Perpetual Pavement Design

An Introduction to the PerRoad Program

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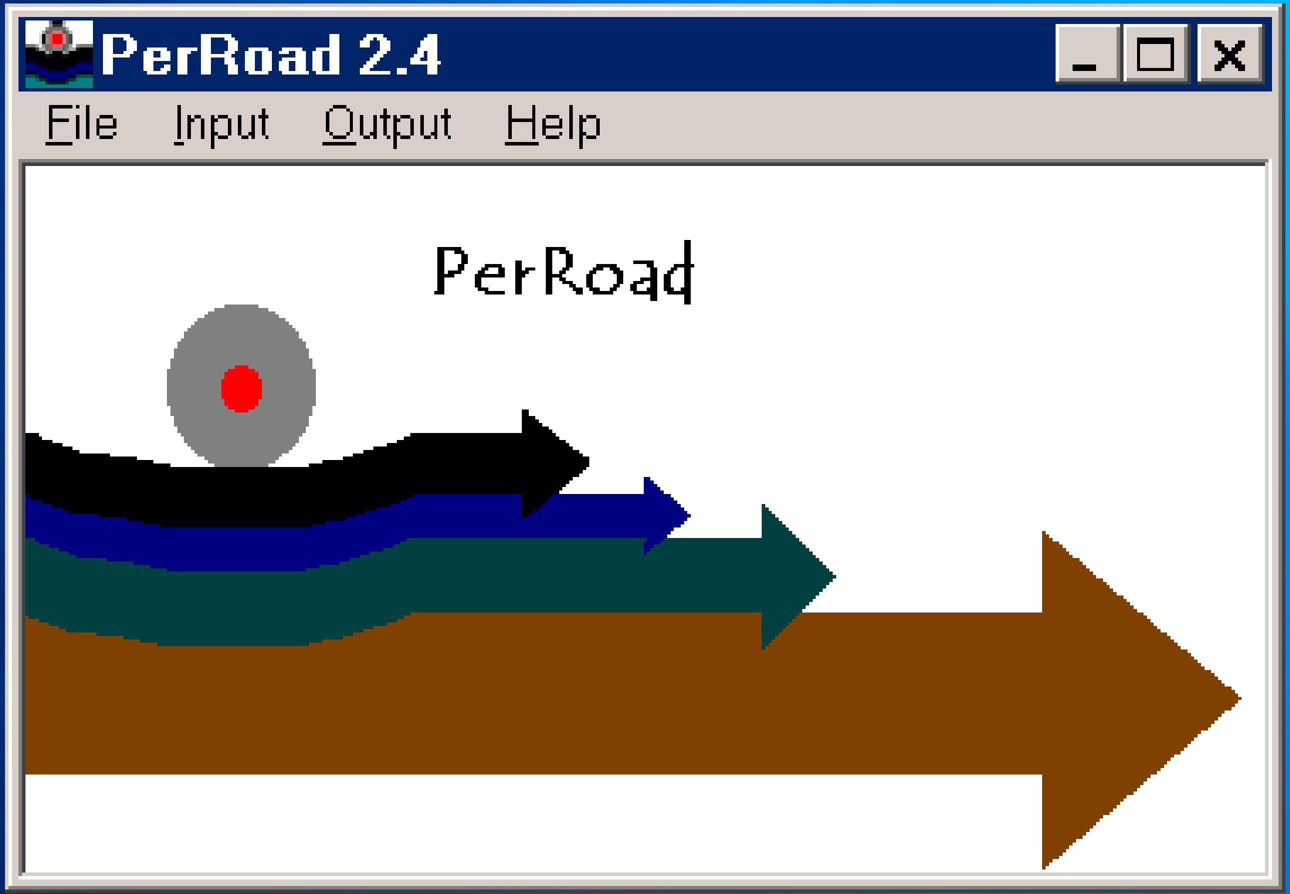
Perpetual Asphalt Pavements

- ***Philosophy***: to avoid or indefinitely delay damage associated with traffic load repetitions
  - Structural rutting (subgrade permanent deformation)
  - Traditional fatigue cracking, starting at the bottom of the asphalt layer
- ***Practice***: determine layer thickness and materials requirements to fulfill assumptions
  - Establish design and acceptance criteria for pavement materials to avoid:
    - Rutting in the asphalt layer
    - Top-down cracking
    - Low temperature cracking
    - Moisture damage

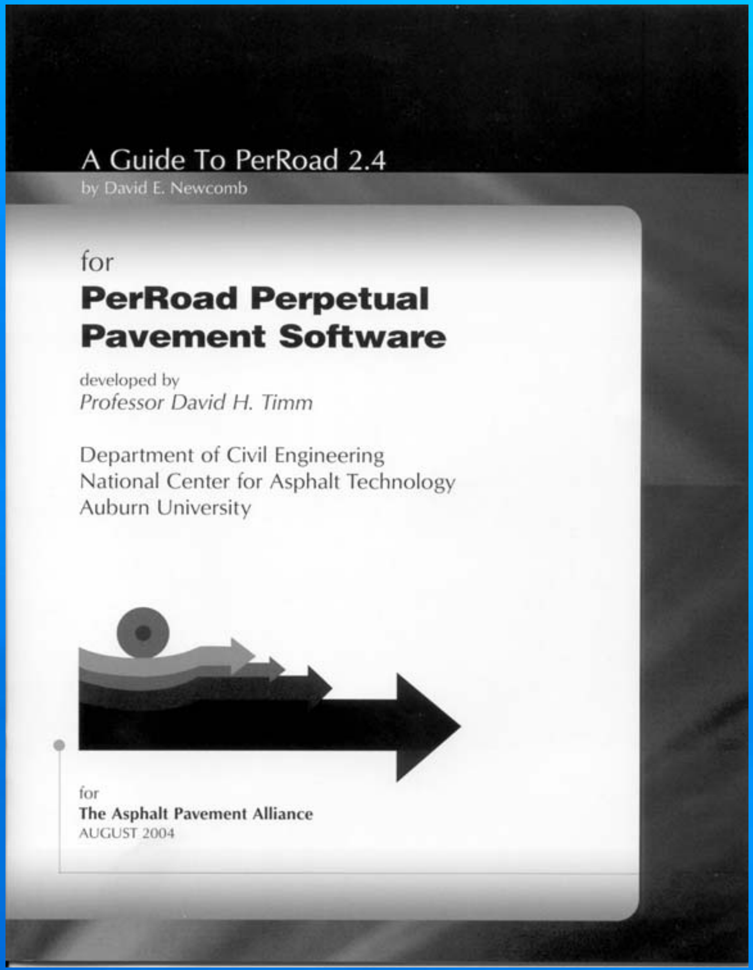
PerRoad 2.4

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



User's Guide Available

- At booth or pdf can be downloaded
- Compiles the help files included in the program



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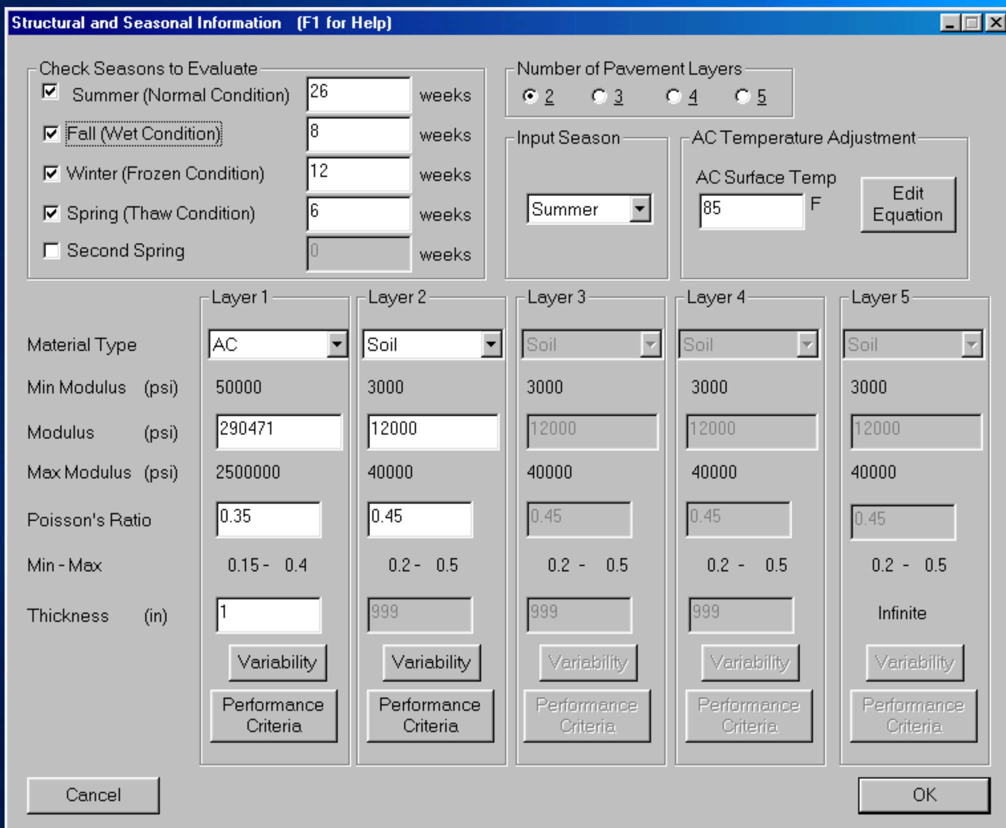
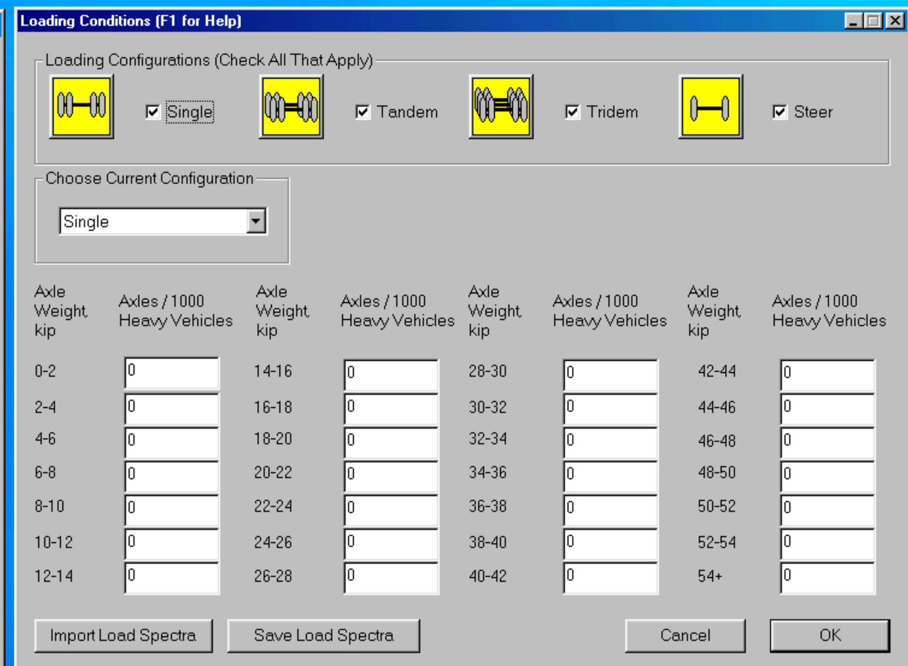
Perpetual Pavement Design Software





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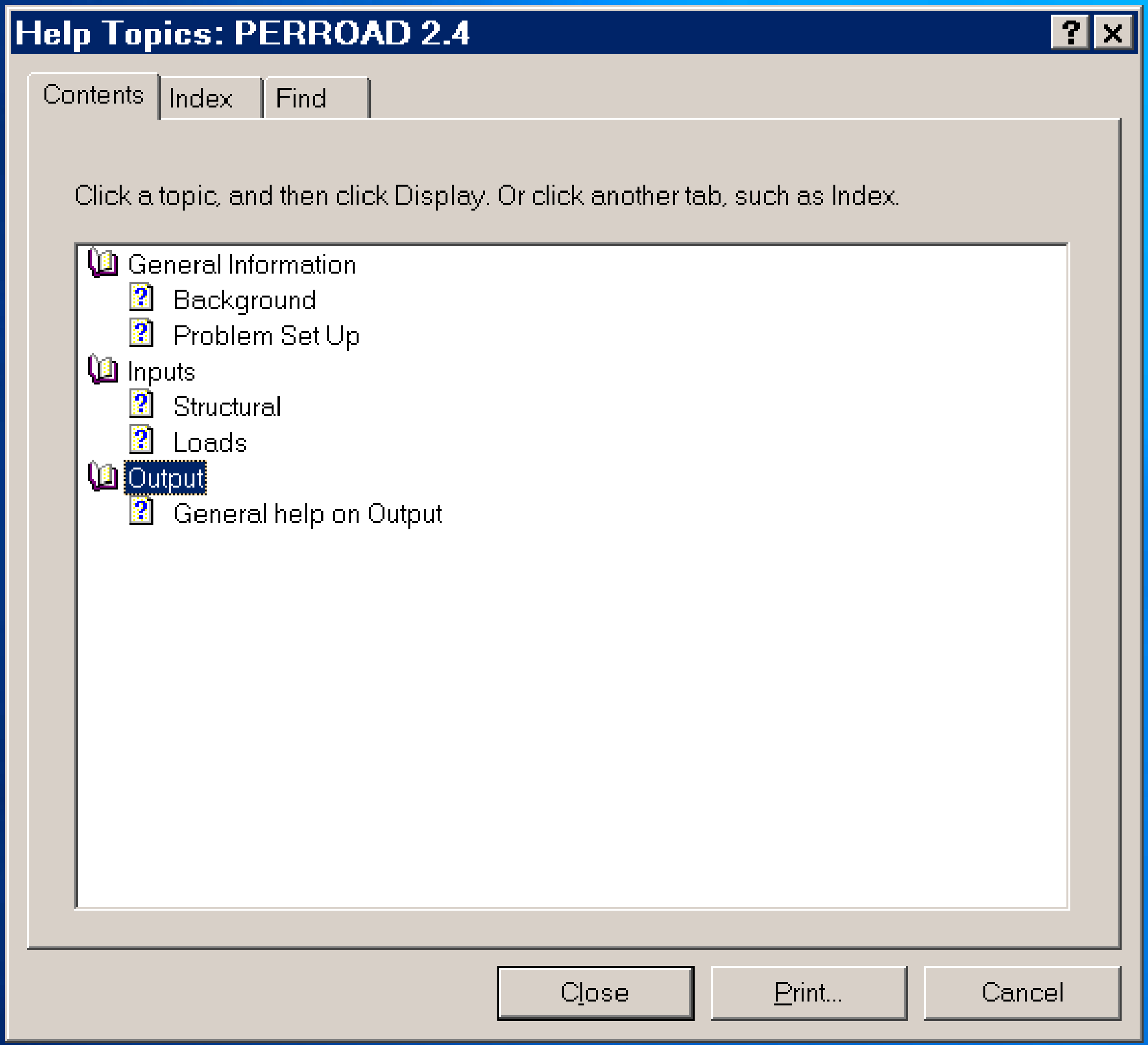
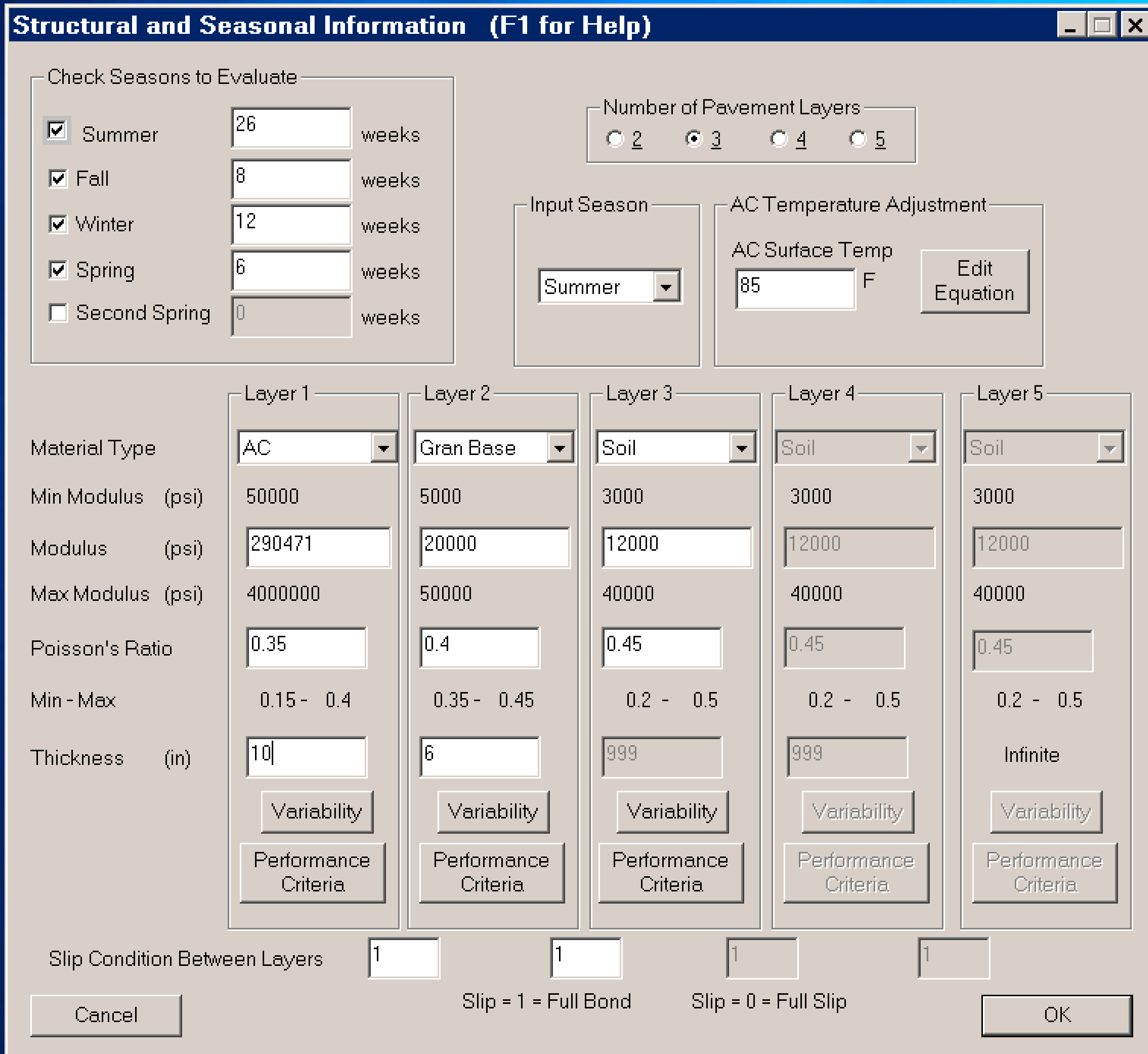
Help File

- Help, Contents and Index
- F1 from any program window




Structural and Seasonal Information (F1 for Help)
Check Seasons to Evaluate
Summer 26 weeks
Fall 8 weeks
Winter 12 weeks
Spring 6 weeks
Second Spring 0 weeks
Number of Pavement Layers
2 3 4 5
Input Season
Summer
AC Temperature Adjustment
AC Surface Temp
85 F
Edit Equation
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
Material Type
AC
Gran Base
Soil
Soil
Soil
Min Modulus (psi)
50000
5000
3000
3000
3000
Modulus (psi)
290471
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
6
999
999
Infinite
Variability
Performance Criteria
Slip Condition Between Layers
1
1
1
1
Slip = 1 = Full Bond
Slip = 0 = Full Slip
Cancel
OK

AC - Temperature Relationship (F1 for Help)

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

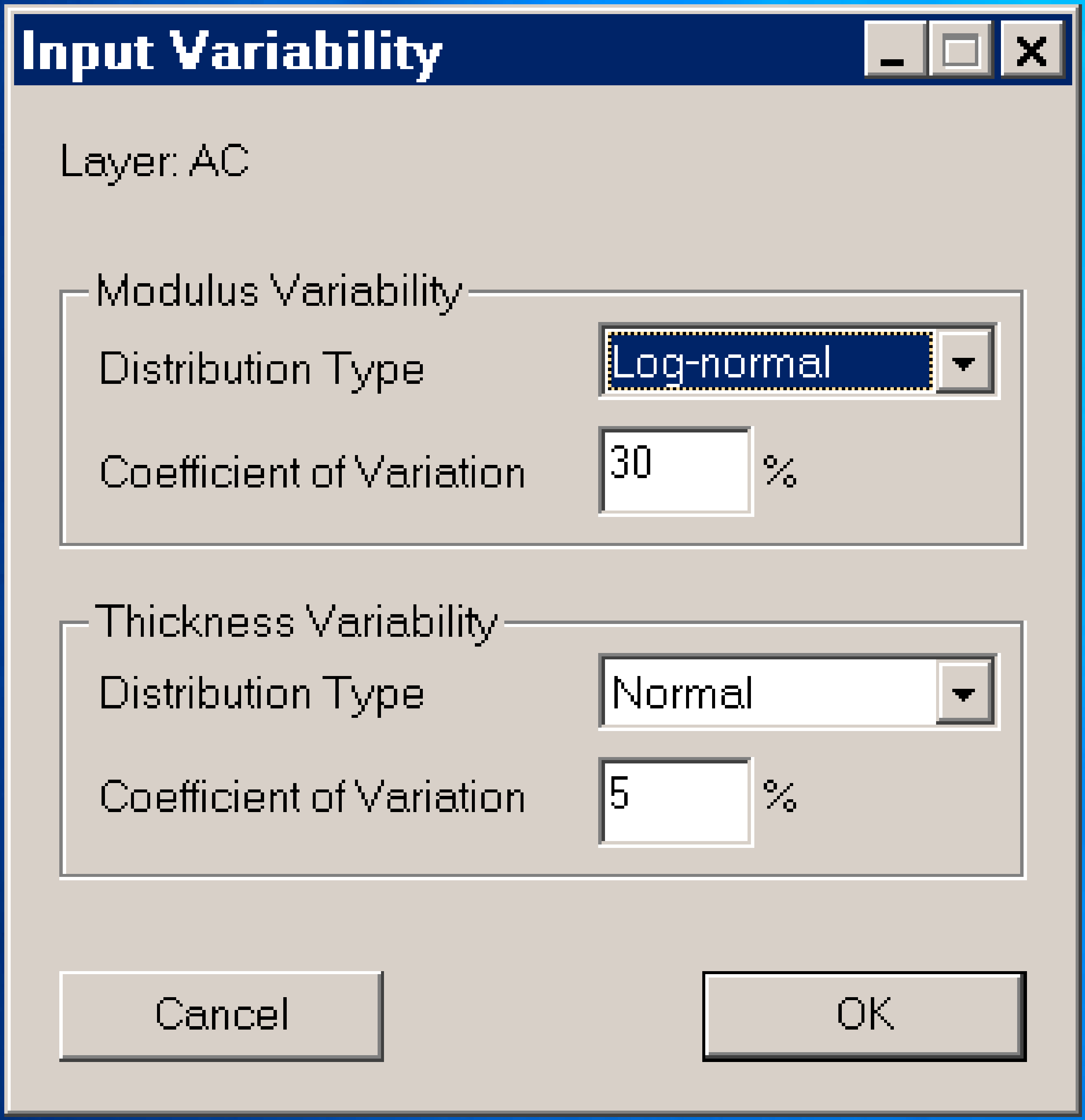
Q1	16693.4
Q2	26.2
Q3	-1459.7

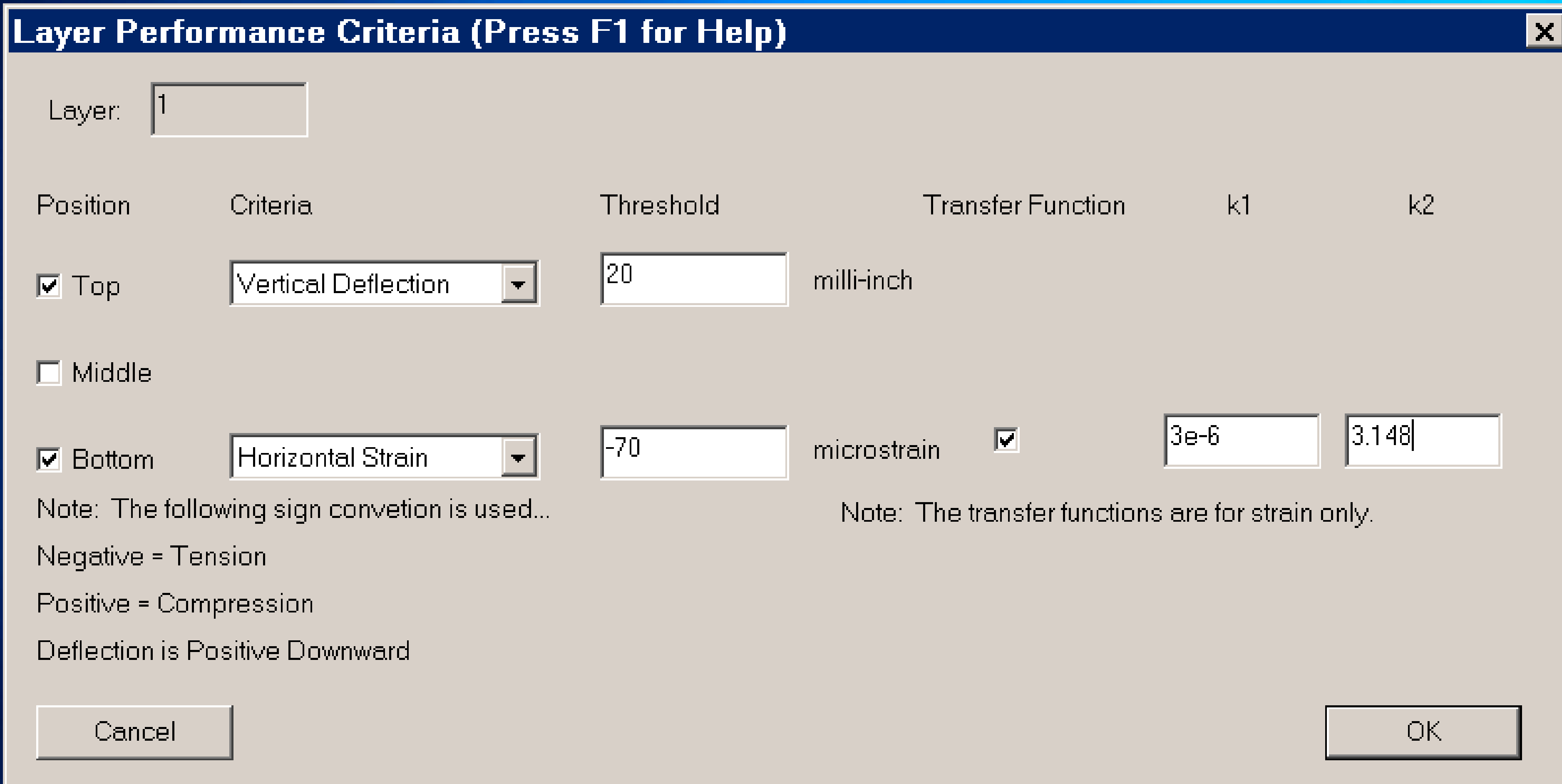
Note: Changing these coefficients will update ALL of the asphalt concrete seasonal moduli, according to temperature.

Reset

Cancel

OK


Input Variability
Layer: AC
Modulus Variability
Distribution Type
Log-normal
Coefficient of Variation
30
%
Thickness Variability
Distribution Type
Normal
Coefficient of Variation
5
%
Cancel
OK


Layer Performance Criteria (Press F1 for Help)
Layer: 1
Position
Criteria
Threshold
Transfer Function
k1
k2
Top
Vertical Deflection
20
milli-inch
Middle
Bottom
Horizontal Strain
-70
microstrain
3e-6
3.148
Note: The following sign convetion is used...
Negative = Tension
Positive = Compression
Deflection is Positive Downward
Note: The transfer functions are for strain only.
Cancel
OK

Loading Conditions (F1 for Help)

Loading Configurations (Check All That Apply)

- [x] Single
- [x] Tandem
- [x] Tridem
- [ ] Steer

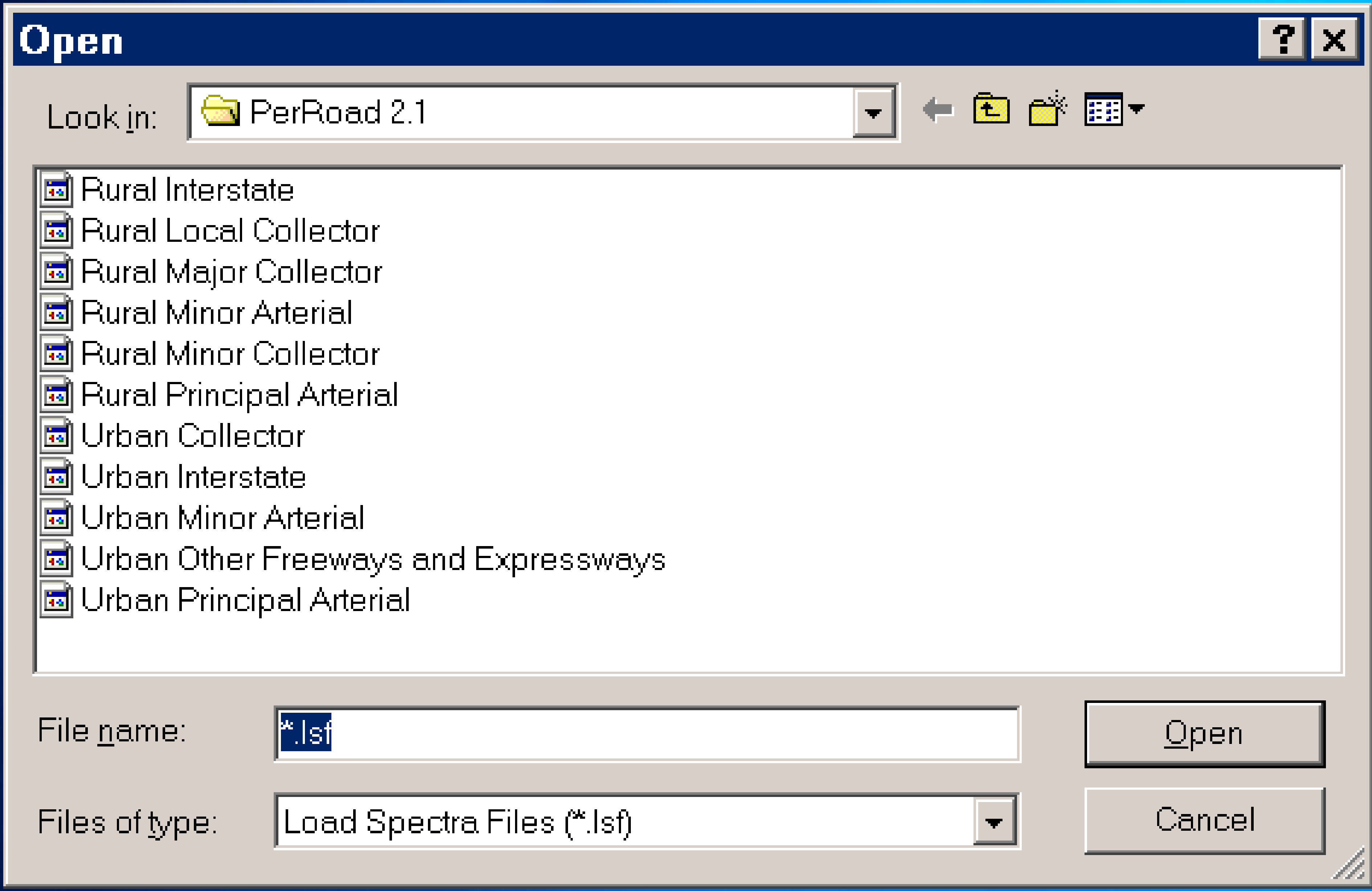
Choose Current Configuration: Single

Current Axles Per Day in Design Lane: 1000

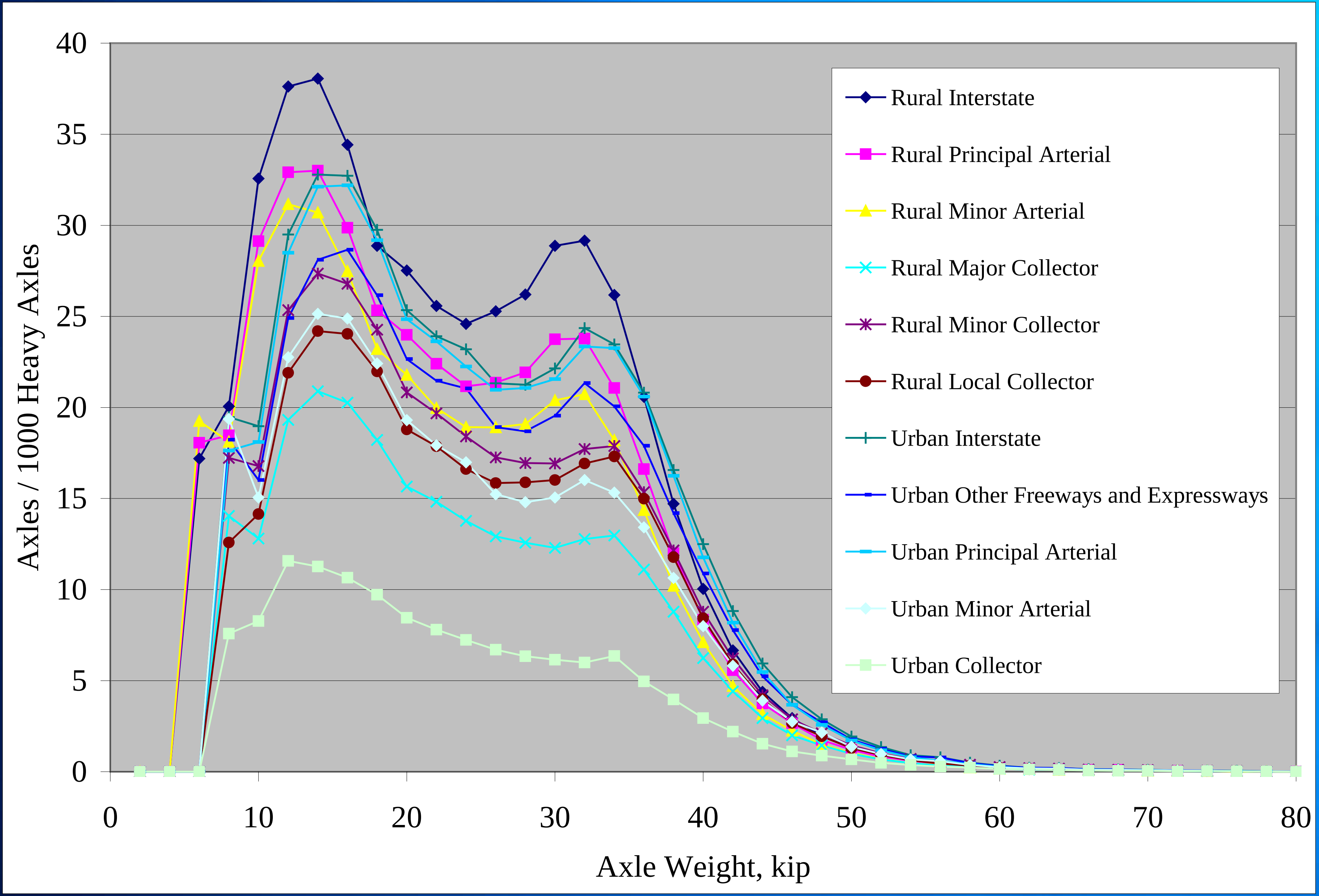
Axle Growth Rate: 4 %

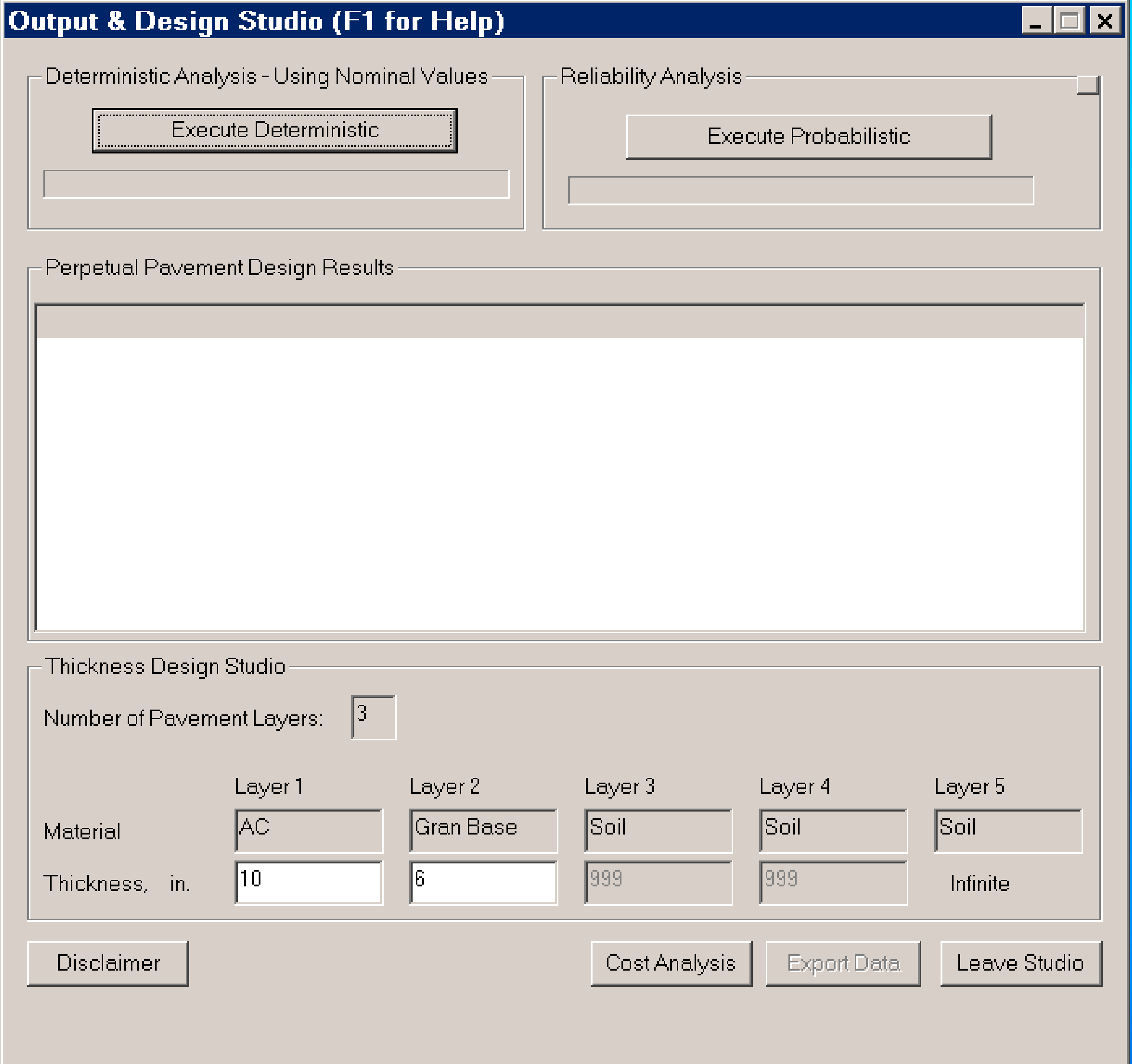
Axle Weight, kip	Axles / 1000 Heavy Axles	Axle Weight, kip	Axles / 1000 Heavy Axles	Axle Weight, kip	Axles / 1000 Heavy Axles	Axle Weight, kip	Axles / 1000 Heavy Axles
0-2	0	28-30	0.357	56-58	0	84-86	0
2-4	40.626	30-32	0.269	58-60	0	86-88	0
4-6	54.164	32-34	0.123	60-62	0	88-90	0
6-8	73.084	34-36	0.075	62-64	0	90-92	0
8-10	123.87	36-38	0.043	64-66	0	92-94	0
10-12	106.33	38-40	0.039	66-68	0	94-96	0
12-14	47.816	40-42	0	68-70	0	96-98	0
14-16	24.161	42-44	0	70-72	0	98-100	0
16-18	15.277	44-46	0	72-74	0	100-102	0
18-20	9.142	46-48	0	74-76	0	102-104	0
20-22	4.946	48-50	0	76-78	0	104-106	0
22-24	2.48	50-52	0	78-80	0	106-108	0
24-26	1.235	52-54	0	80-82	0	108-110	0
26-28	0.719	54-56	0	82-84	0	110+	0

Cancel | Import Load Spectra | Save Load Spectra | OK


Open
Look in:
PerRoad 2.1
Rural Interstate
Rural Local Collector
Rural Major Collector
Rural Minor Arterial
Rural Minor Collector
Rural Principal Arterial
Urban Collector
Urban Interstate
Urban Minor Arterial
Urban Other Freeways and Expressways
Urban Principal Arterial
File name:
*.lsf
Files of type:
Load Spectra Files (*.lsf)
Open
Cancel

Tandem Axles





Output & Design Studio (F1 for Help)
Deterministic Analysis - Using Nominal Values
Execute Deterministic
Reliability Analysis
Execute Probabilistic
Perpetual Pavement Design Results
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.
10
6
999
999
Infinite
Disclaimer
Cost Analysis
Export Data
Leave Studio

Deterministic Output

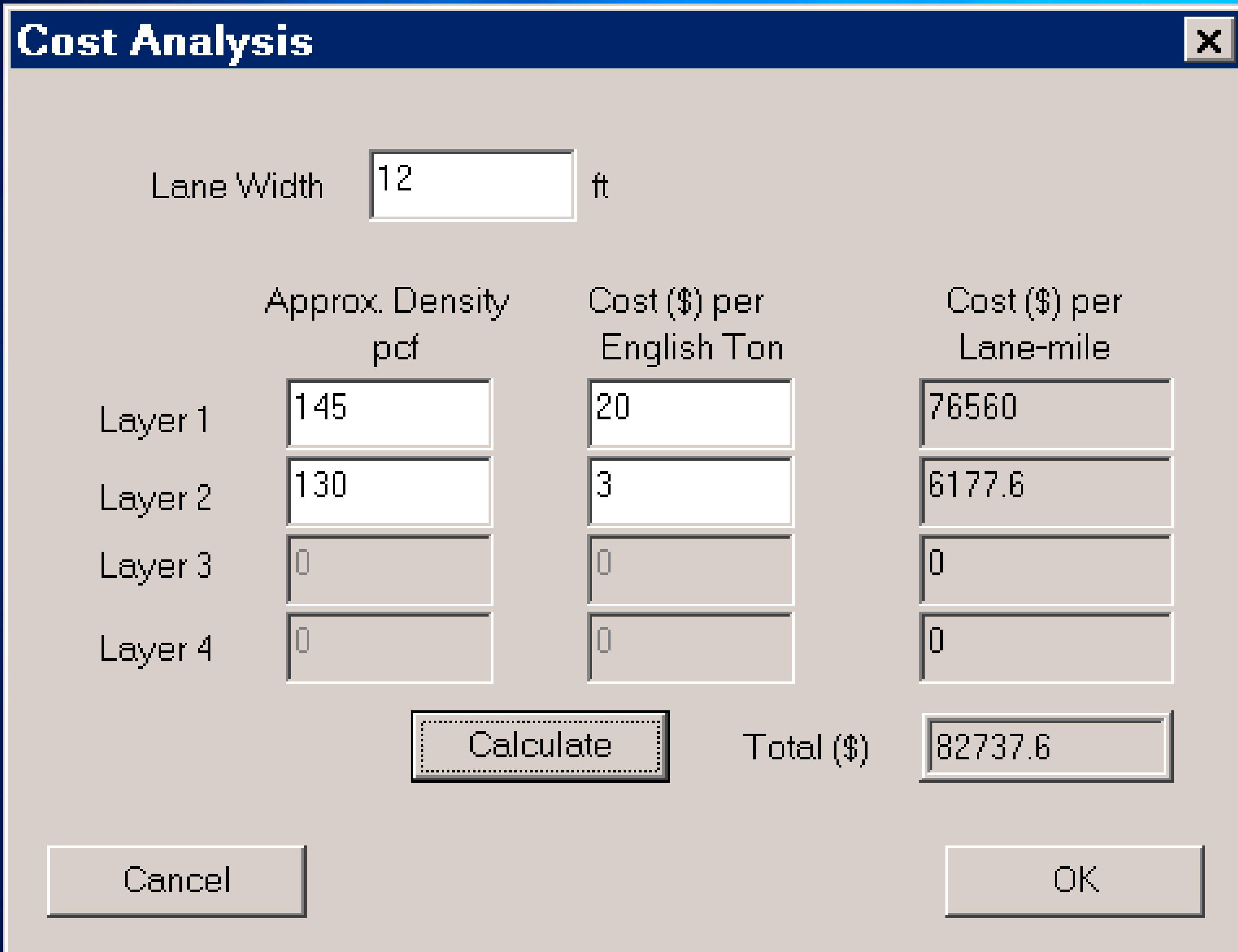
Perpetual Pavement Design Results

Layer	Location	Criteria	Threshold	Worst Case	Units	Perpetual?
1	Top	Vertical Defl...	20.	18.102	milli-in	Yes
1	Bottom	Horizontal Str...	-70.	-119.73	microstrain	No
3	Top	Vertical Strain	200.	232.91	microstrain	No

Probabilistic Output

Perpetual Pavement Design Results

Layer	Location	Criteria	Threshold	Un...	Probabi...	Damage/MESAL	Life Estimate, yrs
1	Top	Vertical Defl...	20.	mil...	100.	NA	NA
1	Bottom	Horizontal Str...	-70.	mi...	95.	7.5949e-003	42.11
3	Top	Vertical Strain	200.	mi...	99.	NA	NA


Cost Analysis
Lane Width 12 ft
Approx. Density pcf
Cost ($) per English Ton
Cost ($) per Lane-mile
Layer 1 145 20 76560
Layer 2 130 3 6177.6
Layer 3 0 0 0
Layer 4 0 0 0
Calculate
Total ($) 82737.6
Cancel
OK

Example results: I-40 in Oklahoma

- Obtained traffic classification, weight data
  - Average 2,063 Flexible ESAL/day (2002)
- Adjusted to fit input categories in software
- Assumed materials characteristics, thicknesses for evaluation

Typical Section

2” SMA (PG 76-28)

3” S3 (PG 76-28)

6” (var) S2 or S3 (PG 64-22)

3” S3 (PG 64-22)
N_{des} = 50, designed @
2% air voids

E_{SG} = 8 ksi

Layer 1:

E_{sum} = 400 ksi

$E_{spr/fall}$ = 750 ksi

E_{winter} = 1300 ksi

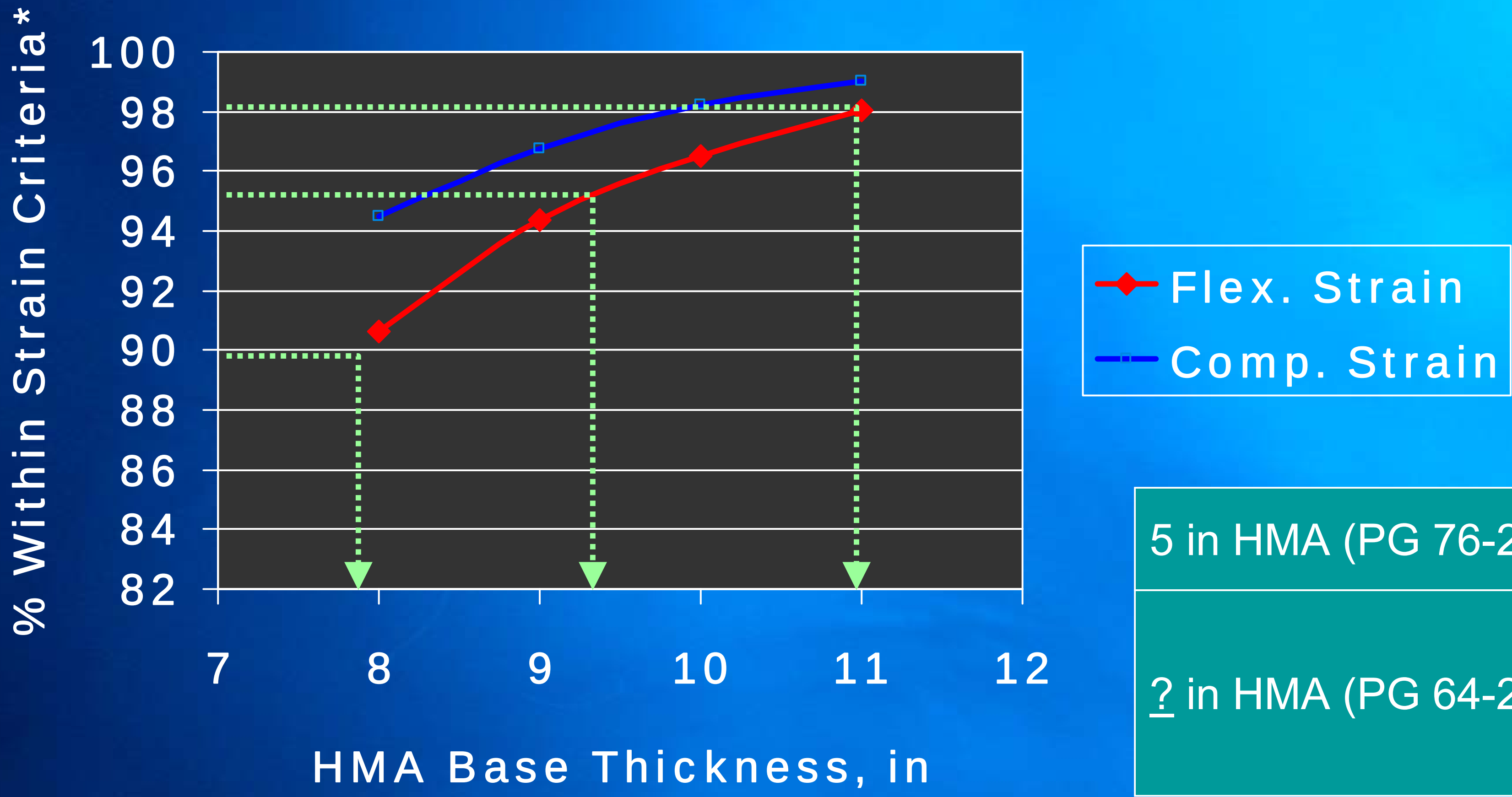
Layer 2:

E_{sum} = 400 ksi

$E_{spr/fall}$ = 500 ksi

E_{winter} = 600 ksi

Results, Probabilistic Analysis

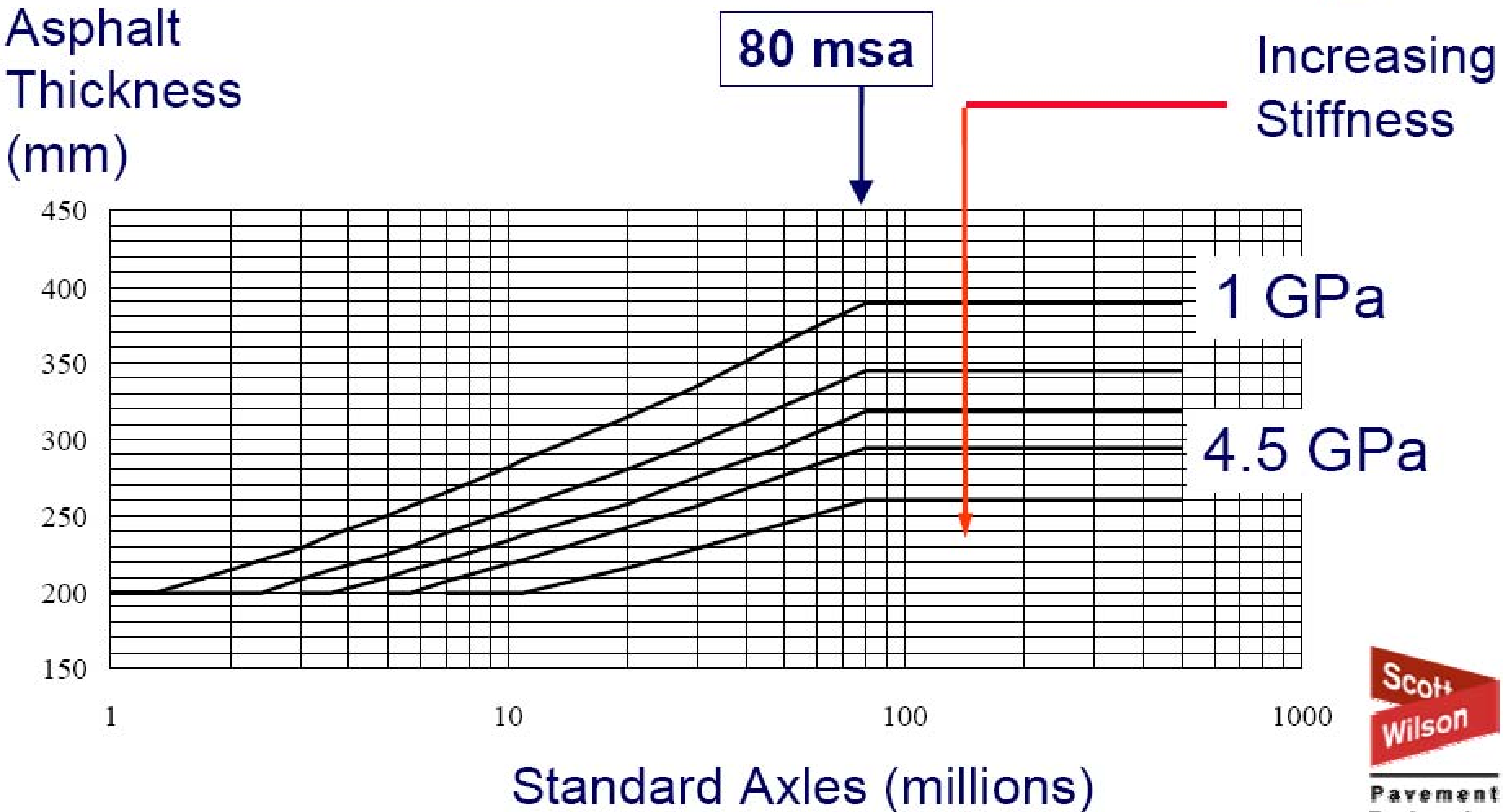


5 in HMA (PG 76-28)
? in HMA (PG 64-22)

* Percentage of heavy load applications where the strain level is less than the defined criterion

ncpe Nottingham Centre for Pavement Engineering
50 Years

Design Chart



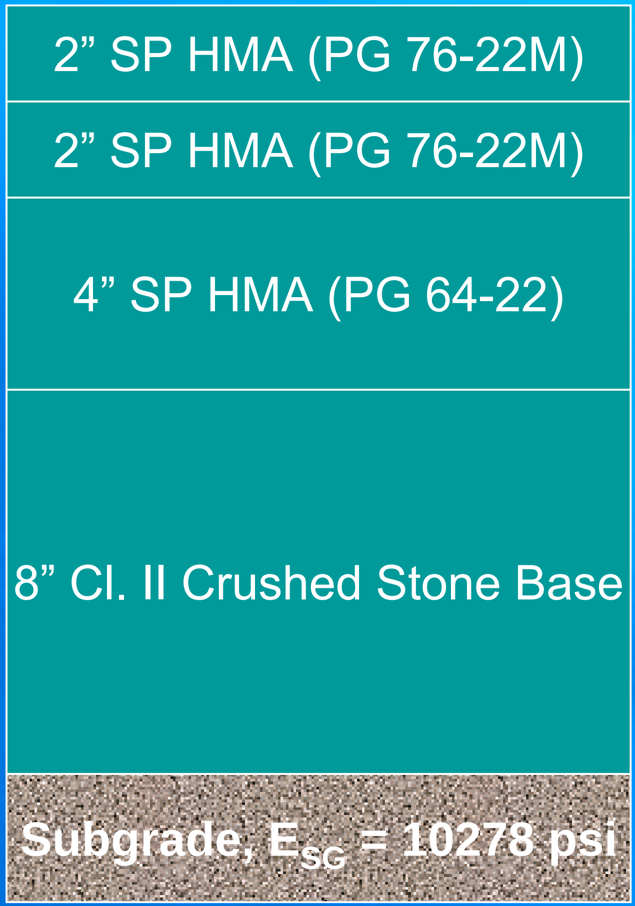
Scott Wilson
Pavement Engineering

What else could you do?

- Assume different materials, different stiffness (PG 76 for HMA base course)
- Apply long life concept to rehabilitation design
  - Properly characterize materials to remain
  - Rubblize concrete pavement (if existing pavement is PCC)
- Use as a tool to evaluate 1993 AASHTO Guide designs

New Pavement Design, US 167, Lincoln Parish

- Recently designed using 1993 AASHTO Guide
  - DARWin
- Northern Louisiana
- 2,940,156 ESAL over 20 year design period
  - 2341 loaded axles/day
  - 1.7% growth rate



US 167, Lincoln Parish

Parameter	Case 1 8/8	Case 1a 8/**12**	Case 1b **9**/8
ε_f (prob)	-174.7 (90%)	-169.2 (90.7%)	-149.7 (94.9%)
ε_v (prob)	468.8 (89.9%)	423.14 (92.6%)	402.3 (94.3%)
Time, 10% damage	15.3 yrs	15.9 yrs	31.9 yrs

PerRoad Software

- PerRoad is a useful tool for evaluating flexible pavement designs
- PerRoad is a good way to transition into the ME design procedure
- PerRoad training is available!
  - Simply contact your local asphalt industry association representative

Thanks!

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