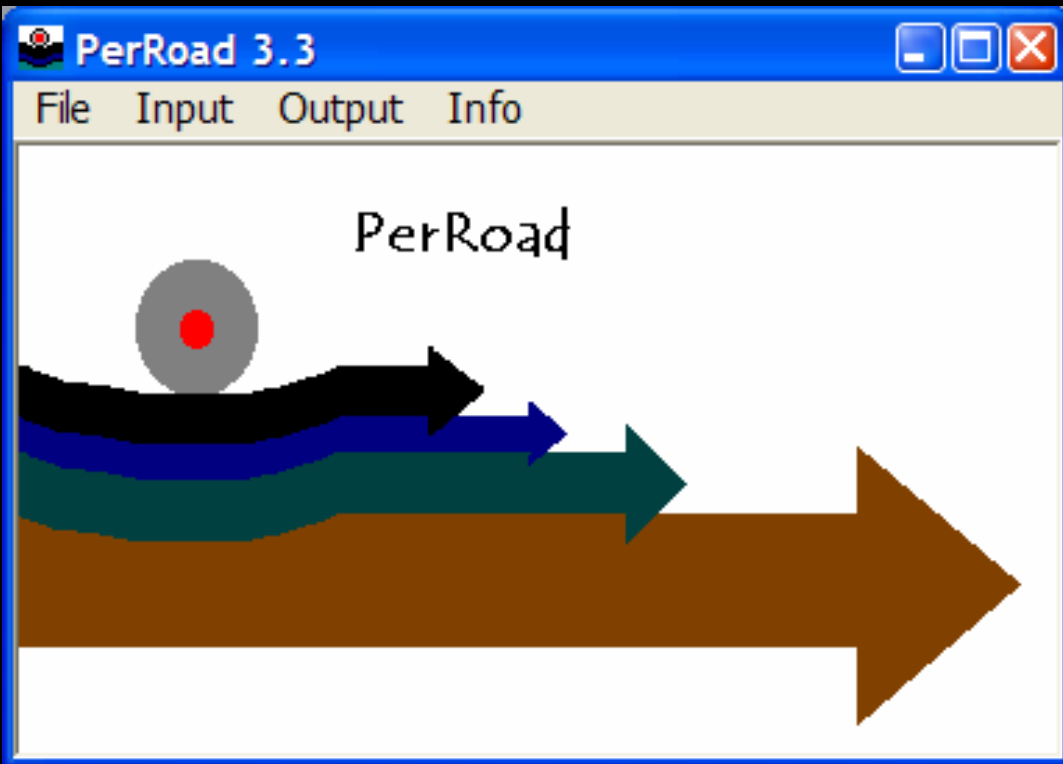


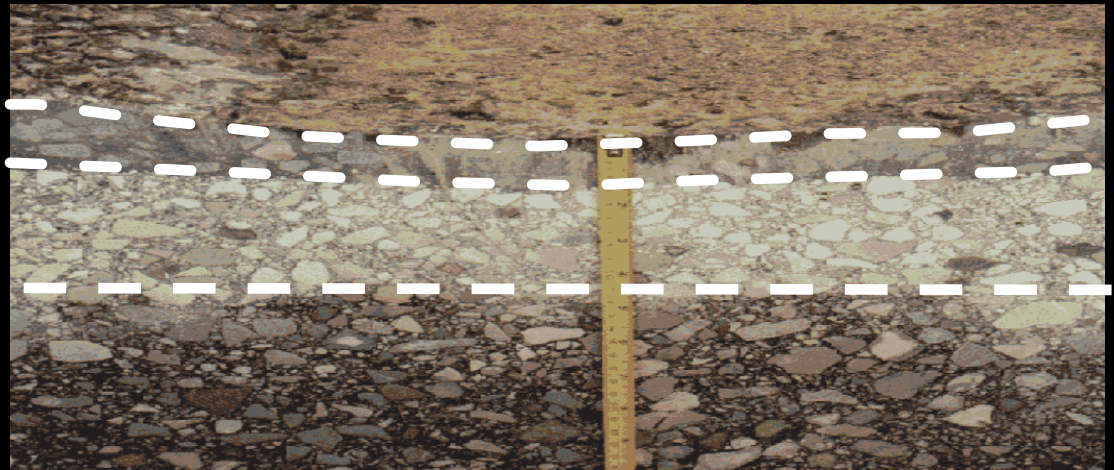
# Comparing PerRoad and the MEPDG



Dr. David Timm, P.E.  
Auburn University

# Goal of Perpetual Pavement Design

- Design the structure such that there are no deep structural distresses
  - Bottom up fatigue cracking
  - Structural rutting
- All distresses can be quickly remedied from surface
- Result in a structure with 'Perpetual' or 'Long Life'

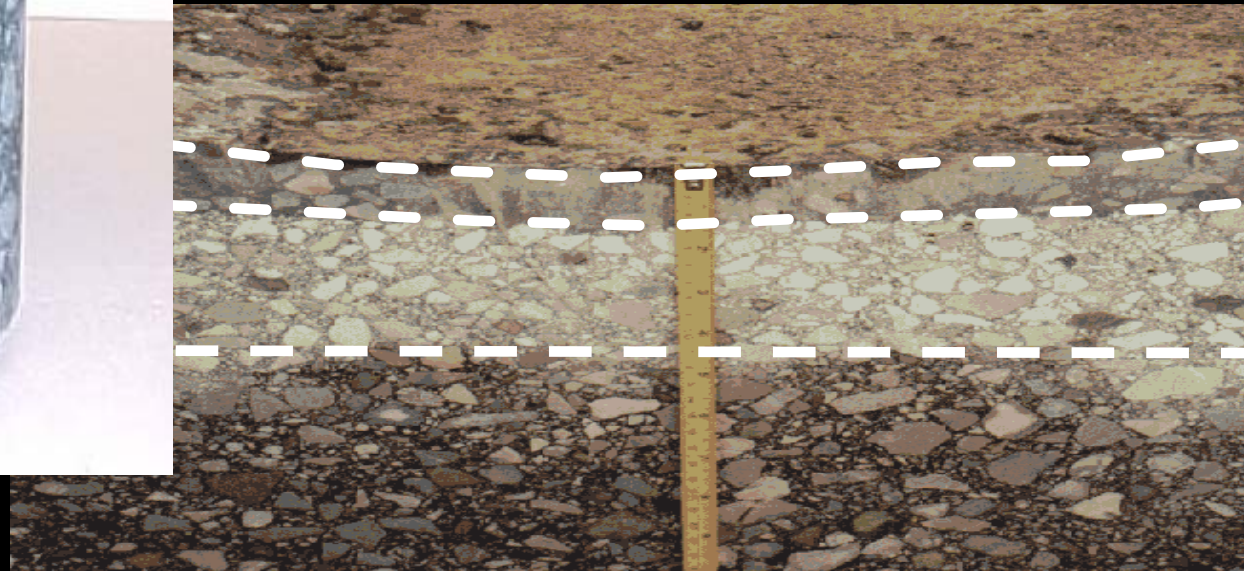


# Surface Distresses Only

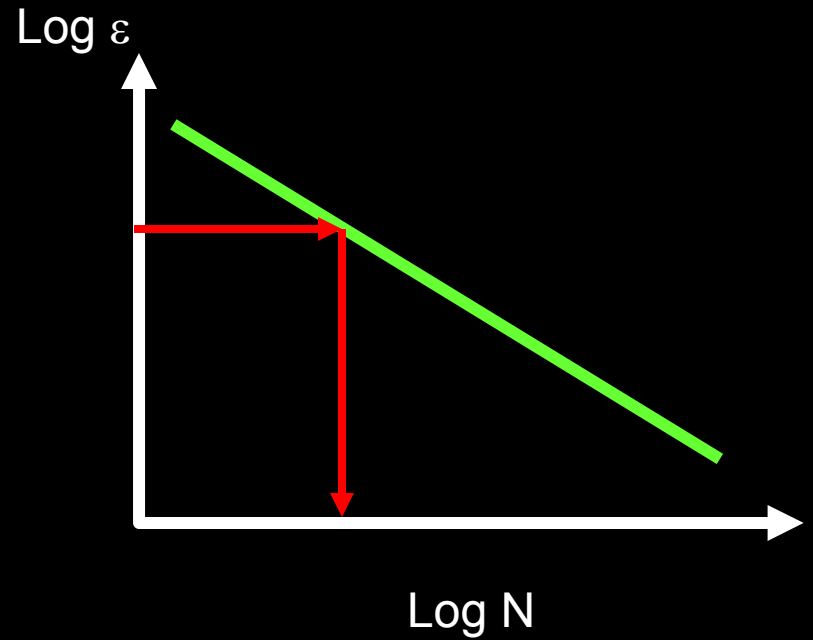
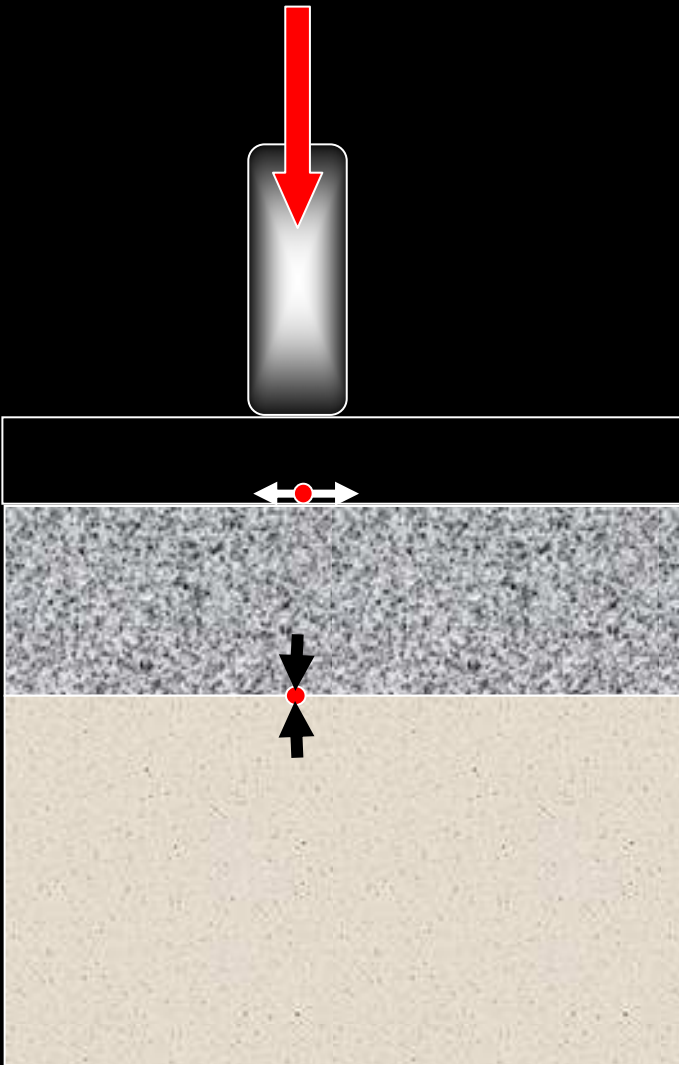


**Top Down Cracking**

**Non-Structural Rutting**



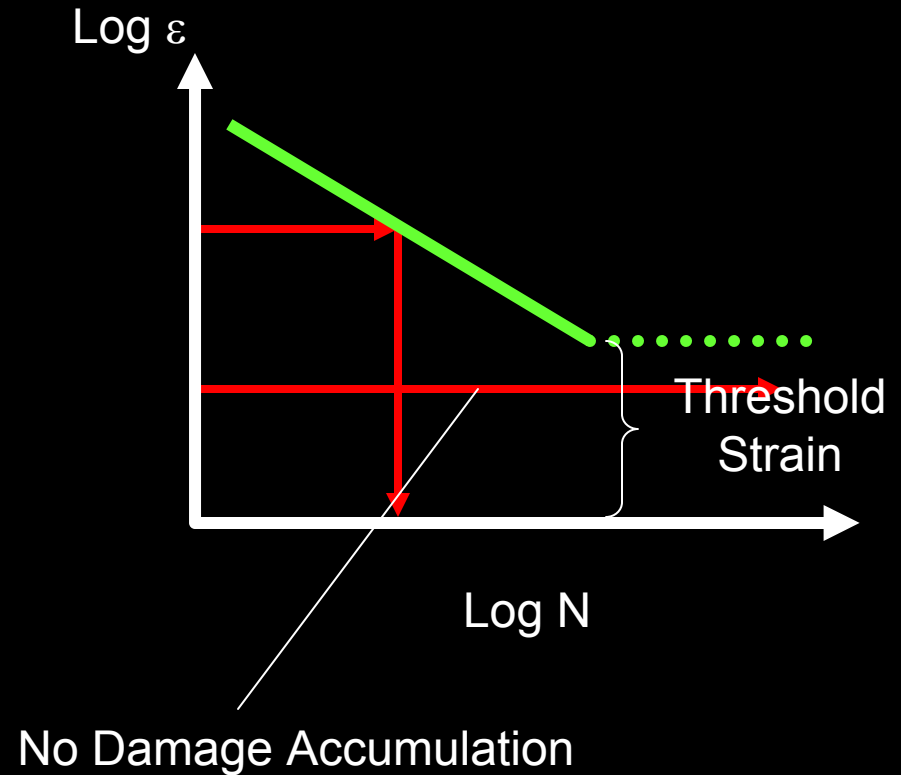
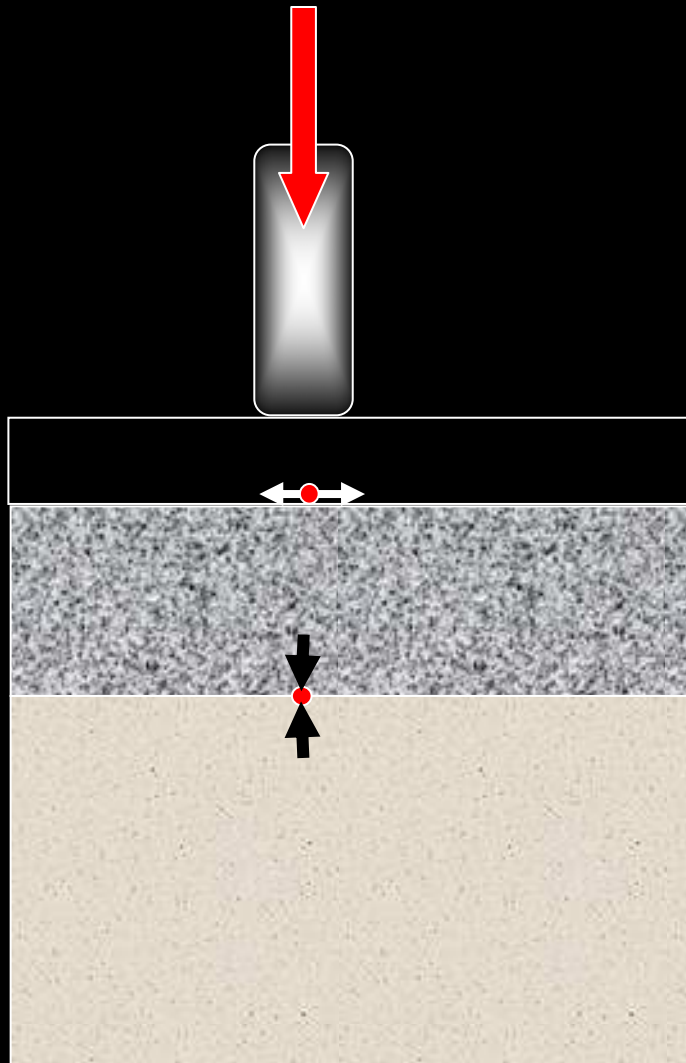
# M-E Design Fundamentals



Miner's Hypothesis

$$D = \sum \frac{n}{N}$$

# M-E Perpetual Pavement Design



Miner's Hypothesis

$$D = \sum \frac{n}{N}$$

# Similarities Between PerRoad and MEDPG

- Both use layered elastic analysis
  - PerRoad: WESLEA
  - MEDPG: JULEA
- Both use load spectra
- Both simulate seasonal effects
- Both can incorporate endurance limit
- Both predict specific modes of distress
  - Strain-based transfer functions

*The differences  
are in the level of complexity*



# Key Differences Between PerRoad and MEPDG

- Treatment of reliability
  - MEPDG: reliability applied after prediction of average pavement distresses
  - PerRoad: reliability modeled using Monte Carlo simulation that considers input variability
- Computer run time
  - MEPDG: > 40 minutes
  - PerRoad: < 3 minutes
- Selection of endurance limits
  - MEPDG: bottom-up fatigue in AC only
  - PerRoad: User-defined at top, mid and bottom of any layer

# PerRoad Structural Inputs

**Structural and Seasonal Information (F1 for Help)**

# of Layers:  2  3  4  5

Seasonal Information

Season:  Summer  Fall  Winter  Spring  Spring2 Current Season: Summer

Duration (weeks): 26

Mean Air Temperature, F: 78

Temperature Correction:

Layer 1: Material Type: AC PG Grade: 70 -22

Layer 5: Soil

Modulus Variability: Distribution Type: Log-normal Coefficient of Variation: 30 %

**Layer Performance Criteria (Press F1 for Help)**

Layer: 1

Position	Criteria	Threshold	Transfer Function	k1	k2
<input type="checkbox"/> Top					
<input type="checkbox"/> Middle					
<input checked="" type="checkbox"/> Bottom	Horizontal Strain	-70	microstrain	<input checked="" type="checkbox"/>	2.83e-006 3.148

Note: The following sign convention is used...  
Negative = Tension  
Positive = Compression  
Deflection is Positive Downward

Note: The transfer functions are for strain only.

Cancel Change Cancel Changes Accept Changes

# MEPDG Structural Inputs

- Required inputs depend on level of design
- Ultimately, modulus of each layer is determined
- Examples of asphalt input data...
  - $E^*$  (frequency, temperature)
  - $G^*$  (temperature)
  - Mixture volumetrics
  - Thermal conductivity
  - Heat capacity
  - Surface shortwave absorptivity

Asphalt Material Properties

Level: 3

Asphalt material type: Asphalt concrete

Layer thickness (in): 10

Asphalt Mix  Asphalt Binder  Asphalt General

General

Reference temperature (F°): 70

Poisson's Ratio

Use predictive model to calculate Poisson's ratio.

Poisson's ratio: 0.35

Parameter a:

Parameter b:

Gravimetric Properties (Mix Design)

Binder content by weight (%):

Optimum binder content (OBC) (%):

Design air voids used to select OBC (%):

Volumetric Properties as Built

Effective binder content (%): 11

Air voids (%): 7.5

Total unit weight (pcf): 148

Thermal Properties

Thermal conductivity asphalt (BTU/hr-ft-F°): 0.67











Heat capacity asphalt (BTU/lb-F°): 0.23

OK Cancel View HMA Plots

# PerRoad Traffic

Vehicle Type Distribution (Press F1 for Help)
\_ □ ×

Roadway Functional Classification: Rural Interstate

Vehicle Classification	% AADTT	Average Number of Axles Per Vehicle		
		Single	Tandem	Tridem
 4	<input type="text" value="1.2"/>	<input type="text" value="1.62"/>	<input type="text" value="0.39"/>	<input type="text" value="0"/>
 5	<input type="text" value="9.4"/>	<input type="text" value="2"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
 6	<input type="text" value="3.3"/>	<input type="text" value="1.02"/>	<input type="text" value="0.99"/>	<input type="text" value="0"/>
 7	<input type="text" value="0.5"/>	<input type="text" value="1"/>	<input type="text" value="0.26"/>	<input type="text" value="0.83"/>
 8	<input type="text" value="7.4"/>	<input type="text" value="2.38"/>	<input type="text" value="0.67"/>	<input type="text" value="0"/>
 9	<input type="text" value="68.9"/>	<input type="text" value="1.13"/>	<input type="text" value="1.93"/>	<input type="text" value="0"/>
 10	<input type="text" value="1.2"/>	<input type="text" value="1.19"/>	<input type="text" value="1.09"/>	<input type="text" value="0.89"/>
 11	<input type="text" value="6.1"/>	<input type="text" value="4.29"/>	<input type="text" value="0.26"/>	<input type="text" value="0.06"/>
 12	<input type="text" value="0.8"/>	<input type="text" value="3.52"/>	<input type="text" value="1.14"/>	<input type="text" value="0.06"/>
 13	<input type="text" value="1.2"/>	<input type="text" value="2.15"/>	<input type="text" value="2.13"/>	<input type="text" value="0.35"/>
<b>Total</b>	<input type="text" value="100"/>			

Input Load Spectra by Vehicle Type

Current Configuration: Single

	% Axles
le	<input type="text" value="0"/>
t	<input type="text" value="0"/>
p	<input type="text" value="0"/>
8	<input type="text" value="0"/>
00	<input type="text" value="0"/>
02	<input type="text" value="0"/>
04	<input type="text" value="0"/>
06	<input type="text" value="0"/>
08	<input type="text" value="0"/>
10	<input type="text" value="0"/>
0+	<input type="text" value="0"/>
tal	<input type="text" value="100"/>

22-24	<input type="text" value="0.68"/>	46-48	<input type="text" value="0"/>	70-72	<input type="text" value="0"/>	94-96	<input type="text" value="0"/>
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# MEPDG Traffic

- Very detailed traffic characterization
  - Monthly adjustments
  - Daily adjustments
  - Tire spacings and placement

**Axle Load Distribution Factors**

**Axle Load Distribution**

Level 1: Site Specific

Level 2: Regional

Level 3: Default

**View**

Cumulative Distribution

Distribution

**Axle Types**

Single Axle

Tandem Axle

Tridem Axle

Quad Axle

**Axle Factors by Axle Type**

	Season	Veh. Class	Total	3000	4000	5000	6000	7000
	January	4	100.00	1.8	0.96	2.91	3.99	6.8
	January	5	100.00	10.05	13.21	16.42	10.61	9.22
	January	6	100.00	2.47	1.78	3.45	3.95	6.7
	January	7	100.00	2.14	0.55	2.42	2.7	3.21
	January	8	100.00	11.65	5.37	7.84	6.99	7.99
	January	9	100.00	1.74	1.37	2.84	3.53	4.93
	January	10	100.00	3.64	1.24	2.36	3.38	5.18
	January	11	100.00	3.55	2.91	5.19	5.27	6.32
	January	12	100.00	6.68	2.29	4.87	5.86	5.97
	January	13	100.00	8.88	2.67	3.81	5.23	6.03

# PerRoad Output

Output & Design Module (F1 for Help)

Reliability Analysis

Perform Analysis

Perpetual Pavement Design Results

Percent Below Critical	Damage/Million Axle	Years to D=0.1
82.6	1.2513e-002	51.168

Thickness Design Studio

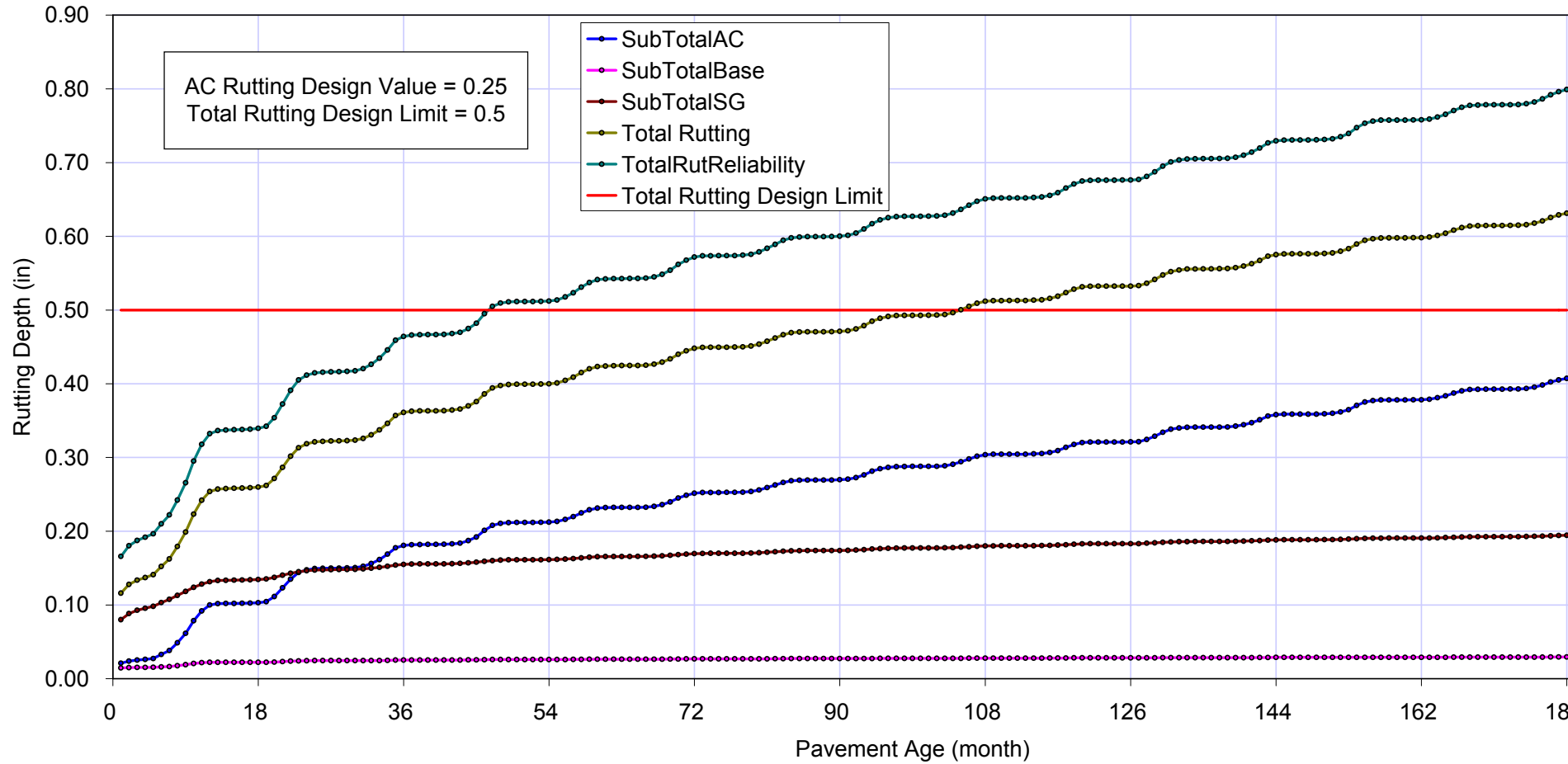
Number of Pavement Layers: 3

	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Material	AC	Gran Base	Soil	Soil	Soil
Thickness, in.	12	12	999	999	Infinite

Disclaimer Cost Analysis Export Data Leave Module

# MEPDG Output

Permanent Deformation: Rutting

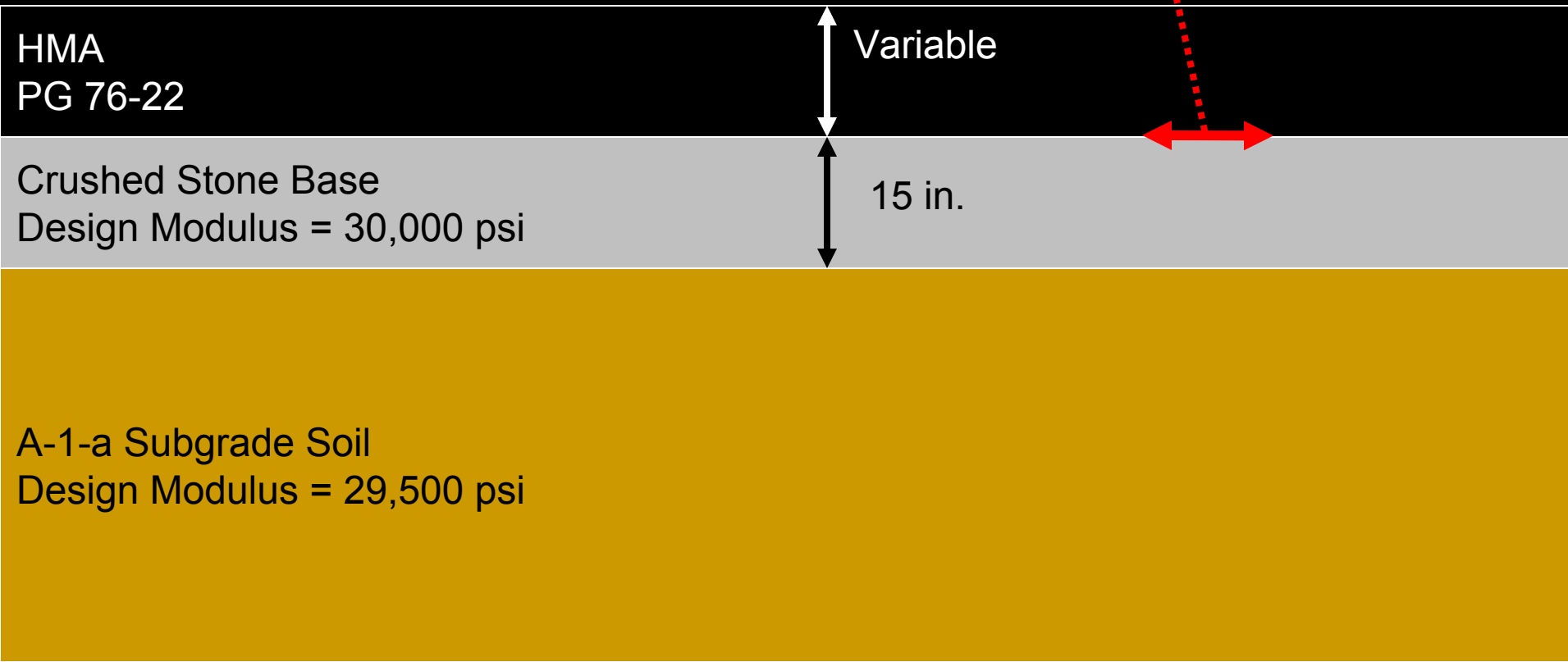


# Design Comparison

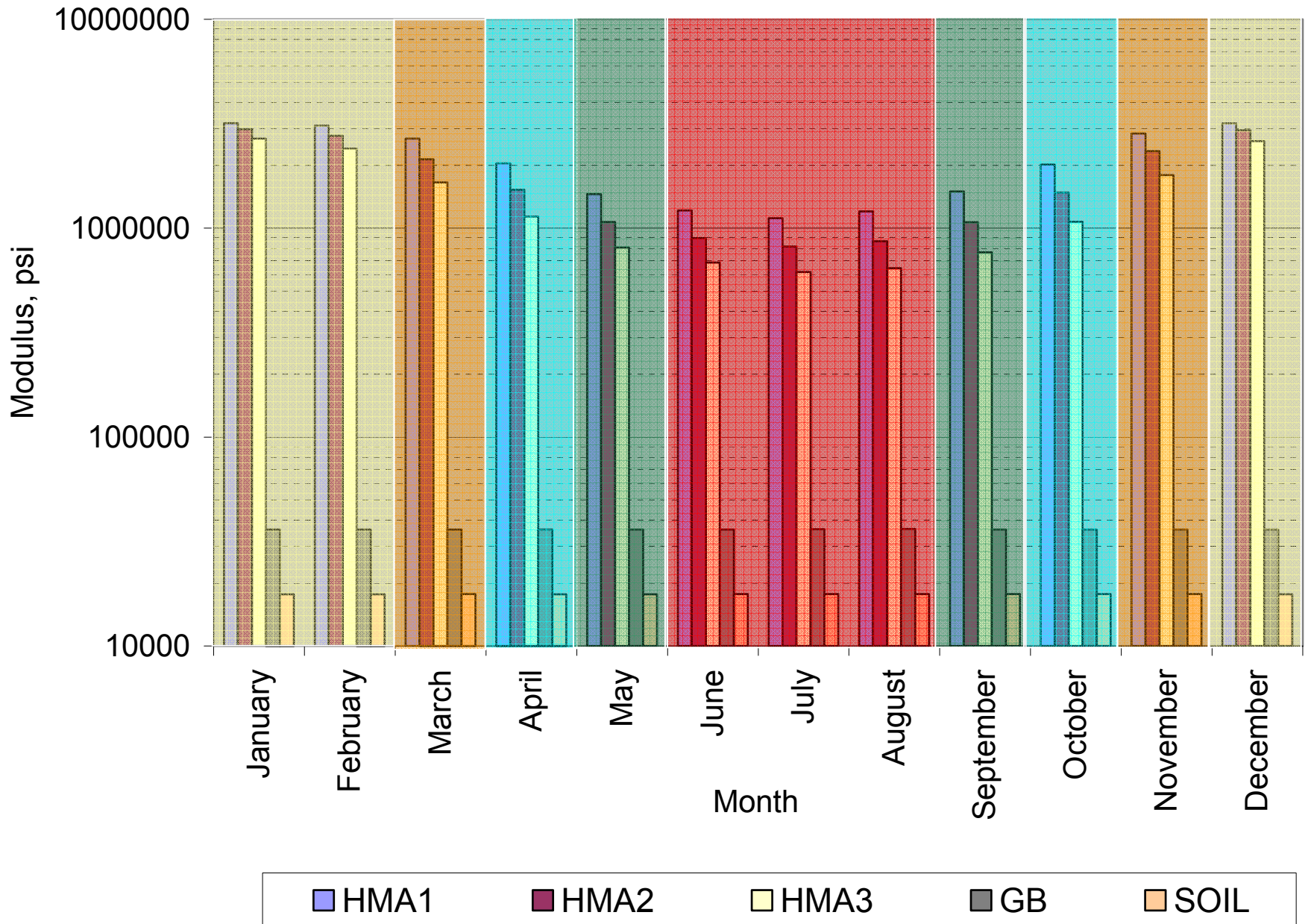
- 40 yr. design period
- Fatigue analysis only
- 4500 AADTT
- 4% Growth
- Load Spectra = MEPDG Default
- Alabama Climate
- Level 3 input parameters
- Alabama Climate

## 4 Thresholds

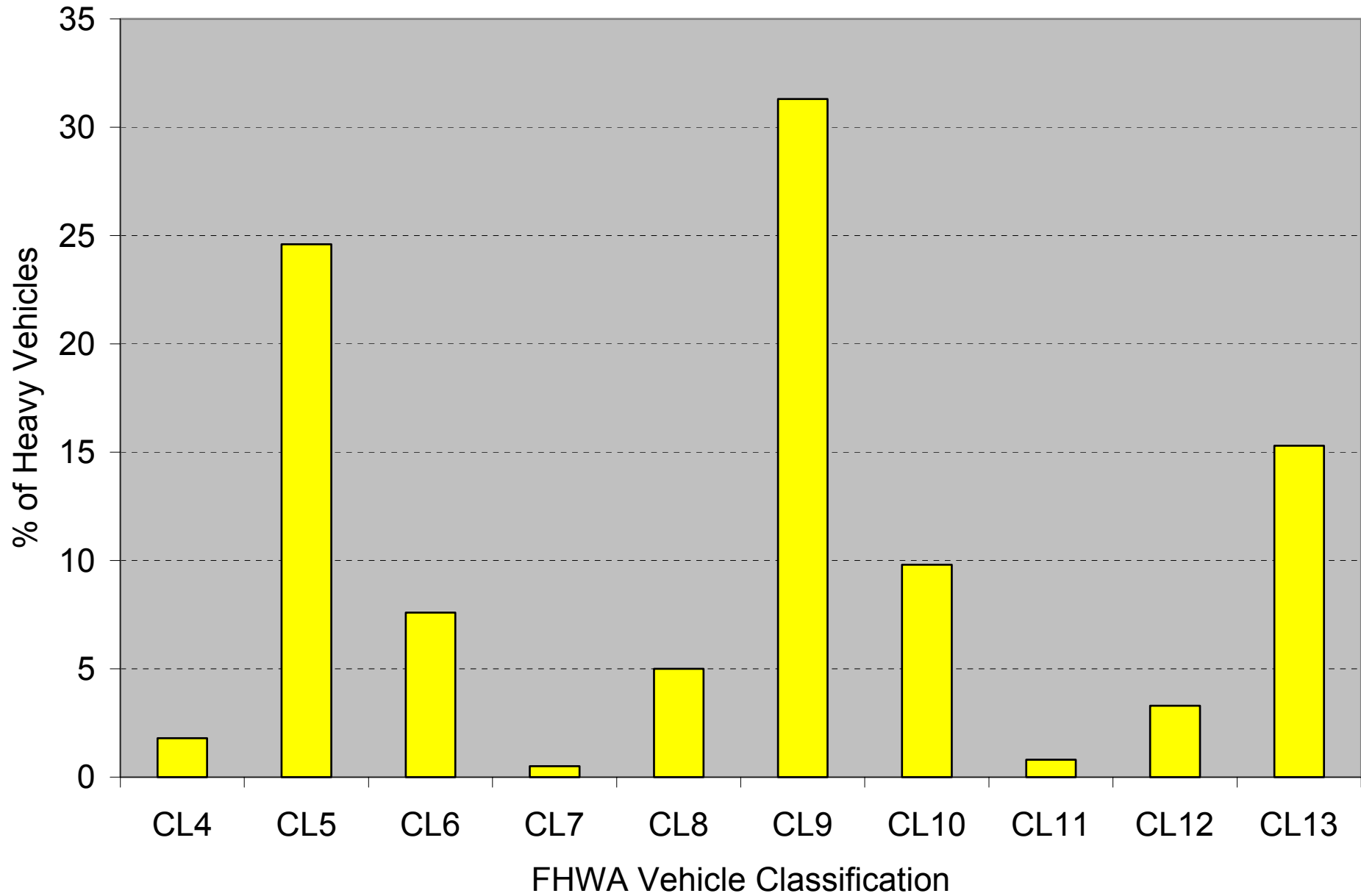
0  $\mu\epsilon$   
70  $\mu\epsilon$   
100  $\mu\epsilon$   
200  $\mu\epsilon$



# Seasonal Layer Moduli



# Traffic



# MEPDG Transfer Function

- Calibrated to specific level of pavement damage

$$N_f = 0.00432 * C * 0.007566 * \left(\frac{1}{\epsilon_t}\right)^{3.9492} \left(\frac{1}{E}\right)^{1.281}$$

$$C = 10^M$$

$$M = 4.84 \left[ \frac{Vb}{Va + Vb} - 0.69 \right]$$

$$FC = \left(\frac{1}{60}\right) \left[ \frac{6000}{1 + e^{C_1 * C'_1 + C_2 * C'_2 \log(D)}} \right]$$

$$C'_2 = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

**Designed to two levels  
of fatigue damage**

**8%**

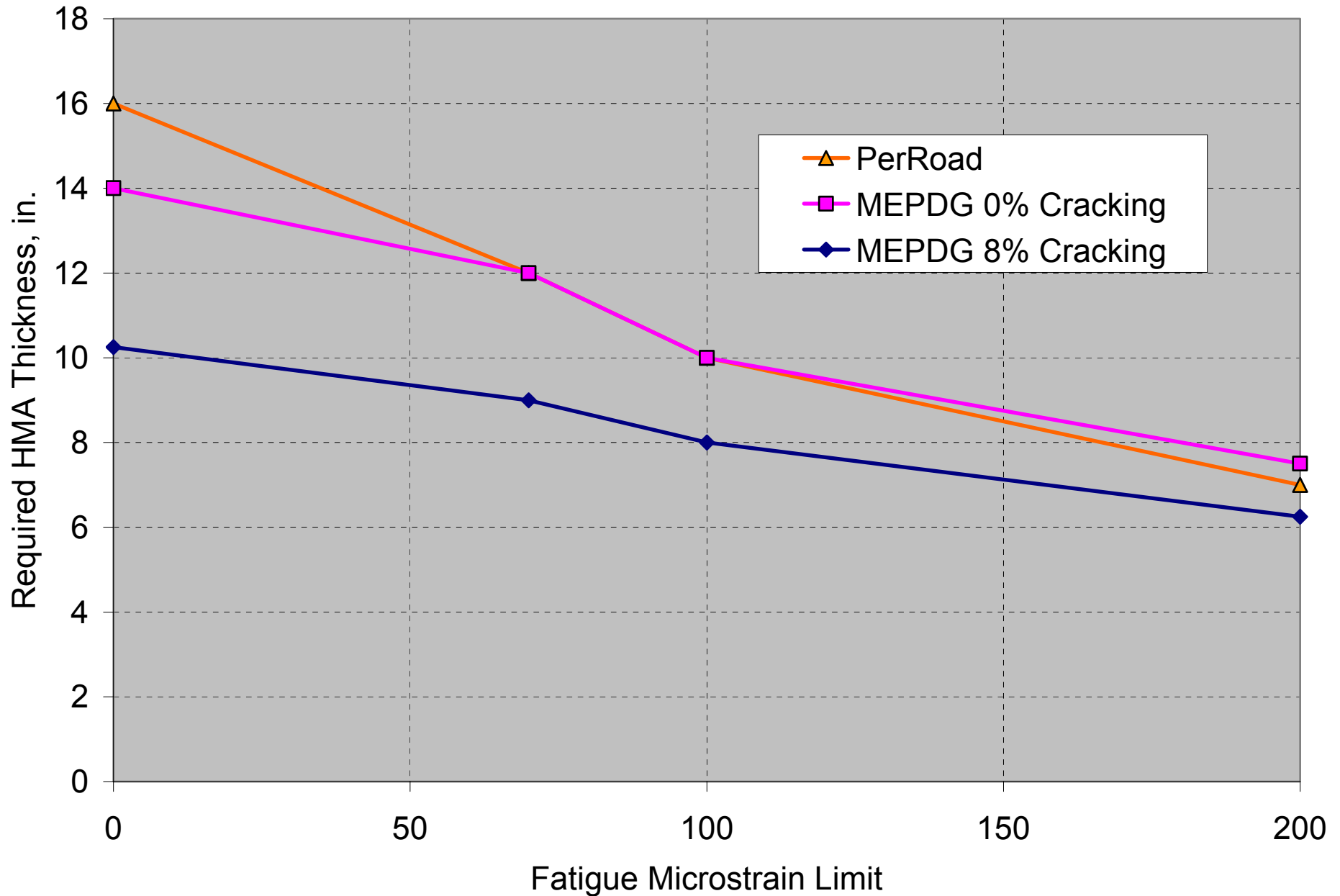
**0%**

# PerRoad Transfer Function

- Calibrated to crack initiation
- Pavement Designed to  $D = 0.1$  (0% Cracking)

$$N_f = 2.83 * 10^{-6} \left( \frac{1}{\epsilon_t} \right)^{3.148}$$

# Results



# Summary and Conclusions

- MEPDG and PerRoad share common design philosophy
  - Differences lie in...
    - Level of complexity
    - Handling of reliability
    - Calibration data set
- MEPDG can handle flexible and rigid M-E design
- PerRoad intended for long-life flexible M-E design
- Despite differences, both programs can arrive at similar design thicknesses

*Thank You!*

