE – FHWA Pooled Fund TPF-5(165)
Google “BCOA ME”
Selecting a Pavement Design Tool

Concrete on Asphalt
Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

Concrete on Concrete
Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.
Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Asphalt – Bonded:

COA-B (Full Depth and Composite)
Can Design: Bonded on Asphalt

FREE Mechanistic – Empirical design tool specifically for Concrete Overlays of Asphalt
- Assumes a partially bonded condition
- Developed at University of Pittsburgh under FHWA Pooled Fund TPF-5(165)
- Incorporates climatic loading
- Joint spacing is featured as an input
- Allows for design with macrofibers directly

https://www.engineering.pitt.edu/Sub-Sites/Faculty-Subsites/J_Vandenbossche/BCOA-ME/BCOA-ME/

Or google “BCOA ME”
Can Design:
Bonded on Asphalt

BCOA – ME

≤ 4.5 ft Corner Break

5 to 7 ft Long. & Diag Crack

10 x 12 ft
12 x 12 ft
12 x 15 ft Trans. Crack

Positive ΔT

Negative ΔT
Note: Please specify ESALs before proceeding to the rest of the inputs.

**GENERAL INFORMATION**

Latitude (degree):

Longitude (degree):

Elevation (ft):

Estimated Design Lane ESALs:

Maximum Allowable Percent Slabs Cracked (%):

Desired Reliability against Slab Cracking (%):

**CLIMATE**

AASHTO Region ID:
## Existing Structure

**Post-milling HMA Thickness (in):** 6

**Composite Modulus of Subgrade Reaction, k-value (psf/in):** 150

**Does the existing HMA pavement have transverse cracks?**
- Yes
- No

**HMA Fatigue:** Adequate

## HMA Properties in the Wheelpath:

**P200 of HMA (%):** 4.3

**P200 of subbase (%):** 50

**Effective Binder Content by Volume (%):** 12.5

**Air Voids (%):** 7

## PCC Overlay Properties

## PCC Properties:

**Average 28-day Flexural Strength (three-point bend):** 650
Estimated PCC Elastic Modulus (psi): 400000
Coefficient of Thermal Expansion ($10^{-6}$ in/in°F): 5.5
Cement Content (lb/cy): 550
Fiber Type: No Fibers

JOINT DESIGN:
Joint Spacing (ft): 6 x 6
Dowel Bar Diameter (in): 0
Shoulder Type: Not Tied

CALCULATE DESIGN

PERFORMANCE ANALYSIS

Residual Strength from fibers (if any), $f_{r50}$ (psi): 0
Calculated PCC Overlay Thickness (in): 4.26
Design PCC Overlay Thickness (in): 4.5
Is there potential for reflective cracking? No
Predicted Faulting (in): (Effect of fibers on faulting is not directly considered) Solved.
Selecting a Pavement Design Tool

Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.
Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Asphalt – Unbonded:

FREE Industry Developed Tool Based on PCA Method

COA-U (Full Depth and Composite)
Can Design:

- Unbonded on Asphalt
- Unbonded on Concrete
- Bonded on Concrete

- FREE, industry-developed, mechanistic-empirical design method
  - Primarily for cities, counties, streets and roads, parking & industrial
- Utilizes PavementDesigner Method (formerly StreetPave/PCA method) developed for JPCP with modifications
- Allows for the use of synthetic macrofibers
- Joint spacing provided as an output
- Failure mechanisms of Cracking and Erosion
Can Design:

- **Unbonded Concrete on Asphalt (UCOA)**
  - Treats existing asphalt as a subbase layer

- **Unbonded Concrete on Concrete (UCOC)**
  - \( T_{UCOC} = \sqrt{T_{required}^2 - T_{effective}^2} \)

- **Bonded Concrete on Concrete (BCOC)**
  - \( T_{BCOC} = T_{required} - T_{effective} \)
Welcome to Pavement Designer, a free web-based pavement design tool for streets, local roads, parking lots, and intermodal/industrial facilities.

Best viewed using Chrome on Windows or Safari for MacOS.

Start Designing
CONCRETE STREETS
A long-lasting solution for conventional over the road traffic. This module can be used to design jointed plain concrete pavement (JPCP), continuously reinforced concrete pavement (CRCP), roller-compacted concrete pavement (RCC), overlays, and composite pavements with stabilized bases and soils. This module should be used for the design of county, town, and city streets.
OVERLAY
For existing pavements that require additional capacity or rehabilitation. Overlays can be unbonded or bonded to existing asphalt or concrete pavements. By utilizing the existing structure, overlays provide a long-lasting pavement.

METHODOLOGY: ACPA
StreetPave/IPCA Method, AASHTO 93
Select Overlay Type

- Bonded Concrete
- Unbonded Concrete
- Unbonded Asphalt
- Bonded Asphalt
Selecting a Pavement Design Tool

Concrete on Asphalt
Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric properties.

COA–B (Full Depth and Composite)

Concrete on Concrete
Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)

COC–U (JPCP and CRCP)
Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Concrete – Bonded:

FREE Industry Developed Tool Based on PCA Method

May want to call an expert!

ICPA, ACPA, CP Tech are happy to help!
Pavement ME
A.K.A. MEPDG

Can Design:

- Unbonded on Asphalt
- Bonded on Asphalt
  "SJPCP"
- Unbonded on Concrete
- Bonded on Concrete

AASHTO’s current design/analysis tool
  - Current version is 2.6 (Version 3 coming soon!)
- License is yearly-based subscription
- Incorporates climate data
- Allows most control of all design tools
- Features joint spacing as an input
- Failure mechanisms include IRI, Faulting, and Cracking
  - SJPCP only includes longitudinal cracking

https://me-design.com/MEDesign/
Pavement ME  
A.K.A. MEPDG

Can Design:

- Unbonded on Asphalt
- Bonded on Asphalt  "SJPCP"
- Unbonded on Concrete
- Bonded on Concrete
Selecting a Pavement Design Tool

Concrete on Asphalt
Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from degraded to good—as well as geometric needs.

COA–B (Full Depth and Composite)

Concrete on Concrete
Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)

COC–U (JPCP and CRCP)
Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Concrete – Unbonded:

- **UBOL – ME**: FREE Industry Developed Tool Based on PCA Method
- **COC-U (JPCP and CRCP)**
Can Design:

Unbonded on Concrete

Stress Analysis

Top-down and joint damage

Effect of Interlay Erosion

2 cases
- No void
- 24-in long, lane-wide void

http://uboldesign3.azurewebsites.net/
UBOL – ME – Accounts for Bond Breaker Type

- Nonwoven Geotextile or Asphalt Interlayer

<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 13269, 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>≥ 450 g/m² (13.3 oz/yd²)*</td>
<td>ISO 9864 (ASTM D 5261)</td>
</tr>
<tr>
<td></td>
<td>≥ 500 g/m² (14.7 oz/yd²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤ 550 g/m² (16.2 oz/yd²)</td>
<td></td>
</tr>
<tr>
<td>Thickness under load (pressure)</td>
<td>([a] At 2 kPa (0.29 psi); ≥ 3.0 mm (0.12 in.)</td>
<td>ISO 9863-1 (ASTM D 5199)</td>
</tr>
<tr>
<td></td>
<td>[b] At 20 kPa (2.9 psi); ≥ 2.5 mm (0.10 in.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[c] At 200 kPa (29 psi); ≥ 0.10 mm (0.04 in.)</td>
<td></td>
</tr>
<tr>
<td>Wide-width tensile strength</td>
<td>≥ 10 kN/m (685 lb/ft)</td>
<td>ISO 10319 (ASTM D 4956)</td>
</tr>
<tr>
<td>Wide-width maximum elongation</td>
<td>≤ 130 percent</td>
<td>ISO 10319 (ASTM D 4956)</td>
</tr>
<tr>
<td>Water permeability in normal direction under load (pressure)</td>
<td>≥ 1.0 x 10⁻⁶ m/s (3.3 x 10⁻⁴ ft/s) at 20 kPa (2.9 psi)</td>
<td>DIN 68500-4 (modified ASTM D 5433)</td>
</tr>
<tr>
<td>In-plane water permeability (transmissivity) under load (pressure)</td>
<td>([a] ≥ 5 x 10⁻⁶ m/s (1.6 x 10⁻⁴ ft/s) at 20 kPa (2.9 psi)</td>
<td>ISO 12958 (ASTM D 6574)* or ISO 12958 (modified ASTM D 4716)</td>
</tr>
<tr>
<td></td>
<td>([b] ≥ 2 x 10⁻⁶ m/s (6.6 x 10⁻⁸ ft/s) at 200 kPa (2.9 psi)</td>
<td></td>
</tr>
<tr>
<td>Weather resistance</td>
<td>Retained strength ≥ 80 percent</td>
<td>EN 12224 (ASTM D 4355) 500 hrs exposure for 40°C</td>
</tr>
</tbody>
</table>

Table 4. Recommended geotextile thickness

<table>
<thead>
<tr>
<th>Overlay Thickness</th>
<th>Recommended non-woven geotextile thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 in.</td>
<td>13.3 oz/yd²</td>
</tr>
<tr>
<td>≥ 5 in.</td>
<td>14.7 oz/yd²</td>
</tr>
</tbody>
</table>

- [https://cptechcenter.org/geotextiles/](https://cptechcenter.org/geotextiles/)
## TPF-5(269) UBOL Design

### Reliability analysis
- Yes

### Climate station
- Des Moines IA

| Design Life, years: | 20 |
| Two-way AADTT Year 1: | 1000 |
| Joint Spacing, ft | 6 |
| PCC Flexural Strength, psi: | 600 |
| Cracking Reliability, % | 90 |
| Linear Yearly Growth, % | 3 |
| Dowel Diameter, in | 0 |
| Existing PCC Thickness, in: | 8 |
| Faulting Reliability, %: | 90 |
| Number of Lanes | 2 |
| Shoulder Type | Tied PCC |
| Existing PCC modulus, psi: | 4000000.0 |
| Interlayer Type | Fabric |

### Required PCC Overlay Thickness:
- 6.40 in

### Cracking at Specified Reliability:
- 14.55%

### Faulting at Specified Reliability:
- 0.007 in

### Cracking at 50% Reliability:
- 2.08%

### Faulting at 50% Reliability:
- 0.002

### Design Traffic:
- 8.2 million EQALs
Selecting a Pavement Design Tool

Concrete on Asphalt
Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

Concrete on Concrete
Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

What About AASHTO 93?
AASHTO 93

Can Design:
- Unbonded on Asphalt
- Unbonded on Concrete
- Bonded on Concrete

Utilizes AASHTO 93/86 design equations with modifications.

Change in Serviceability

Thickness

Standard Normal Deviate

Overall Standard Deviation

Log(ESAL) = \( Z_R \cdot s_o + 7.35 \cdot \log(D+1) - 0.06 + \sum + \Delta \)

Terminal Serviceability

\( +(4.22 - 0.32 \cdot p_i) \cdot \log \)

_load transfer

Modulus of Rupture

\( \left[ \frac{S_c' \cdot C_d \cdot (D^{0.75} - 1.132)}{215.63 \cdot J \cdot \left[ D^{0.75} - \frac{18.42}{(E_c / k)^{0.25}} \right]} \right] \)

Drainage Coefficient

Overall Standard Deviation

Load Transfer

Modulus of Elasticity

Modulus of Subgrade Reaction
Can Design:

- Unbonded Concrete on Asphalt (UCOA)
  - Treats existing asphalt as a subbase layer

- Unbonded Concrete on Concrete (UCOC)
  - $T_{UCOC} = \sqrt{T_{\text{required}}^2 - T_{\text{effective}}^2}$

- Bonded Concrete on Concrete (BCOC)
  - $T_{BCOC} = T_{\text{required}} - T_{\text{effective}}$
AASHTO 93

- Wholly empirical – AASHO Road Test
- Limited inference space:
  - Materials
  - Structural sections
  - Soils
  - Traffic
  - Climate
- Failure is “Serviceability”

PERCENT SURVIVING WITH PSI ABOVE 2.5

<table>
<thead>
<tr>
<th>Load Applications, thousands</th>
<th>Concrete</th>
<th>Asphalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>200</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>400</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>600</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>800</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>1,000</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

TYPICAL SECTIONS

ASPHALT

- Surface
- Base
- Subbase

CONCRETE

- Concrete
- Subbase

THICKNESS

- 5"
- 10"
- 15"
- 20"
AASHTO 93 vs. ME

AASHTO 93
- Wide range of structural and rehabilitation designs
- Limited structural sections
- 1 climate/2 years
- All climates over 20-50 years
- 50+ million load reps
- 1.1 million load reps
- 1 set of materials
- New and diverse materials

AASHTO Pavement ME
## Design Tool Summary

<table>
<thead>
<tr>
<th>Designs for:</th>
<th>AASHTO 93</th>
<th>PavementDesigner</th>
<th>BCOA – ME</th>
<th>UBOL – ME</th>
<th>Pavement ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbonded on Asphalt</td>
<td>Yes¹</td>
<td>Yes¹</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Bonded on Asphalt</td>
<td></td>
<td>Links to BCOA-ME</td>
<td>Yes</td>
<td></td>
<td>Yes (SJPCP)</td>
</tr>
<tr>
<td>Unbonded on Concrete</td>
<td>Yes¹</td>
<td>Yes¹</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bonded on Concrete</td>
<td>Yes¹</td>
<td>Yes¹</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Failure Criteria:

<table>
<thead>
<tr>
<th>Failure Criteria</th>
<th>AASHTO 93</th>
<th>PavementDesigner</th>
<th>BCOA – ME</th>
<th>UBOL – ME</th>
<th>Pavement ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracking</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Faulting</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes²</td>
</tr>
<tr>
<td>IRI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes²</td>
</tr>
</tbody>
</table>

### Additional Design Information:

<table>
<thead>
<tr>
<th>Additional Design Information</th>
<th>AASHTO 93</th>
<th>PavementDesigner</th>
<th>BCOA – ME</th>
<th>UBOL – ME</th>
<th>Pavement ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanistic – Empirical</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Climatic Loading</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Joint Spacing</td>
<td></td>
<td></td>
<td>Output</td>
<td>Input</td>
<td>Input</td>
</tr>
<tr>
<td>Design with Fibers in Tool</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

¹ Via modifications to conventional JPCP design  
² Not in SJPCP Module
Overlay Jointing Practices

Joint Spacing

- Thinner overlays tend to have shorter joint spacings
- See Guide to Overlays for detailed information

Dowel & tie bar use

- Dowels normally not necessary for overlay thicknesses < 7 in.
- For unbonded overlays ≥ 5 in., use tie bars at longitudinal joints
Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents
Additional Considerations in Overlay Design

- Shoulders / Widening
- Vertical Grade Changes
  - Overhead Clearance
  - Barriers and Rails
  - Safety Edge
  - Drainage Structures
- Transitions
Foreslope Adjustment Options

- Safety Edge

Note: To allow proper finishing with paver a minimum 1-inch vertical face is required at the end of the safety edge.
Materials – Mixture Design


- Standard concrete mixtures whenever possible
- Minimize the use of accelerated mixtures
- Focus on project sequencing to accommodate maintenance of traffic
- Optimized gradation – Tarantula Curve / Shilstone Chart
- Reduced paste content – durability and shrinkage
- Inclusion of Fibers?

Webinars and resources at [https://cptechcenter.org/concrete-overlays/](https://cptechcenter.org/concrete-overlays/)
Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents
Concrete Overlay Quantity Control
Concrete Overlay Quantities
IDEAL SITUATION

• Quality of PCC is Uniform
  (set milling depth to remove exactly overlay depth and not worry about profile or smoothness)

• Profile is Perfect
  (never is)

• Concrete is bid in sq. yards;
  (Should be cu. yds for material & sy.yds. for placement)
Concrete Overlay Quantities
-REALITY SITUATION-

- Concrete is bid in sq. yards for placement, cubic yards for material
- Profile is not perfect and needs corrected
- Cross slope needs correction

PCC OVERLAY

Hold Minimum Thickness

Profile needs corrected

Slope varies

EXISTING PAVEMENT
Concrete Overlay Approach

If existing surface needs some improvement in cross slope or profile grade and want minimum survey:

- Must maintain minimum pavement thickness
- Contractor sets recommended grade
- Allow to mill to get cross slope and profile

Area to be filled
Mill to get profile
**Quantity Estimates**

- **Estimating plan quantity**
  - Overlay cubic yard pay item is to adjust the theoretical volume by an appropriate factor that accounts for the non-uniformity of the existing surface.

<table>
<thead>
<tr>
<th>Concrete Overlay Thickness</th>
<th>½” Placement Tolerance as a % of Design Thickness</th>
<th>Additional % Adjustment for Gross Surface Irregularities in the Existing Surface</th>
<th>Total Adjustment Factor to be Applied to Theoretical Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>4”</td>
<td>12.5%</td>
<td>5%</td>
<td>17.5%</td>
</tr>
<tr>
<td>6”</td>
<td>8.3%</td>
<td>5%</td>
<td>13.3%</td>
</tr>
<tr>
<td>8”</td>
<td>6.3%</td>
<td>5%</td>
<td>11.3%</td>
</tr>
<tr>
<td>10”</td>
<td>5.0%</td>
<td>5%</td>
<td>10.0%</td>
</tr>
<tr>
<td>12”</td>
<td>4.2%</td>
<td>5%</td>
<td>9.2%</td>
</tr>
</tbody>
</table>
Specifications and Construction Documents

- Guide specifications and standard drawings and design details available in CP Tech Center Resources
- Plans can be simple
  - Typical Section

- https://cptechcenter.org/concrete-overlays/