SIMPLIFIED PAVEMENT DESIGN TOOL FOR LPA PROJECTS

Introduction to

- www.pavexpressdesign.com

M Dudley Bonte

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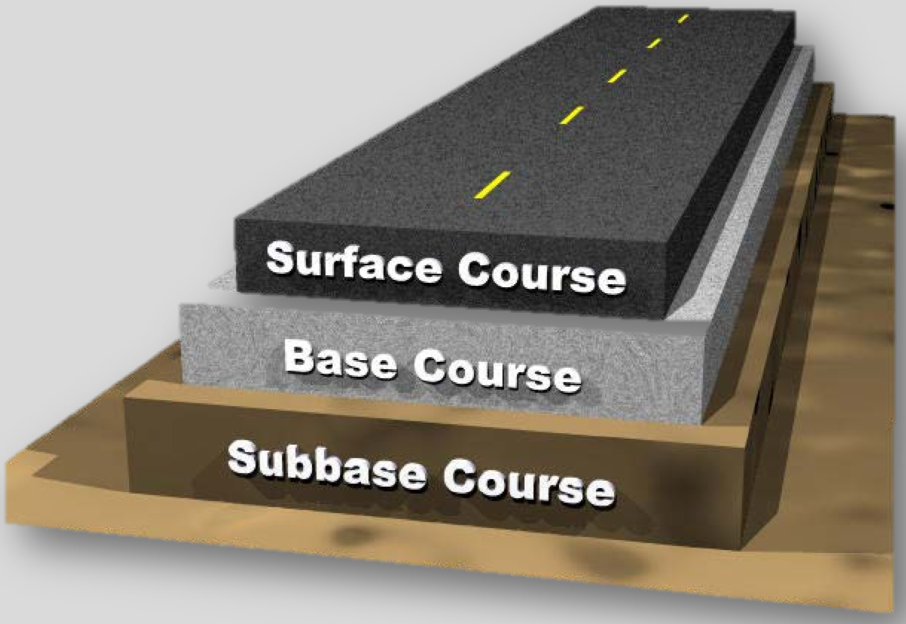
PaveXpress
A Simplified Pavement Design Tool
www.PaveXpressDesign.com

What Is PaveXpress?

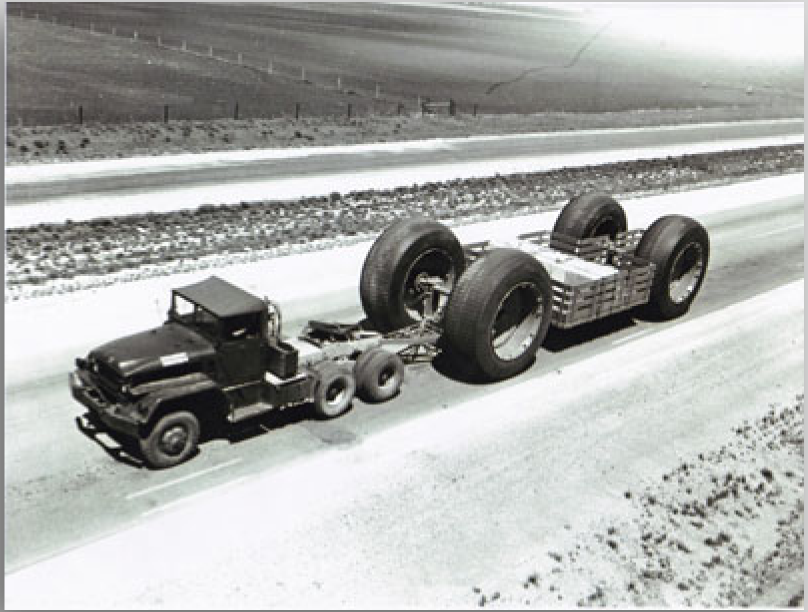
A free, online tool to help you create simplified pavement designs using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

- 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



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

1993 AASHTO Design Guide Equation — Basic Overview



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 — Basic Overview

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

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 — Basic Overview

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

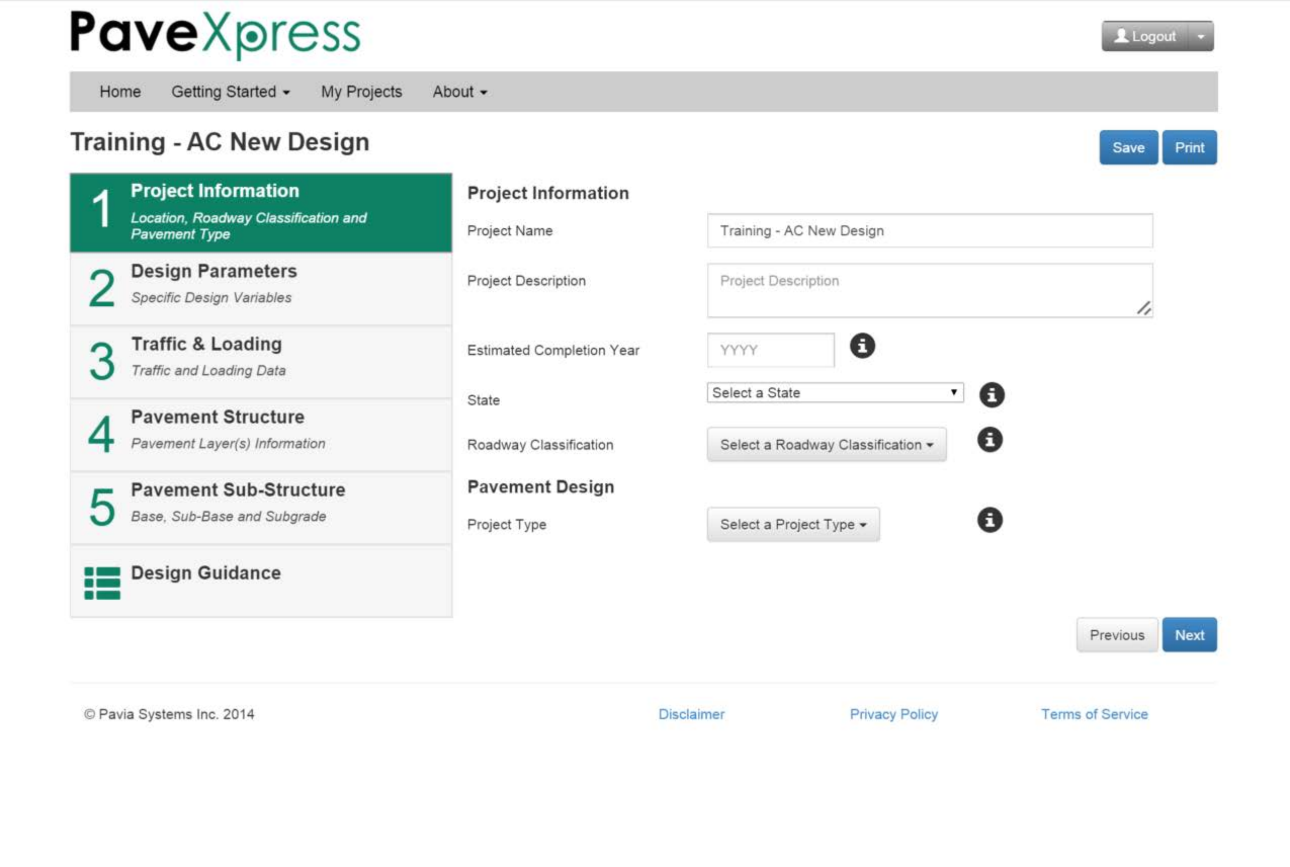
Once the total pavement *SN* is calculated, the thickness of each layer within the pavement structure is calculated

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

Where:

a_i = i^{th} layer coefficient
D_i = i^{th} layer thickness (inches)
m_i = i^{th} layer drainage coefficient

Screen 1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1 Project Information

Location, Roadway Classification and Pavement Type

Screen 1

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.

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.

Roadway Classifications

Interstate: *All routes that comprise the Dwight D. Eisenhower National System of Interstate and Defense Highways belong to the "Interstate" functional classification category and are considered Principal Arterials.*

Arterials/Highways: *The roads in this classification have directional travel lanes are usually separated by some type of physical barrier, and their access and egress points are limited to on- and off-ramp locations or a very limited number of at-grade intersections. These roadways serve major centers of metropolitan areas, provide a high degree of mobility. They can also provide mobility through rural areas. Unlike their access-controlled counterparts, abutting land uses can be served directly.*

Local: *Local roads are not intended for use in long distance travel, due to their provision of direct access to abutting land. Bus routes generally do not run on Local Roads. They are often designed to discourage through traffic. Collectors serve a critical role in the roadway network by gathering traffic from Local Roads and funneling them to the Arterial network.*

Residential/Collector: *The roads in this classification have the lowest traffic loadings and are basically comprised of automobiles and periodic truck service traffic, such as garbage trucks, etc. The "Collector" name appended to this classification fits more with the "Local" classification above, i.e., "Collector/Local."*

1 **Project Information**

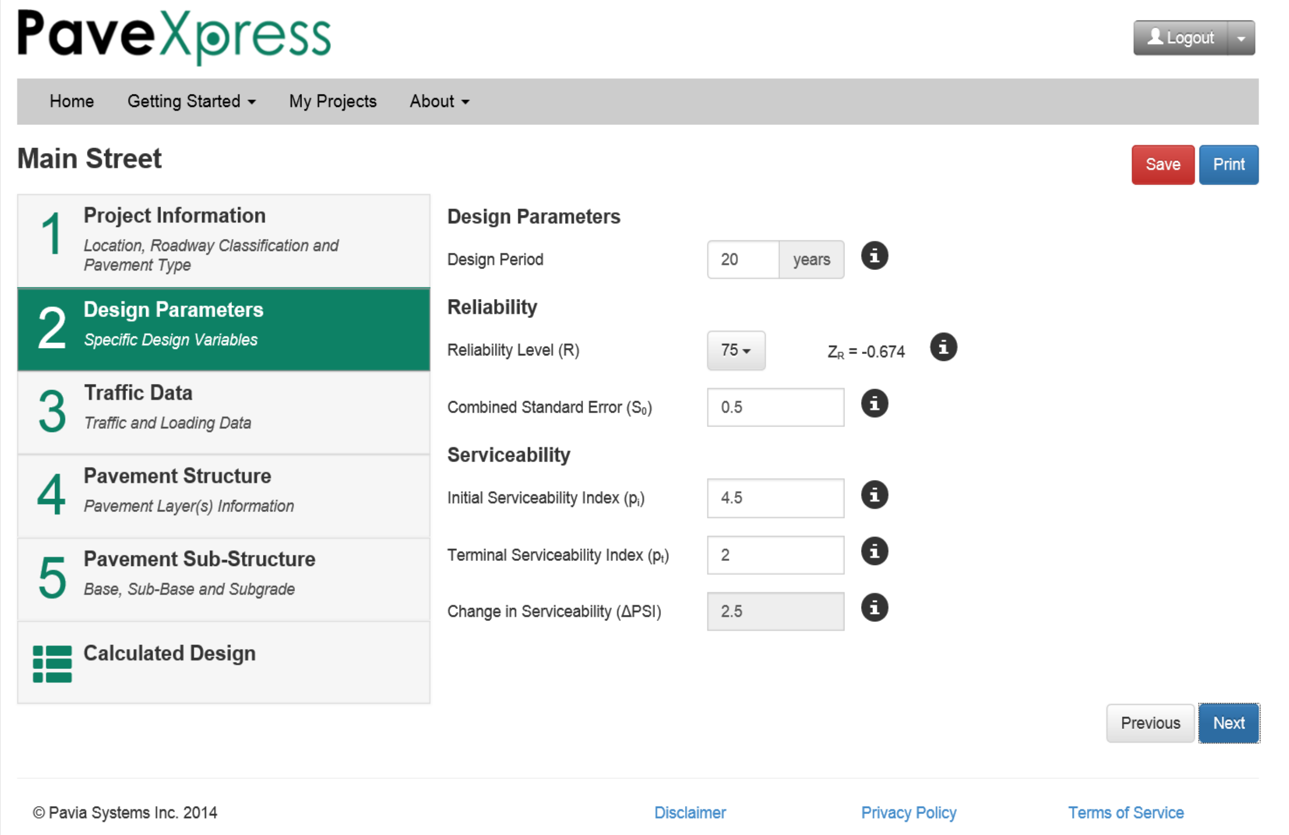
Location, Roadway Classification and Pavement Type

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 (No Design Performed)

This presentation will focus on New Asphalt designs

Screen 2



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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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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.

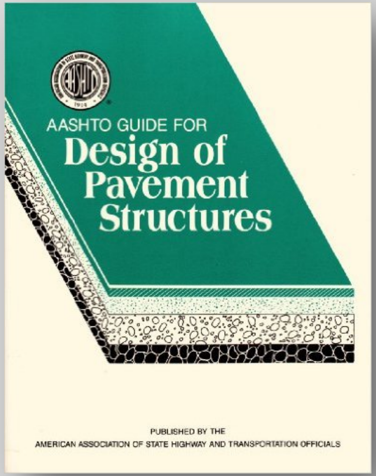
2) **Reliability Level (*R*)** is the probability that a pavement section designed using the process will perform satisfactorily over the traffic and environmental conditions for the design period. This is then used to determine the corresponding Z_R.

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

2 Design Parameters

Specific Design Variables

Screen 2

3) **Combined Standard Error (S_0)** A variable that defines the overall design uncertainty involved in the traffic and performance design inputs (the likelihood that actual observed values during the pavement's serviceable life will deviate from these inputs). It is not recommended to change this from 0.5 for flexible pavements.

2 Design Parameters

Specific Design Variables

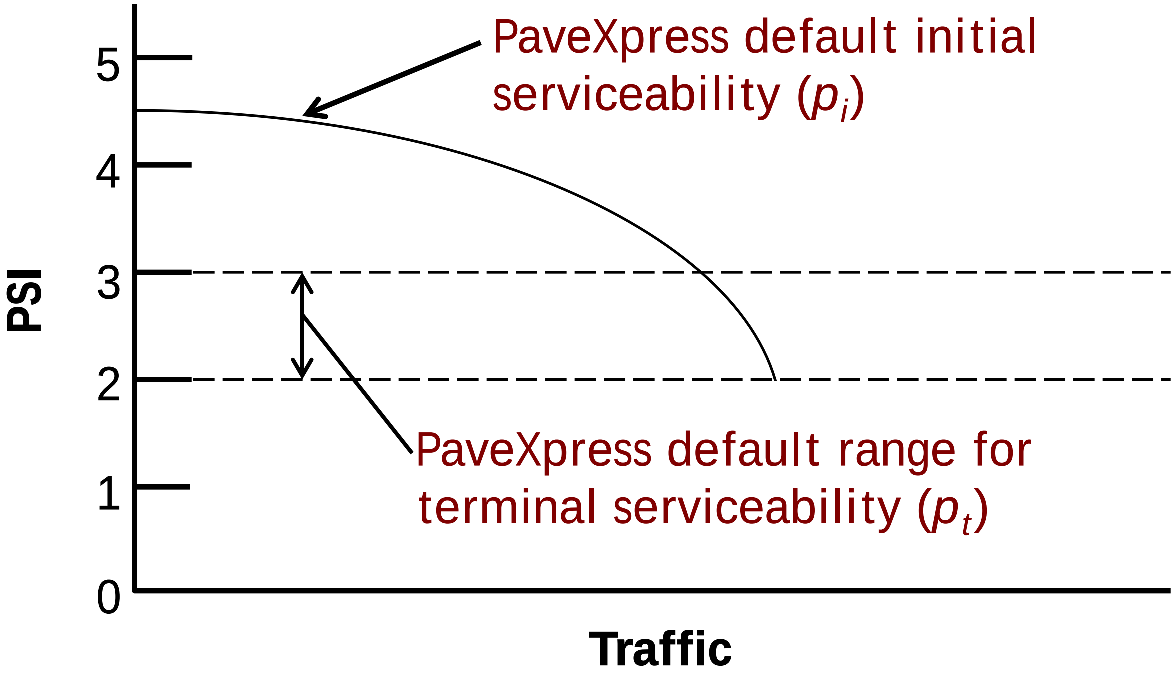
Screen 2

4) **Initial Serviceability Index (p_i)** is the Present Serviceability Index (*PSI*) of the pavement immediately after construction.

5) **Terminal Serviceability Index (p_t)** is the *PSI* when the pavement is considered to have exhausted its serviceable life.

6) **Change in Serviceability (Δ*PSI*)** is the difference in *PSI* between the time of the pavement's construction and the end of its serviceable life. PaveXpress calculates this number based on the designer's inputs for p_i and p_t ($\Delta PSI = p_i - p_t$).

Present Serviceability Index Concept

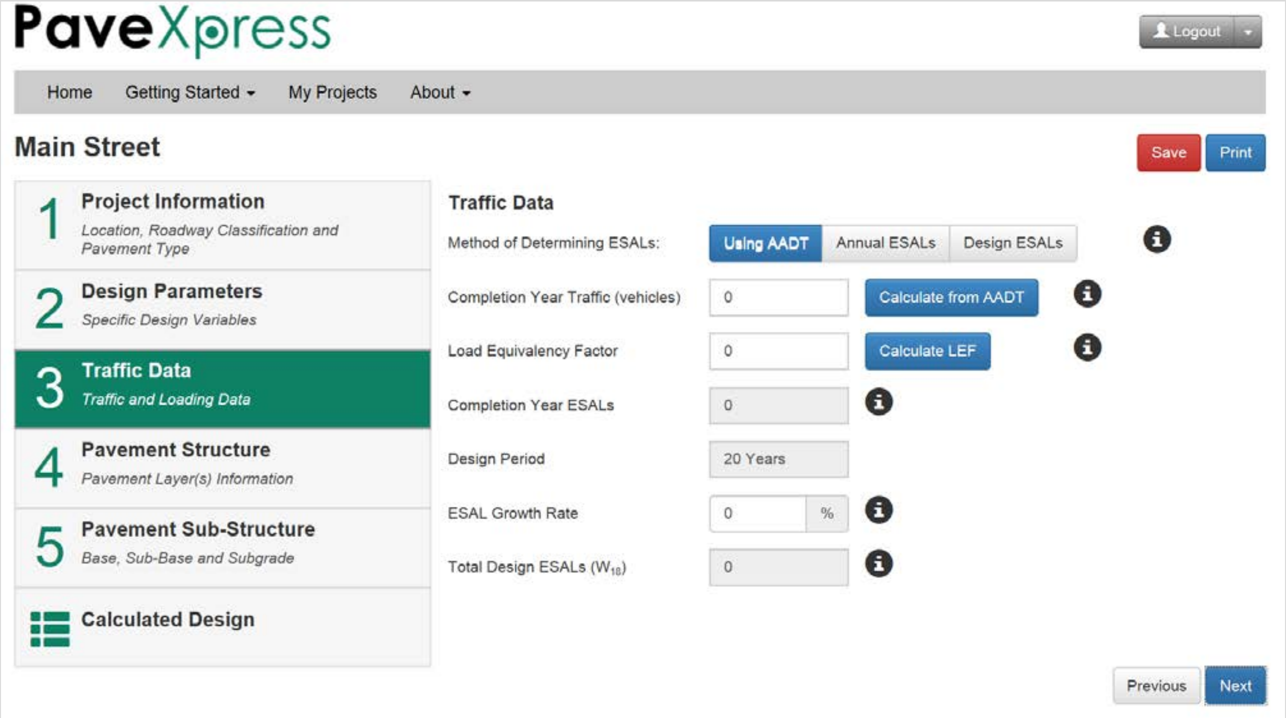


Roadway Classification Effect On PaveXpress Default Values

	Interstate	Arterials/ Highway	Local	Residential/ Collector
Design Period	40 years	30 years	20 years	20 years
Reliability Level	95	85	75	50
Combined Standard Error (S_0)	0.5	0.5	0.5	0.5
Initial Serviceability Index (p_i)	4.5	4.5	4.5	4.5
Terminal Serviceability Index (p_t)	3.0	3.0	2.0	2.0
Change in Serviceability (ΔPSI)	1.5	1.5	2.5	2.5

Screen 3

AADT

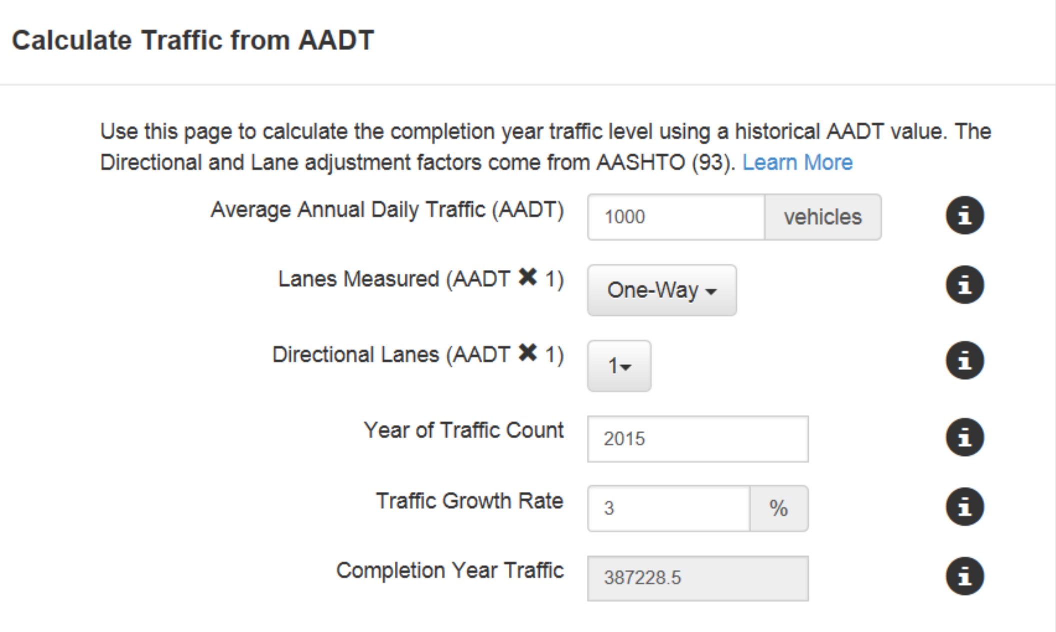


3 Traffic Data

Traffic and Loading Data

Screen 3

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



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3 Traffic Data

Traffic and Loading Data

Screen 3

1) Method of Determining ESALS
by Average Annual Daily Traffic

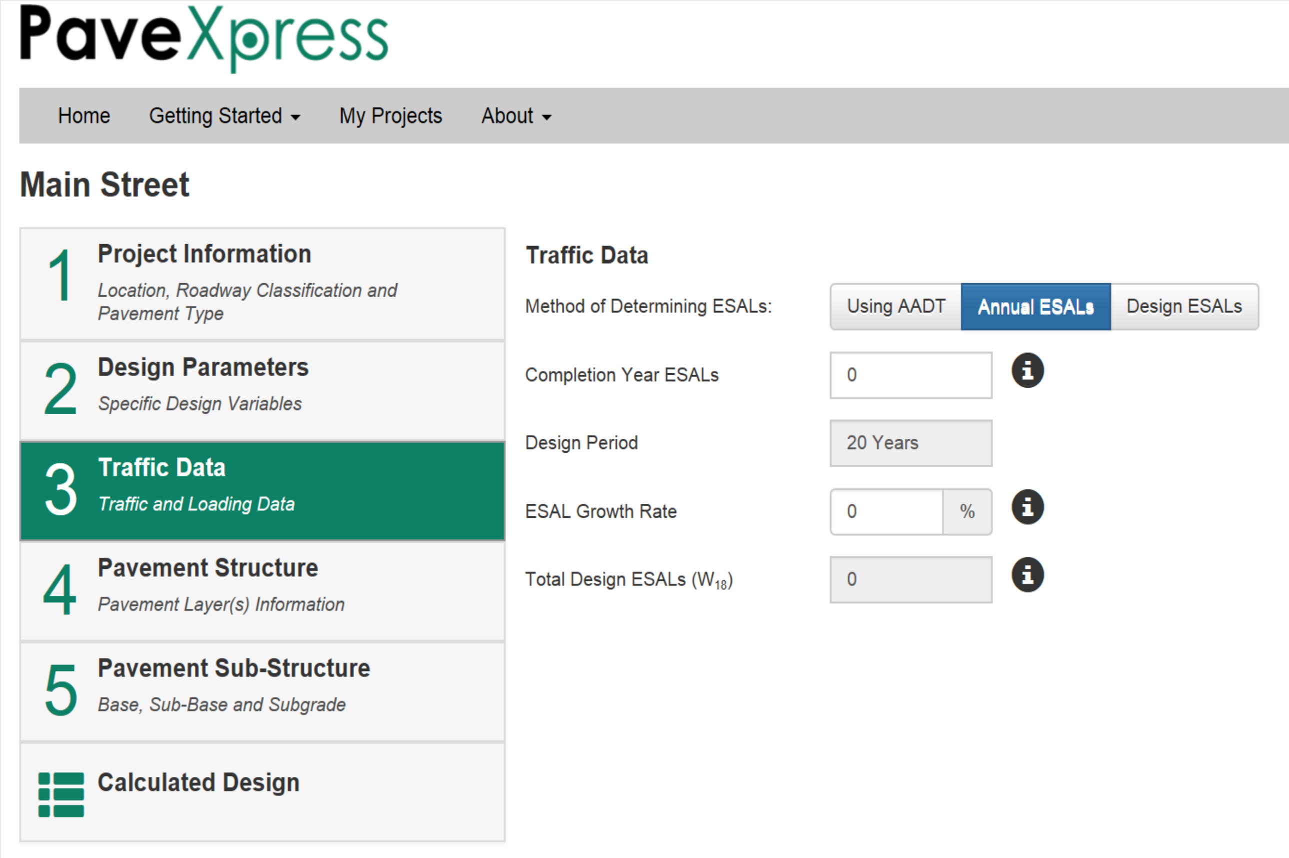
Calculate Load Equivalency Factor

Use this dialog to establish the Composite Load Equivalency Factor for your project section. The values are used to then determine the ESALs from the vehicle count provided earlier. Default values suggested are from Washington State DOT.

	% of Traffic	Weighted Load Equivalency Factor (LEF)
	0 %	✖ 0.0001
	0 %	✖ 0.4
	0 %	✖ 1
	0 %	✖ 1.75
	0 %	✖ 0
Total	0 %	

Load Equivalency Factor: 0

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

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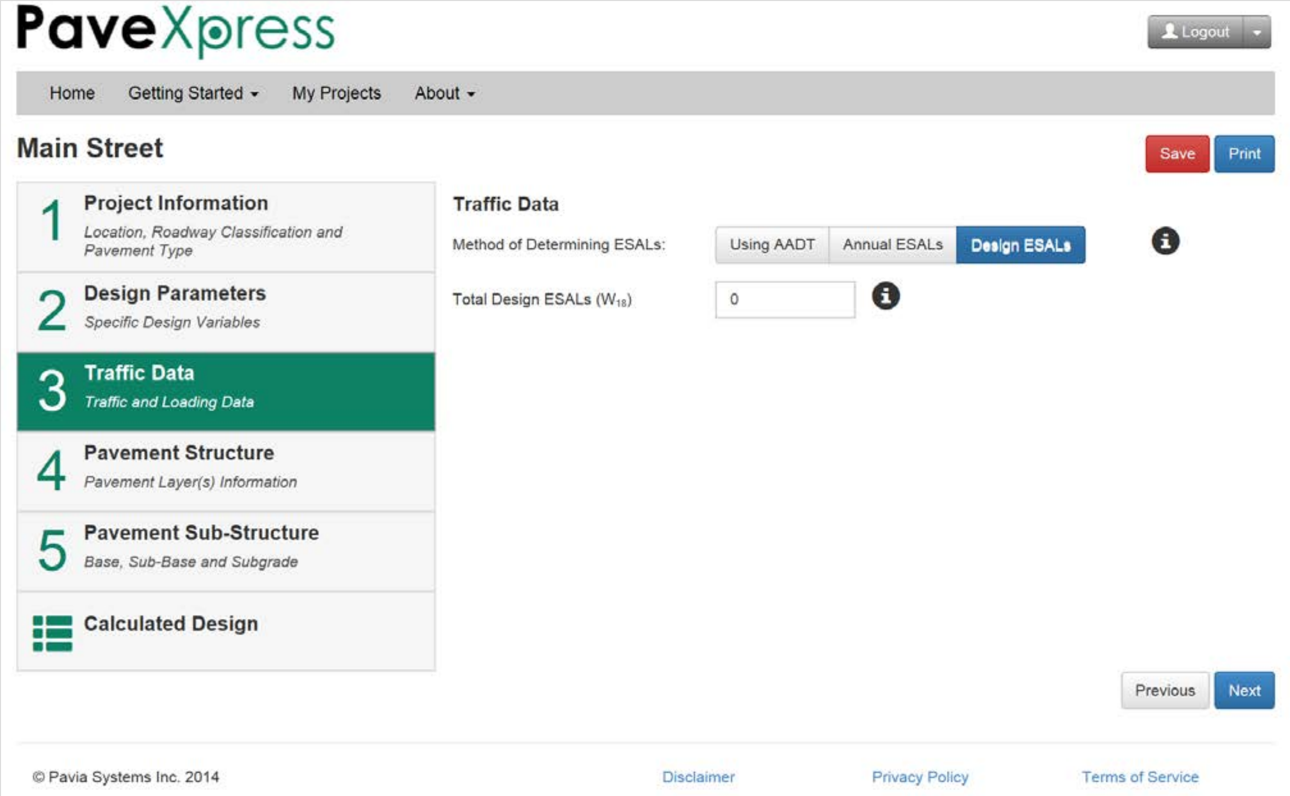
Screen 3

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.

Treating Multiple Asphalt Layers Differently

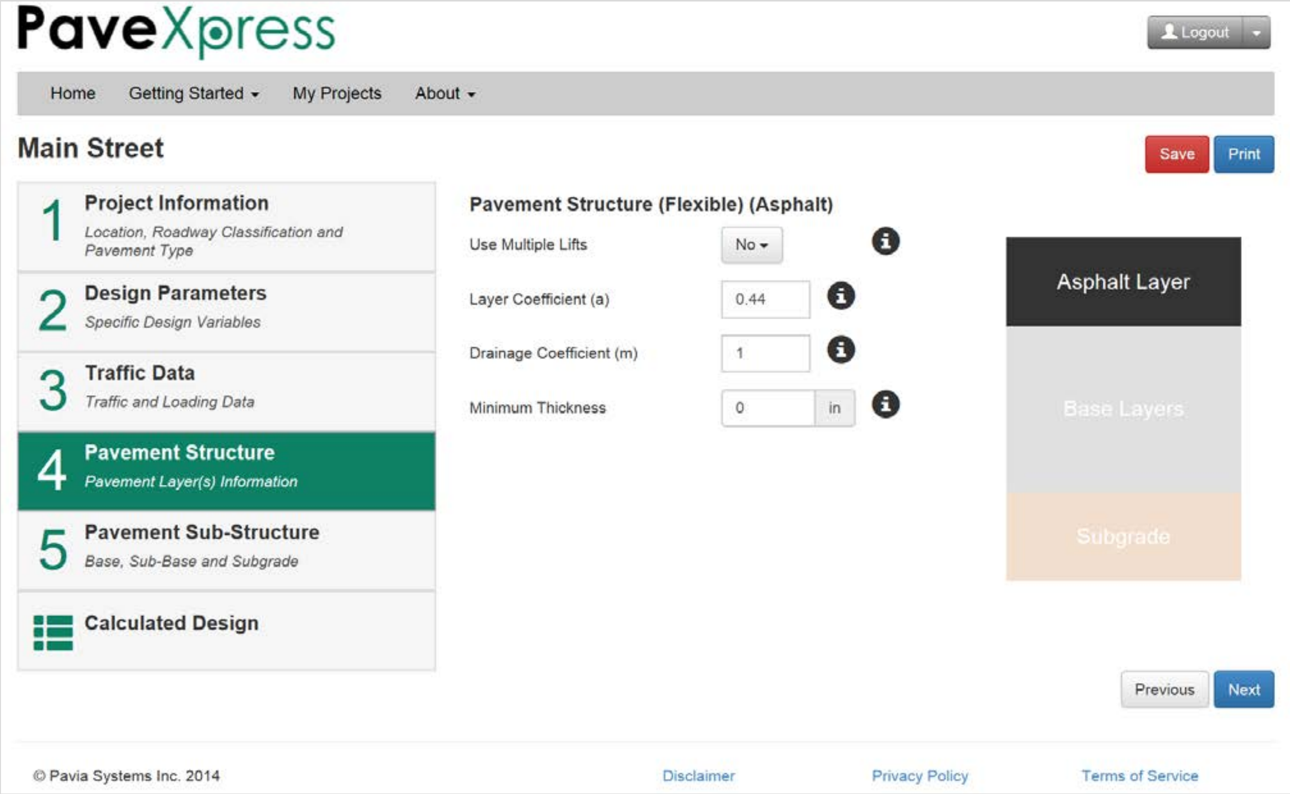
PaveXpress allows the designer to input for each lift of asphalt a different:

- *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



4 Pavement Structure

Pavement Layer(s) Information

Screen 4

1) **Layer Coefficient** is a measure of the relative ability of the material to function as a structural component of the pavement. It is used with layer thickness to determine the structural number (*SN*).
2) **Drainage Coefficient** represents the relative loss of strength in a layer due to its drainage characteristics and the total time it is exposed to near-saturation moisture conditions. The designer may increase the value from the default of 1 when drainage conditions are favorable, decrease when drainage conditions are poor.
3) **Minimum Thickness** is the minimum allowable layer thickness (either per specification, or based on practical construction limitations of the material).

Layer Coefficient Considerations

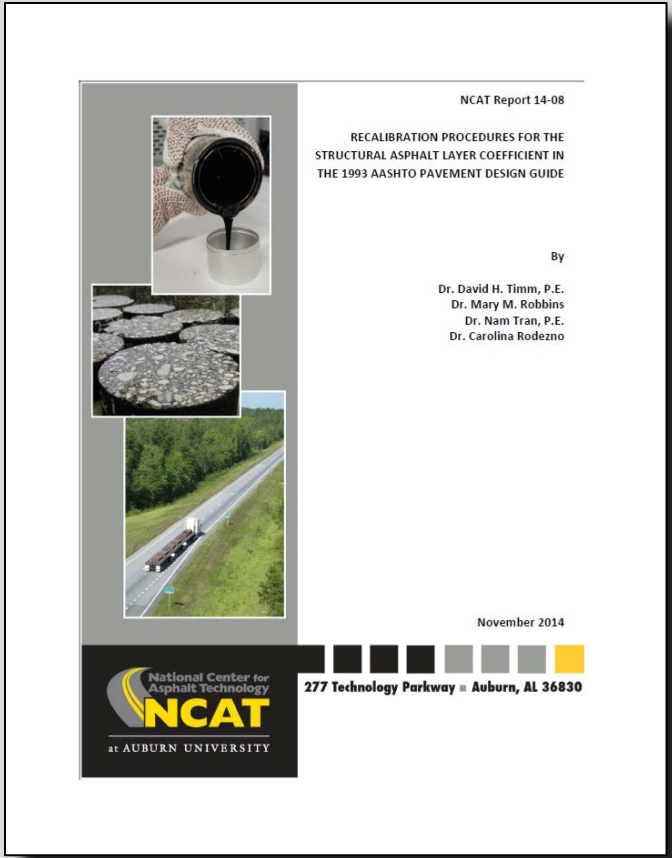
Average values of layer coefficients for materials used in the AASHO Road Test were as follows:

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.

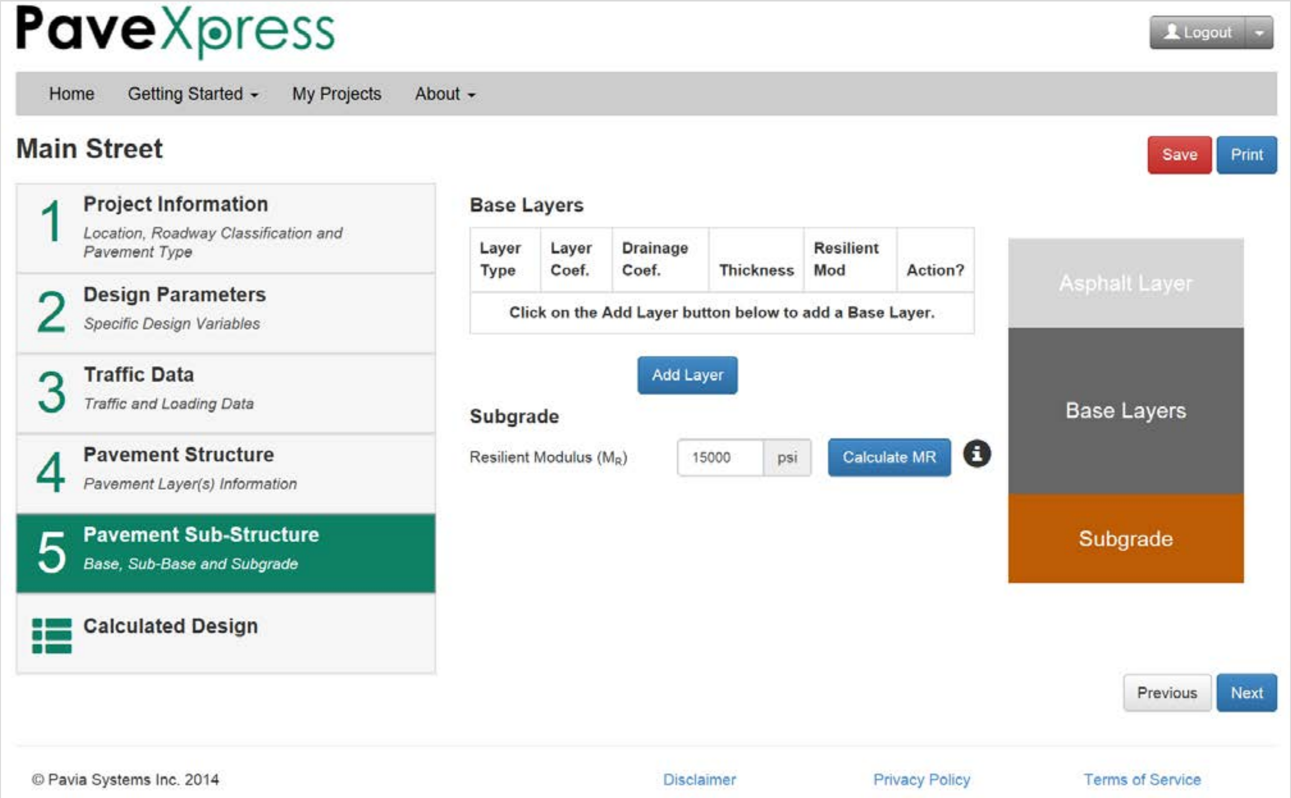


Drainage Coefficient Considerations

1993 Design Guide Table 2.4 — Recommended m_i Values for Modifying Structural Layer Coefficients of Untreated Base and Subbase Materials in Flexible Pavements

Quality of Drainage	Percentage of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
	< 1%	1–5%	5–25%	> 25%
Excellent	1.40–1.35	1.35–1.30	1.30–1.20	1.20
Good	1.35–1.25	1.25–1.15	1.15–1.00	1.00
Fair	1.25–1.15	1.15–1.05	1.00–0.80	0.80
Poor	1.15–1.05	1.05–0.80	0.80–0.60	0.60
Very Poor	1.05–0.95	0.95–0.75	0.75–0.40	0.40

Screen 5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15000
psi
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Adding an Aggregate Base Layer

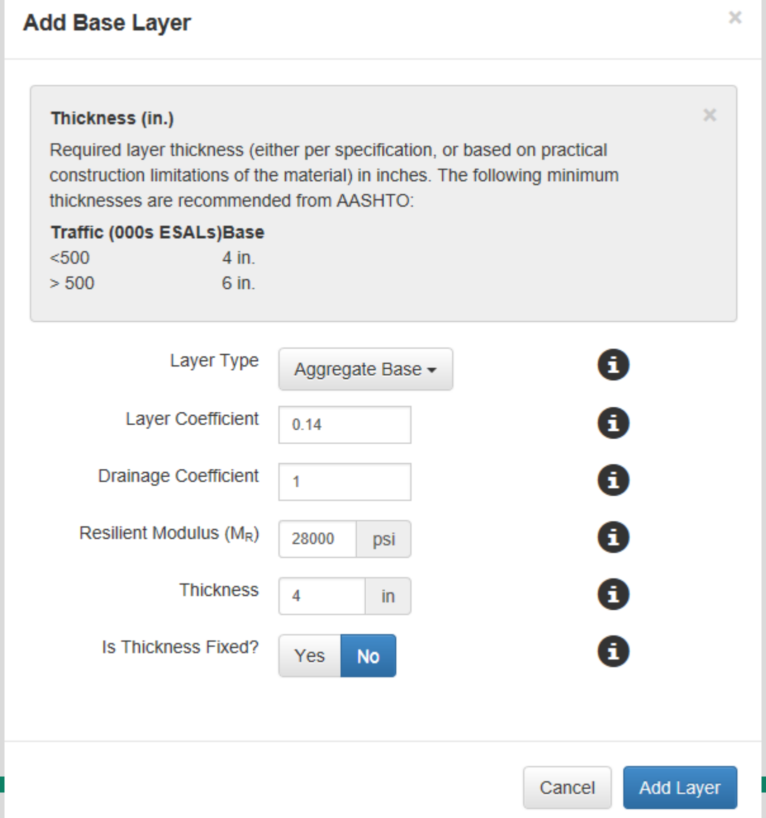
The designer can add an aggregate base layer (or any other type of base or subbase layer) here.

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:

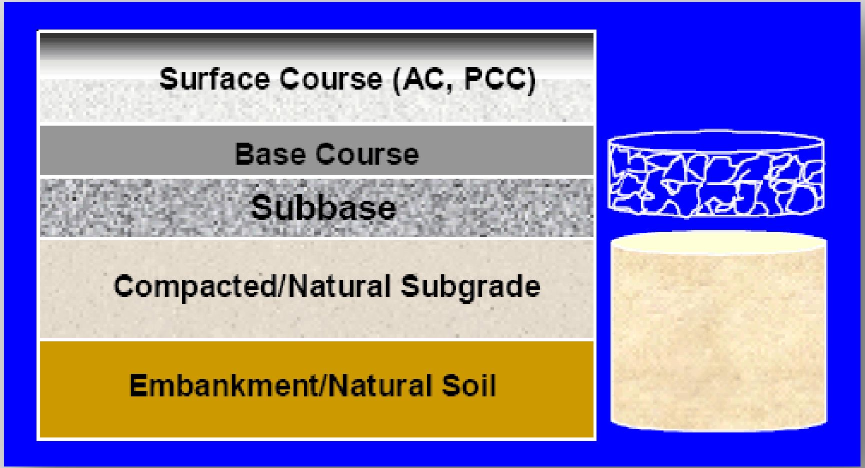
4″	< 500 ESALs
6″	> 500 ESALs



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)



California Bearing Ratio (CBR)

The CBR Test can be performed either in the lab(AASHTO T 193, ASTM D 1883) or in the field in situ (ASTM D4429).

The CBR is a simple test that compares the bearing capacity of a material with a standard well-graded crushed stone, which has a reference CBR value of 100%.

Fine-grained soils typically have values less than 20.

Using the Dynamic Cone Penetrometer to Estimate CBR

The Dynamic Cone Penetrometer (DCP) Test can be performed in the field in situ (ASTM D6951) and used to estimate CBR values.

The U.S. Army Corps of Engineers Waterways Experiment Station developed the following relationship between Dynamic Penetration Index (DPI) and CBR:

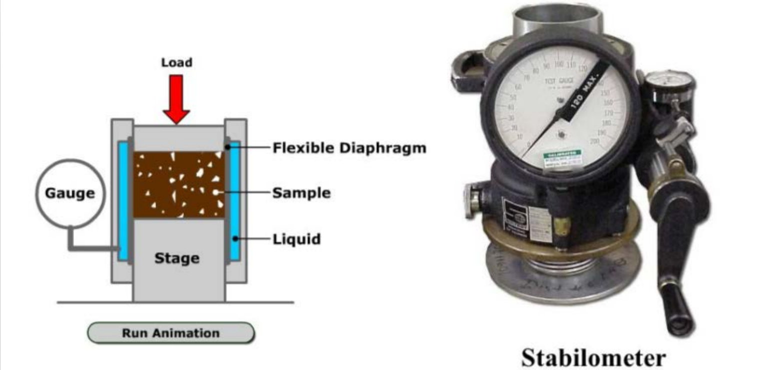
$$\log_{10}(\text{CBR}) = 2.46 - 1.12 \log_{10}(\text{DPI})$$

**Other   have been developed also.*

DCP Testing at the NCAT Test Track

Resistance Value (*R*)

The Resistance Test is performed in the lab (AASHTO T 190, ASTM D 2844).



It tests both treated and untreated laboratory compacted soils or aggregates with a stabilometer and expansion pressure devices. It tests the ability of the material to resist lateral spreading due to an applied vertical load.

A range of values are established from 0 to 100, where 0 is the resistance of water and 100 is the resistance of steel.

Resilient Modulus (M_R)

The Resilient Modulus Test is performed in the lab (AASHTO T 307, ASTM D 2844).

It is a measure of the soil stiffness and tri-axially tests both treated and untreated laboratory compacted soils or aggregates under conditions that simulate the physical conditions and stress states of materials beneath flexible pavements subjected to moving wheel loads.

As a mechanistic test measuring fundamental material properties, it is often thought preferable to the empirical CBR and *R*-value tests.

Resilient Modulus (M_R)

PaveXpress uses some common empirical expressions used to estimate M_R from CBR and R-values:

$$M_R = 2555 \times \mathrm{CBR}^{0.64}$$

$$M_R = 1000 + (555 \times R)$$

Although these equations may help the designer evaluate materials, it is usually best to determine M_R *directly through testing, if possible, rather than from the use of correlation equations.*

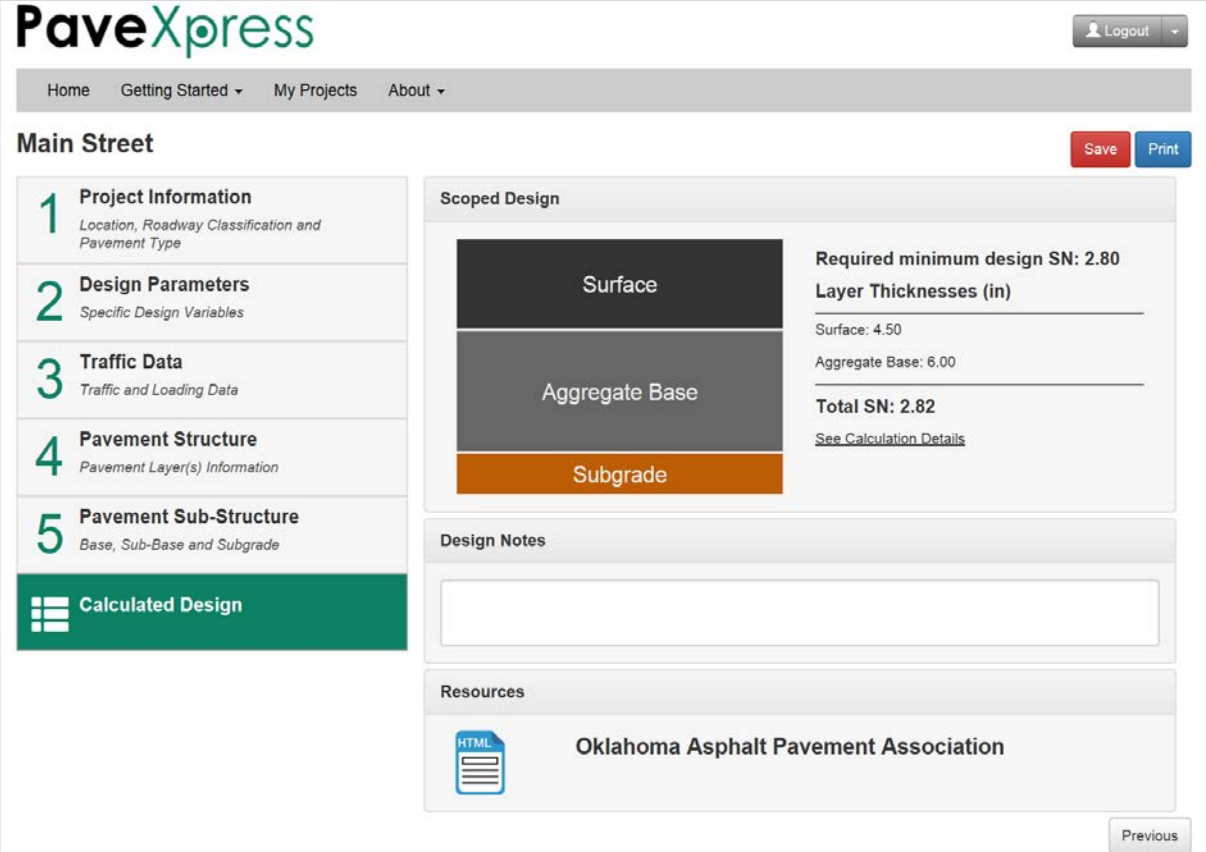
Subgrade Considerations

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



Screen 6

Calculated Design

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.

QUESTIONS?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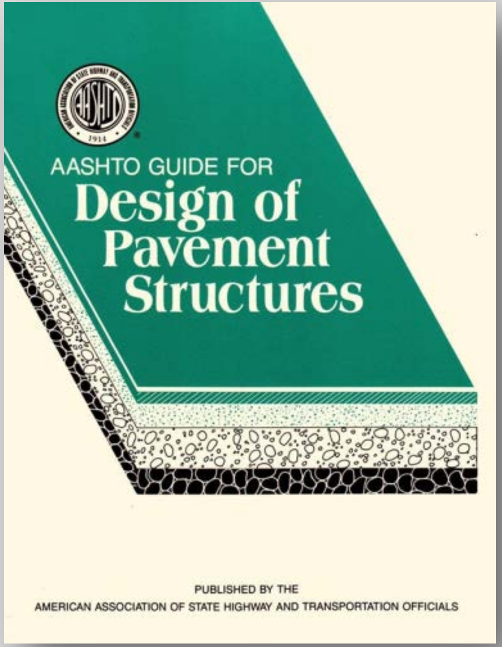
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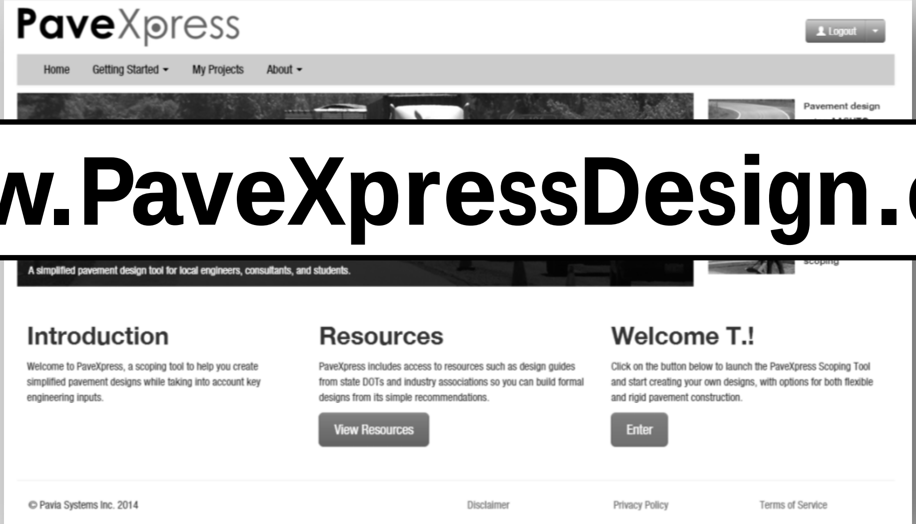

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