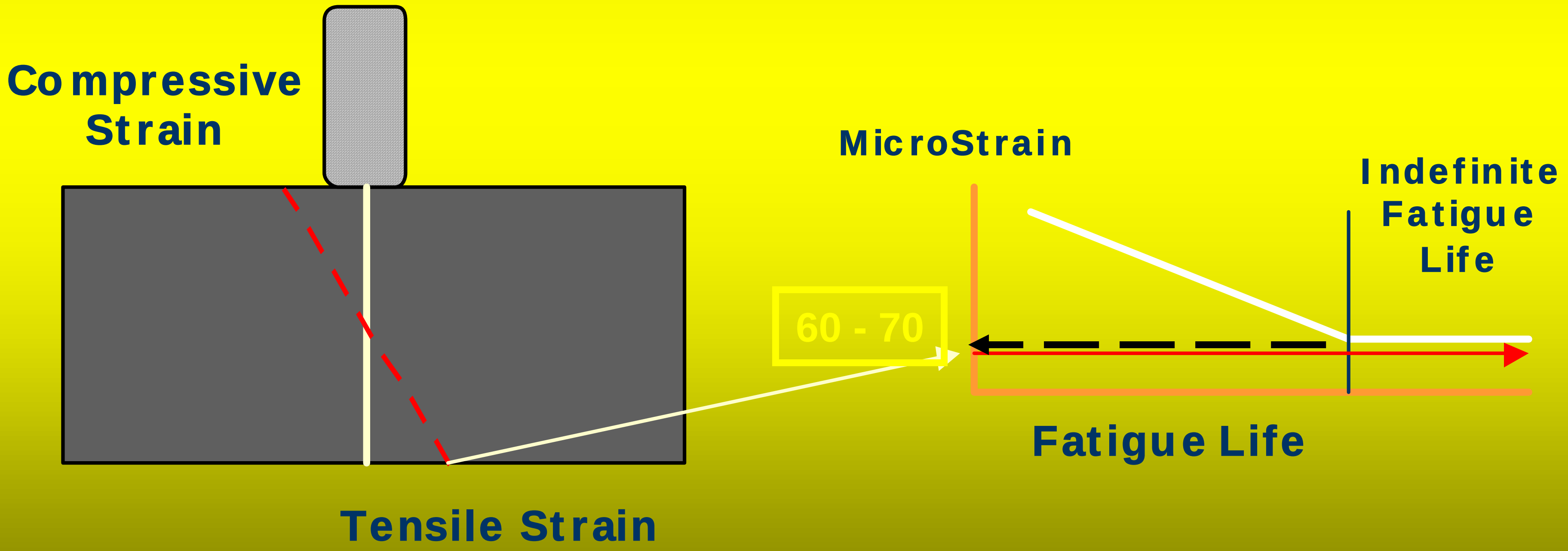
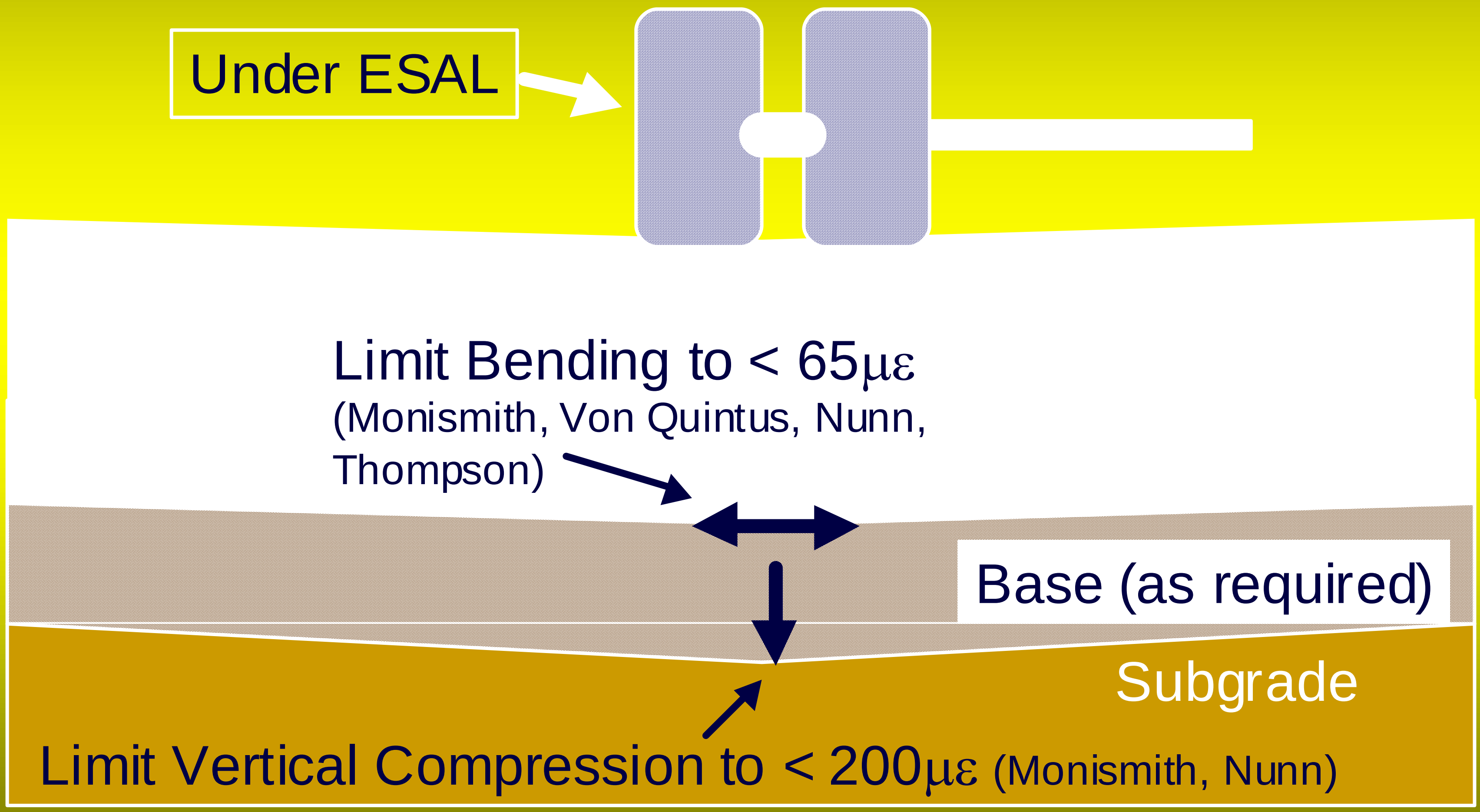
- Fatigue Resistant Asphalt Base
  - Minimize Tensile Strain with Pavement Thickness
  - Thicker Asphalt Pavement = **Lower Strain**
  - Strain Below Fatigue Limit = **Indefinite Life**



Mechanistic Performance Criteria



$$$$ Comparison for Pa DOT

PRICES

HMA Base	$ 29.00/ton	
HMA Rich Bottom	29.90/ton	(+1/2% AC @ $180/ton)
HMA PG 64-22	36.36/ton	
HMA PG 76-22	42.00/ton	
Scratch Course	34.00/ton	
Seal Coat Shoulder	0.85/sy	
Mill 2-inches	0.80/sy	
Deep Patching	81.00/sy	

Notes: 4-inches of Rich Bottom is an additional $ 0.20/sy
2-inches of PG 76-22 Wearing is an additional $ 0.62/sy

$$$$ Comparison for Pa DOT
Perpetual Pavement vs DOT AASHTO

Scenario			Initial	LCC
14.5-inch Pavement Section				
PP 15/15	vs	DOT 10/10	+ 3.1 %	- 8.1 %
PP 15/12	vs	DOT 15/10		- 2.4 %
16-inch Pavement Section				
PP 15/15	vs	DOT 10/10	+ 1.9 %	- 7.5 %
PP 15/12	vs	DOT 15/10		- 2.3 %

sign reflects perpetual pavement advantage (-) or disadvantage (+)

Comparison of Alternates

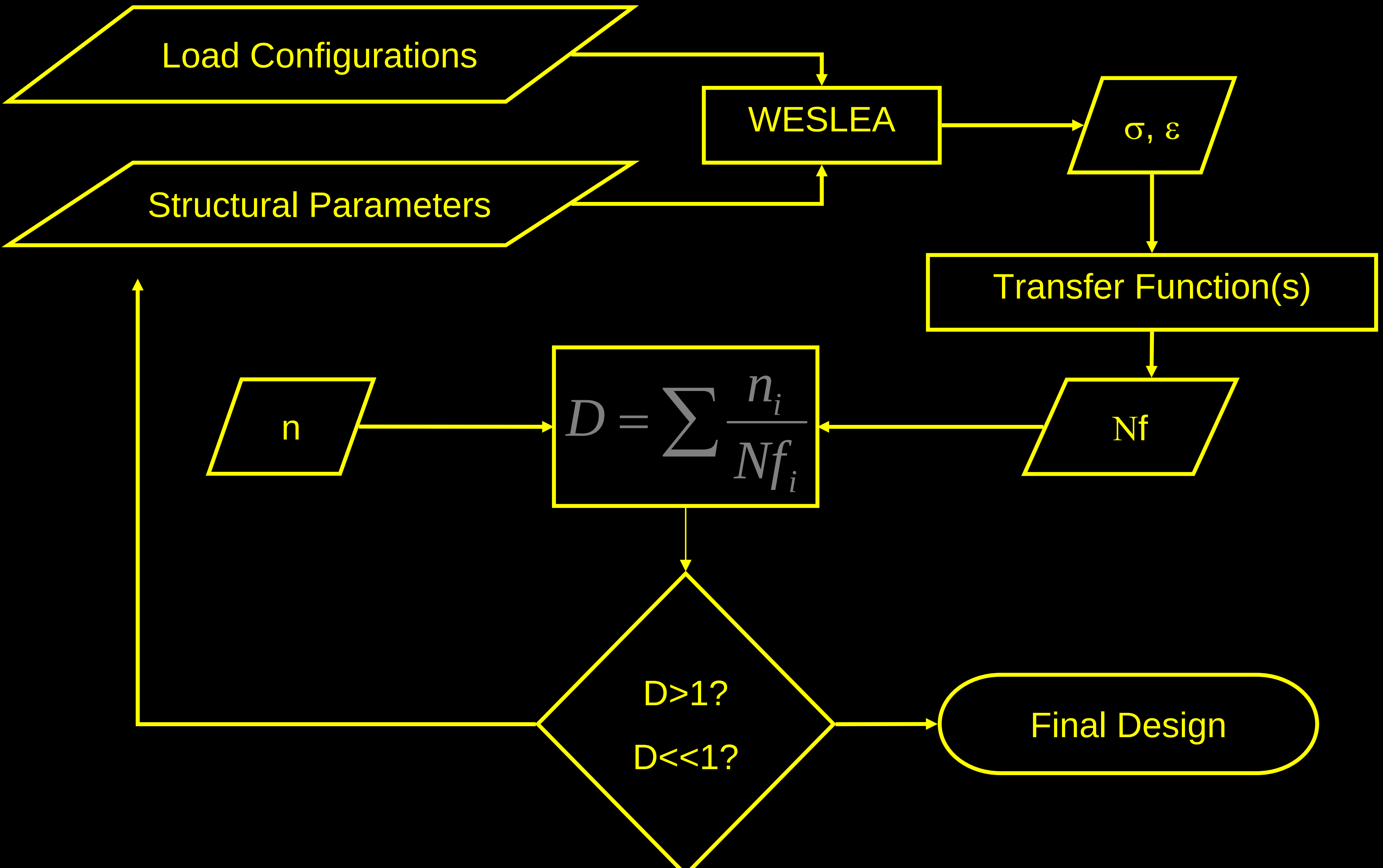
Alternate	X-section AC	Strain	Comp	$/SY
1 standard subgrade	2,3,10,4,8	74	498	36.52
2 standard	2,3,10,4,12	58	225	33.80
3 pp PG76	2,7,3,4,8	62	130	33.06
4 pp PG 76 subgrade	2,8,4,4,12	70	188	40.80
5 pp PG 70	2,8,4,4,12	50	105	36.19

HMA, Rich Bottom, ATPB, Subbase

Perpetual Pavement Design Software

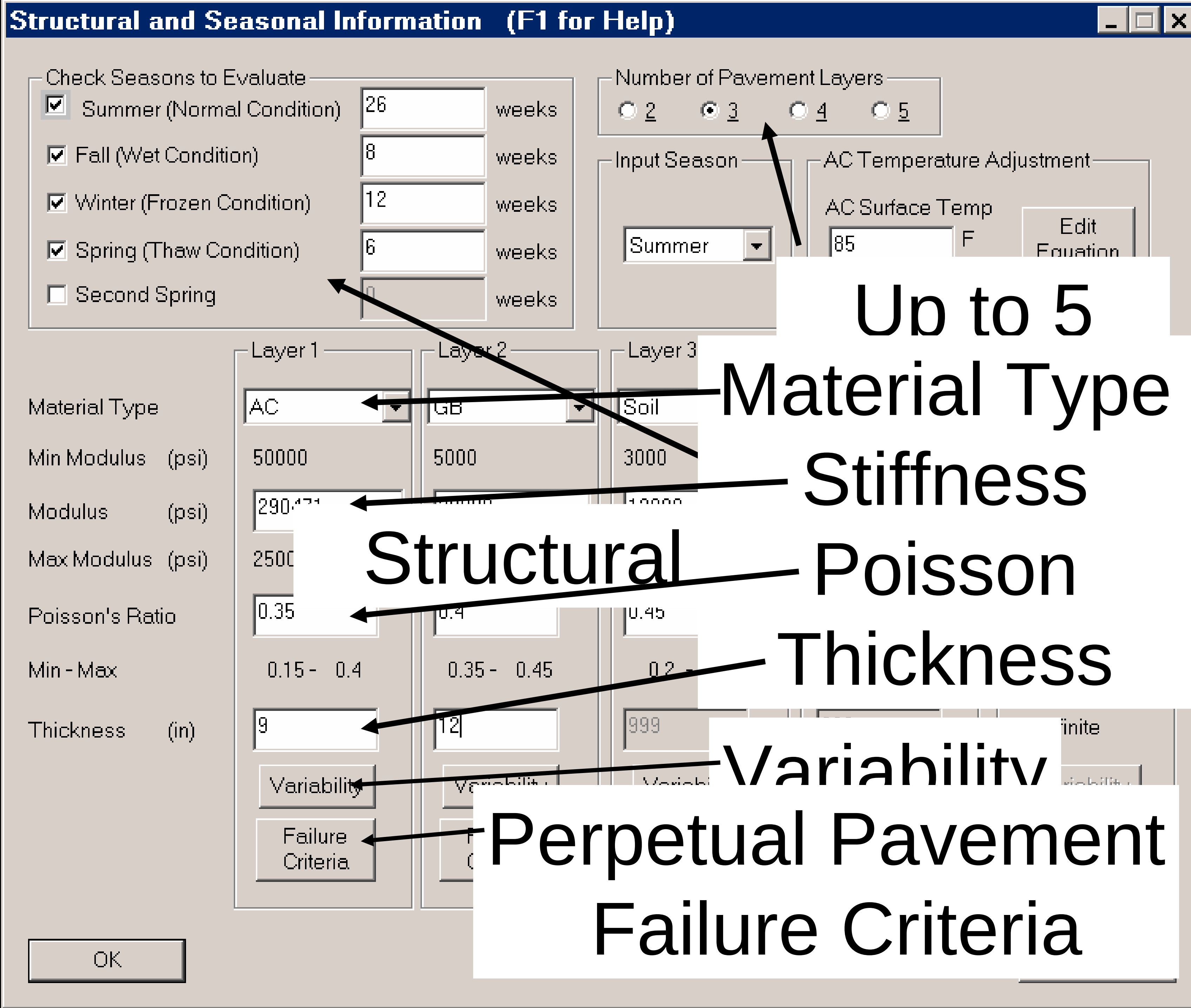
Under development by Dr. David Timm at NCAT
for the Asphalt Pavement Alliance

M-E Design Framework



Key Software Components

- Based on fully functional M-E design software
- Layered elastic analysis
- Incorporates
  - Seasonal effects
  - Thickness variability
  - Material property variability
  - Load Spectra or ESALs
  - Deterministic and Probabilistic analyses
  - Conventional M-E design and Perpetual Pavement Design


Structural and Seasonal Information (F1 for Help)
Check Seasons to Evaluate
Summer (Normal Condition)
26
weeks
Fall (Wet Condition)
8
weeks
Winter (Frozen Condition)
12
weeks
Spring (Thaw Condition)
6
weeks
Second Spring
weeks
Number of Pavement Layers
2
3
4
5
Input Season
Summer
AC Temperature Adjustment
AC Surface Temp
85
F
Edit
Up to 5
Layer 1
Layer 2
Layer 3
Material Type
AC
GB
Soil
Min Modulus (psi)
50000
5000
3000
Modulus (psi)
Max Modulus (psi)
Poisson's Ratio
0.35
Min - Max
0.15 - 0.4
0.35 - 0.45
Thickness (in)
9
12
999
Variability
Failure Criteria
OK
Stiffness
Structural
Poisson
Thickness
Perpetual Pavement
Failure Criteria

Asphalt Modulus vs. Temperature

AC - Temperature Relationship (F1 for Help)

$$E_{AC} = Q_1 * e^{\left(\frac{(T+Q_2)^2}{Q_3}\right)}$$

Q1: 16693.4

Q2: 26.2

Q3: -1459.7

Note: Changing these coefficients will update ALL of the asphalt concrete seasonal moduli, according to temperature.

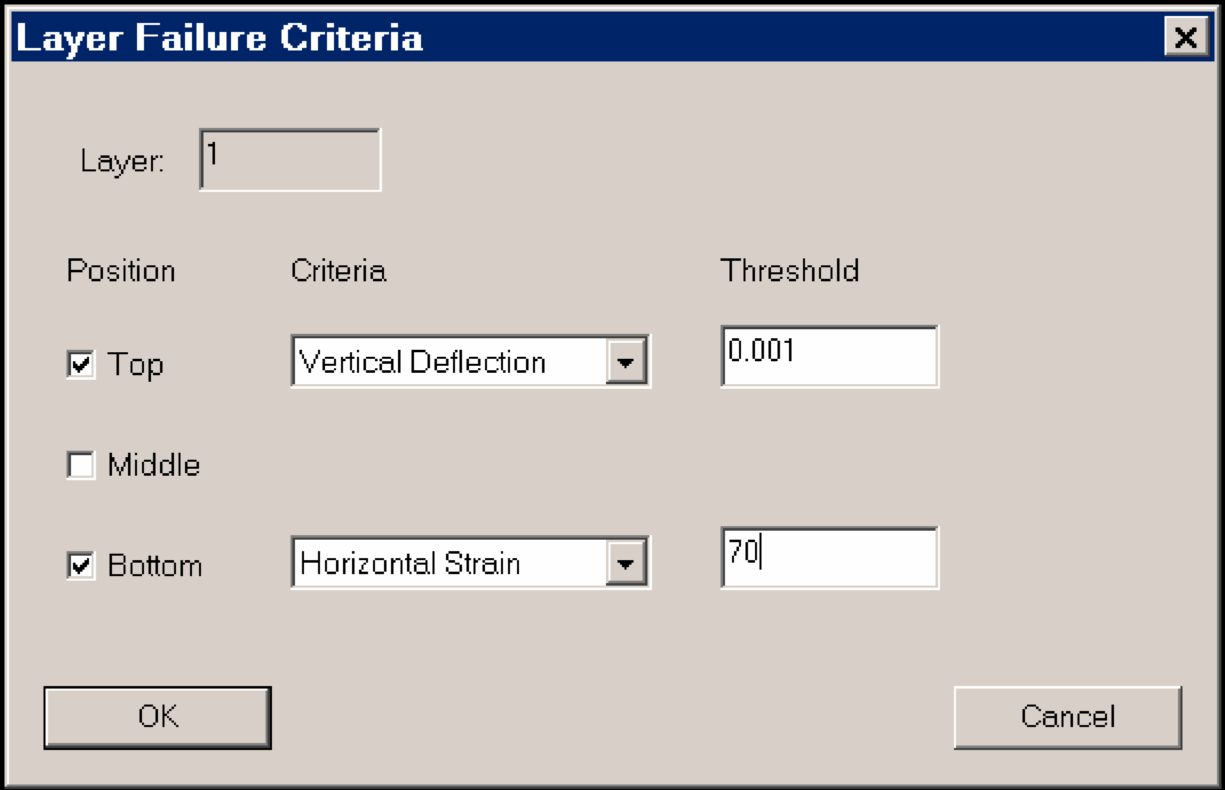
Reset

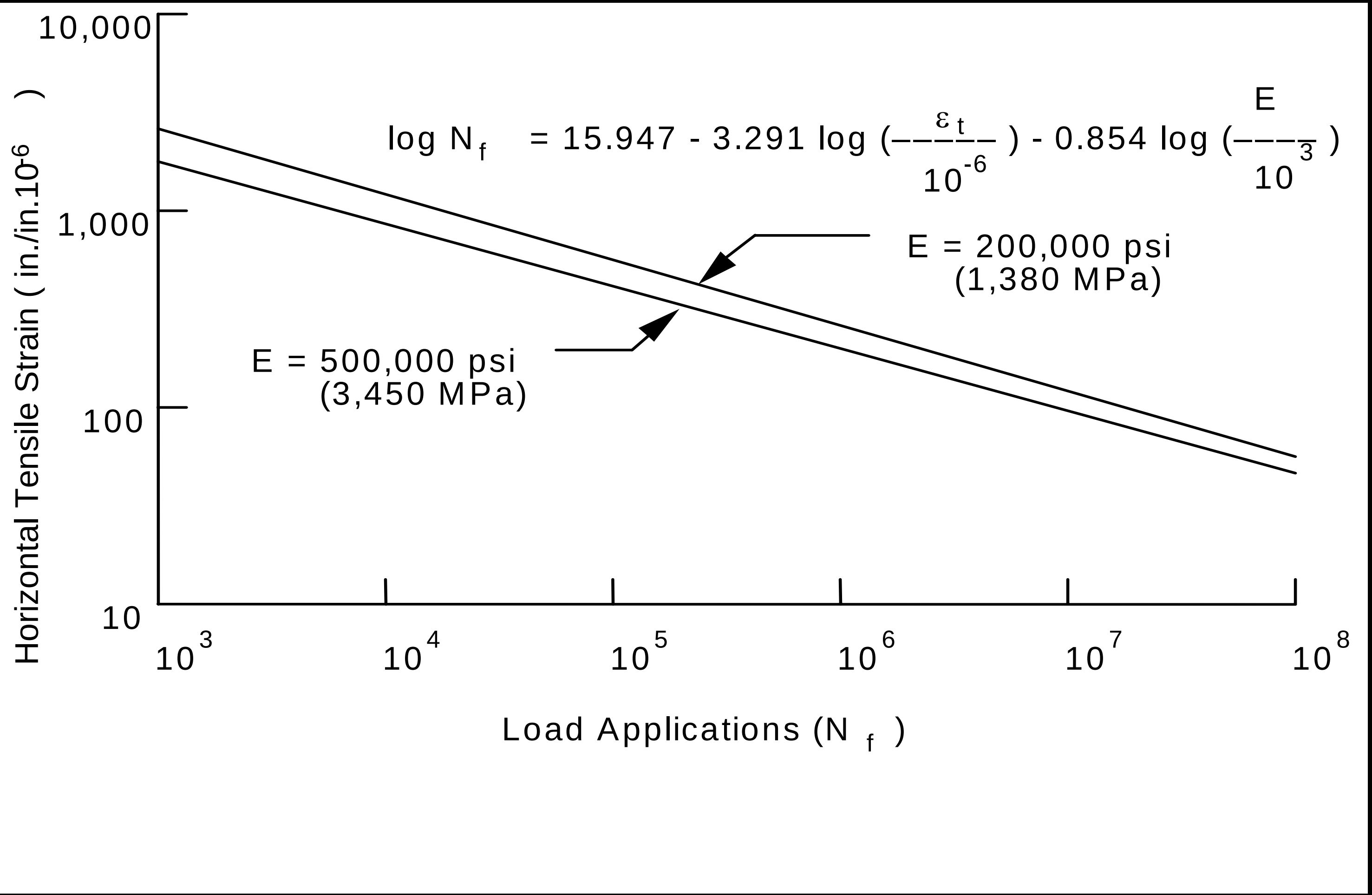
OK

Cancel

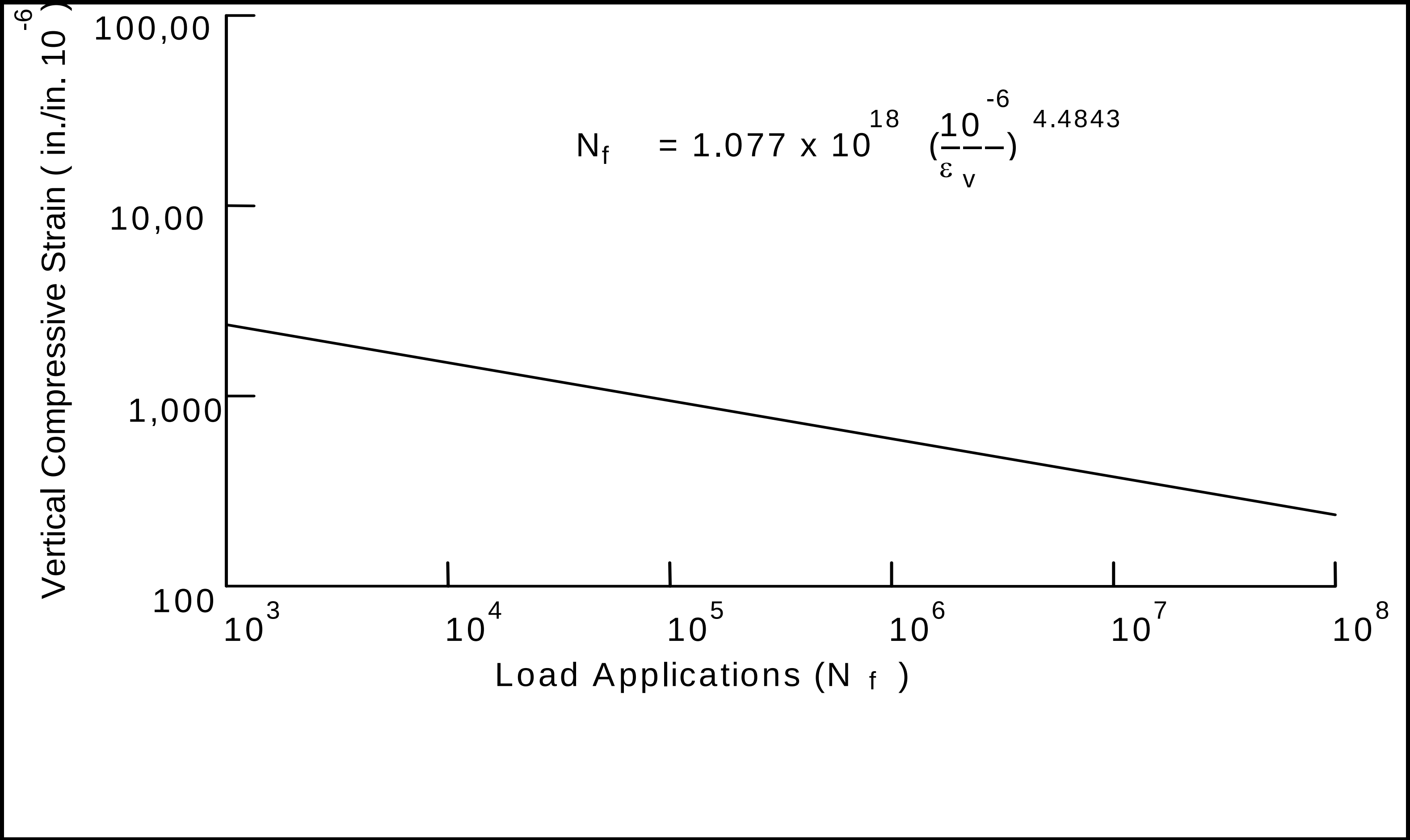
Perpetual Pavement Failure Criteria

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



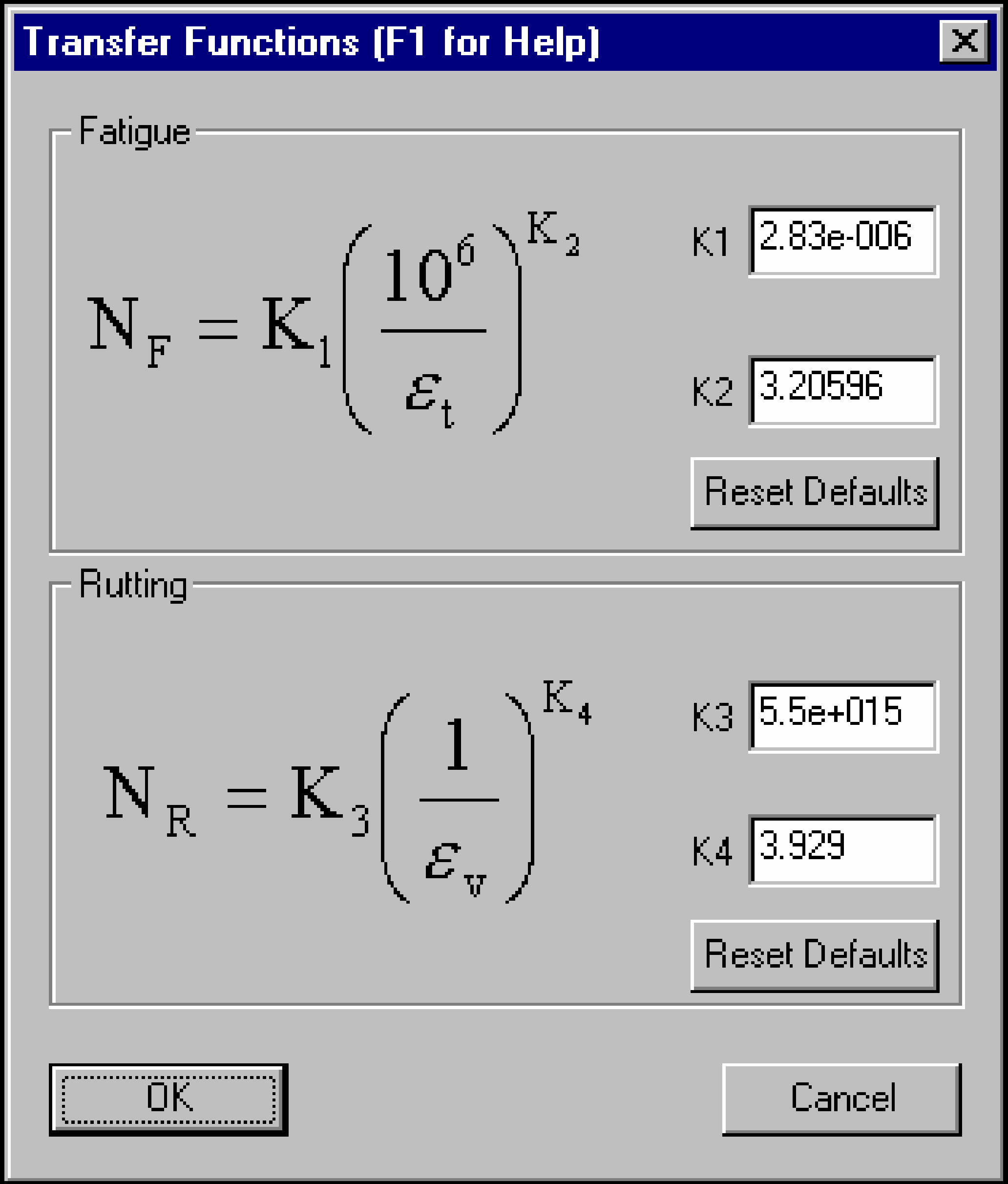


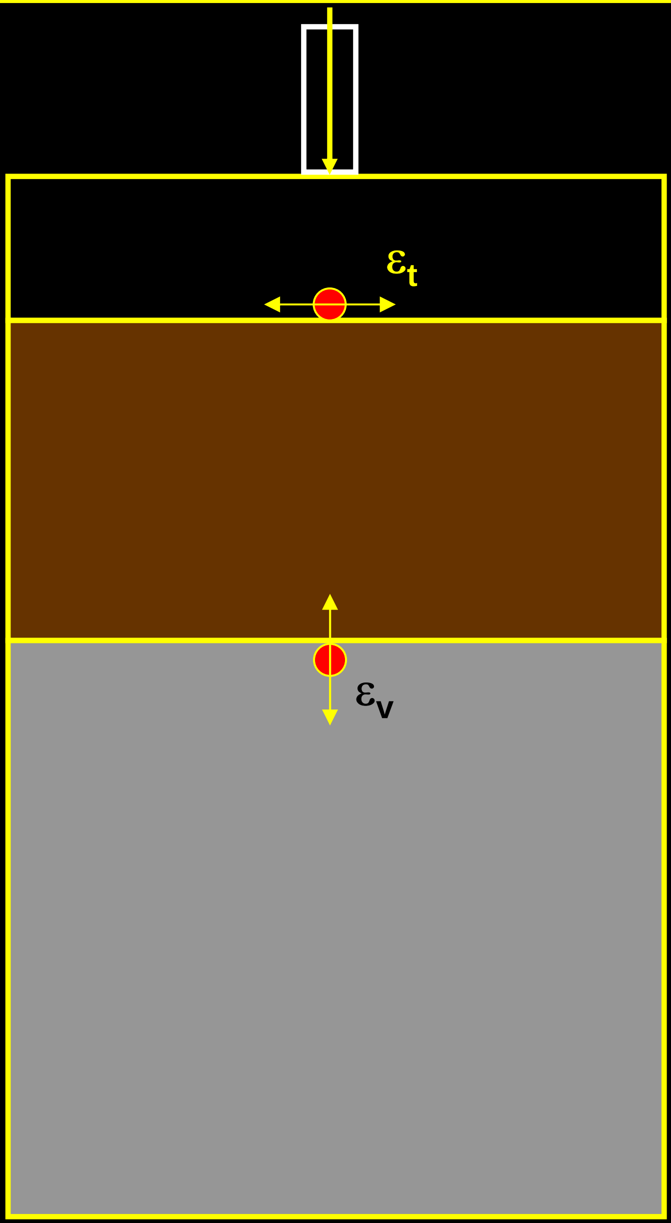
Fatigue Cracking and $N_{fatigue}$



Total Pavement Rut Depth and $N_{rutting}$

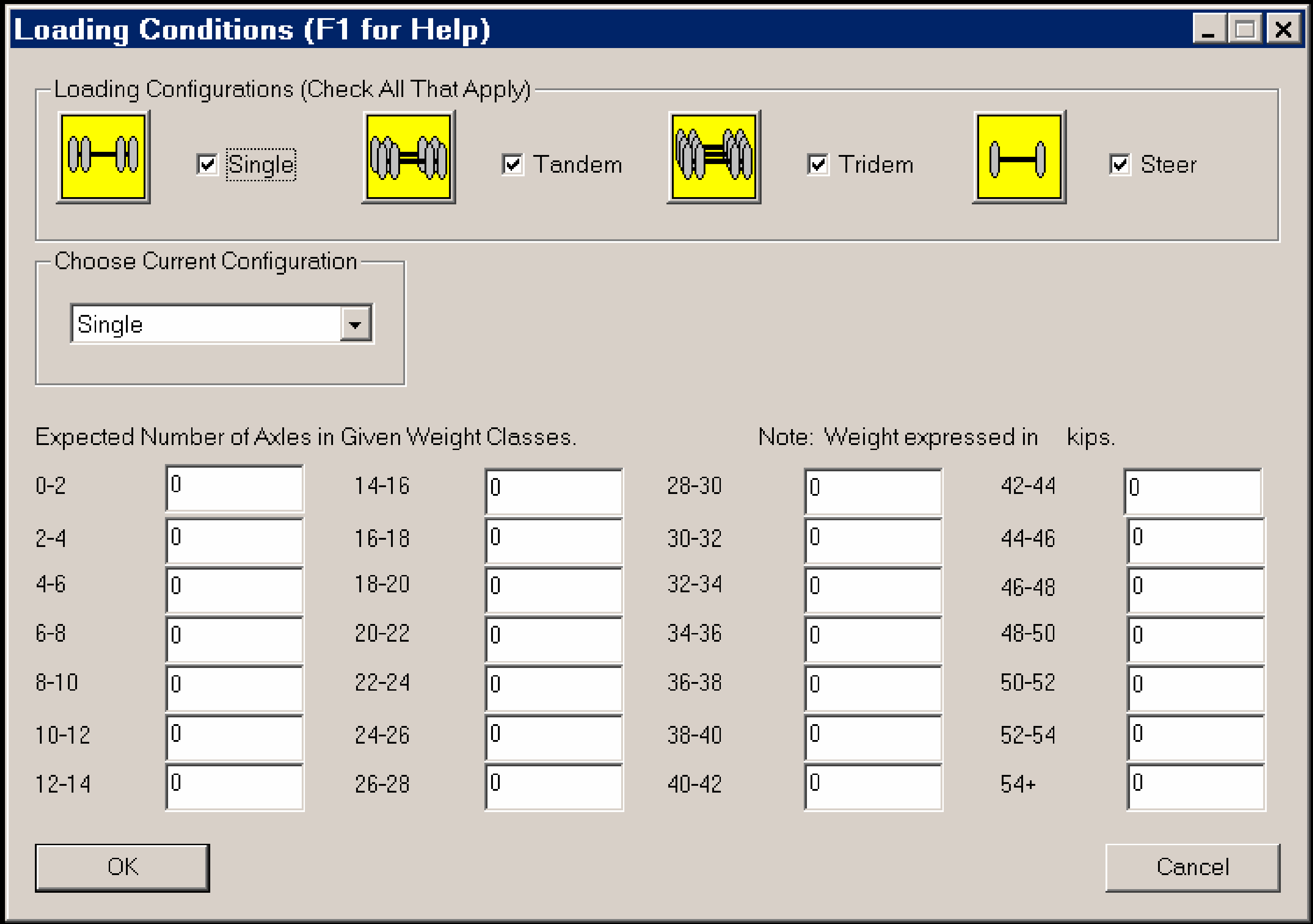
Transfer Functions



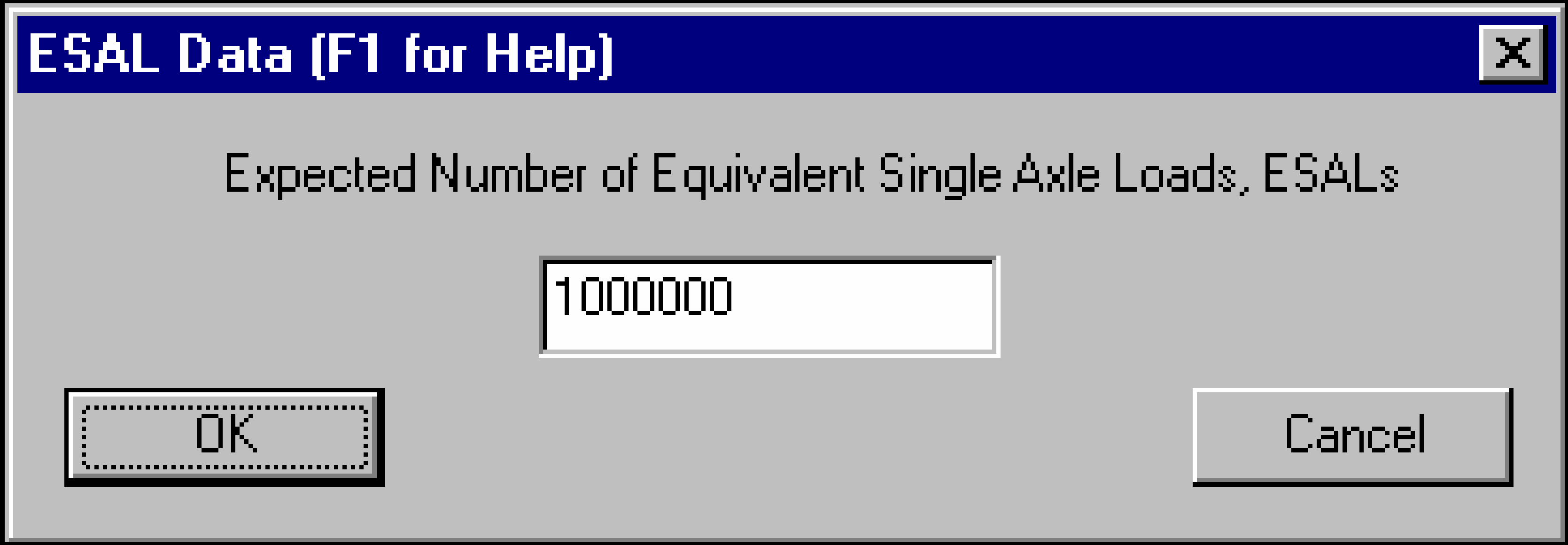


Load Spectra

- Consider weight distributions of singles, tandems, tridem and steer axles separately



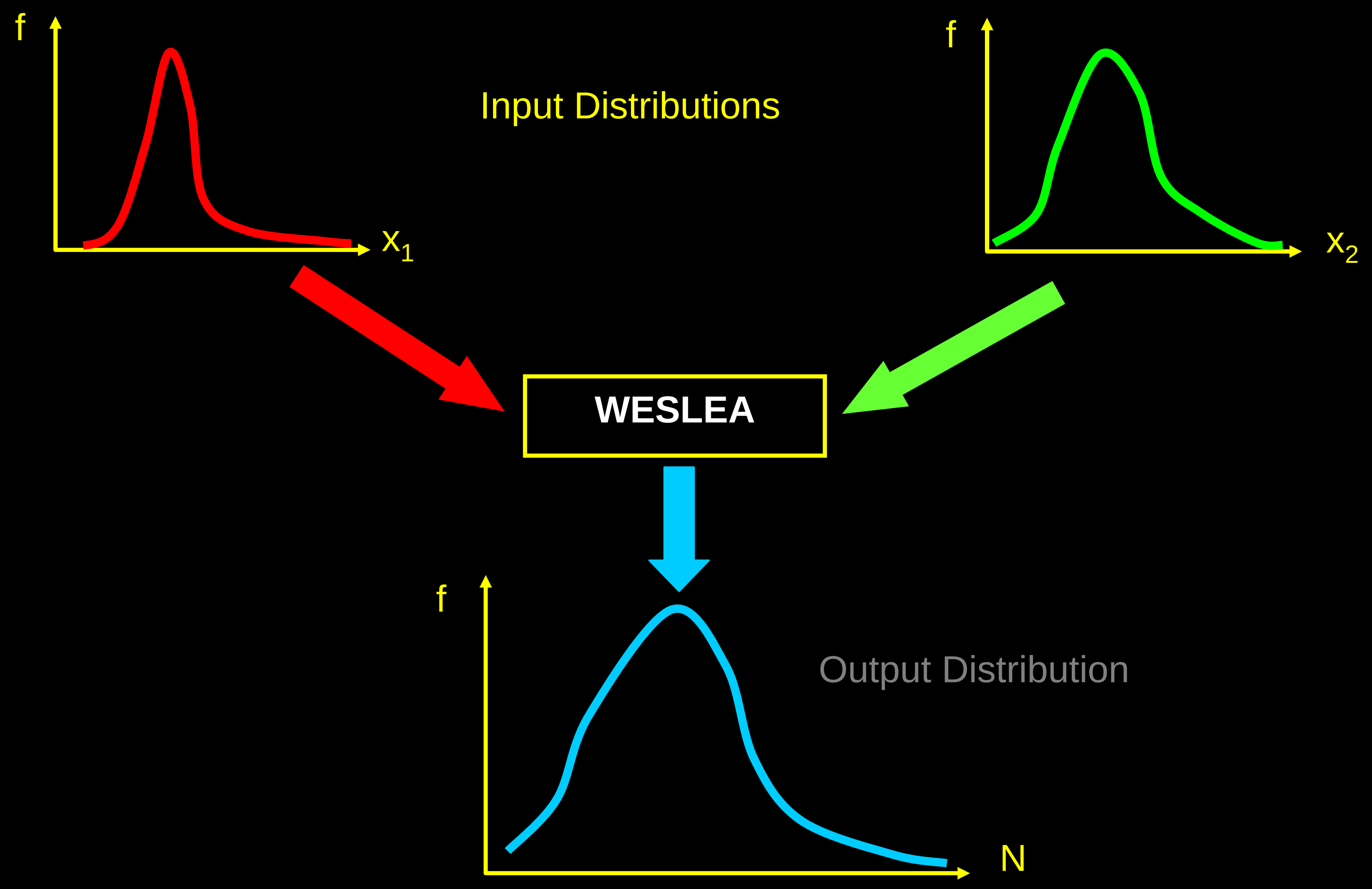
ESAL Approximation



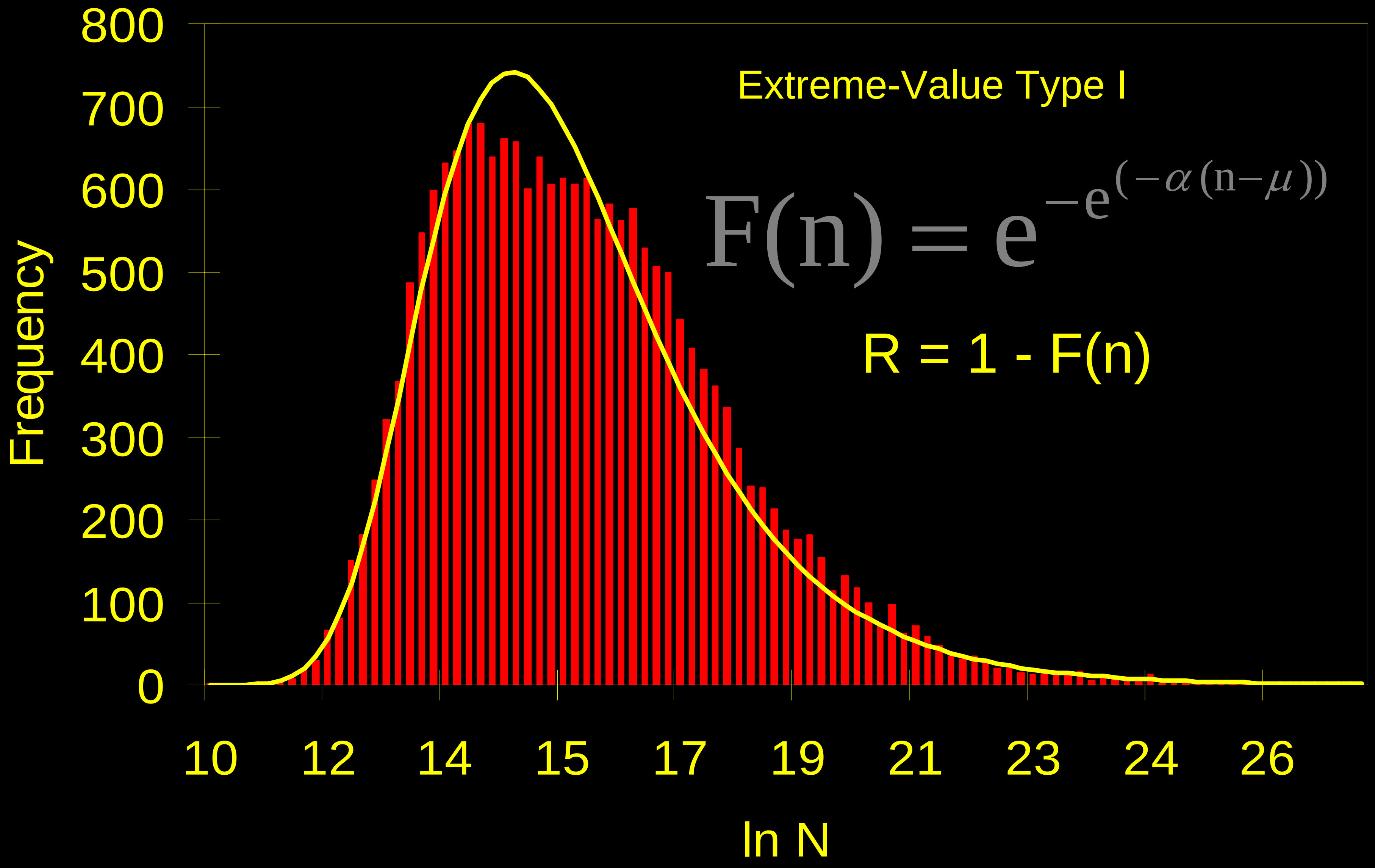
Analysis

- Deterministic:
  - Program considers possible combinations of material properties and loadings
  - Calculates pavement responses
  - Determines if thresholds are exceeded (i.e., non-perpetual)
- Probabilistic:
  - 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

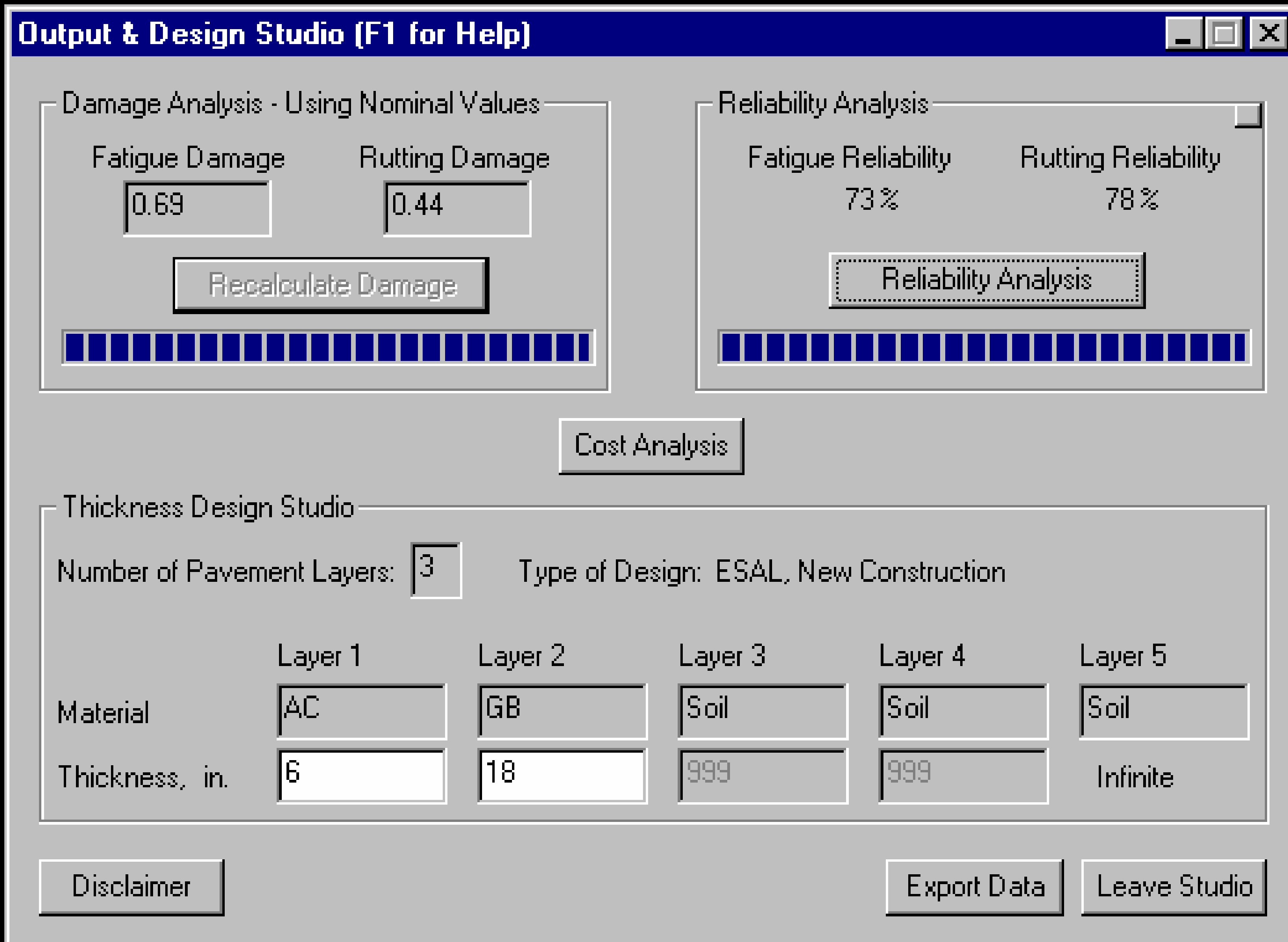
Monte Carlo Simulation



Characteristic Distribution



Program Output



Miner’s Hypothesis

- Provides the ability to sum damage for a specific distress type
- $D = \Sigma\, n_i/N_i \leq 1.0$

where n_i = actual number of loads during condition i

N_i = allowable number of loads during condition i