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THE SMOOTH QUIET RIDE

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2018 Local Roads Workshop

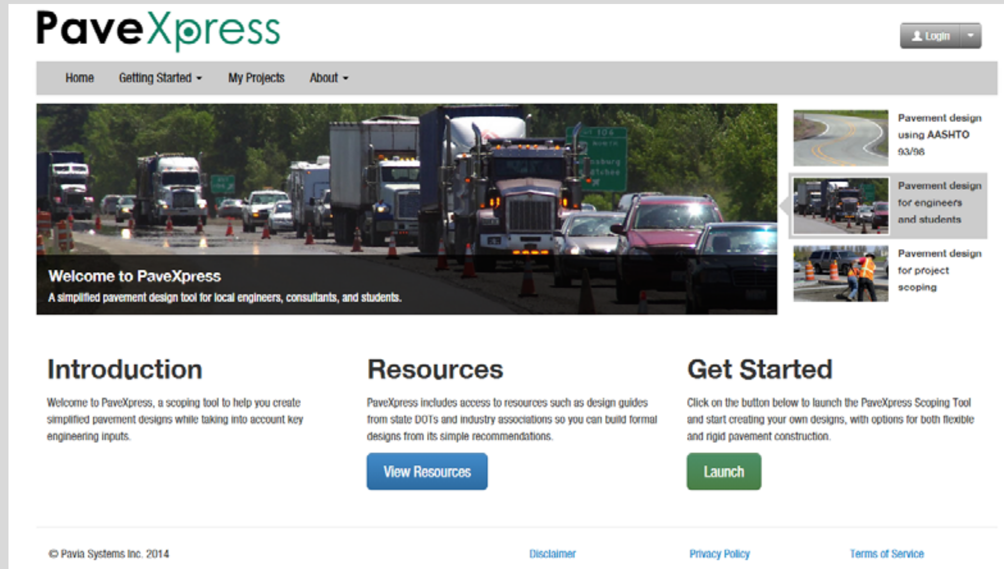
PaveXpress Update

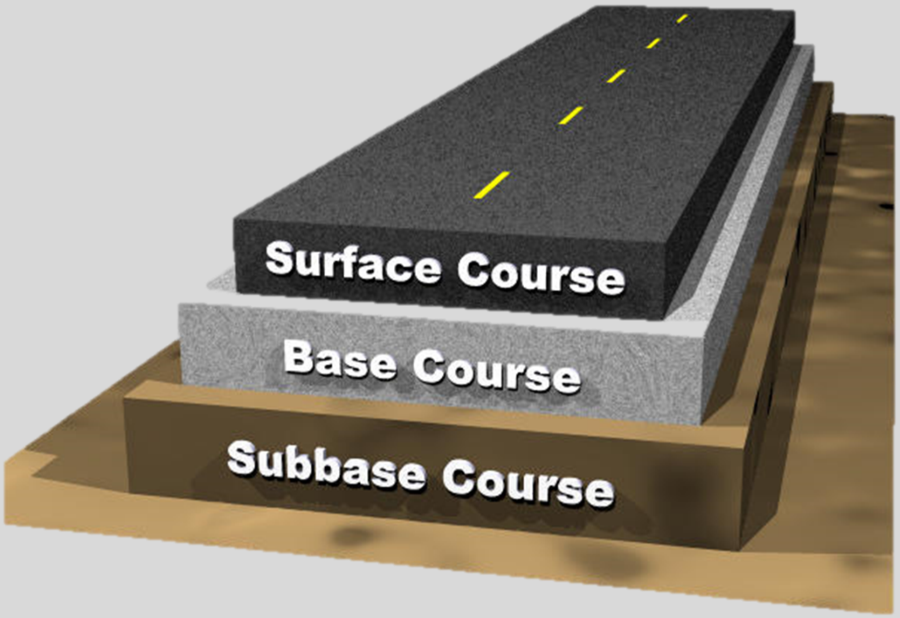
March 2018


PaveXpress
A Simplified Pavement Design Tool
www.PaveXpressDesign.com

Brief Overview

- Why PaveXpress?
- What Is PaveXpress?
- An Introduction
- Overview of the System
- Recent Additions
- New Learning Module





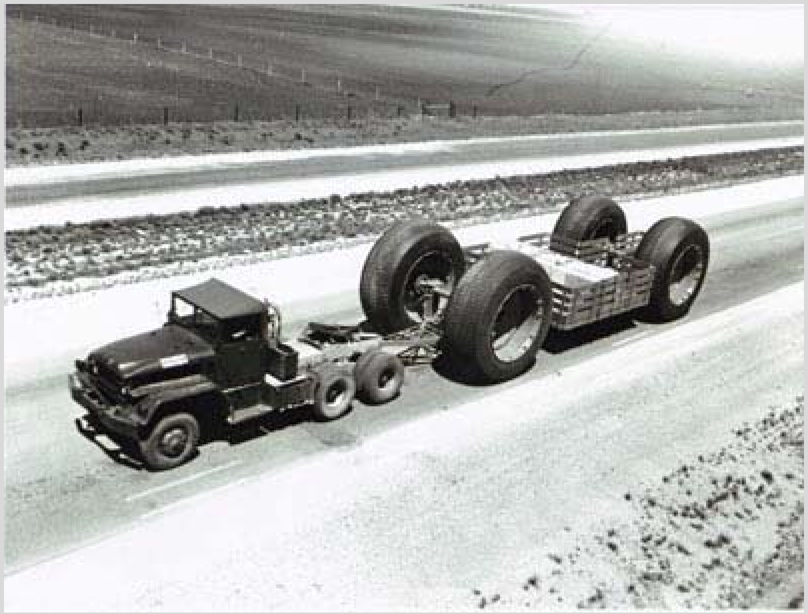
AASHTO has been developing MEPDG for high volume roads, but a gap has developed for local roads and lower volume roads.

What Is PaveXpress?

A free, online tool to help you create simplified pavement designs using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

- Accessible via the web and mobile devices
- Free – no cost to use
- Based on AASHTO pavement design equations
- User-friendly
- Share, save, and print project designs
- Interactive help and resource links

1993 AASHTO Design Guide Equation



The equation was derived from empirical information obtained at the AASHO Road Test.

The solution represents the average amount of traffic that can be sustained by a roadway before deteriorating to some terminal level of serviceability, according to the supplied inputs.

1993 AASHTO Design Guide Equation

$$\log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.4 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where:

- W_{18} = the predicted number of 18-kip equivalent single axle load (ESAL) applications
- Z_R = standard normal deviate
- S_0 = combined standard error of the traffic prediction and performance prediction
- ΔPSI = difference between the initial design serviceability index (p_i) and the design terminal serviceability index (p_t)
- M_R = resilient modulus of the subgrade (psi)

1993 AASHTO Design Guide Equation

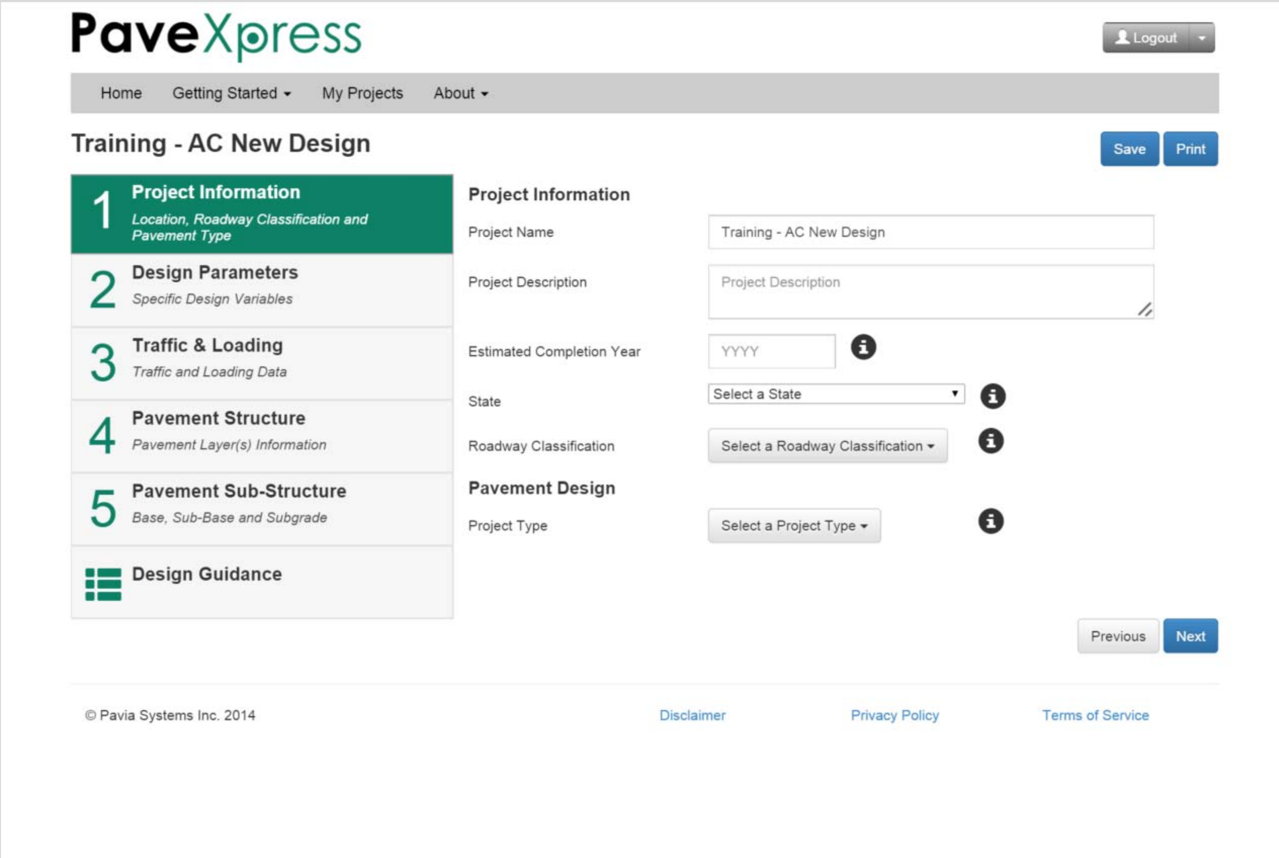
The designer inputs data for all of the variables except for the structural number (*SN*), which is indicative of the total pavement thickness required.

Once the total pavement *SN* is calculated, the thickness of each layer within the pavement structure is calculated

$$SN = a_1 D_1 m_1 + a_2 D_2 m_2 + a_3 D_3 m_3 + \cdots + a_i D_i m_i$$

Where:

a_i = i^{th} layer coefficient
D_i = i^{th} layer thickness (inches)
m_i = i^{th} layer drainage coefficient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4 Pavement Structure
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Base, Sub-Base and Subgrade
Design Guidance
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Project Name
Training - AC New Design
Project Description
Project Description
Estimated Completion Year
YYYY
State
Select a State
Roadway Classification
Select a Roadway Classification
Pavement Design
Project Type
Select a Project Type
Previous
Next
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Screen 1

Screen 1

1 Project Information

Location, Roadway Classification and Pavement Type

1) **Project Name** is an open field, allowing the user to input any desired information.
2) **Description** is an open field, allowing the user to input any desired information.
3) **Estimated Completion Year** field is used to extrapolate the growth in traffic that may occur while the project is being constructed. Traffic data inputs use data beginning in completion year.
4) **State** uses a drop-down box that allows the user to select the state.

1

Project Information

Location, Roadway Classification and Pavement Type

Screen 1

5) **Roadway Classification** drop-down box allows the user to indicate the functional classification that best describes how the pavement will be used. In PaveXpress, the selection affects default values for design period, reliability, and initial & terminal serviceability index. These default values can be overridden by the user.

Access control is a key factor in the realm of functional classification. For example, all Interstates are "limited access" or "controlled access" roadways. "Access" refers to the ability to access the roadway and not the abutting land. It is difficult to find hard-and-fast rules defining classifications, so some degree of judgment must be exercised here.

1 **Project Information**

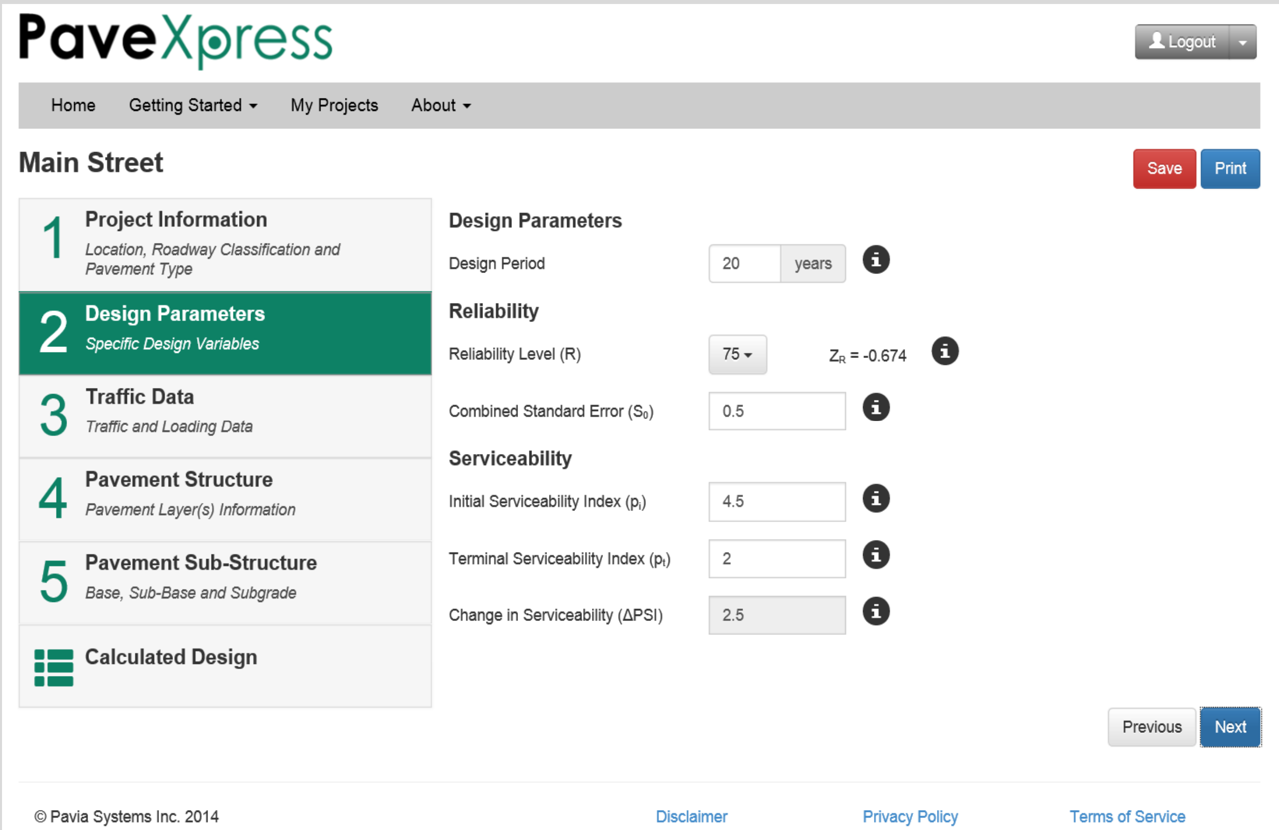
Location, Roadway Classification and Pavement Type

Screen 1

6) **Project Type** drop-down box allows the user to indicate the type of pavement being designed:
   - New Asphalt, 1993 AASHTO Design Guide
   - New Concrete, 1998 Supplement
   - AC Overlay on Asphalt, 1993 Guide
   - AC Overlay on Concrete or Composite

This presentation will focus on New Asphalt designs and AC Overlay on Asphalt designs

Screen 2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Pavement Layer(s) Information
5 Pavement Sub-Structure
Base, Sub-Base and Subgrade
Calculated Design
Design Parameters
Design Period
20 years
Reliability
Reliability Level (R)
75
Z_R = -0.674
Combined Standard Error (S_0)
0.5
Serviceability
Initial Serviceability Index (p_i)
4.5
Terminal Serviceability Index (p_t)
2
Change in Serviceability (ΔPSI)
2.5
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Next
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2 **Design Parameters**

Specific Design Variables

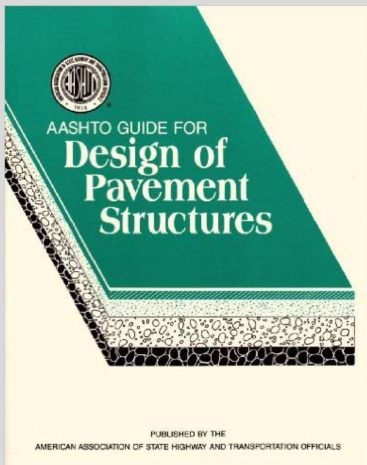
Screen 2

1) **Design Period** is the length of time the design is intended to last before the pavement reaches the end of its serviceable life and requires rehabilitation.
2) **Reliability Level (*R*)** is the probability that a pavement section designed using the process will perform satisfactorily over the traffic and environmental conditions for the design period. This is then used to determine the corresponding Z_R.

AASHTO Suggested Reliability Levels For Various Functional Classifications

Reliability Level (*R*): 50% to 95%, depending on Roadway Classification

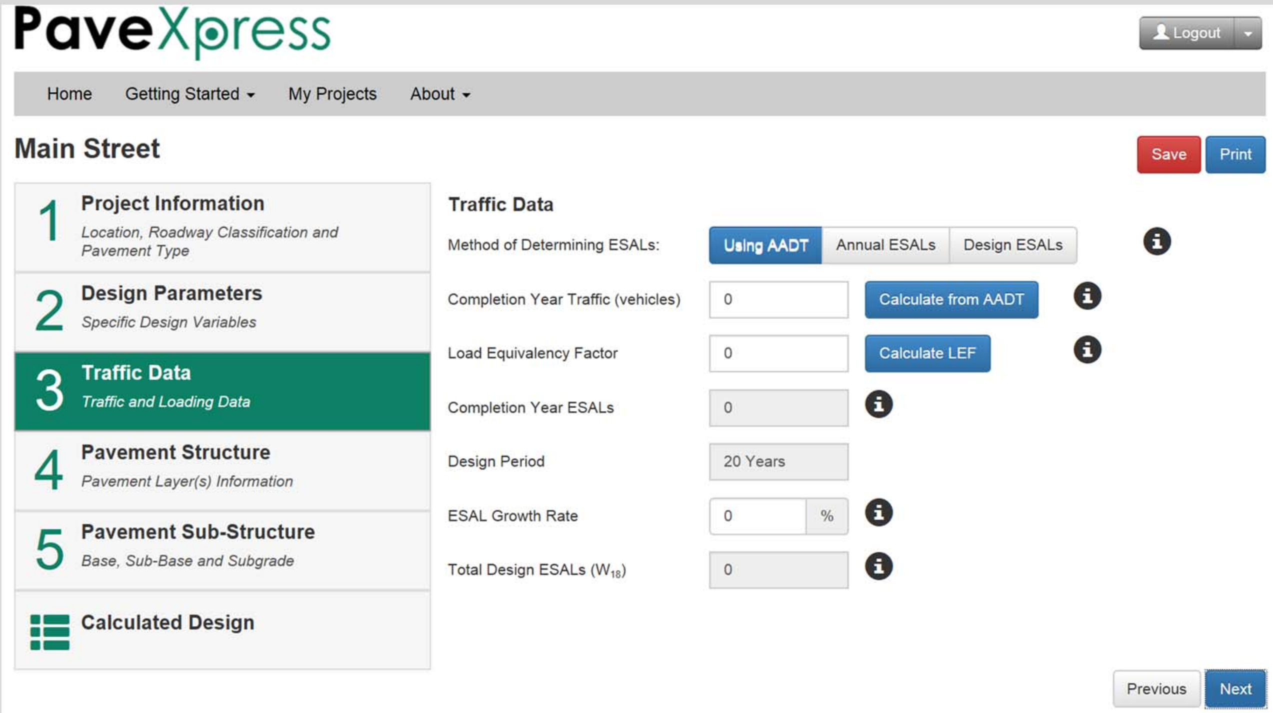
The probability that a pavement section designed using the process will perform satisfactorily over the traffic and environmental conditions for the design period. This is then used to look up Z_R, the standard normal deviate which is the standard normal table value corresponding to a desired probability of exceedance level. Suggested levels of reliability for various Functional Classifications (1993 AASHTO Guide, Table 2.2, page II-9):



Functional Classification	Recommended Level of Reliability	
	Urban	Rural
Interstate and Other Freeways	85–99.9	80–99.9
Principal Arterials	80–99	75–95
Collectors	80–95	75–95
Local	50–80	50–80

Screen 3

AADT



3 Traffic Data

Traffic and Loading Data

Screen 3

1) **Method of Determining ESALS** by Average Annual Daily Traffic

Calculate Traffic from AADT

Use this page to calculate the completion year traffic level using a historical AADT value. The Directional and Lane adjustment factors come from AASHTO (93). Learn More

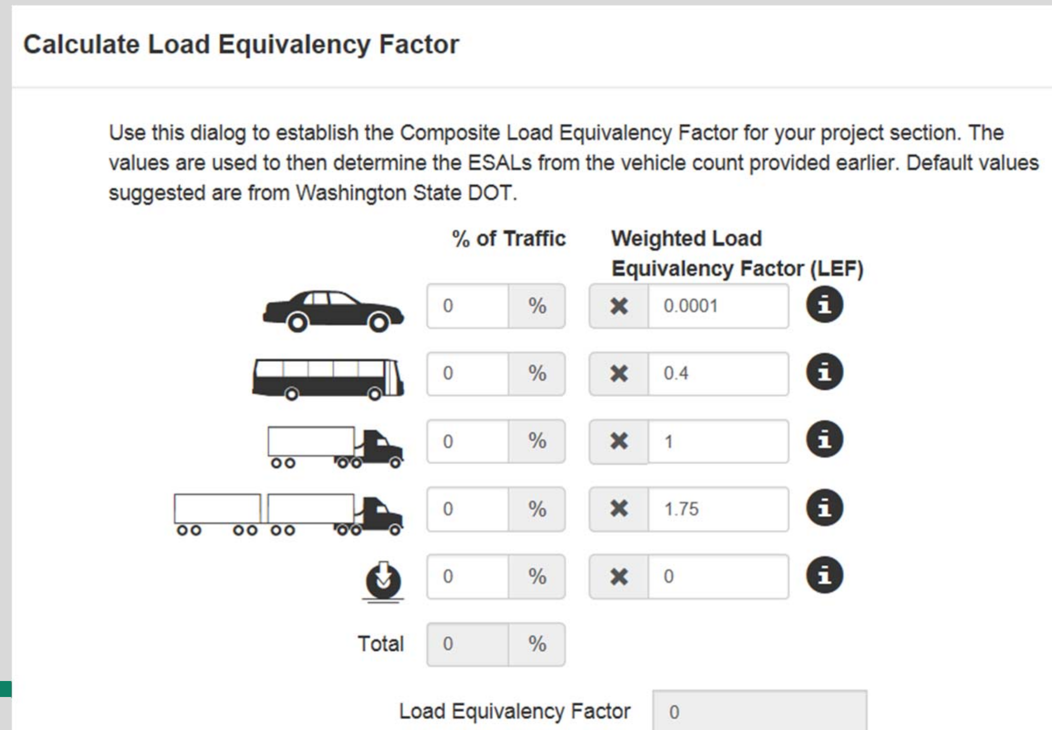
Average Annual Daily Traffic (AADT)	1000	vehicles
Lanes Measured (AADT ✖ 1)	One-Way	
Directional Lanes (AADT ✖ 1)	1	
Year of Traffic Count	2015	
Traffic Growth Rate	3	%
Completion Year Traffic	387228.5	

3 Traffic Data

Traffic and Loading Data

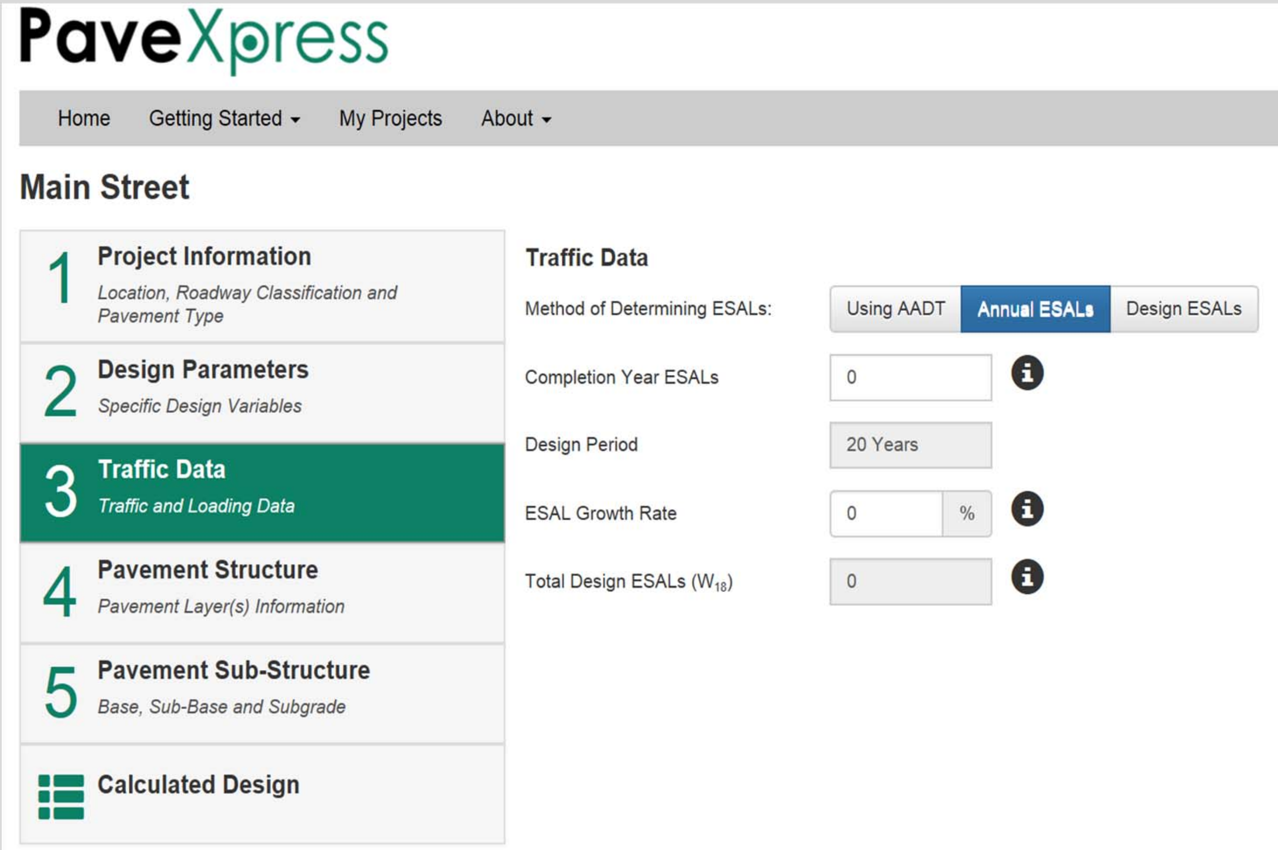
Screen 3

1) **Method of Determining ESALS** by Average Annual Daily Traffic



Screen 3

Annual ESALs



3 Traffic Data

Traffic and Loading Data

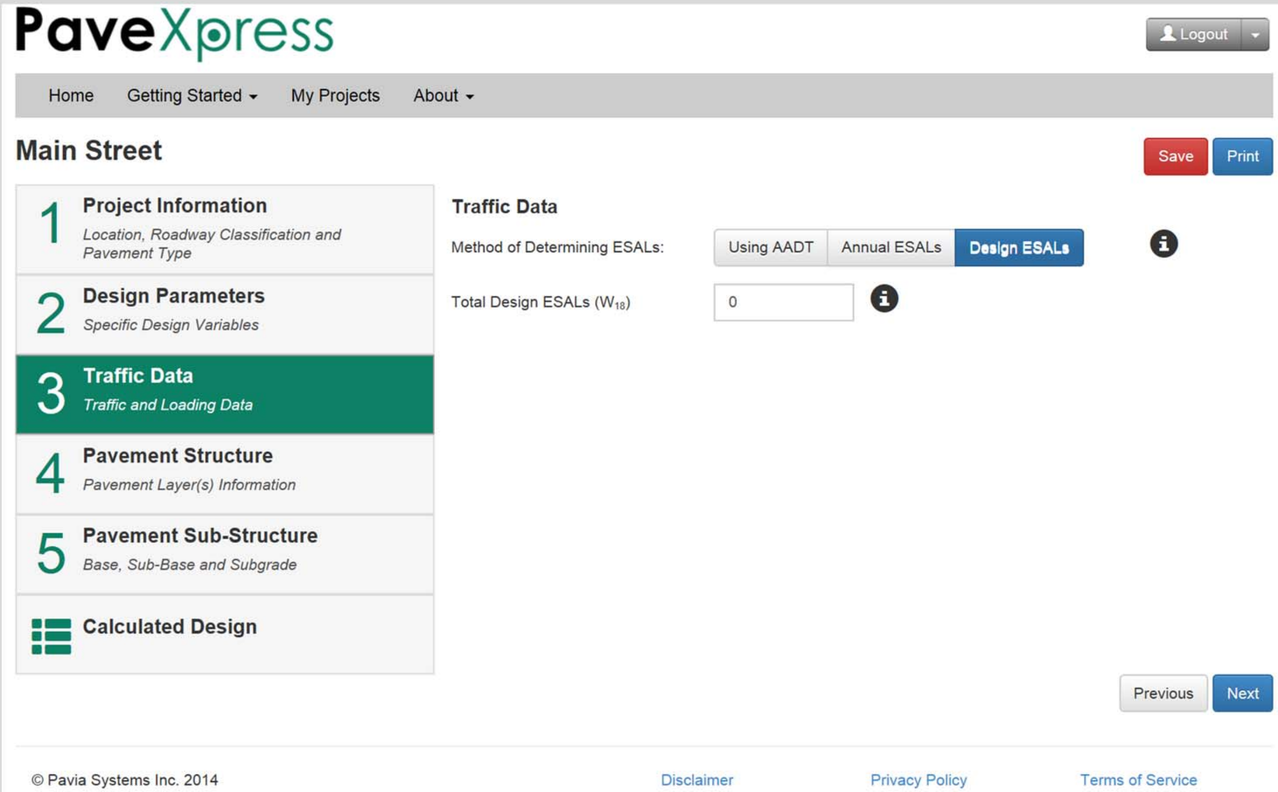
Screen 3

1) Method of Determining ESALS
by Average Annual ESALs

Traffic Data

Method of Determining ESALs:	Using AADT / **Annual ESALs** / Design ESALs	
Completion Year ESALs	21,000	i
Design Period	20 Years	
ESAL Growth Rate	4 %	i
Total Design ESALs (W_{18})	978,000	i

Screen 3
Design ESALs

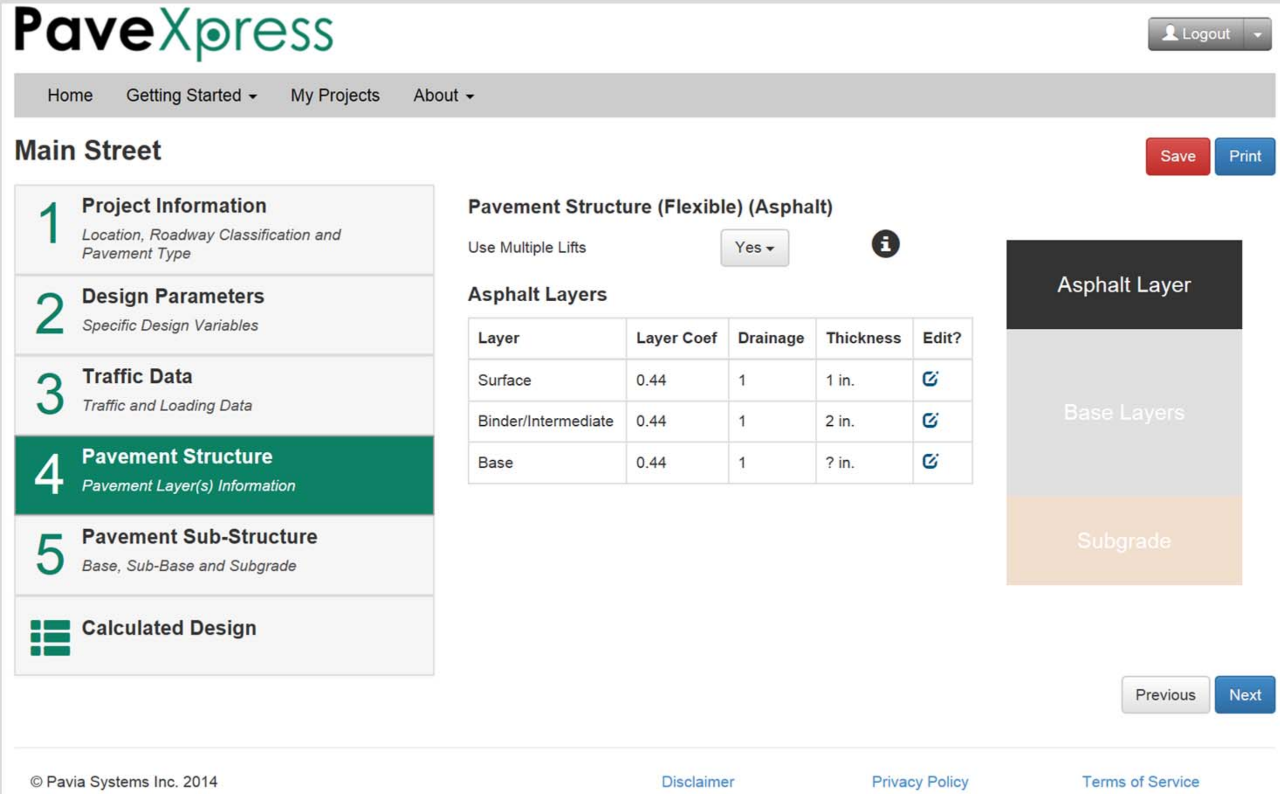


Where Can I Find Traffic Data?

- Many DOTs post their traffic count data online
- Contact the Traffic Division of the DOT
- Contact the Traffic Division of the city, if available
- If no official traffic count is available, conduct a short-term count
- Interview local people and businesses

The bottom line is, try to document in some way why you selected the number for input into the design software.

Screen 4
Multiple Asphalt Lifts



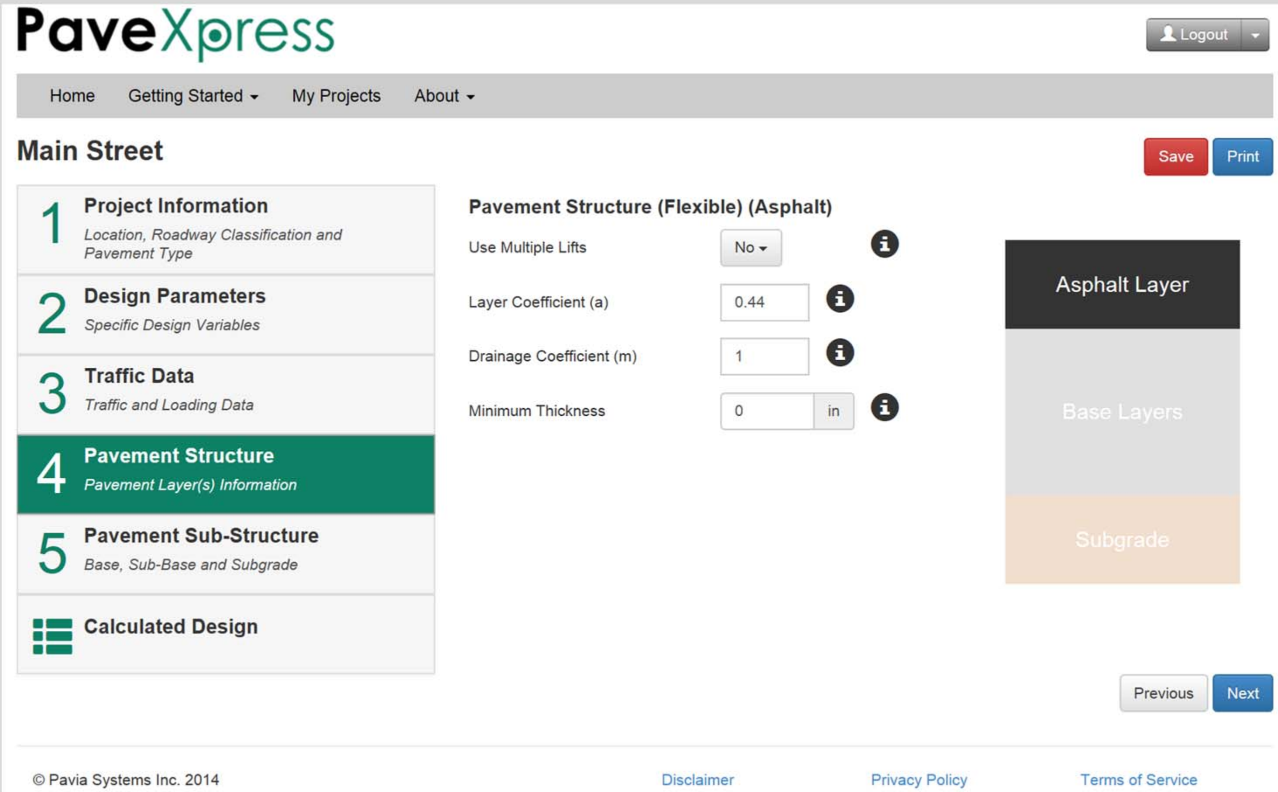
Treating Multiple Asphalt Layers Differently

PaveXpress allows the designer to input for each lift of asphalt a different:

- *layer coefficient*
- *drainage coefficient*
- *thickness*

The designer can either specify individual inputs for the surface, intermediate (binder) course, and base (leaving the program to calculate the base thickness), or input all asphalt info as a single lift and split it into separate lifts afterward.

Optimum Lift Thickness = 4 × NMAS



Screen 4

Single Asphalt Lifts

PaveXpress

Layer Coefficient Considerations

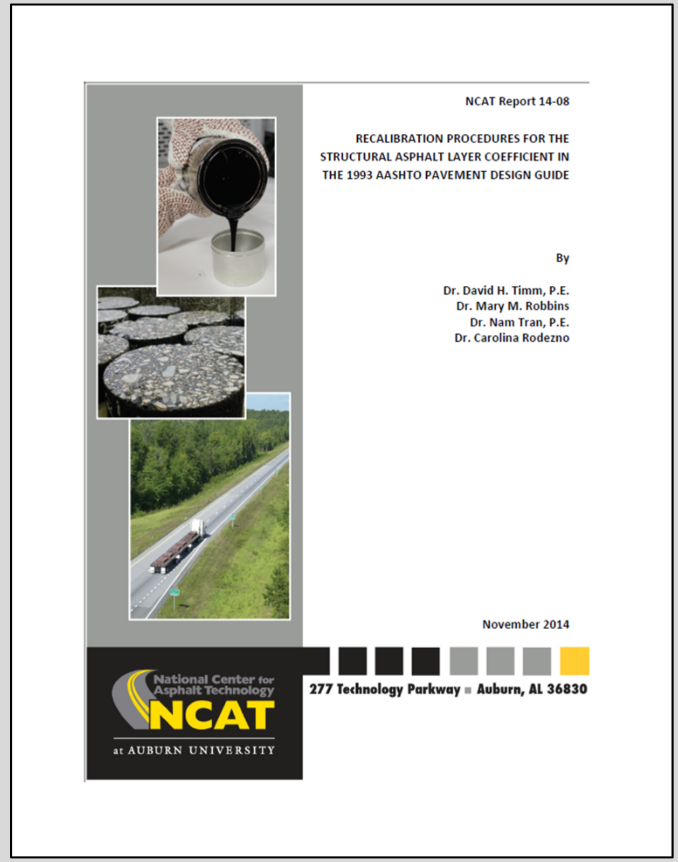
Average values of layer coefficients for materials used in the AASHO Road Test were as follows:

Asphalt Surface Course	0.44
Crushed Stone Base Course	0.14
Sandy Gravel Subbase	0.11

Keep in mind that these values were empirically derived from a road test with one climate, one soil type, and one asphalt mix type.

The asphalt layer coefficient used for the Road Test was actually a weighted average of values ranging from 0.33 to 0.83.

More recent studies at the NCAT Test Track found that for Alabama, an asphalt layer coefficient of 0.54 better reflected actual performance.


NCAT Report 14-08

RECALIBRATION PROCEDURES FOR THE STRUCTURAL ASPHALT LAYER COEFFICIENT IN THE 1993 AASHTO PAVEMENT DESIGN GUIDE

By

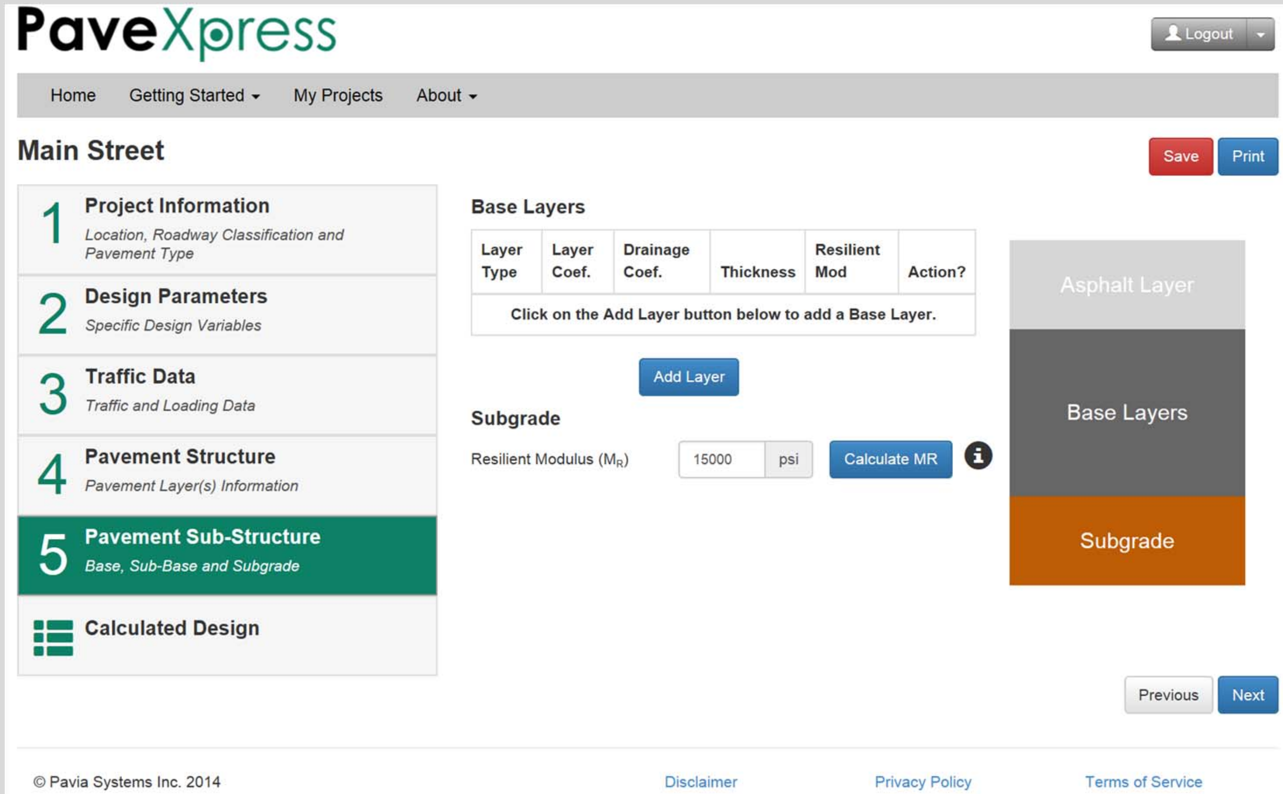
Dr. David H. Timm, P.E.
Dr. Mary M. Robbins
Dr. Nam Tran, P.E.
Dr. Carolina Rodezno

November 2014

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

277 Technology Parkway ■ Auburn, AL 36830

Screen 5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Calculated Design
Base Layers
Layer Type | Layer Coef. | Drainage Coef. | Thickness | Resilient Mod | Action?
Click on the Add Layer button below to add a Base Layer.
Add Layer
Subgrade
Resilient Modulus (M_R)
15000
psi
Calculate MR
Asphalt Layer
Base Layers
Subgrade
Previous
Next
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Adding an Aggregate Base Layer

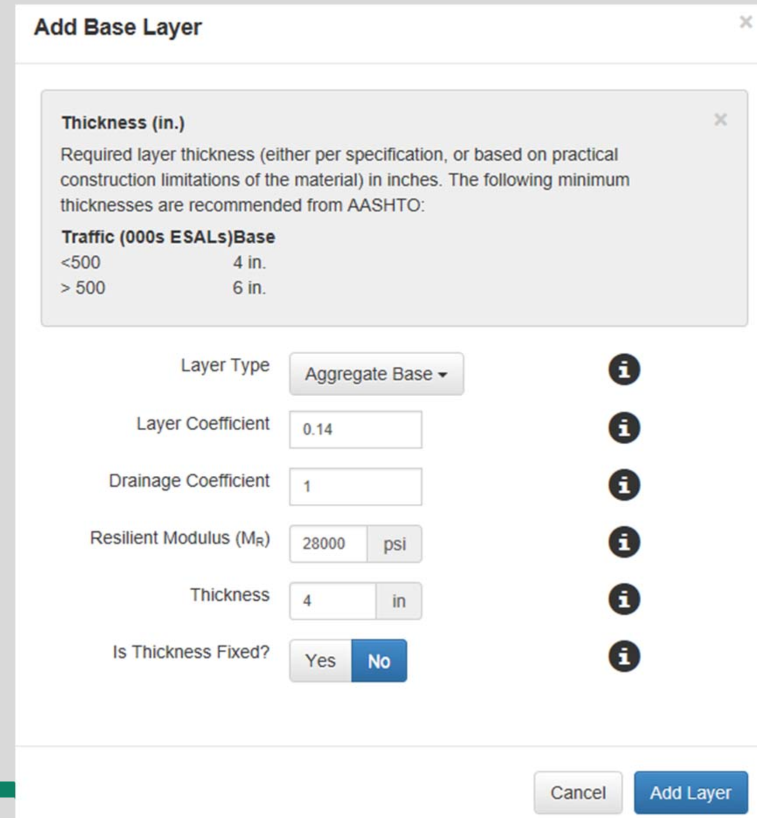
The designer can add an aggregate base layer (or any other type of base or subbase layer) here.

The default layer coefficients are reasonable, but can be overridden.

The default resilient modulus (M_R) values came from SHRP2 research, and can also be overridden.

The AASHTO recommended minimum thickness values are:

4″	< 500 ESALs
6″	> 500 ESALs

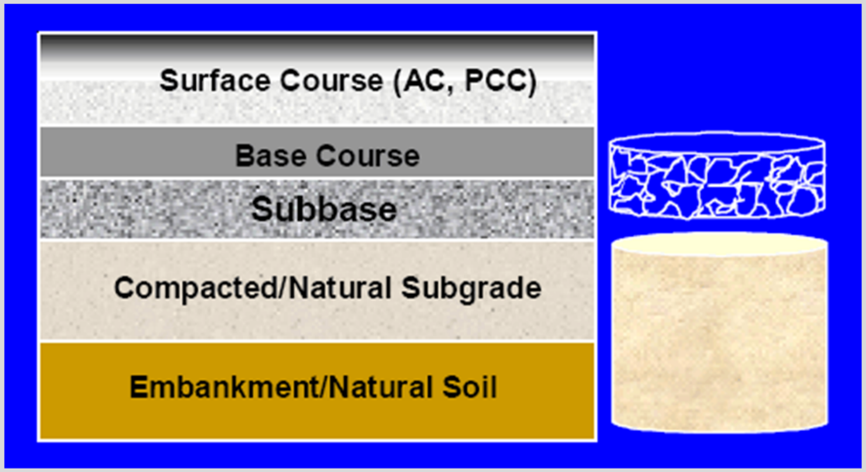


PaveXpress

Subgrade Considerations

The most common methods of classifying the subgrade for pavement design are:

- California Bearing Ratio (CBR)
- Resistance Value (*R*)
- Resilient Modulus (M_R)

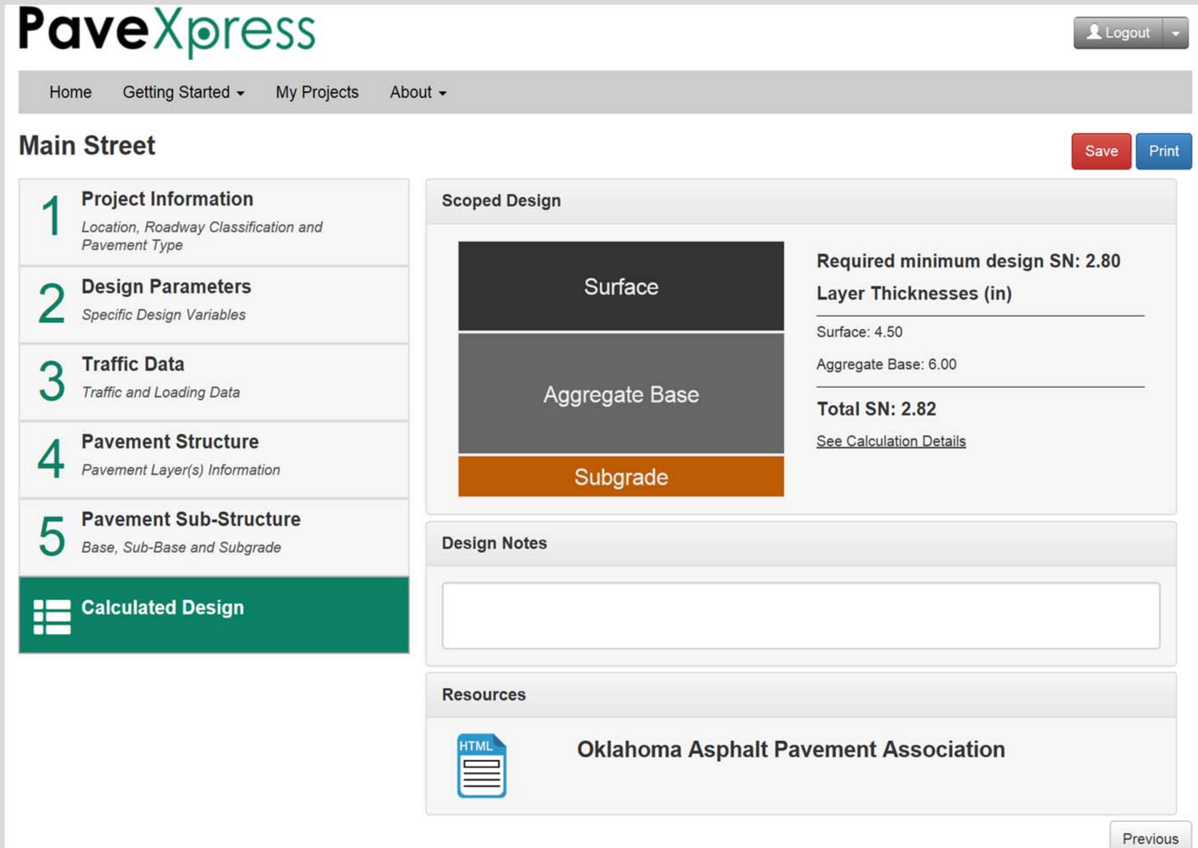


Subgrade Considerations

The Asphalt Institute publication IS-91 gives the following test values for various subgrade qualities:

Relative Quality	*R*-Value	California Bearing Ratio	Resilient Modulus (psi)
Good to Excellent	43	17	25,000
Medium	20	8	12,000
Poor	6	3	4,500

Note that different design guides will show different ranges for the various subgrade qualities – use engineering judgment when evaluating subgrade design inputs.



Screen 6

Calculated Design

Calculated Design

Screen 6

Recommendation:

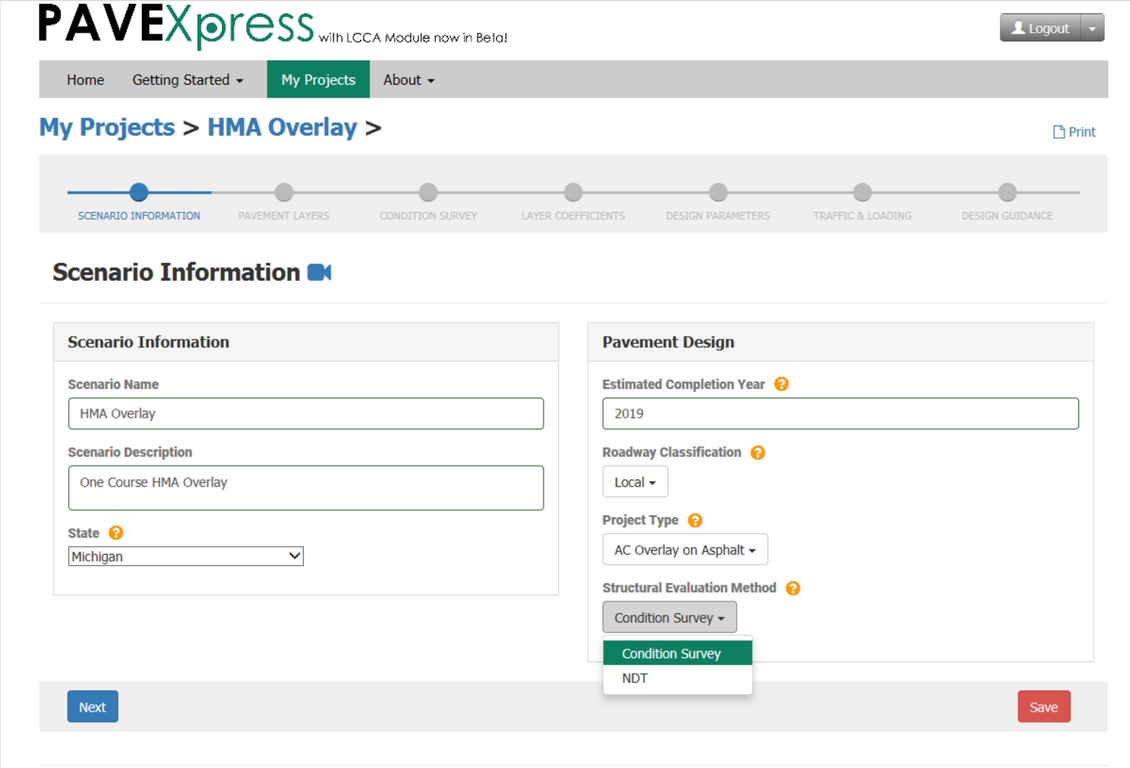
Perform multiple iterations of the design with different plausible input values to get a sense of the range of pavement structures needed to carry the anticipated loads in various scenarios.

Use engineering judgment to select the optimum pavement structure.

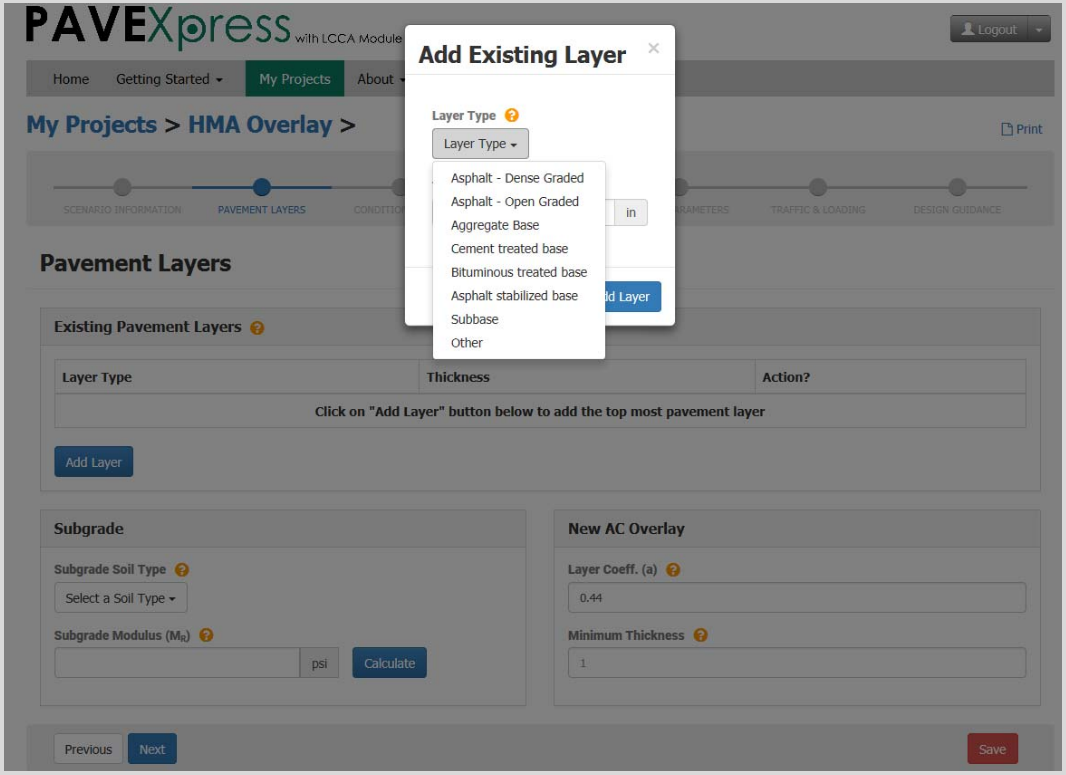
PaveXpress for AC Overlay Design

- AC Overlay Design for Flexible Pavement Rehabilitation Only
- Evaluation Methods for Existing AC Pavement
  - Condition Survey
  - Non-Destructive Deflection Testing
- Includes Questions on Coring and Milling
  - Delamination/Stripping
  - Top-Down or Bottom-Up Cracking
- Adjustment to Existing Pavement Layer Coefficients

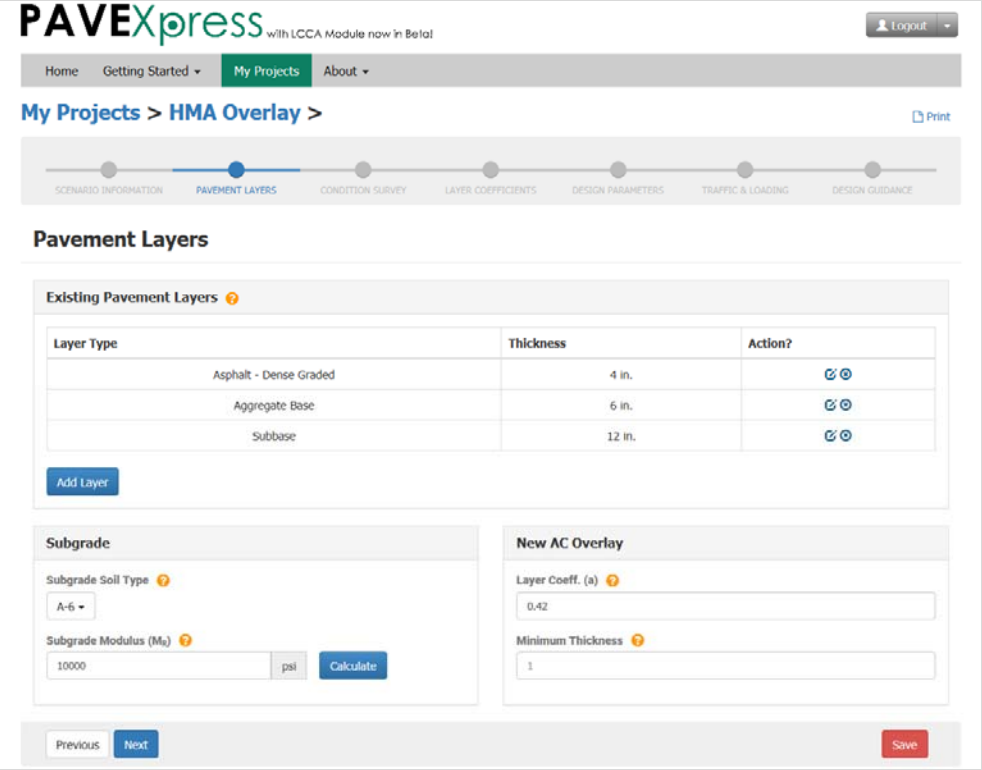
AC Overlay Design



AC Overlay Design



AC Overlay Design



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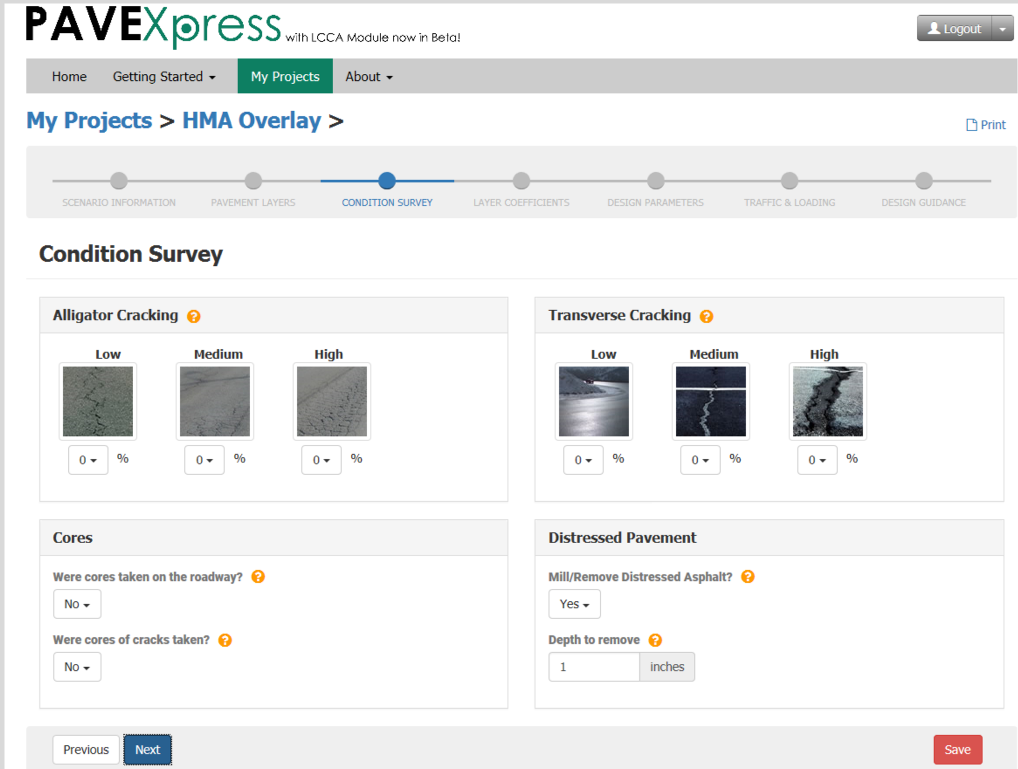
AC Overlay Design



AC Overlay Design

PAVEXpress with LCCA Module now in Beta!

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Print

SCENARIO INFORMATION — PAVEMENT LAYERS — CONDITION SURVEY — LAYER COEFFICIENTS — DESIGN PARAMETERS — TRAFFIC & LOADING — DESIGN GUIDANCE

Layer Coefficients

Layers

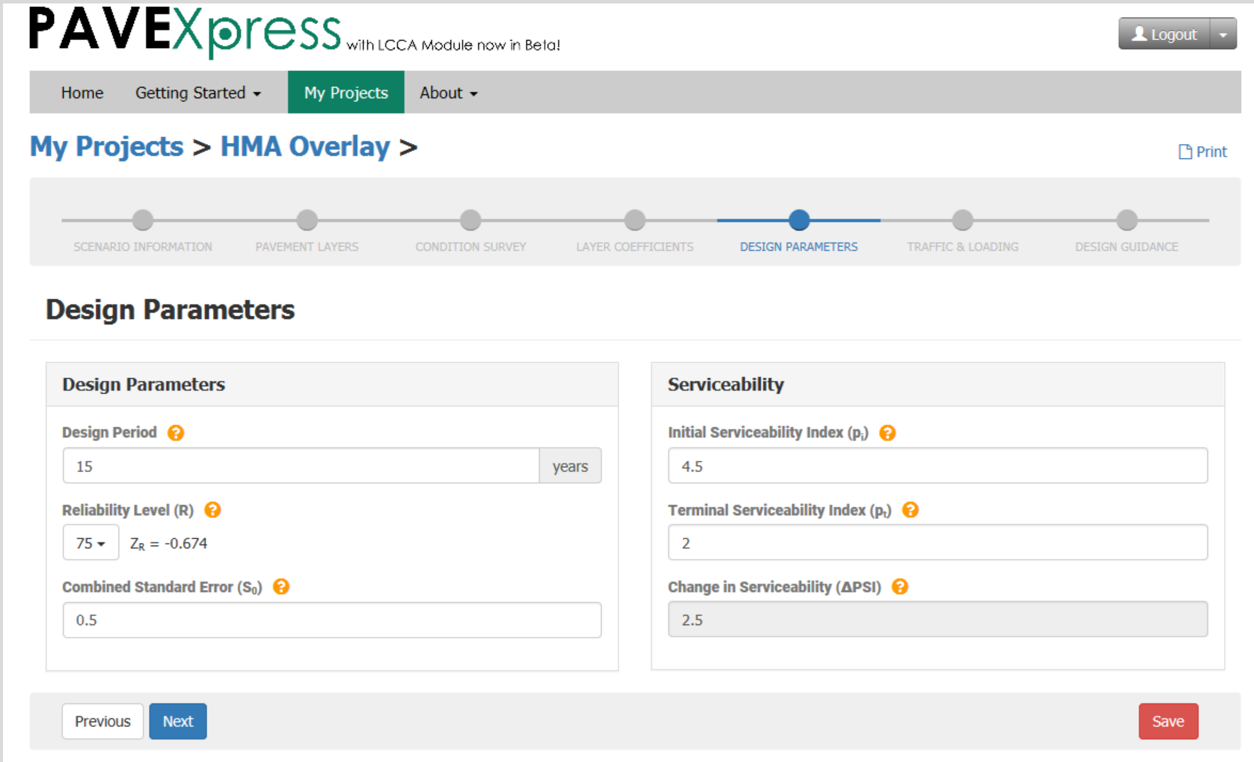
Layer Type	Existing Thickness	AASHTO Recommendation	Layer Coef. (a)	Drainage Coef. (m)	SN
Asphalt - Dense Graded	4"	0.35 to 0.40	0.35	1	1.4
Aggregate Base	6"	0.00 to 0.1	0.1	1	0.6
Subbase	12"	0.00 to 0.1	0.08	1	1.0

SN_{eff} 3.0

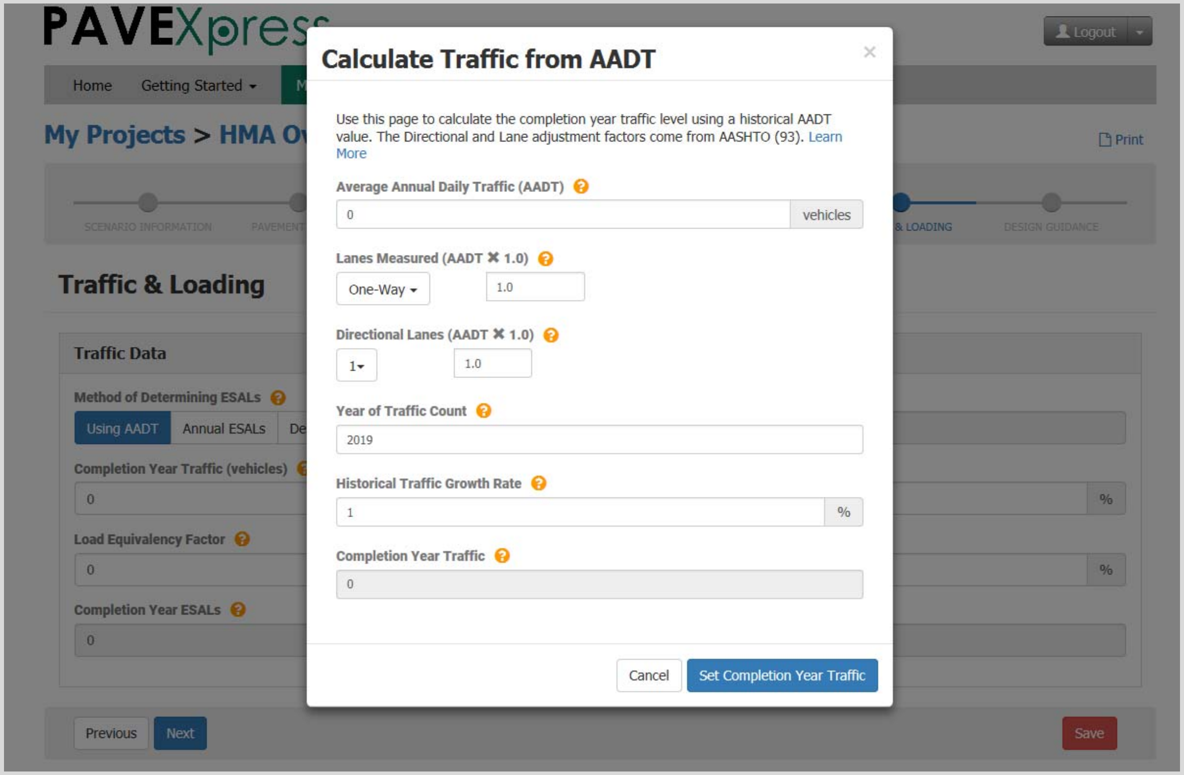
⚠ You have elected to remove 2 inches of pavement from the surface. This may impact the layer coefficient you select.

Previous | Next | Save

AC Overlay Design



AC Overlay Design



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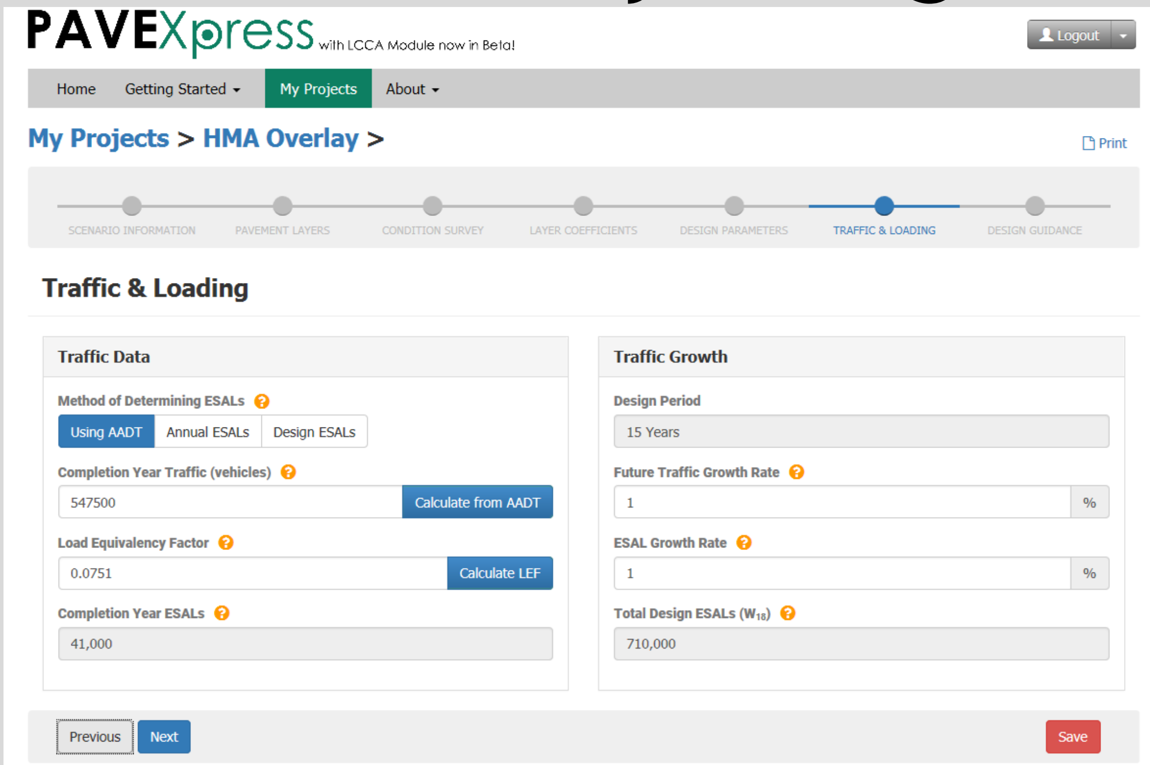
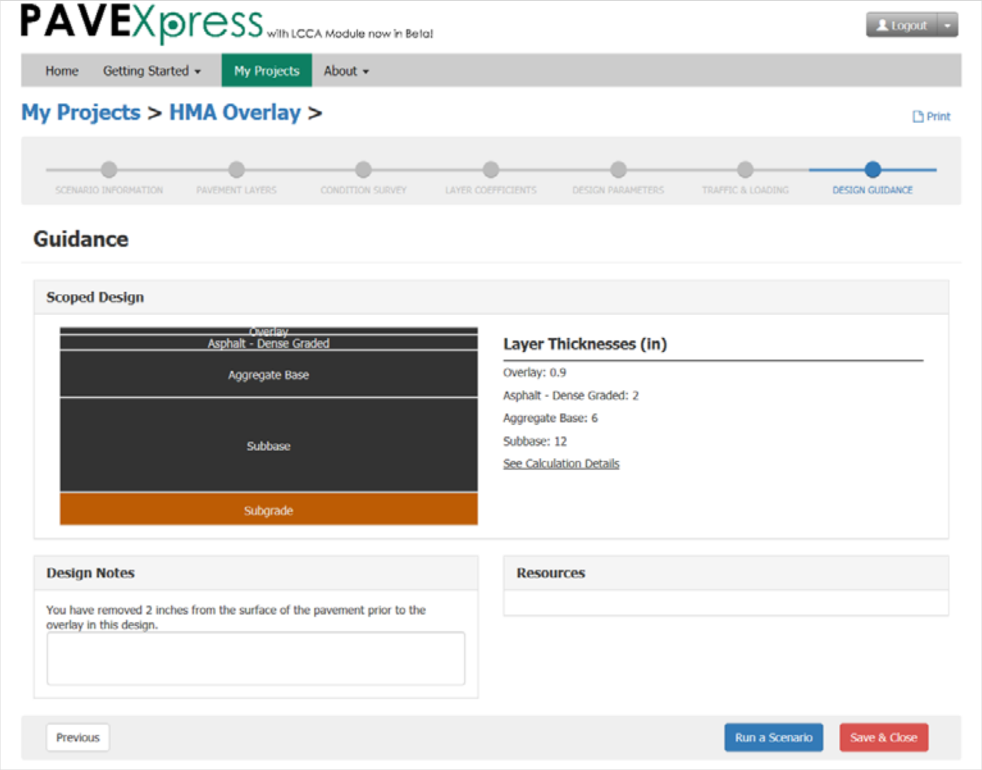
AC Overlay Design



AC Overlay Design



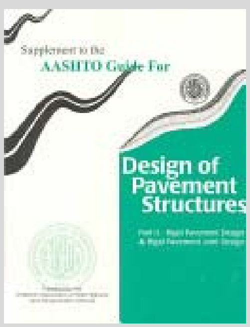
Screen 6

Design Guidance

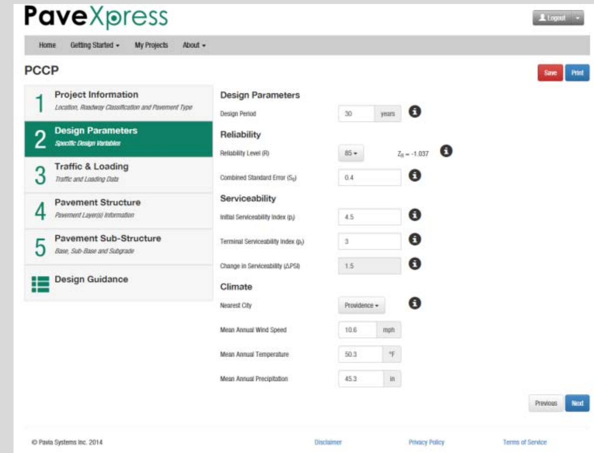
Overlay: Once the existing pavement information is input, PaveXpress uses the AASHTO equations to calculate the existing or effective structural number (*SN*) of the pavement. From the design and loading information, the required *SN* to support the loadings over the design life is calculated. The difference in the required *SN* and the existing *SN* is converted to an overlay thickness. If this thickness is less than minimum thickness input on Screen 2 or the required *SN* is less than the existing *SN*, then PaveXpress will report the minimum overlay thickness value.

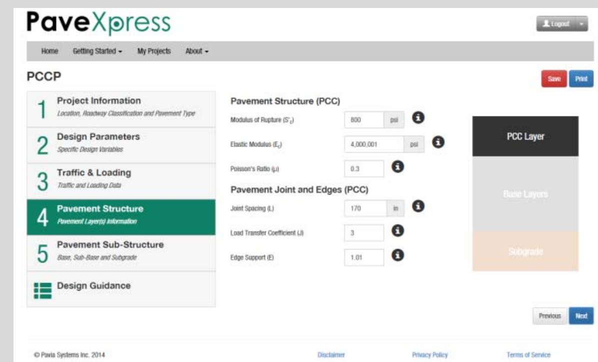
Rigid Pavements

PaveXpress can also be used to design rigid pavements in accordance with the AASHTO Design Guide 1998 Supplement for Rigid Pavements.



The steps are similar, but geared toward the values and inputs important to concrete pavements.





1998 AASHTO Design Guide Equation — Basic Overview

$$\log_{10}(W_{18}) = Z_R \times S_0 + 7.35 \times \log_{10}(D+1) - 0.06 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5-1.5}\right)}{1+\frac{1.624\times 10^7}{(D+1)^{8.46}}} + (4.22 - 0.32p_t) \times \log_{10}\left[\frac{(S_c')(C_d)(D^{0.75}-1.132)}{215.63(J)\left(D^{0.75}-\frac{18.42}{\left(E_c/k\right)^{0.25}}\right)}\right]$$

Where:

W_{18}	=	the predicted number of 18-kip equivalent single axle load (ESAL) applications
Z_R	=	standard normal deviate
S_0	=	combined standard error of the traffic prediction and performance prediction
D	=	slab depth (inches)
ΔPSI	=	difference between the initial design serviceability index (p_i) and the design terminal serviceability index (p_t)
S_c'	=	modulus of rupture of PCC (flexural strength)
C_d	=	drainage coefficient
J	=	load transfer coefficient
E_c	=	elastic modulus of PCC
k	=	modulus of subgrade reaction

Layered Elastic Analysis

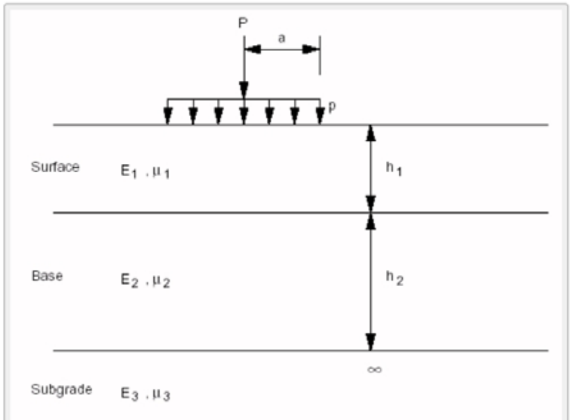


Figure 1. Layered elastic inputs.

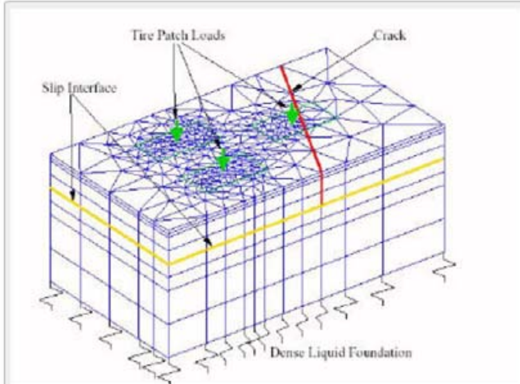
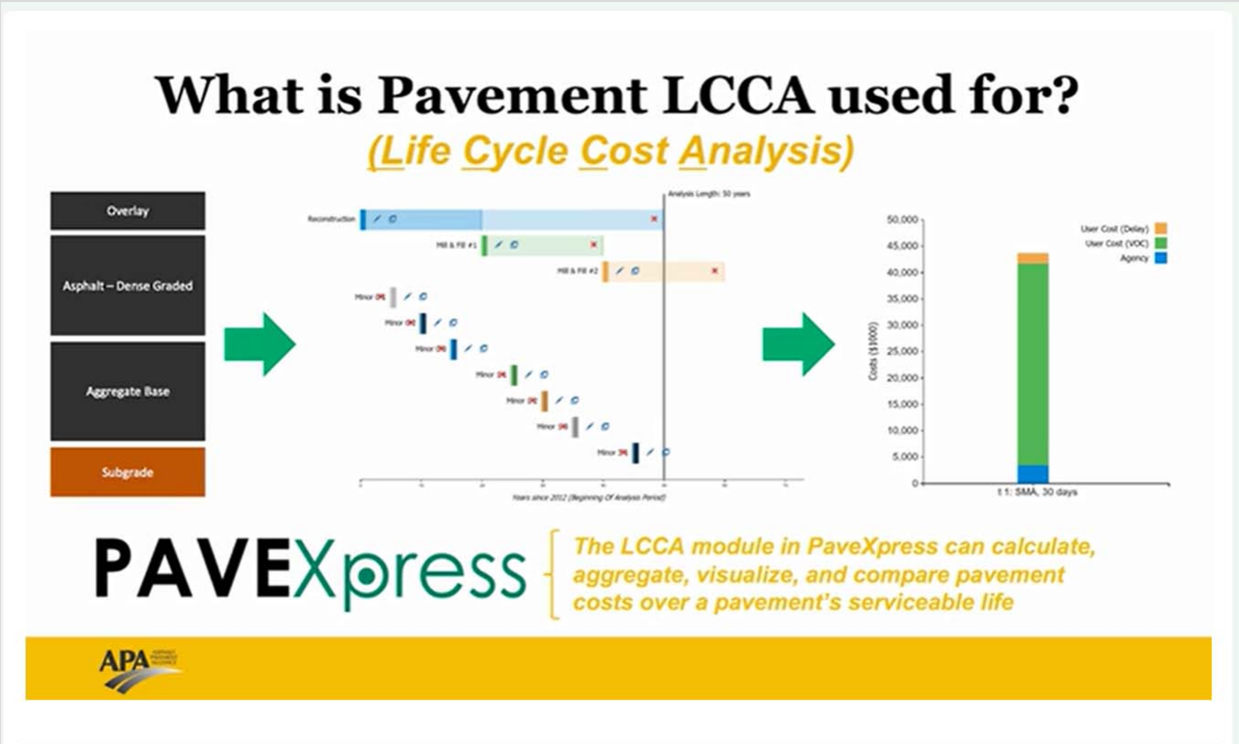


Figure 3. EverFlex 3-D drawing (adapted from Wu, 2001). The drawing shows the discrete elements, wheel loads (tire patch loads), a modeled crack and a slip interface (where on layer can slip - move independently - from another).

Recent Additions to PaveXpress

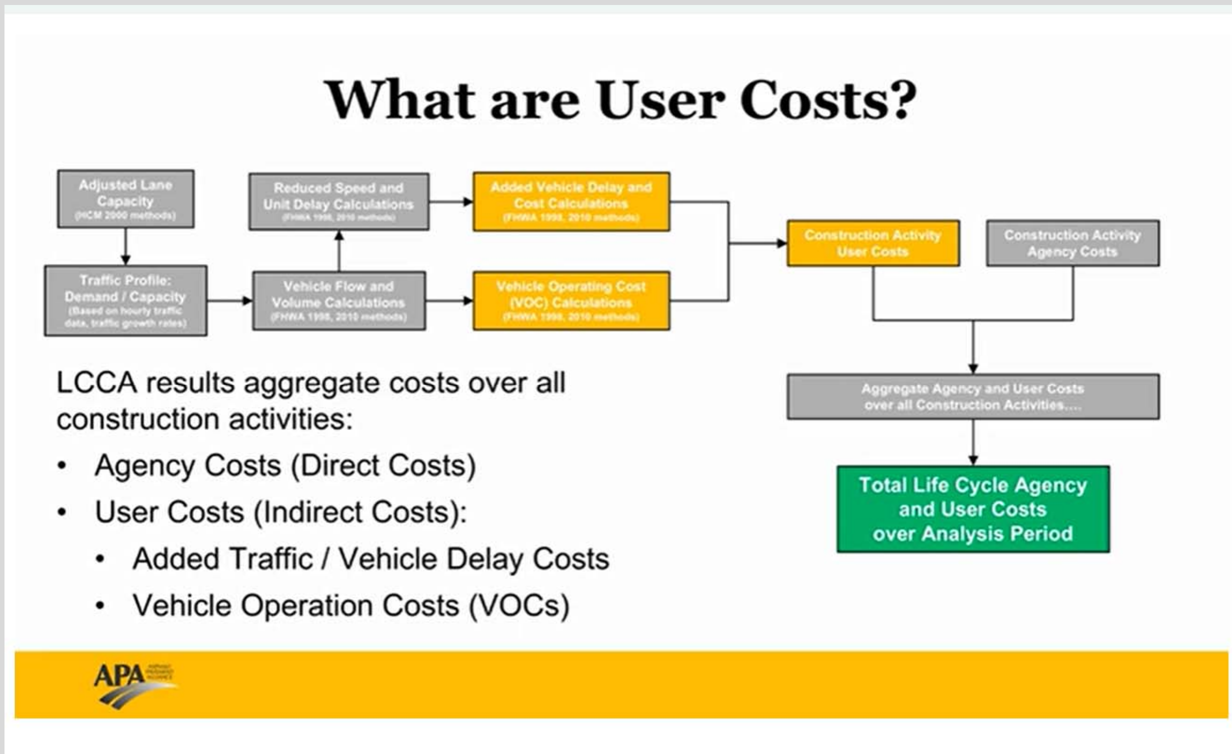
Life Cycle Cost Analysis

Life Cycle Cost Analysis

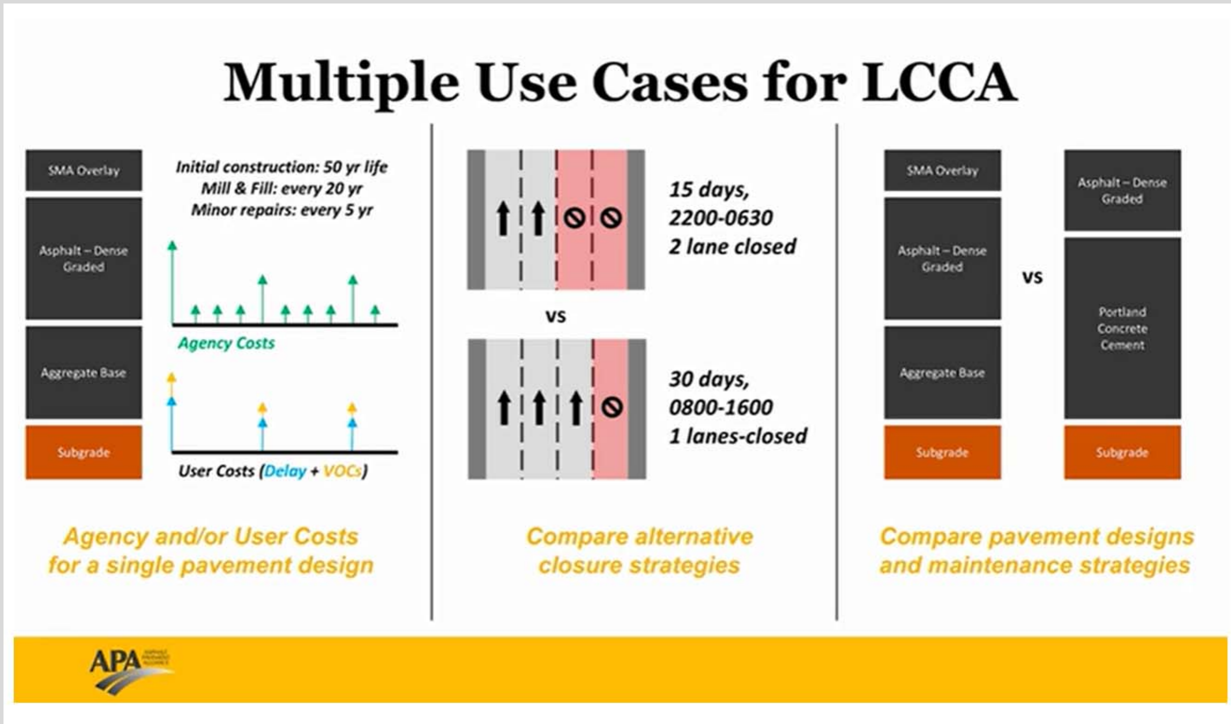


Life Cycle Cost Analysis

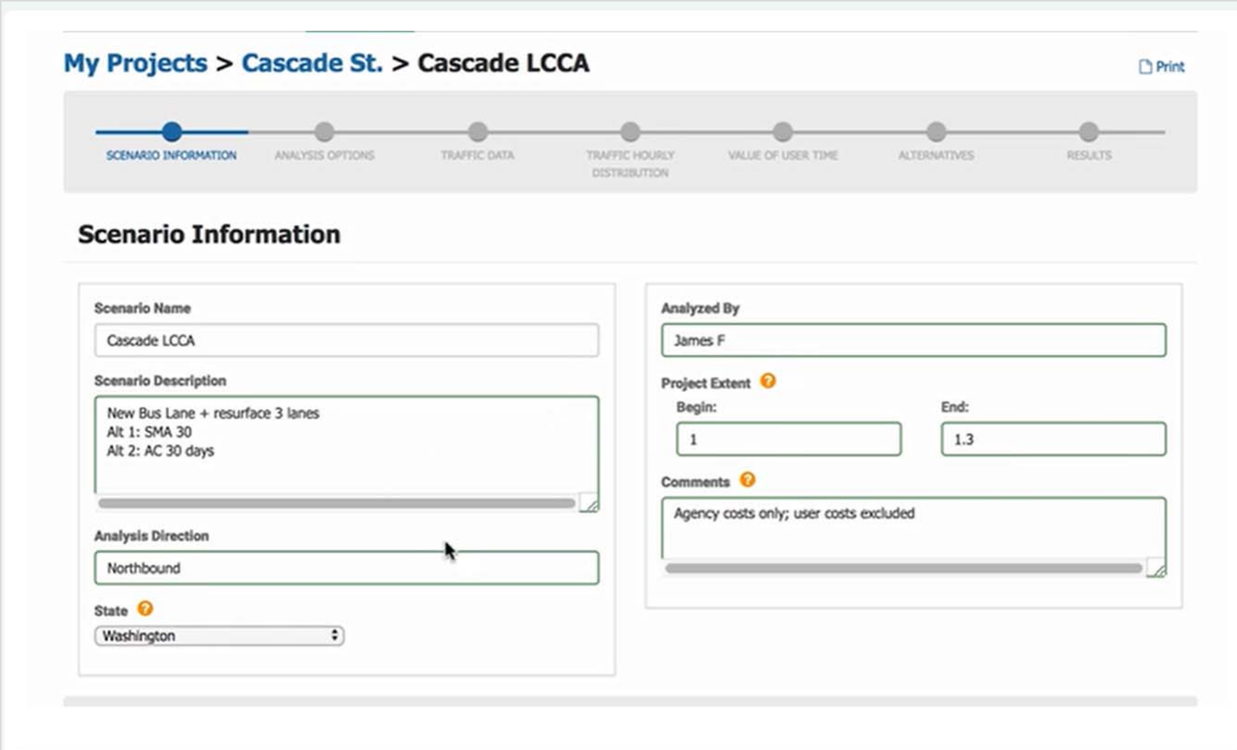
Life Cycle Cost Analysis



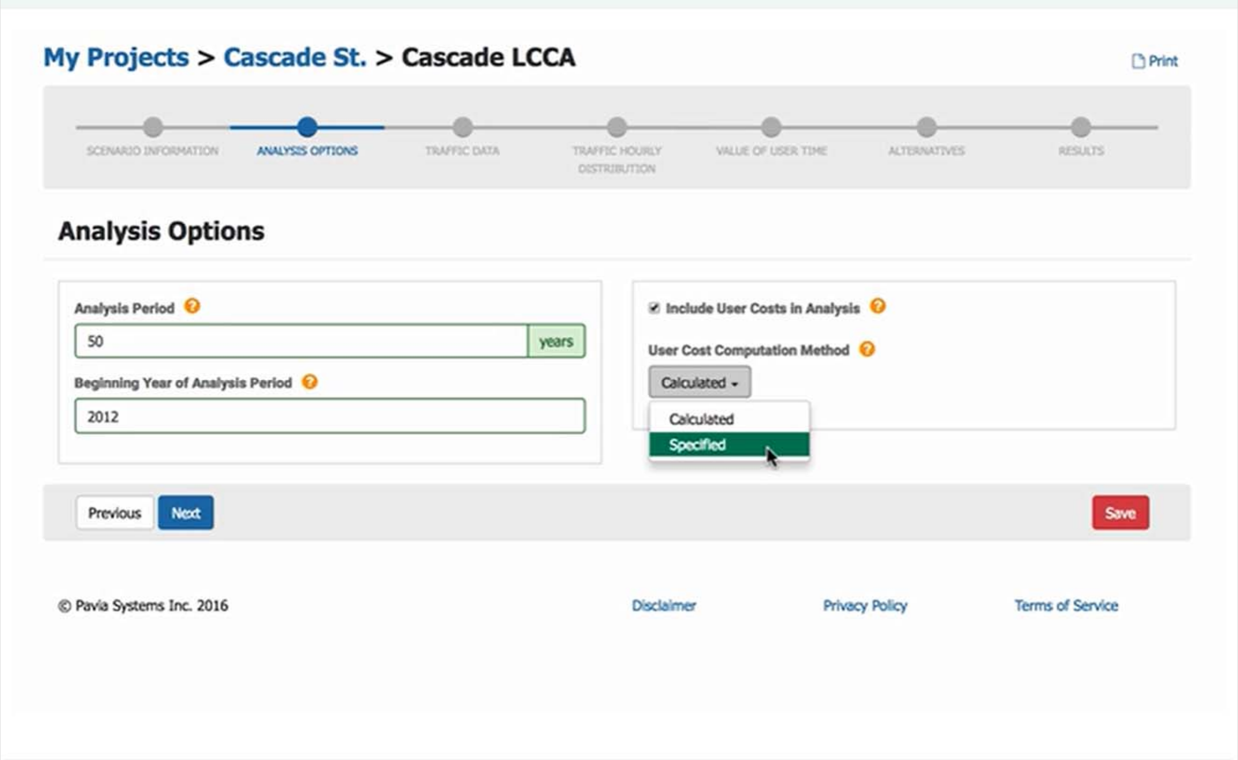
Life Cycle Cost Analysis



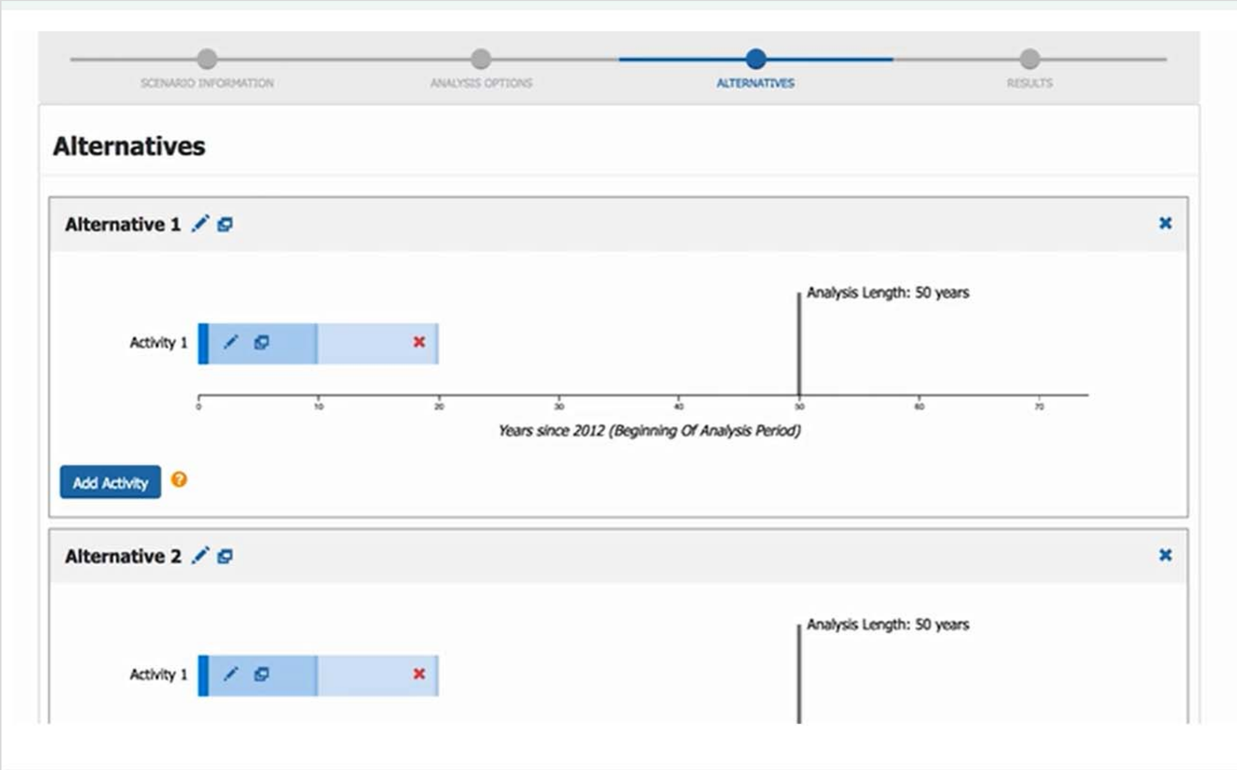
Life Cycle Cost Analysis



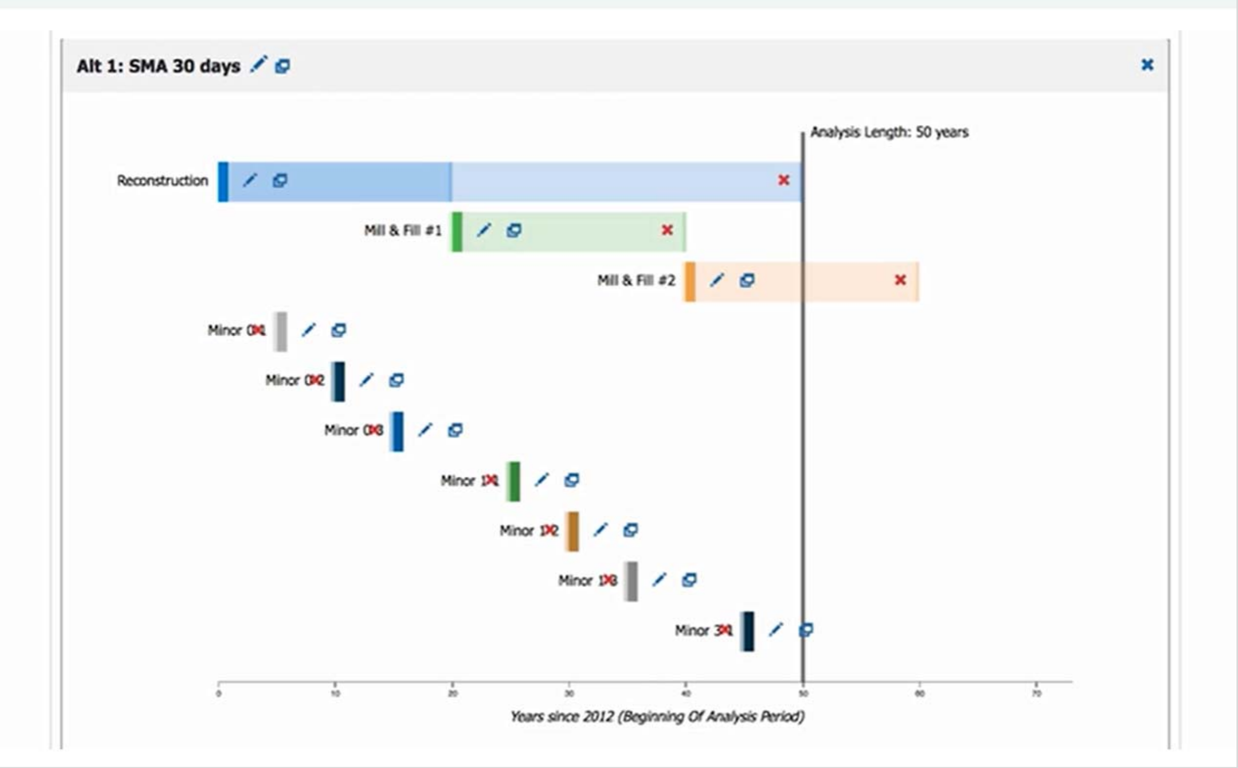
Life Cycle Cost Analysis



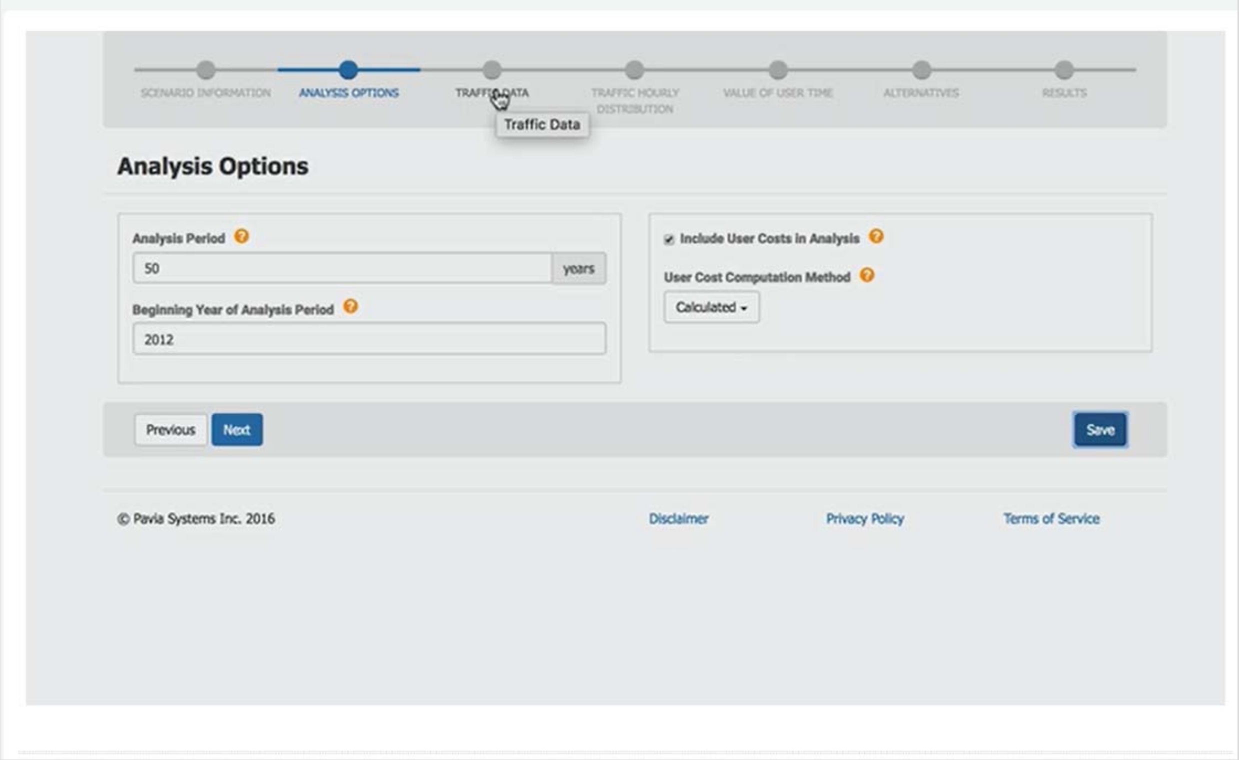
Life Cycle Cost Analysis



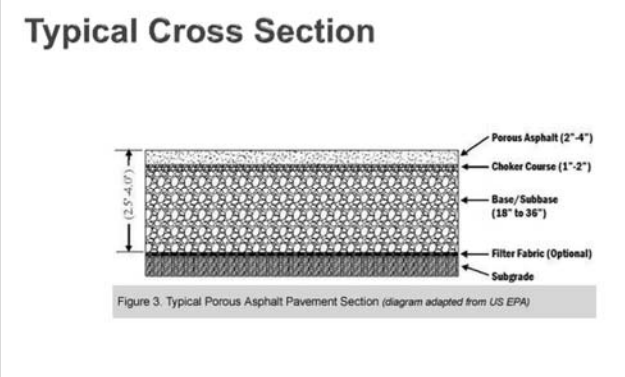
Life Cycle Cost Analysis



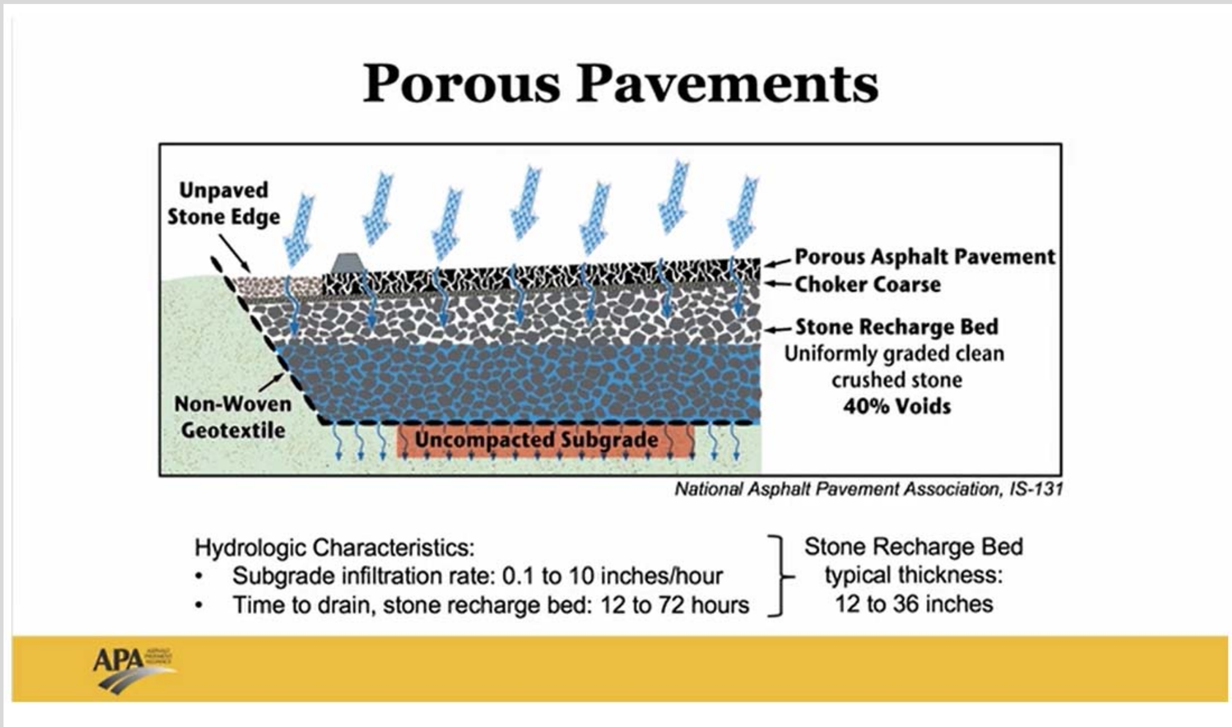
Life Cycle Cost Analysis



Porous Pavement Design



Porous Pavement Design

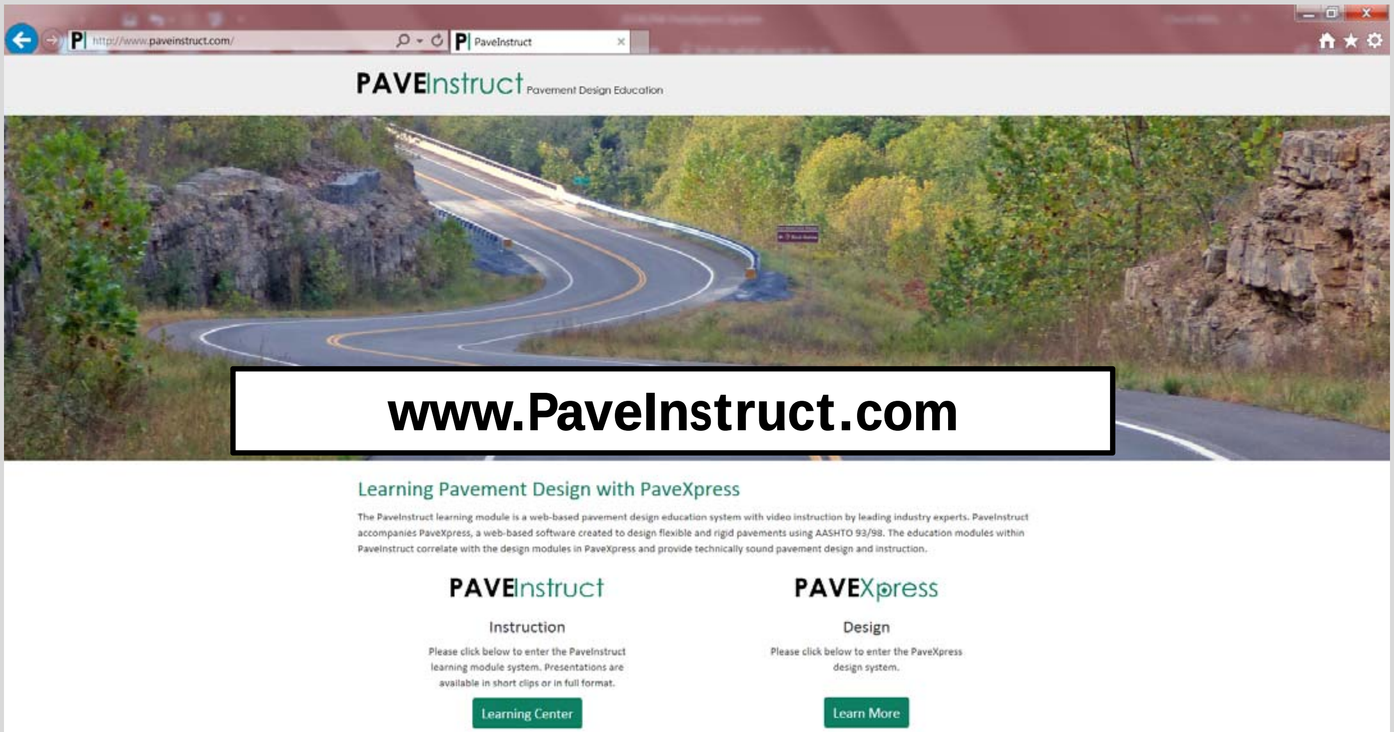


PaveXpress Learning Module

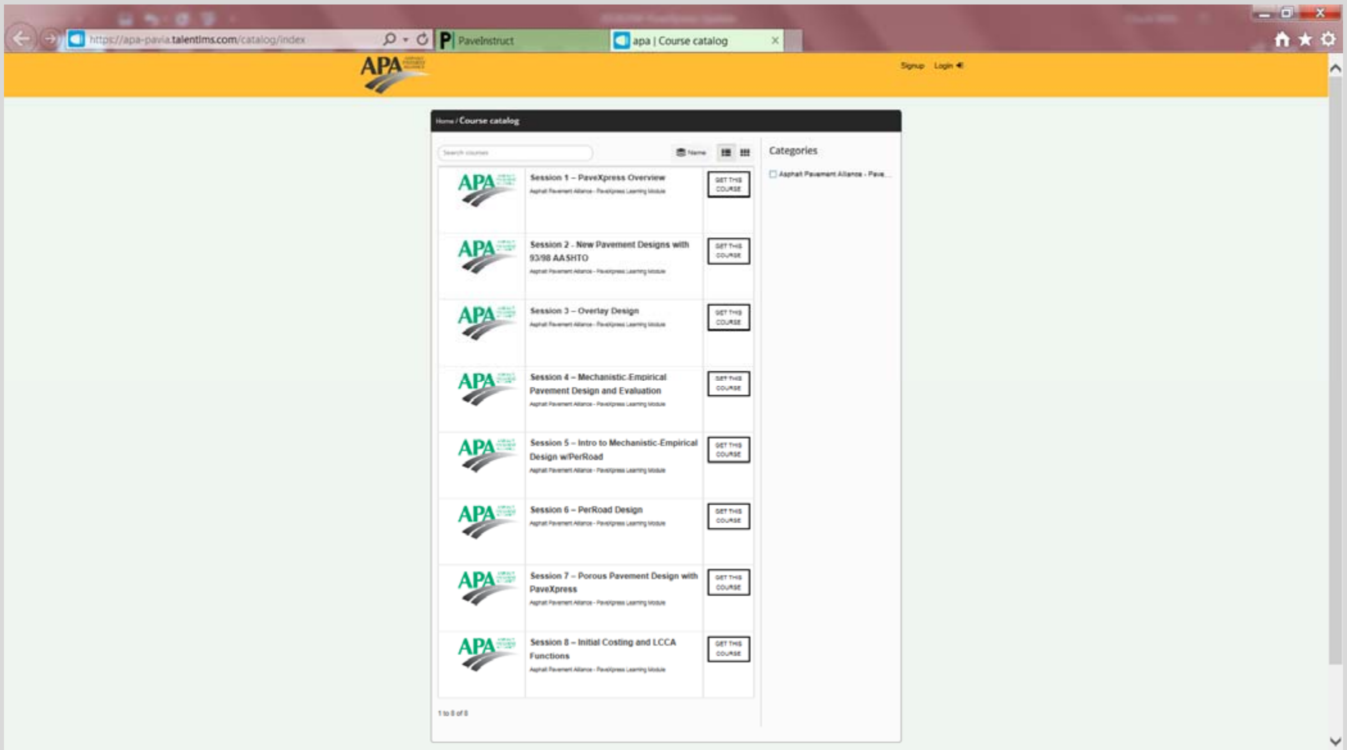
complement to PaveXpress

- Available on-demand via web
- Flexible and rigid pavement design
- Detailed use of PaveXpress
- Leading industry expert instructors
- No cost to user
- PDHs available

PaveInstruct



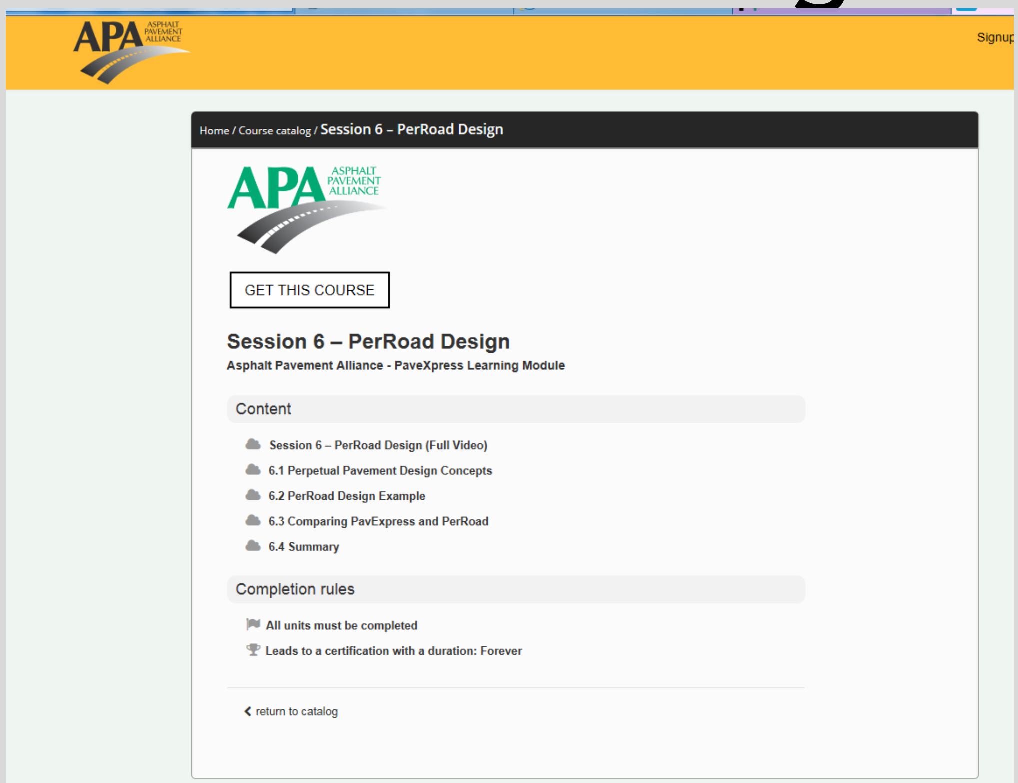
PaveInstruct Learning Modules



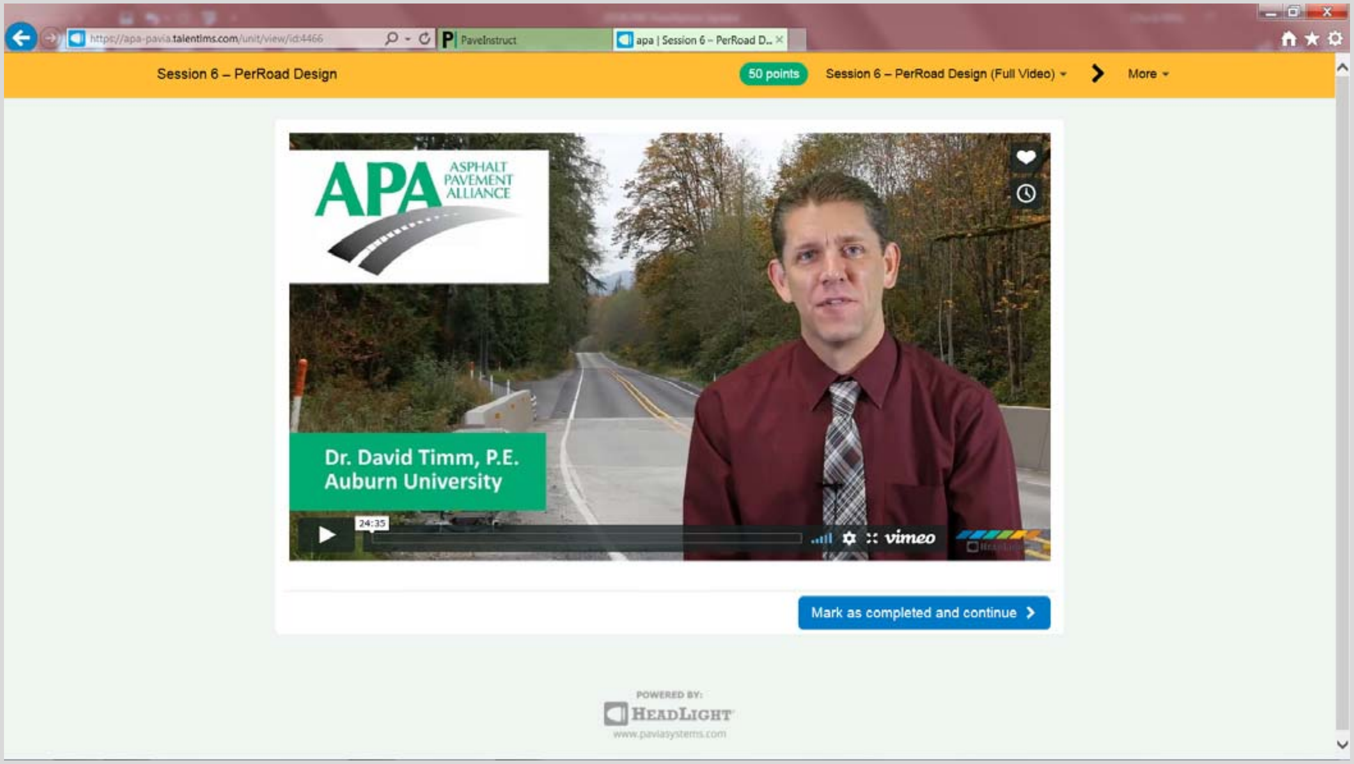
PaveInstruct Learning Modules

- PaveXpress Overview
- New Pav’t Design
- Overlay Design
- M-E Design and Evaluation
- Intro to M-E Design w/ PerRoad
- PerRoad Design
- Porous Pav’t Design
- Initial Costing and LCCA Functions

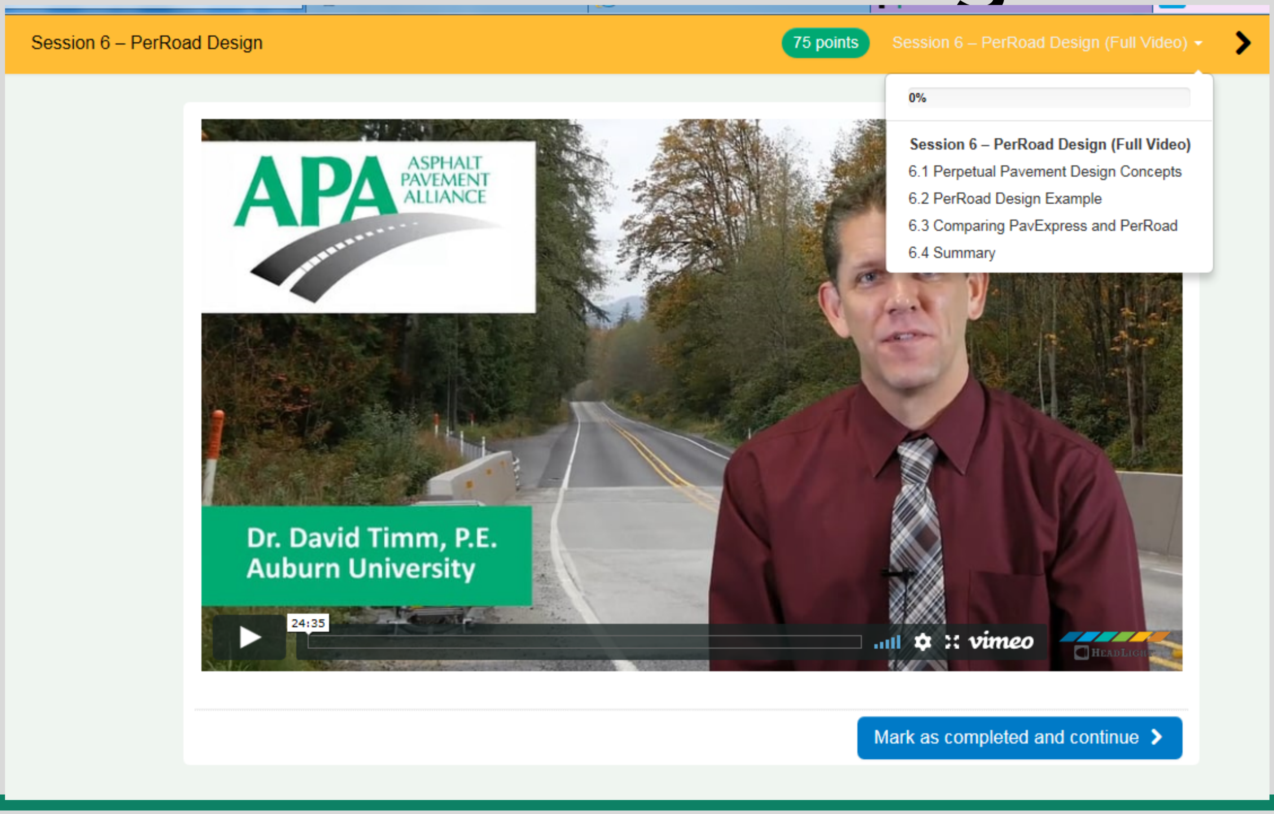
PaveInstruct Learning Modules



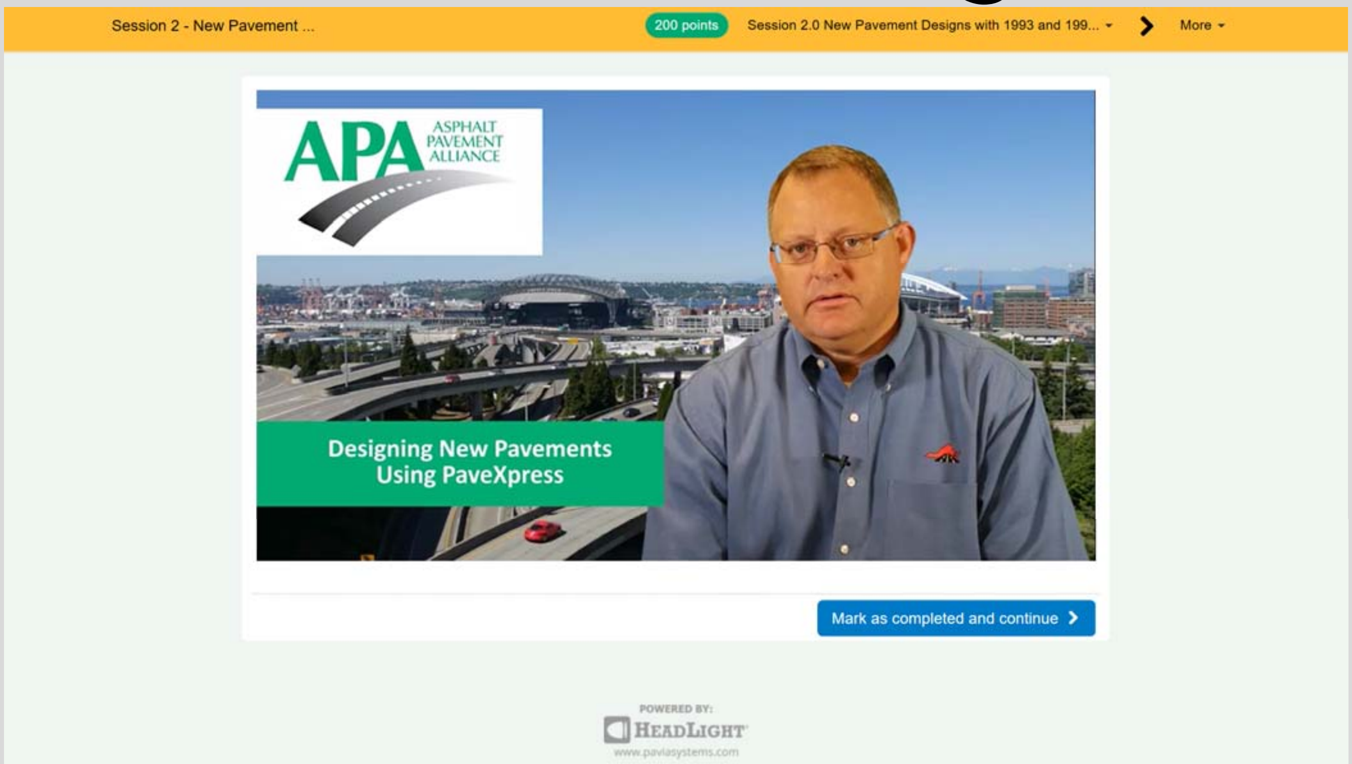
PaveInstruct Learning Modules



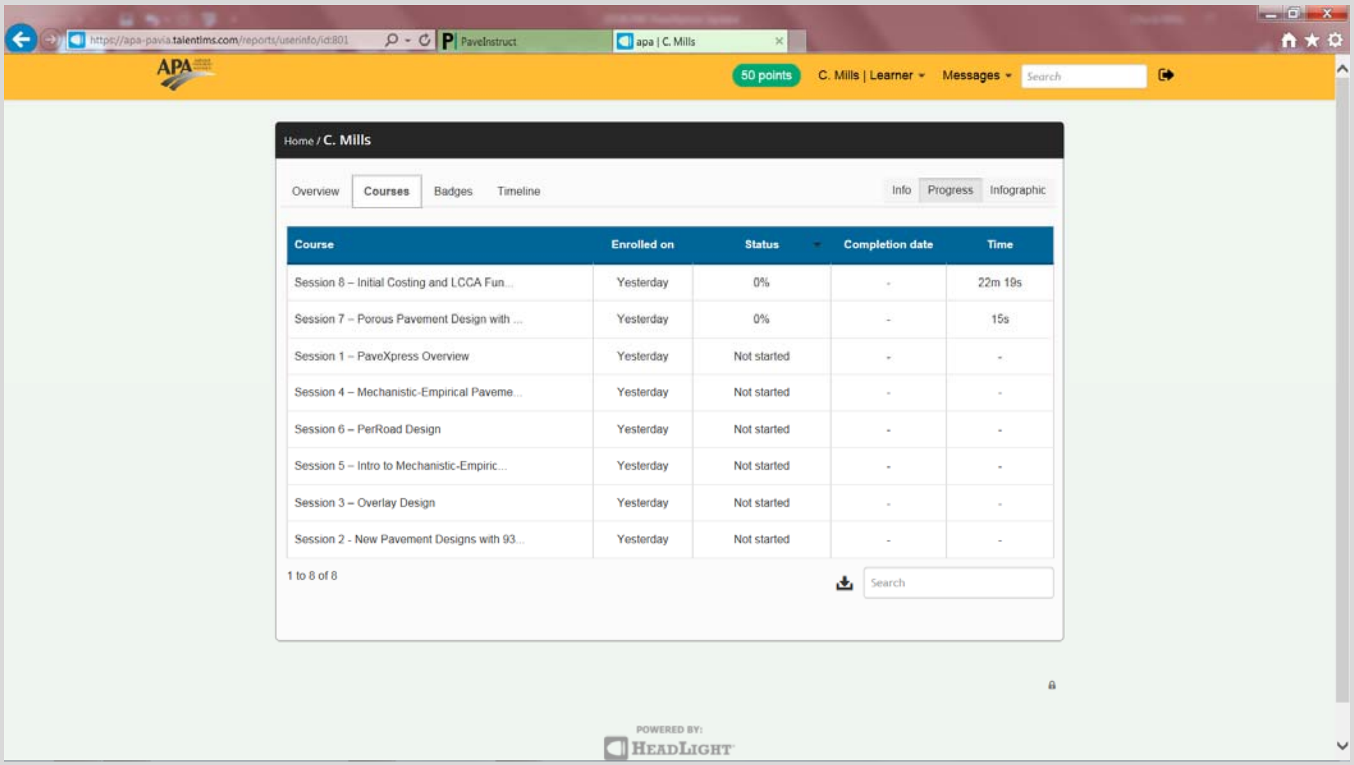
PaveInstruct Learning Modules



PaveInstruct Learning Modules



PaveInstruct Learning Modules



Other Resources

Asphalt Pavement Association of Michigan

Perpetual Pavements – PerRoad

PerRoad 4.4

PerRoad uses the mechanistic-empirical design philosophy. The program couples layered elastic analysis with a statistical analysis procedure (Monte Carlo simulation) to estimate stresses and strains within a pavement. Version 4.4 provides design results as percentile responses and as conventional designs with transfer functions. In order to predict strains that would prove detrimental for fatigue cracking or structural rutting, PerRoad requires the following inputs:

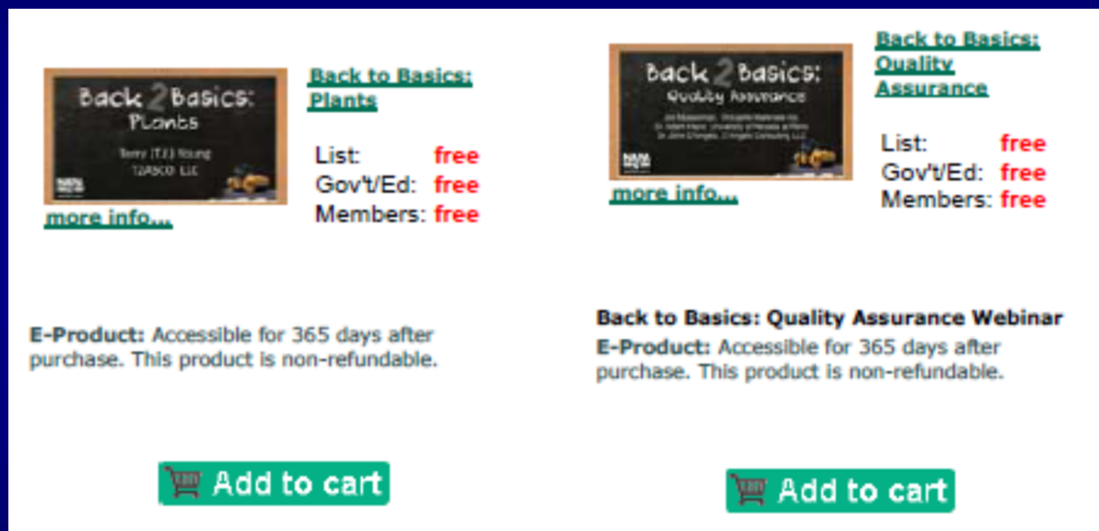
PerRoadXpress 1.0

PerRoadXpress is an easy-to-use, all-on-one-screen program for designing Perpetual Pavements for low- and medium-volume roads and parking lots. The designer chooses a type of asphalt cement. PerRoadXpress then allows the designer either to use defaults for traffic and soil, or to input the actual values if they are known. Granular base thicknesses from 0 to 10 inches are included. The software quickly provides the user with a recommendation for the total thickness of asphalt pavement needed for a particular situation. PerRoadXpress was developed

http://www.asphaltroads.org/why-asphalt/engineering/perpetual-pavement/

Other Resources

NAPA Webinar Series – Back to Basics



http://store.asphaltpavement.org/index.php?categoryID=140

Other Resources

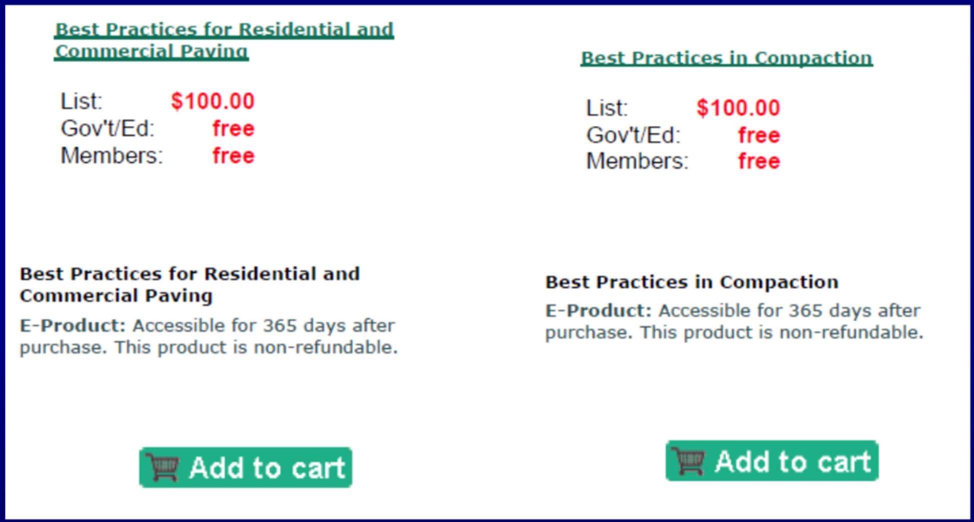
NAPA Webinar Series – Back to Basics

- Forensics
- Funding
- Maintenance & Rehabilitation
- Tack Coat
- Aggregate
- Binder
- Compaction
- Mix Design
- Pavement Design
- Paving

http://store.asphaltpavement.org/index.php?categoryID=140

Other Resources

NAPA Webinar Series – Best Practices in Paving


Best Practices for Residential and Commercial Paving

List: $100.00
Gov't/Ed: free
Members: free

Best Practices for Residential and Commercial Paving

E-Product: Accessible for 365 days after purchase. This product is non-refundable.

Add to cart

Best Practices in Compaction

List: $100.00
Gov't/Ed: free
Members: free

Best Practices in Compaction

E-Product: Accessible for 365 days after purchase. This product is non-refundable.

Add to cart

http://store.asphaltpavement.org/index.php?categoryID=131

Other Resources

NAPA Webinar Series – Best Practices in Paving

- Residential and Commercial Paving
- Compaction
- Milling & Profiling
- Pavement Repair
- Work Zone Safety
- Paver Operations
- Positioning Technology for Asphalt Pavements
- Leadership, Communication & Planning in Paver Operations

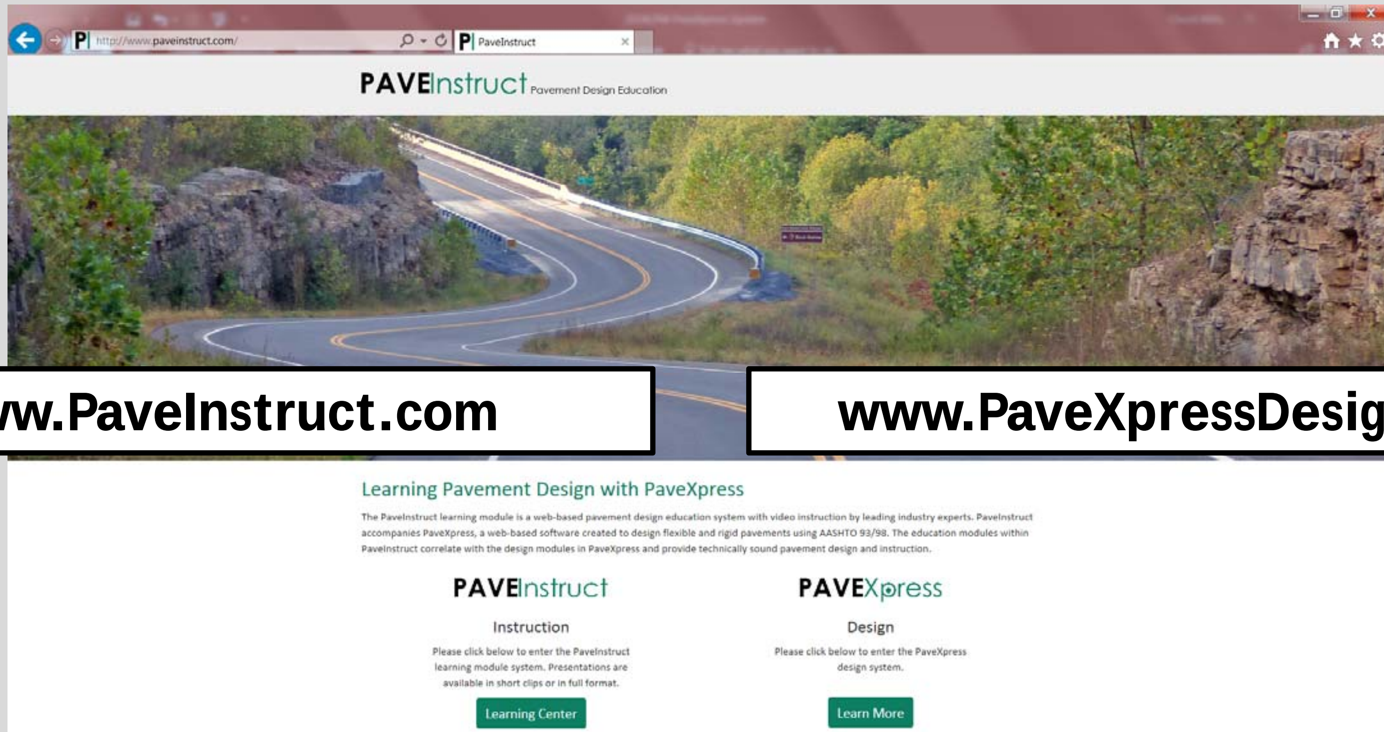
http://store.asphaltpavement.org/index.php?categoryID=131

Other Resources

Other Tools

http://www.asphaltpavement.org/multicool

Questions?



www.PaveInstruct.com

www.PaveXpressDesign.com