Probabilistic Aspects of Fatigue

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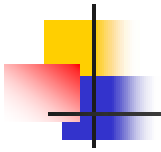

Probabilistic Aspects of Fatigue

- Introduction
- Basic Probability and Statistics
- Statistical Techniques
- Analysis Methods
- Characterizing Variability
- Case Studies
- **FatigueCalculator.com**
- GlyphWorks

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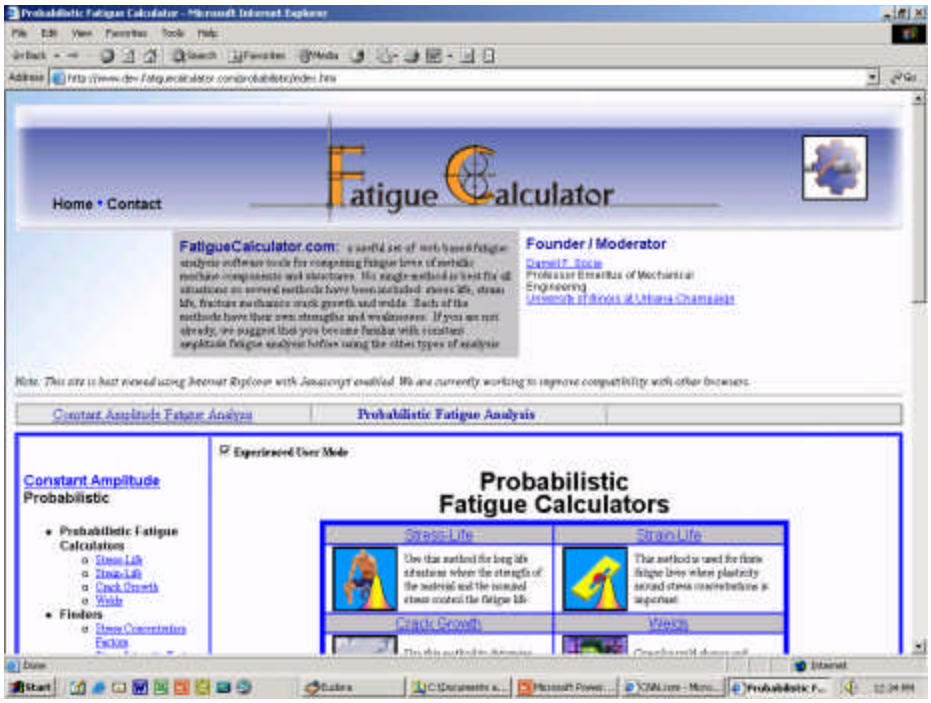
Probabilistic Fatigue Analysis

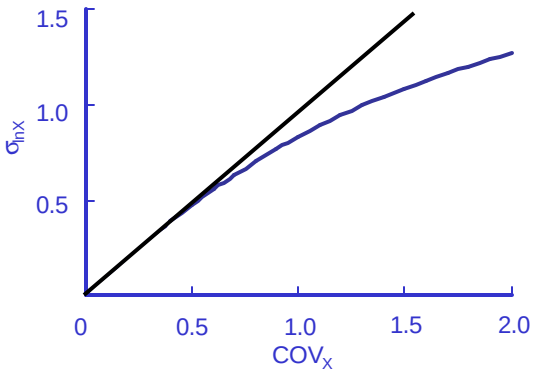


Modeling Variability

Central Limit Theorem:

Products: $Z = X_1 \bullet X_2 \bullet X_3 \bullet X_4 \bullet \ldots\ldots X_n$

$Z \rightarrow$ LogNormal as n increases



$\sigma_{lnX} \sim COV_X$

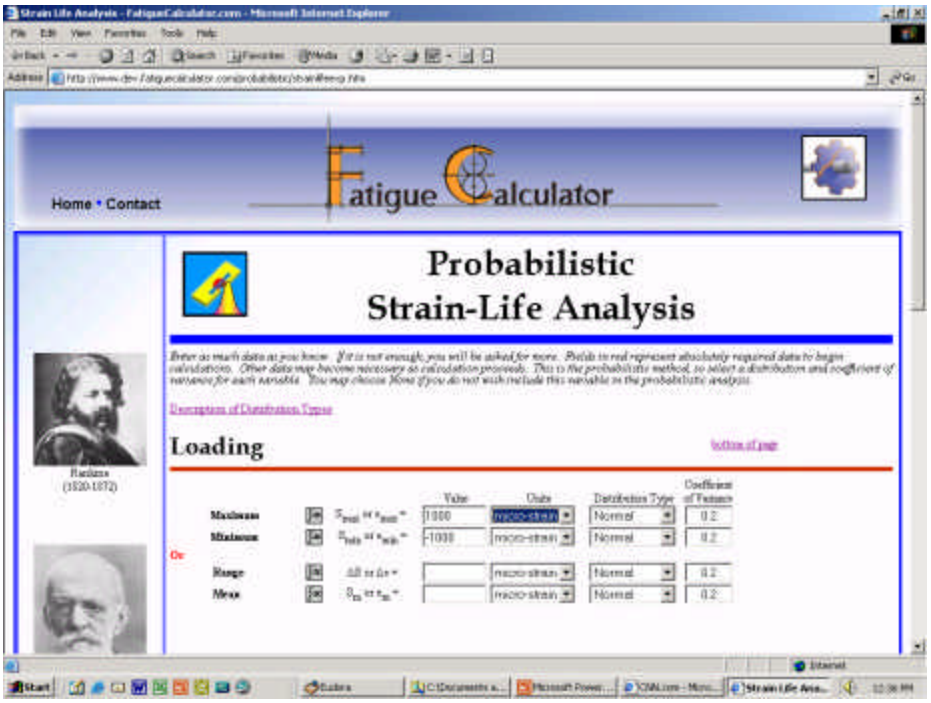
COV_X is a good measure of variability

COV and LogNormal Distributions

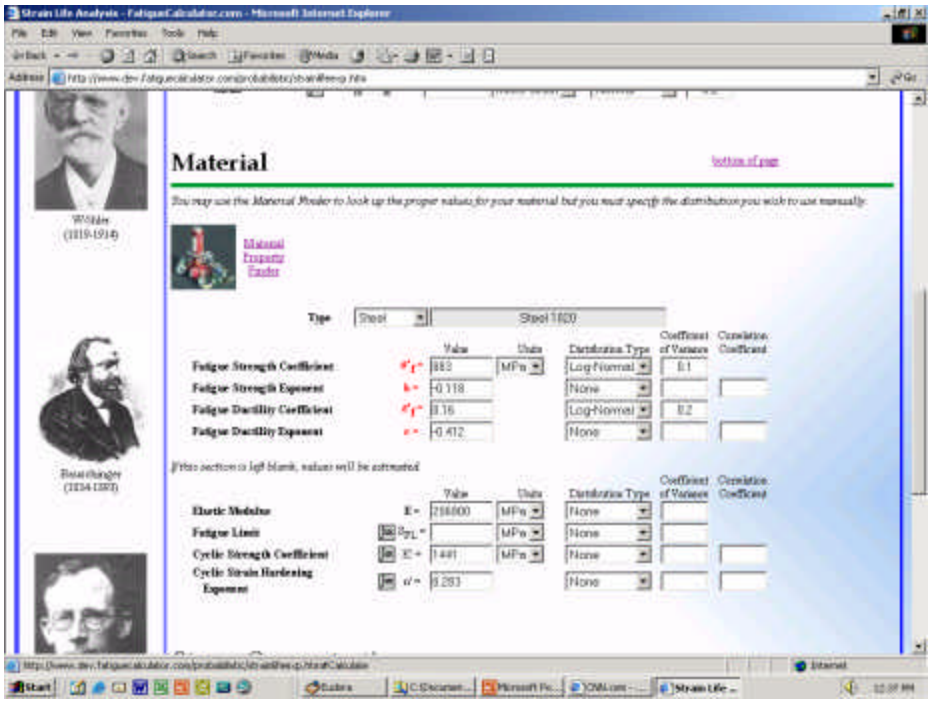
COV_X	Standard Deviation, lnx		
	1 68.3%	2 95.4%	3 99.7%
0.05	1.05	1.11	1.16
0.1	1.10	1.23	1.33
0.25	1.28	1.66	2.04
0.5	1.60	2.64	3.92
1	2.30	5.53	11.1

99.7% of the data is within a factor of $\pm$ 1.33 of the mean for a COV = 0.1

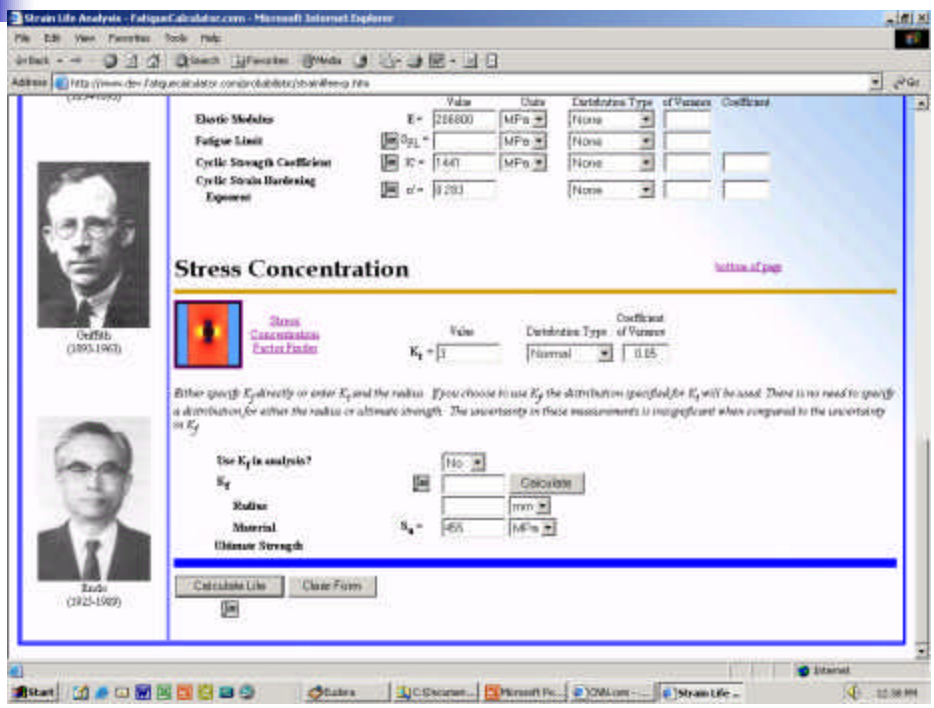
Strain Life Analysis



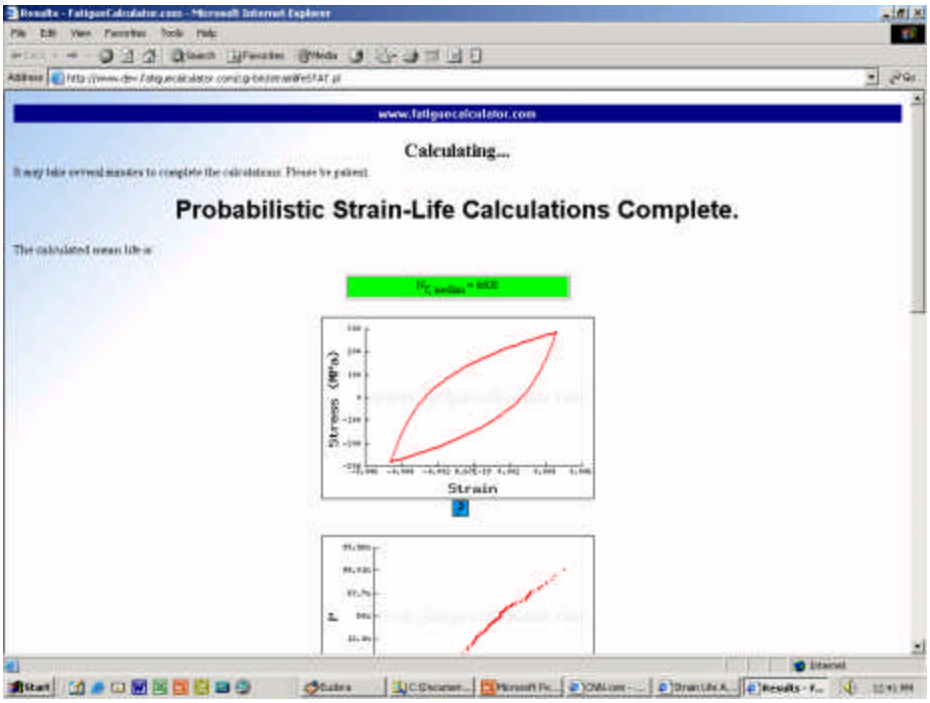
Material Properties



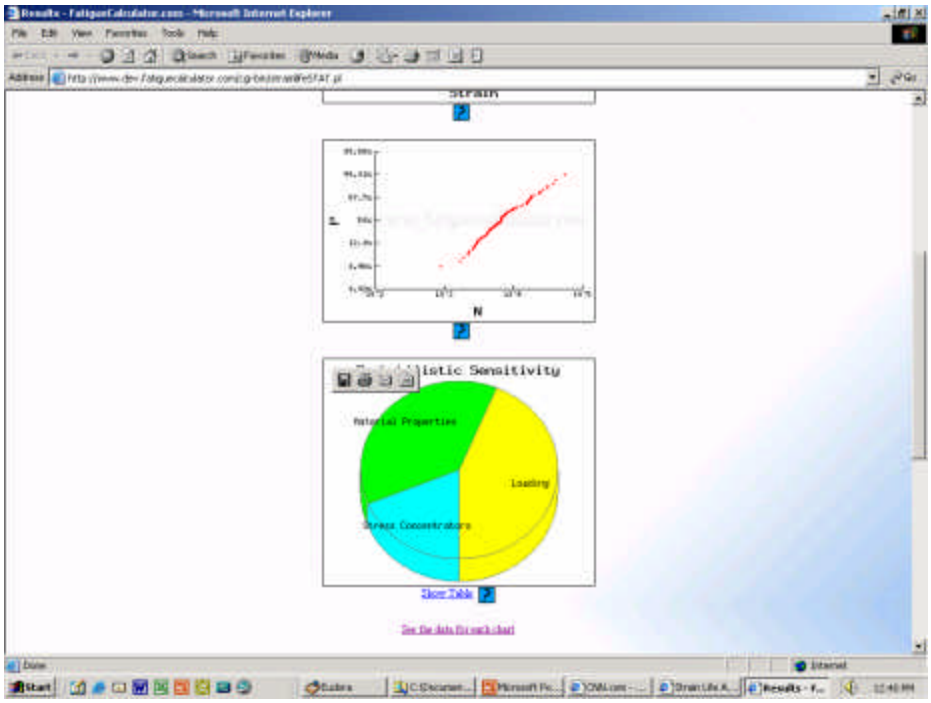
Stress Concentration



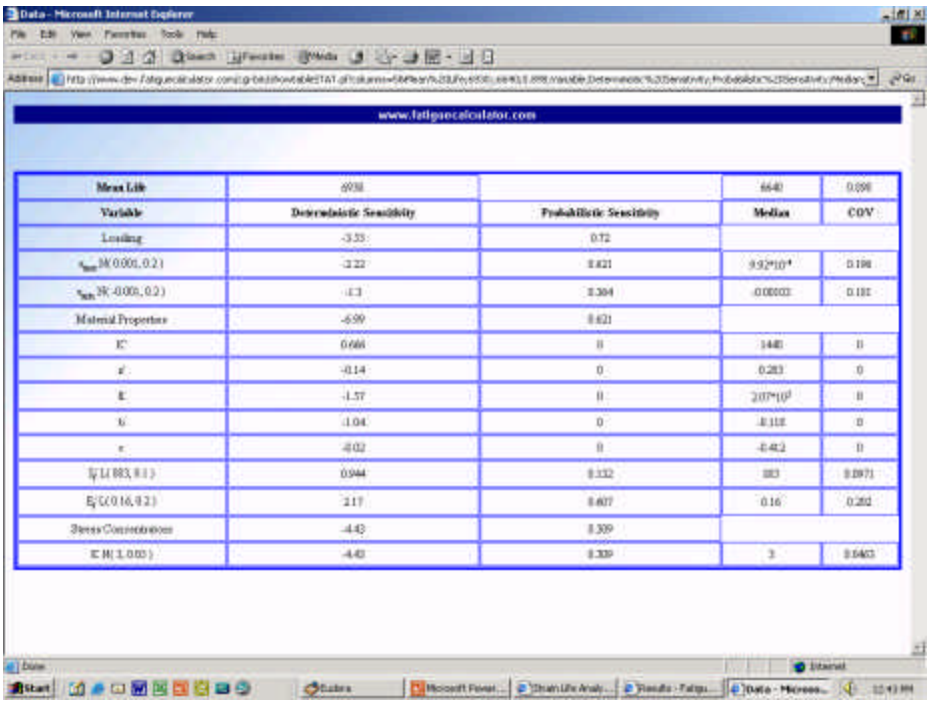
Results



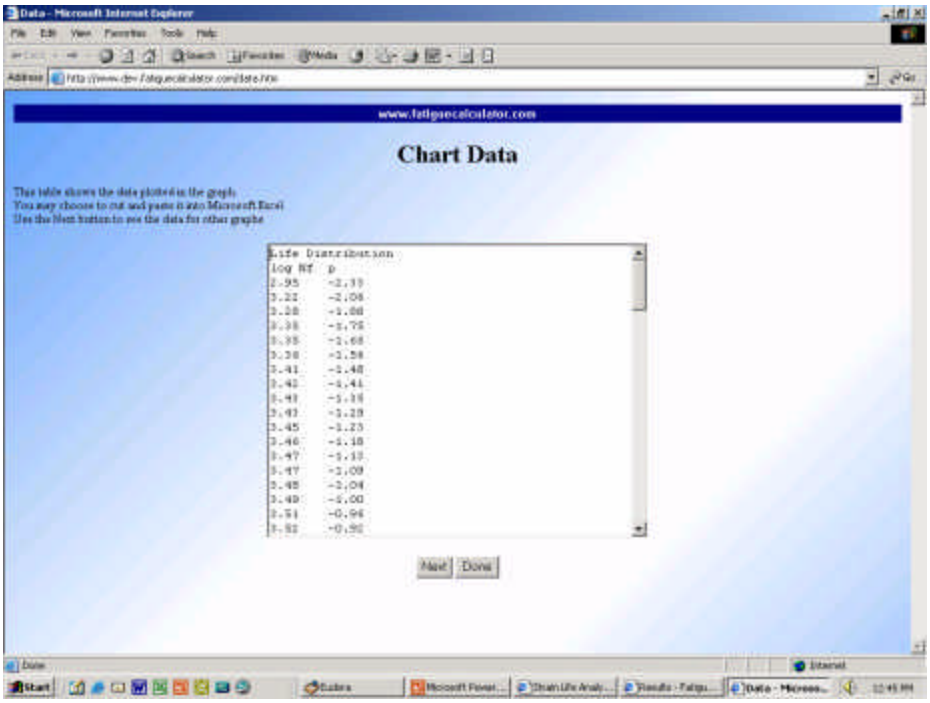
Results (continued)



Results (continued)



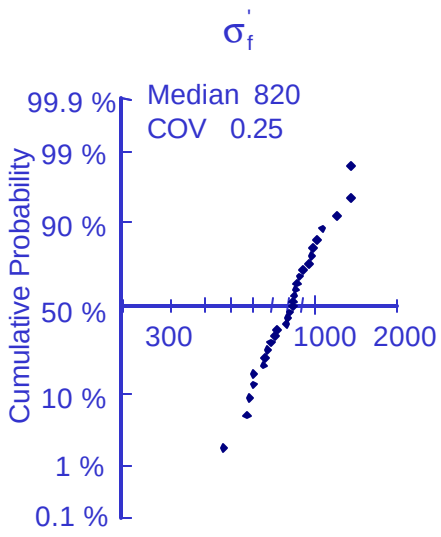
Results (continued)

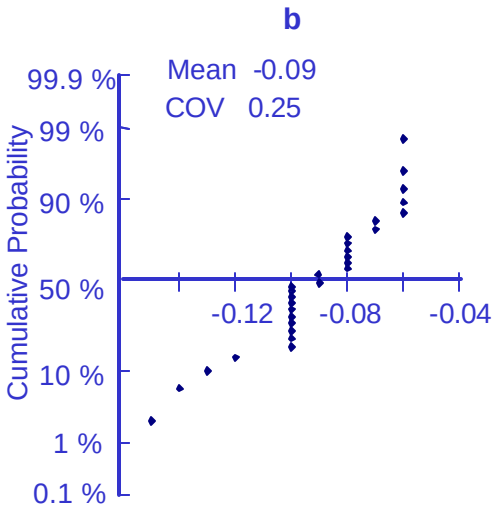


Ten Simulations

	Life	COV
	6470	0.959
	6930	0.898
	6710	0.688
	6640	0.908
	6580	0.869
	6470	0.959
	7010	0.723
	6690	0.908
	6170	0.791
	6560	0.971
Mean	6623	0.8674
COV	0.038	0.114

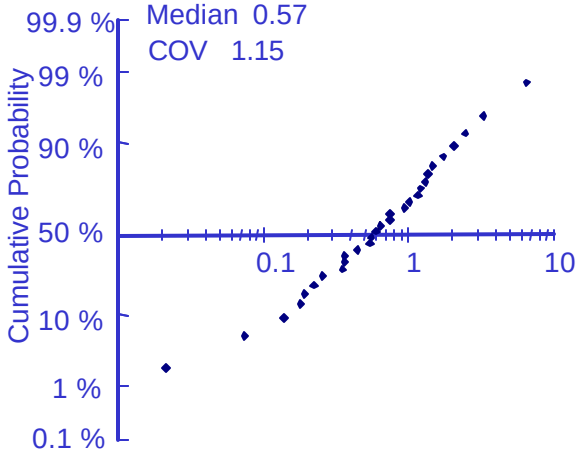
29 Individual Data Sets



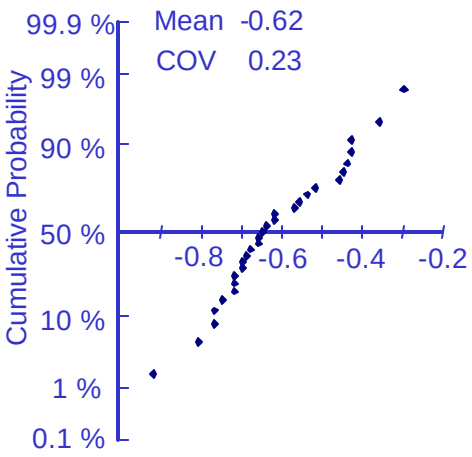


29 Individual Data Sets (continued)

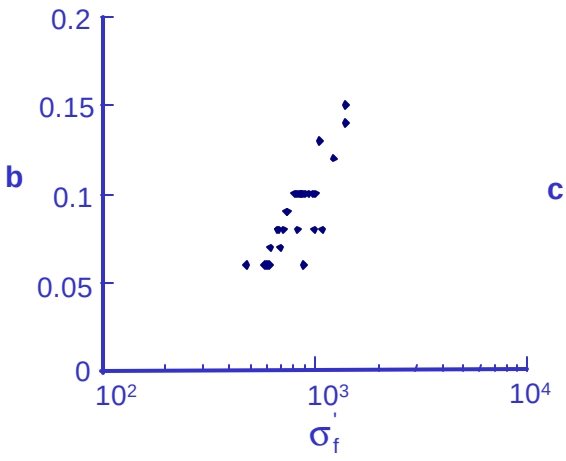
ε_f'



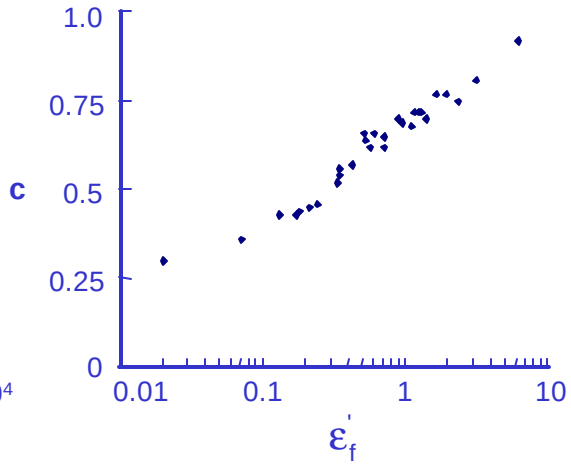
c



Correlation

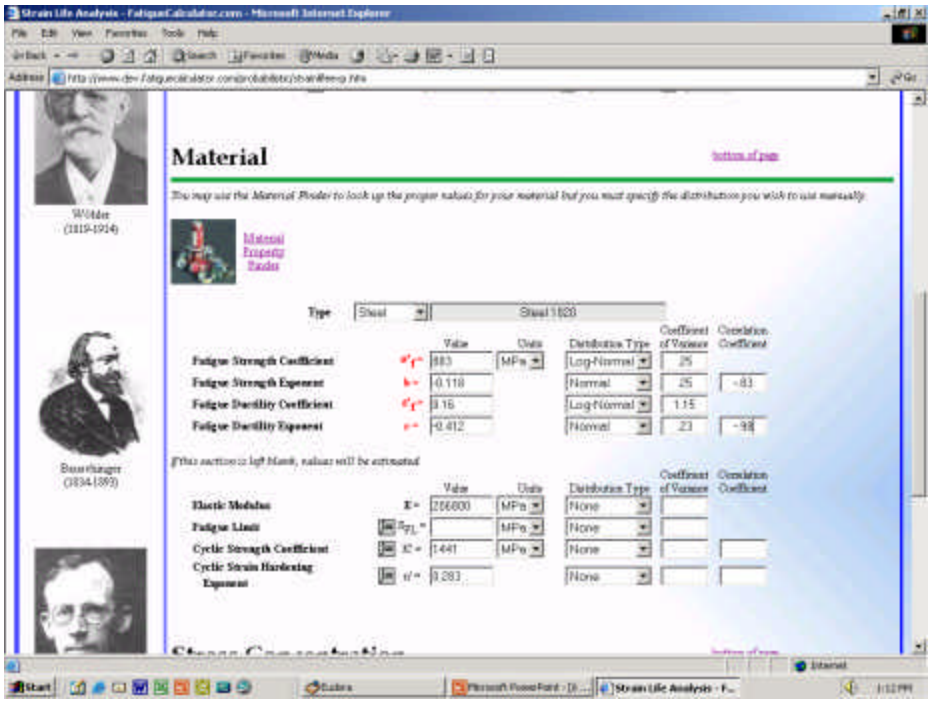


ρ = -0.828

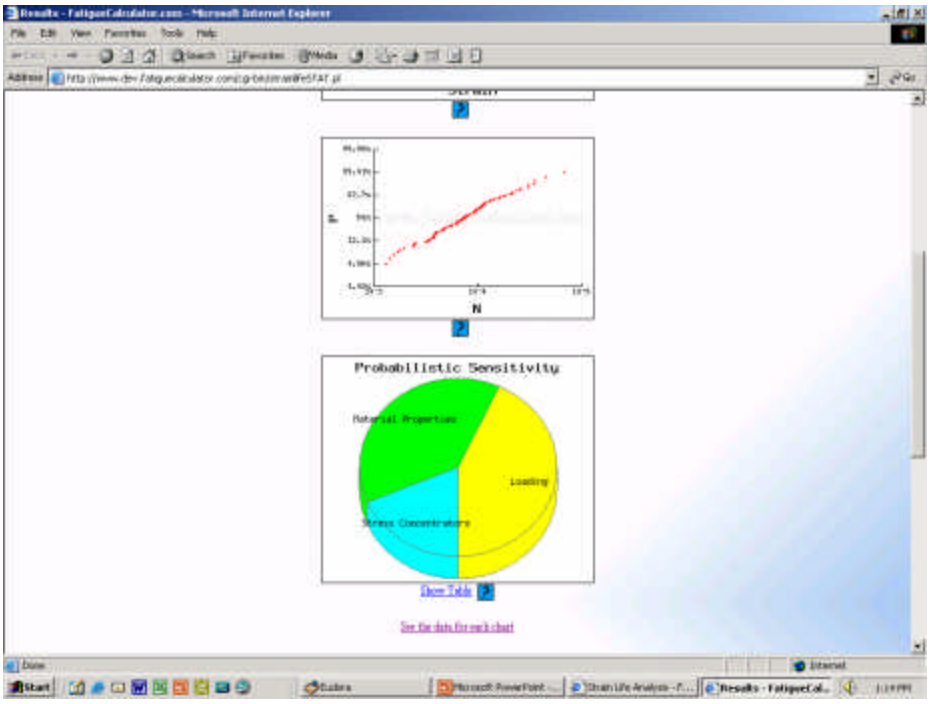


ρ = -0.976

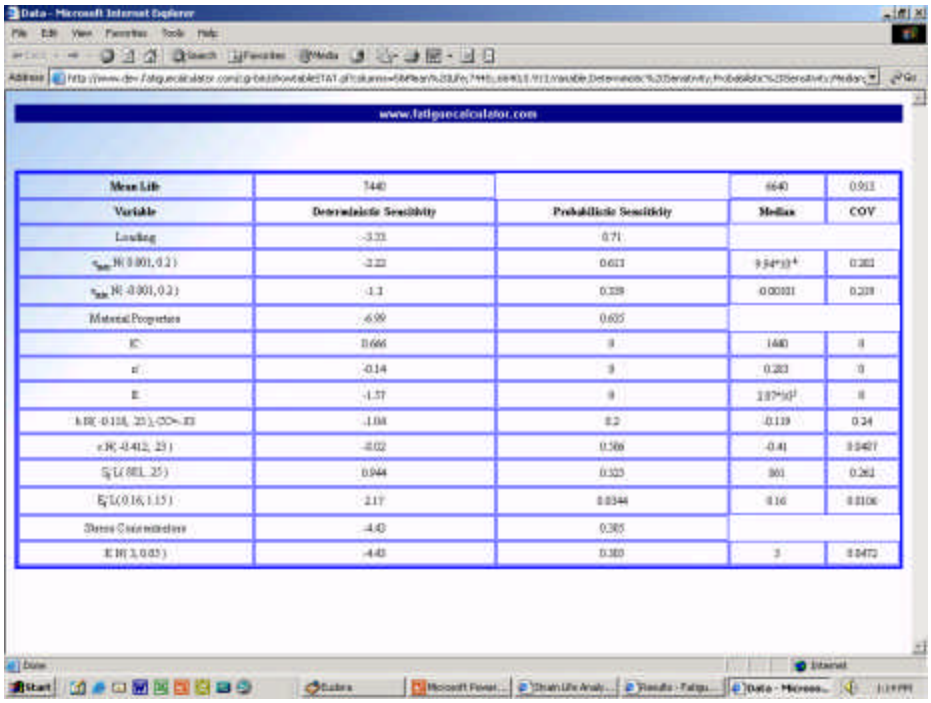
Correlated Variables



Results (continued)

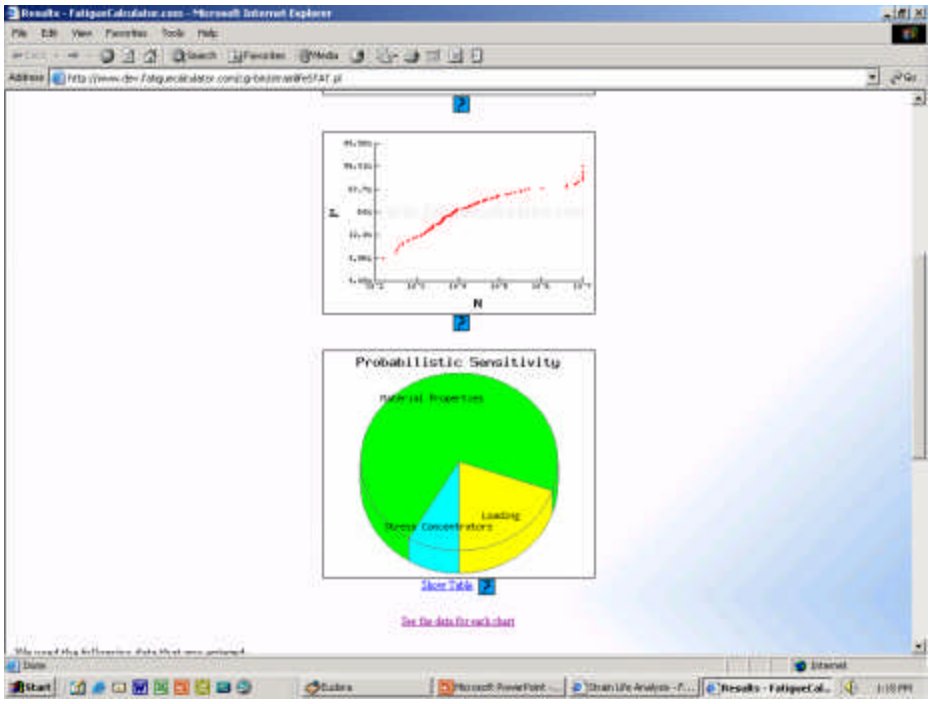


Results (continued)

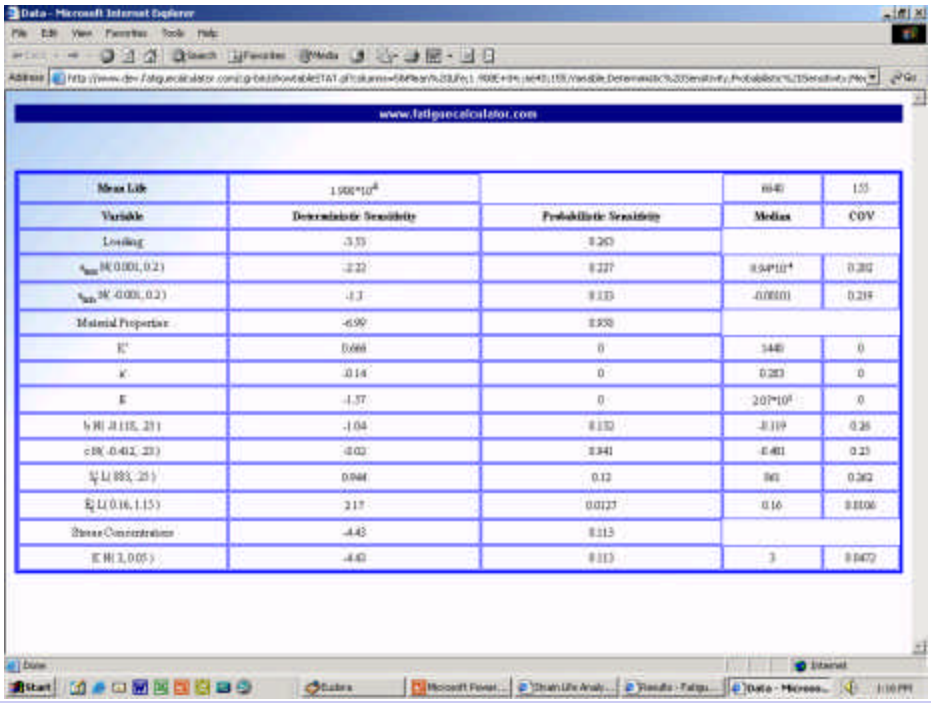


Mean Life	7440		6640	0.913
Variable	Deterministic Sensitivity	Probabilistic Sensitivity	Median	COV
Loading	-3.33	0.71		
σ_{app} N(0.001, 0.2)	-2.22	0.613		
σ_{app} N(-0.001, 0.2)	-1.1	0.339		
Material Properties	-6.99	0.605		
K'	0.666	0	1440	0
n'	-0.14	0	0.203	0
E	-1.57	0		0
b N(-0.118, .25), COV=.33	-1.04	0.2	-0.119	0.24
ε_f' N(-0.412, .25)	-0.02	0.586	-0.41	0.0427
σ_f' LN(883, .25)	0.944	0.323	901	0.262
ε_f' LN(0.16, 1.15)	2.17	0.0344	0.16	0.0106
Stress Concentration	-4.43	0.385		
K_t N(3, 0.03)	-4.43	0.385	3	0.0472

Uncorrelated Variables



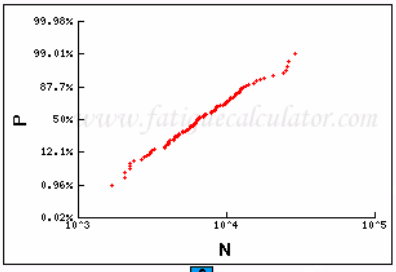
Results (continued)

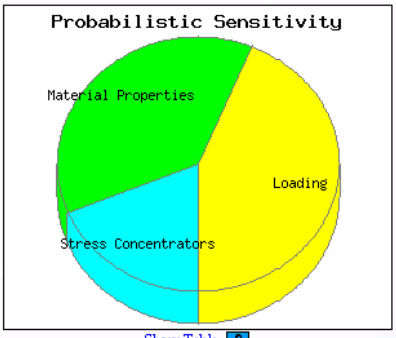


Mean Life	$1.908*10^6$		6640	155
Variable	**Deterministic Sensitivity**	**Probabilistic Sensitivity**	**Median**	**COV**
Loading	-3.55	0.265		
σ_{max} N(0.001, 0.2)	-2.22	0.227	$6.64*10^4$	0.202
σ_{min} N(-0.001, 0.2)	-1.3	0.133	-0.00101	0.219
Material Properties	-6.99	0.959		
E'	0.666	0	1440	0
ν	-0.14	0	0.283	0
E	-1.57	0	$2.07*10^5$	0
b_0 N(-0.115, .25)	-1.04	0.152	-0.119	0.26
c N(-0.412, .25)	-0.02	0.341	-0.481	0.25
σ_f' LN(893, .25)	0.948	0.12	861	0.262
ε_f' LN(0.16, 1.15)	2.17	0.0127	0.16	0.0106
Stress Concentration	-4.43	0.113		
K_t N(3, 0.05)	-4.43	0.113	3	0.0472

Strain Amplitude

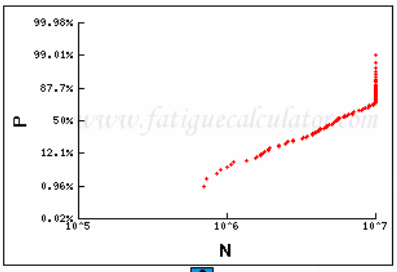
± 1000

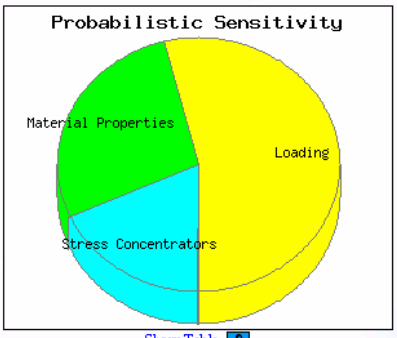




Show Table

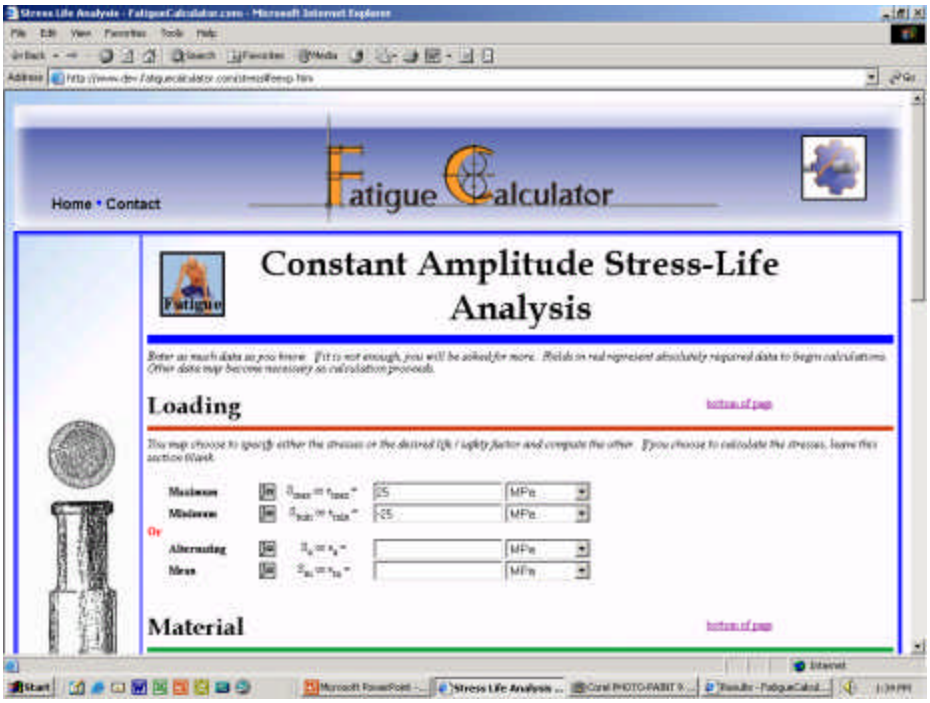
± 250



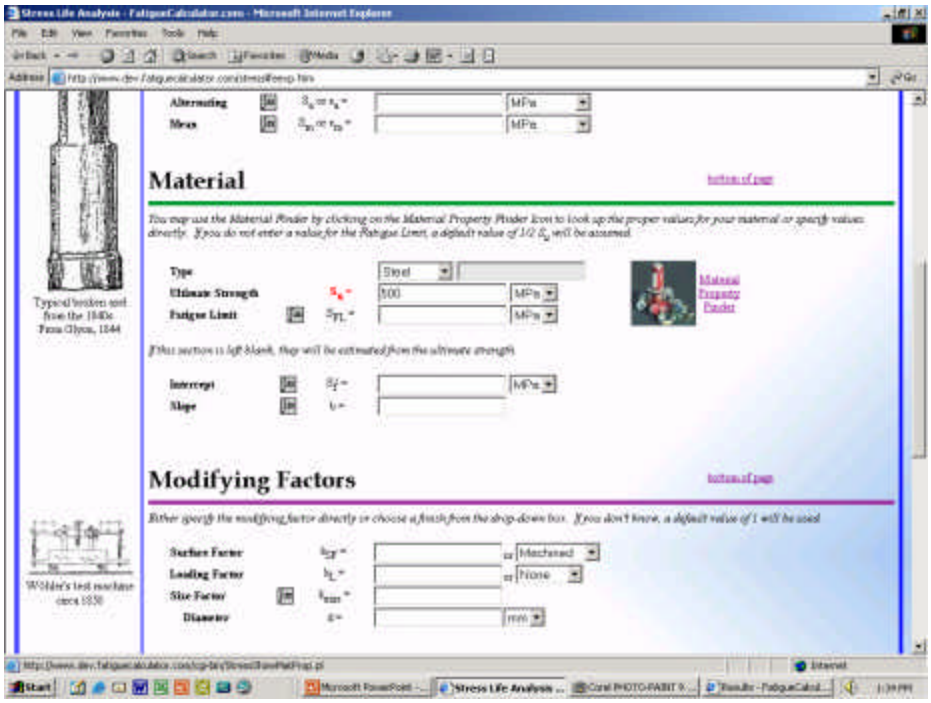


Show Table

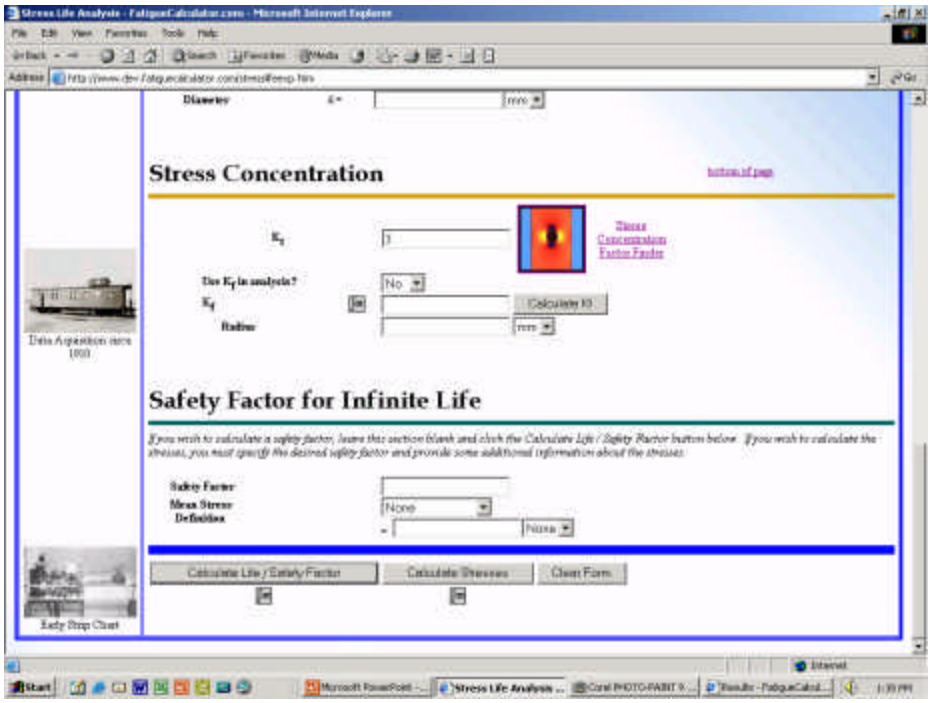
Deterministic Analysis



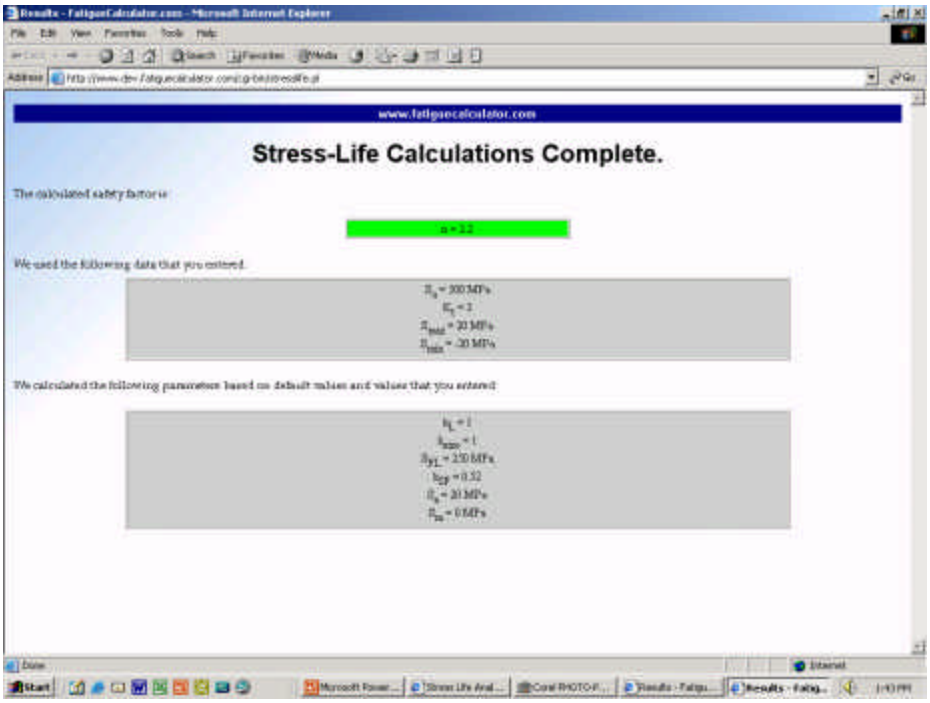
Deterministic Analysis (continued)



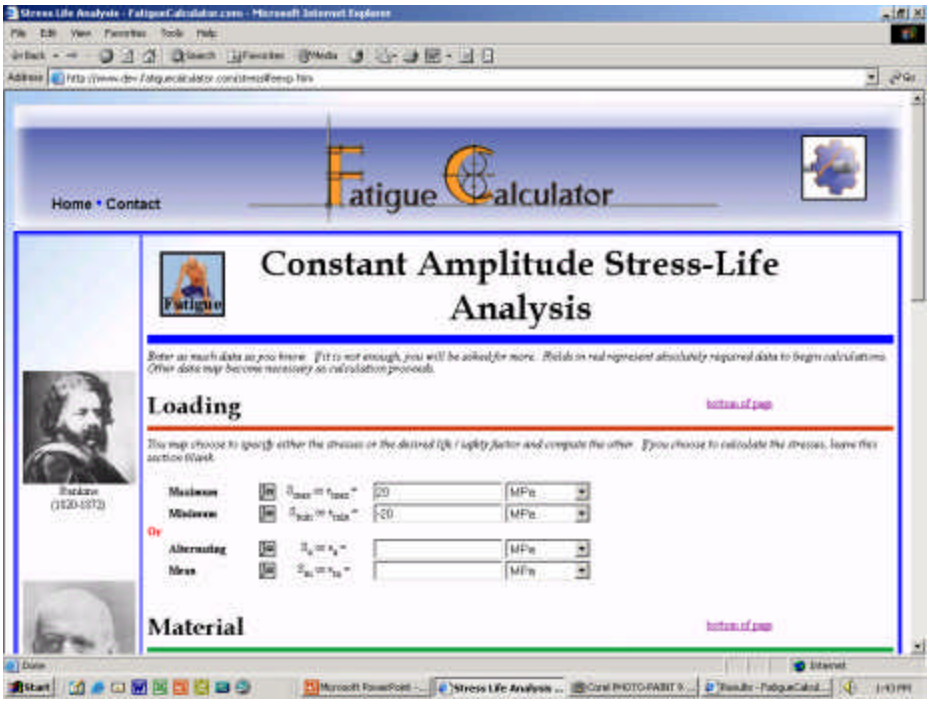
Deterministic Analysis (continued)



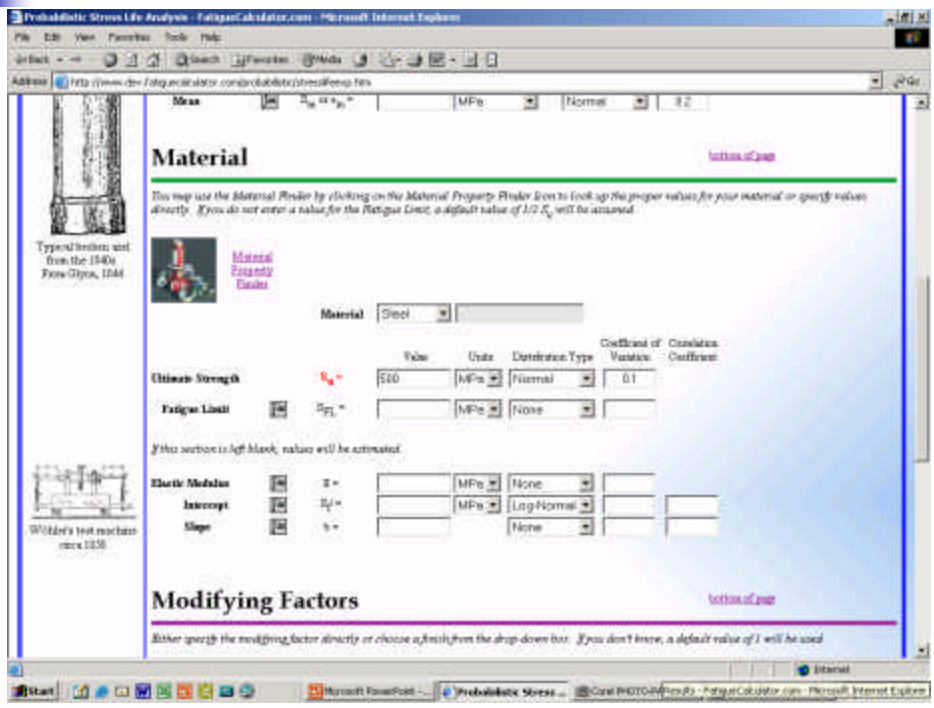
Deterministic Analysis Results



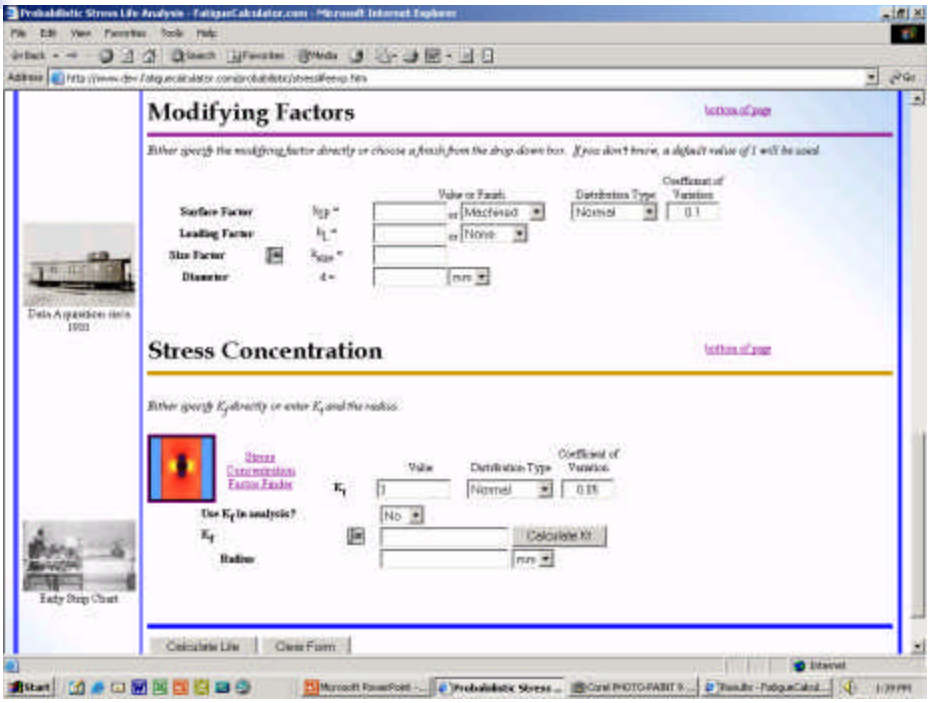
Probabilistic Analysis



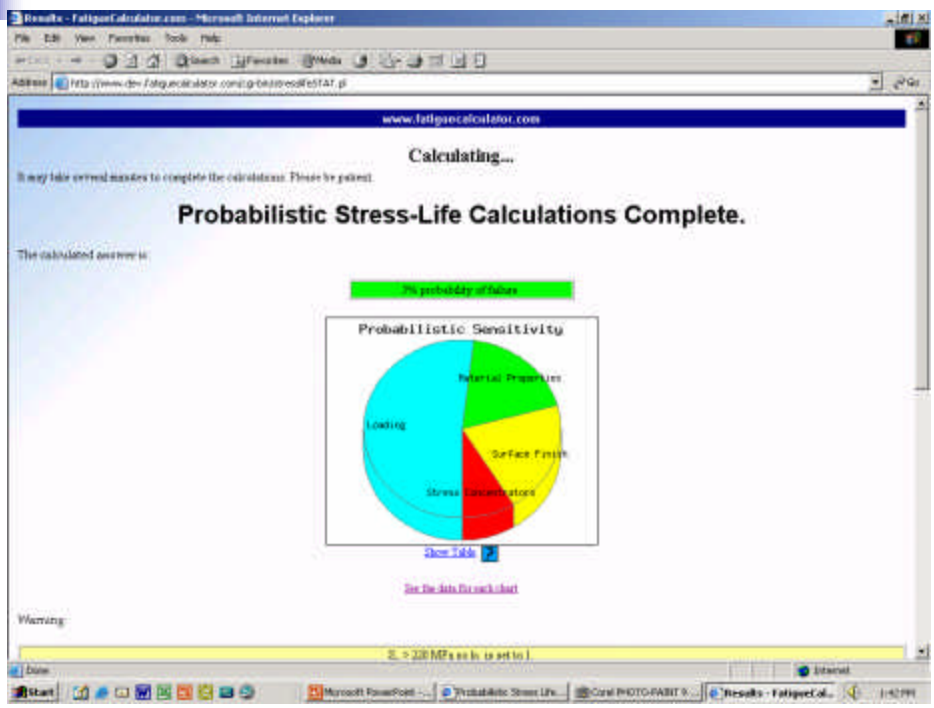
Probabilistic Analysis (continued)



Probabilistic Analysis (continued)



Probabilistic Analysis Results



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