

**BONDED CONCRETE OVERLAY OF ASPHALT PAVEMENTS  
MECHANISTIC-EMPIRICAL DESIGN GUIDE (BCOA-ME):  
USER'S GUIDE**

---

**USER'S GUIDE**

University of Pittsburgh  
Department of Civil and Environmental Engineering  
Pittsburgh, Pennsylvania 15261



*Prepared by:*

Nicole Dufalla

Zichang Li

Julie M. Vandenbossche, Ph.D., P.E.

*Prepared for:*

FHWA Pooled Fund Project: TPF-5-165

*Additions (July 2021):*

Sushobhan Sen, Ph.D. (faulting model)

*Prepared for:*

Pennsylvania Department of Transportation

California Department of Transportation

National Road Research Alliance

August 2013  
(Last revised: July 2021)

# BCOA-ME User's Guide

This instruction manual is to be used along with the Bonded Concrete Overlay on Asphalt Mechanistic-Empirical Design Guide (BCOA-ME). A list of definitions for all abbreviations used is provided at the end of the instruction manual.

## I. GENERAL INFORMATION

### Geographic Information

Click on the “Geographic Information” button to be presented with two input options.

#### Level 1 Input – Exact location is known

The project geographical location information can be obtained from a smartphone, a GPS or by clicking on the “Open Webpage” button to be directed to <http://veloroutes.org/elevation/> where latitude, longitude, and elevation can be given for any address. If the hyperlink is not working correctly, copy and paste the link into your web browser. Note that the latitude, longitude and elevation cannot be directly cut and pasted from this website into the design sheet but must be manually entered.

- a. *Latitude* - Manually enter the geographic latitude in degrees.
- b. *Longitude* - Manually enter the geographic longitude in degrees.
- c. *Elevation* - Manually enter the elevation above sea level in feet.

#### Level 2 Input – Nearest city is known

Choose the closest city to the project location from the drop-down menu that represents a similar elevation and climatic conditions as the project location. The latitude, longitude, elevation, AMDAT region, and sunshine zone will be automatically entered once the selection is made.

### Design ESALs

#### Level 1 Input – ESALs are known

With the incorporation of the faulting model, Level 1 is no longer available. The user is required to provide Level 2 inputs.

#### Level 2 Input – ADT is known

Click on the “ESALs Calculator” button to estimate the number of design ESALs. The one-way ADT must be entered along with the following information.

##### a) *Design Life:*

Enter the design life. The default value is 10 years.

##### b) *Terminal Serviceability*

Enter the terminal serviceability from the drop-down menu. The default value is 2.0.

*c) Number of Lanes*

Enter the number of traffic lanes in each direction. The default value is 1 lane in each direction.

*d) Percent Trucks*

Enter the percentage of the ADT that is classified as trucks without the percent sign. The default value is 6 (%).

*e) ADTT Growth Rate*

Enter the projected growth rate in the volume of truck traffic as a percentage without the percent sign. The default value is 3 (%).

*f) Traffic Growth Rate Type*

Select the ADTT growth rate type from the drop-down menu as either linear or non-linear. The default is non-linear.

*g) Road Category*

Select the road classification from the drop-down menu. The default road type is collector.

Level 3 Input – ADT is unknown

All inputs from Level 2 are required except ADT. ADT will be estimated based on roadway classification.

**Maximum Allowable Percent Slabs Cracked**

Enter the Percent Slabs Cracked in percentage. A 25 percent cracking value is recommended for this procedure.

**Desired Reliability against Slab Cracking**

Enter the Reliability in percentage. A conservative reliability of 85 percent is recommended for this procedure.

**II. CLIMATE**

**AMDAT Region**

Enter the Annual Mean Daily Average Temperature region between 1 and 7. Clicking the hyperlink will show a map of these regions.

**Sunshine Zone**

Enter the Annual Concentrating Solar Resource zone between 1 and 6. Clicking the hyperlink will show a map of these zones.

**III. EXISTING STRUCTURE**

**Post Milling HMA Thickness**

Enter the post-milling HMA layer thickness in inches. It is limited to between 3 and 10 inches thick.

**HMA Condition**

Select the HMA condition from the drop-down menu as “Marginal” if the percent fatigue cracking in the existing HMA is between 0 to 8% or “Adequate” if the percent fatigue cracking is between 8 to 20%. This will produce a reduction in HMA stiffness of 5% and 13%, respectively. Clicking on the “Examples” button will show examples of fatigue cracking.

**Composite Modulus of Subgrade Reaction, k-value**

The composite k-value represents the composite stiffness of all layers below the asphalt. If the existing pavement structure consists of a concrete pavement that was overlaid with asphalt and the asphalt layer is not bonded to the old concrete pavement, then the concrete layer should be considered when defining the stiffness of the composite k-value. If the asphalt overlay is still bonded to the old concrete pavement, then the stiffness of the concrete layers should be considered when defining the stiffness of the HMA layer.

Click on the hyperlink to the ACPA app for estimating the composite k-value for pavements with multiple layers below the asphalt or if the asphalt layer was constructed directly on top of a subgrade with a known resilient modulus: <http://apps.acpa.org/apps/kValue.aspx> (If the hyperlink is not working correctly, copy and paste the link into your web browser.) A default value of 150 psi/in is given. If the composite k-value evaluated by the ACPA app is greater than 500 psi/in, use 500 psi/in for the design as increasing the stiffness higher than 500 psi/in has a negligible effect on the stress/deflection reduction in a BCOA.

**Does the existing HMA pavement have non-deteriorated transverse cracks?**

Select “Yes” or “No” from the drop-down menu to indicate if non-deteriorated temperature cracks are present in the existing HMA pavement. Non-deteriorated transverse cracks must have a width less than the maximum aggregate top size in the concrete mix of the overlay. The design process includes a check to determine if there is the potential for reflective cracking to occur. This does not affect the design thickness but indicates whether preemptive measures should be taken prior to placing the overlay to prevent reflective cracking into the overlay. See the technical note Steps to Take to Get from Project Selection through the Construction of BCOAs [1] for guidance on how to address both deteriorated transverse cracks as well as non-deteriorated transverse cracks that are indicated to have the potential to induce reflective cracking in the overlay.

**HMA Properties in the Wheelpath:****P200 of HMA (%)**

Enter the percentage of aggregates in the HMA mixture passing #200 sieve. This value must be between 2% and 20%. The default value is 5%.

**P200 of Subbase (%)**

Enter the percentage of aggregates passing #200 sieve in the layer immediately below the asphalt layer (base, subbase, or subgrade). This value must be between 5% and 70%. The default value is 50%.

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

Enter the effective asphalt binder content of the mix (volume fraction). This is the proportion of the asphalt binder in the mix excluding the binder absorbed by the aggregates. The value must be between 4% and 15%, however, during the calculation the value is limited to 10%. There is no significant change in faulting for values between 10 and 15%. The default value is 7.5%.

#### **Air Voids (%)**

Enter the percentage of air voids in the HMA mixture. The value must be between 2% and 12%. The default value is 7%.

### **IV. PCC OVERLAY**

#### **Concrete Strength**

Select and enter either the *average* 28-day flexural (third point) strength (as determined by ASTM C 78) or the *average* 28-day compressive strength from the drop down menu.

#### **Estimated Elastic Modulus**

##### Level 1 Input – PCC Elastic Modulus is known

Enter the elastic modulus of the concrete layer in psi. The default value is 4,000,000 psi.

##### Level 2 Input – PCC Elastic Modulus is unknown

Click the “E<sub>PCC</sub> Calculator” button and the PCC elastic modulus will be estimated using the concrete strength input.

#### **Coefficient of Thermal Expansion**

##### Level 1 Input – CTE is known

Enter the coefficient of thermal expansion in units of inch/inch°F.

##### Level 2 Input – CTE is unknown

Click on the “CTE Calculator” button to enter a type of coarse aggregate from the dropdown menu. The default value is  $5.5 \times 10^{-6}$  inch/inch°F.

#### **Fiber Type**

Select the type of fiber from the drop-down menu. If no fiber is to be used, select “No fibers”. Click on the Fiber Guide button for a detailed explanation of the options and how fibers are incorporated into the design.

#### **Fiber Content**

Enter the volume of fibers to be added to the concrete in lb/yd<sup>3</sup>.

#### **Joint Spacing**

Select the joint spacing dimensions from the given drop down menu presented as transverse by longitudinal joint spacing dimensions. For rectangular slabs with joint spacing less than 7 ft, select

square slab size with the same dimension as the largest side. Guidance on selecting the joint spacing can be found in reference 1.

NOTE: Performance from MnROAD indicated that using a ¼ inch reservoir and sealing with an asphalt sealant performs better than not sealing for ultra-thin whitetopping (< 4.5 in). The MnROAD data showed, the difference in the performance between of the sealed and unsealed sections with a 5-in bonded whitetopping was not significantly different. This BCOA-ME assumes the bonded whitetopping sections are sealed as described above.

## **V. RESULTS**

After clicking the Calculate Design button, the program evaluates the design thickness based on the fatigue cracking model. The final recommended design thickness is presented along with the results of a check to determine if there is a potential for the development of reflective cracking from the asphalt layer up into the overlay. This “check” will not affect the recommended overlay thickness.

If the recommended design thickness is within the acceptable range, the program uses that thickness to calculate faulting over the specified service life. An interactive bar chart showing the development of cumulative faulting as a function of each year is displayed. This chart shows the cumulative faulting calculated in the 9<sup>th</sup> month (September) of each year of the service life. A general limit of 0.125 in for faulting is also shown. If the predicted faulting exceeds the agency-defined maximum allowable value, the design inputs must be modified to decrease the faulting.

If the recommended design thickness is higher than the maximum allowable value, then faulting will not be calculated. On the other hand, if it lower than the minimum allowable thickness, then the faulting will be calculated for the minimum allowable thickness. An exception to this is if the joint spacing is less than 4.5 ft (short slabs), in which case faulting will not be calculated. In all of the above cases, the program will display an appropriate message to inform the user.

Any other errors will be displayed at the bottom of the page. The user must fix these errors before the program can proceed. Once the design is completed, the user can print the results using the Print Page button.

### **Reference:**

1. Sachs S. and J.M Vandebossche, Technical Note: Steps to Take to Get from Project Selection through the Construction of BCOAs, University of Pittsburgh, Pittsburgh, PA, August 2013.

### **Abbreviation Definitions**

**ADT:** Average Daily Traffic

**ADTT:** Average Daily Truck Traffic  
**AMDAT:** Annual Mean Daily Average Temperature  
**CTE:** Coefficient of Thermal Expansion  
**ESALs:** Equivalent Single Axle Loads  
**HMA:** Hot Mix Asphalt  
**PCC:** Portland Cement Concrete