PRESENTED BY:

TXAPA

Texas Asphalt Pavement Association

MATERIALS & ASPHALT PAVEMENT SOLUTIONS

Designing Asphalt Pavements

Dennis Turner, P.E.

Texas Asphalt Pavement Association

What Are Some Pavement Design Methods?

1) “How thick can we afford to make it?”

2) “If a given cross-section has worked before on a road similar to this one, that same section should work here”

=

3) Pavement thickness design software or methodology

PAVEXpress

PerRoad

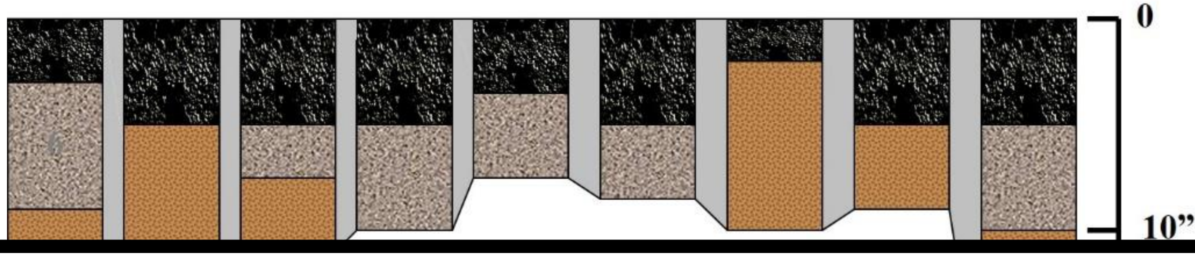
FPS 23

V1.3 8-312023

Empirical Pavement Design

Empirical: *based on, concerned with, or verifiable by observation or experience rather than theory*

The basis of the AASHTO 1993 Design Guide and PAVEXpress design equations developed from the AASHO Road Test in the late ‘50’s and early ‘60’s



$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Empirical Pavement Design

LIMITATIONS:

- The equations were developed based on the specific pavement materials and roadbed soil present at the AASHO Road Test.
- The equations were developed based on the environment at the AASHO Road Test only.
- The equations are based on an accelerated two-year testing period rather than a longer, more typical 20+ year pavement life. Therefore, environmental factors were difficult, if not impossible, to extrapolate out to a longer period.
- The loads used to develop the equations were operating vehicles with identical axle loads and configurations, as opposed to mixed traffic.

And yet, the AASHTO design guide has been used, mostly successfully, for decades

Mechanistic-Empirical Pavement Design

Mechanistic: *relating to theories which explain phenomena in purely physical or deterministic terms*

Mechanistic-empirical (ME), as the name indicates, uses both mechanistic and empirical equations to model how a pavement structure responds to environmental and loading conditions.

Mechanistic part calculates strains resulting from given stresses

Empirical part uses “transfer function” to relate strains to distresses (rutting/ cracking)

AASHTOWare Pavement (annual license fee - $6,400 for one workstation) is the software created to perform mechanistic “pavement thickness designs.”

TxDOT Approach

Established Standard Operating Procedure (SOP) – Statewide and District

- Defined Roles and Responsibilities
- Input Selection and Documentation
- Data Collection Sources/Methods
- “Pavement” vs “Geotech” Data

Modified Texas Triaxial Design Method

FPS23 – Layered Elastic (“Modulus”) Model of Pavement

- TxME Checks for Rutting/Cracking)

Pavement Manual

Revised June 2021

What Is PAVEXpress?

- **Free** - no cost to use
- **Accessible** - via the web and mobile
- **Standards Based** - AASHTO and/or industry standard practices
- **User-friendly** - streamlined user interface and user experience
- **Collaborative** - share, save, and print
- **Interactive** - help and resources

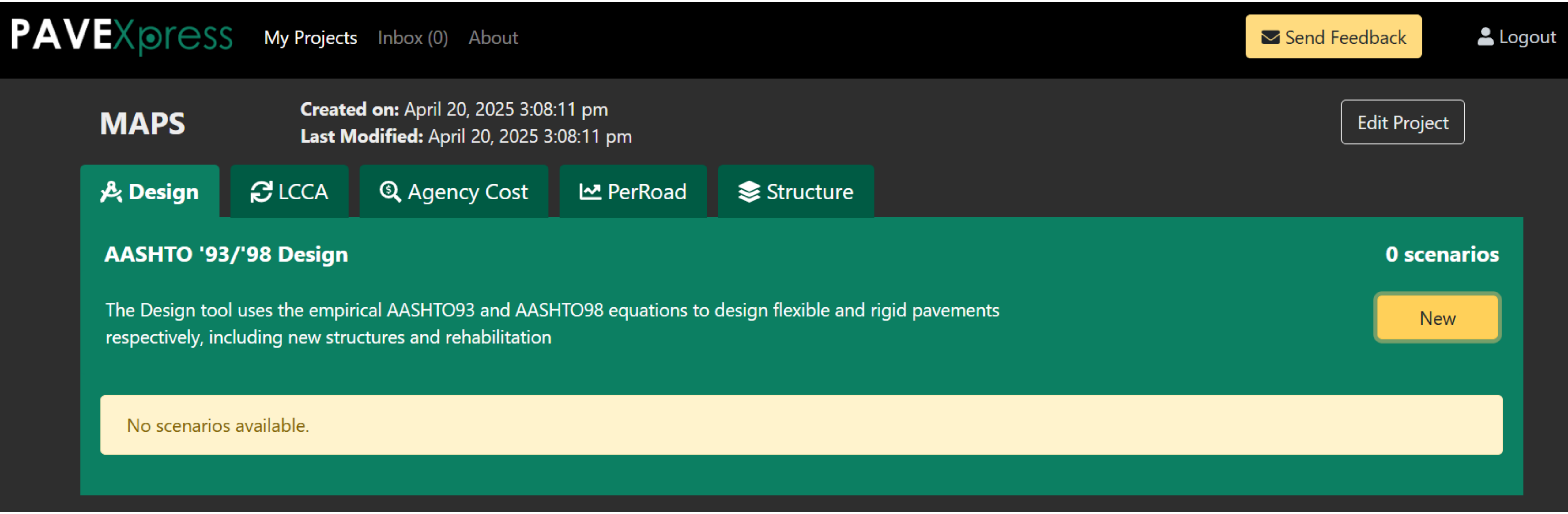
www.PAVEXpress.com

PAVEInstruct : on-line instruction by industry experts

PerRoad Design Example

http://paveinstruct.com/

PAVEXpress includes several options



www.PAVEXpress.com

Important Design Parameters

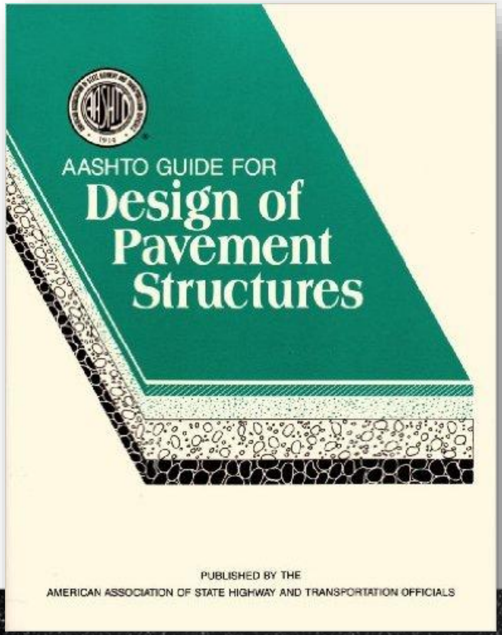
1) **Design Period** is the length of time the design is intended to last before the pavement reaches the end of its serviceable life and requires rehabilitation.

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

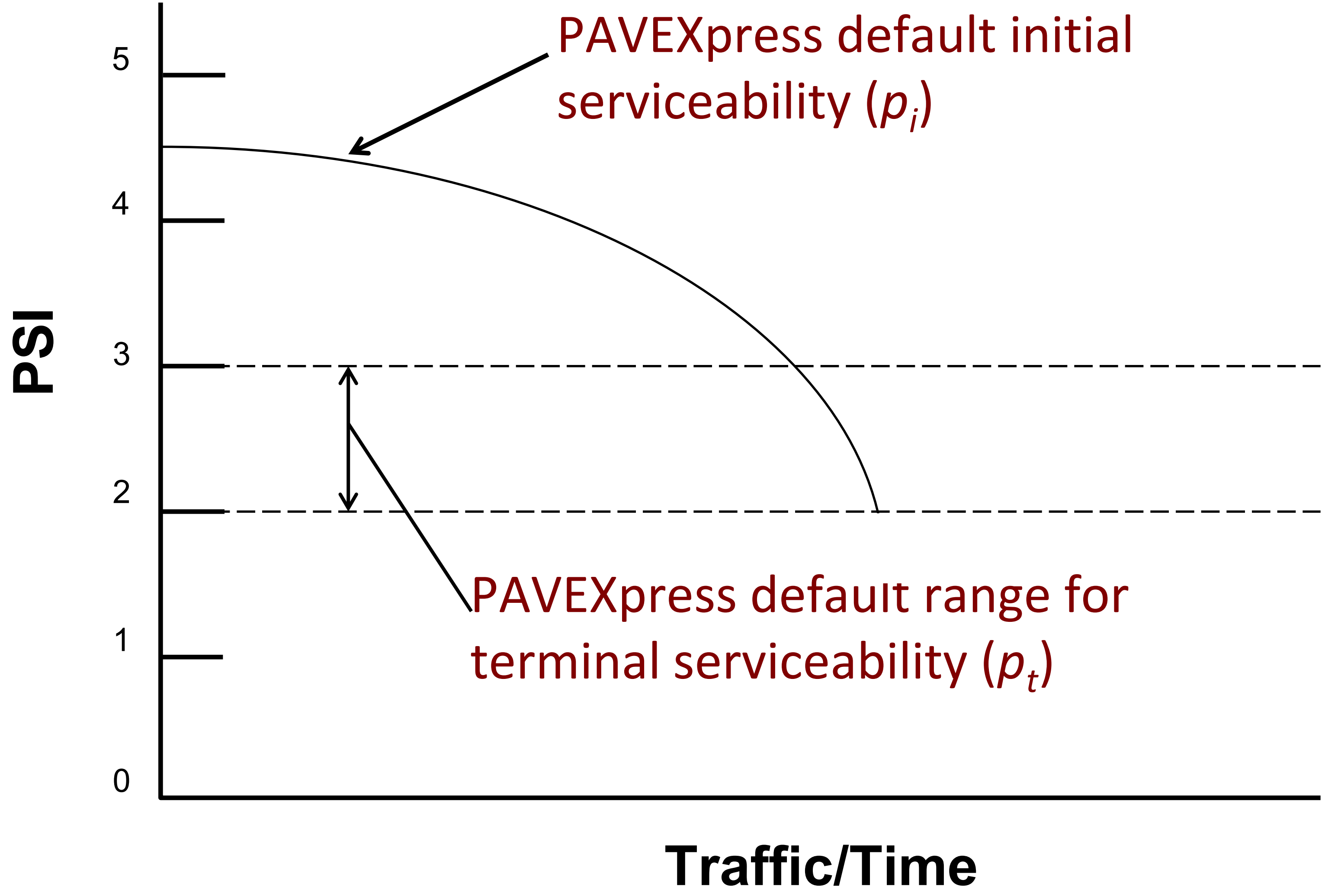
Important Design Parameters

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

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

5) **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



www.PAVEXpress.com

Important Design Parameters

6) **Traffic & Loading** indicates the expected pavement loading over its design life. PAVEXpress allows the traffic & loading to be entered in one of three different ways:

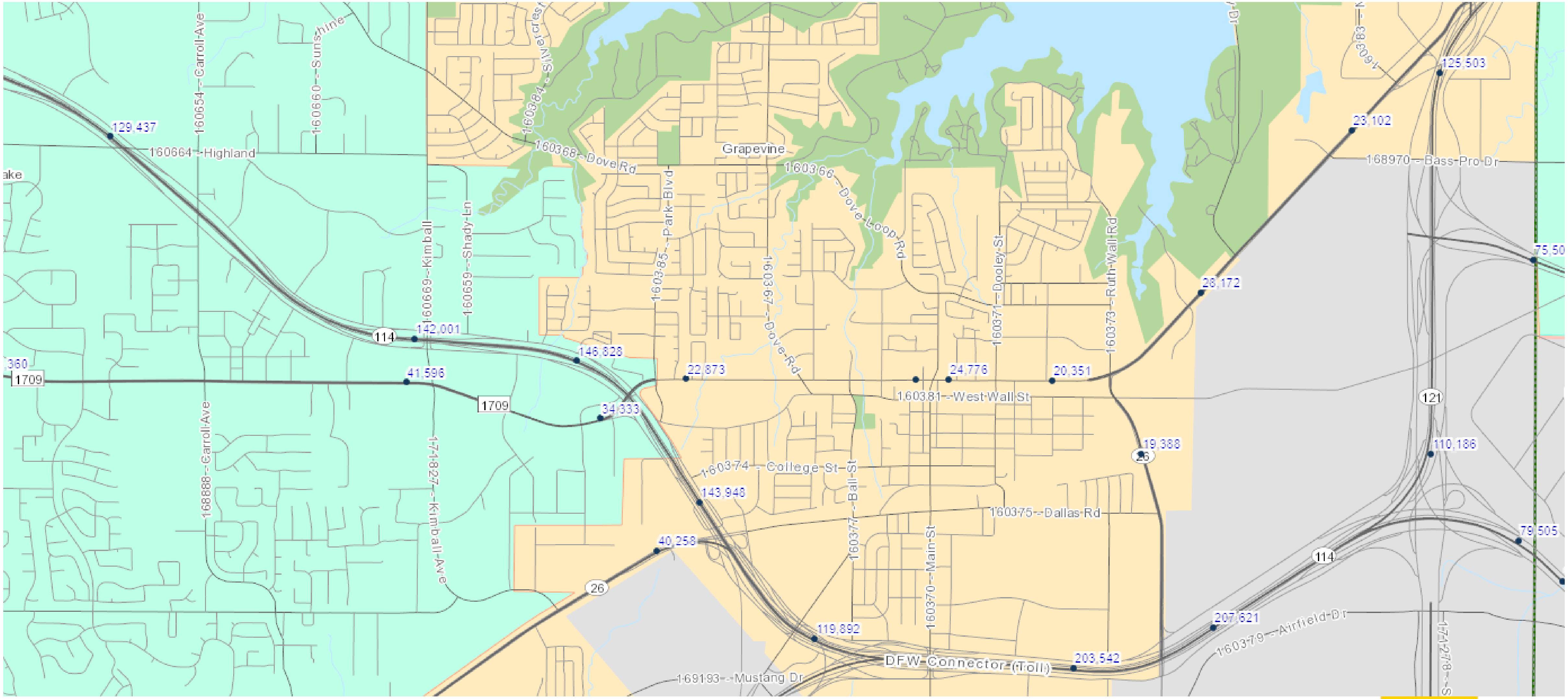
- **Annual Average Daily Traffic** – includes load equivalency factor (from traffic type by percentage), design period in years, estimated future traffic and ESAL growth rate
- **Annual ESALs** – includes design period and ESAL growth rate
- **Design ESALs** – direct input of design ESALs

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.

Where Can I Find Traffic Data?



https://txdot.maps.arcgis.com/apps/webappviewer/index.html?id=06fea0307dda42c1976194bf5a98b3a1

Important Design Parameters

7) **Layer Coefficient** - represents the relative strength of the material.

8) **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.

9) **Minimum Thickness** is the minimum thickness the designer will allow, regardless of the calculations. Asphalt Institute recommends a minimum asphalt lift thickness of 3”.

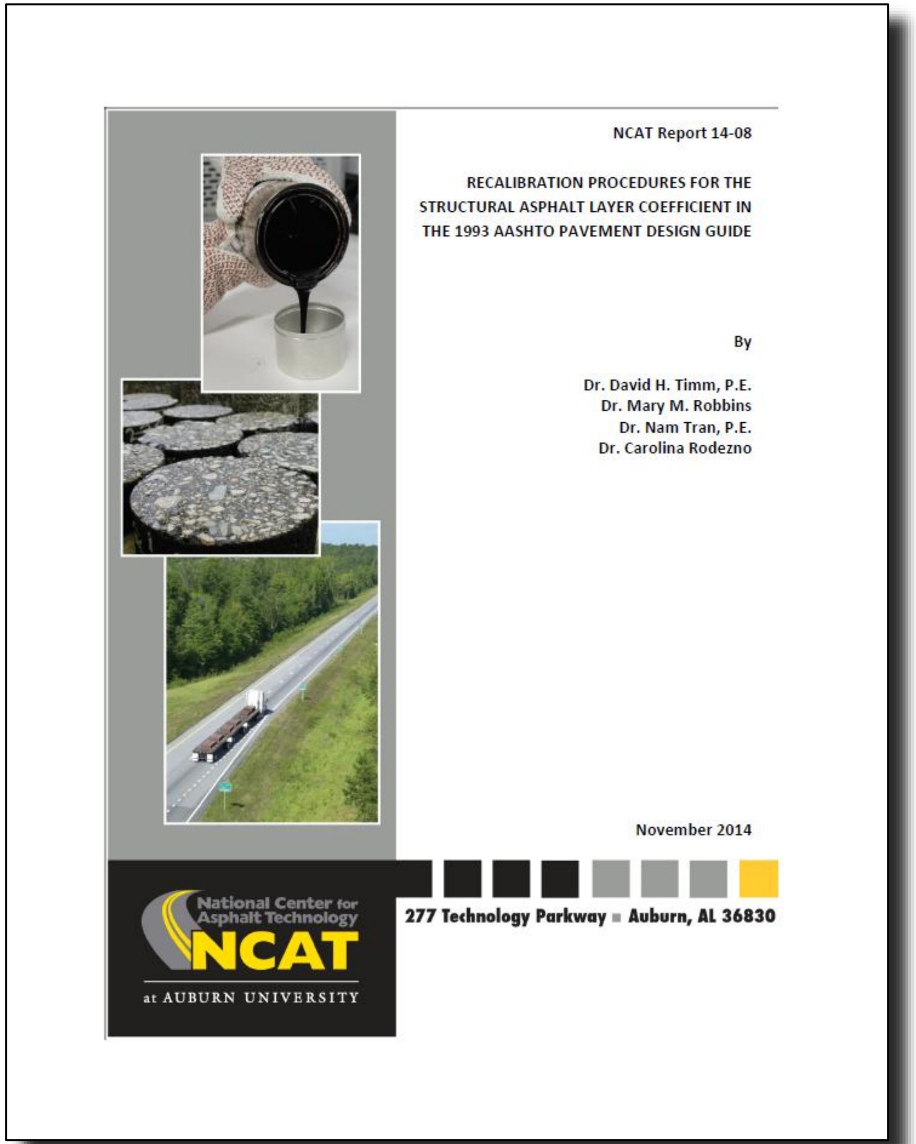
Layer Coefficient Considerations

Typical layer coefficients:

Asphalt Surface Course	0.44**
Asphalt Treated/Black Base	0.34
Full Depth Reclamation	0.30
Crushed Stone/Flex Base	0.14
Sandy Gravel Subbase	0.11
Stabilized Subgrade	0.11

** NCAT Test Track study shows a layer coefficient of 0.54 or higher can be achieved with modified binders.

** TxDOT FPS23 recognizes higher modulus values for thicker sections and use of SMA/Superpave mixes.


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

Subgrade Considerations

PAVEXpress allows input of subgrade strength by R-Value, California Bearing Ratio, or Resilient Modulus. 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.

Results

PAVEXpress My Projects Inbox (0) About

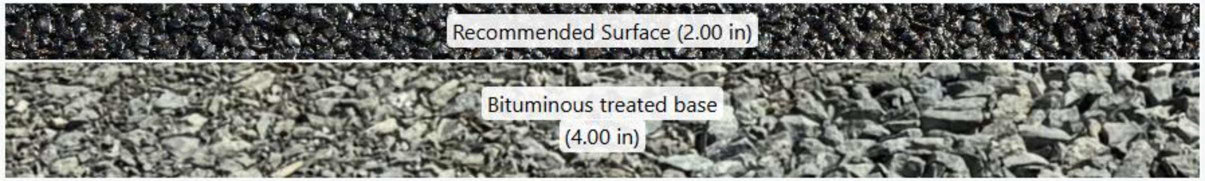
MAPS 2026_Example 1

MAPS 2026_0002
AASHTO '93/'98: Flexible Pavement Design

Met

Scenario Information | *Design Parameters* | *Traffic & Loading* | *Pavement Structure* | *Substructure*

Pavement Diagram



Layer Thicknesses (in)

Recommended Surface: 2.00 in
Bituminous treated base: 4.00 in

Total SN: 2.24 (Required minimum design SN: 2.05)

Print

Details

Scenario: MAPS 2026_0002

Created By: Dennis Turner, dturner@texasasphalt.org

Last Modified: April 27, 2026 2:54:54 pm

Design Parameters

Design Period: 20 years

Reliability Level (R): 70%

Combined Standard Error (S_0): 0.5

Initial Servicability Index (p_i): 4.5

Terminal Servicability Index (p_t): 2

Delta Servicability Index (ΔPSI): 2.5

Total Design ESALs (W_{18}): 1,250,000

Layers

Recommended Surface - Asphalt

Thickness: 2.00 in

Bituminous treated base - Base

Thickness: 4.00 in

Structural Coefficient: 0.34

Drainage Coefficient: 1

Calculated Design

Design Guidance

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.

Comparing Design Alternatives

- Policy Decisions – Pavement Class/Project Limits
- Layer Coefficient Math Exercise
- Layer Strength/Stiffness Compatibility
- Remove vs Recycle
- Flex Base vs Black Base
- Lift Thickness Minimum/Maximum
- Base Repair vs Reclamation
- Quantify Base Repair Estimates
- Number of Specified Mix Types

Practical Pavement Design Tips

- Keep It Simple – Design, Constructability, and Consistency
- Transitions, Driveways, Manholes, Handwork
- Understand the Roadway, Existing Pavement/Subgrade
  - Site and Core Photo Logs, Phenolphthalein, DCP, Proofroll
  - Don’t Guess…Visit the Site and Run Tests
- Understand the Traffic…Especially the Trucks
- Know the Inputs, Iterate Options, Run a Sensitivity Analysis
- Consider the Impact of Time From Design and Construction
- Good Communication between Civil, Geotech, and Owner

QUESTIONS?

MATERIALS & ASPHALT PAVEMENT SOLUTIONS