Steel $S_{10^6} = 60\,ksi$, $S_{10^3} = 140\,kpsi$] corrected for C_L C_D C_S etc.,

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LOADING

Typical Block [5 cycles @ 80 ksi; 2 @ 90 ksi; 1 @ 100 ksi] ← 20 seconds

PREDICT life

$$\log_{10} S_f = b \log_{10} N + \log_{10}(a) \quad (*)$$

$$\log_{10}(140) = 3b + \log_{10} a$$

$$\log_{10}(60) = 6b + \log_{10} a$$

because $\log_{10} 10^3 = 3$

$$3b = \log_{10}(60) - \log_{10}(140)$$

$$\Rightarrow b = -0.123$$

$$\log_{10}(a) = \log_{10}(60) - 6b = 2.5414$$

find life @ each stress level.

Rearrange (*)

$$\log_{10} N = \frac{\log_{10}(S_f) - \log_{10}(a)}{b}$$

$$\Leftrightarrow N = 10^{\left(\frac{\log_{10} S_f - \log_{10} a}{b}\right)}$$

We know $\log_{10}(a)$, b, S_f

$S_f = 80$ ksi $\Rightarrow$ 9.58×10^4 cycles (5)

90 $\Rightarrow$ 3.67×10^4 cycles (2)

100 $\Rightarrow$ 1.55×10^4 cycles (1)

fraction of life "used up" in one block:

$$\sum \frac{n_i}{N_i} = \frac{5}{9.58 \times 10^4} + \frac{2}{3.67 \times 10^4} + \frac{1}{1.55 \times 10^4}$$

$$= 0.0001712$$

How many blocks to failure?

$$\frac{1}{0.0001712} \approx 5800$$

$$\text{lifetime} = \frac{(5800)(20 \text{ seconds})}{(60)(60)} \approx 32.5 \text{ hours.}$$

N.3.

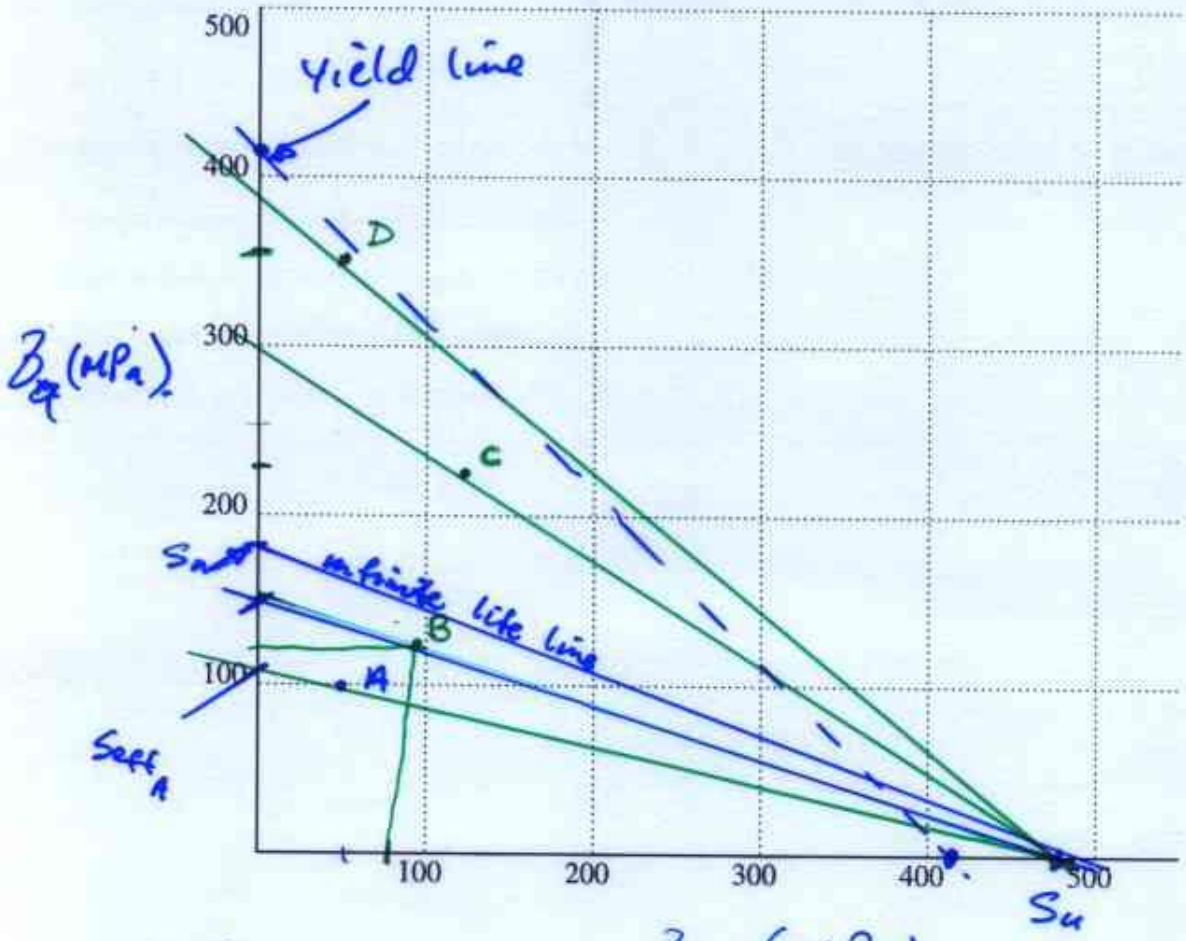
10 Sample Problem

A critical notch is subject to varying nonsteady loading. A typical 6 second period includes the following loading condition

- 2 cycles at $\sigma_a = 100MPa$ and $\sigma_m = 50MPa$
- 4 cycles at $\sigma_a = 125MPa$ and $\sigma_m = 75MPa$
- 2 cycles at $\sigma_a = 225MPa$ and $\sigma_m = 125MPa$
- 1 cycle at $\sigma_a = 350MPa$ and $\sigma_m = 50MPa$

The part is made from aluminium, and has the following properties: $S_u = 480$MPa, $S_y = 410$MPa. Correcting for geometry, surface, etc., the fatigue properties of the notch are: $S_{10^3} = 450$MPa, $S_{10^6} = 180$MPa.

Calculate the expected life of the component.



	σ_{eff}
A	100 MPa
B	150 MPa
C	300 MPa
D	390 MPa

use these to find N (lifetime).

$$\log_{10}(S_f) = b \log_{10}(N) + \log_{10}(a)$$

$$\left.\begin{aligned} \log_{10}(450) &= 86 + \log_{10}(a) \\ \log_{10}(180) &= 66 + \log_{10}(a) \end{aligned}\right\} \text{Solve}$$

$b = -0.13265$ $\quad \log_{10}(a) = 3.0512$

$$N = 10^{\left(\frac{\log_{10}(S_f) - 3.0512}{-0.13265}\right)}$$

Subst in 110, 150, 300, 390 for S_f

$N \rightarrow$ 4×10^7 | 4×10^6 | 2.13×10^4 | 2.943×10^3

4×10^7: ∞ ; 4×10^6: sorting ∞

1 block $\quad \frac{4}{4\times10^6} + \frac{2}{2.127\times10^4} + \frac{1}{2.943\times10^3} = \sum \frac{n_i}{N_i}$

$\frac{4}{4\times10^6}$: not important here

$\sum \frac{n_i}{N_i} = 0.000435 \Rightarrow \frac{1}{0.000435}$ blocks to failure

≈ 2299 blocks $\quad$ 6 seconds per block

$\frac{(2299)(6)}{(60)(60)} = \sim 3.8$ hours