Composite Criteria for Asphalt Cracking Failure and Subgrade Rutting Failure

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LHI

assembled by L. H. Irwin from Ullidtz (1987) and additional sources
Note: Data lines marked * (blue) were not included when computing the average coefficients.

Asphalt Horizontal Tensile Strain Criteria E = 435,100 psi for Asphalt Institute and Shell equations

	K	a	b	10	100	1,000	10,000	25,000	100,000	1,000,000	10,000,000	100,000,000
Asphalt Inst.	240	3.29	-0.85	7,943	3,945	1,959	973	736	483	240	119	59
TRL - 1	224	4.32	0	3,219	1,889	1,108	650	526	382	224	131	77
NAASRA	225	5.00	0	2,250	1,420	896	565	471	357	225	142	90
TRL - 2 *	201	4.16	0	3,200	1,840	1,058	608	488	350	201	116	66
Shell	201	4.47	-0.375	2,641	1,578	943	563	459	336	201	120	72
Denmark DTU	195	5.62	0	1,513	1,004	667	442	376	294	195	129	86
(Asph. Inst & Shell E' =	**435098 psi)**		Average =>		1,967	1,114	639	514	370	217	128	77
	3000 MPa)											
New ME-PDG	240	3.9492	-1.281	4,429	2,472	1,380	770	611	430	240	134	75

Asphalt Average Fit

Nf	Nf/10^6	log(10) Nf	Avg. Strain	log(10) Strain
100	0.0001	-4.00	1967	3.294
1,000	0.0010	-3.00	1114	3.047
10,000	0.0100	-2.00	639	2.805
25,000	0.0250	-1.60	514	2.711
100,000	0.1000	-1.00	370	2.569
1,000,000	1.0000	0.00	217	2.336
10,000,000	10.0000	1.00	128	2.109
100,000,000	100.0000	2.00	77	1.885

Regression Output:

Constant		2.342205	**219.9 => K avg**
Std Err of Y Est		0.009216	
R Squared		0.999673	
No. of Observations		8	
Degrees of Freedom		6	
X Coefficient(s)	-0.23457281		**4.263 => a avg**
Std Err of Coef.	0.001731892		

Subgrade Vertical Compressive Strain Criteria E = 23,205 psi for Denmark DTU equation

	K	a	b	10	100	1,000	10,000	25,000	100,000	1,000,000	10,000,000	100,000,000
NAASRA *	1230	2.14	0	266,903	91,005	31,029	10,580	6,895	3,607	1,230	419	143
Shell	885	4.00	0	15,738	8,850	4,977	2,799	2,226	1,574	885	498	280
Denmark DTU	750	3.26	1.16	25,633	12,649	6,242	3,080	2,325	1,520	750	370	183
Dorman & Metcalf	658	4.98	0	6,641	4,183	2,634	1,659	1,380	1,045	658	414	261
Nottingham	451	3.57	0	11,343	5,951	3,123	1,638	1,267	860	451	237	124
TRL	453	3.95	0	8,355	4,664	2,604	1,454	1,153	811	453	253	141
Asphalt Inst.	482	4.48	0	6,297	3,766	2,253	1,347	1,098	806	482	288	172
Monismith *	480	4.47	0	6,307	3,768	2,251	1,345	1,096	803	480	287	171
(Denmark E' =	**23205 psi)**		Average =>		6,677	3,639	1,996	1,575	1,103	613	343	194
	160 MPa)											

Subgrade Average Fit

Nf	Nf/10^6	log(10) Nf	Avg. Strain	log(10) Strain
100	0.0001	-4.00	6677	3.825
1,000	0.0010	-3.00	3639	3.561
10,000	0.0100	-2.00	1996	3.300
25,000	0.0250	-1.60	1575	3.197
100,000	0.1000	-1.00	1103	3.042
1,000,000	1.0000	0.00	613	2.788
10,000,000	10.0000	1.00	343	2.536
100,000,000	100.0000	2.00	194	2.287

Regression Output:

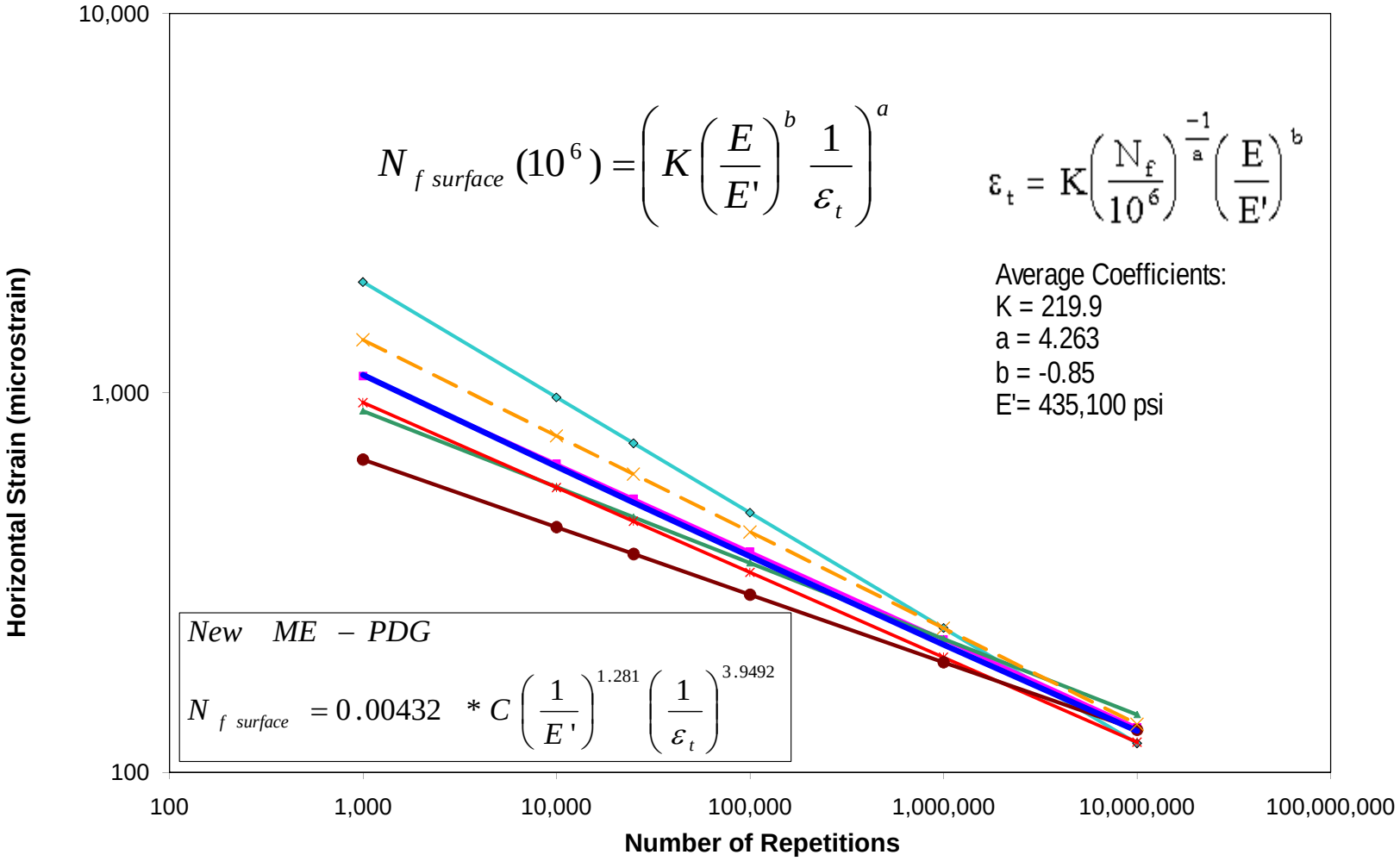
Constant		2.791419	**618.6 => K avg**
Std Err of Y Est		0.005884	
R Squared		0.999888	
No. of Observations		8	
Degrees of Freedom		6	
X Coefficient(s)	-0.256201536		**3.903 => a avg**
Std Err of Coef.	0.001105681		

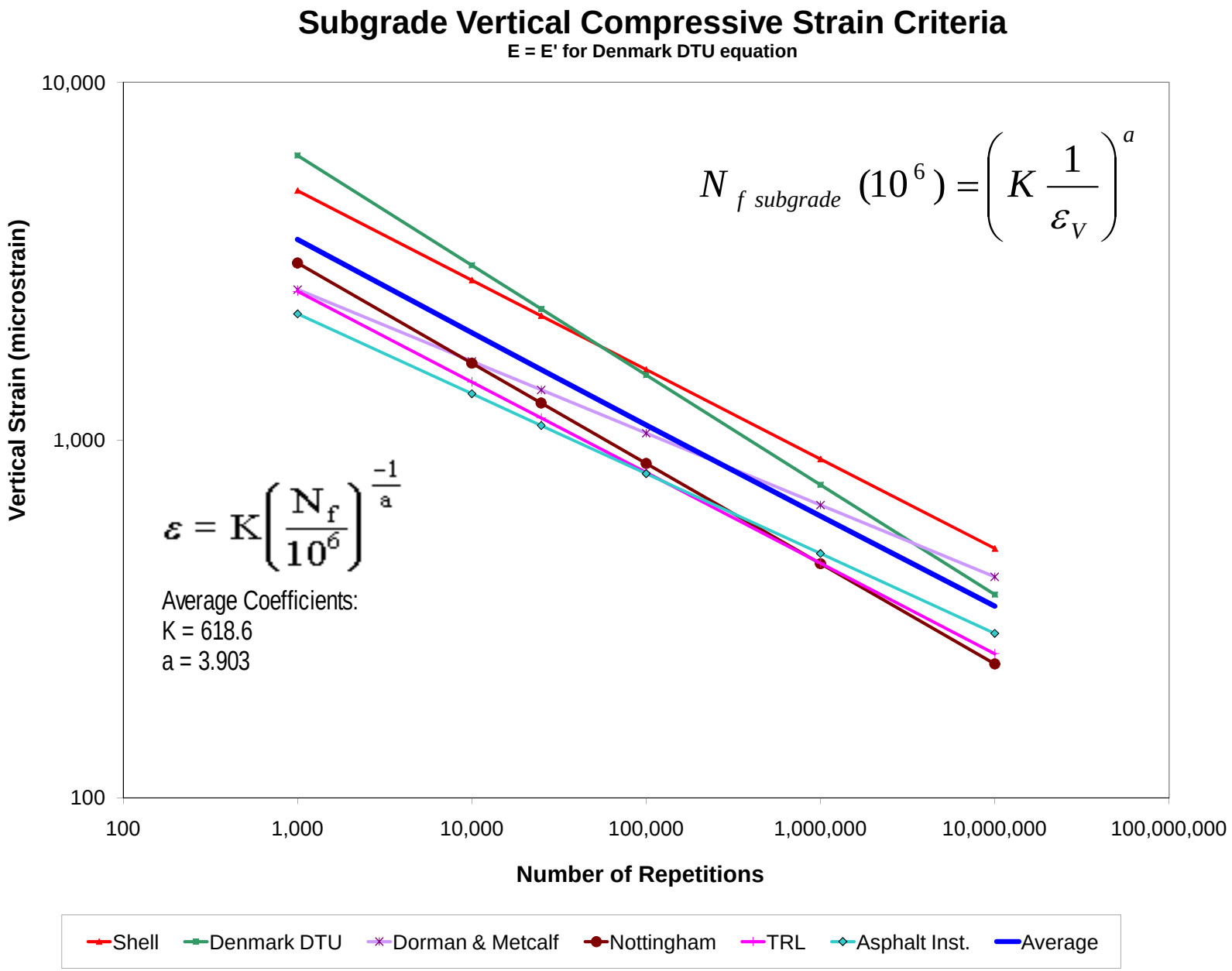
Equation Solver --- (Red = input, Blue = output)

Asphalt Strain, ustrain	Modulus, psi	Nf	Subgrade Strain, ustrain	Nf
38.16	4,000,000	563,933	150	252,194,184

Asphalt Horizontal Tensile Strain Criteria

E = E' for Asphalt Inst. and Shell equations




Subgrade Vertical Compressive Strain Criteria
E = E' for Denmark DTU equation
10,000
1,000
100
Vertical Strain (microstrain)
100
1,000
10,000
100,000
1,000,000
10,000,000
100,000,000
Number of Repetitions
$N_{f\ subgrade}\ (10^6) = \left(K \frac{1}{\varepsilon_V} \right)^a$
$\varepsilon = K\left(\frac{N_f}{10^6}\right)^{\frac{-1}{a}}$
Average Coefficients:
K = 618.6
a = 3.903
Shell
Denman DTU
Dorman & Metcalf
Nottingham
TRL
Asphalt Inst.
Average