Perpetual Pavement Design
An Introduction to the PerRoad Program

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Michigan Asphalt Conference
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Overview

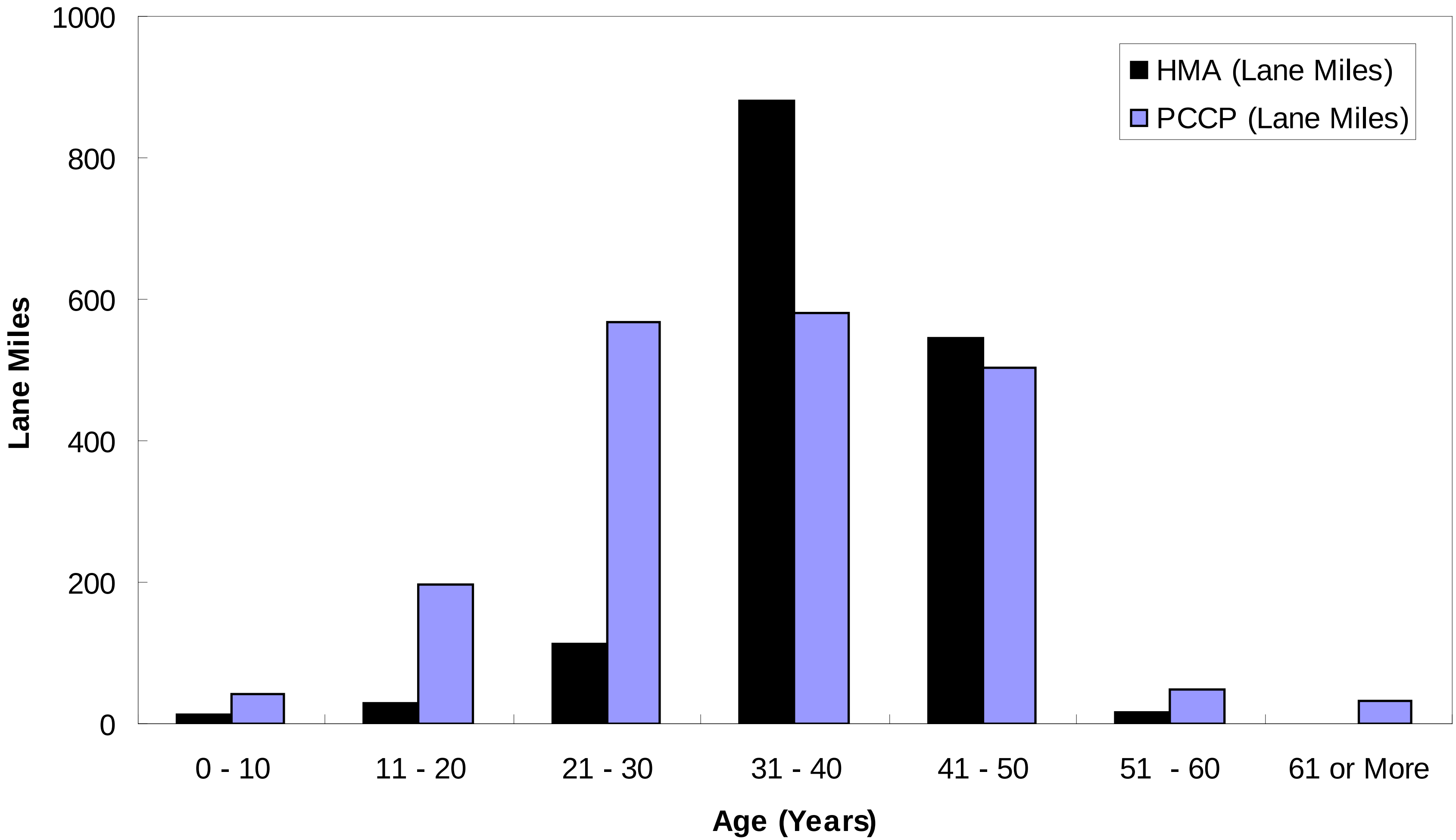
- Pavement design background
  - Layered elastic theory
- Perpetual pavement design philosophy
  - Sensitivity Study
- Program basics
- Example problems – Design simulations

WHY ARE PERPETUAL PAVEMENTS IMPORTANT?

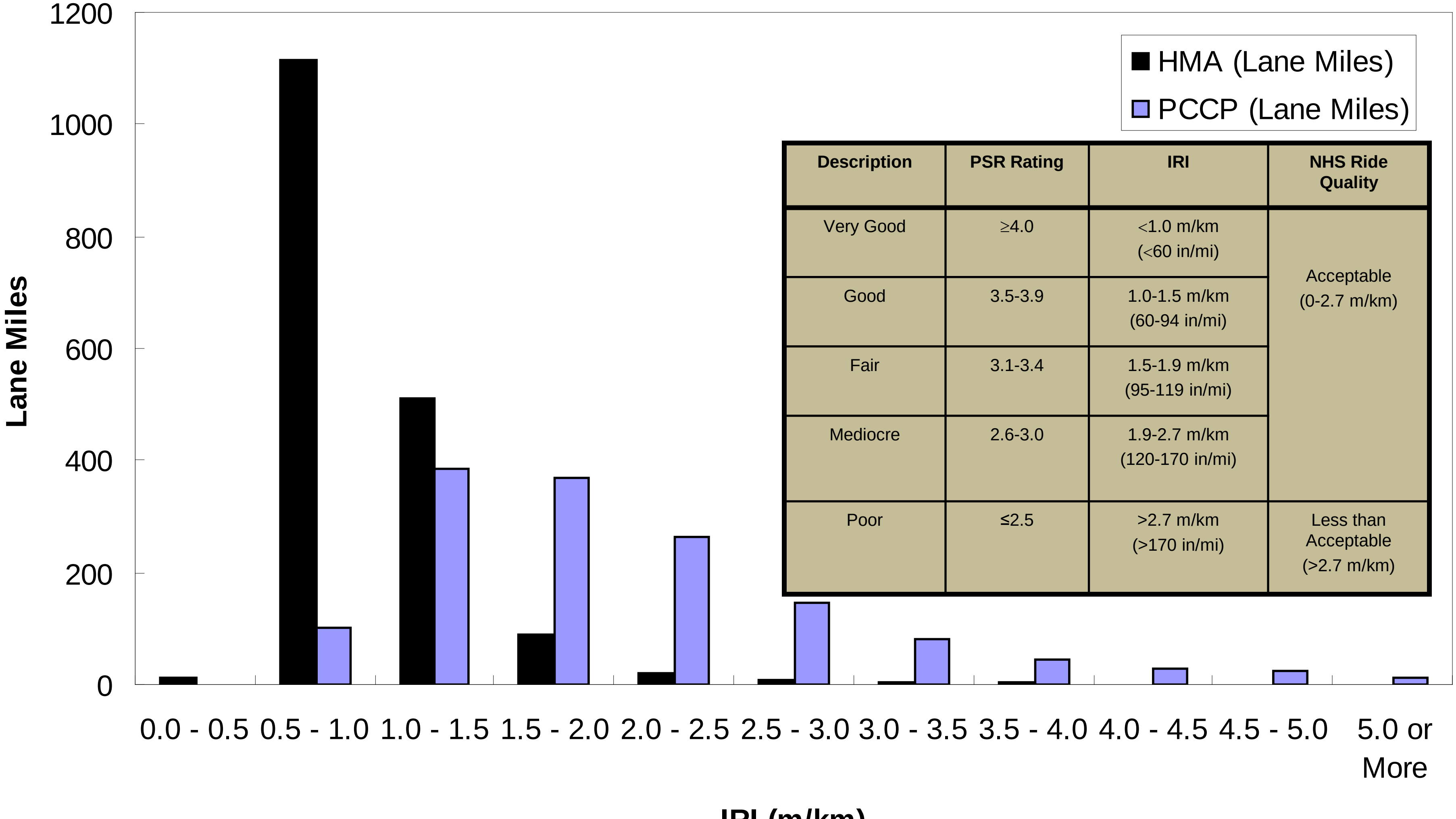
Perpetual Pavement Award

- Started by the Asphalt Pavement Alliance in 2001.
- Road must be >35 years old.
- No thickness increase >4 inches.
- No overlay interval less than 13 years.
- Nominated by DOT.

Washington State Performance

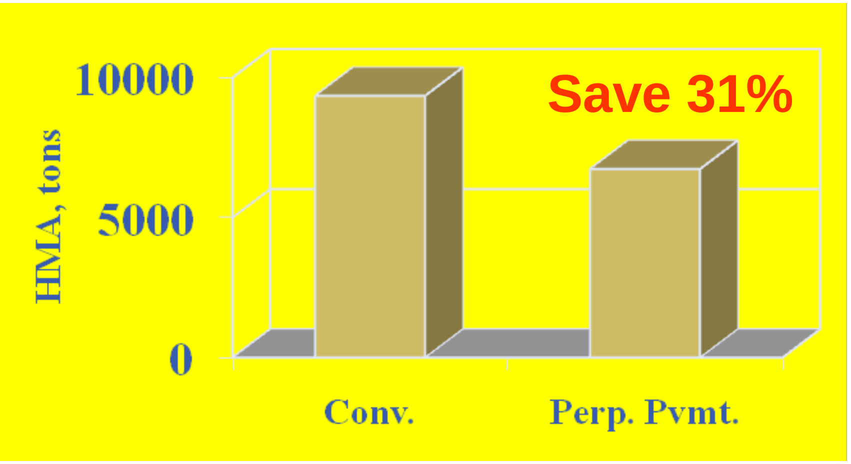


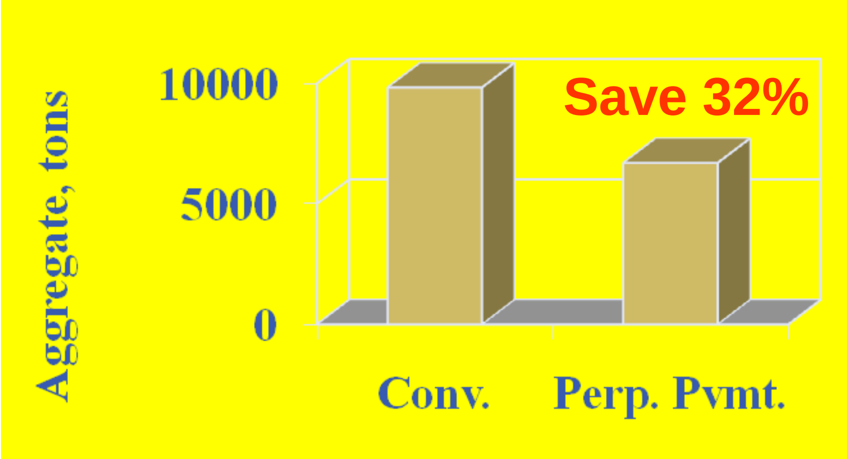
Washington State Performance



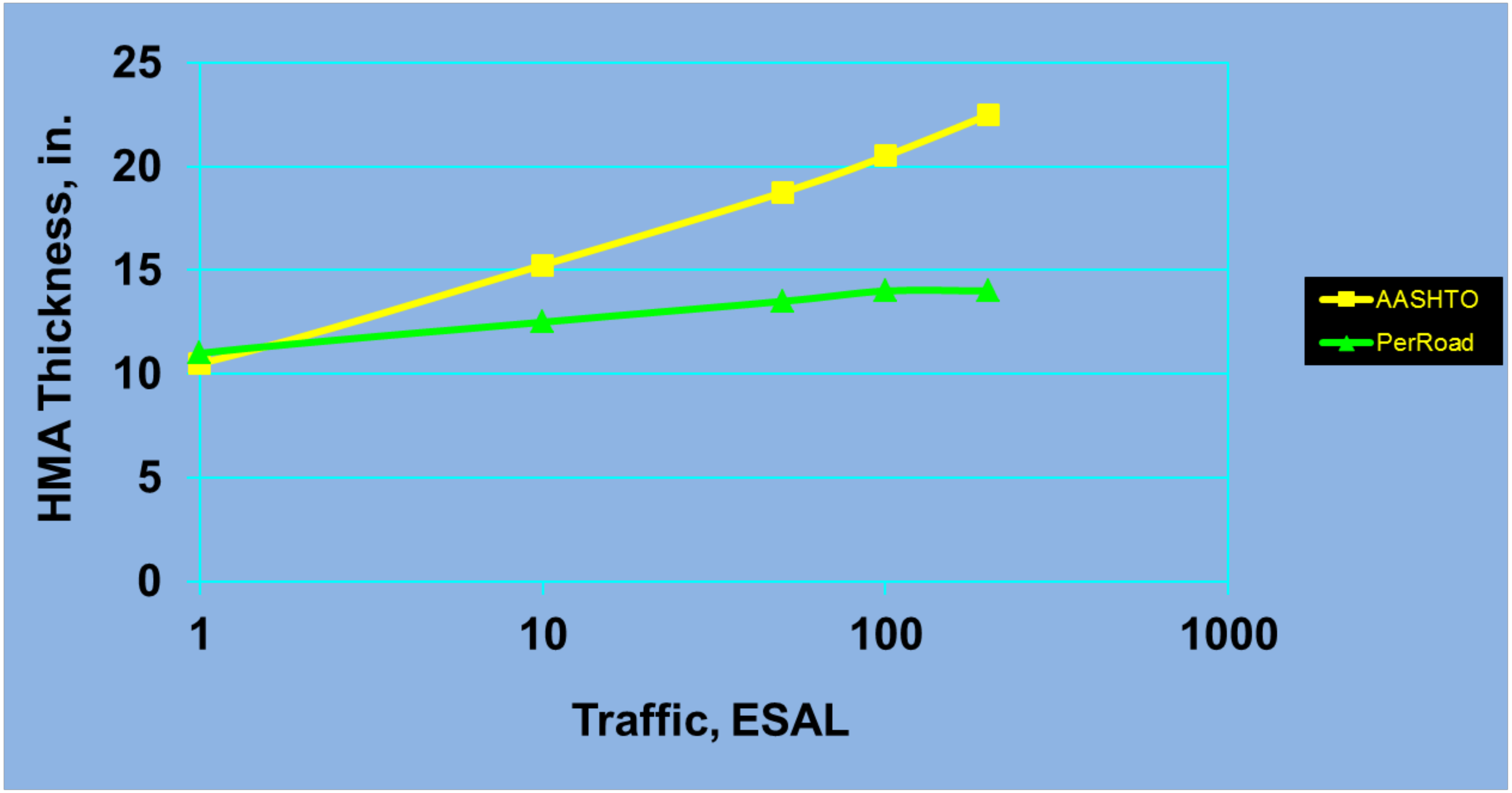
Description	PSR Rating	IRI	NHS Ride Quality
Very Good	≥4.0	<1.0 m/km (<60 in/mi)	Acceptable (0-2.7 m/km)
Good	3.5-3.9	1.0-1.5 m/km (60-94 in/mi)	
Fair	3.1-3.4	1.5-1.9 m/km (95-119 in/mi)	
Mediocre	2.6-3.0	1.9-2.7 m/km (120-170 in/mi)	
Poor	≤2.5	>2.7 m/km (>170 in/mi)	Less than Acceptable (>2.7 m/km)

Material Usage



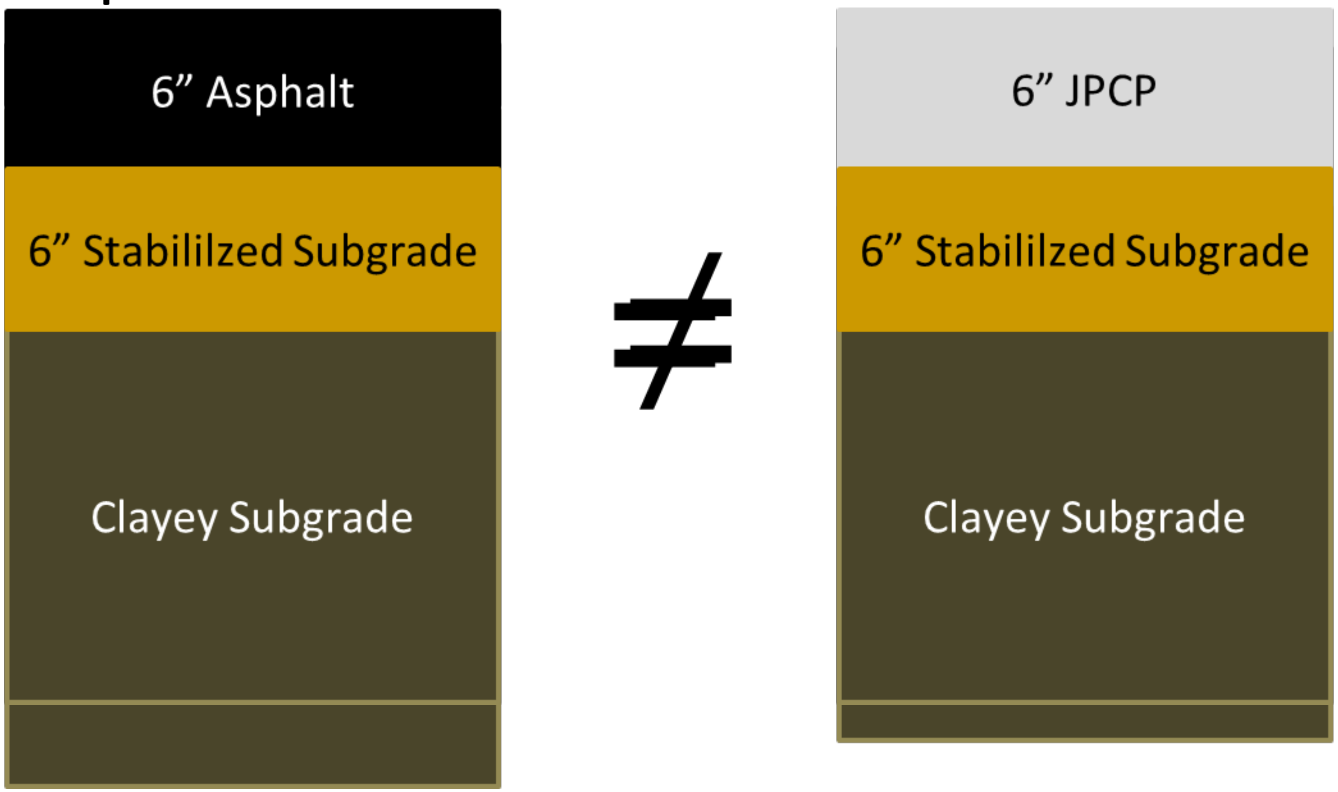


Perpetual Pavement versus Conventional Design



A City in Texas

- Asphalt Performance Problems
- Ban Asphalt?



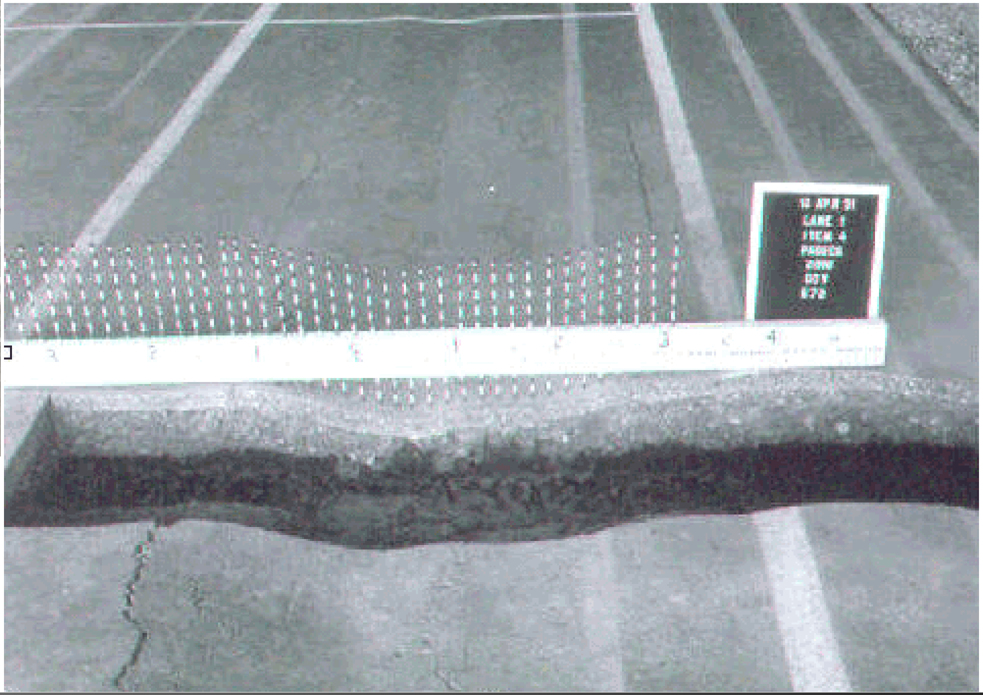
Goal of Perpetual Pavement Design

- 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'

Avoid These!

Bottom-Up Fatigue

Structural Rutting



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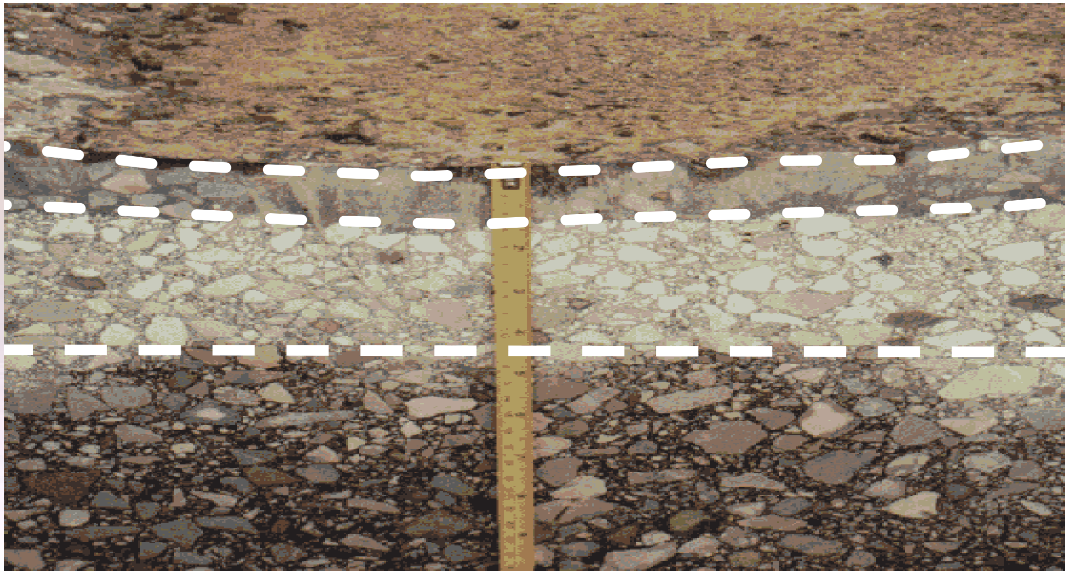
Surface Distresses Only

Top Down Cracking

Non-Structural Rutting



Pavement Design:
Where were we?

- Using 1960s performance equations
- 1950s type of load
- Thin pavement structures (Max. 6” HMA)
- Meaning of structural coefficients
- Limited reliability analysis
- Some movement to M-E

AASHO Road Test Trucks

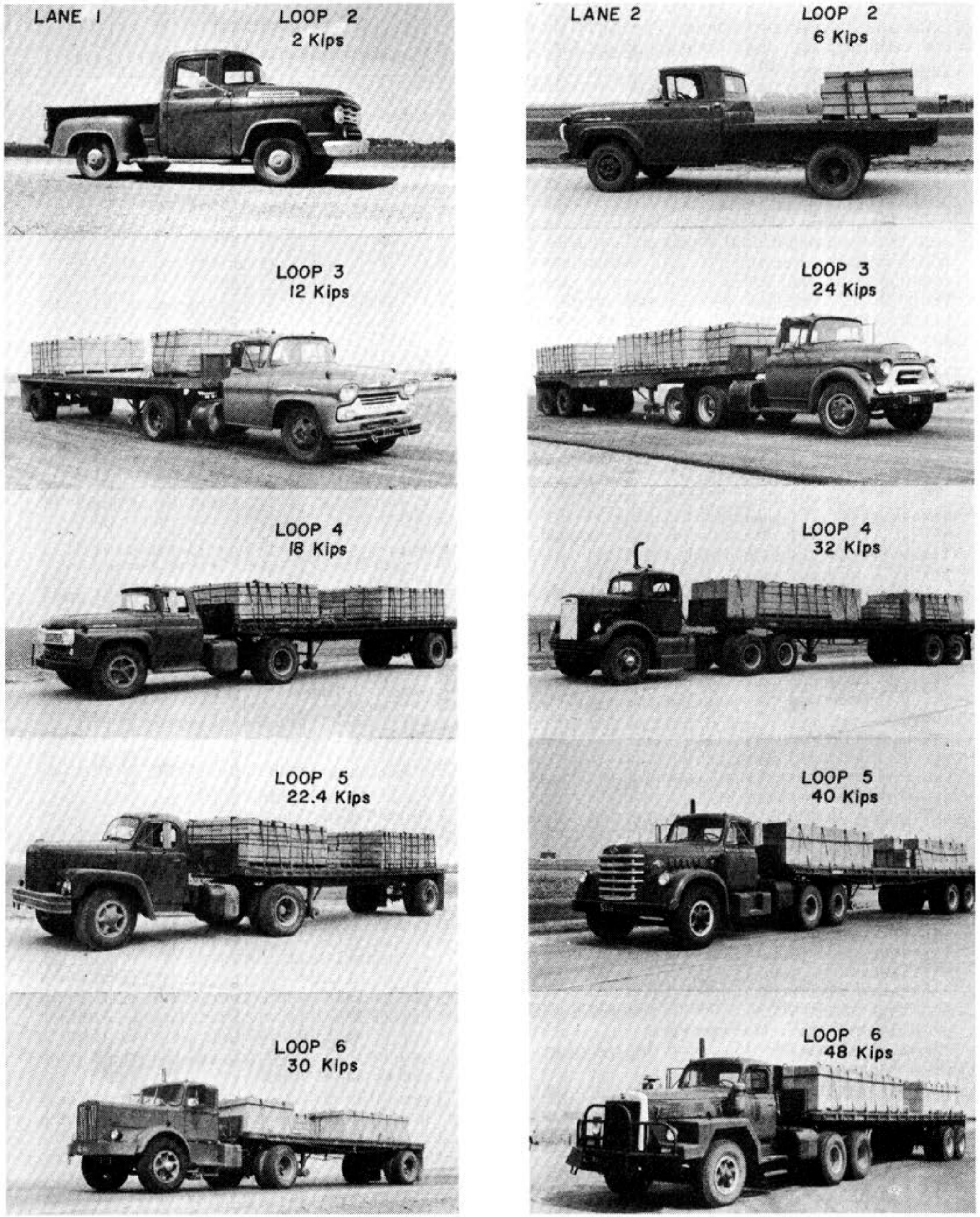
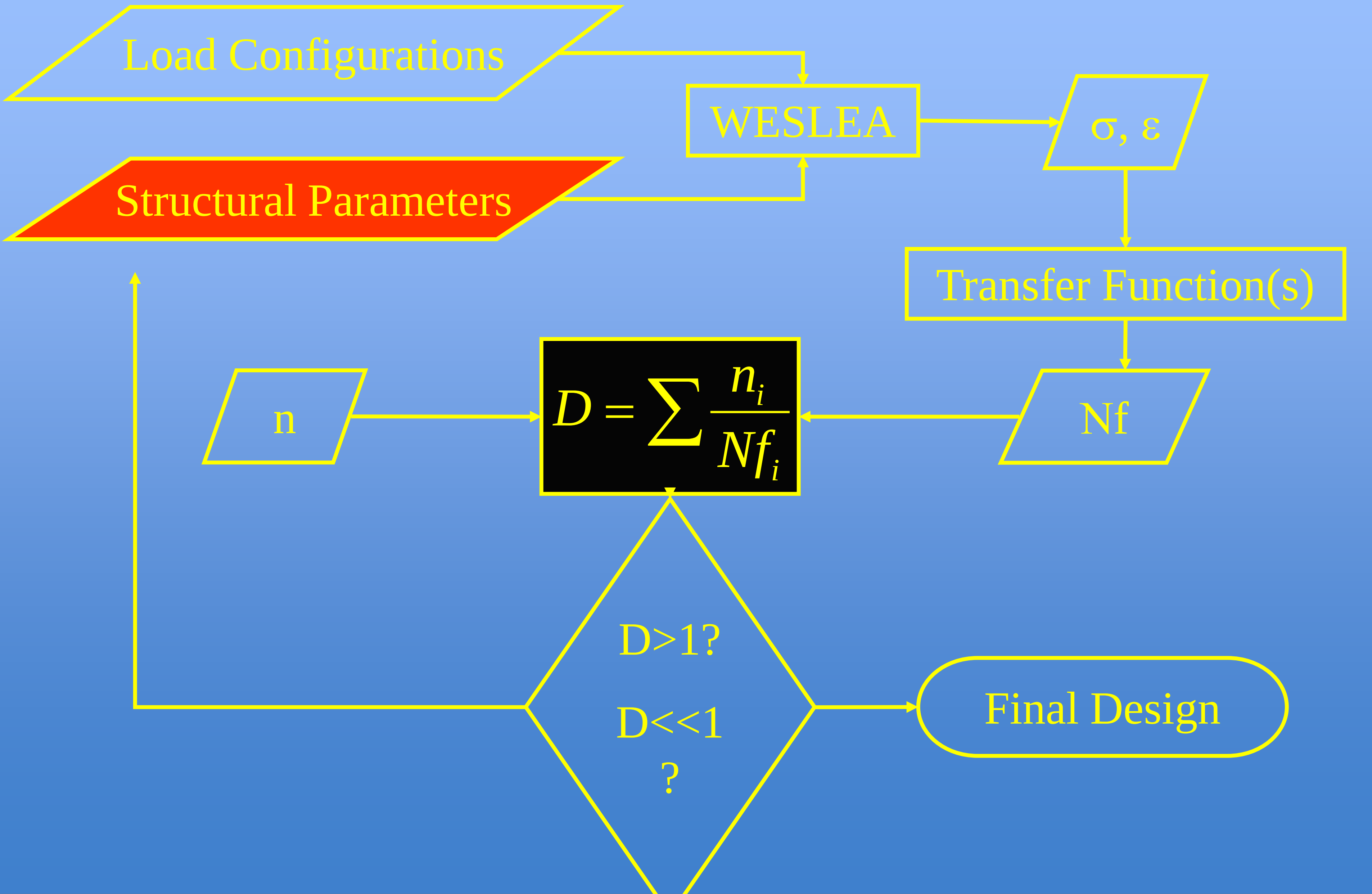
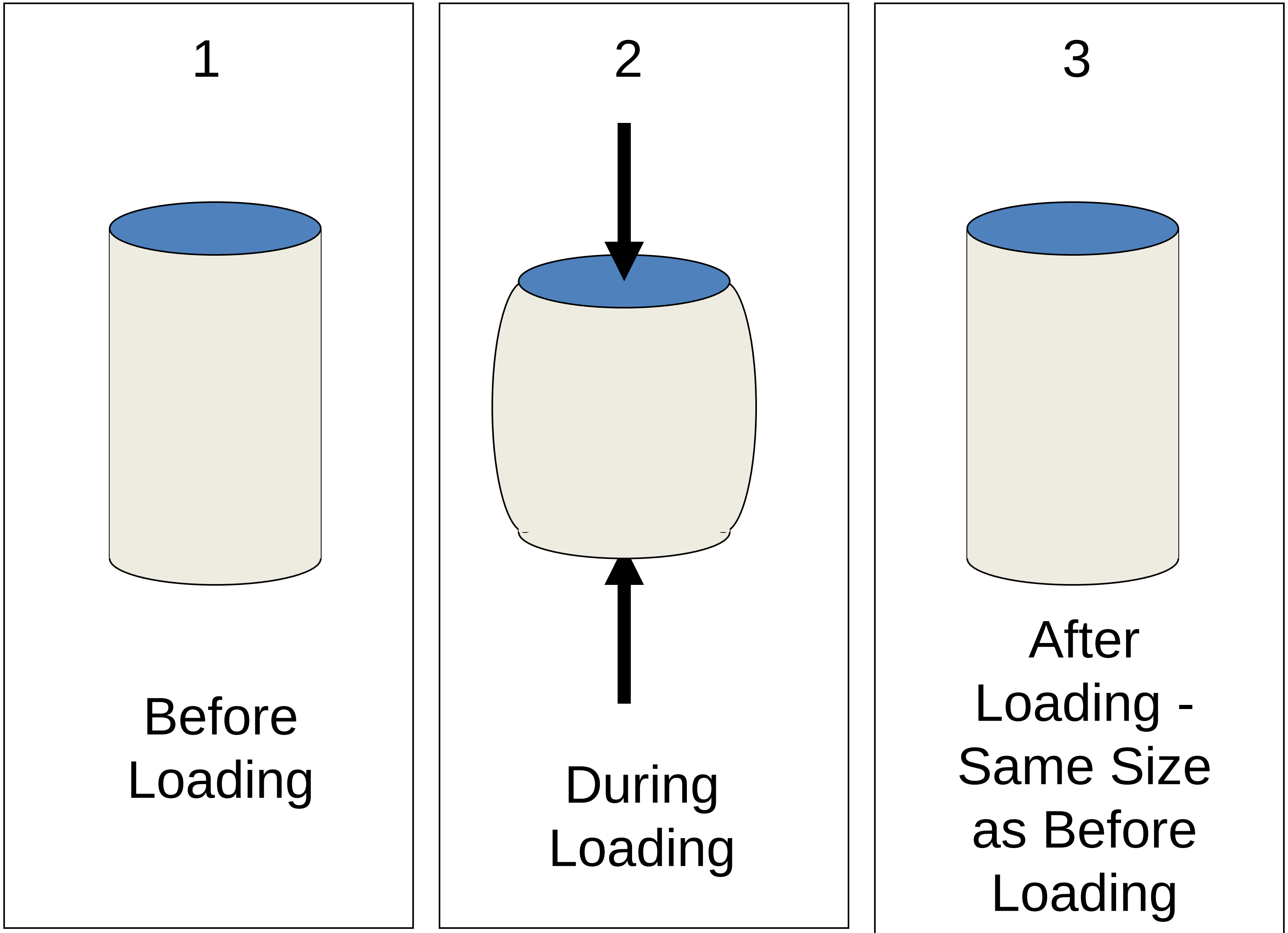


FIGURE 3 AASHO Road Test truck traffic.

M-E Design Framework

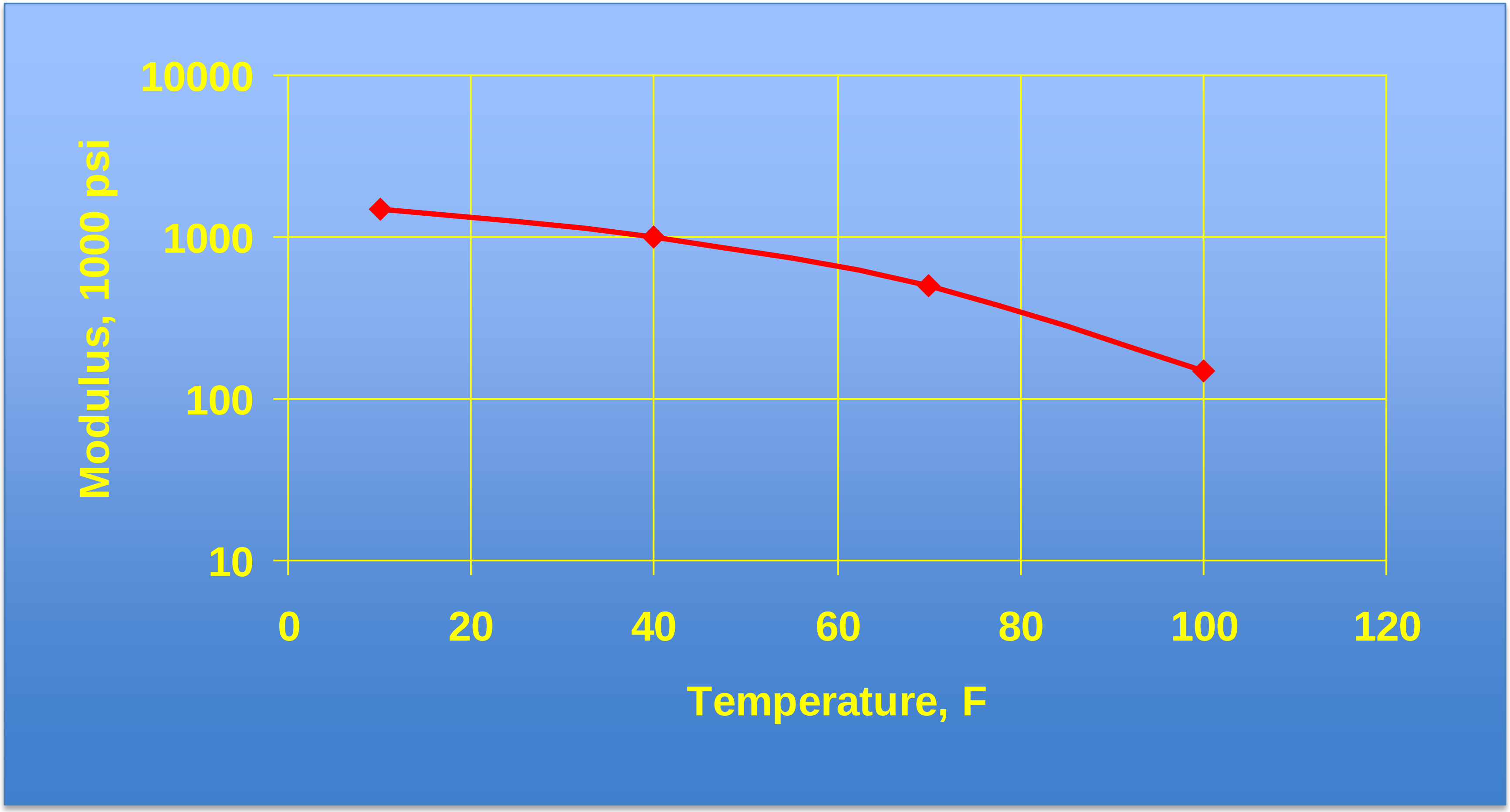


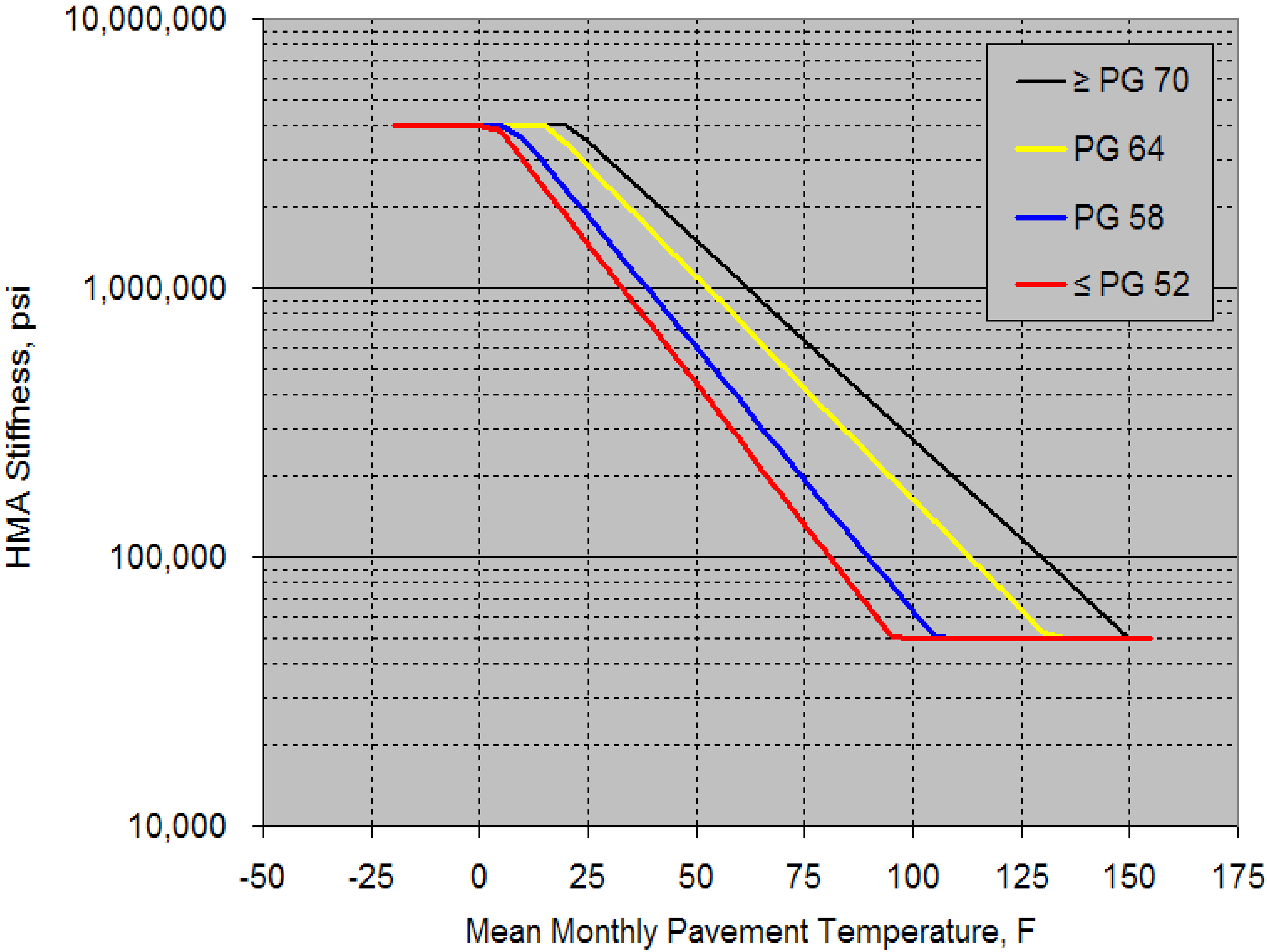


How an Elastic Material Behaves.

Dynamic Modulus Test

HMA Modulus Versus Temperature

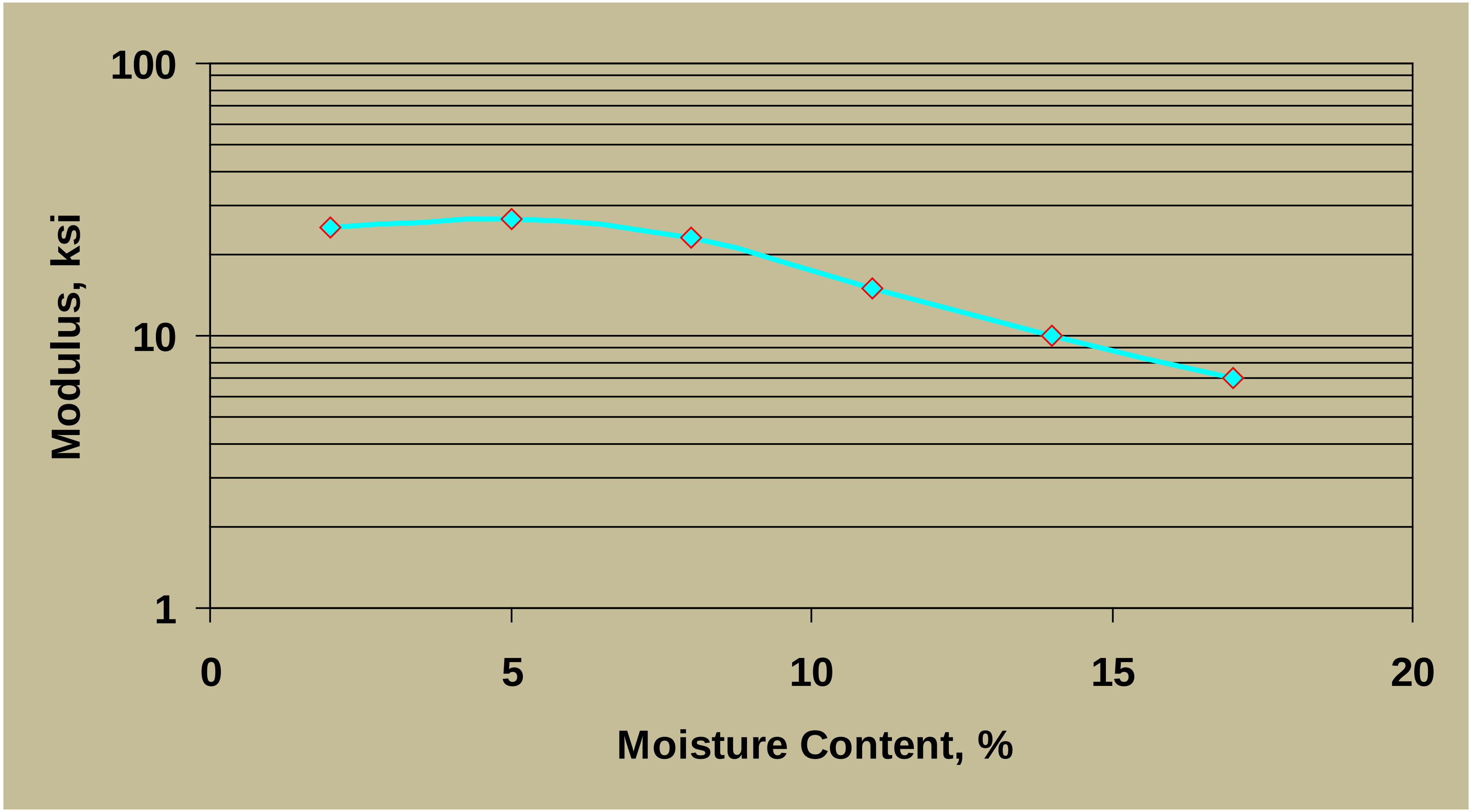




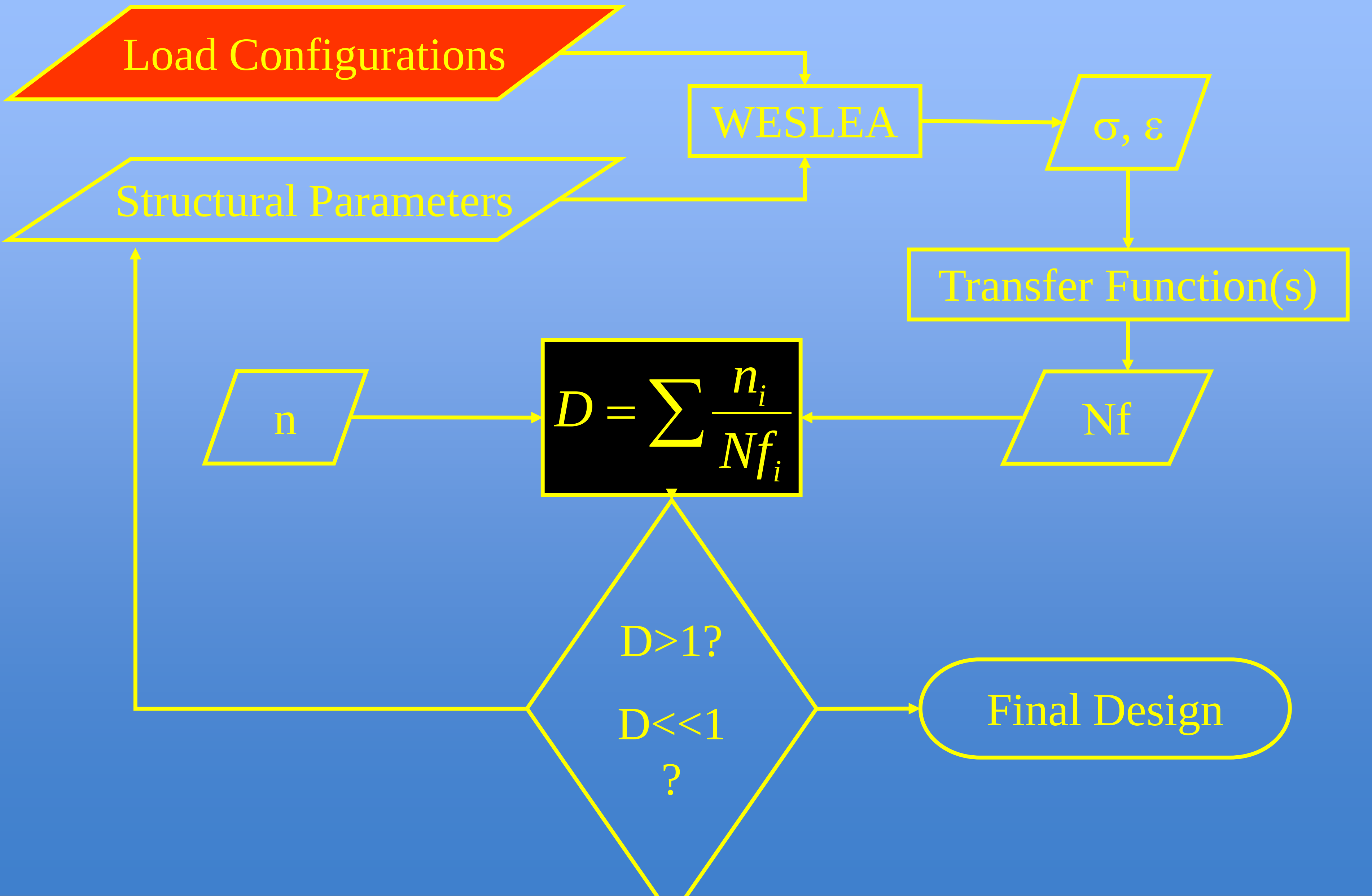
10,000,000
1,000,000
100,000
10,000
HMA Stiffness, psi
≥ PG 70
PG 64
PG 58
≤ PG 52
-50
-25
0
25
50
75
100
125
150
175
Mean Monthly Pavement Temperature, F

Soil Modulus Testing

Effect of Moisture Content

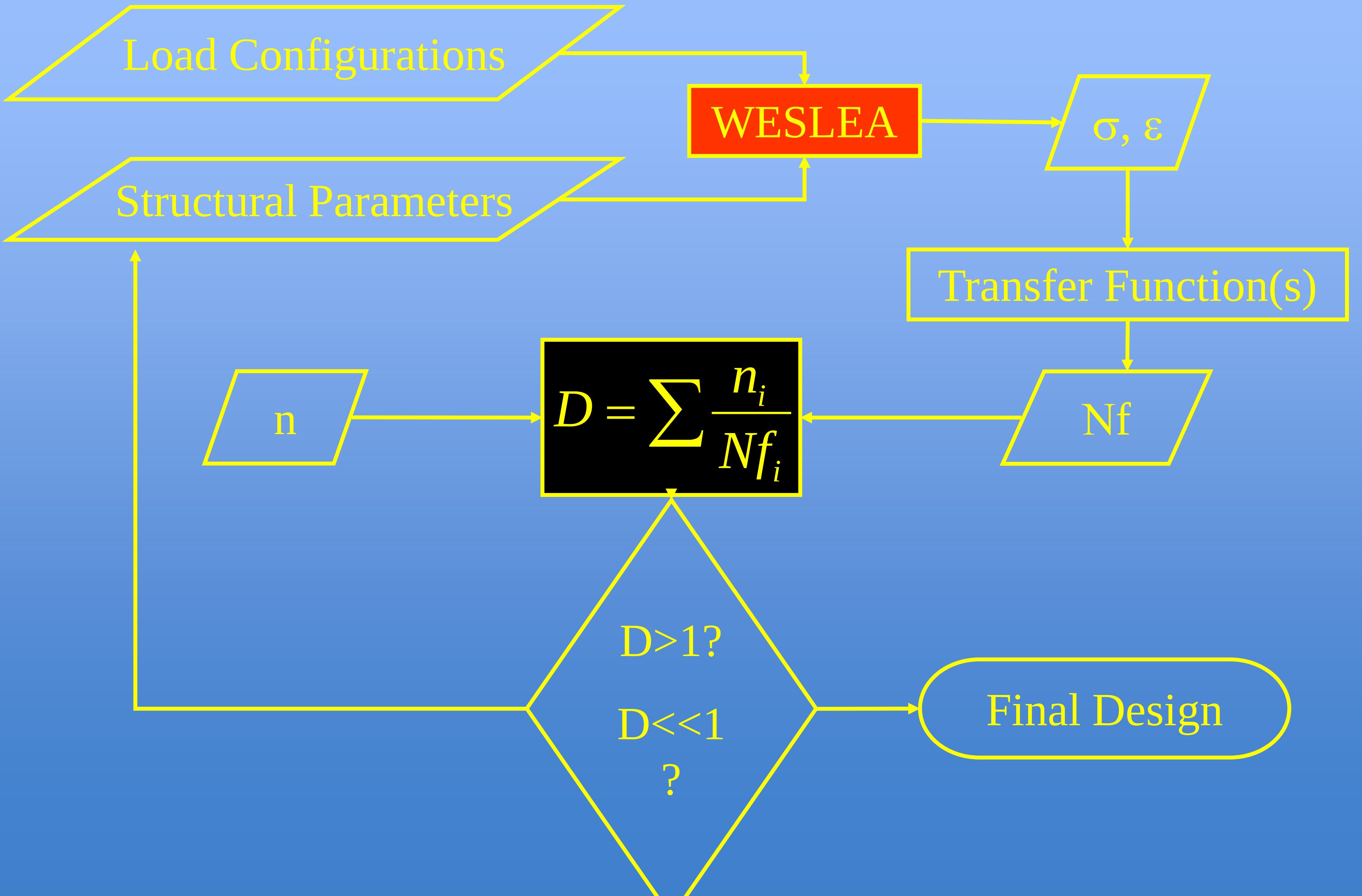


M-E Design Framework



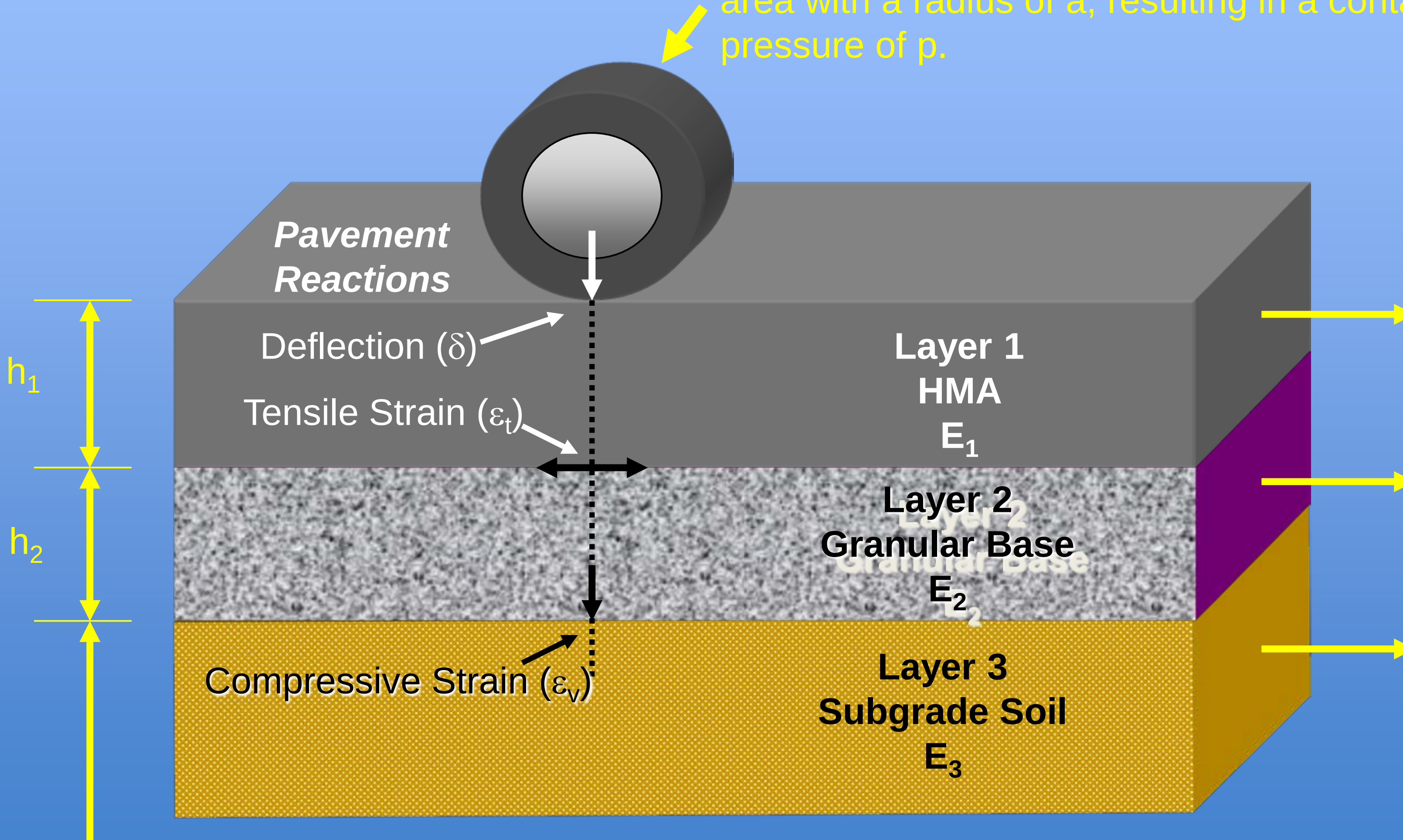

EXIT
15
NCUU 284274
J&R

M-E Design Framework



Three Layer Systems

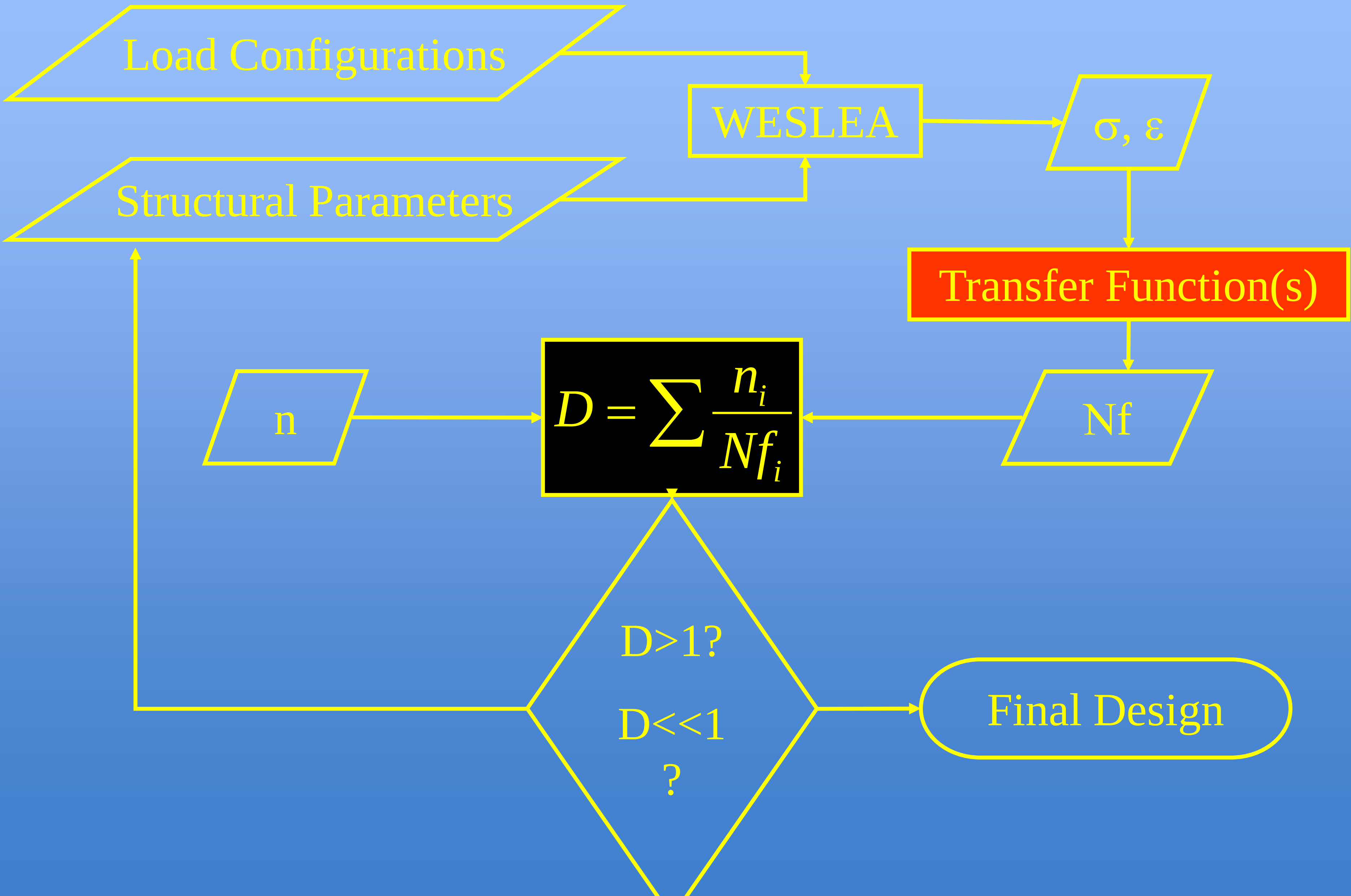
Tire has a total load P, spread over a circular area with a radius of a, resulting in a contact pressure of p.



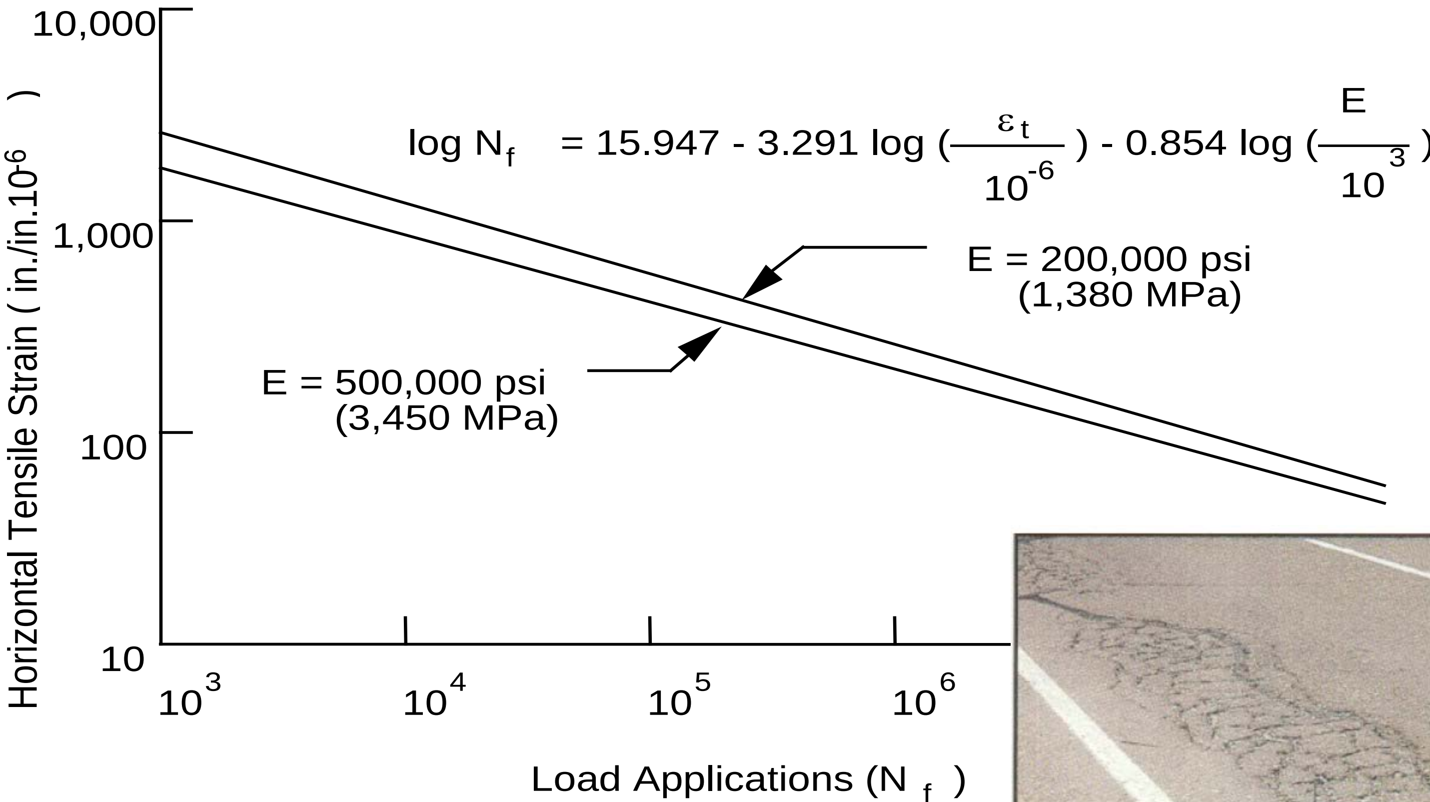
No horizontal boundary, assume layers extend infinitely.

No bottom boundary, assume soil goes on infinitely.

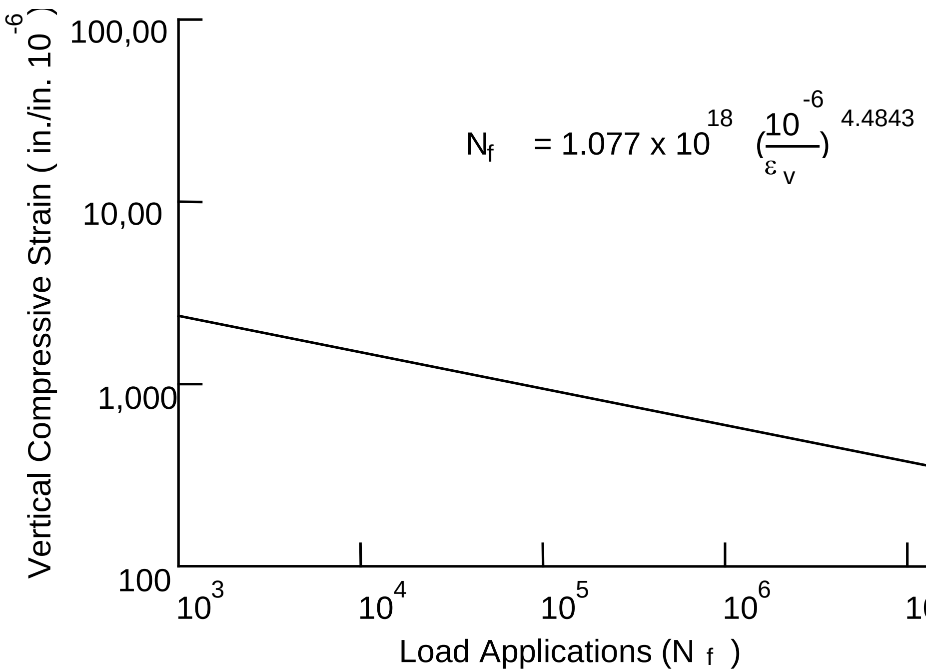
M-E Design Framework

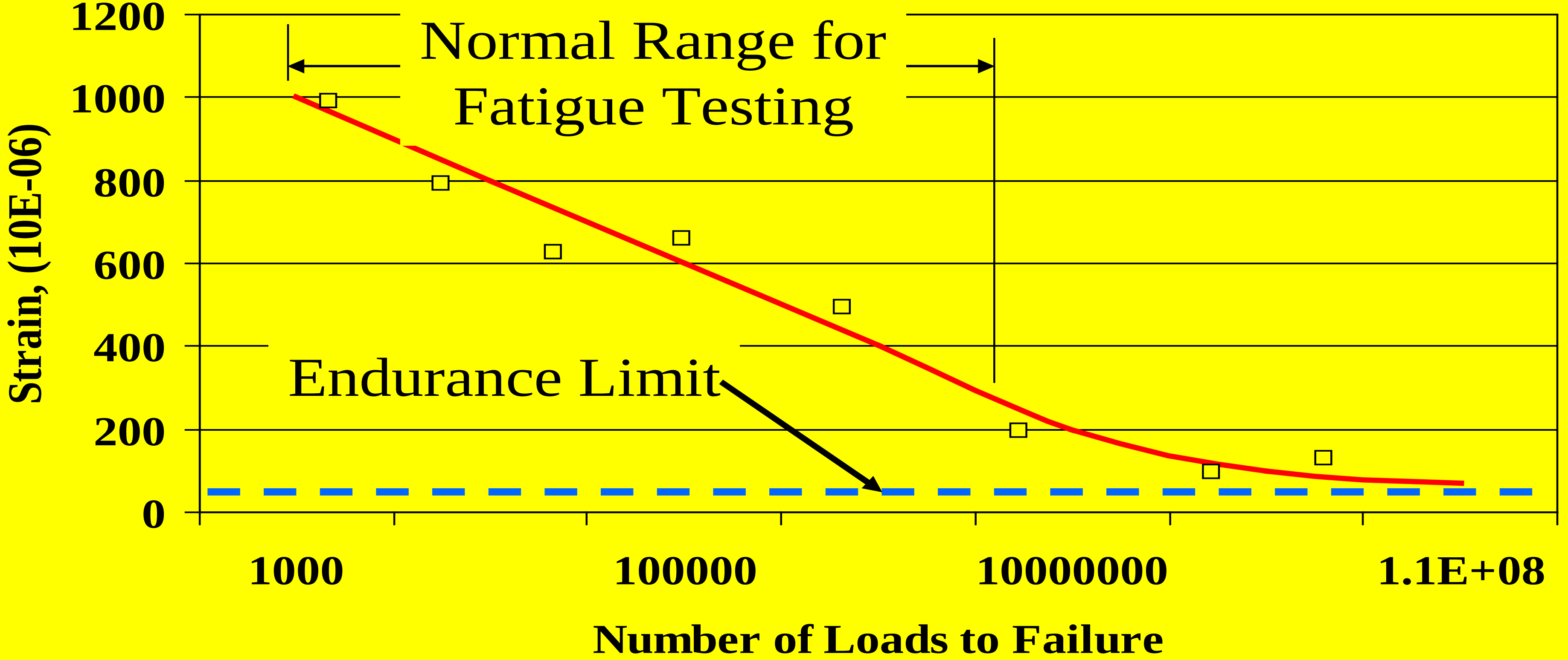


Fatigue Transfer Function

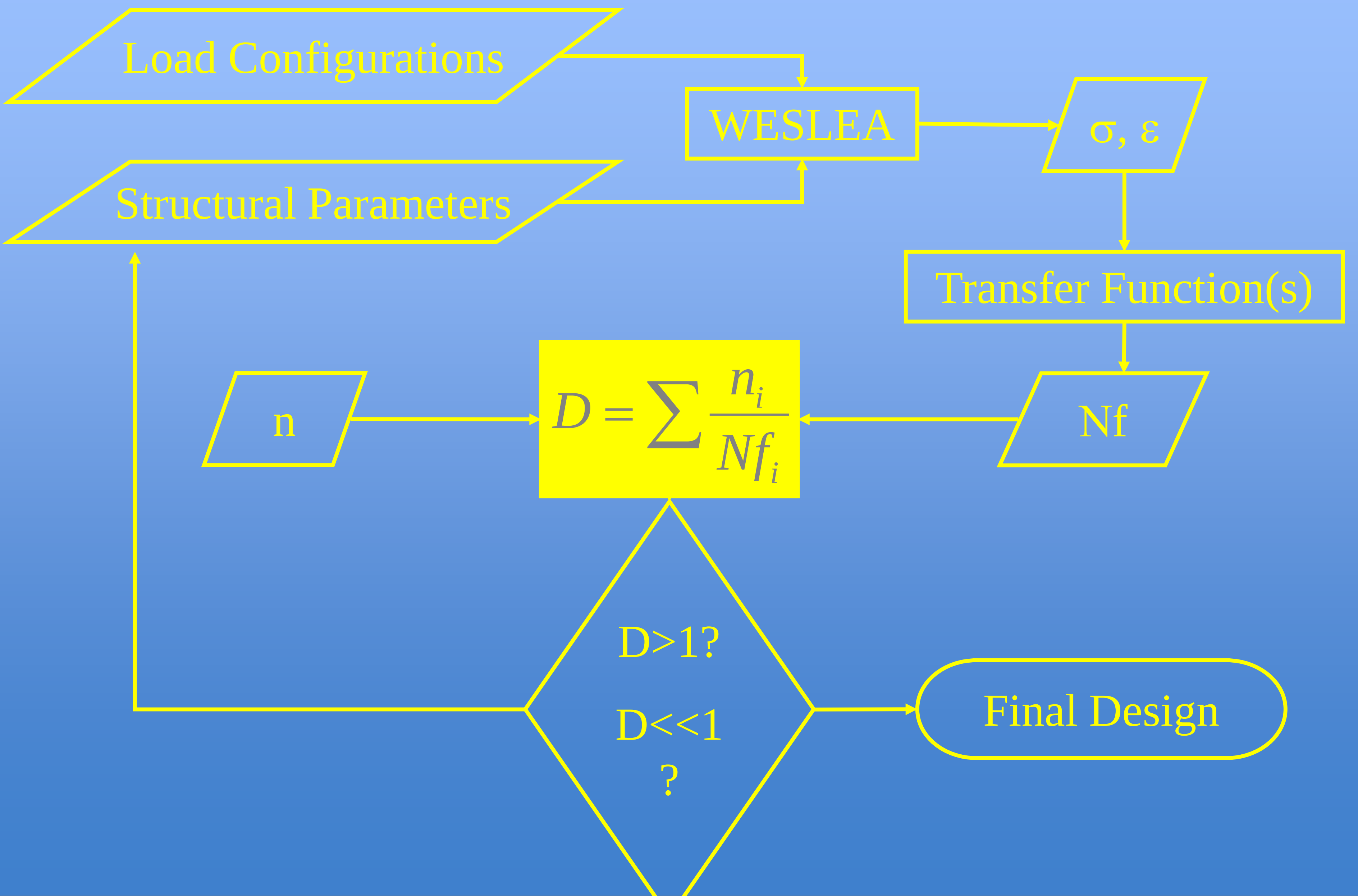


Rutting Transfer Function




Normal Range for Fatigue Testing
Endurance Limit
1200
1000
800
600
400
200
0
Strain, (10E-06)
1000
100000
10000000
1.1E+08
Number of Loads to Failure

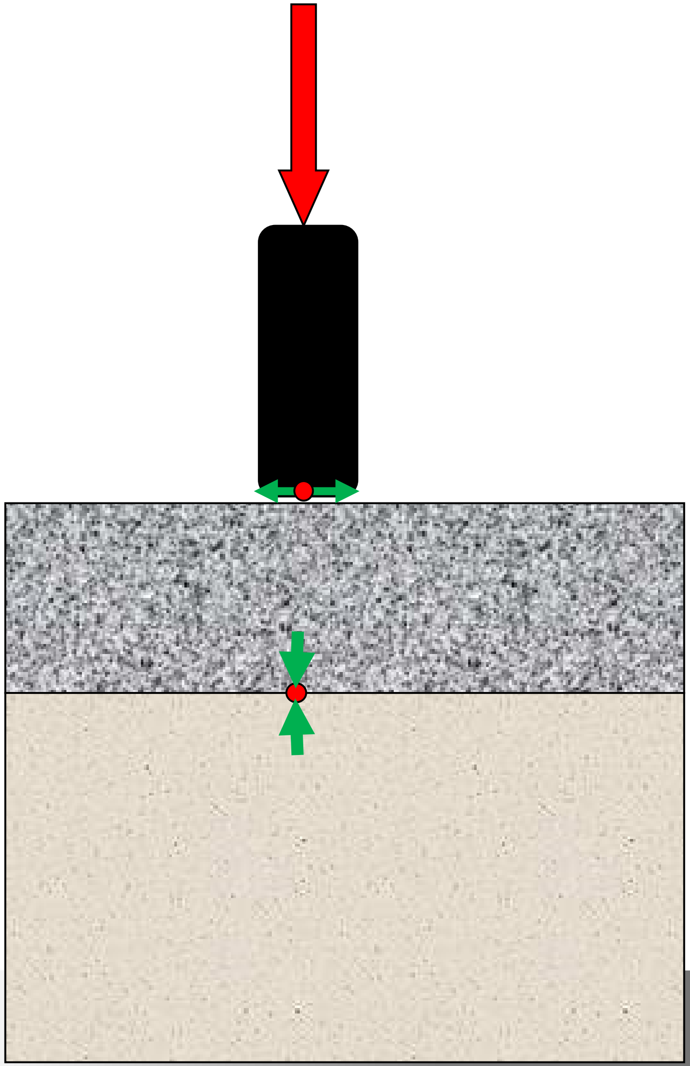
M-E Design Framework

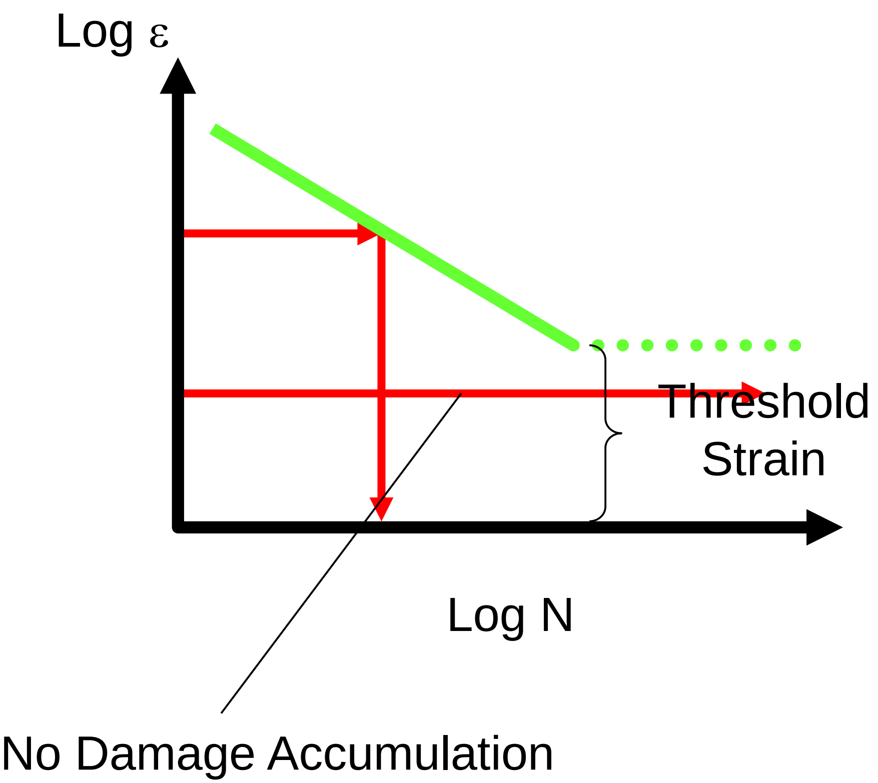


Structural/Performance Analysis

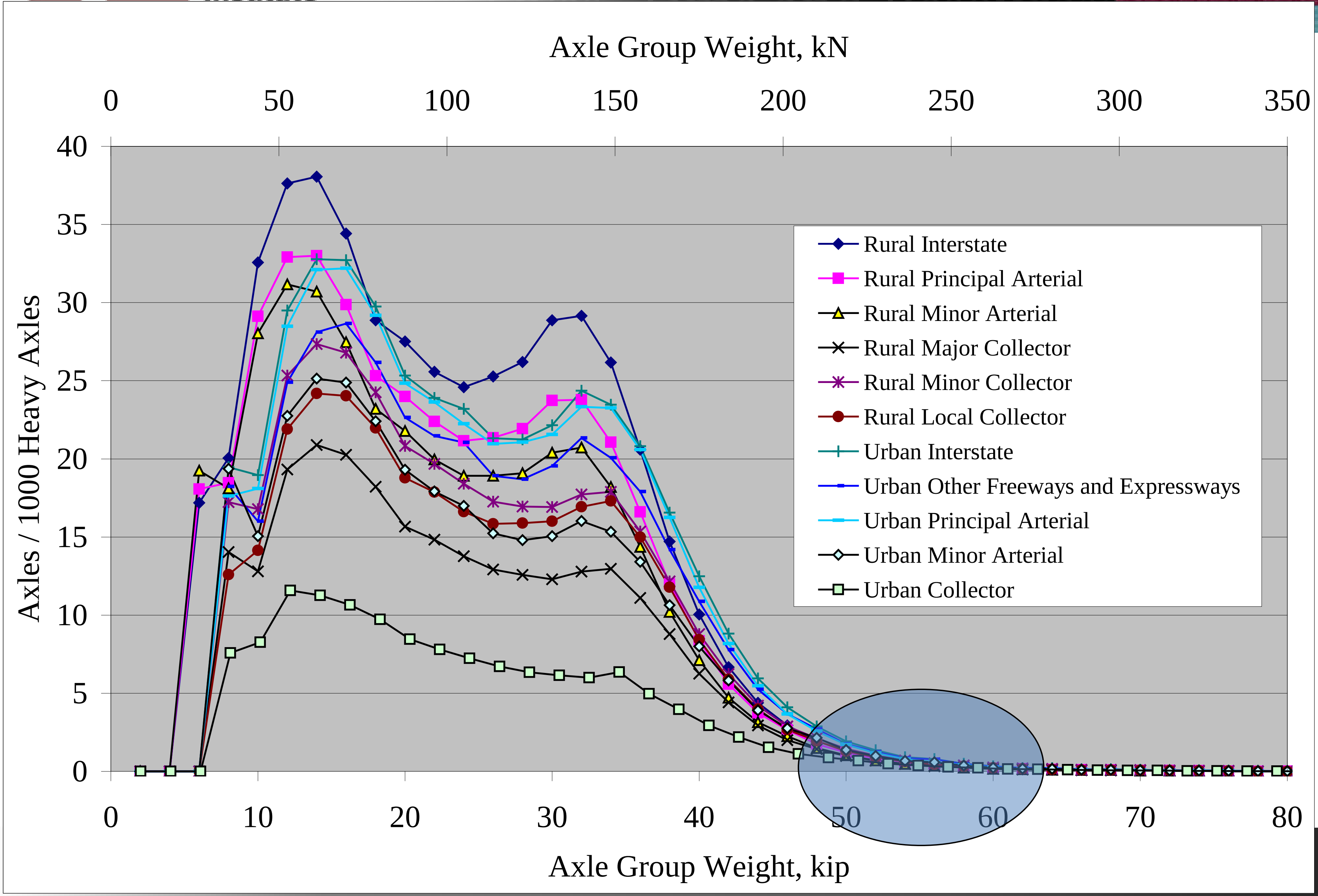
- Initial trial design
  - Initial estimate of layer thickness
  - Required repairs to the existing pavement
  - Pavement materials characterization
- Analyzed by cumulative damage incrementally over time using
  - Structural response
  - Performance models

Perpetual Pavement Design



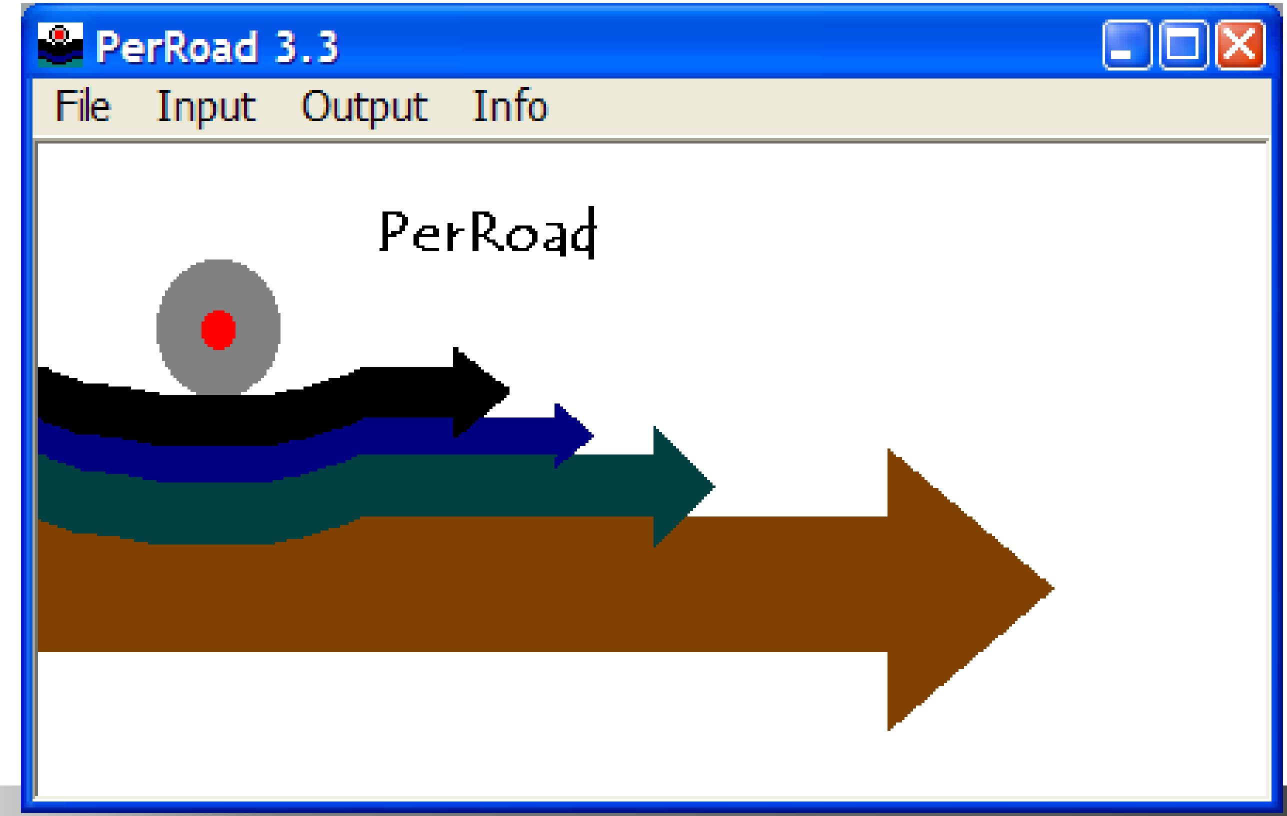


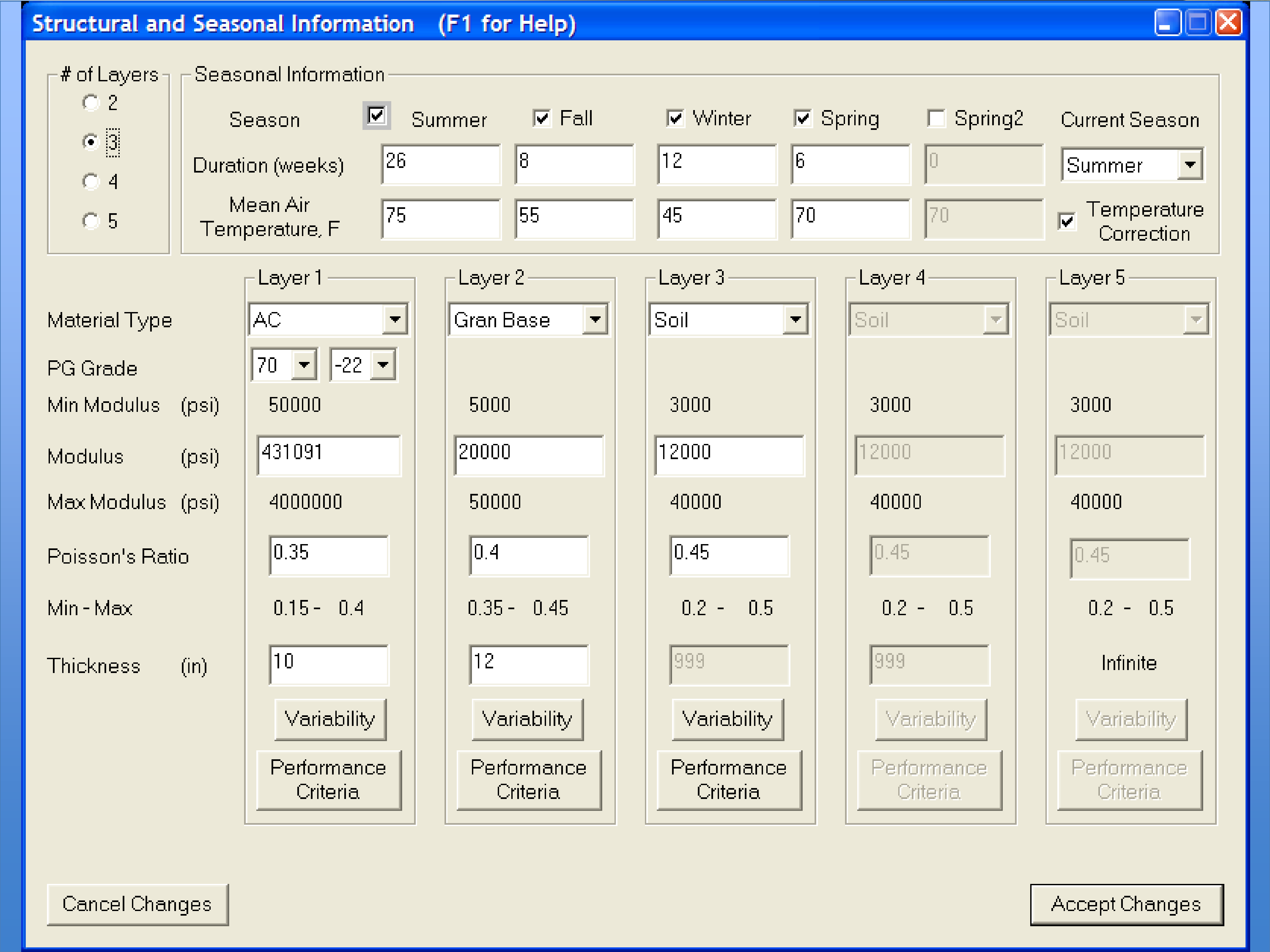
Tandem Axles



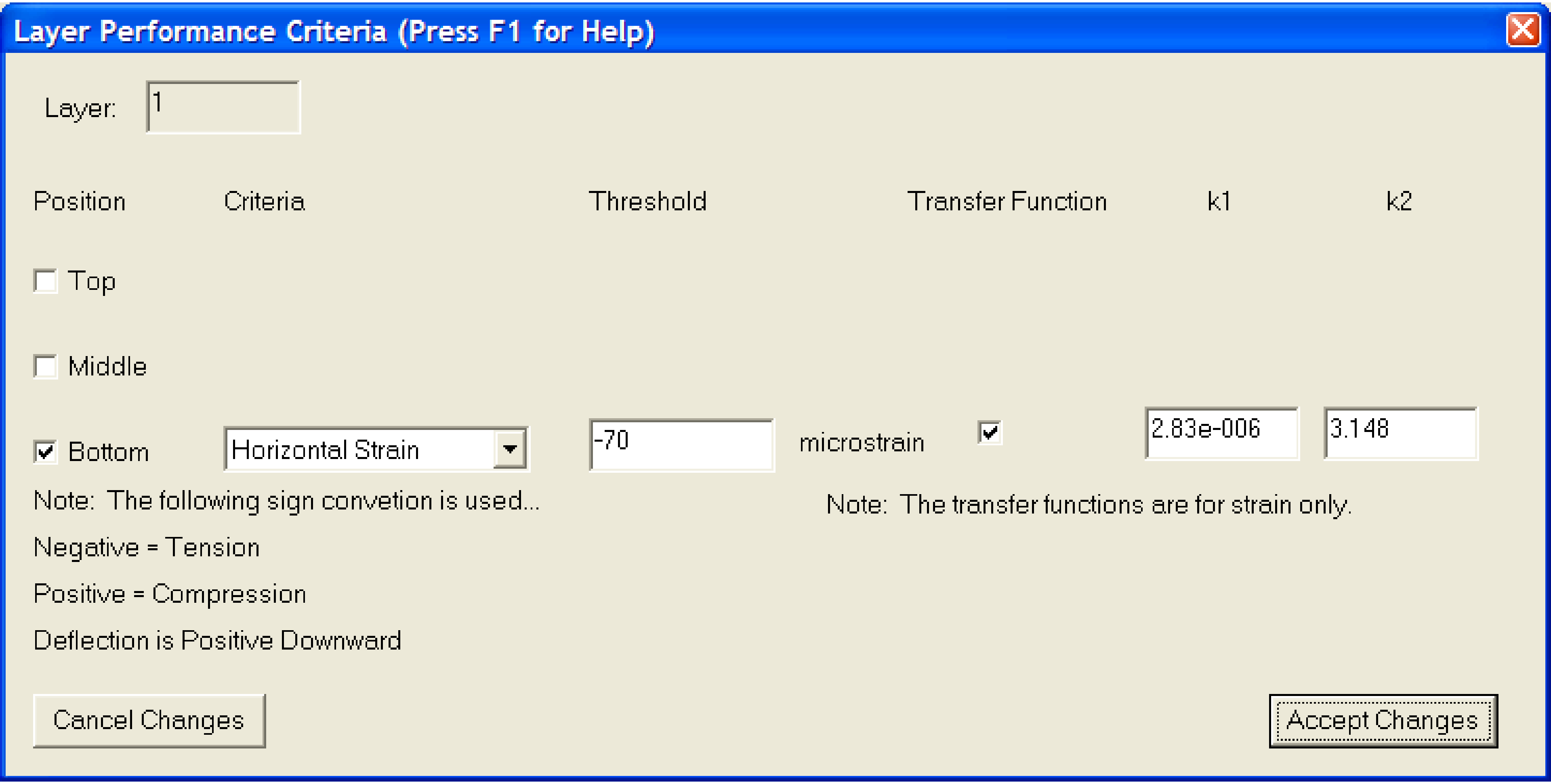
PerRoad 3.3

- Sponsored by APA
- Developed at Auburn University / NCAT
- M-E Perpetual Pavement Design and Analysis Tool





Structural and Seasonal Information (F1 for Help)
# of Layers
2
3
4
5
Seasonal Information
Season
Summer
Fall
Winter
Spring
Spring2
Current Season
Duration (weeks)
26
8
12
6
0
Summer
Mean Air Temperature, F
75
55
45
70
70
Temperature Correction
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Material Type
AC
Gran Base
Soil
Soil
Soil
PG Grade
70
-22
Min Modulus (psi)
50000
5000
3000
3000
3000
Modulus (psi)
431091
20000
12000
12000
12000
Max Modulus (psi)
4000000
50000
40000
40000
40000
Poisson's Ratio
0.35
0.4
0.45
0.45
0.45
Min - Max
0.15 - 0.4
0.35 - 0.45
0.2 - 0.5
0.2 - 0.5
0.2 - 0.5
Thickness (in)
10
12
999
999
Infinite
Variability
Performance Criteria
Cancel Changes
Accept Changes


Layer Performance Criteria (Press F1 for Help)
Layer: 1
Position
Criteria
Threshold
Transfer Function
k1
k2
Top
Middle
Bottom
Horizontal Strain
-70
microstrain
2.83e-006
3.148
Note: The following sign convetion is used...
Note: The transfer functions are for strain only.
Negative = Tension
Positive = Compression
Deflection is Positive Downward
Cancel Changes
Accept Changes

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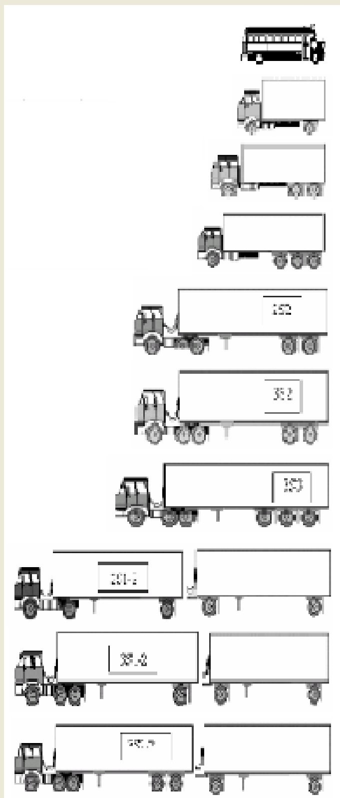
Lives, Time and Resources

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	1.2	1.62	0.39	0
5	9.4	2	0	0
6	3.3	1.02	0.99	0
7	0.5	1	0.26	0.83
8	7.4	2.38	0.67	0
9	68.9	1.13	1.93	0
10	1.2	1.19	1.09	0.89
11	6.1	4.29	0.26	0.06
12	0.8	3.52	1.14	0.06
13	1.2	2.15	2.13	0.35
Total	100			

Cancel Changes

Accept Changes

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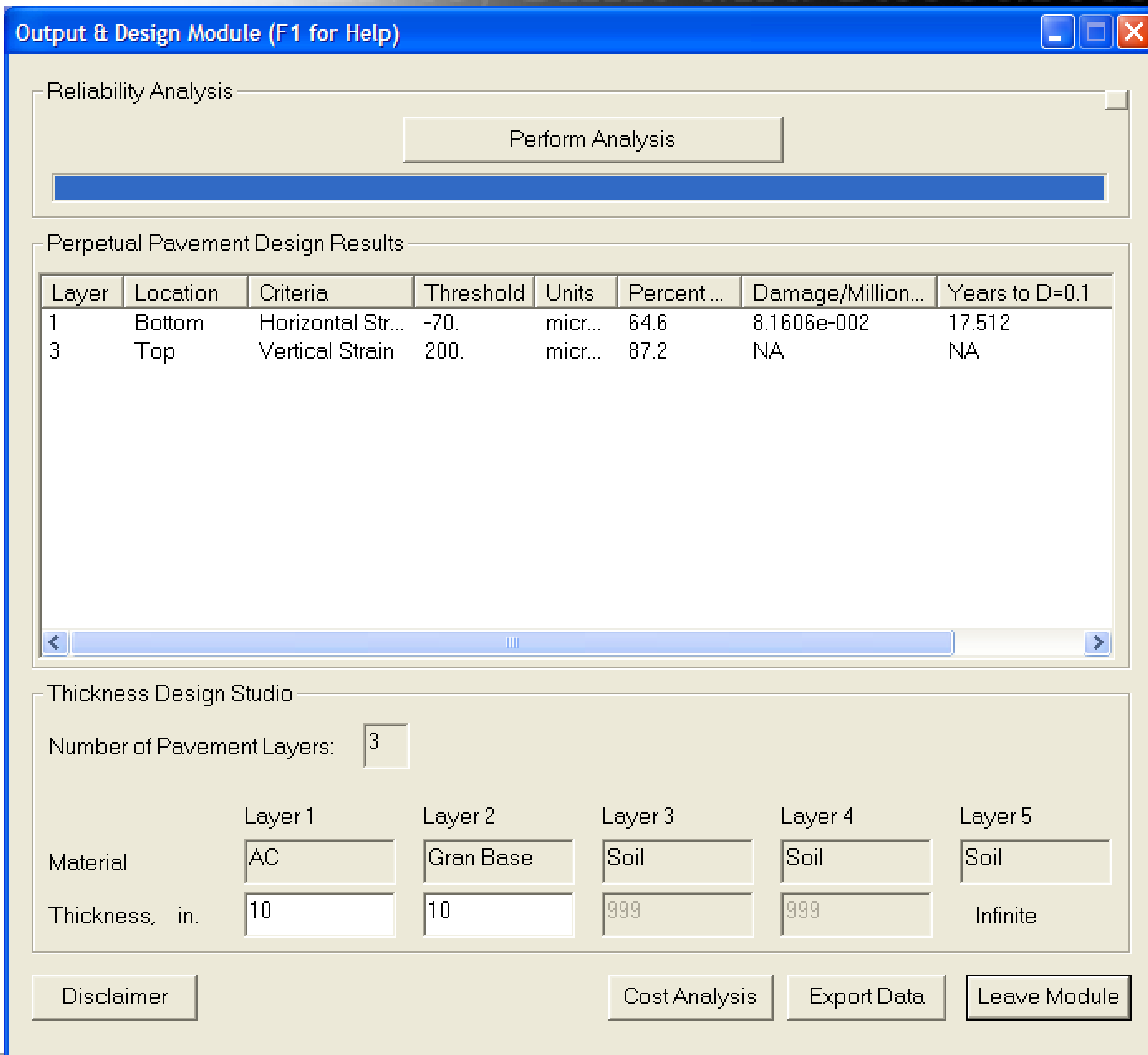
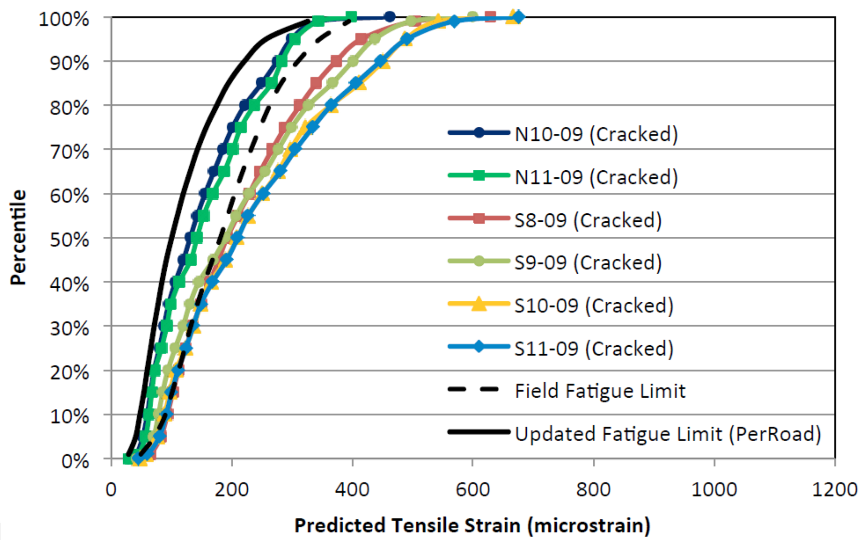
Saving Lives, Time and Resources

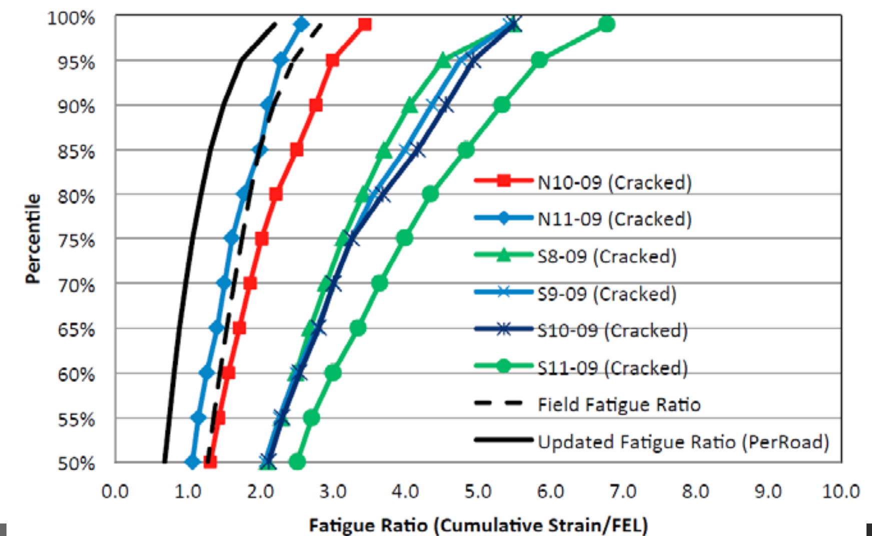


Coming Refinement

- Currently a single fatigue endurance limit is used.
- Results in one-size fits all – overly conservative
- Use FEL Ratio. Use distribution of strains.

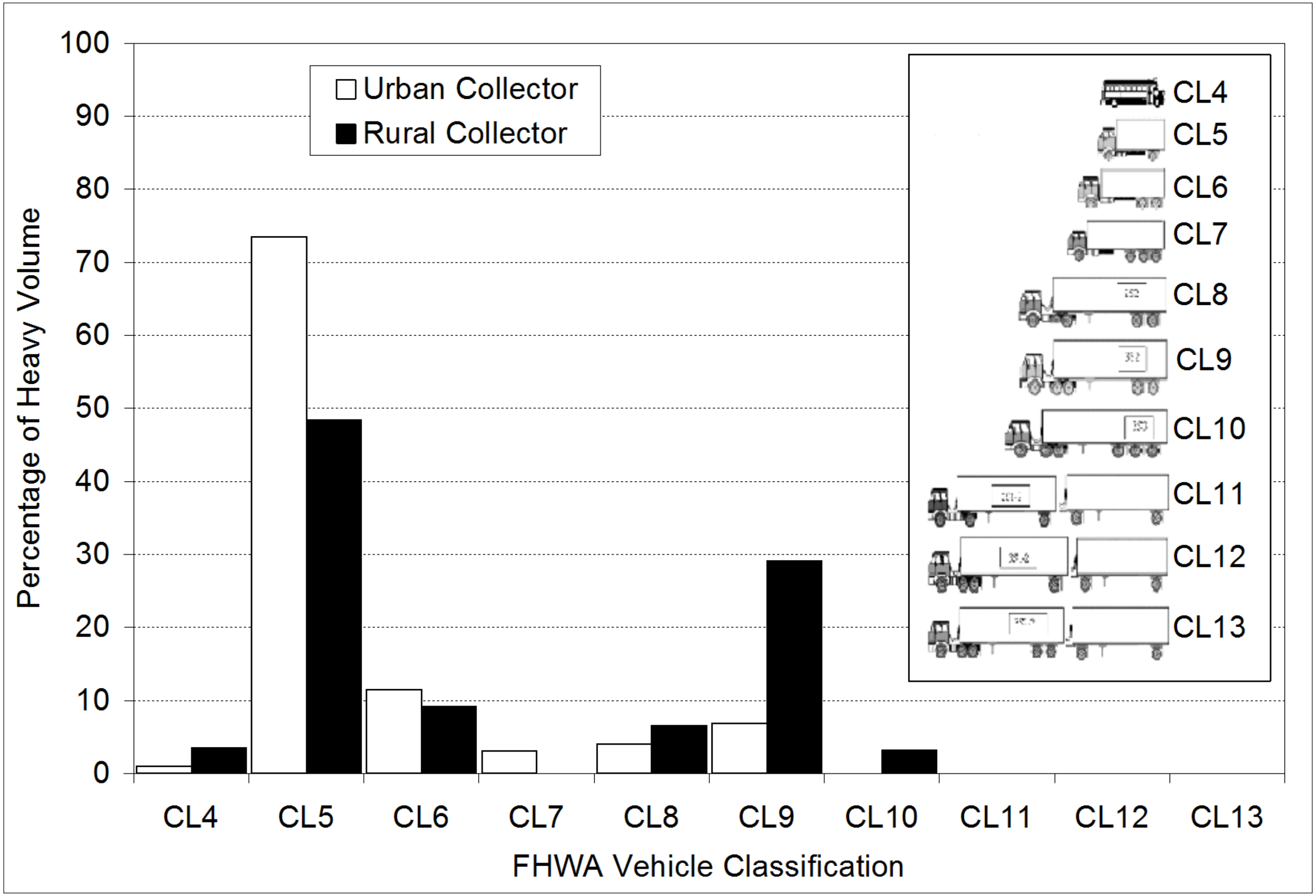
Ratio = FEL_n/FEL_{lab}






PerRoadXPress
LEE
148
COUNTY
ROAD MAY BE
SUBJECT TO SUDDEN
CATASTROPHIC
SINKHOLE COLLAPSE
WEIGHT
LIMIT
13
TONS
DETOUR

Vehicle Type Distributions



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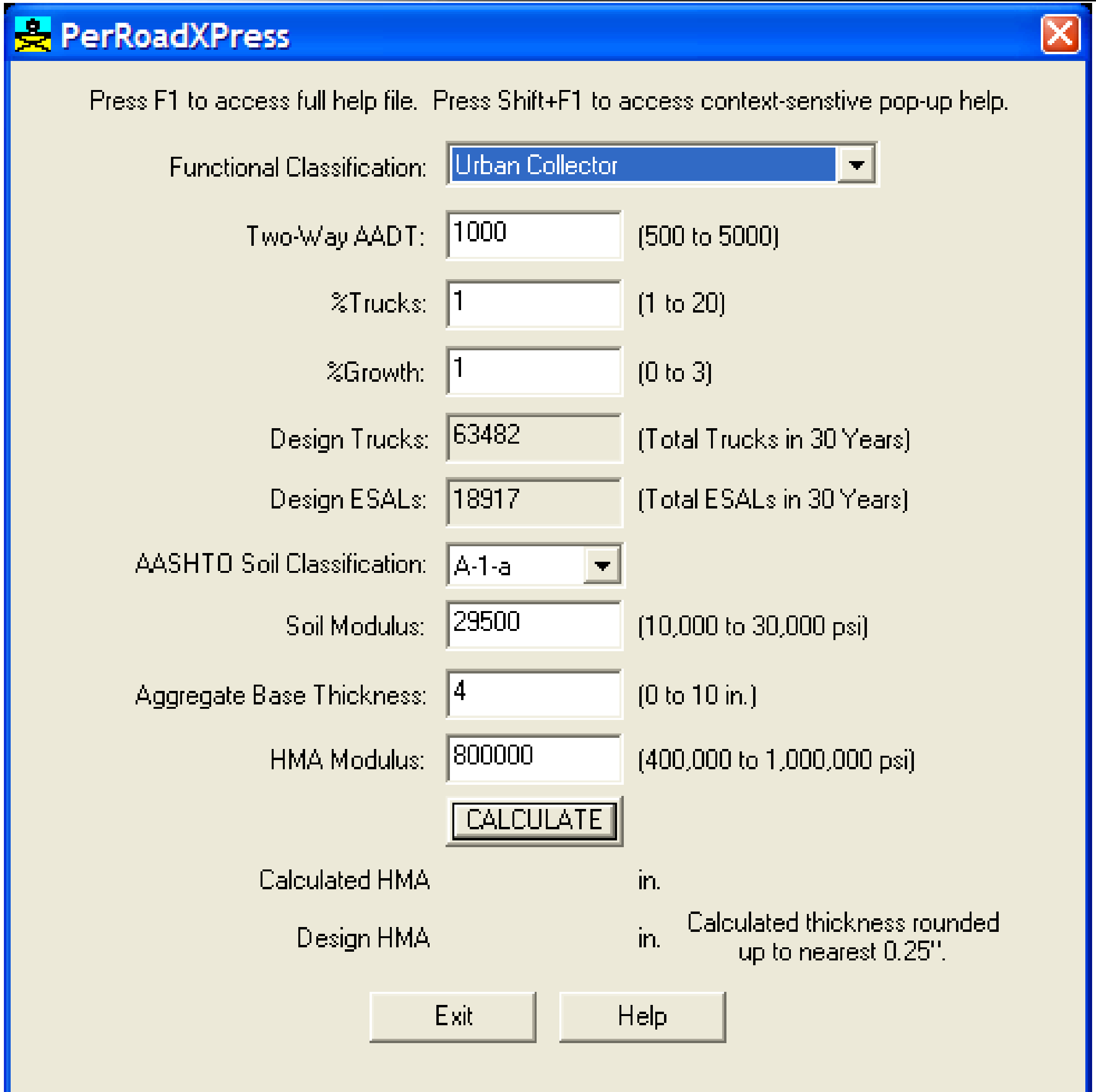

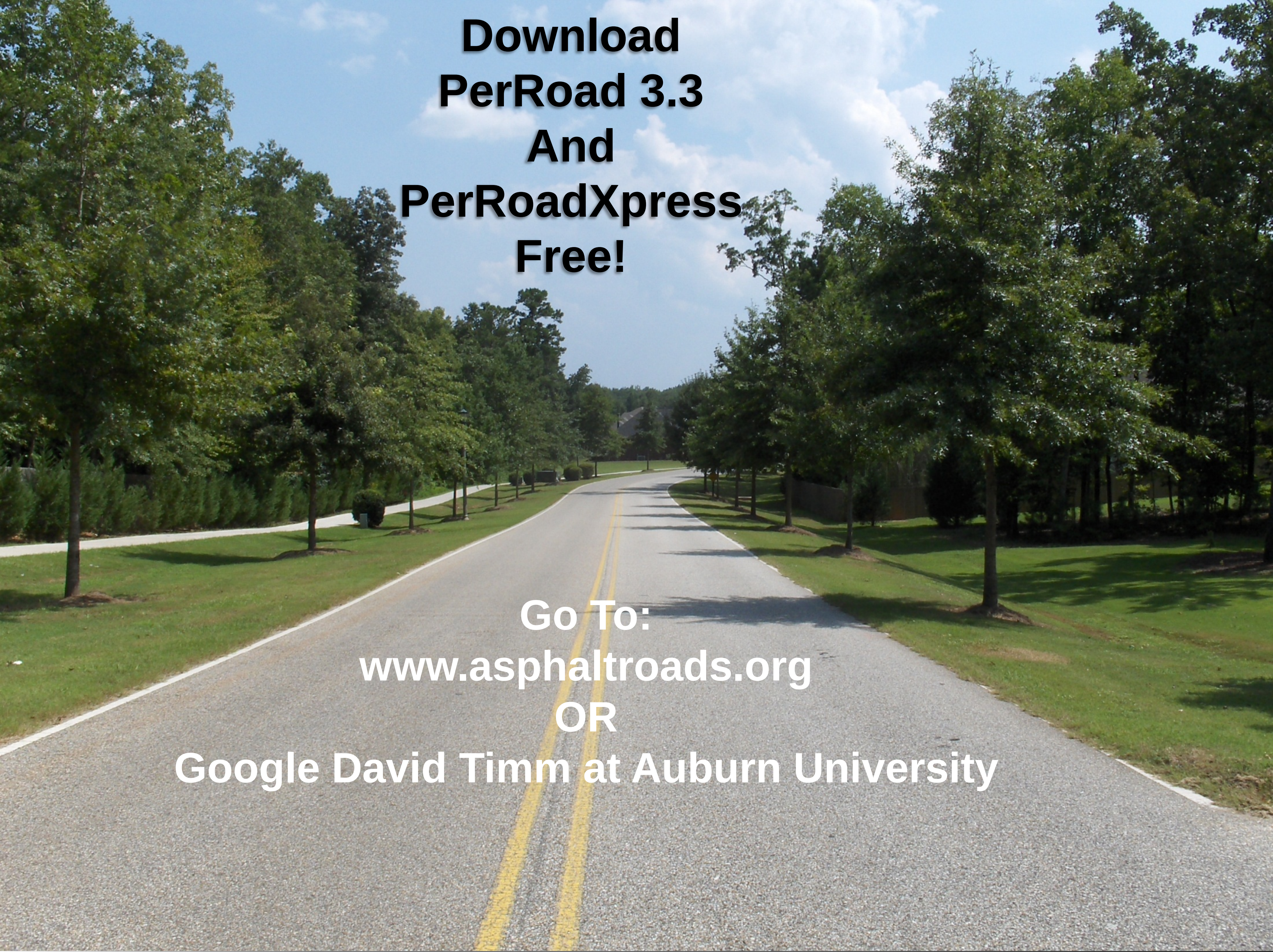
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Google David Timm at Auburn University

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At the 2016 AAPT Meeting:

- Leading Edge Workshop: Cracking Tests
- 5 Presentations on Cracking Tests
- Symposium: Balanced Mix Design
- 5 Presentations on High RAP/RAS
- Implementation of Specifications
- Aging Behavior
- Forum Topic: World Asphalt Market