MUNICIPAL ASPHALT PAVEMENT SOLUTIONS

ROSENBERG, TEXAS ★ MAY 7, 2025

PRESENTED BY:

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Texas Asphalt Pavement Association

Designing Asphalt Pavements

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Director of Engineering and Training

Asphalt Institute

What Are Some Pavement Thickness 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 cross section should work here"

=

3) Pavement thickness design software or methodology

PAVEXpress

PerRoad

PvD AASHTOWare Pavement ME Design

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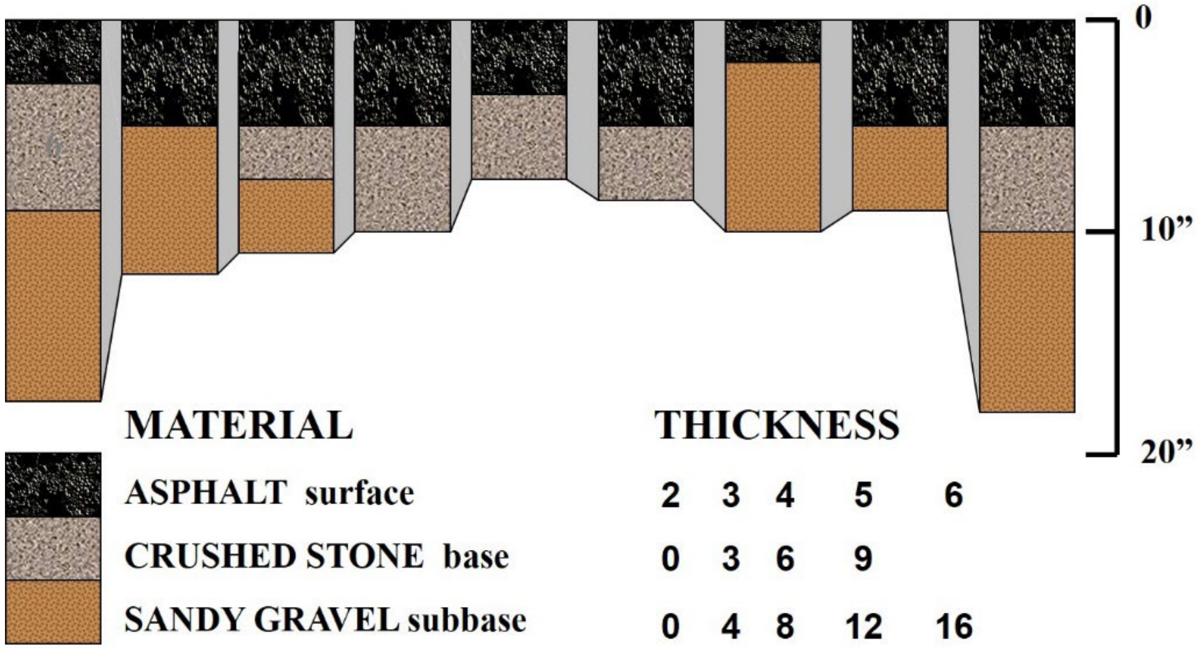
Empirical Pavement Design

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



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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

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Mechanistic-Empirical Pavement Design

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

Mechanistic-empirical (ME) pavement design, as the name indicates, uses both mechanistic and empirical equations to model how a pavement (materials + thickness) responds to a given set of environmental and loading conditions.

Mechanistic part calculates strains resulting from given stresses

Empirical part uses “transfer function” to relate strains to pavement distresses (rutting, cracking, etc.)

Mechanistic-Empirical Pavement Design

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

Whereas PAVEXpress (free) results in actual pavement thicknesses, AASHTOWare Pavement gives rut depth, percent of cracking

Agency establishes maximum allowable criteria and pavement thickness is adjusted until distress are within acceptable limits

Agency should calibrate to local materials & conditions for optimal results

Practical Pavement Design Considerations

Both PAVEXpress and AASHTOWare Pavement have their pros and cons

Local agencies tend to prefer the free empirical pavement design methodologies to the annual expense of the mechanistic-empirical design software

This section of the presentation will discuss key inputs needed for pavement thickness design using PAVEXpress

What Is PAVEXpress?

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

- **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

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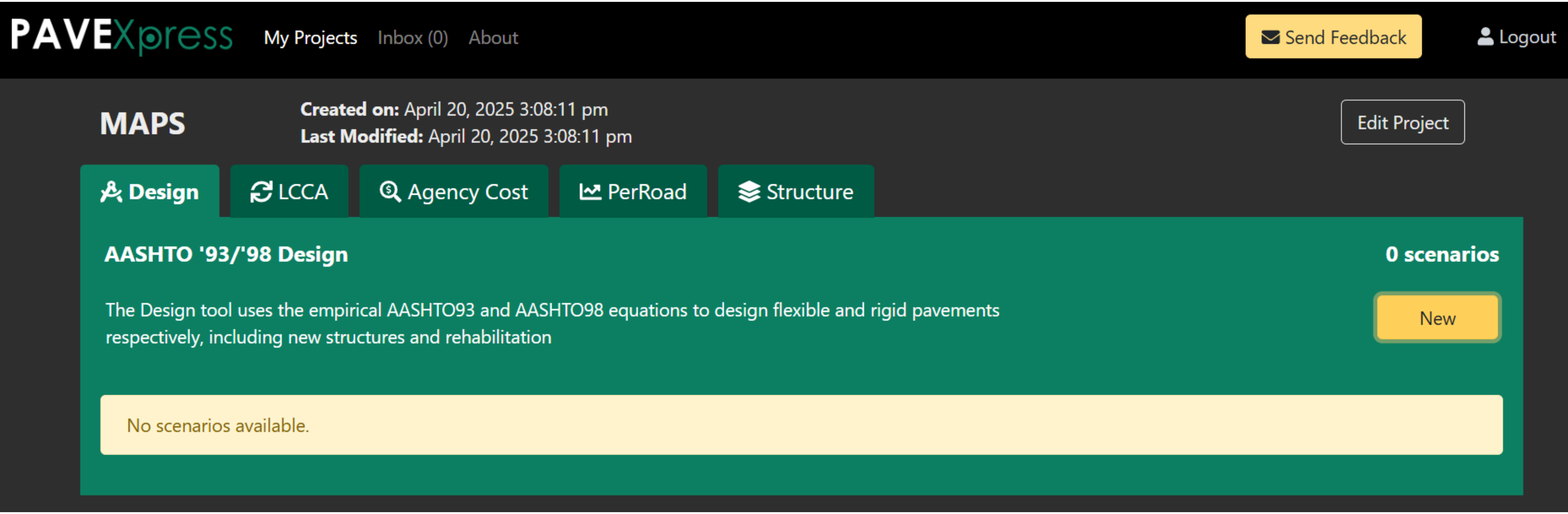
PAVEInstruct : on-line instruction by industry experts

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.

www.PAVEXpress.com

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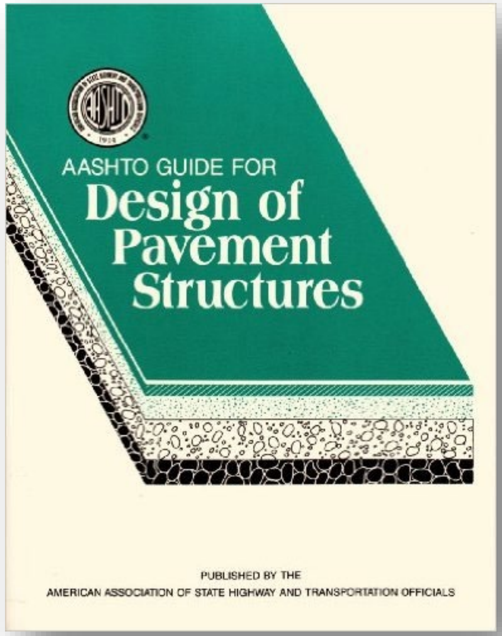
AASHTO Suggested Reliability Levels For Various Functional Classifications

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

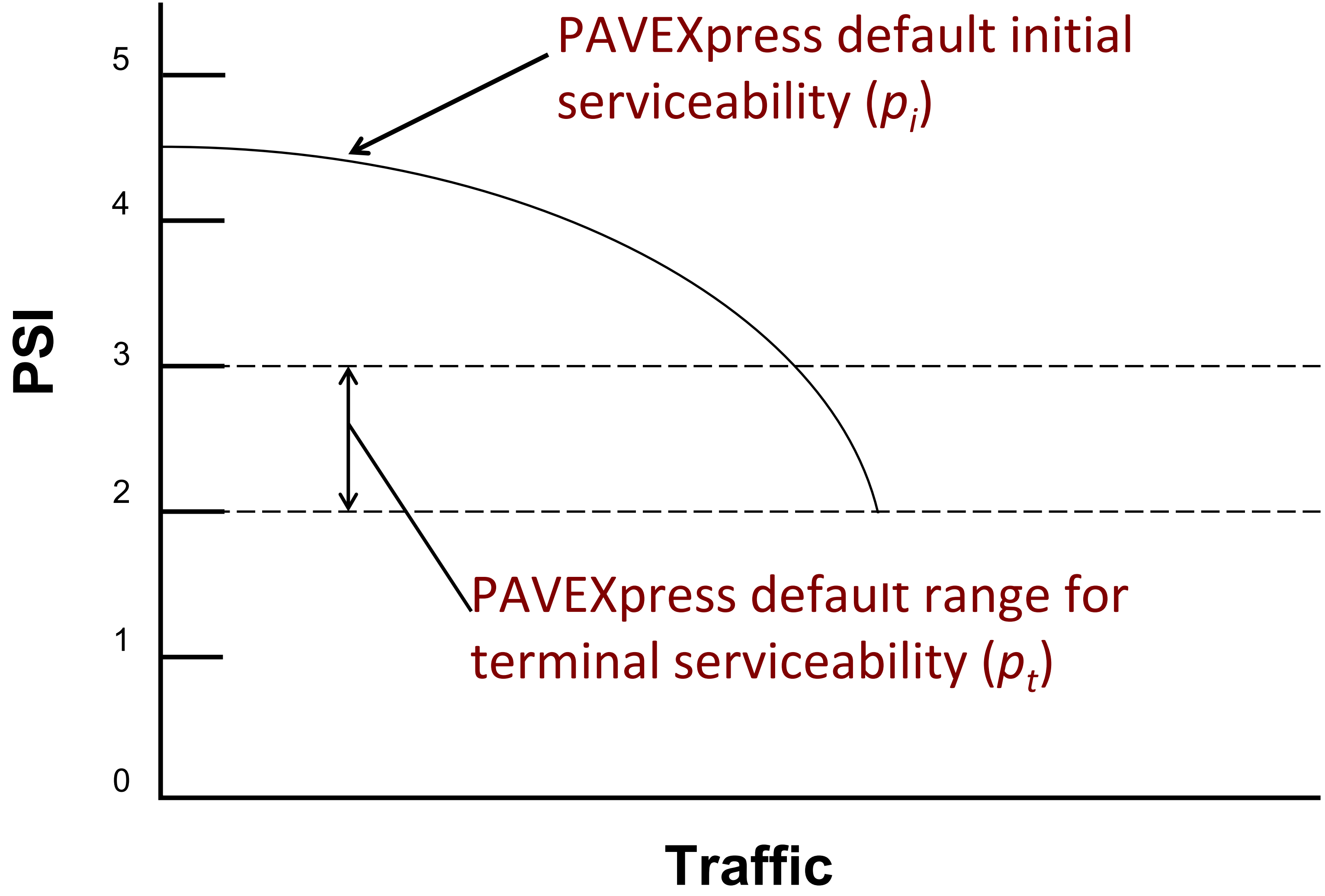
Important Design Parameters

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



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:

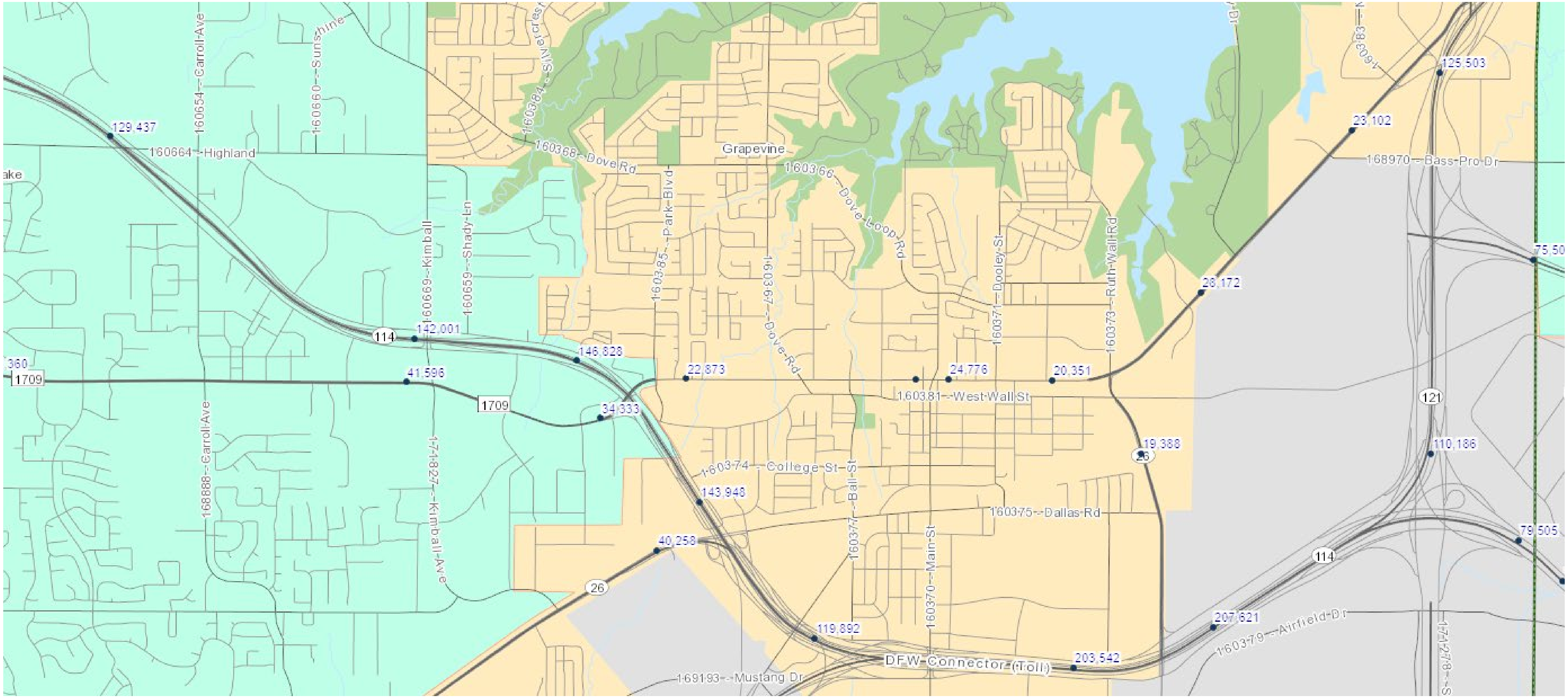
- **Annual Average Daily Traffic** – includes load equivalency factor (from traffic type by percentage), design period in years, estimated future traffic and ESAL growth rate
- **Annual ESALs** – includes design period and ESAL growth rate
- **Design ESALs** – direct input of design ESALs

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".

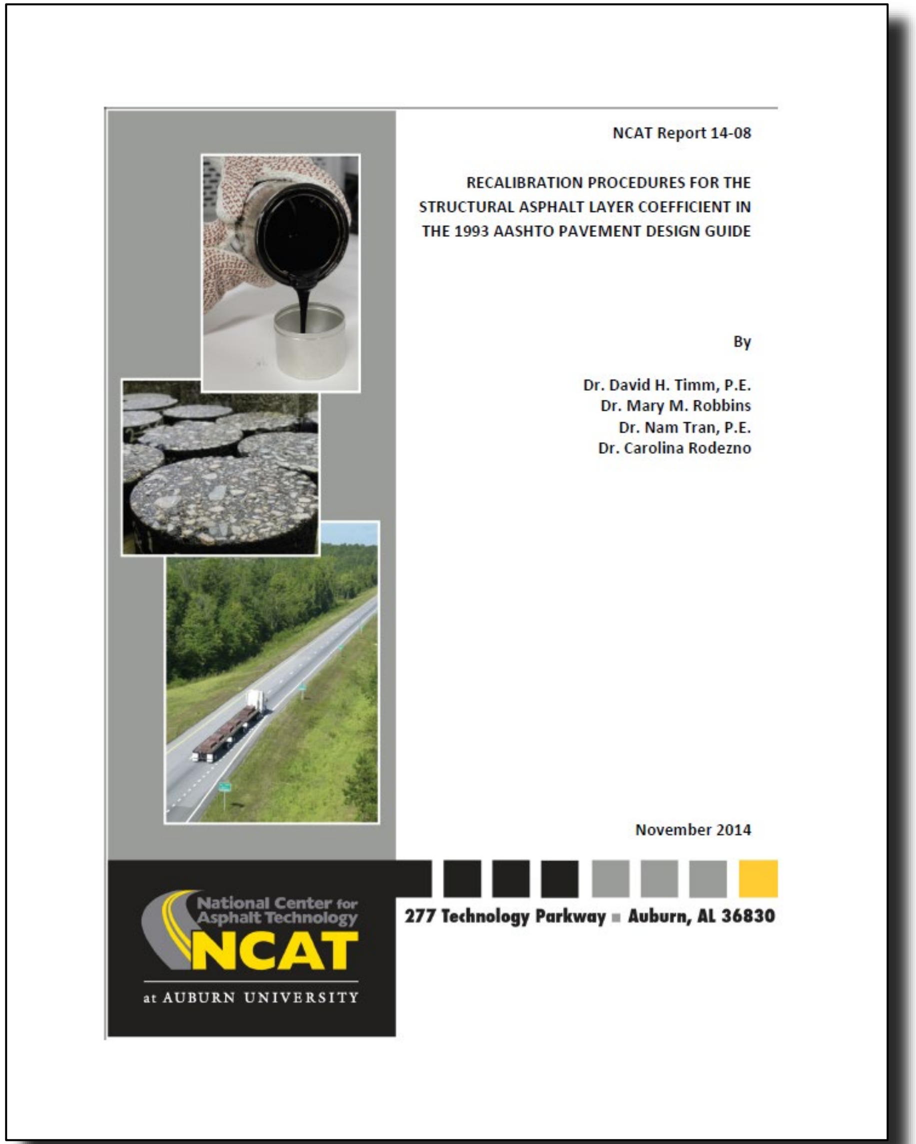
Layer Coefficient Considerations

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.

More recent studies at the NCAT Test Track found that for Alabama, an asphalt layer coefficient of 0.54 better reflected actual performance. Higher assumed layer coefficients result in thinner pavement sections. Use 0.44 unless data using local materials indicates otherwise.



NCAT Report 14-08

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

By

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Dr. Mary M. Robbins
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November 2014

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

277 Technology Parkway ▪ Auburn, AL 36830

Adding an Aggregate Base Layer

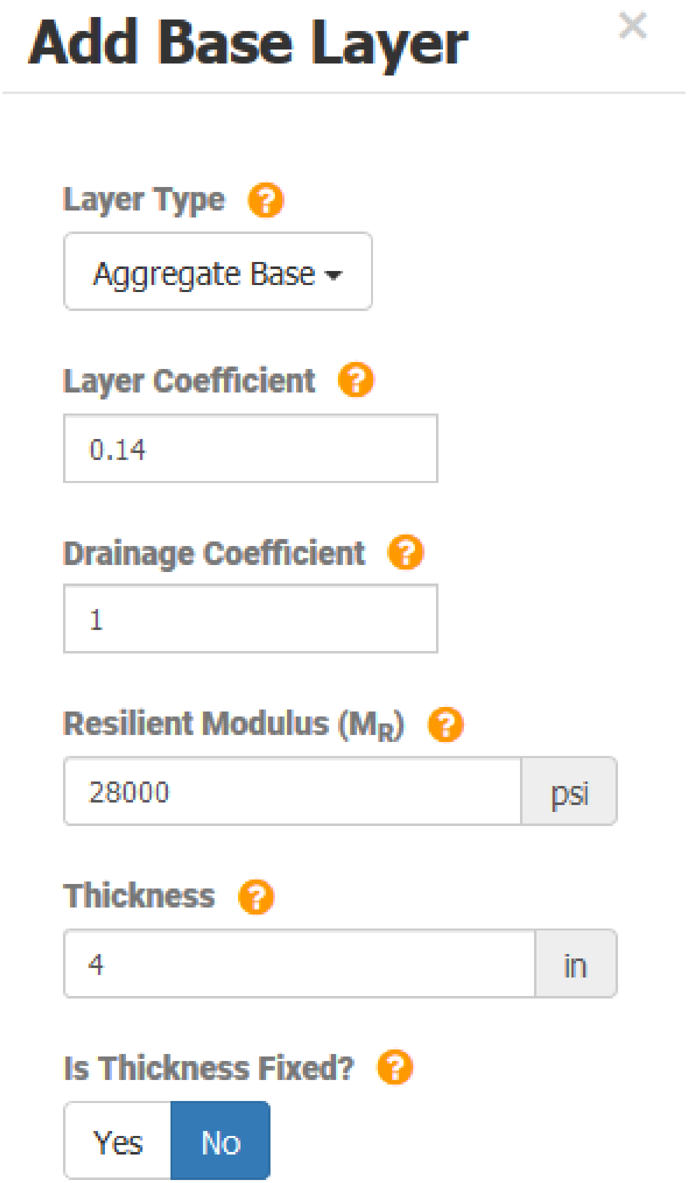
The designer can add an aggregate base layer (or any other type of base or subbase layer) here.

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 for aggregate bases are:

4″ < 500,000 ESALs
6″ > 500,000 ESALs



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:

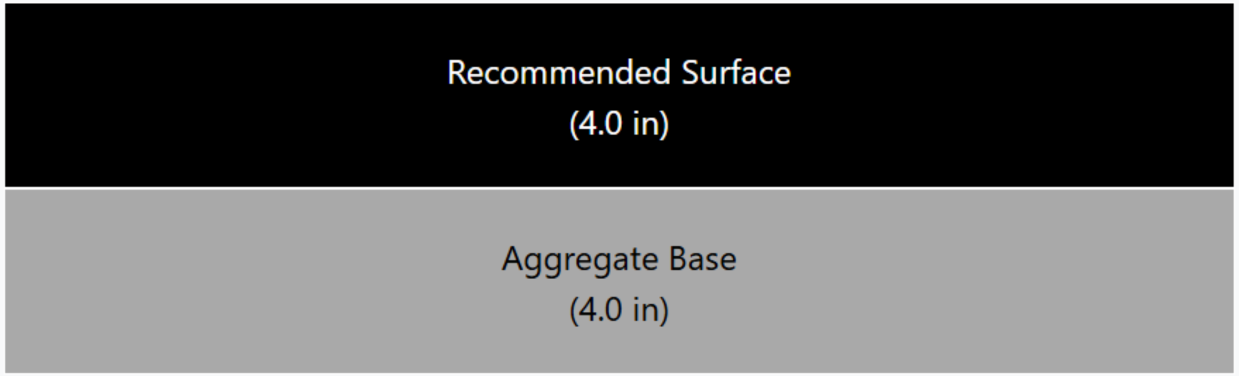
Relative Quality	*R*-Value	California Bearing Ratio	Resilient Modulus (psi)
Good to Excellent	43	17	25,000
Medium	20	8	12,000
Poor	6	3	4,500

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

Results

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

Pavement Diagram



Required minimum design SN: 2.30

Layer Thicknesses (in)

Recommended Surface: 4.0 in

Aggregate Base: 4.0 in

Total SN: 2.32

Print

Details

Scenario: New Asphalt Pavement Design

Created By: Danny Gierhart, dgierhart@asphaltinstitute.org

Last Modified: April 20, 2025 5:46:39 pm

Design Parameters

Design Period: 20 years

Layers

Recommended Surface - Asphalt

Thickness: 4 in

Aggregate Base - Base

Thickness: 4 in

Structural Coefficient: 0.14

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.

Example Aggregate base / No Aggregate Base Comparison

Traffic (ESALs)	Subgrade Modulus (psi)					
	5,000		10,000		15,000	
	6” Agg	No Agg.	6” Agg	No Agg.	6” Agg	No Agg.
150,000	4.5”	6.5”	3.5”	5.0”	3.5”	4.5”
200,000	4.5”	6.5”	3.5”	5.0”	3.5”	4.5”
250,000	5.0”	7.0”	3.5”	5.5”	3.5”	4.5”
300,000	5.0”	7.0”	4.0”	5.5”	4.0”	5.0”
350,000	5.5”	7.0”	4.0”	5.5”	4.0”	5.0”

Another important consideration: Drainage

Water will try to find its way into the pavement structure through precipitation. How do we try to prevent it?

Roadway geometry

- crown *(typically 2% slope [1/4" / foot]; need minimum of 1% slope)*
- superelevation around curves
- properly maintained drainage (curb & gutter, drainage ditches, etc.)

Impermeability

- impermeable asphalt mixtures
- building good quality joints
- properly sealing cracks

Another important consideration: Drainage

Other options:

- edge drains and underdrains *(only effective if maintained)*
- intentionally porous pavement with stone recharge bed (see video)

Another important consideration: Drainage

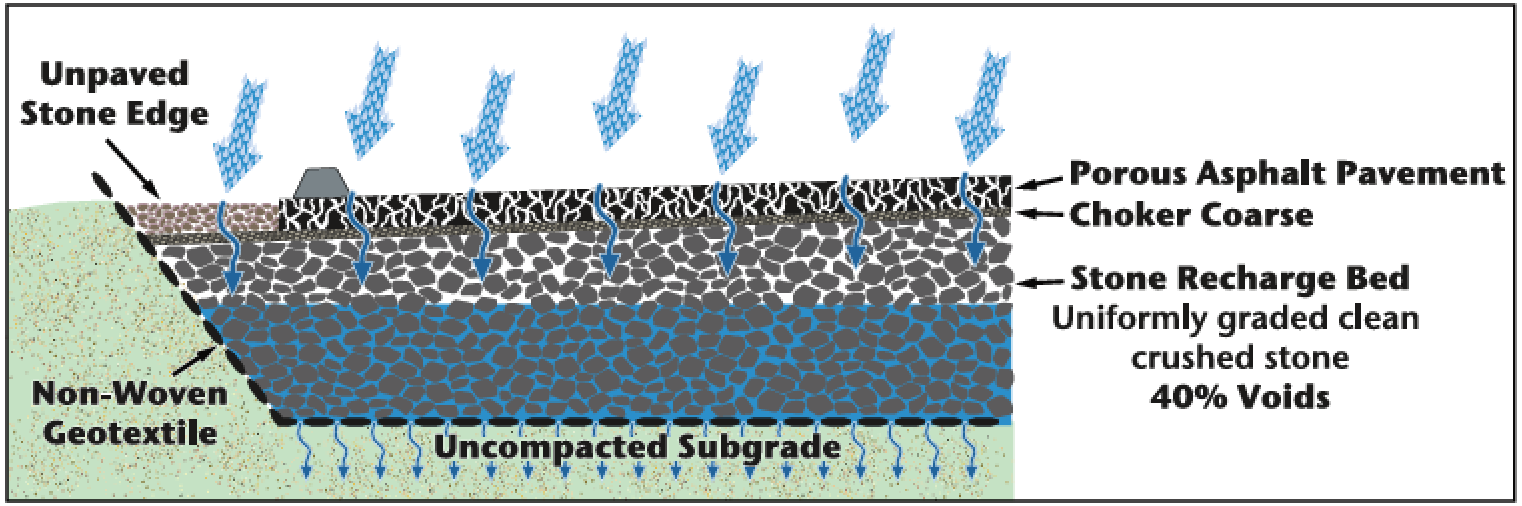
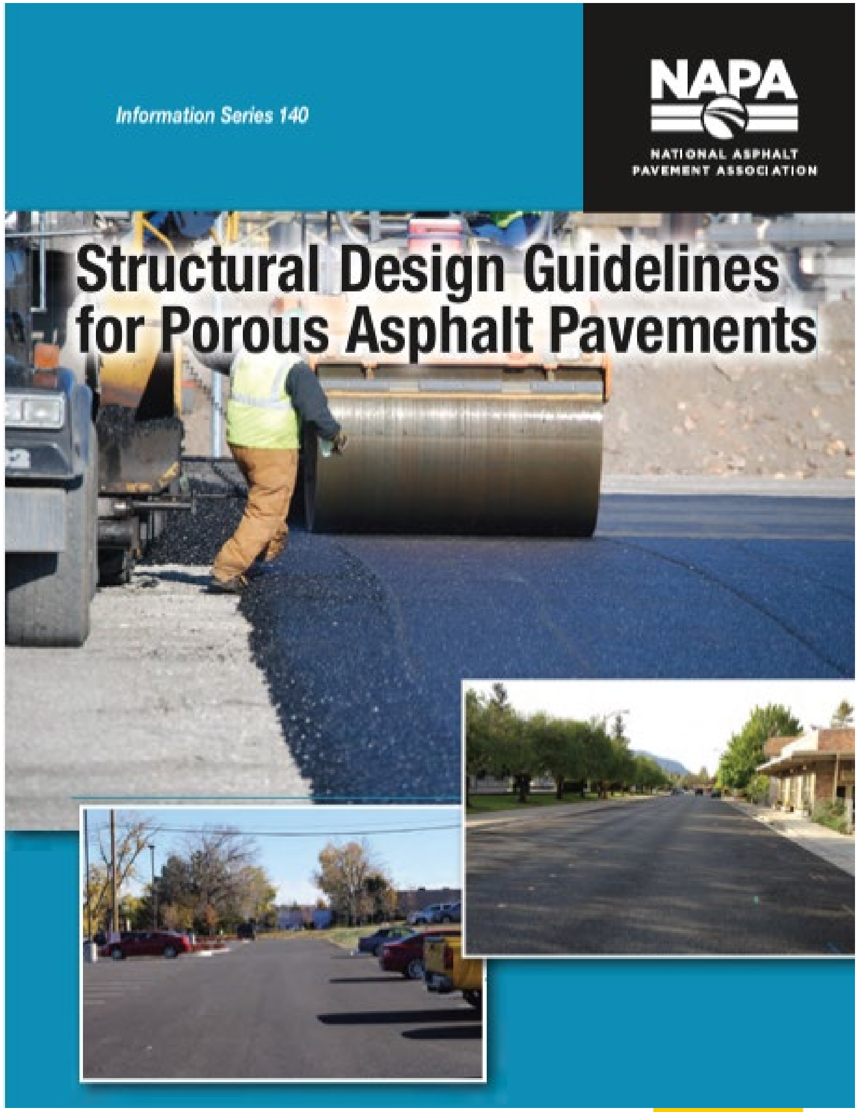


Figure 1. Typical cross-section of a porous asphalt pavement



Need to Consider Longitudinal Joint Design and Construction:

typically the weakest part of a pavement structure

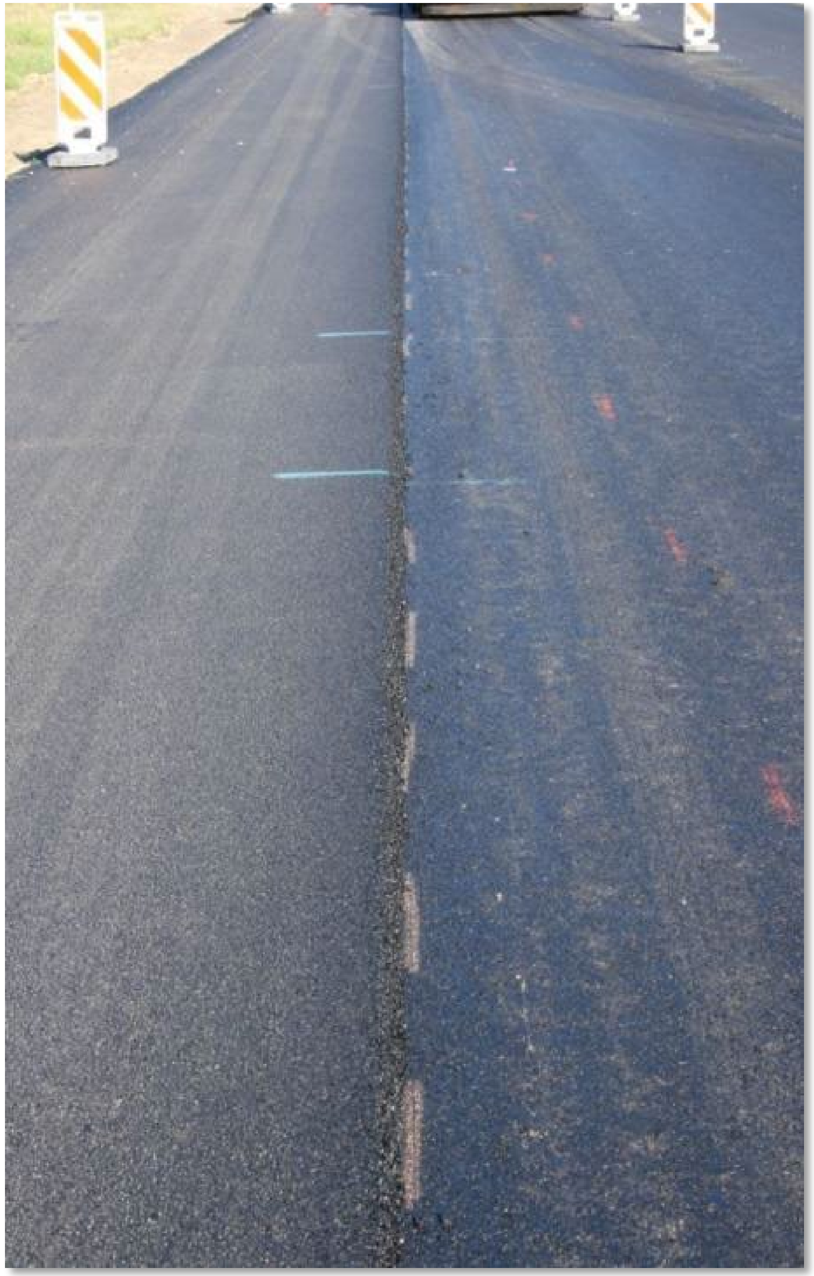


Photo: Carlos Rosenberger

Note how good the rest of the lanes look; only the longitudinal joint is in bad shape

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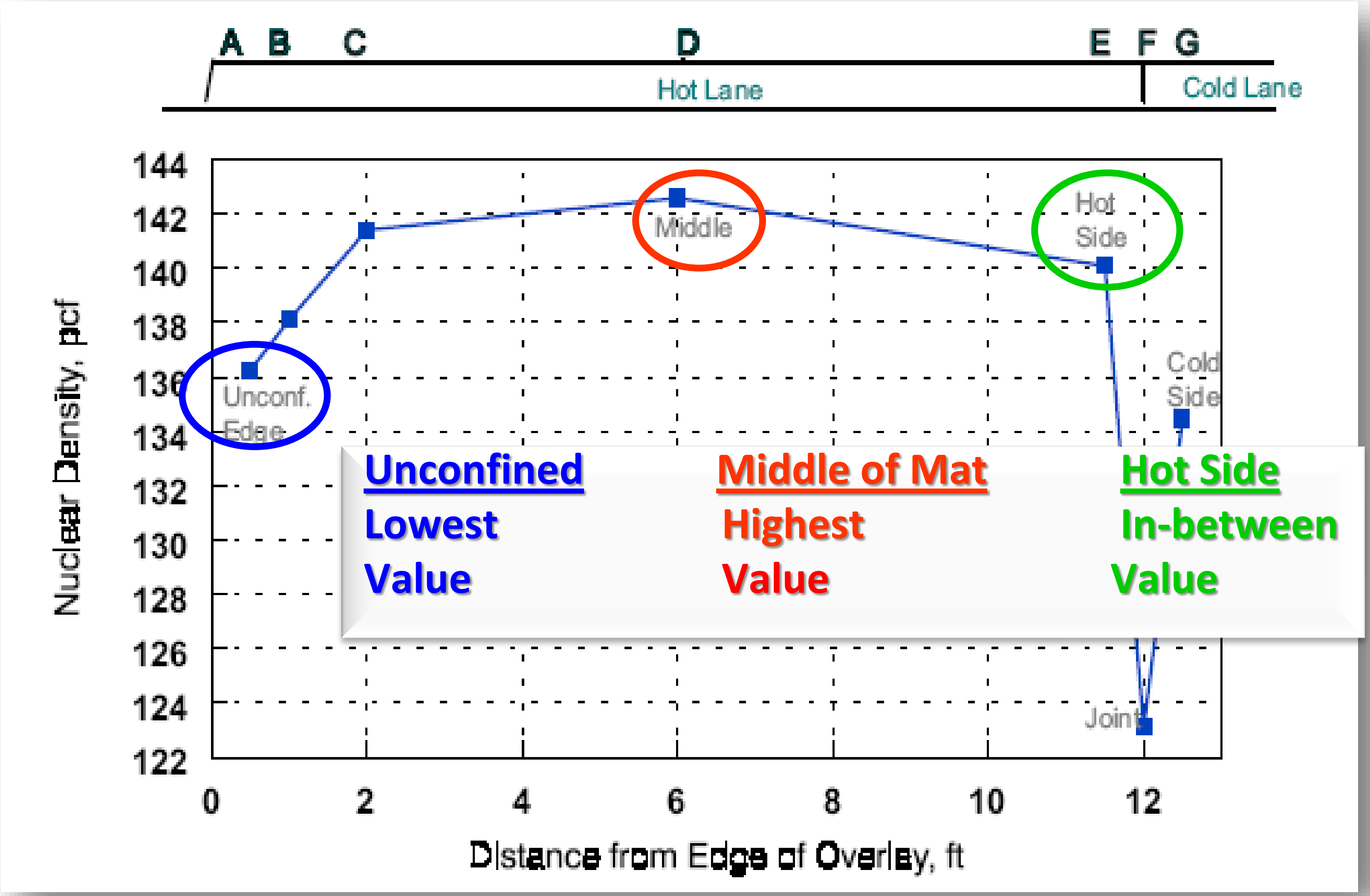
Longitudinal Joints Are An Agency and Industry Concern

Longevity is very important - it impacts:

- DOT Program Costs
- Asphalt Industry's Livelihood
  - LCCA
  - Alternate Bid Competitiveness
- Traveling Public
  - "…Stay Out"

Typical Nuclear Density Profile

Texas Transportation Institute Study



Terms:

Hot side
Confined side
Supported side

Cold side
Unconfined side
Unsupported sid

New construction in Oklahoma back in 2003 - not yet opened to traffic.

Permeable at the Longitudinal Joint several days after a rain event

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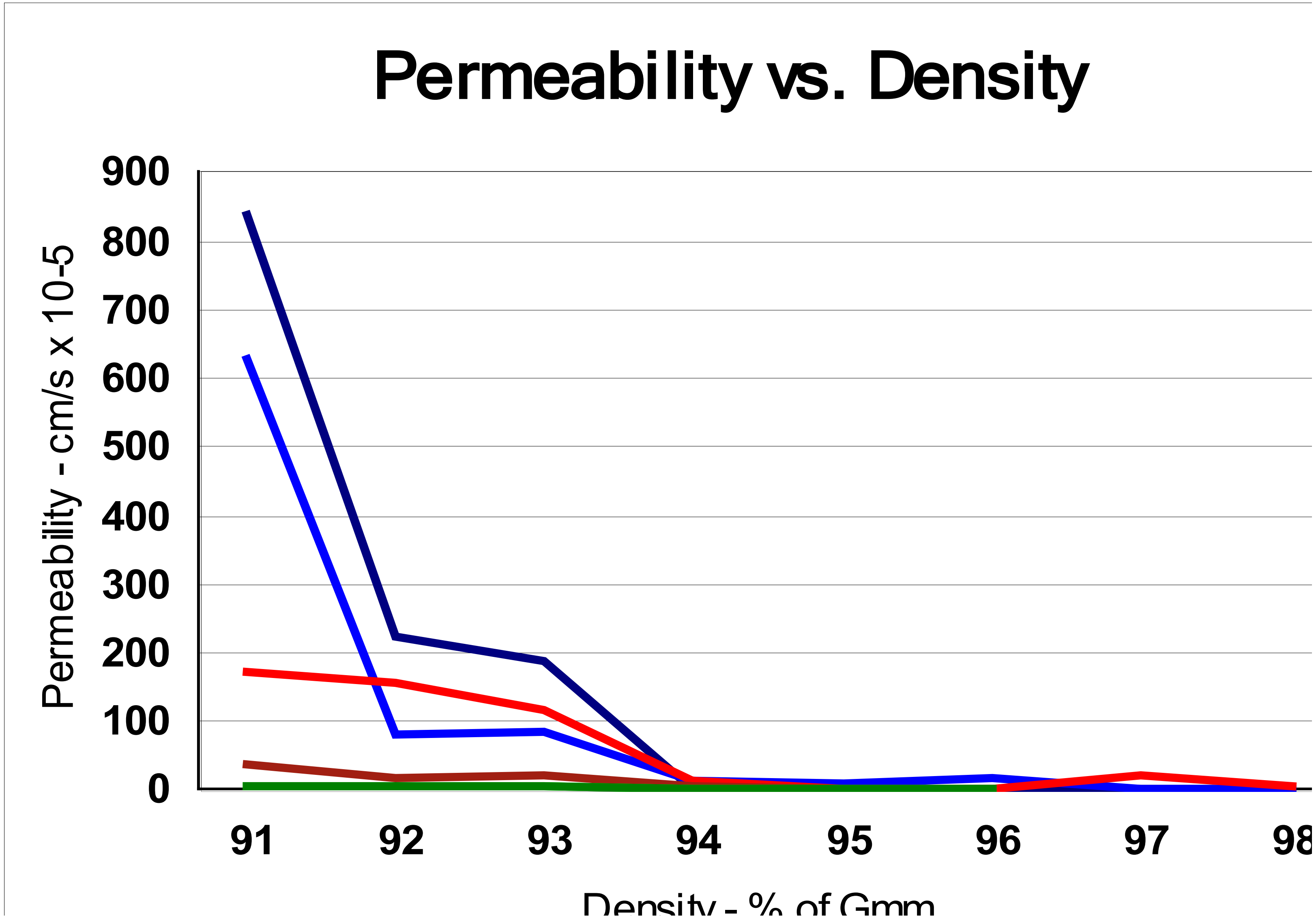
25.0 mm Superpave Mixtures



Mix # 1
(coarsest possible)

Mix # 6
(finest possible)

Gierhart - 2003

Danny Gierhart photo

The Best Longitudinal Joint:
Echelon Paving

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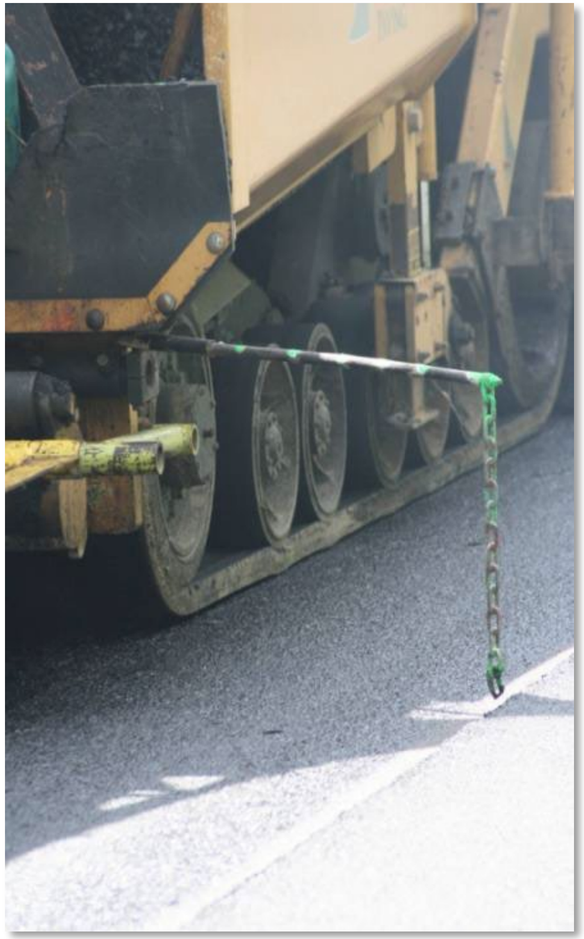
Echelon Paving Longitudinal Joint

Joint passes between the quarters

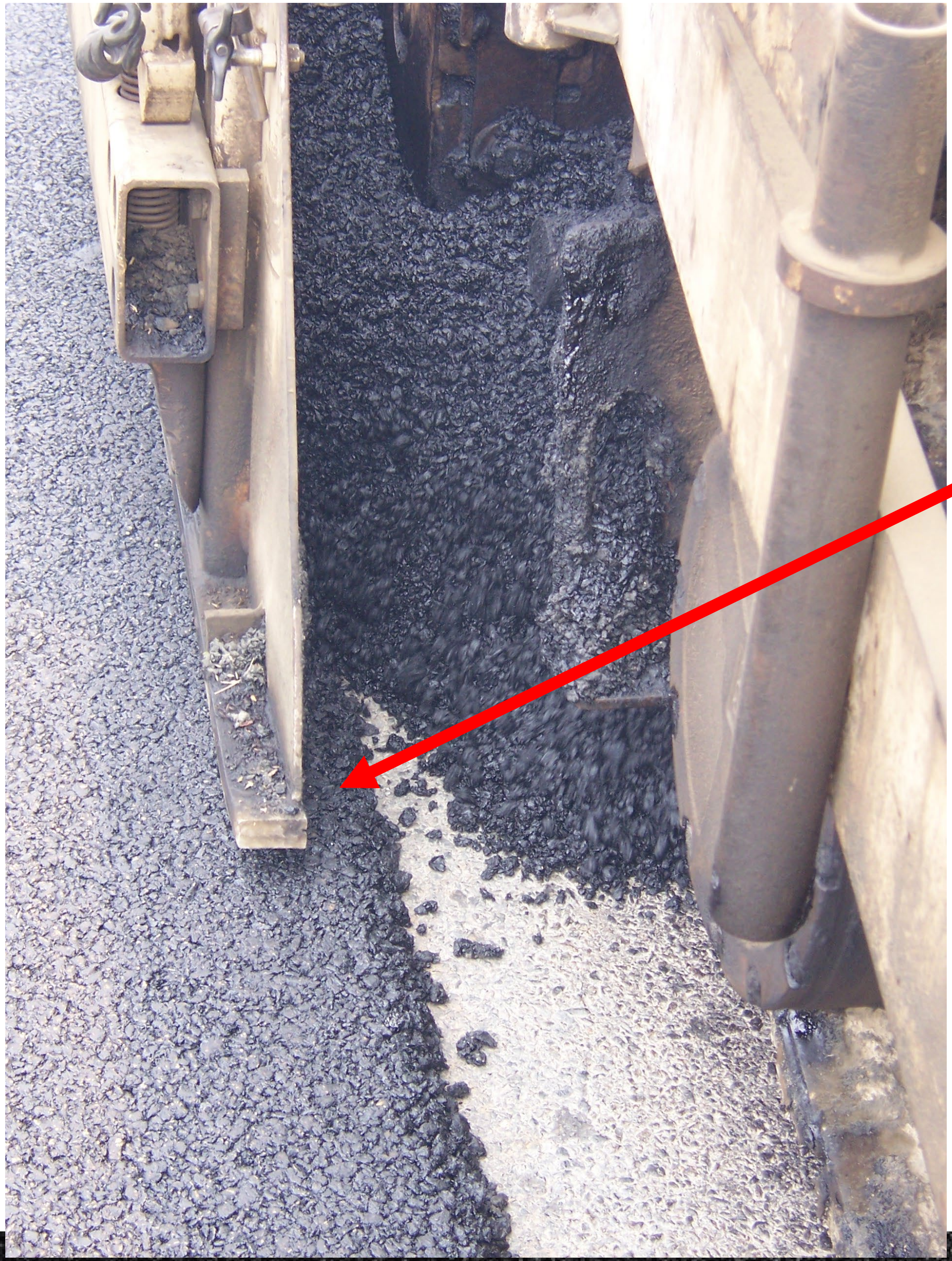
Tack Coat

Tack past full width of mat to provide confinement, minimize lateral movement of unsupported edge

First Pass Must Be Straight!



Stringline for reference, and/or skip paint, guide for following



Proper Overlap:

- 1.0 ± 0.5 inches
- Exception: Milled or sawed joint should be 0.5 inches

All Photos show Bottom of Lift

(Note voids in top two from no overlap)

Core #2 (No Overlap)

Core #7 (No Overlap)

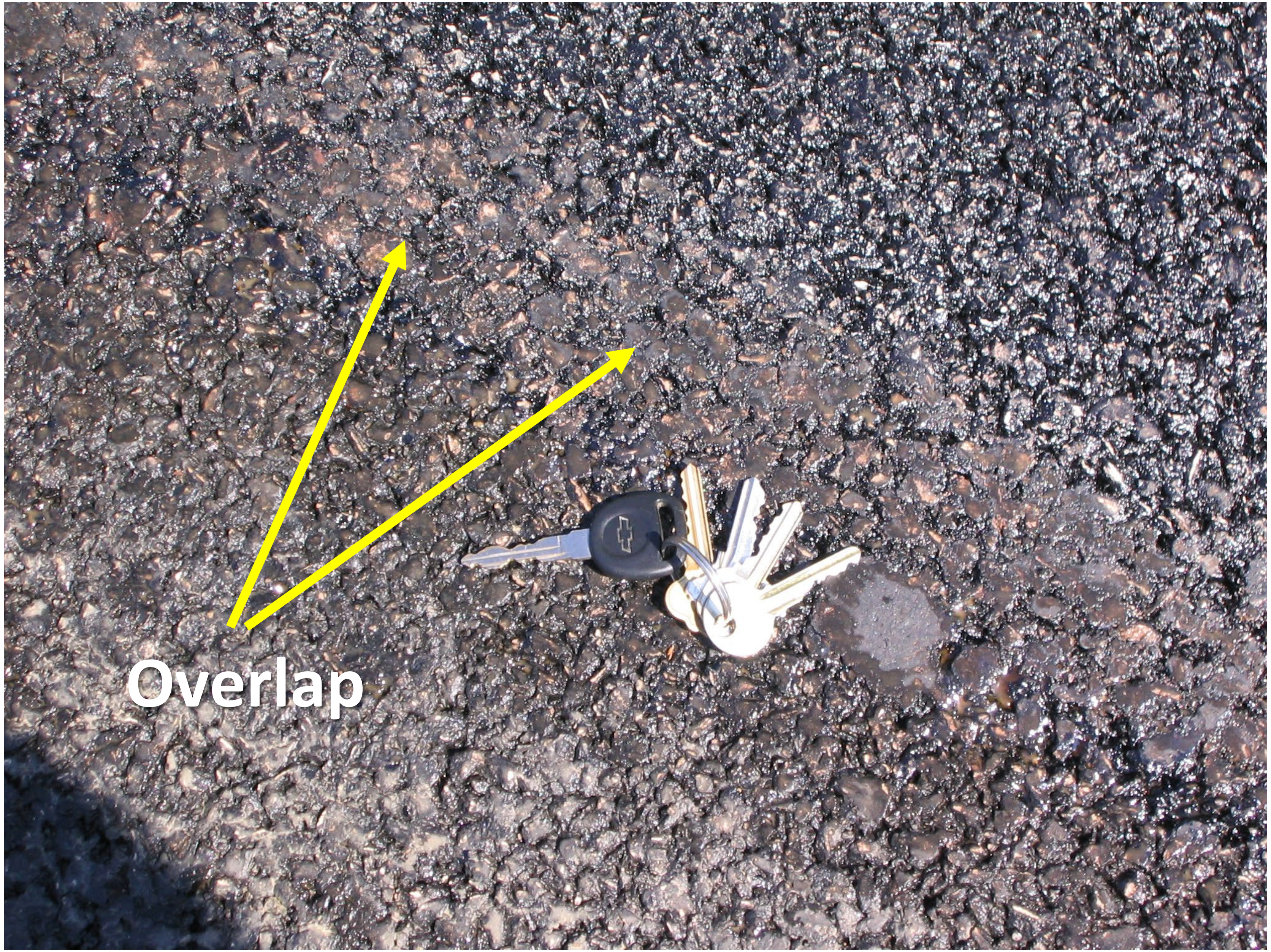
Core #9 (Overlap 1 ½”)

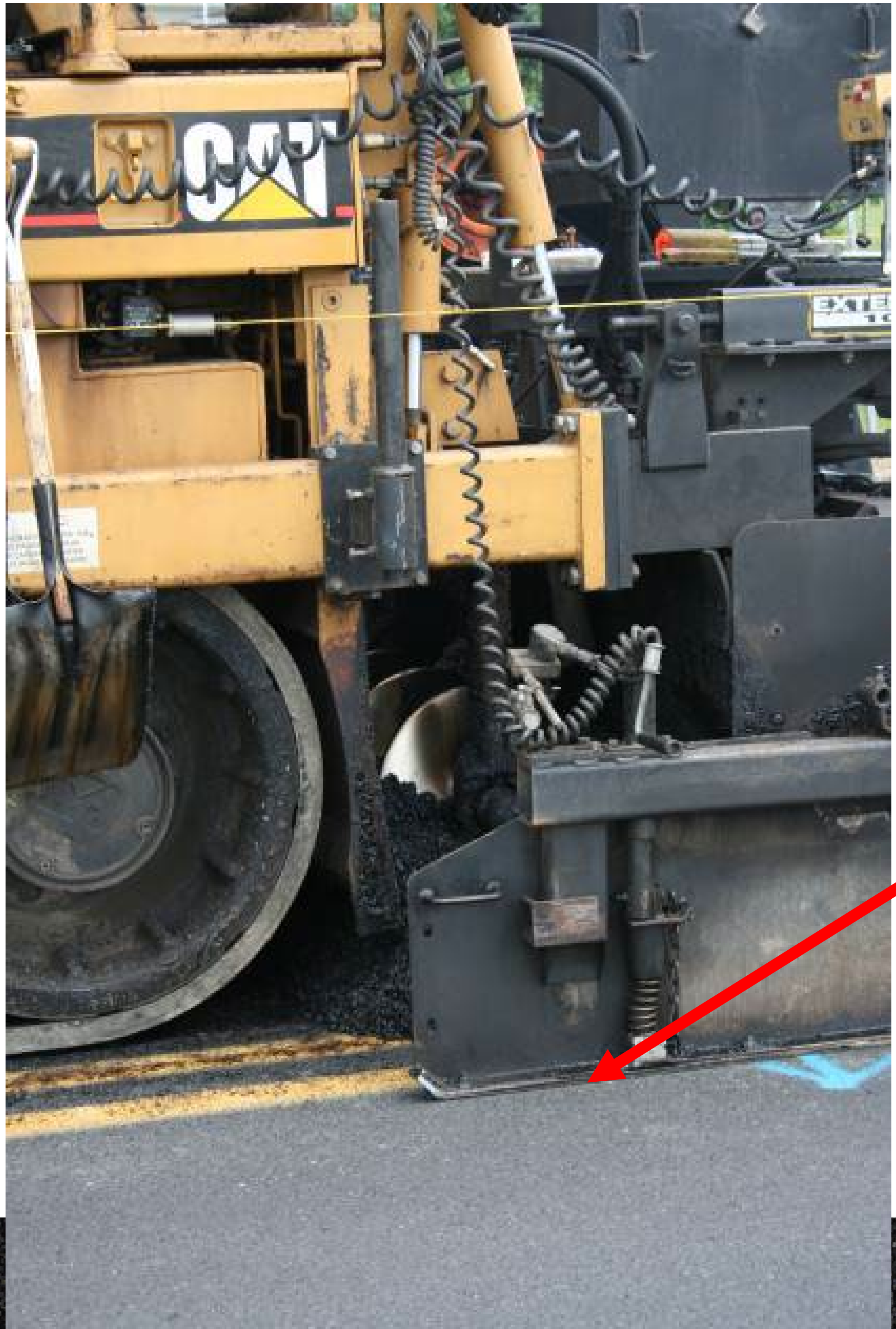
Core #10 (Overlap 1 ½”)

Photo: Bridenbaugh & Colella

Overlapped joint not as pretty, but will perform much better!

(Crushed aggregate on surface will sluff off and leave great joint)



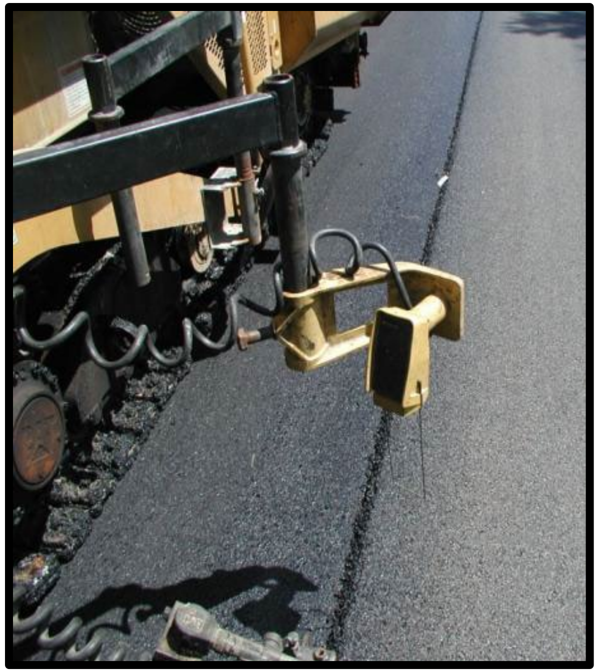


End Gate Should Be Seated Flat on the Existing Surface

Not riding on top of lift

When Closing Joint, Set Paver Automation to Never Starve the Joint of Material

- **Target final height difference of +0.1" on hot-side versus cold side**
  - **NH spec requires 1/8" higher**
- **Joint Matcher (versus Ski) is best option to ensure placing exact amount of material needed**
- **If hot-side is starved, roller drum will "bridge" onto cold mat and no further densification occurs at joint**



Do NOT Rake Across the Joint

(starves material at joint)

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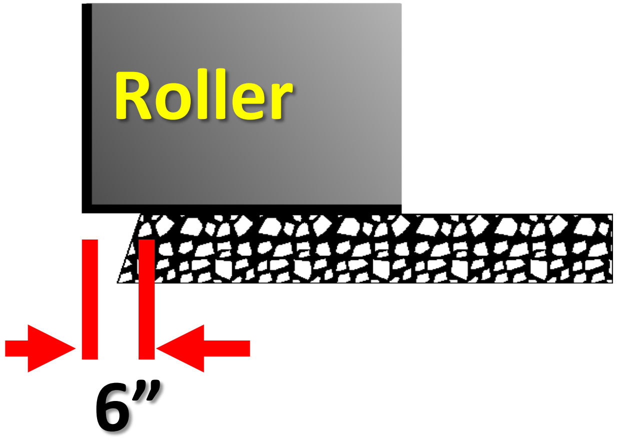
Rolling Unconfined Side?

opinions split 50-50 on where to put 1st pass

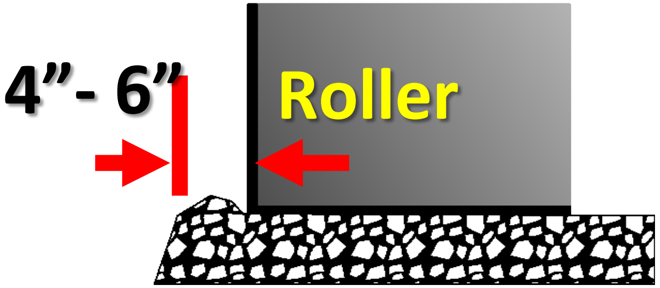
Option 1

Hang over 4-6"

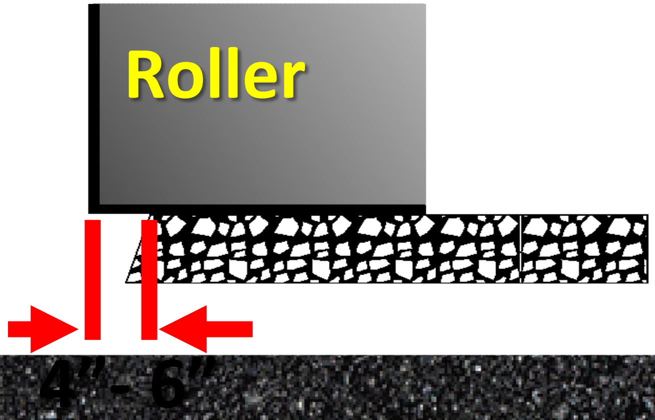


Option 2

1st Pass 4"-6" inside



2nd Pass hang over 4"-6"

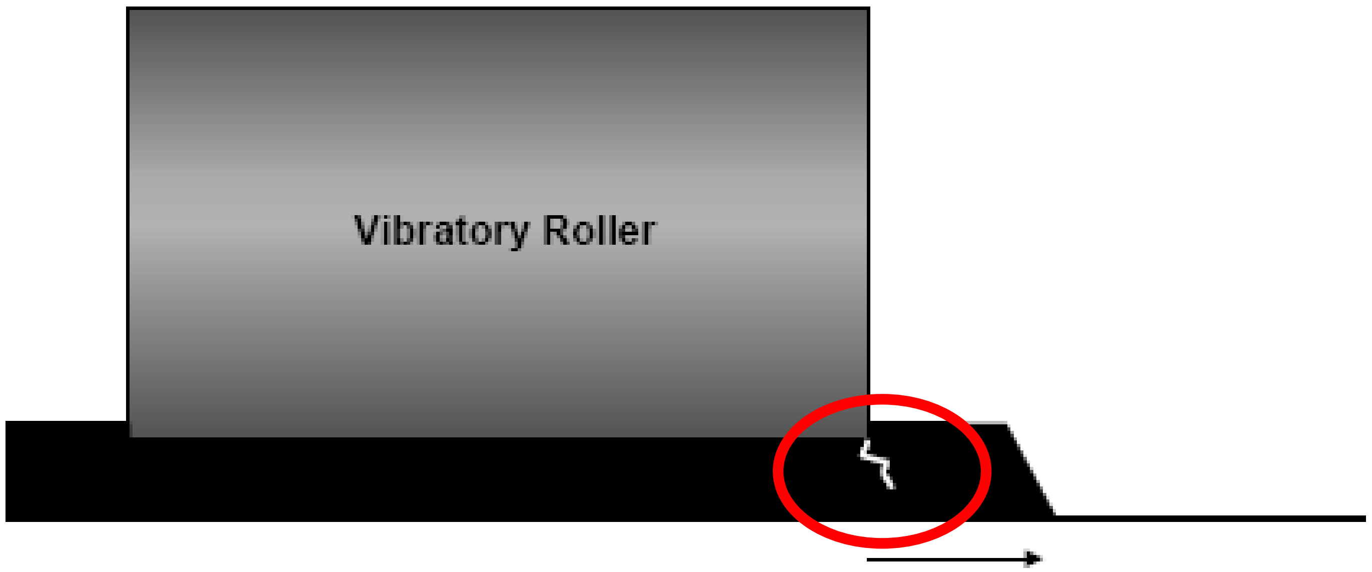


What We Don't Want

Figure 4

Rolling Uncompacted Edge

(First Paver Pass)



Edge of drum inside unsupported edge

Can cause cracking near the edge and lateral mix movement at the unsupported edge

Rolling the Supported Edge

Asphalt Institute Recommendation:

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OTHER OPTIONS

- Mill & Pave One Lane at a Time
- Cut Back joint
- Joint Heaters
- Joint Adhesives (hot rubberized asphalt)
- Surface Sealers Over Joint
- Rubber Tire Rollers
- Warm Mix Asphalt
- Intelligent Compaction

GOAL

14-year-old surface, incredible long-term joint performance

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QUESTIONS?