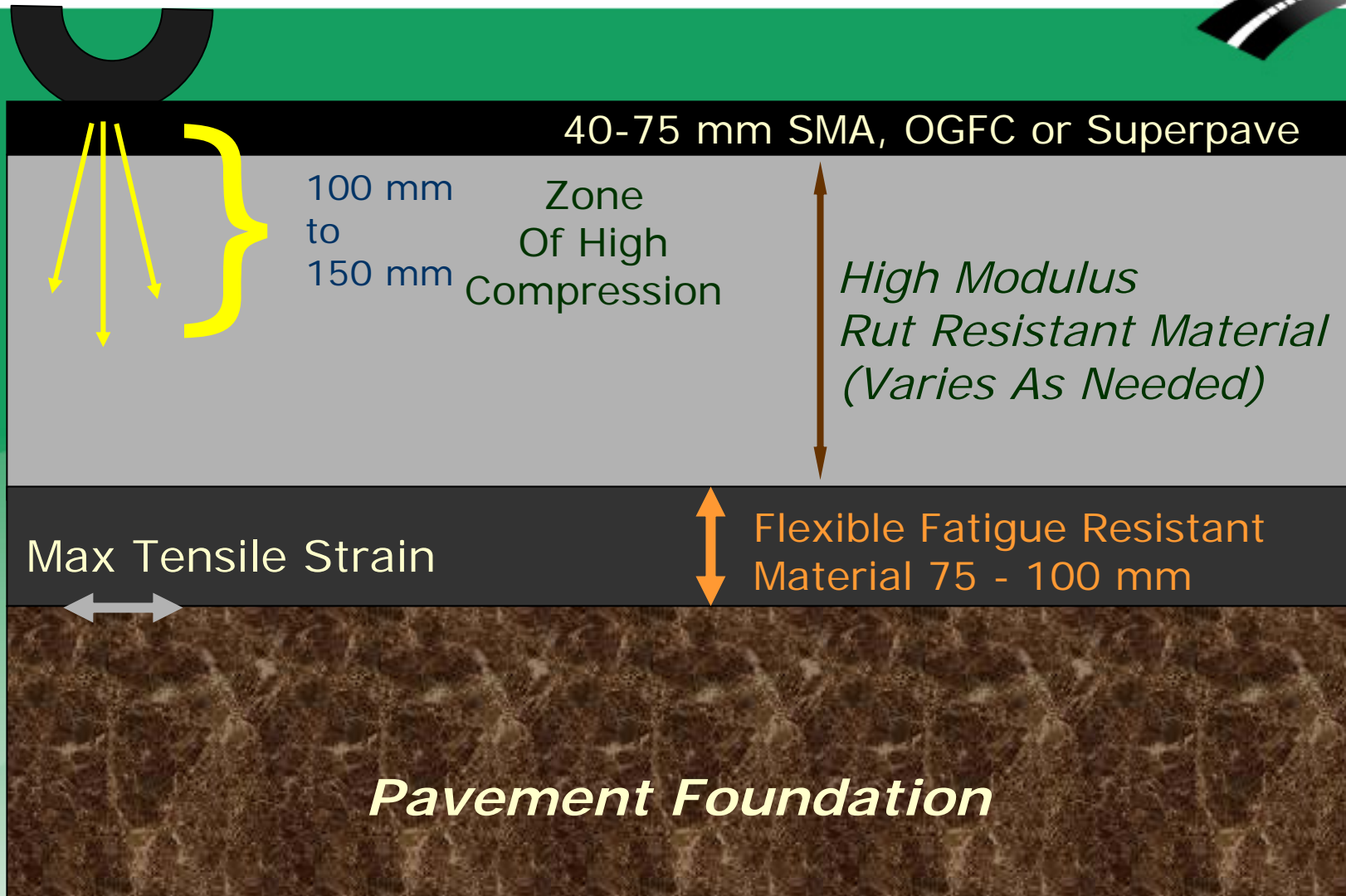


Perpetual Pavements

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Perpetual Pavements



Value

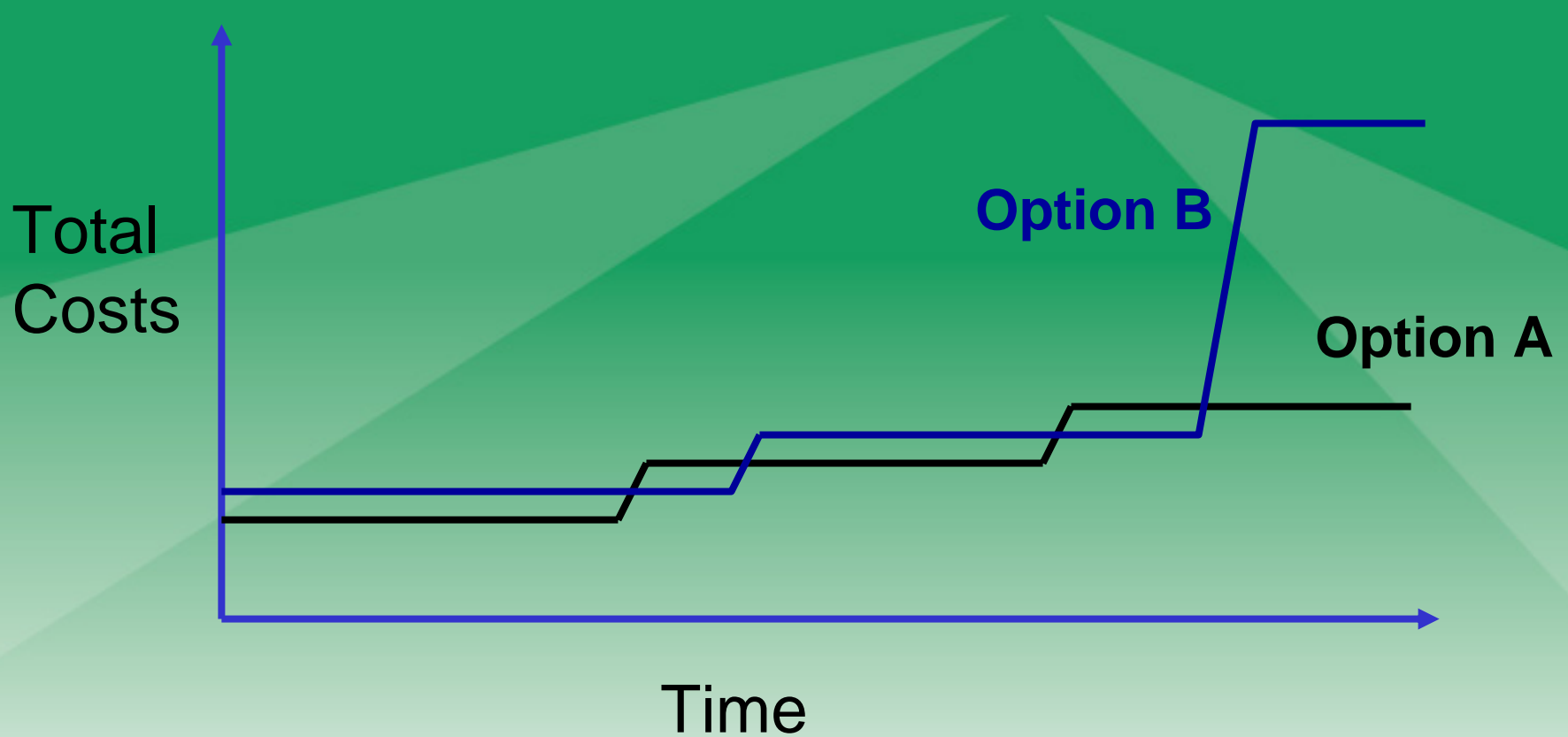
Quality in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for. A product is not quality because it is hard to make and costs a lot of money, as manufacturers typically believe. This is incompetence. Customers pay only for what is of use to them and gives them value. Nothing else constitutes quality.

Peter Drucker

Perpetual Pavements



Economics

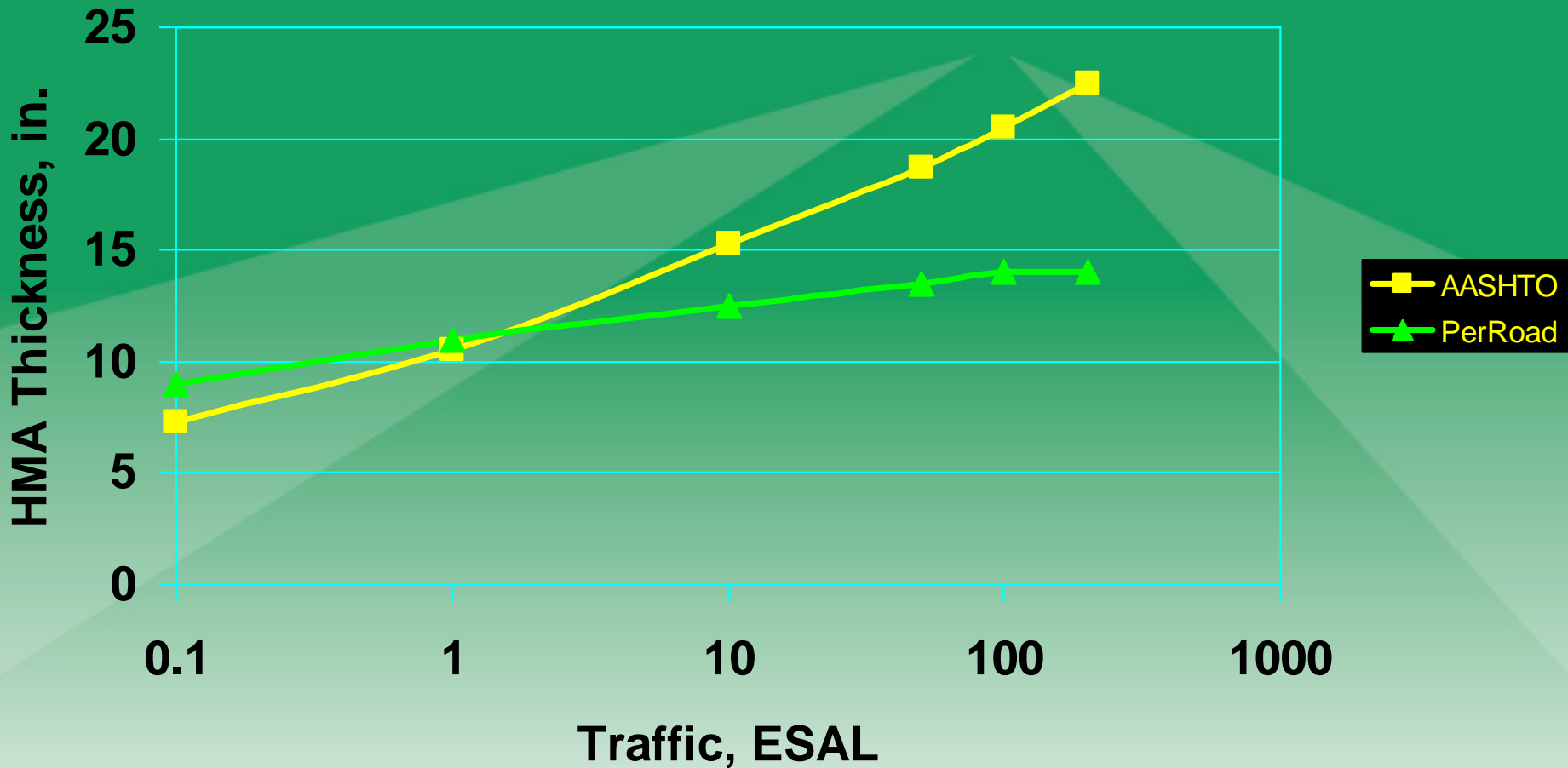


Why are Perpetual Pavements Important?

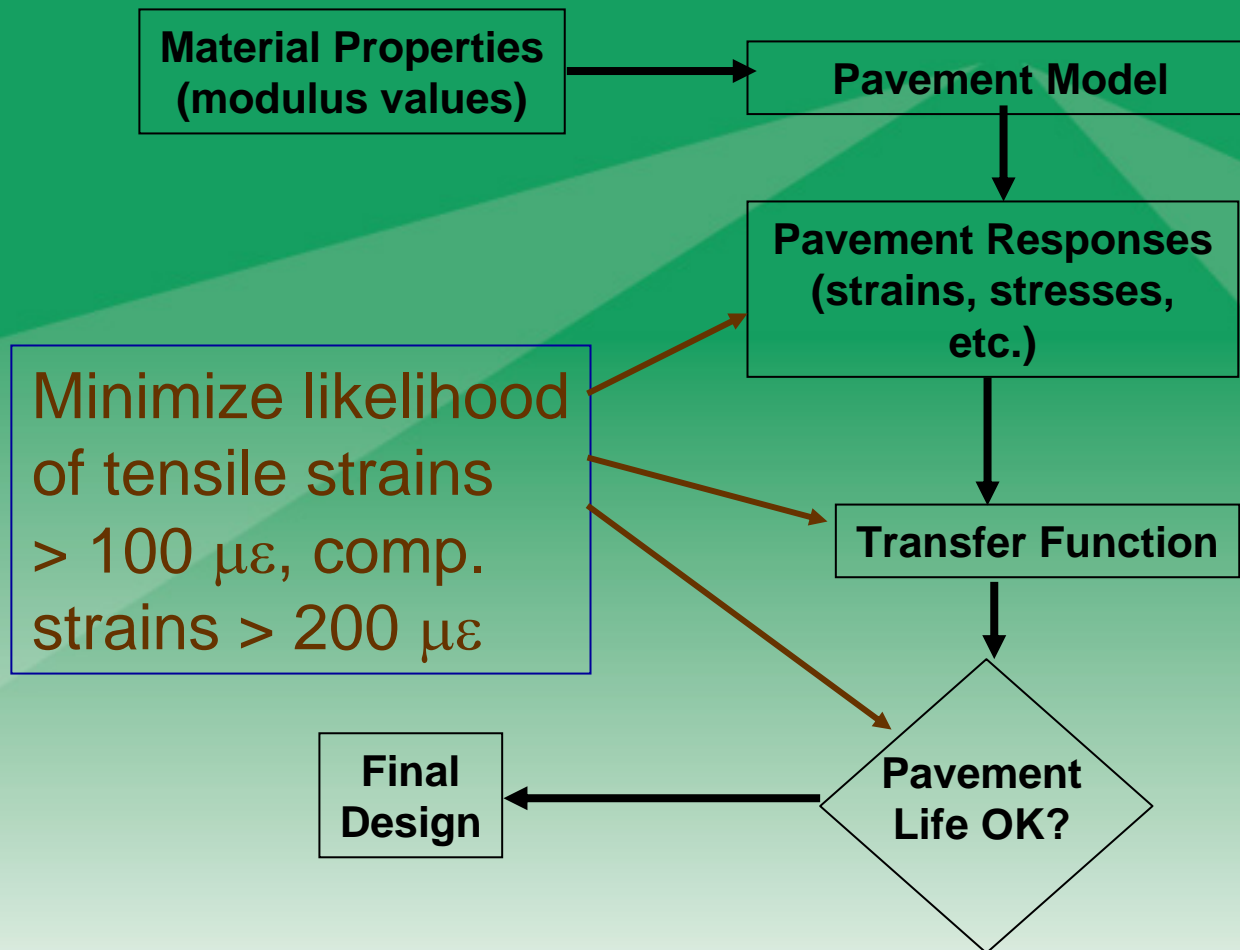
- Lower Life Cycle Cost
 - Better Use of Resources
 - Low Incremental Costs for Surface Renewal
- Lower User Delay Cost
 - Shorter Work Zone Periods
 - Off-Peak Period Construction

Perpetual Pavements

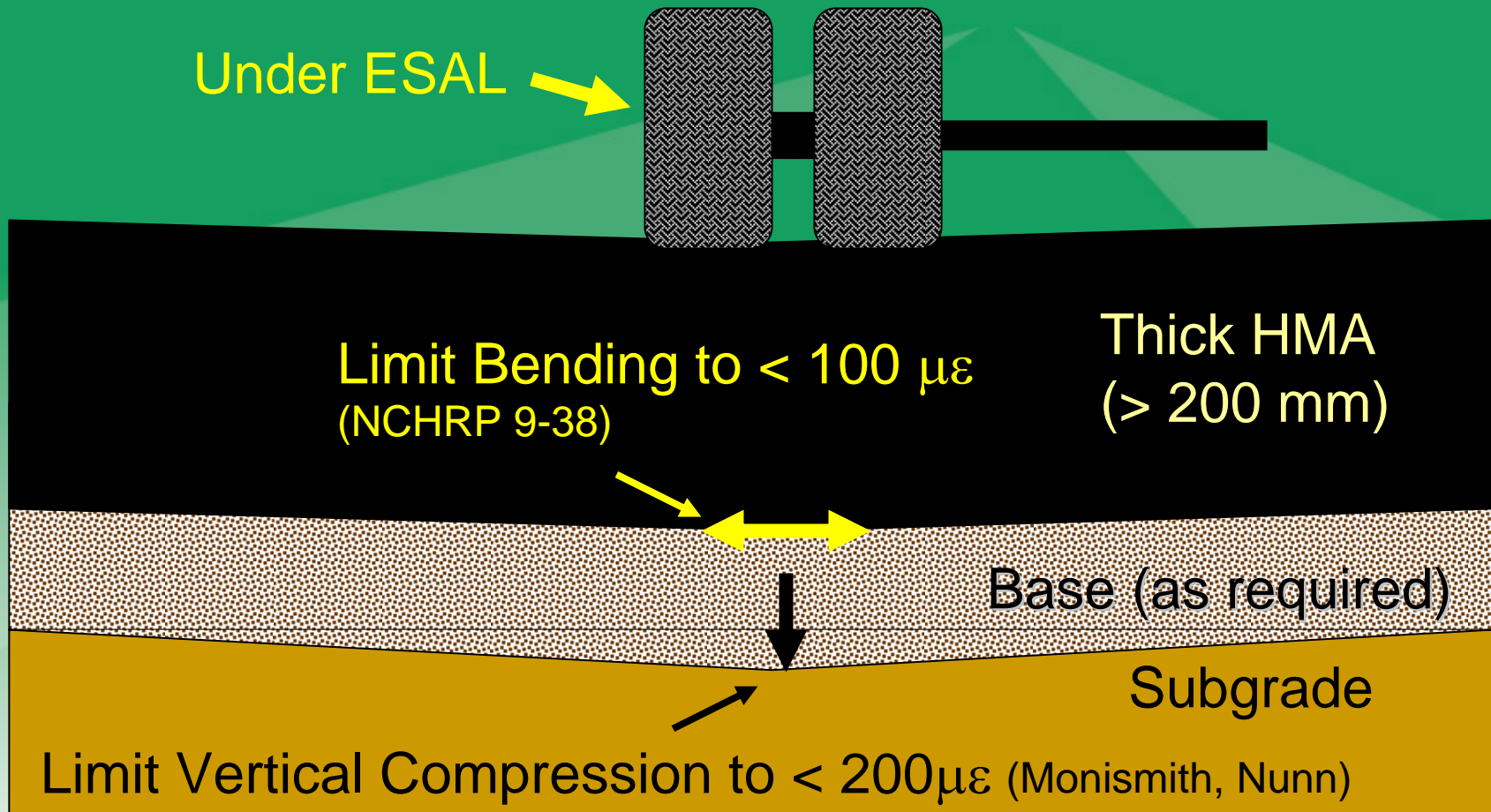
Perpetual Pavement versus Conventional Design



Mechanistic-Based Design

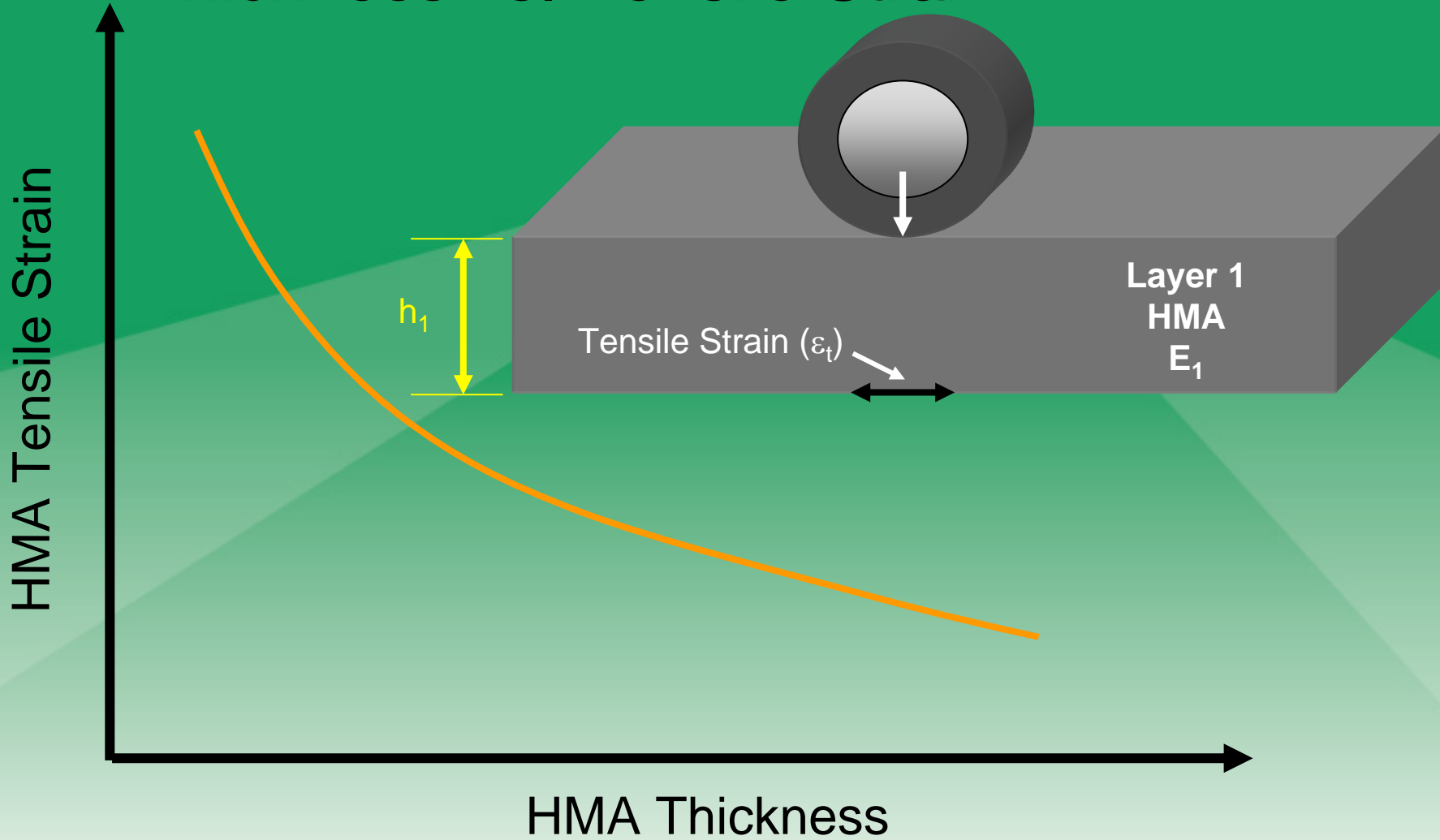


Mechanistic Performance Criteria

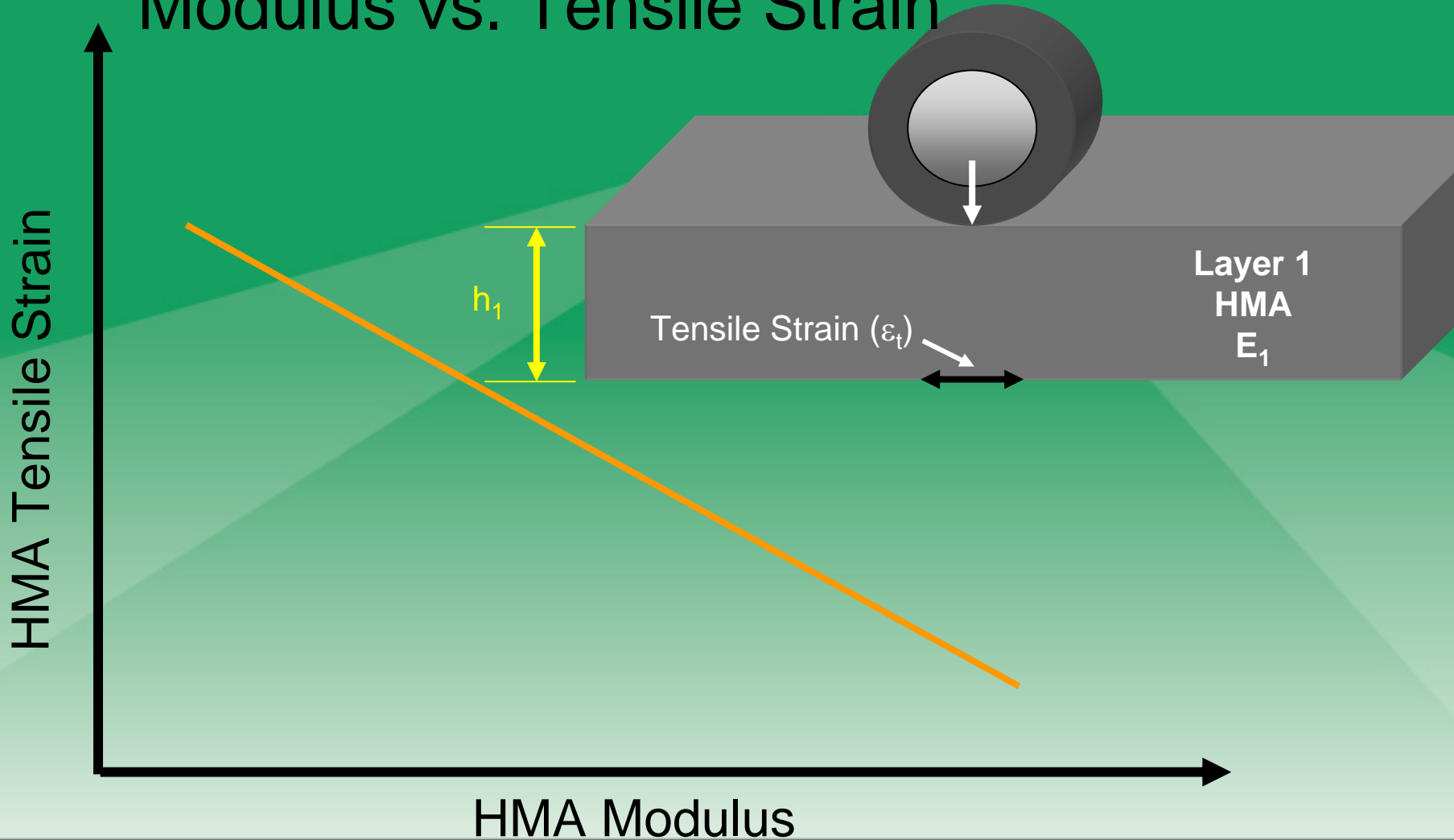


Perpetual Pavements

Thickness vs. Tensile Strain

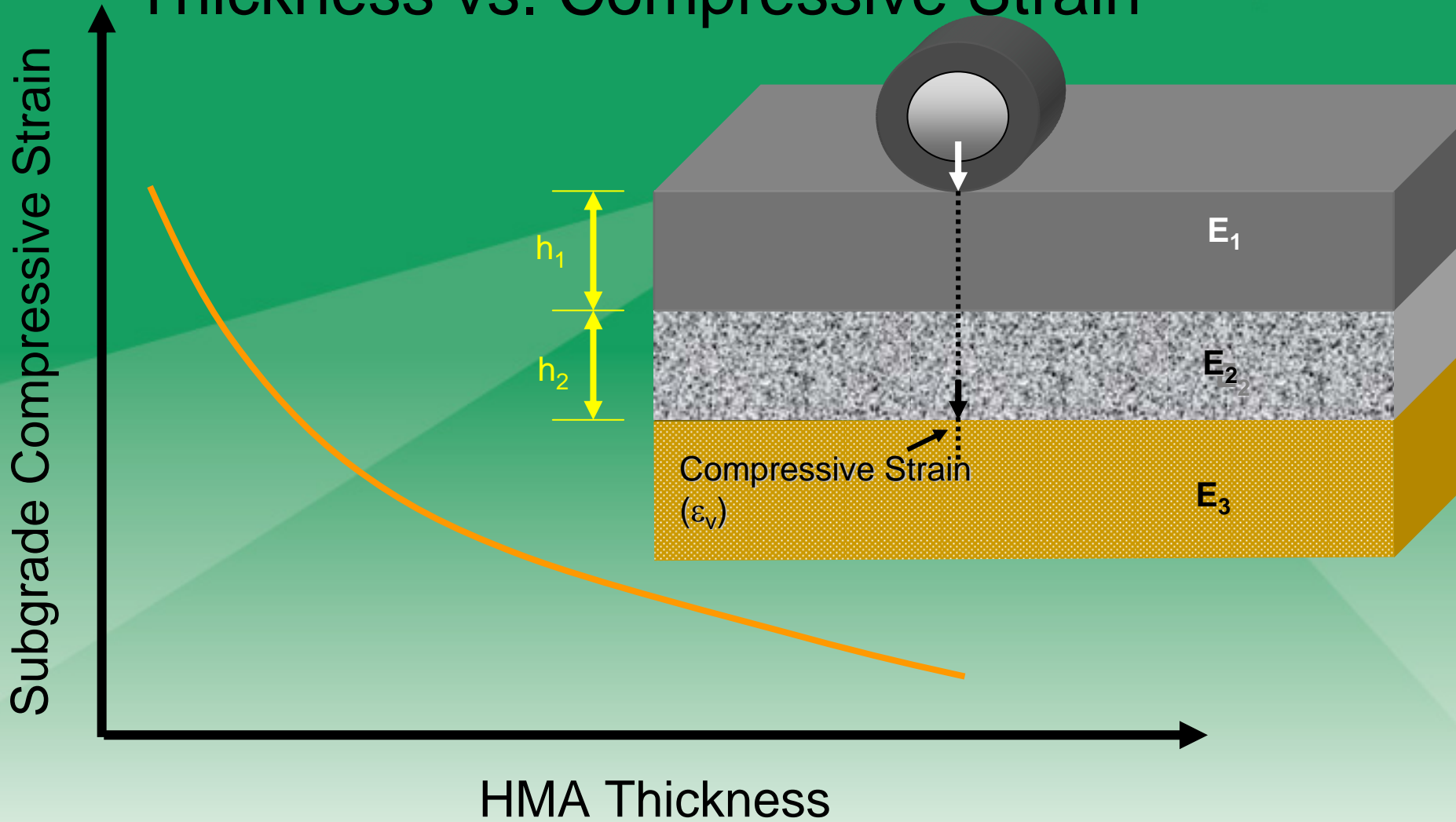


Modulus vs. Tensile Strain

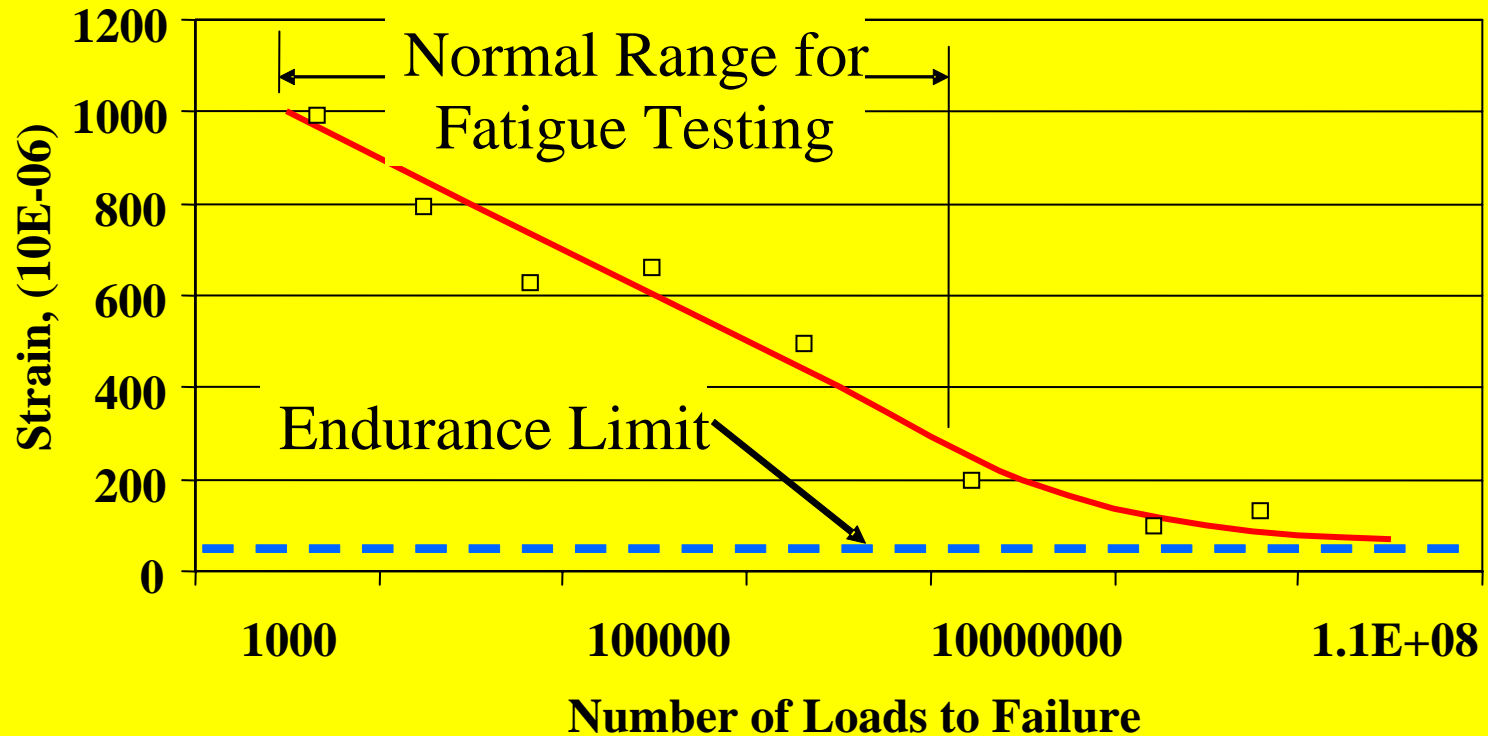


Perpetual Pavements

Thickness vs. Compressive Strain

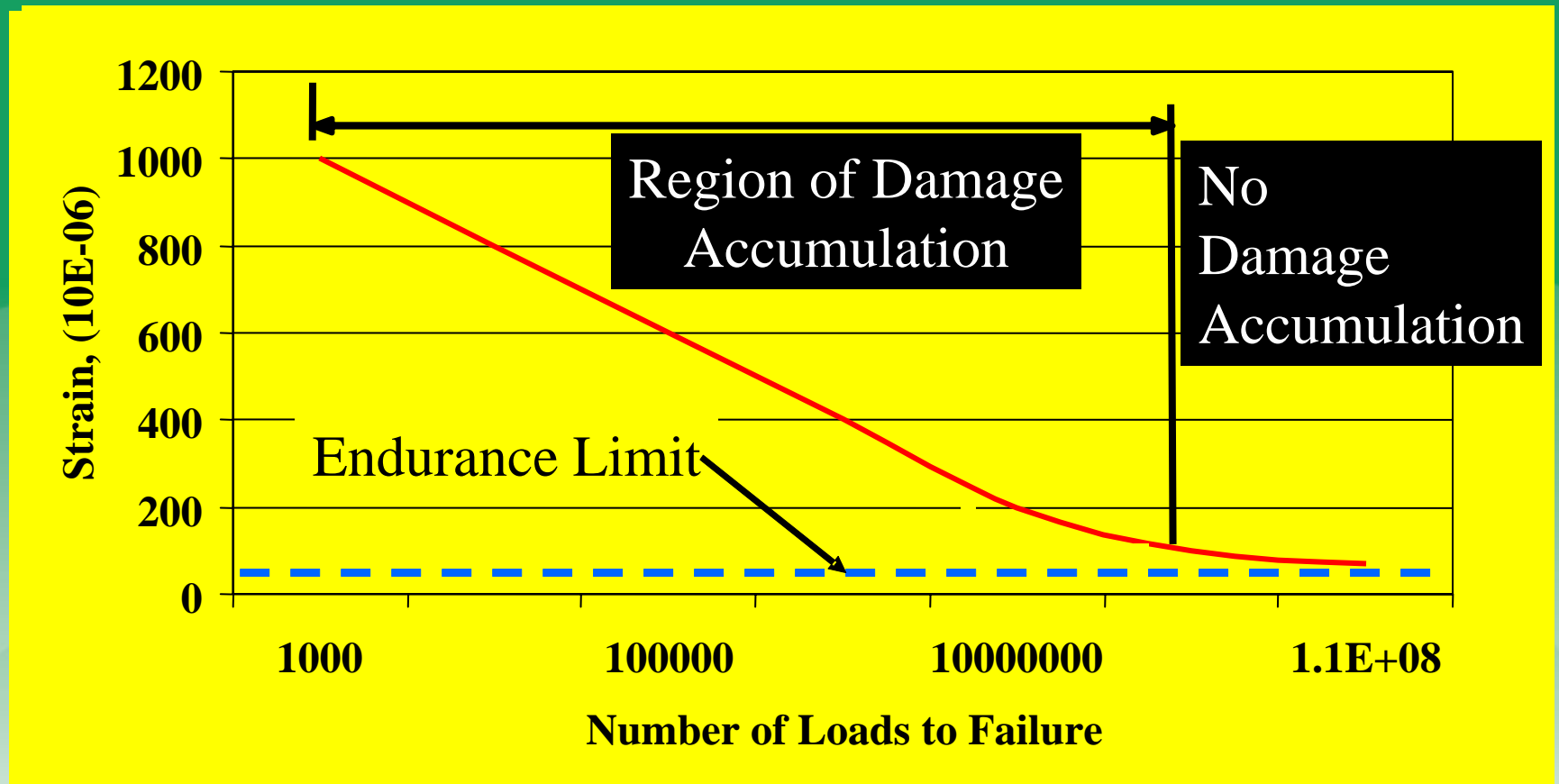


Perpetual Pavements



Normal Fatigue Testing Results Versus
Endurance Limit Testing

Perpetual Pavements



Does the Endurance Limit Exist?

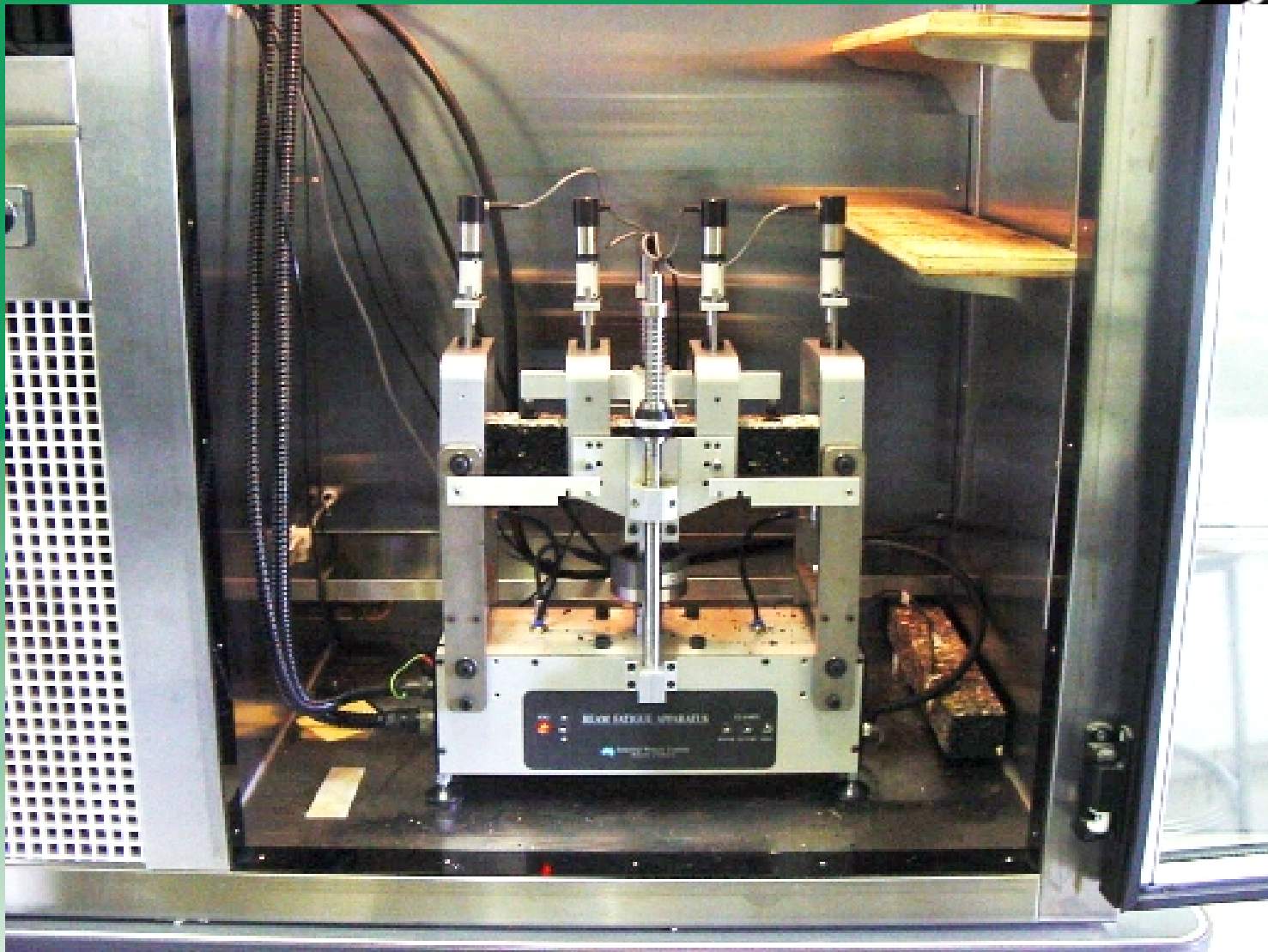
- University of Illinois Study
 - 70 $\mu\epsilon$ reasonable
- NCHRP Project 9-38
 - 100 $\mu\epsilon$ for unmodified asphalt
 - 250 $\mu\epsilon$ for modified asphalt
- NCHRP Project 9-44 – Validating the Endurance Limit
 - Endurance Limit Workshop
- In the new MEPDG to be adopted by AASHTO

Significance of Fatigue Endurance Limit

“....such a limit would provide a thickness limit for the pavement..Increasing the thickness beyond the limiting thickness... would provide no increased structural resistance to fatigue damage and represent an unneeded expense.”

Prof. Carpenter

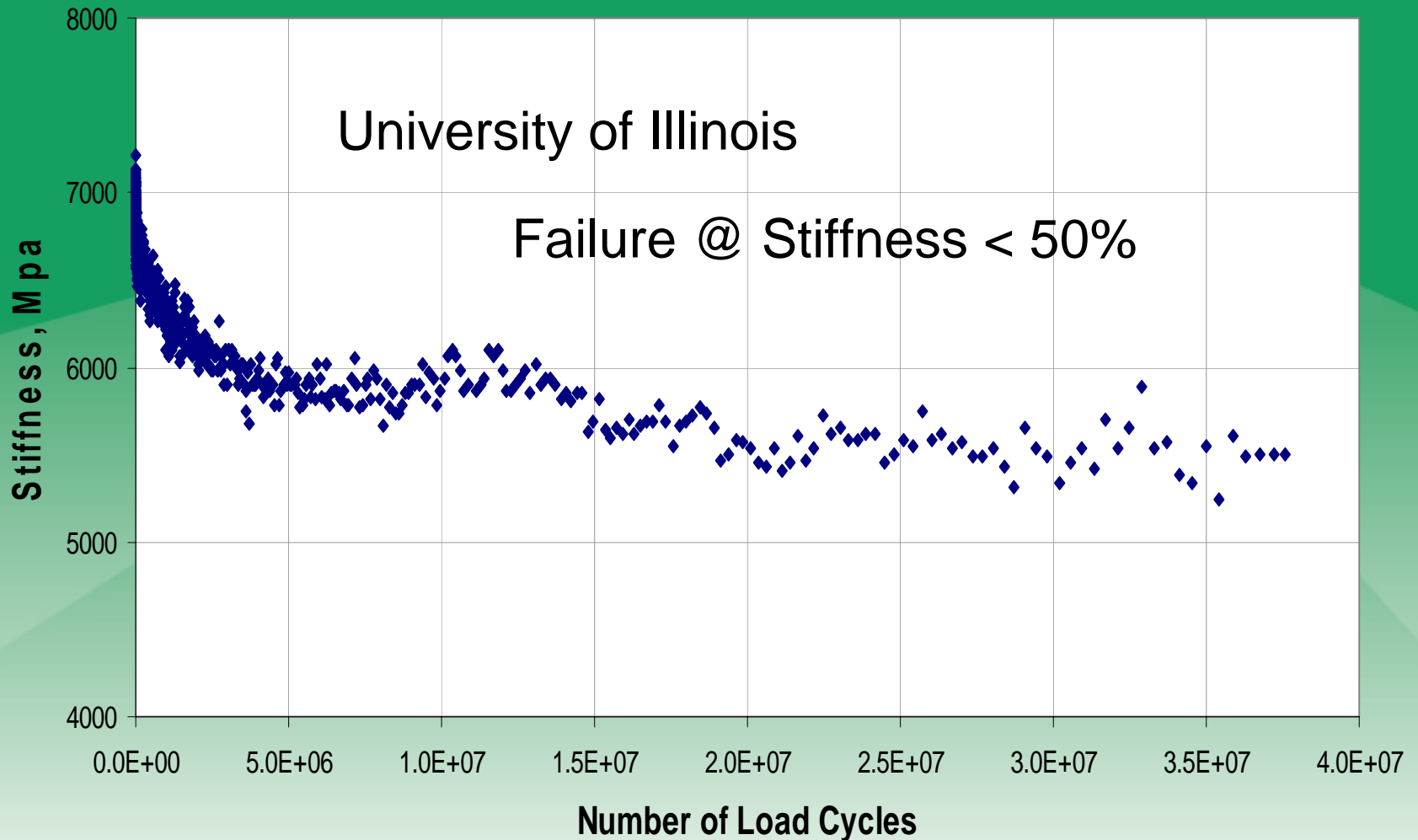
Perpetual Pavements



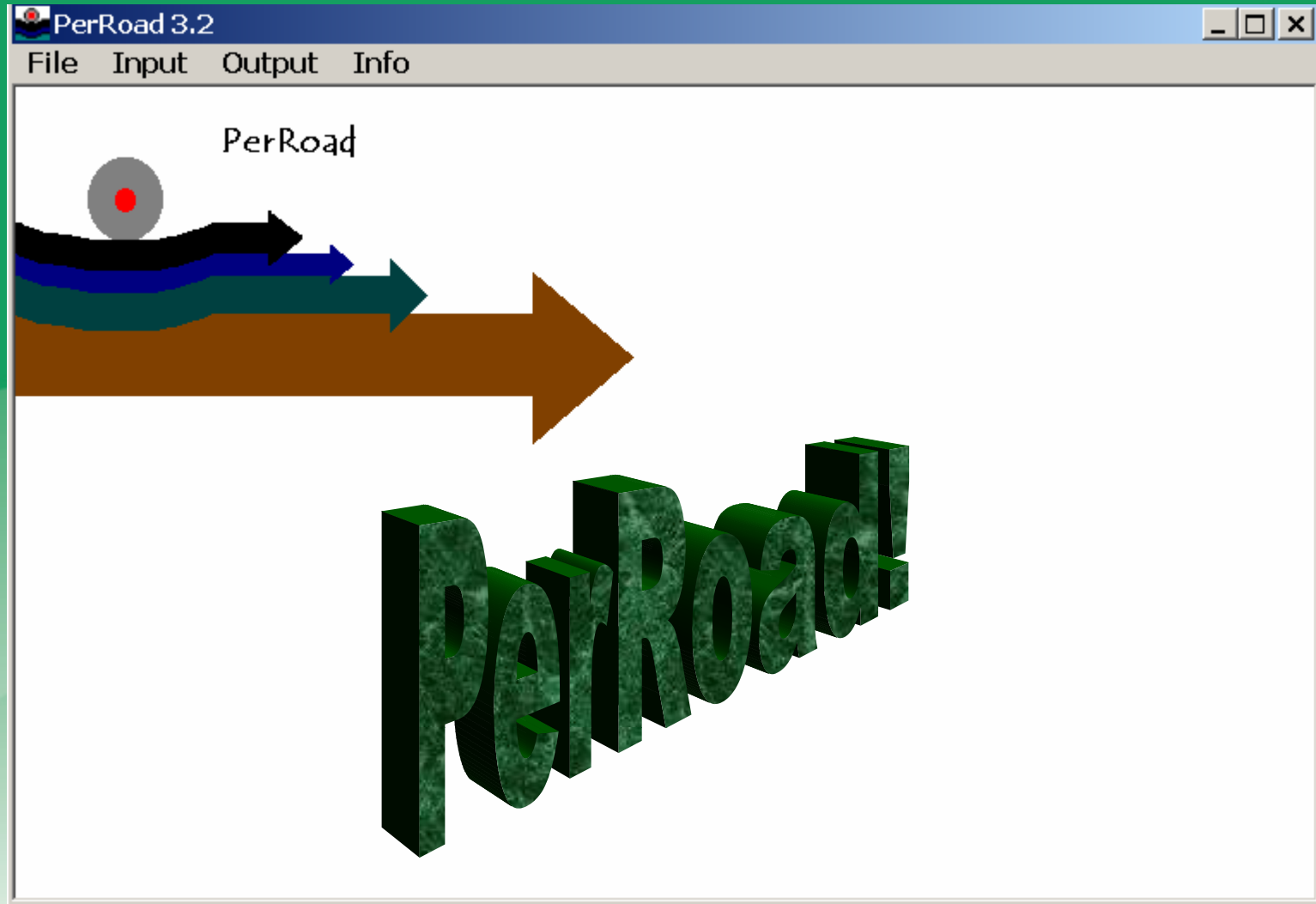
THE NEW ASPHALT, ABSOLUTELY!

SMOOTH | DURABLE | SAFE | QUIET

70 Micro Strain Test



Perpetual Pavements



THE NEW ASPHALT, ABSOLUTELY!

SMOOTH | DURABLE | SAFE | QUIET

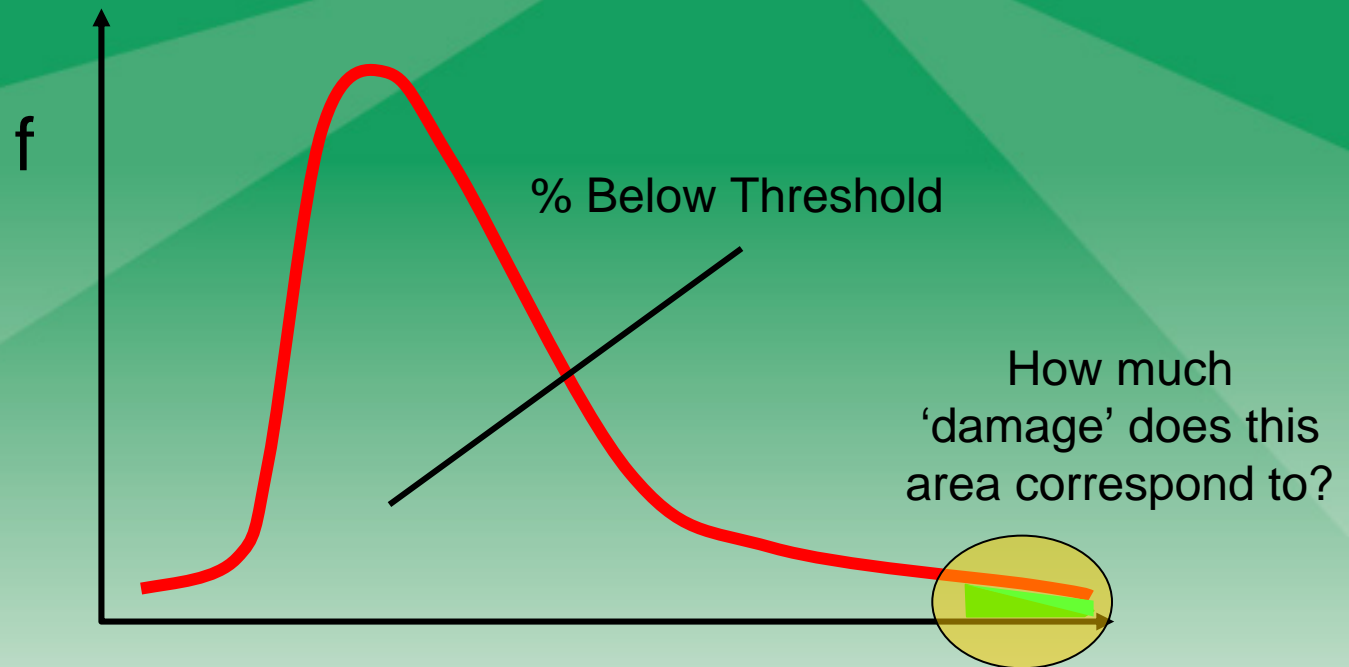
Analysis

- Program uses Monte Carlo simulation to model input distributions
 - Load, Materials, thickness
- A distribution of pavement response is determined
- Reliability = probability that response(s) below threshold, OR
- Damage/Million ESAL, OR
- Time to Damage = 0.1

Perpetual Pavements

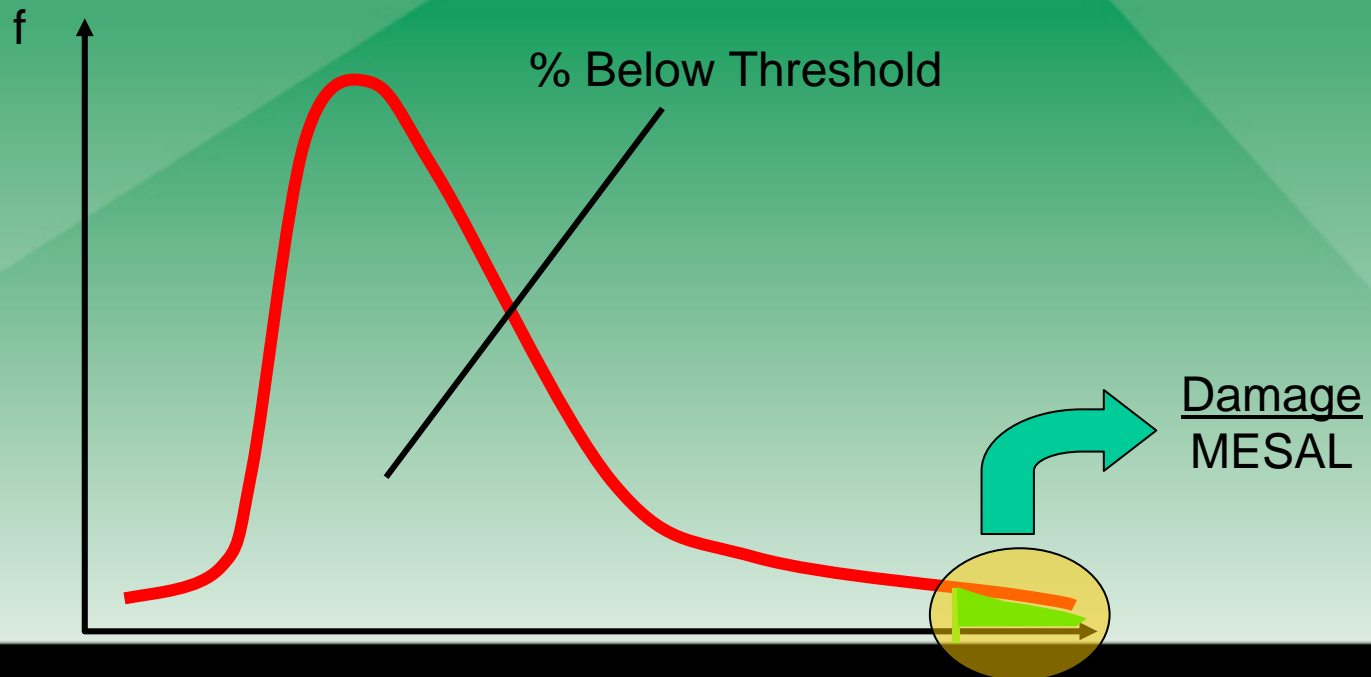
% Below Threshold

- Design should have high % below threshold



'Damage Computation'

- For responses exceeding threshold, compute N using transfer function
 - User defined
- Calculate damage accumulation rate
 - $\text{Damage} / \text{MESAL}$

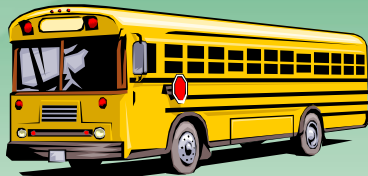


Perpetual Pavements

Estimated Long Life

- Convert damage rate into an estimated life
 - Use traffic volume and growth
 - Calculate when damage = 0.1
 - Use for Low Vol. Roads (t ~30 yrs.)

Low Volume Traffic



10 - 20/wk



3 - 5/wk



10 - 20/wk

Key Components

- Based on fully functional M-E design software
- Layered elastic analysis
- Incorporates
 - Seasonal effects
 - Thickness variability
 - Material property variability
 - Load Spectra or Traffic Count
 - Probabilistic analyses

Perpetual Pavements

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): Summer: 26, Fall: 8, Winter: 12, Spring: 6, Spring2: 0

Mean Air Temperature, F: Summer: 70, Fall: 70, Winter: 70, Spring: 70, Spring2: 70 Temperature Correction

	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Material Type	AC	Soil	Soil	Soil	Soil
PG Grade	70 -22				
Min Modulus (psi)	50000	3000	3000	3000	3000
Modulus (psi)	522958	12000	12000	12000	12000
Max Modulus (psi)	4000000	40000	40000	40000	40000
Poisson's Ratio	0.35	0.45	0.45	0.45	0.45
Min - Max	0.15 - 0.4	0.2 - 0.5	0.2 - 0.5	0.2 - 0.5	0.2 - 0.5
Thickness (in)	10	999	999	999	Infinite
	Variability	Variability	Variability	Variability	Variability
	Performance Criteria	Performance Criteria	Performance Criteria	Performance Criteria	Performance Criteria
Slip Condition Between Layers	Full Bond	Full Bond	Full Bond	Full Bond	

Cancel Changes Accept Changes

Perpetual Pavements

Perpetual Pavement Performance Criteria

- Designer selects location(s) in layer
- Type of criteria (stress, strain, deflection)
- Threshold value and transfer function

Layer Performance Criteria (Press F1 for Help) x

Layer:

Position	Criteria	Threshold	Transfer Function	k1	k2
<input type="checkbox"/> Top					
<input type="checkbox"/> Middle					
<input checked="" type="checkbox"/> Bottom	<input type="text" value="Horizontal Strain"/>	<input type="text" value="-70"/>	microstrain <input checked="" type="checkbox"/>	<input type="text" value="2.83e-006"/>	<input type="text" value="3.15"/>

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

Note: The transfer functions are for strain only.

Perpetual Pavements

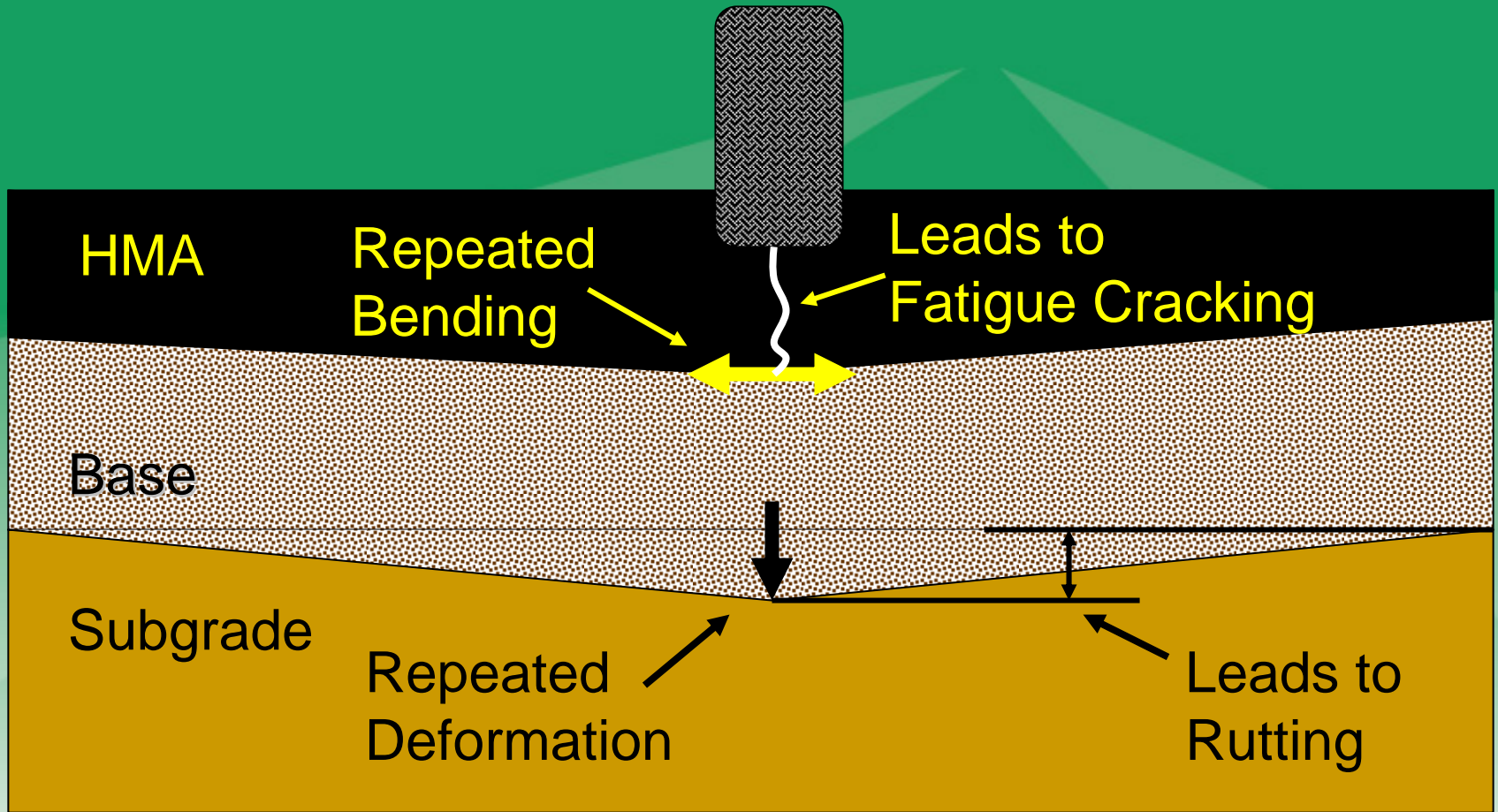
Traffic

Vehicle Type Distribution (Press F1 for Help)

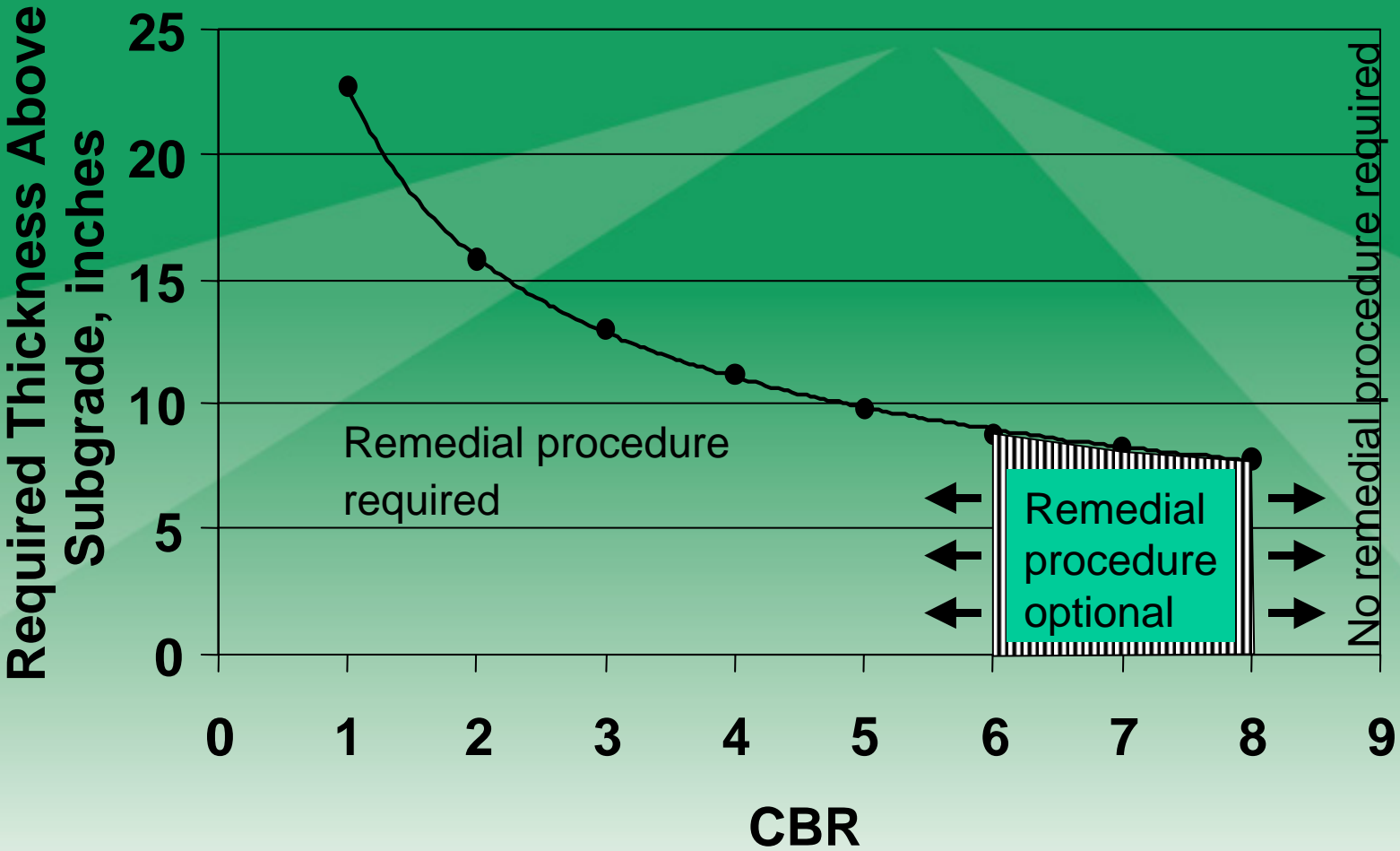
Roadway Functional Classification: Rural Interstate

Vehicle Classification	% AADTT			
4	<input type="text" value="1.2"/>			
5	<input type="text" value="9.4"/>			
6	<input type="text" value="3.3"/>			
7	<input type="text" value="0.5"/>			
8	<input type="text" value="7.4"/>	<input type="text" value="1"/>	<input type="text" value="0.26"/>	<input type="text" value="0.83"/>
9	<input type="text" value="68.9"/>	<input type="text" value="2.38"/>	<input type="text" value="0.67"/>	<input type="text" value="0"/>
10	<input type="text" value="1.2"/>	<input type="text" value="1.13"/>	<input type="text" value="1.93"/>	<input type="text" value="0"/>
11	<input type="text" value="6.1"/>	<input type="text" value="1.19"/>	<input type="text" value="1.09"/>	<input type="text" value="0.89"/>
12	<input type="text" value="0.8"/>	<input type="text" value="4.29"/>	<input type="text" value="0.26"/>	<input type="text" value="0.06"/>
13	<input type="text" value="1.2"/>	<input type="text" value="3.52"/>	<input type="text" value="1.14"/>	<input type="text" value="0.06"/>
Total	<input type="text" value="100"/>	<input type="text" value="2.15"/>	<input type="text" value="2.13"/>	<input type="text" value="0.35"/>

Performance Goals - Avoid These

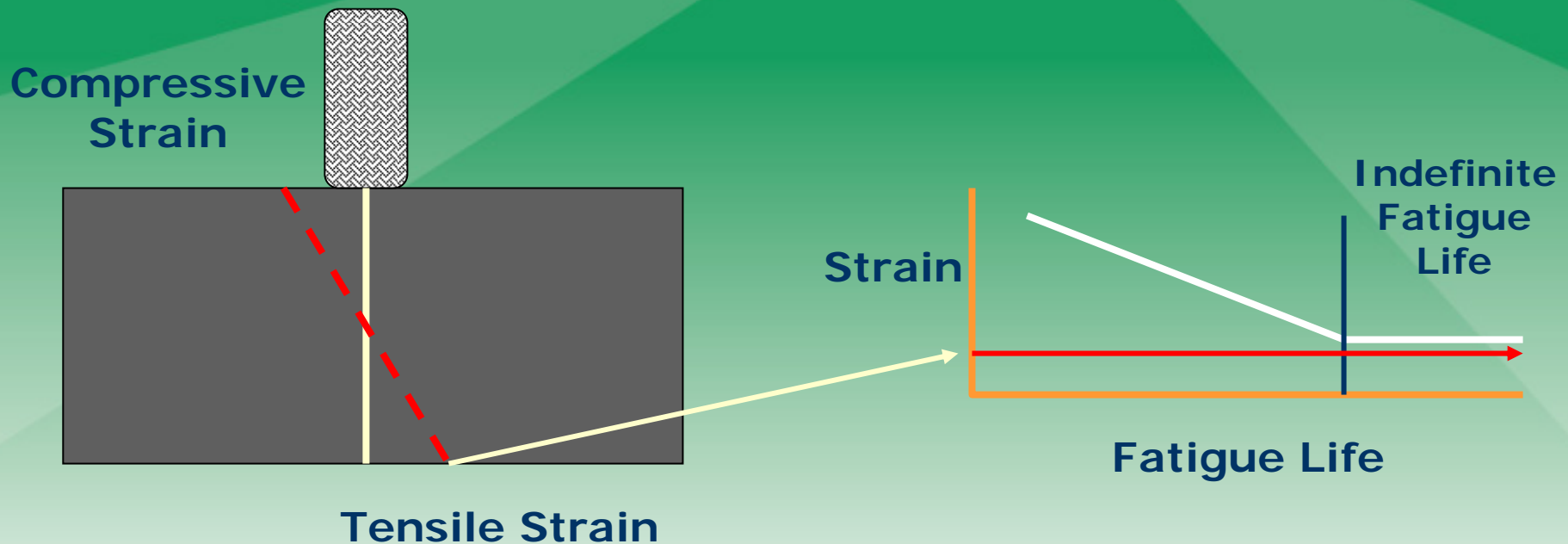


Foundation - Illinois

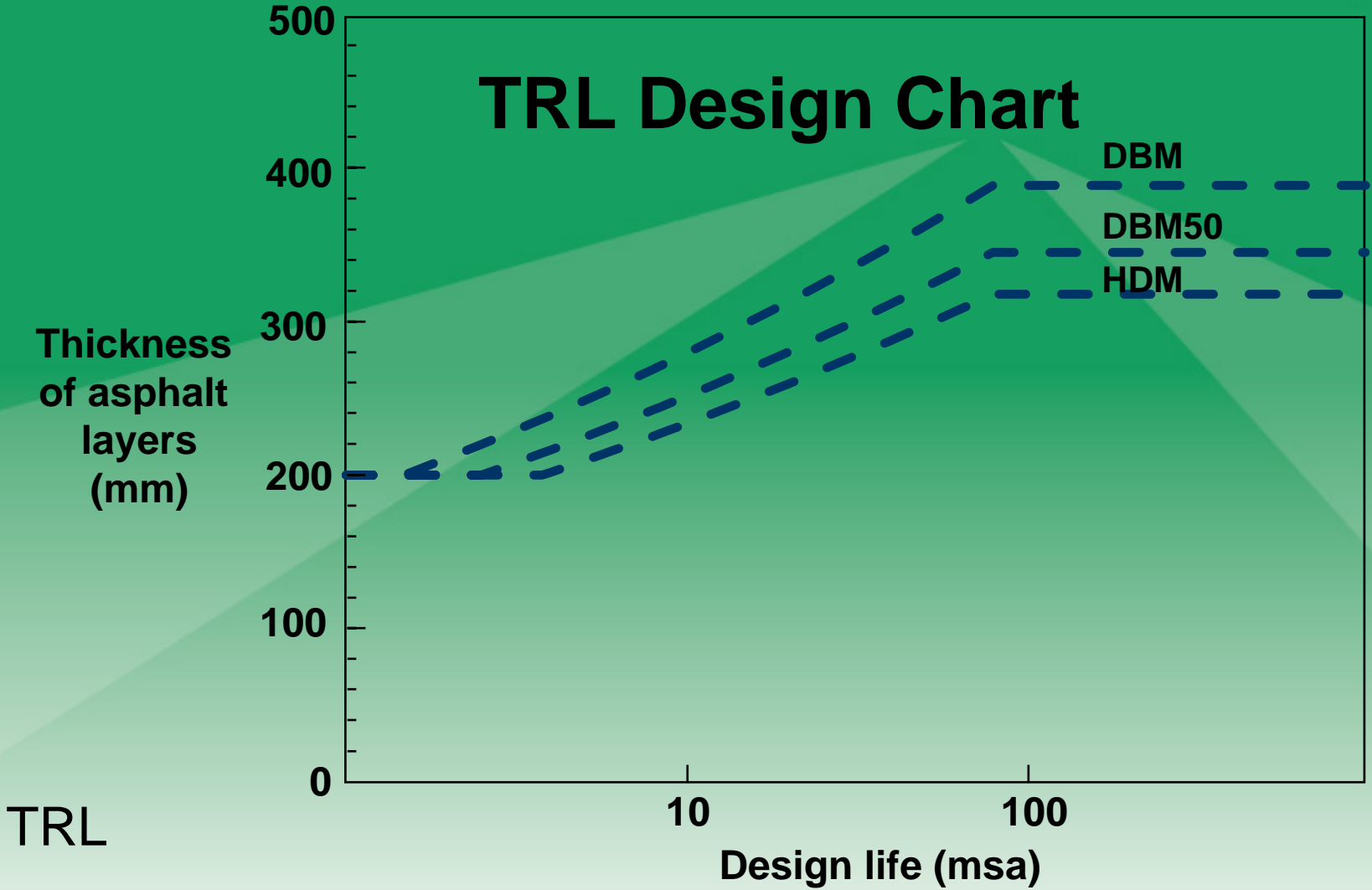


Perpetual Pavements

- › Fatigue Resistant Asphalt Base
 - » Minimize Tensile Strain with Pavement Thickness
 - » Thicker Asphalt Pavement = **Lower Strain**
 - » Strain Below Fatigue Limit = **Indefinite Life**



Perpetual Pavements



TRL

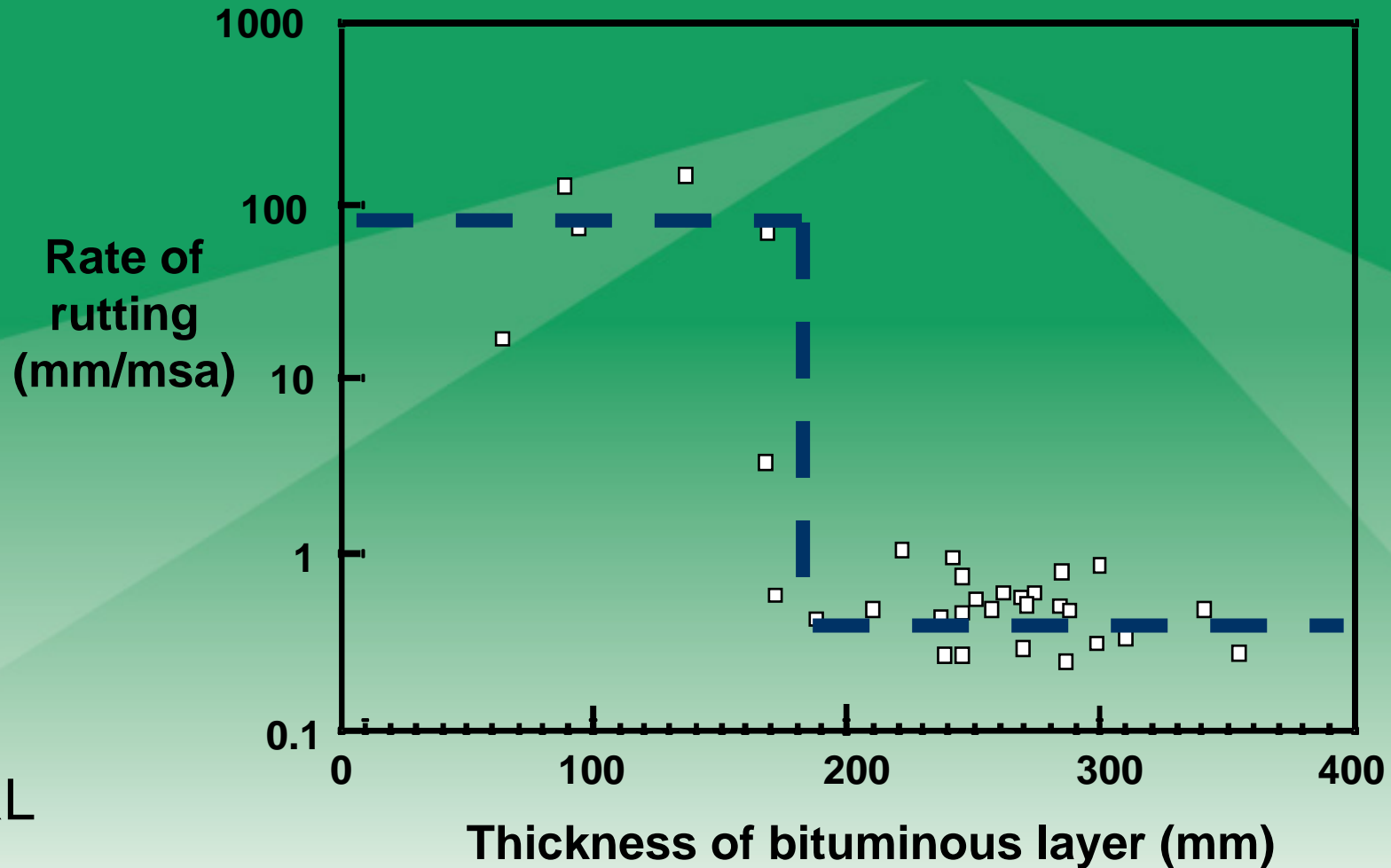
Perpetual Pavements



- › Rut Resistant Upper Layers
 - Aggregate Interlock
 - » *Crushed Particles*
 - » *Stone-on-Stone Contact*
 - Binder
 - » *High Temperature PG*
 - » *Polymers*
 - » *Fibers*
 - Air Voids
 - » *Avg. 4% to 6% In-Place*
 - Surface
 - » *Renewable*
 - » *Tailored for Specific Use*



RATE OF RUTTING vs ASPHALT THICKNESS



TRL

Perpetual Pavements



Performance of Washington Interstate Flexible Pavements (based on 284 km)

Statistic	Time Since Original Construction (years)	Thickness of Original AC (mm (in.))	Time from Original Construction to First Resurfacing (years)
Average	31.6	230 (9.2)	12.4
Range	23 to 39	100 to 345	2 to 25

Ohio Study of Flexible Pavements

- Examined Performance on 4 Interstate Routes
 - HMA Pavements - Up to 34 Years without Rehabilitation or Reconstruction
 - “No significant quantity of work . . . for structural repair or to maintain drainage of the flexible pavements.”
 - Only small incremental increases in Present Cost for HMA pavements.

Perpetual Pavements

FHWA - Data from Long-Term Pavement Performance Study

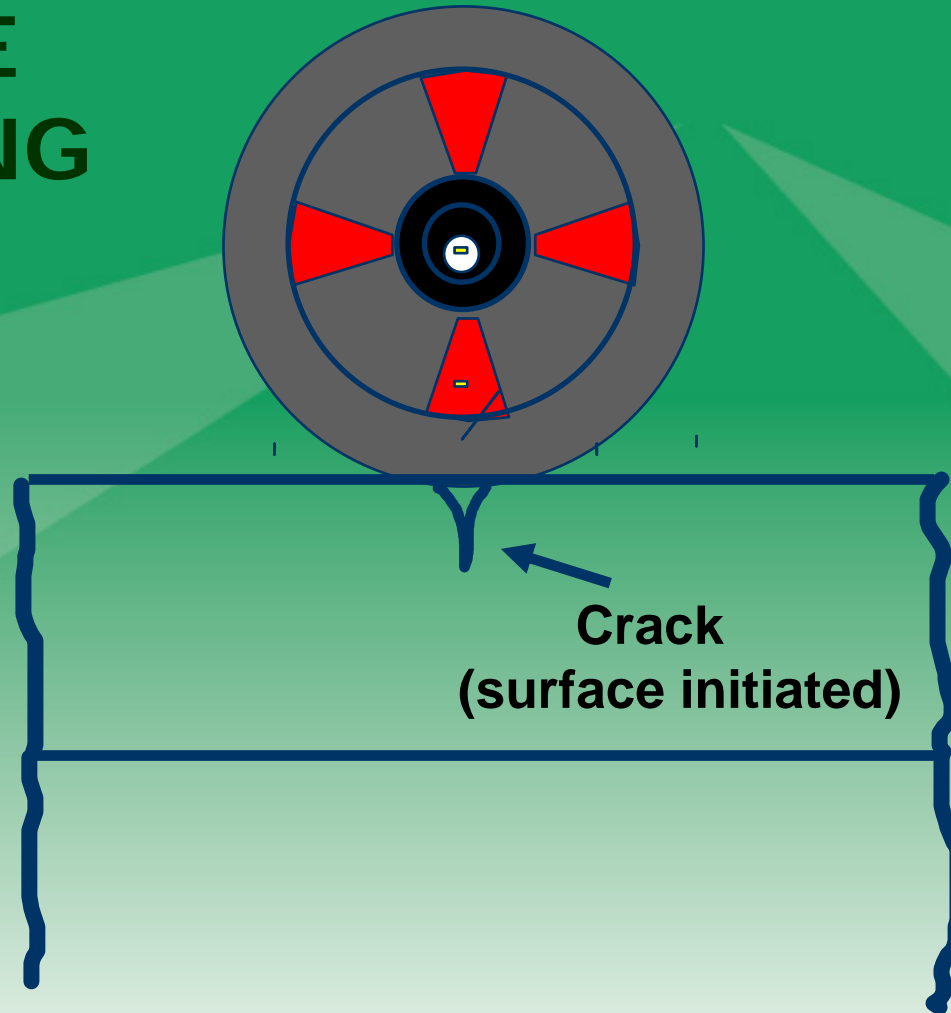
- Data from GPS-6 (FHWA-RD-00-165)
- Conclusions
 - *Most AC Overlays \geq 15 years before Rehab*
 - *Many AC Overlays $>$ 20 years before Significant Distress*
 - Thicker overlays mean less:
 - Fatigue Cracking
 - Transverse Cracking
 - Longitudinal Cracking

Perpetual Pavements



SURFACE CRACKING

WHEEL LOAD



Crack
(surface initiated)

TRL

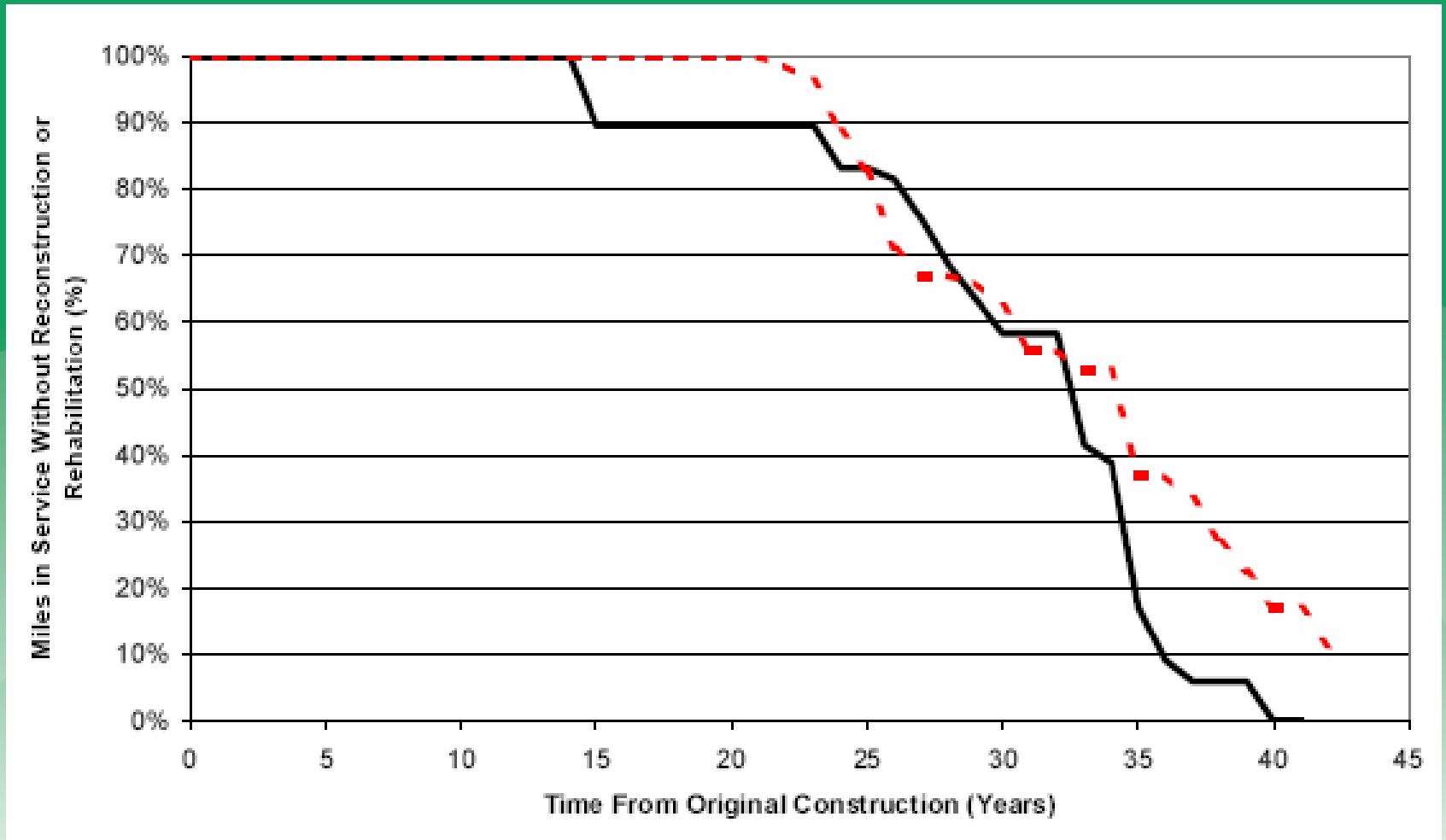
Perpetual Pavements

New Jersey I-287 Surface Cracking



Perpetual Pavements

Study of Kansas Interstates



Current Perpetual Pavement Efforts

- Europe
- California
- Colorado
- Illinois
- Kentucky
- Michigan
- Ohio
- Oregon
- Texas
- Wisconsin


Possible Distresses

- > *Top-Down Fatigue*
- > *Thermal Cracking*
- > *Raveling*

Solutions

- > *Mill & Fill*
- > *Thin Overlay*

Structure Remains Intact
50 - 100 mm



High Quality SMA, OGFC or Superpave

20+ Years
Later



Perpetual Pavements



Perpetual Pavement

- › Structure Lasts 50+ years.
 - » Bottom-Up Design and Construction
 - » Indefinite Fatigue Life
- › Renewable Pavement Surface.
 - » High Rutting Resistance
 - » Tailored for Specific Application
- › Consistent, Smooth and Safe Driving Surface.
- › Environmentally Friendly
- › Avoids Costly Reconstruction.

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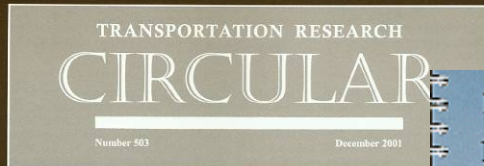
References



Perpetual Pavements

A Synthesis

APA 101



Perpetual Bituminous Pavements

TRANSPORTATION RESEARCH BOARD / NATIONAL RESEARCH COUNCIL ON HIGHWAY TRANSPORTATION SAFETY



Design of long-life flexible pavements for heavy traffic

by M.E. Skaar, A. Brown, D. Weston and J.C. Nicholls

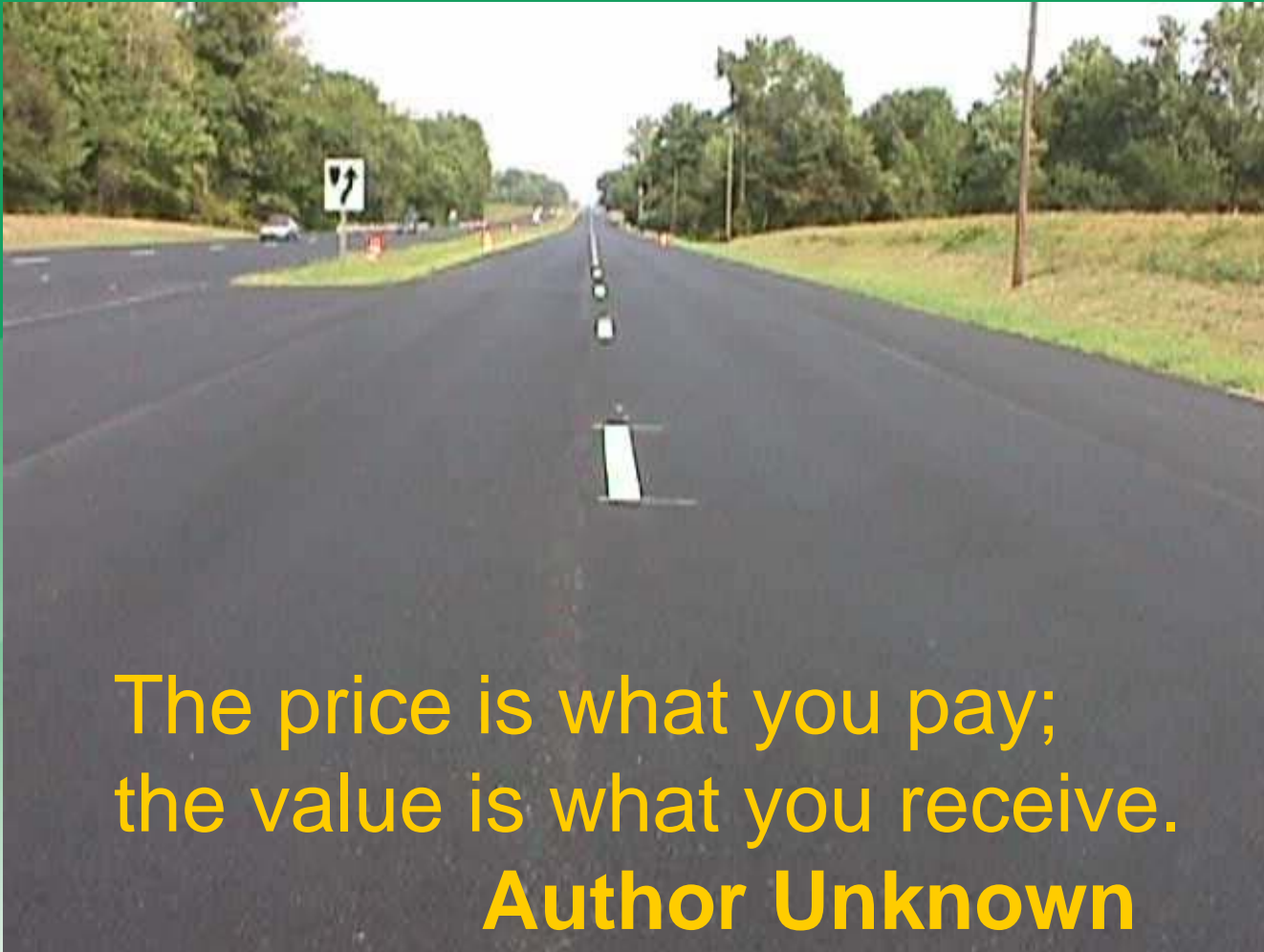
TRB Report 850

- Int'l Conferences on Perpetual Pavements
 - Int'l Soc. for Asphalt Pavements – 2004
 - Ohio – 2006

Perpetual Pavements



Value - Paraphrased



The price is what you pay;
the value is what you receive.

Author Unknown