Basics of a Good Road
- Concrete Pavements

Road Scholar Program
Part II

Mike Byers
Indiana Chapter – American Concrete Pavement Association
Chapter/States Associations of ACPA
SLR Pavement Markets

- New/Reconstruction of Concrete Pavements
- Concrete Overlays
  - Unbonded
  - Whitetopping
  - Ultra-Thin Whitetopping (UTW)
- Concrete Inlays
  - Intersections
  - Roundabouts
  - Bus Pads
  - Alleys
- Concrete Pavement Restoration
Different Pavement Types

Concrete Section

- Subgrade
- Subbase

Asphalt Section

- Subgrade
- Subbase
- Base
- Asphalt Layer
Concrete’s Rigidness spreads the load over a large area and keeps pressures on the subgrade low.
Streets and Local Roads Thickness Design Procedure

- **Longitudinal joint**
- **Transverse joint**
- **Subgrade**
- **Subbase or base**
- **Surface Texture**
  - Surface smoothness or rideability
- **Tiebars**
- **Concrete materials**
- **Dowel bars**

**Thickness Design**
Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled

- Jointed Reinforced

- Continuously Reinforced
Jointed Plain

8 – 15 ft

Plan

Profile

or
Jointed Plain
Concrete Pavement Design Requires Selecting Appropriate Features

- Subgrade modification
- Drainage system
- Subbase
- Joint Spacing
  - 15 ft
  - 18 ft
- Dowels
- Thickness
  - 6 in
  - 8 in
  - 10 in
- Reinforcement
- Joint Sealant
  - None
  - Hot pour
  - Silicone
  - Preformed
- Surface Texture
  - Transverse tine
  - Burlap drag
- Shoulder
  - Asphalt
  - Concrete
Now Using Mechanistic-Empirical Design (MEPDG) to Optimize
Empirical Design Procedures
- Based on observed performance
  - AASHO Road Test

Mechanistic Design Procedures
- Based on mathematically calculated pavement responses
  - PCA Design Procedure (PCAPAV)
  - StreetPave (ACPA Design Method)

Ottawa, Illinois (approximately 80 miles southwest of Chicago) between 1956 and 1960
New Design Tools for SLR

- MEPDG – Mechanistic-Emperical Design Guide
- StreetPave Software
  - Concrete Thickness
  - Asphalt Institute Design Thickness
  - Life Cycle Cost Analysis
- Information Sheet IS184
- Thickness Design Manual for Concrete Streets and Local Roads EB109
- Equivalent Pavement Design Charts
Equivalent Pavement Design

Equivalency Chart
For Concrete and Asphalt Pavements

Concrete and asphalt pavements are not only made of different materials, but they also carry traffic loads in entirely different ways. This means that the thickness design procedures for concrete and asphalt pavements are also different. The structural number concept has, however, been used to estimate concrete and asphalt pavement sections.

The structural number of a particular pavement section is simply the summation of the layer thicknesses multiplied by their respective layer coefficients, as shown in Figure 1.

The concept of layer coefficients was developed during the road test conducted by the American Association of State Highway Officials (AASHO), to account for all of the materials and layers in an asphalt pavement structure.

![Image](https://example.com/image.png)

Figure 1: Calculation of the structural number for a paved asphalt section.

The following table lists layer coefficients for various materials:

<table>
<thead>
<tr>
<th>Material</th>
<th>Layer Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>0.50</td>
</tr>
<tr>
<td>Asphalt Surface</td>
<td>2.0</td>
</tr>
<tr>
<td>Plantix (high stability)</td>
<td>0.36 - 0.44</td>
</tr>
<tr>
<td>Roastite (low stability)</td>
<td>0.10 - 0.20</td>
</tr>
<tr>
<td>Sand Asphalt</td>
<td>0.20 - 0.40</td>
</tr>
<tr>
<td>Bituminous-Treated Base</td>
<td>0.10 - 0.94</td>
</tr>
<tr>
<td>Coarse-Graded Base</td>
<td>0.10 - 0.90</td>
</tr>
<tr>
<td>Sand Asphalt</td>
<td>0.10 - 0.30</td>
</tr>
<tr>
<td>Lime Treated</td>
<td>0.18 - 0.15</td>
</tr>
<tr>
<td>Crushed Stone</td>
<td>0.18 - 0.14</td>
</tr>
<tr>
<td>Sandy Gravel</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Used for estimating purposes only.

Residential
Design variables: k = 100, ADTT = 5.
Light axle load category, 20 year design lift, unreinforced, 600 psi concrete flexural strength
Concrete: Design thickness = 6.0 inches (DNF = 9.0 x 0.50 = 4.5)
Asphalt: 1.5 inches High stability asphalt on a coarse-graded base (8.0 inches)

Collector
Design variables: k = 100, ADTT = 50.
Medium axle load category, 50 year design lift, unreinforced, 600 psi concrete flexural strength
Concrete: Design thickness = 7.0 inches (DNF = 7.0 x 0.50 = 3.5)
Asphalt: 1.5 inches High stability asphalt on a coarse-graded base (8.0 inches)

Minor Arterial
Design variables: k = 200, ADTT = 500.
Heavy axle load category, 50 year design lift, unreinforced, 600 psi concrete flexural strength
Concrete: Design thickness = 8.5 inches (DNF = 8.5 x 0.50 = 4.3)
Asphalt: 1.5 inches High stability asphalt on a coarse-graded base (10.0 inches)

Major Arterial
Design variables: k = 200, ADTT = 1000.
Very Heavy axle load category, 50 year design lift, unreinforced, 600 psi concrete flexural strength
Concrete: Design thickness = 11.0 inches (DNF = 11.0 x 0.50 = 5.5)
Asphalt: 1.5 inches High stability asphalt on a coarse-graded base (12.5 inches)
Design Aids
The latest design and cost analysis tool from ACPA…

- Design & compare thickness requirements and costs for concrete and asphalt pavements

- Features:
  - Updated mechanistic design method for concrete pavement
    - Fatigue and erosion analysis
    - Jointing spacing & load transfer recommendations
    - Thickness rounding and reliability considerations
    - Analysis of existing concrete pavements
  - Life cycle cost analysis module
  - Printable summary reports and charts
    - Design summary
    - Design factor sensitivity & life-cycle plots
  - User-friendly format and features
    - Walkthrough Wizard
    - Help information for all inputs
Principles of Design

Load stresses

Curling/Warping stresses

Volume change stresses

Jointing

Thickness
SLR Pavement Design

- Street classification and traffic
- Geometric design
- Subgrades and subbases
- Concrete quality
- Thickness design
- Jointing
- Construction specifications
<table>
<thead>
<tr>
<th>Street Class</th>
<th>Description</th>
<th>Two-way Average Daily Traffic (ADT)</th>
<th>Two-way Average Daily Truck Traffic (ADTT)</th>
<th>Typical Range of Slab Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Residential</td>
<td>Short streets in subdivisions and similar residential areas – often not through-streets.</td>
<td>Less than 200</td>
<td>2-4</td>
<td>4.0 - 5.0 in. (100-125 mm)</td>
</tr>
<tr>
<td>Residential</td>
<td>Through-streets in subdivisions and similar residential areas that occasionally carry a heavy vehicle (truck or bus).</td>
<td>200-1,000</td>
<td>10-50</td>
<td>5.0 - 7.0 in. (125-175 mm)</td>
</tr>
<tr>
<td>Collector</td>
<td>Streets that collect traffic from several residential subdivisions, and that may serve buses and trucks.</td>
<td>1,000-8,000</td>
<td>50-500</td>
<td>5.5 - 9.0 in. (135-225 mm)</td>
</tr>
<tr>
<td>Business</td>
<td>Streets that provide access to shopping and urban central business districts.</td>
<td>11,000-17,000</td>
<td>400-700</td>
<td>6.0 - 9.0 in. (150-225 mm)</td>
</tr>
<tr>
<td>Industrial</td>
<td>Streets that provide access to industrial areas or parks, and typically carry heavier trucks than the business class.</td>
<td>2,000-4,000</td>
<td>300-800</td>
<td>7.0 - 10.5 in. (175-260 mm)</td>
</tr>
<tr>
<td>Arterial</td>
<td>Streets that serve traffic from major expressways and carry traffic through metropolitan areas. Truck and bus routes are primarily on these roads.</td>
<td>4,000-15,000 (minor)</td>
<td>300-600</td>
<td>6.0 - 9.0 in. (150-225 mm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4,000-30,000 (major)</td>
<td>700-1,500</td>
<td>7.0 - 11.0 in. (175-275 mm)</td>
</tr>
</tbody>
</table>
Geometric Design

Utilities

Increase Edge Support
- Integral Curb
- Tied Curb & Gutter
- Widened Lanes (2 feet no parking)
- Parking Lanes
- Rural Areas – Tied Concrete Shoulders

Street Widths
- Minimum width of 25 ft.
- Maximum Cross Slope of 2 percent (¼” per ft.)
- Traffic Lanes 10-12 feet
- Parking Lanes 7-8 feet
Subbase vs. NO Subbase

For Concrete Pavements
Subbase vs. NO Subbase

- Heavy Traffic?? > 120 Trucks/day = subbase
- Fine grain soils prone to erosion
- Presence of moisture/water
  - Potential pumping

Presence of all above conditions suggests need for subbase
Subgrade and Subbases

For Concrete Pavements
Subgrade and Subbases

- **Subgrade**
  - Natural ground, graded, and compacted on which the pavement is built.

- **Subbase**
  - Layer of material directly below the concrete pavement.
UNIFORMITY: The Key To GOOD PAVEMENT PERFORMANCE
Design for Uniform Support

Three Major Causes for Non-Uniform Support

- Expansive Soils
- Differential Frost Heave
- Pumping (loss of support)
Subbase vs. NO Subbase

- Presence of fine-grained soil
- Presence of water
- Sufficient volume of trucks to cause soil pumping (> 100 trucks/day)
- Pavements on > 15% grade
# Subgrade Properties

## Modulus of Subgrade Reaction, k-value

<table>
<thead>
<tr>
<th>Plate load on subgrade</th>
<th>Plate deflection on subgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>k = 5.0 psi</td>
<td>0.5 in</td>
</tr>
</tbody>
</table>

\[ k = \frac{5.0 \text{ psi}}{0.5 \text{ in}} = 100 \text{ psi/in.} \]

## Plate-Load Test

- **Reaction**
- **Stacked Plates**
- **Pressure Gauge**
- **Subgrade**
Subgrade Properties

- Plate-load test is rarely performed
  - time consuming & expensive

- Estimate k-value by correlation to other tests
  - e.g. California Bearing Ratio (CBR) or R-value tests

- Lean concrete subbases increases k-value substantially
## Subgrade Properties

### Correlated k-values for Subgrade Support

<table>
<thead>
<tr>
<th>Type</th>
<th>Amount of Support</th>
<th>Historical k-values (pci)</th>
<th>California Bearing Ratio (CBR), % (ASTM D 1183)</th>
<th>Resistance Value (R-value) (ASTM D 2844)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine-grained with high amounts of silt/clay</td>
<td>Low</td>
<td>75 - 120</td>
<td>2.5 - 3.5</td>
<td>10 - 22</td>
</tr>
<tr>
<td>Sand and sand-gravel with moderate silt/clay</td>
<td>Medium</td>
<td>130 - 170</td>
<td>4.5 - 7.5</td>
<td>29 - 41</td>
</tr>
<tr>
<td>Sand and sand-gravel with little or no silt/clay</td>
<td>High</td>
<td>180 - 220</td>
<td>8.5 - 12</td>
<td>45 - 52</td>
</tr>
</tbody>
</table>
Subgrade and Subbases

Design Summary

- Subgrade strength is not a critical element in the thickness design. ★ Has little impact on thickness.
- Need to know if pavement is on:
  - Subgrade (k ≈ 25 MPa/m (100 psi/in.)),
  - Granular subbase (k ≈ 40 MPa/m (150 psi/in.)),
  - Asphalt treated subbase (k ≈ 80 MPa/m (300 psi/in.))
  - Cement treated/lean concrete subbase (k ≈ 125 MPa/m (500 psi/in.)).
Subgrade and Subbases

Performance Summary

- Proper design and construction are **absolutely necessary** if the pavement is to perform.
  - Must be **uniform** throughout pavement’s life.
- Poor subgrade/subbase preparation can not be overcome with thickness.
  - Any concrete pavement, built of any thickness, will have problems on a poorly designed and constructed subgrade or subbase.
Subbase Effects

At the AASHO Road Test, concrete pavements with granular bases could carry about 30% more traffic.

The current design procedures allows concrete pavements built with granular bases to carry about 5 - 8% more traffic.
Drainable Subbase??

- Aggregate Quality – marginal D-cracking?
- Traffic Level – high volume may warrant drainable subbase
- Edge drains behind curb still good detail
Basics of Thickness Design
Biggest Impact on Thickness Design

- Concrete Strength
- Joint Spacing
- Edge Support
- CTE – Coefficient of Thermal Expansion
- Reliability
Design & compare thickness requirements and costs for concrete and asphalt pavements

Features:
- Updated mechanistic design method for concrete pavement
  - Fatigue and erosion analysis
  - Jointing spacing & load transfer recommendations
  - Thickness rounding and reliability considerations
  - Analysis of existing concrete pavements
- Life cycle cost analysis module
- Printable summary reports and charts
  - Design summary
  - Design factor sensitivity & life-cycle plots
- User-friendly format and features
  - Walkthrough Wizard
  - Help information for all inputs
Thickness Design for Streets and Local Roads

StreetPave User Inputs & Outputs

- **Global Settings**
  - Region
  - Units (English or Metric)
  - Terminal Serviceability
  - Percent Slabs Cracked at end of design Life

- **Design Life**

- **Reliability**

- **Traffic**

- **Pavement Properties**

- **Thickness/Dowel/Jointing Recommendations**
Design Example – Inputs

- Design life = 30 years
- k-value = 100 pci
- Concrete flexural strength = 600 psi
- Load transfer (dowels) = yes
- Edge support = yes
- Traffic category = Collector
- 2-way ADTT = 100
- Reliability = 80%
- Percent Slabs Cracked = 15%
Thickness Design Procedure

Design controlled by:

- Fatigue usually controls design of light-traffic pavements
  - Single-axles usually cause more fatigue damage

- Erosion usually controls design of undoweled medium- and heavy-traffic pavements
  - Tandem-axles usually cause more erosion damage
  - Tridem-axles usually cause more erosion damage
Thickness Design Procedure
Concrete Properties

- **Flexural Strength**
  (Modulus of Rupture, ASTM C 78)
  - Avg. 28-day strength in 3rd-point loading

- **Other Factors**
  - Concrete Strength Gain with Age
  - Fatigue Properties

![Third-point Loading Diagram](image)
Thickness Design Procedure
Concrete Properties

Compressive Strength $f'_c$

$S'_c = 8-10 \sqrt{f'_c}$

- $f'_c = \text{Compressive Strength (psi)}$
- $S'_c = \text{Flexural Strength (psi)}$
Basics of Thickness Design
Stress / Fatigue

- Compressive strength: ~4000 psi
- Flexural strength: ~600 psi
Strength Correlations

Compressive Strength, psi

Flexural Strength, psi

MR = 7.5 \times f'c^{0.5} \quad MR = 9 \times f'c^{0.5} \quad MR = 10 \times f'c^{0.5}
# Thickness Design Procedure

## Concrete Properties

Comparison of $f'_{c}$, MR, and Required Thickness

<table>
<thead>
<tr>
<th>Compressive Strength (psi)</th>
<th>Flexural Strength (psi)</th>
<th>Design Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000</td>
<td>450 – 550 (500)</td>
<td>6.5 (6.43) PCA 7.0</td>
</tr>
<tr>
<td>4000</td>
<td>510 – 630 (600)</td>
<td>5.5 (5.25) PCA 6.5</td>
</tr>
<tr>
<td>5000</td>
<td>570 – 710 (700)</td>
<td>5.0 (4.86) PCA 6.0</td>
</tr>
</tbody>
</table>

Life 30 years, Collector (2), k-value 162, Reliability 80 %, plus C & G, 2 % annual growth
Design Period/Life

- 20 to 35 years is commonly used
- Shorter or longer design period may be economically justified in some cases

- High performance concrete pavements
- Long-life pavements
- A special haul road to be used for only a few years
- Cross-overs
- Temporary lanes
Design Reliability

- Practically everything associated with pavement design is variable
  - Variability in mean design inputs—traffic, materials, subgrade, climate, and so on
  - Error in performance prediction models

- Simply Stated, the reliability is the factor of safety of the pavement design

- Level selected depends on type of roadway and expected performance
### Levels of Reliability for Pavement Design

<table>
<thead>
<tr>
<th>Functional Classification of Roadway</th>
<th>Recommended Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urban</strong></td>
<td><strong>Rural</strong></td>
</tr>
<tr>
<td>Interstates, Freeways, and Tollways</td>
<td>85 – 99</td>
</tr>
<tr>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Principal Arterials</td>
<td>80 – 99</td>
</tr>
<tr>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Collectors</td>
<td>80 – 95</td>
</tr>
<tr>
<td></td>
<td>80</td>
</tr>
<tr>
<td>Residential &amp; Local Roads</td>
<td>50 – 80</td>
</tr>
<tr>
<td></td>
<td>70</td>
</tr>
</tbody>
</table>
# Thickness Design

## Recommended Levels of Slab Cracking by Roadway Type

<table>
<thead>
<tr>
<th>Roadway Type</th>
<th>Recommended Percent of Slabs Cracked at End of Design Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Default) INDOT Section 304 Suggested Threshold</td>
<td>15% 10%</td>
</tr>
<tr>
<td>Interstate Highways, Expressways, Tollways, Turnpikes</td>
<td>5% 10%</td>
</tr>
<tr>
<td>State Roads, Arterials</td>
<td>10% 10%</td>
</tr>
<tr>
<td>Collectors, County Roads</td>
<td>15% 10%</td>
</tr>
<tr>
<td>Residential Streets</td>
<td>25% 10%</td>
</tr>
</tbody>
</table>
Effect of Flexural Strength on Thickness

![Graph showing the relationship between Modulus of Rupture (Flexural Strength) in psi and Thickness in inches. The graph displays a downward trend indicating that as the Modulus of Rupture increases, the Thickness decreases.]
Slab Cracking at Year 30 vs. Thickness, for 80% Reliability
Basics of Thickness Design

Deflection / Erosion

- Higher k-value will lower deflections
- Load transfer will lower deflections
Concrete Pavement Design
Deflection/Erosion

**Load Transfer** (slabs ability to share its load with neighboring slabs)

- Dowels
- Aggregate Interlock
- Edge Support
  - Tied curb & gutter
  - Integral curb & gutter
  - Parking lane
  - Tied concrete

\[
\Delta L = x \\
\Delta U = 0
\]

Poor Load Transfer

\[
\Delta L = x/2 \\
\Delta U = x/2
\]

Good Load Transfer
Dowels vs. NO Dowels

Load Transfer

The slabs ability to share its load with its neighboring slab

- **Dowels**
  - High Traffic Volumes (Pavements > 8 in.)
  - (> 120 Trucks/day)

- **Aggregate Interlock**
  - Low Traffic Volumes (Pavements < 7 in.)
## Load Transfer Efficiency

<table>
<thead>
<tr>
<th>Load Transfer Mechanism</th>
<th>LTE, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>aggregate interlock</td>
<td>30 - 80</td>
</tr>
<tr>
<td>stabilized base</td>
<td>50 - 90</td>
</tr>
<tr>
<td>dowel bars</td>
<td>80 - 95</td>
</tr>
</tbody>
</table>
Aggregate Interlock

Shear between aggregate particles below the initial saw cut
Aggregate Interlock
Design - Erosion

Conditions for Pumping

- Subgrade soil that will go into Suspension
- Free water between slab and subgrade
- Frequent heavy wheel loads / large deflections
Dowel bars

- Lengths from 15-18 in.
- 6.0 in. min. embedment length
- Diameter
  - 1.00 - 1.25 in. for SLR
- Epoxy or other coating used in harsher climates for corrosion protection
Dowel Recommendations

- Dowels recommended when ADTT is greater than or equal to 120:

  - If pavement thickness is 6” or less, dowels not recommended
  - If pavement thickness is 6.5” to 7.5”, use 1” dowels
  - If pavement thickness is 8” or greater, use 1 1/4“ – 1 1/2” dowels
Faulting Model

Traffic, million ESALs

Faulting, in

Dense-graded base
No dowel

Permeable base
No dowel

Dense-graded base
1-in dowel

Dense-graded base
1.25-in dowel
Construction of Concrete Pavement

- Plant Operations
- Central Mixed Concrete
- Truck Mixed Concrete
- Paving Operations
- Slipform Paving
- Paving Operations
- Fixed Form Paving
- Saw & Seal

Central Mix Concrete Batch Plant
Construction Specifications

- **Smoothness**
  - 10-20 ft. Straightedge
  - Profilograph Index

- **Texture**
  - Speeds less than 40 mph
    - Burlap Drag
    - Astroturf Drag
    - Tined Surface
Curing and Protection
Curing

Curing is one of the most important steps in quality concrete construction and one of the most neglected.

Effective curing is absolutely essential for surface durability.
Membrane Curing of Concrete

Evaporation from water surface

Partially saturated

Saturated

Curing membrane

Concrete
Curing

- The simplest, most economical and widely used method is a liquid membrane which is sprayed on the surface of a slab as soon as possible after finishing.
- Apply at manufacture’s rate of coverage.
- Perform field check to verify application rate.
Effect of Adequate Curing on Hardened Concrete

- Increased
  - Strength
  - Watertightness
  - Abrasion resistance
  - Freeze-thaw resistance
  - Volume stability
Effect of Curing on Strength Development

![Graph showing the effect of curing on strength development](image-url)
Durability = Performance

- Quality Materials
  - Aggregate – AP Approved, uniform gradation
  - Minimum Cement Content
  - Approved Admixtures

- Proper Mix Design – Control to Design

- Moisture/Water Control < 0.45 w/c

- Air Entrainment – 6% ± 1.5%

- Proper Curing – Liquid membrane applied @ manufacturer’s suggested rate
Jointing

- Spacing based on thickness
  - 6” thick – 12’ joint spacing
  - ^’-12” – 15’ joint spacing
  - > 12” thick – 18’ joint spacing
- > 12” thick - saw 1/3 the depth
- High volume traffic – seal joints with silicone or neoprene
- Low volume traffic – seal joints with hot pour rubberized asphalt

What about unsealed joints??
Rehabilitation Strategies

- Three categories:
  - Restoration
  - Resurfacing
  - Reconstruction

Together, known as CPR\(^3\)

- Which is used depends on existing condition.
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
Overlay vs. Reconstruct

- **Expected Performance**
  - UTW (3” – 5”) – 10 to 15 years
  - Thicker overlays (6” – 12”) 15 to 25 years
  - Reconstruction – 25 to 30 years

- **Condition of existing pavement**

- **Clearance issues** – if none can build on top of old PCCP or HMA pavement
PCCP Overlay Design Advancements
Design Aids

Background

This bonded concrete overlay on asphalt (BCOA) thickness design web application is based primarily on the results of FHWA-ICT-08-016, “Design and Concrete Material Requirements for Ultra-Thin Whitetopping”, a research project conducted in cooperation with the Illinois Center for Transportation at the University of Illinois (ICT), the Illinois Department of Transportation (IDOT), and the Federal Highway Administration (FHWA). The web application reflects the views of the ACPA, who is responsible for the facts and accuracy of the data presented within it. The contents do not necessarily reflect the official views or policies of ICT, IDOT, or FHWA, and this application does not constitute a standard, specification, or regulation. Designers should understand the assumptions/limitations of the research on which this tool is based and also be knowledgeable about the various types of concrete overlay offerings and design/construction details of each type.

Acknowledgements

National Concrete Pavement Technology Center

Bonded Concrete Overlay on Asphalt (BCOA) Thickness Designer

General Design Details

Design Lane ESALs: [Estimate ESALs] 0

Slabs Cracked at End of Design Life (%): 20%

R liability (%): 85%

Location: AL, Birmingham

Existing Pavement Structure Details

Remaining Asphalt Thickness (in.): 4

Asphalt Modulus of Elasticity (psi): 350,000

Modulus of Subgrade Reaction (pci): 150 [Calculate k-Value]

Concrete Material Details

Average 28-Day Flexural Strength (psi): 750

Macrolrbers In Concrete: [No] Help

Concrete Modulus of Elasticity (psi): 3,600,000

Coefficient of Thermal Expansion ($10^{-6}$/F): 5.5

Concrete Overlay Details
Design Aids

General Information
- Latitude (degree): 44.53
- Longitude (degree): -93.14
- Elevation (ft): 874
- Estimated Design Lane ESALs: 1000000
- Maximum Allowable Percent Slabs Cracked (%): 25
- Desired Reliability against Slab Cracking (%): 85

Climate
- AMDAT Region ID: 5
- Map of Sunshine Zone: 2

Existing Structure
- Post-milling HMA Thickness (in): 6
- HMA Fatigue: Adequate
- Composite Modulus of Subgrade Reaction, k-value (psf/ln): 150

Geographic Information
ESALs Calculator
Example of Fatigue Cracking
k-value Calculator
New Tools for New Problems
Other Design Developments

Portland Cement Concrete Overlays

Precast Improper Overlay Alternative Selection and Post Construction Increases the Early Life Cost and Decreased Investment Potential

Portland Cement Concrete (PCC) overlays are an opportunity to increase the life of the existing pavement with limited disruption to traffic and minimal environmental impact. The key result is closing pavement rehabilitation alternatives that do not involve the existing traffic and personal conditions and results to poor performing pavement. This performance-based, life cycle approach, incorporates the concept of overlay as an appropriate alternative for pavement rehabilitation, with the PCC overlay as a proven alternative. This approach involves determining the best course of action for the rehabilitation, followed by the implementation of the chosen alternative based on improved design and execution. The PCC overlay is an improvement over the conventional approaches and utilizes the existing pavement base to provide a cost-effective solution.

MNRoad, MnDOT

Thin Whitetopping — the Colorado Experience

Thin Whitetopping is a cost-effective, sustainable, and aesthetically pleasing alternative to conventional asphalt overlays. It involves the application of a thin layer of high-performance asphalt mix, typically below 1 inch, to existing pavements. This process enhances the surface texture, improves drainage, and adds a unique aesthetic to the road surface. The Colorado Department of Transportation (CDOT) has extensively used thin whitetopping to extend the service life of pavements, reduce maintenance costs, and improve safety and mobility. The technology has gained widespread acceptance in the state, and CDOT continues to explore innovative applications to further enhance its benefits.

Wadsworth Blvd., Colorado DOT

islab2000

E3ES Consultants

Michigan Department of Transportation

Michigan Technological University

University of Minnesota

University of Illinois
Single Best Reference

www.cptechcenter.org

Third Edition expected out in Spring 2014

Guide to CONCRETE OVERLAYS
Sustainable Solutions for Resurfacing and Rehabilitating Existing Pavements

A practical approach to understanding and successfully using concrete overlays, from selection to opening

Family of Concrete Overlays

Concrete Overlays

Bonded Resurfacing Family
- Bonded Concrete Resurfacing of Concrete Pavements
- Bonded Concrete Resurfacing of Asphalt Pavements
- Bonded Concrete Resurfacing of Composite Pavements

Unbonded Resurfacing Family
- Unbonded Concrete Resurfacing of Concrete Pavements
- Unbonded Concrete Resurfacing of Asphalt Pavements
- Unbonded Concrete Resurfacing of Composite Pavements
**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.
9” PCCP over old Chip & seal road
Allisonville Road

7” – 11” PCCP over 2 lane HMA street
Bremen Highway – St. Joseph County

4.0 “ PCCP Inlay
6.0 “PCCP Overlay of Existing HMA Pavement
CR 275W – Cass County

6.5” Unbonded PCCP Overlay of 50+ year old PCCP
CR 275W – Plate Dowels
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.
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

Transverse or Longitudinal Joint/Crack

Near vertical edges.

Transverse Milling (Half-moon)

Transverse or Longitudinal Joint/Crack
TYPICAL SPALLS
REMOVAL

Milling
TYPICAL MILLED AREA
PDR IN PROGRESS
CURING

- Use curing compound
Diamond Grinding

- Improves ride by removing:
  - Faulting at joints
  - Slab warping
  - Surface deformations caused by studded tires
- Reestablishes skid resistance
- Corrects cross-slope
ACPA Apps Library

Welcome to ACPA's online application library. Here you will find a collection of web and desktop-based applications created to assist you in the design, construction, and analysis of concrete pavements.

ACPA Members and customers of affiliated ACPA Chapter/State Paving Associations:
Visit ACPA's Concrete Pavement Resource Center to search and browse a collection of over 1,000 concrete pavement related technical references published by ACPA, FHWA, IPRF, IGGA, CP Tech Center, and other industry groups.

Note: There is a known compatibility issue with Internet Explorer 10. To mitigate the issue, please run IE10 in compatibility mode or download and use Google Chrome.
SLR Publications

Information Sheet - Maturity Testing of Concrete

Information Sheet - Concrete Pavement for GA Business & Commuter Aircraft

Information Sheet - Longevity and Performance of DG Pavements

Information Sheet - Specification Guideline for Dowel Bar Retrofit

Engineering Bulletin - Early Cracking Causes/Solutions


www.pavement.com
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Thank You