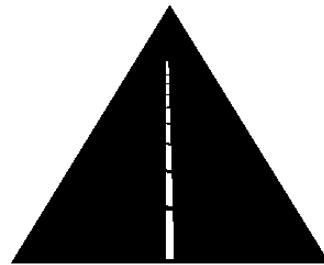


Using Perpetual Pavement Concepts

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Goals:

- Understand how you could apply perpetual pavement concepts without the complicated analysis
- Not a substitute for pavement design
- Improve the crack resistance of pavements

A perpetual pavement is a pavement that _____.



Pavement Design Evolution

Pre-1960s: Experience

1962 – 1993: AASHTO Pavement Design Guide

- **Empirical: Based on performance of Illinois test track from 1958 – 1960**
- **Limitations: soil; climate; asphalt; max thickness 6 inches; loading**
- **Design Limitations: more traffic = more thickness**




PaveXpress

- Free online tool based on the AASHTO 1993 guide and 1998 supplement.




PaveXpress

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Check out PaveXpress
A simplified pavement design tool for flexible and rigid pavements using AASHTO 93/98.

-  Pavement design using AASHTO 93/98
-  Pavement design for engineers and students
-  Pavement design for project scoping

Introduction

Welcome to PaveXpress, a scoping tool to help you create simplified pavement designs while taking into account key engineering inputs.

Resources

PaveXpress includes access to resources such as design guides from state DOTs and industry associations so you can build formal designs from its simple recommendations.

[View Resources](#)

Get Started

Click on the button below to launch the PaveXpress Scoping Tool and start creating your own designs, with options for both flexible and rigid pavement construction.

[Launch](#)

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Pavement Design Evolution

1990s: Mechanistic-Empirical Design

Mechanistic modeling

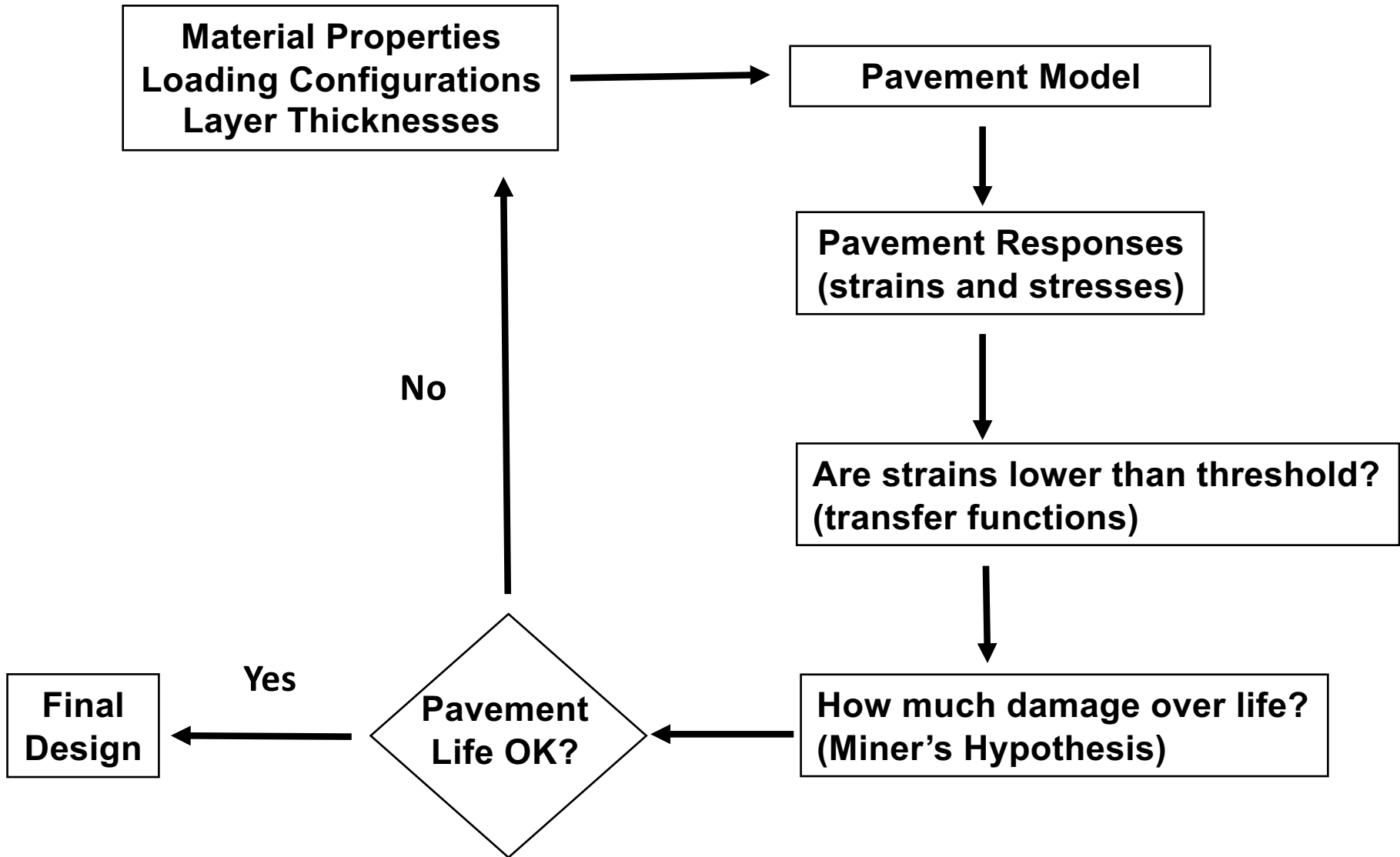
Empirical performance

Damage accumulation

Design assessment



M-E Design



M-E Design Software

The screenshot shows the AASHTOWare website interface. At the top left is the AASHTOWare logo with the AASHTO logo below it. A navigation menu includes links for About AASHTO, Bookstore, Software, Meetings, Committees, Programs, Newsroom, and Resources. A search bar is located to the right of the menu. On the left side, there is a vertical menu with categories: About AASHTOWare (Catalog, Software Accessibility, Software Requests, Standards and Guidelines, Task Force Resources, Public Downloads, Contact Us, What's New, Latest News), Project Solicitations (RFPs/RFIs, FAQ), Sign In, and Register. Below this is a video player showing a construction site with a play button and text: "50 States, Washington D.C., Puerto Rico & Canadian Provinces, 100 Consulting Firms". The main content area features five software icons: Pr Project, Br Bridge, Pv Pavement, Sa Safety, and Rw Right of Way. The "Pv Pavement" icon is highlighted with a red triangle. Below the icons, the "Pv Pavement" software is featured with a large red heading "Pavement" and a sub-heading "For state-of-the-art pavement design". The text describes AASHTOWare Pavement ME Design as the next generation of pavement design software, built upon the National Cooperative Highway Research Program mechanistic-empirical pavement design guide. It highlights that the software reflects eight years of research and development involving both AASHTO members and the National Cooperative Highway Research Program (NCHRP). The text states that the research and development process and resulting software beautifully illustrate the power and effectiveness of the cooperative development practice behind all AASHTOWare products. Continuous improvement of pavement process continues under NCHRP, the Federal Highway Administration and state agencies. It notes that Pavement ME Design represents a quantum leap forward from previous processes, allowing engineers to precisely predict pavement performance because the software incorporates material mechanics, climate data, axle-load spectra and other advances. At the bottom, it provides technical support contact information: "For technical support, contact the Pavement ME Design Help Desk toll free at 1-877-500-3496 or email pavementmedesign@ara.com". On the right side, there is a red callout box with a quote from Judith Corley-Lay, State Pavement Management Engineer, North Carolina DOT: "I like it that each agency can decide for itself where to set the failure criteria. I have used the 'Optimize' function to speed the design along. It is easy and intuitive."

AASHTOWare
AASHTO

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Advisory
Training Webinars
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Pv Pavement
ME Design
AASHTO

"I like it that each agency can decide for itself where to set the failure criteria. I have used the 'Optimize' function to speed the design along. It is easy and intuitive."

Judith Corley-Lay, State Pavement Management Engineer, North Carolina DOT

For technical support, contact the Pavement ME Design Help Desk toll free at 1-877-500-3496 or email pavementmedesign@ara.com

Pavement Design Evolution

2000s: Perpetual Pavement Concept

Asphalt materials will not accumulate damage below a certain strain level



Perpetual Pavements

Will a perpetual pavement ever crack?



Perpetual Pavements

Structural Life

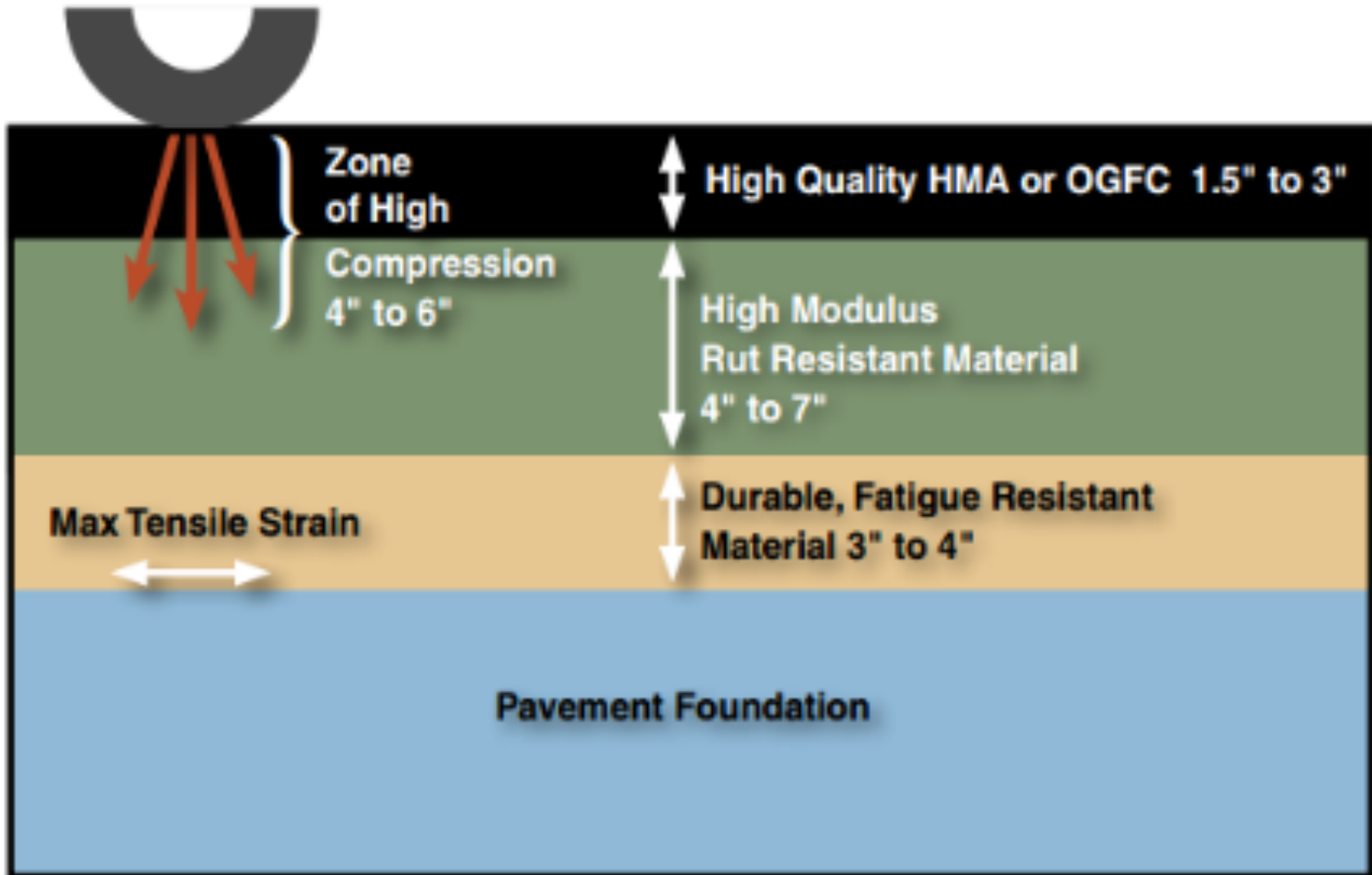
- Performance life of the underlying asphalt base, aggregate base, and subgrade.

Functional Life

- Performance life of the wearing course or surface asphalt layer.

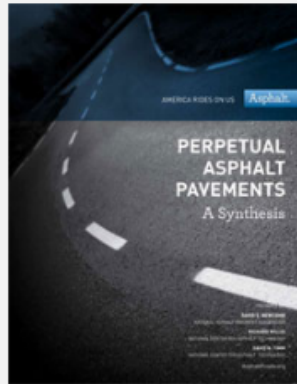


Perpetual Pavement Design



Perpetual Pavements

The Perpetual Pavement concept was first articulated in 2000 and the concept has rapidly gained acceptance.



The APA's newest technical document on the subject is [Perpetual Asphalt Pavements: A Synthesis](#). This comprehensive publication captures the activities that have taken place over the last decade, synthesizes the information in way that is useful to providing guidance for Perpetual Pavement design and construction, and provides a vision for further research and development to refine Perpetual Pavements.

Perpetual Pavement Design Software

The APA offers two versions of its software for the design and analysis of Perpetual Pavements. Both versions of the software are available as free downloads.

PerRoad 3.5

PerRoad is 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. In order to predict the strains which would prove detrimental for fatigue cracking or structural rutting, PerRoad requires the following inputs:

- Seasonal pavement moduli and annual coefficient of variation (COV)
- Seasonal resilient moduli of unbound materials and annual COV
- Thickness of bound materials and COV
- Thickness of unbound materials
- Load spectrum for traffic
- Location for pavement response analysis
- Magnitude of limiting pavement responses
- Transfer functions for pavement responses exceeding the user-specified level for accumulating damage

[Download PerRoad 3.5 now](#)

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 in response to requests by public works officials and owners of commercial property.

[Download PerRoadXpress 1.0 now](#)

Basic Concepts of Perpetual Pavements:

Design such that the endurance limit is not exceeded for expected structural distresses

- Bottom-up cracking
- Rutting

Basic Concepts of M-E Design:

Design such that the pavement structure will withstand each type of distress

- Top-down & bottom-up cracking
- IRI
- Thermal cracking
- Rutting

Apply Perpetual Pavement Concepts

Bottom-Up Fatigue Cracking

- **Caused by repeated strains accumulating damage**
- **Prevent damage accumulation by reducing strains below endurance limit**

Bottom-Up Cracking

How low do the strains need to be at the bottom of the pavement section to prevent bottom-up cracking?

Bottom-Up Cracking

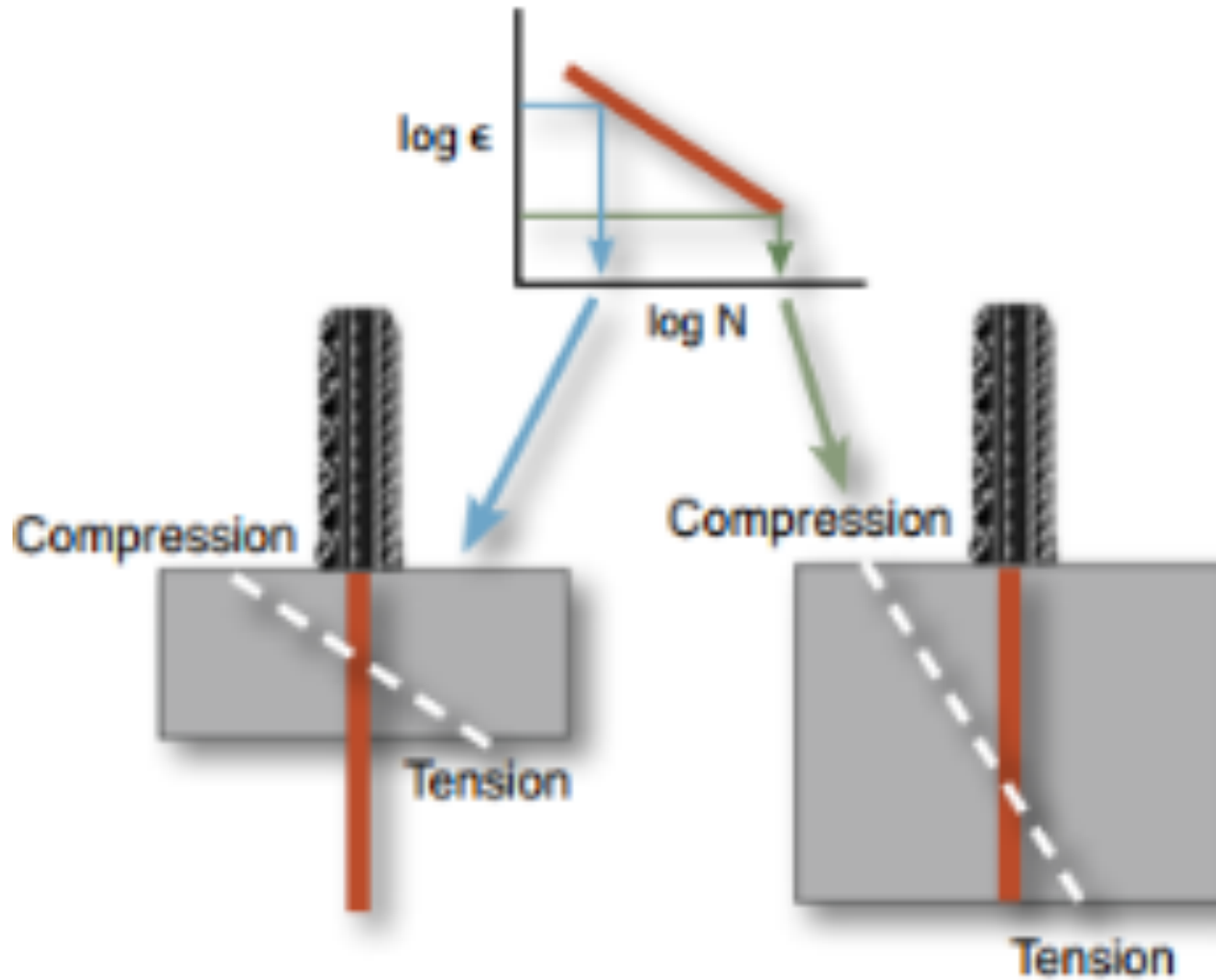
How do we make our pavement sections more resistant to bottom-up cracking?

Bottom-Up Cracking

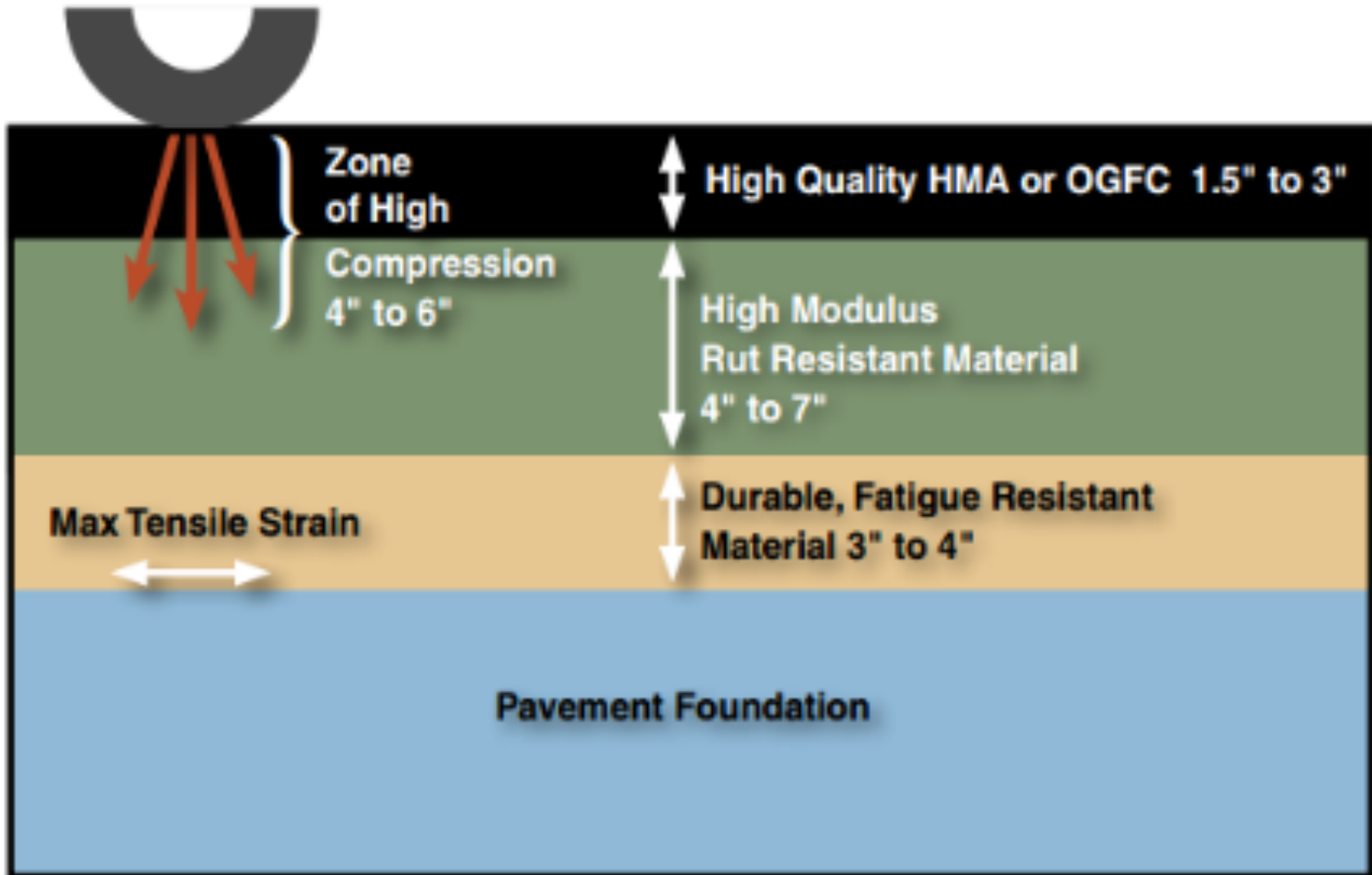
How do we make our pavement sections more resistant to bottom-up cracking?

- Increase thickness
- Increase asphalt & decrease voids in base lift

Perpetual Pavement Design



Bottom-Up Cracking



Bottom-Up Cracking

WA research shows that pavements 5-6 inches in thickness will crack top-down not bottom-up



Apply Perpetual Pavement Concepts

Top-Down Cracking

- **Caused by environmental conditions, aging/oxidation of binder, and sometimes stresses**
- **Slow by improving durability (crack resistance) of mix**

Top-Down Cracking

How can we improve the durability of asphalt pavement mixes?

- **Better Density**
- **Increase Asphalt Binder Content**
- **Use Softer Binders**

Top-Down Cracking – Increase Density

How important is density?

- Increased cracking resistance
- Reduced permeability
- Reduced rates of aging and oxidation
- Increased strength and stiffness
- Reduced potential for raveling
- Reduced rutting potential

Top-Down Cracking – Increase Density

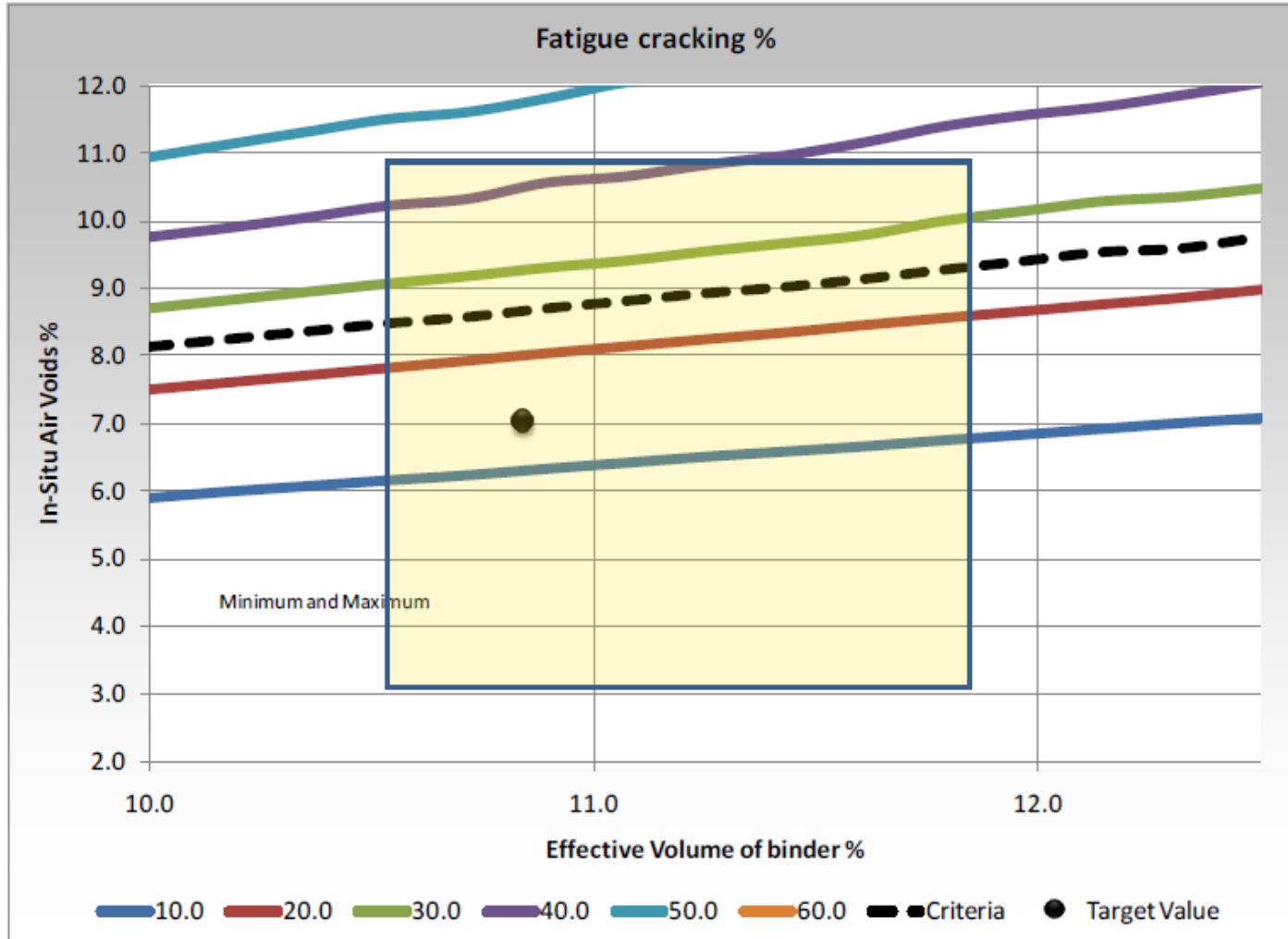
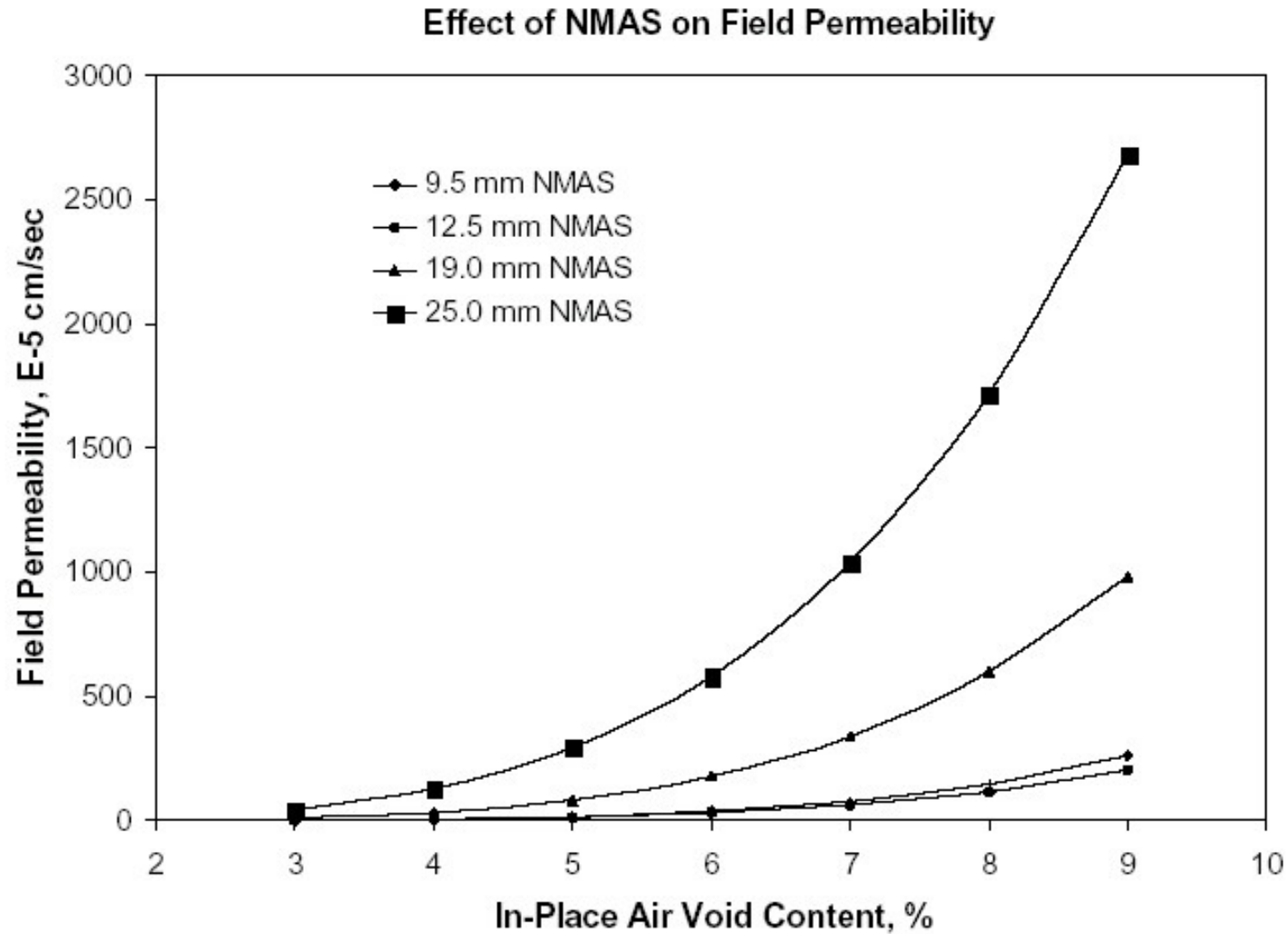


Figure 13. Output Chart for Fatigue Cracking.

Top-Down Cracking – Increase Density



Increase Density

Best performing mixes have:

96% Aggregate and binder

___% Air



Increase Density

What do we require the contractor to get?



Increase Density

Goal: Design a mix that will stabilize at 96% density after 1 to 3 years of secondary compaction.

Assumption: 4% more compaction from secondary compaction.

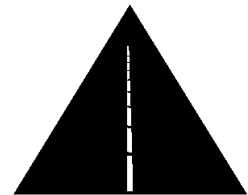
Problem: Local roads are not getting 4% secondary compaction.



Increase Density

How do we design mixes that the contractor can compact to more than 92% density?

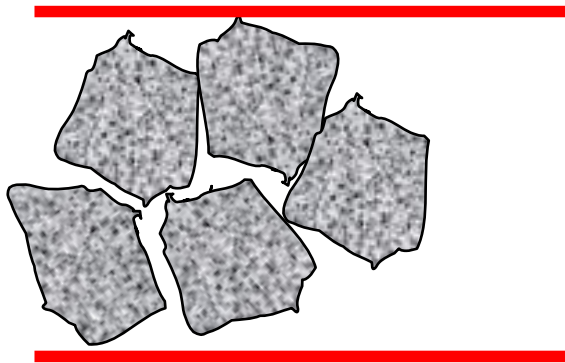
- Actually do a mix design
- Specify selecting binder content at 3.5% air voids (watch volumetrics)
- Adequate lift thicknesses relative to NMAS
- Site conditions conducive to compaction



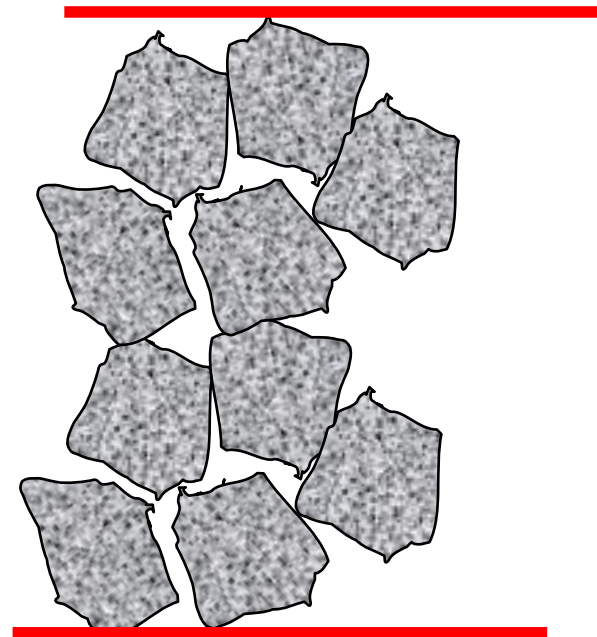
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Increase Density

Adequate Lift Thickness



Lift Thickness/NMAS = 2



Lift Thickness/NMAS = 4

Increase Density

Softer Binders

Selecting the asphalt binder grade:

- **Climate – High and Low Pavement Temp**
- **Volume of traffic**
- **Speed of traffic**
- **RAP content**



Pavement Preservation

What do we want out of a preservation treatment?

- Correct existing surface distress (cracking, rutting, raveling)
- Resist cracking
- Seal the surface
- Smoothness
- Friction
- Drainage
- Last
- Improve structural strength



Thinlays

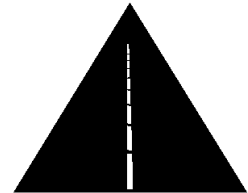
- ✓ **Correct existing surface distress (cracking, rutting, raveling)**
- ✓ **Resist cracking**
- ✓ **Seal the surface**
- ✓ **Smoothness**
- ✓ **Friction**
- ✓ **Drainage**
- ✓ **Last**
- ✓ **Improve structural strength**



Thinlays

Mix designed to resist cracking

- **NMAS =/ $<$ 1/3 lift thickness (for $\frac{3}{4}$ " lift use $\frac{1}{4}$ " NMAS mix)**
- **Binder selected to optimize crack resistance (softest binder that passes rut test), polymers for highest demand areas**
- **RAP and RAS combined with softer base binders to provide optimum value**

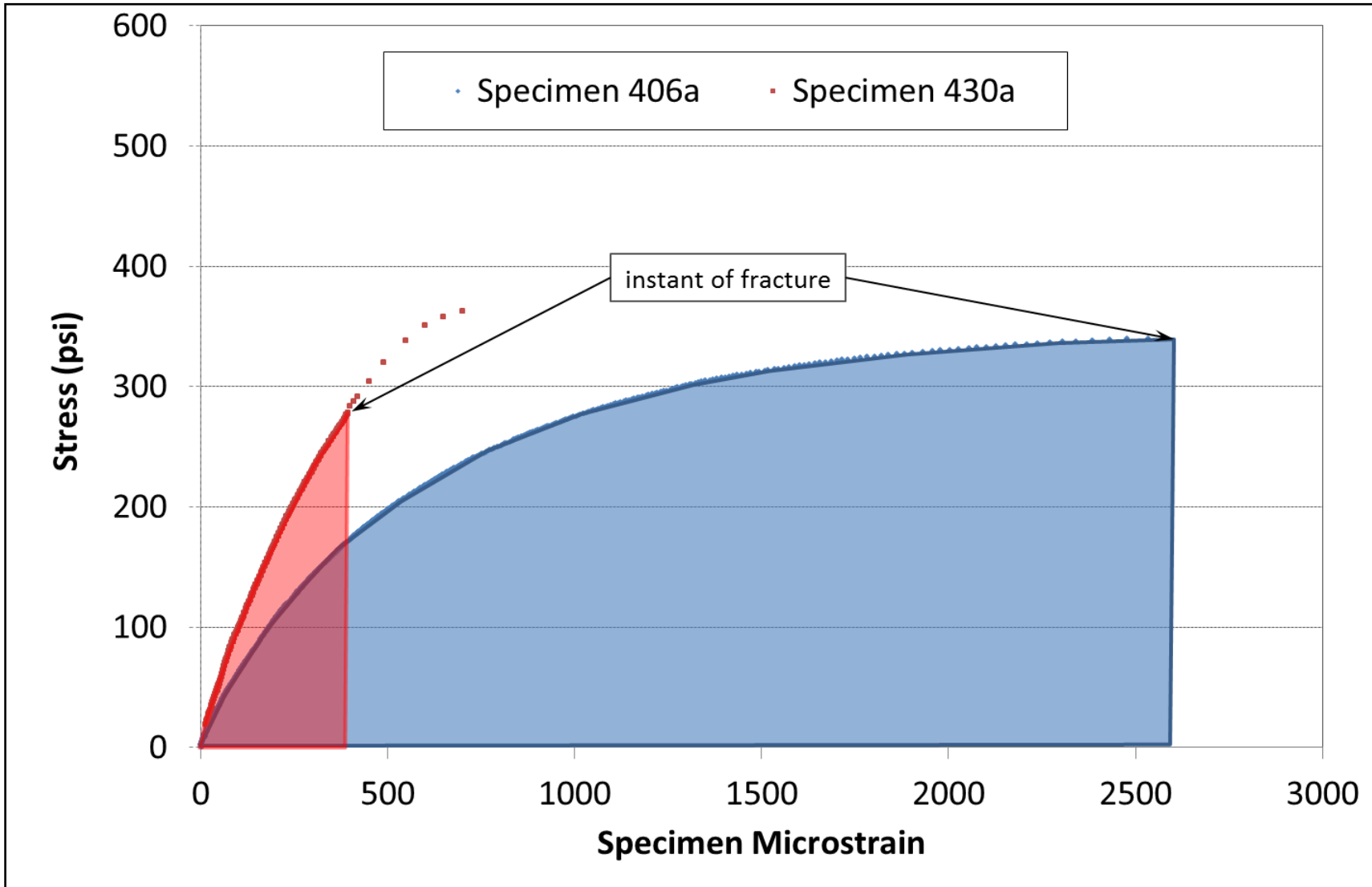


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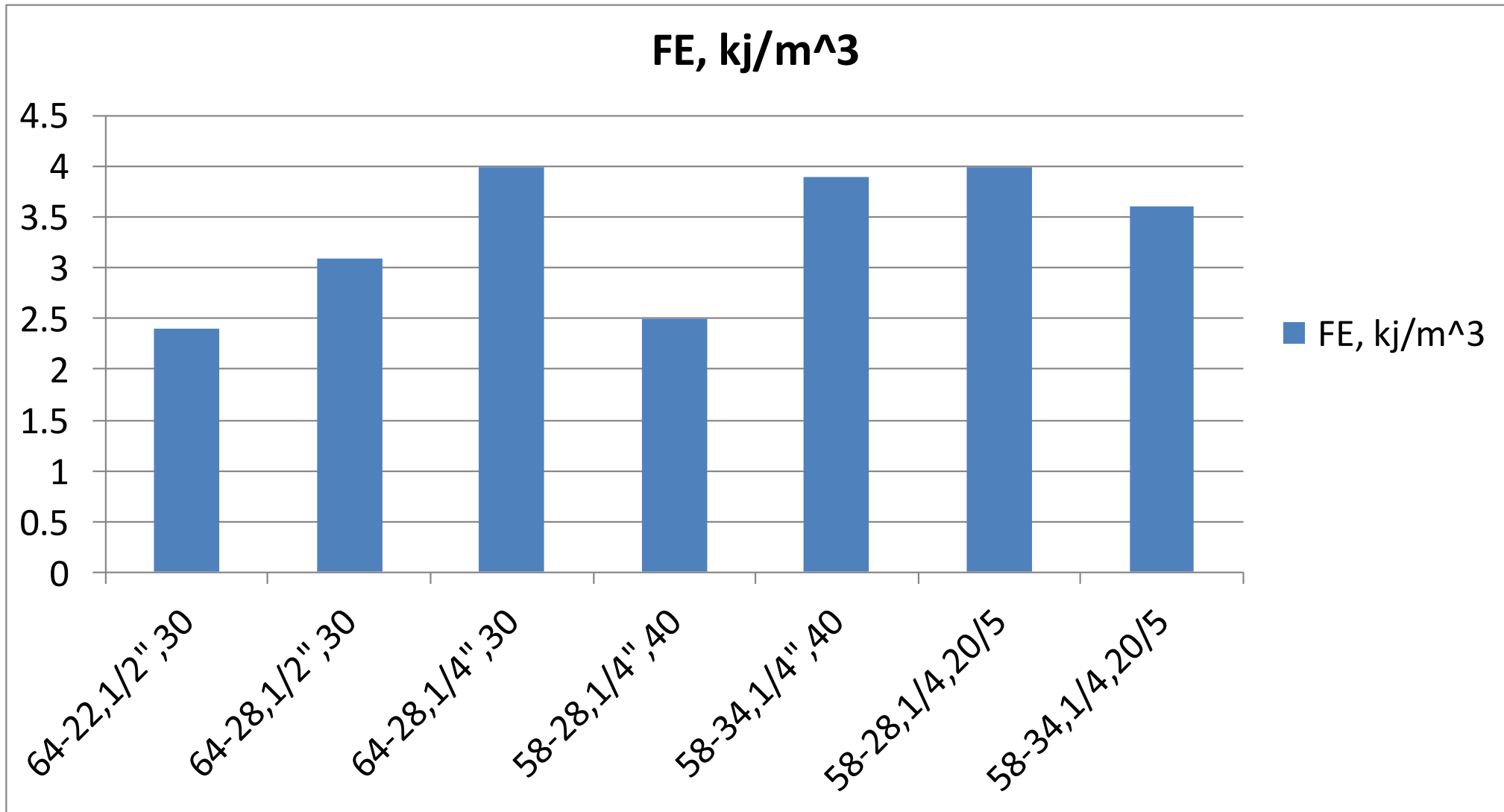
Thinlays

	L3 ½” 30% RAP	L3 ¼” 30% RAP	L3 ¼” 40% RAP	L3 ¼” 50% RAP
Pb	6.2	7.2	7.0	7.0
Pbr	5.9	7.75	7.75	7.75
Binder Grade	64-22 64-28	64-22 64-28	58-28 58-34	58-28 58-34
Binder Replaced	28.5%	32.3%	44.3%	55.4%
Overlay test results	160/430	205/365	350/605	-/65

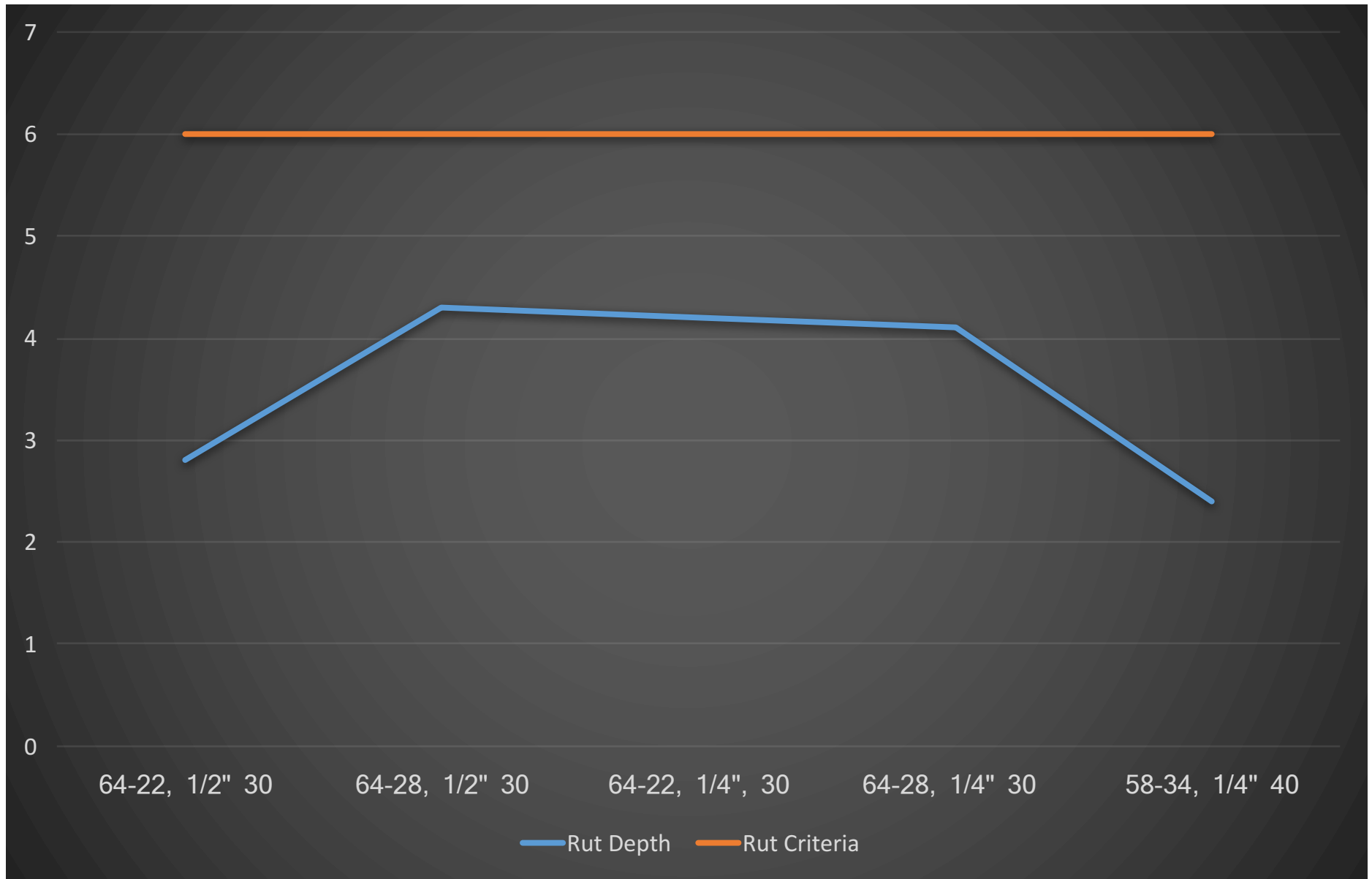
Thinlays – Fracture Energy



Thinlays – Fracture Energy



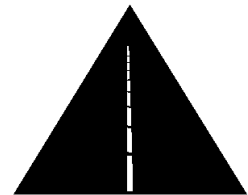
Thinlays



Thinlays

35% Binder Replacement:

- **Going one cold temperature grade lower will more than offset stiffening caused by higher recycled content**
- **Going one cold temperature grade lower will improve crack resistance 33-50% over typical Oregon mix (L3 ½-inch PG 64-22)**



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Pavement Preservation

How much of a benefit is there in an inch?

Thickness	Micro strain	Reps to failure
2	-652	30,234
3	-495	71,537
4	-383	160,693
5	-302	340,507
6	-242	682,133

Smoothness

How important is smoothness?



Smoothness

How can we design for it?

- Proper base preparation
- Milling
- Multiple lifts
- Pre-leveling
- Monitoring laydown temps and rate of cooling
- Warm mix to help compaction

Wearing Course

- Need high performance
- Lower air voids (higher compaction)
- Rut resistance
- Polymer-modified binders

Summary

Bottom-Up Crack Resistance

- Reduce strains at bottom of section
 - Increase thickness whenever possible
- Increase strain resistance at bottom of section
 - Lower base lift air voids
 - Increase base lift binder content

Summary

Top-Down Crack Resistance

- Need stability & durability
 - Polymers in high traffic or loading areas
 - Increase density
 - Proper NMAS for lift thickness
- Pavement Preservation
 - Thinlays use softer binders with increased RAP to get: durability, affordability, and sufficient rut resistance

Summary

Rut Resistance

- Proper mix design & volumetrics
- Thicker sections reduce risk
- Polymers in high traffic & loading areas
- Stiffer binders
- Increased density
- Increased recycled content

Summary

Smoothness

- Proper base preparation
- Milling
- Multiple lifts
- Pre-leveling
- Monitoring laydown temps and rate of cooling
- Warm mix to help compaction



Safety Culture

- Increased separation
- Requests for police presence
- Improved message board
- Responsibility not delegated
- Speed reductions
- Day paving
- New technology
- Solicit contractor suggestions