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

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A perpetual pavement is a pavement that ______________________________.

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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

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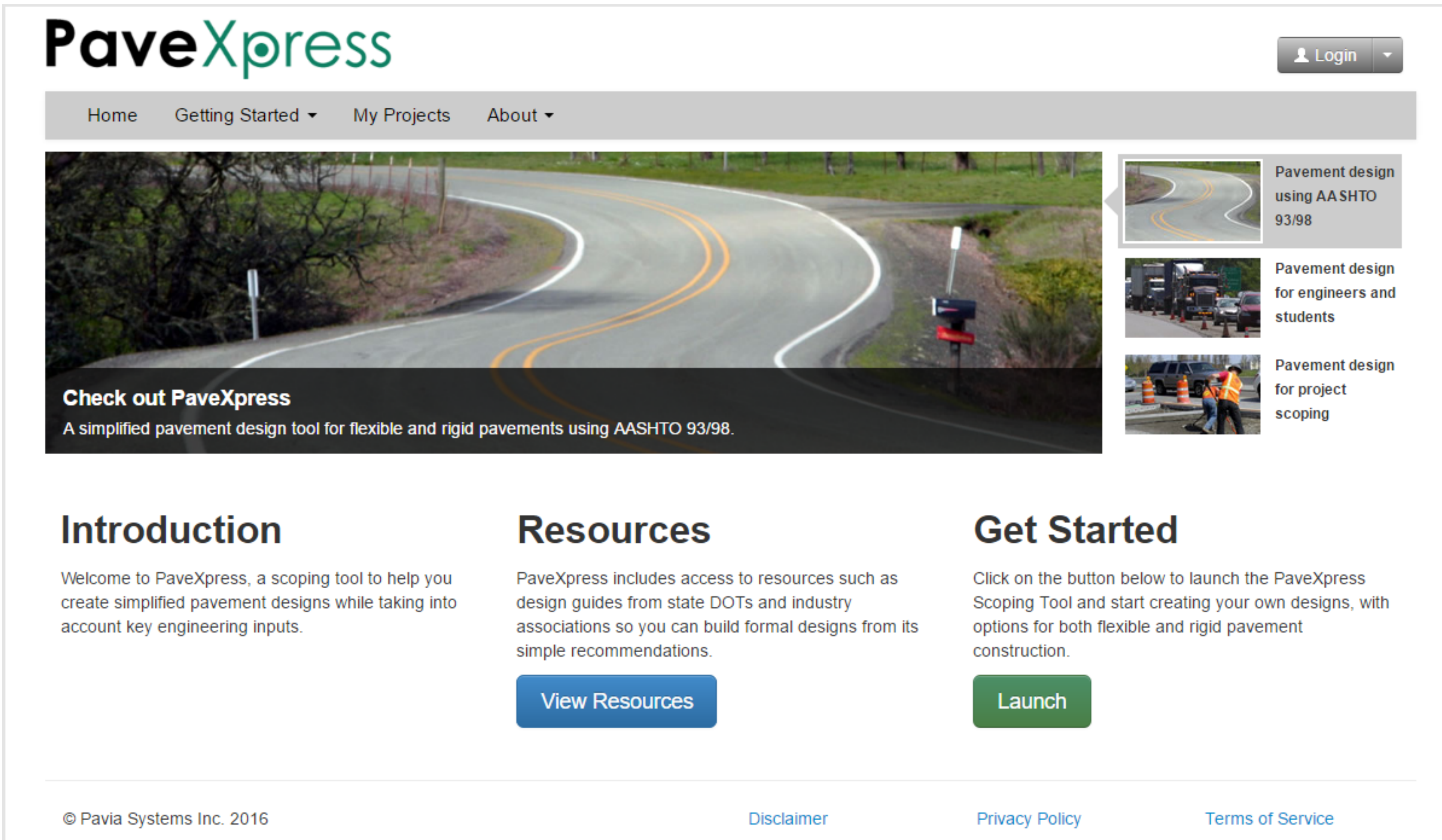
PaveXpress

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



Pavement Design Evolution

1990s: Mechanistic-Empirical Design

- Mechanistic modeling
- Empirical performance
- Damage accumulation
- Design assessment

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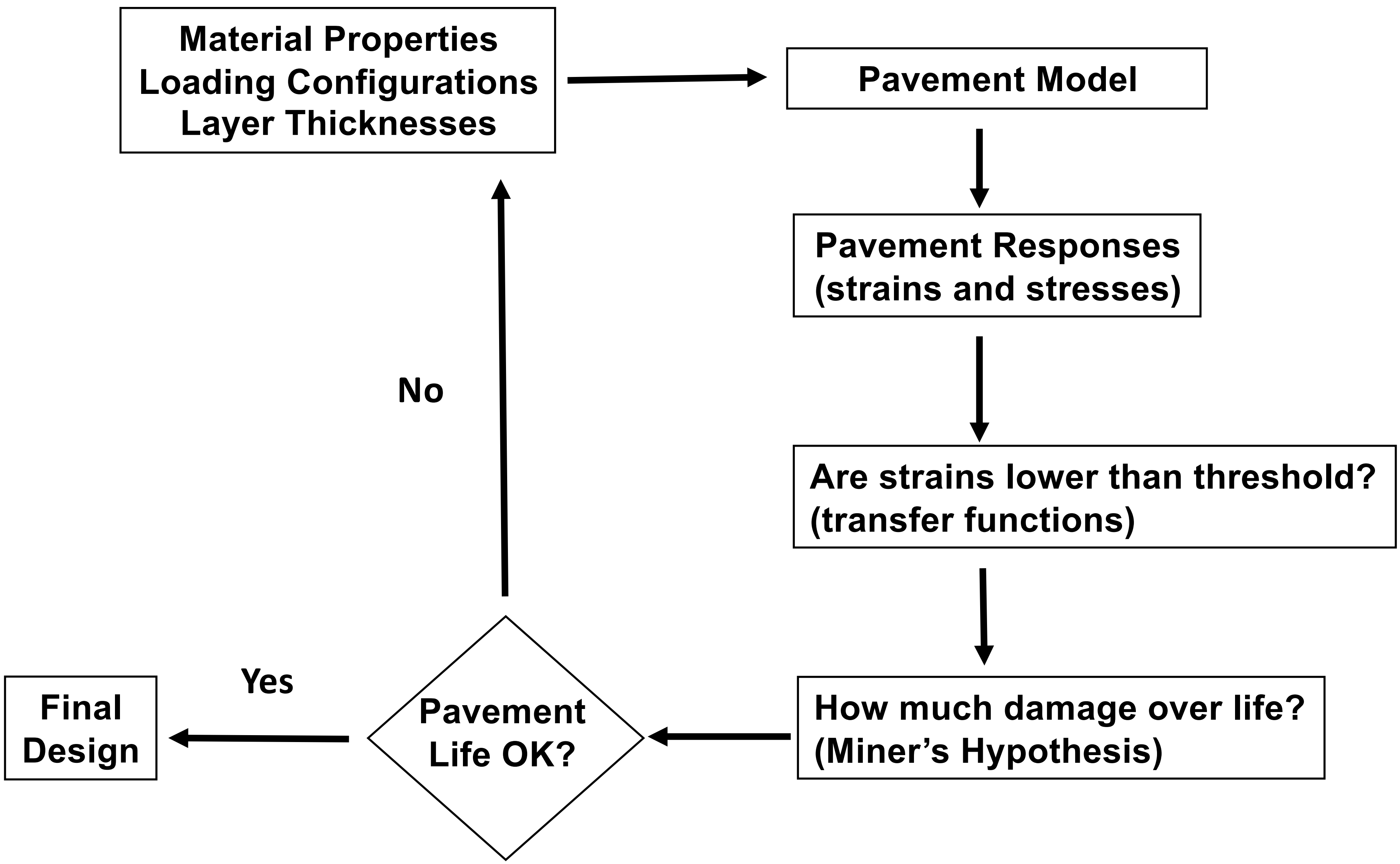
M-E Design



Material Properties
Loading Configurations
Layer Thicknesses
Pavement Model
Pavement Responses
(strains and stresses)
Are strains lower than threshold?
(transfer functions)
How much damage over life?
(Miner’s Hypothesis)
Pavement
Life OK?
No
Yes
Final
Design

M-E Design Software

Pavement Design Evolution

2000s: Perpetual Pavement Concept

Asphalt materials will not accumulate damage below a certain strain level

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Perpetual Pavements

Will a perpetual pavement ever crack?

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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.

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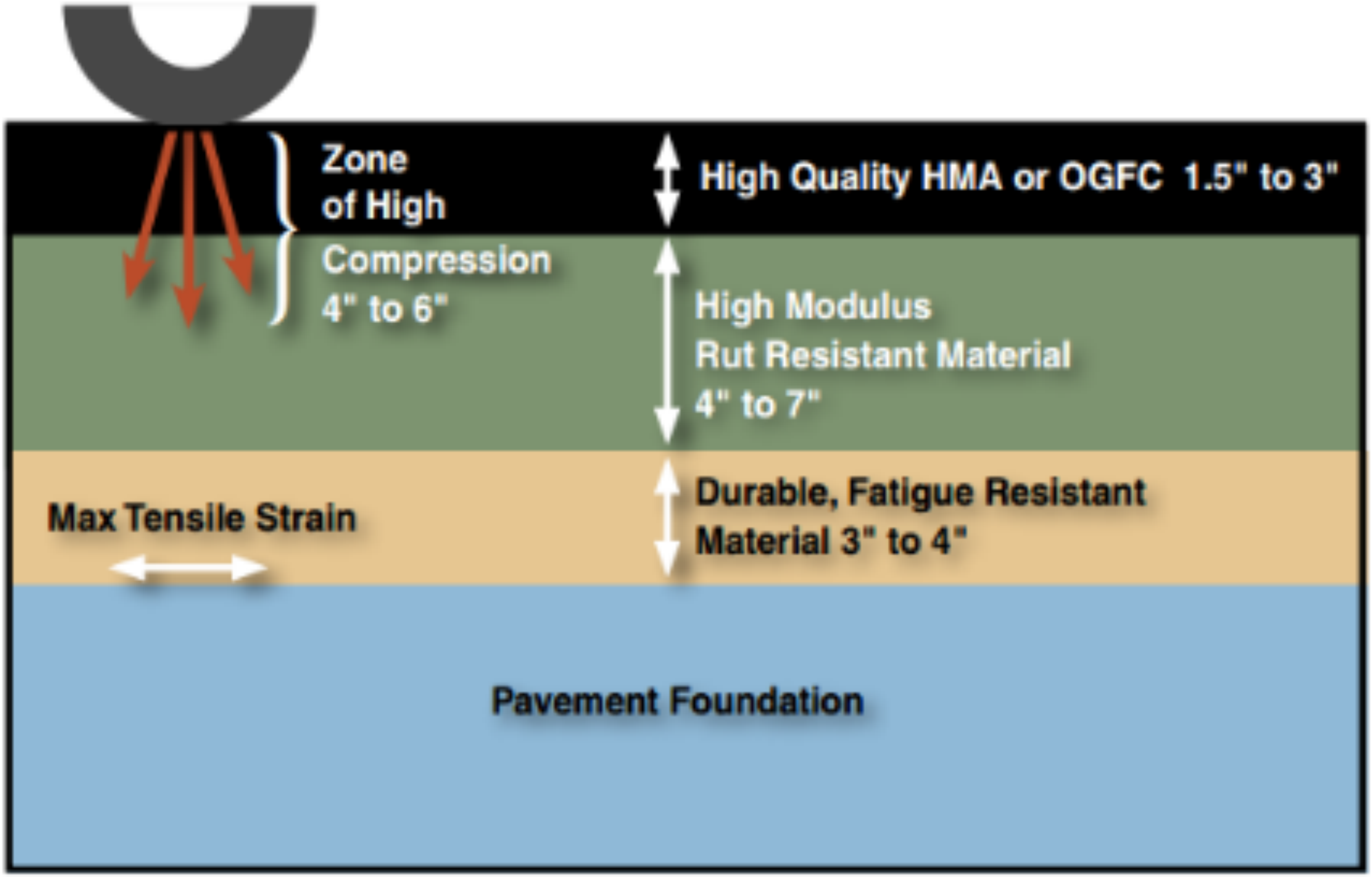
Perpetual Pavement Design



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

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Apply Perpetual Pavement Concepts

Bottom-Up Fatigue Cracking

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

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Bottom-Up Cracking

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

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Bottom-Up Cracking

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

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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

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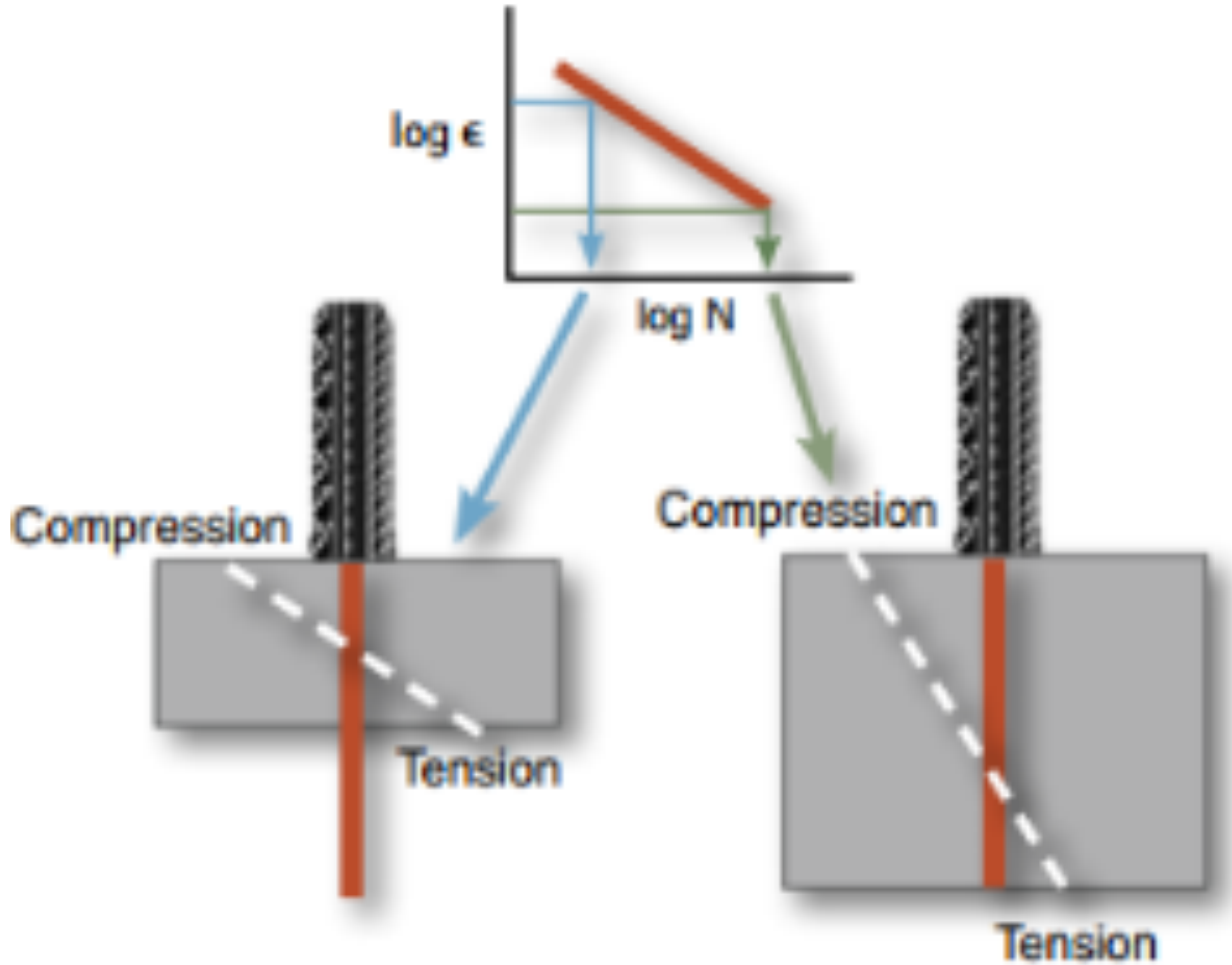
Perpetual Pavement Design



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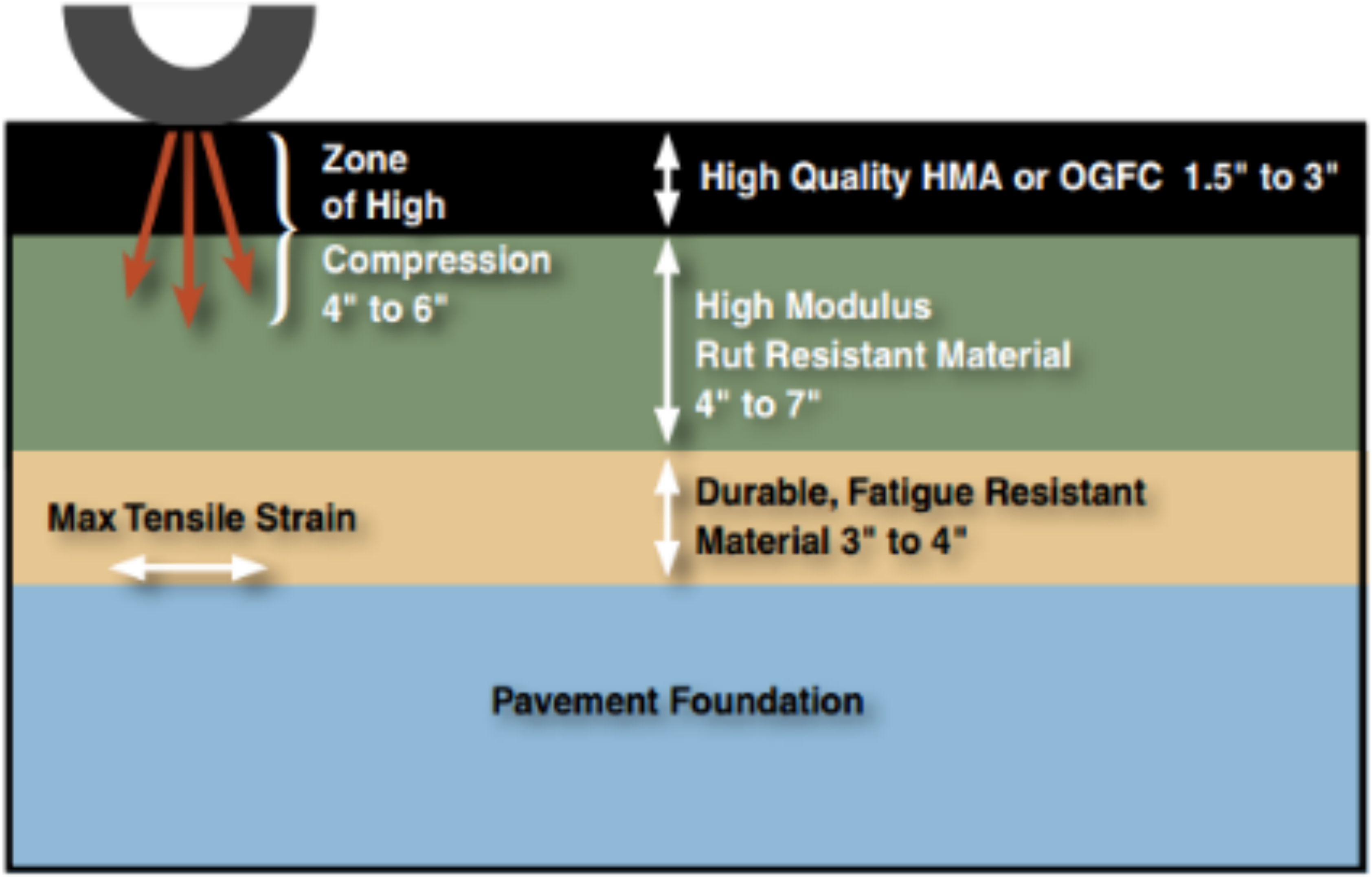
Bottom-Up Cracking



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

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Top-Down Cracking

How can we improve the durability of asphalt pavement mixes?

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

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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

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Top-Down Cracking – Increase Density

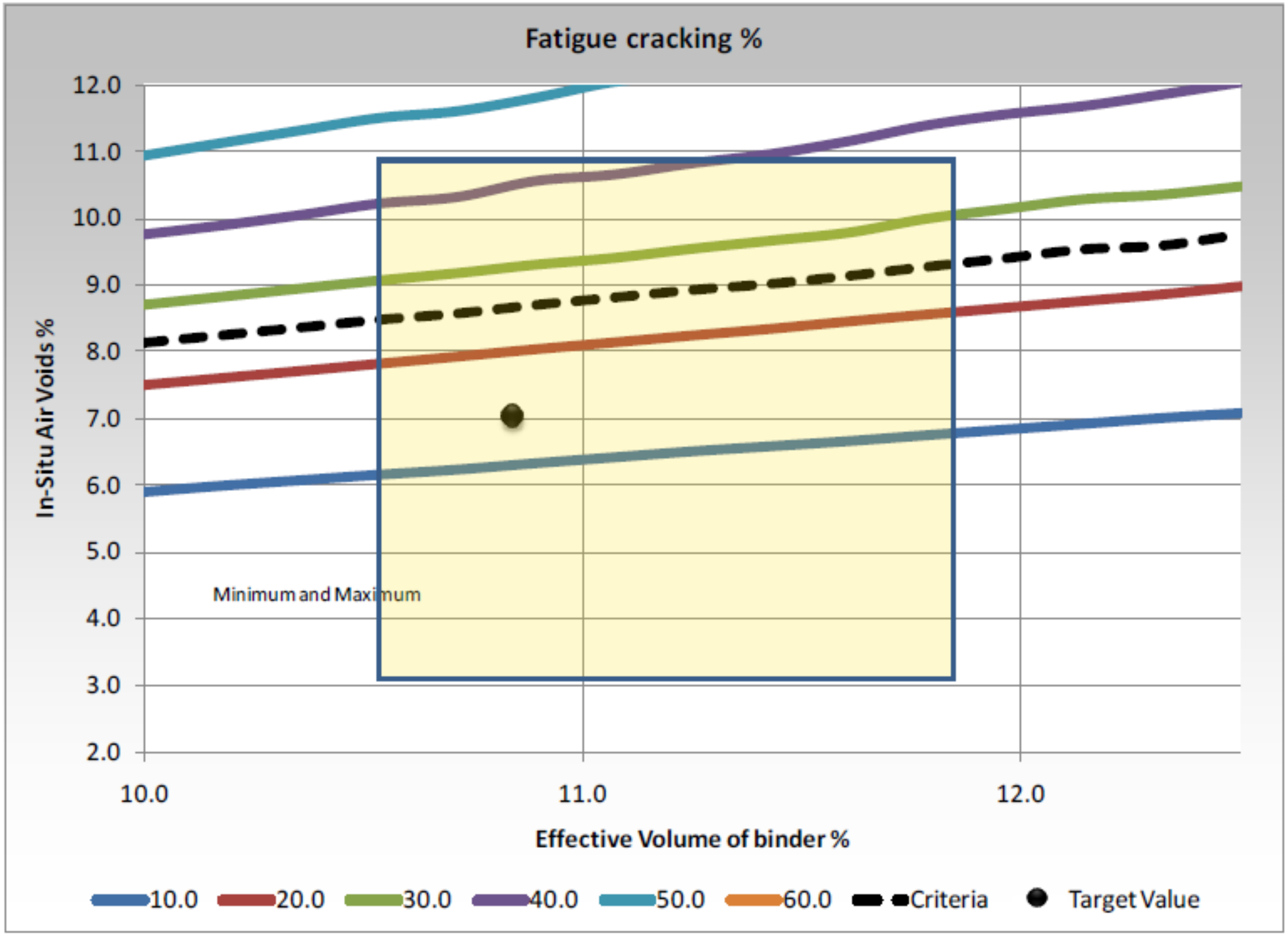
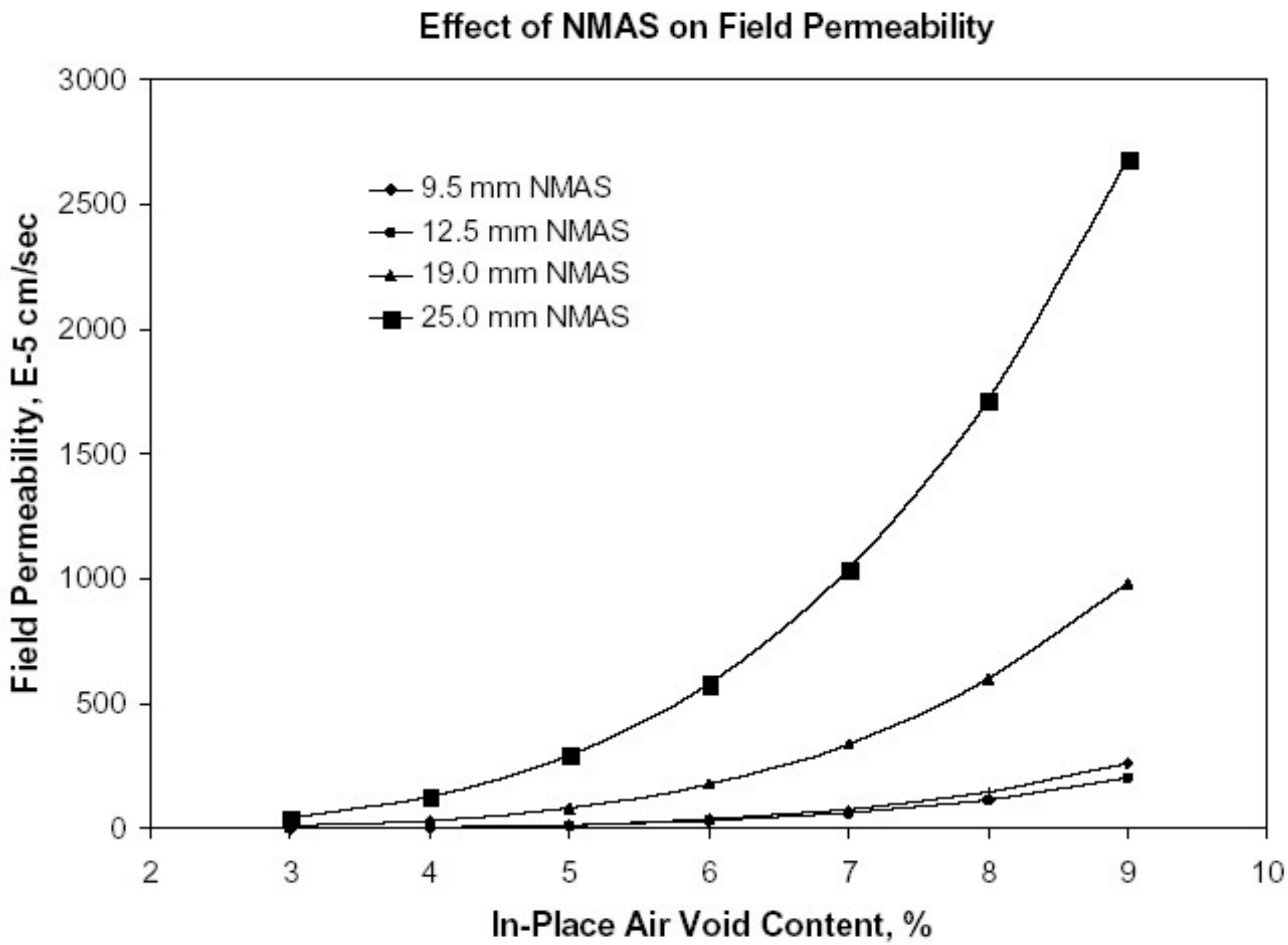


Figure 13. Output Chart for Fatigue Cracking.

Top-Down Cracking – Increase Density



Increase Density

Best performing mixes have:

96% Aggregate and binder

___% Air

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Increase Density

What do we require the contractor to get?

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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.

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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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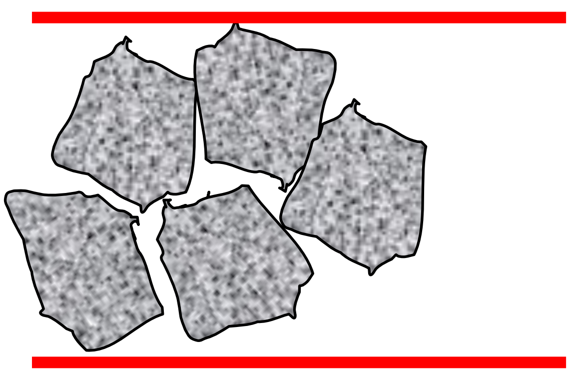
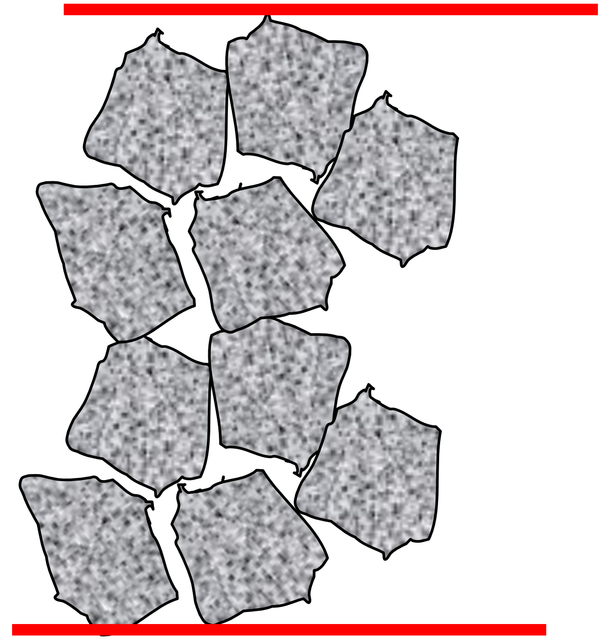
Increase Density

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

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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

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Thinlays

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

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Thinlays

Mix designed to resist cracking

- NMAS =/< 1/3 lift thickness (for ¾” lift use ¼” 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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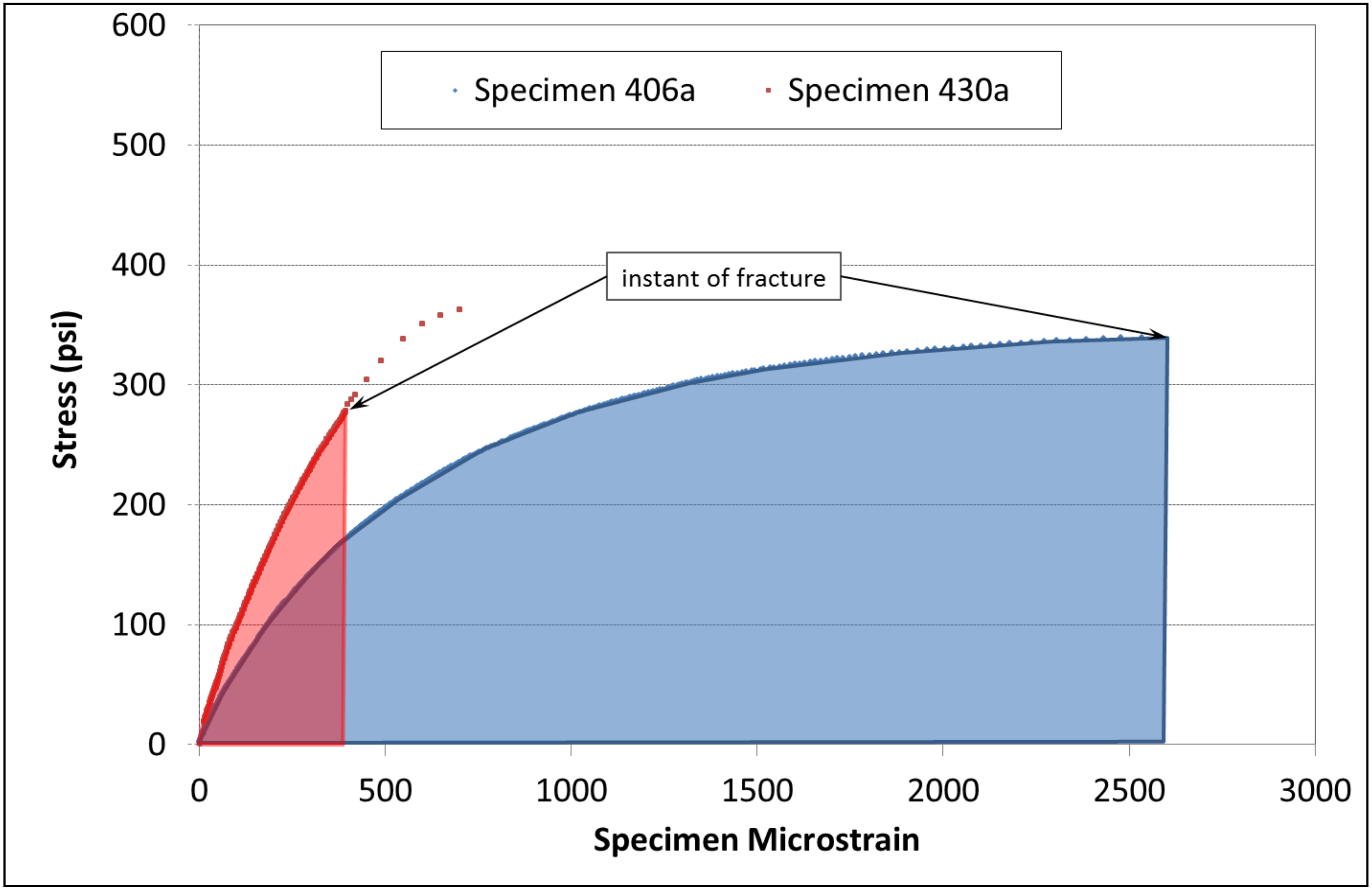
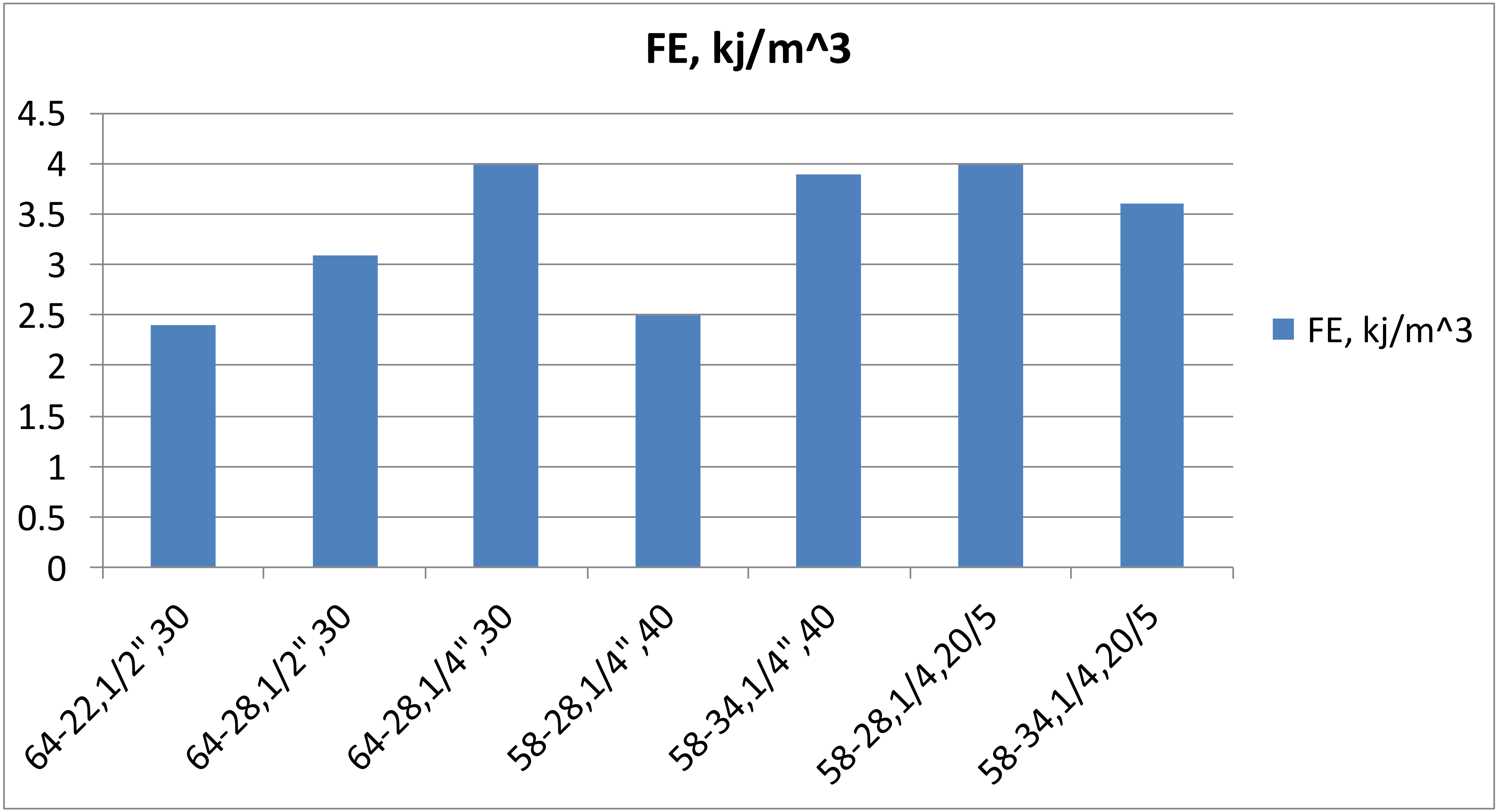
Thinlays

	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

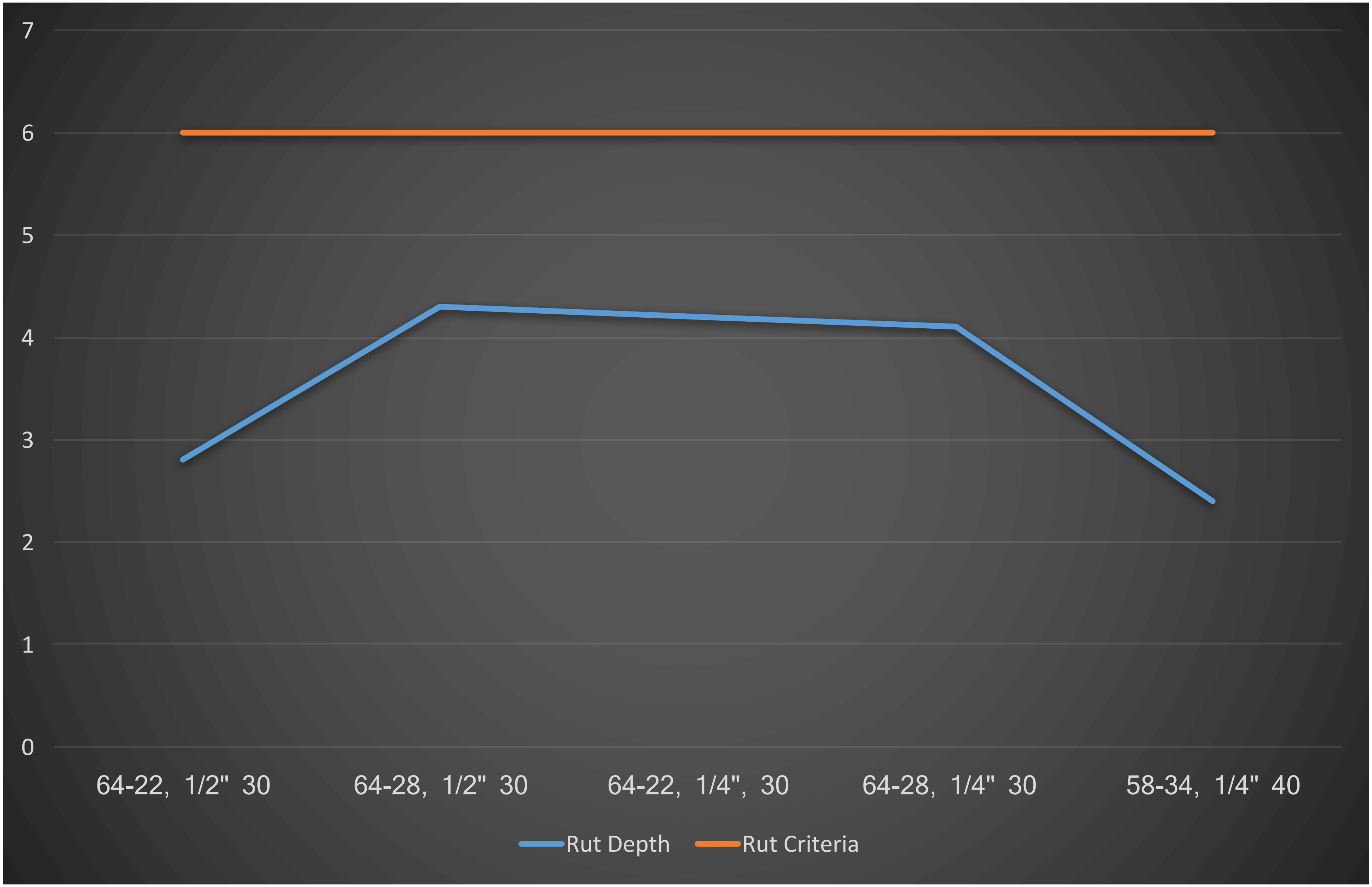
Thinlays – Fracture Energy



Thinlays – Fracture Energy



Thinlays



7
6
5
4
3
2
1
0
64-22, 1/2" 30
64-28, 1/2" 30
64-22, 1/4", 30
64-28, 1/4" 30
58-34, 1/4" 40
Rut Depth
Rut Criteria

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?

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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

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Wearing Course

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

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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

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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

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Summary

Rut Resistance

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

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Summary

Smoothness

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

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Safety Culture

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

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