Designing Concrete Overlays with PavementDesigner.org

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Concrete Overlays

A VERY LONG History of Performance and Cost Effectiveness
Concrete Overlays in the U.S.

- Existing compilations of project details:
The National Concrete Overlay Explorer

1147 Items

658 results out of 1147 cannot be plotted.

Overlay Thickness (in.)
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4

Year Constructed
- 1900 - 1905
- 1910 - 1915
- 1915 - 1920
- 1920 - 1925

Concrete Overlay Type
- Bonded on Asphalt
- Bonded on Composite
- Bonded on Concrete
- Unbonded on Asphalt

Application
- Highway
- Airport
- Street/Road
- NA

State
- AB
- AL
- AR
- AZ

Map data ©2013 Google, MapLink - Terms of Use
The National Concrete Overlay Explorer

U.S. 36, Oakland & Eldorado Intersection
Type of Overlay: Bonded on Asphalt
Application: Highway
Constructed in 1998 in Decatur, IL (Macon County)
Contractor: Illinois Valley Paving
Engineer: Illinois Department of Transportation - District 5
Owner: Illinois Department of Transportation

New Construction Details
Thickness: 3.5 in.
Project Size: 400 square yards
Joint Spacing: 5 ft
Develed Joints: NA
Joints Sealed: NA
Interlayer Material: NA and Thickness: NA
Traffic: 16,500/1450
Integral Widening Constructed with Overlay: NA

Current Conditions
Still In Service: Yes

Local ACPA Chapter or State Paving Associations: Illinois Chapter, Inc. - ACPA
Newest Resource Detailing Performance

- Detailing overlays with up to 35 years of performance!
Increasing in Use!
We Engineers are Conservative!

- 78% Unbonded
- 22% Bonded
... but Bonded is Increasingly Common!
Historically, Mostly on Concrete

- 55% on Concrete
- 40% on Asphalt
- 5% on Composite
... but More and More on Asphalt

![Chart showing percent that are bonded or unbonded from 1910s to 2000s. Each decade is represented with different colors for bonded on asphalt, bonded on composite, bonded on concrete, unbonded on asphalt, unbonded on composite, and unbonded on concrete. The percentage scale ranges from 0% to 100%.](chart.png)
Thin (< 6 in. [150 mm]) Concrete Overlays in the U.S.

Square Yards, Thin Overlays

- Total by 1993: 7,000
- Total by 1999: 450,000
- Total by 2004: 1,200,000
- 2009: 5,456,100
- 2010: 3,226,700

1 square yard = 0.84 square meters
Lots of Guidance Available...
CP Tech Guide on Design

- Released in 2012
- Not a design procedure!
- Background on recommended overlay design techniques
  - 18 pages
- Detailed design examples
  - 35 pages
Design Methods Recommended

Note: StreetPave12, Pitt BCOA-ME, and Pavement ME’s SJPCP released after guide was published
Guide to All Things Overlays!

- Overlay types and uses
- Evaluation & selection
- Design guidance
- Miscellaneous design details
- Overlay materials selection
- Work zones under traffic
- Key points for overlay construction
- Accelerated construction
- Specification considerations
- Repairs of overlays

- Free download at: www.cptechcenter.org
What About Overlay Design in PavementDesigner?

- **StreetPave/PCA Method Overlay Design**
  - Utilizes StreetPave with modification to account for existing surface layer’s condition and thickness

- **Links out to the BCOA-ME**
  - Best method available
  - Incorporates ACPA BCOA and 6x6x6 designs
**Bonded versus Unbonded**

- **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.
Additional Inputs for Overlay Design

- For AASHTO 93, StreetPave Pavement Designer, and Pavement ME, they all use their same “core” to calculate overlay thickness, with a few considerations, e.g.,
  - For unbonded designs, essentially assume existing pavement is the same as subbase in new design and that no friction/bond exists right under surface slabs
  - For bonded over concrete, all calculate a required new concrete thickness and adjust to account for the effective existing pavement thickness
  - Bonded over asphalt/composite is a different game!
Overlay Design – Accounting for Existing Surfaces

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

- Unbonded Concrete on Concrete (UCOC)
  \[ T_{UCOC} = \sqrt{T_{required}^2 - T_{effective}^2} = \sqrt{T_{required}^2 - \left( AF_{joint \ cracks} \times T_{existing} \right)^2} \]

- Bonded Concrete on Concrete (BCOC)
  \[ T_{BCOC} = T_{required} - T_{effective} = T_{required} - AF_{joint \ cracks} \times AF_{durability} \times AF_{fatigue} \times T_{existing} \]
Bonded over Asphalt/Composite

- AASHTO 93: not applicable
- AASHTO ME: SJPCP Module released 2016
- ACPA BCOA and StreetPave: account for bond to asphalt and short slab size, fibers, etc., but supplanted by....
BCOA ME failure modes

- **≤ 4.5 ft**
  - Corner Break
  - Negative ΔT

- **5 to 7 ft**
  - Long. & Diag Crack
  - Positive ΔT

- **10 x 12 ft
  12 x 12 ft
  12 x 15 ft**
  - Trans. Crack
  - Positive ΔT

Images show schematic representations of each failure mode.

[Source: PavementDesigner.org]
BCOA-ME

Inputs

- Stress for corner cracks
  - Jt. Spacing < 4.5 ft
- Stress for long. & diag. cracks
  - Jt. Spacings 5 to 6 ft
- Stress for trans. cracks
  - Jt. Spacings 10 x 12 ft, 12 x 12 ft, 15 x 12 ft

Models:
- PCA Model
- Fatigue model
- ACPA Model
- Pitt Model
- CDOT Model

Result: $h_{pcc}$
PavementDesigner.org

Lets design an overlay!
BUT WHAT ABOUT THESE?
What Designs are Available for Heavy Intermodal/Industrial Vehicles

- ACI 330.2R-17 – Guide for the Design and Construction of Concrete Site Paving for Industrial and Trucking Facilities
  - Uses design tables
  - Lists additional design software:
    - ACPA StreetPave
    - Pavement ME
    - TCPavements / Optipave
    - ACPA AirPave
AirPave Methodology for Heavy Equipment
AirPave Load Distribution

Nose Gear: 5% of Total Weight

Landing Gears: 47.5% of Total Weight
PavementDesigner.org Workshop

Future Updates
Flexibility with PavementDesigner

- Online platform allows for immediate updates as new designs need to be incorporated
- Change log will allow users to see what’s changed
- Simple changes can be applied with in-house development
- Significant changes may require professional help
No More Patches to Download

StreetPave 12 – Patch Change Log

Patch 1 – Recommended
- bug fix to INITIAL FATIGUE/CRACKING CONSUMED values displayed on-screen and in reports
- metric fixes to the composite live value calculator
- added support for analyzing both a dowelled and undowelled asphalt overlay in the existing overlay/pavement screen

Patch 2 – Recommended
- bug fix in reports to properly display rigid SPMs in all scenarios
- added support for formatting and display of help screens for all resolution configurations
- in some cases, decreased minimum asphalt thickness

Specifically when the conditions below are selected, the minimum thicknesses allowed will be:
- **MMAT = 40F (7C)**
  - Full depth asphalt: 4 in. (100 mm)
  - On 6" base: 3 in. (75 mm)
  - On 12" base: 3 in. (75 mm)
- **MMAT = 60F (15 SC)**
  - Full depth asphalt: 4 in. (100 mm)
  - On 6" base: 3 in. (75 mm)
  - On 12" base: 3 in. (75 mm)
- **MMAT = 70F (24C)**
  - Full depth asphalt: 4 in. (100 mm)
  - On 6" base: 3 in. (75 mm)
  - On 12" base: 4 in. (100 mm)

Patch 3 – Recommended
- for dowelled pavement and dowelled unbonded overlay designs where calculated thickness is less than 8 inches (203.2 mm) and the mode of failure is cracking. StreetPave 12 will now allow the user to view the calculated results and reports, even though dowels are not recommended under these conditions
- because the dowelled thickness is less than 8 in. and cracking is the predicted cause of failure, dowel bars typically would not be recommended for the design details you provided
- fixed bug in reports to properly display value for min. required thickness in reports for dowelled pavements
- fixed formatting issue on run analysis screens, where minimum required dowelled thickness value was offset from minimum required undowelled thickness value

Patch 4 – Recommended
- fixed bug with life cycle cost module that caused the initial costs for asphalt surface course, base, and aggregate to reset to default values under certain circumstances
- fixed issue with metric units where the existing concrete thickness for a bonded on concrete overlay was limited to a maximum of 50 mm
- upgraded subgrade modulus coefficient of variation (COV) input to automatically calculate design resilient modulus of the subgrade as the value is being entered
- fixed bug with resilient modulus of the subgrade calculator to allow for calculation in metric units
- adjusted task system to not include help buttons
- fixed reports to properly show the joint crack adjustment factor for applicable overlay designs

Patch 5 – Recommended
- fixed bug issue with design resilient modulus of the subgrade not automatically updating after making changes within the resilient modulus of the subgrade calculator
- updated licensing DLL to address some issues related to Windows 8 compatibility

Patch 6 – Recommended
- fixed a bug introduced with patch 5, that in some cases produced an incorrect result for total fatigue calculator

Patch 7 – Recommended
- updated the licensing module to address incompatibility issues with Windows 8.1
- fixed an issue where in some cases the life cycle cost report would not load properly

Patch 8 – Recommended
- fixed issue where concrete overlay type and various life cycle cost inputs where not saving to project files
- updated reports to remove ‘number of lanes’ field that is no longer used
- updated metric reports to show m units for axle loads in the cracking/faulting table
Potential Updates

The bonded concrete overlay 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.
Faulting Design in PavementDesigner

- If dowels used, faulting mitigated & fails by cracks
- No faulting data collected at the AASHO road test so model developed in 1980s using field performance data from WI, MN, ND, GA, and CA
- Similar to cracking models, the pavement is made thicker, as necessary, until faulting model predicts that the pavement will not fail by faulting during the design life
- PD’s weak point
Potential Updates

- Potential new erosion model based on Professor Zollinger’s research at Texas A&M University
Potential Updates
Check it out now at:
pavementdesigner.org

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