

Steel

$$S_{10^6} = 60 \text{ ksi}$$

$$S_{10^3} = 140 \text{ ksi}$$

corrected for  
 $C_L$   $C_D$   $C_S$   
 etc.,

## LOADING

Typical Block:  $\left[ \begin{array}{l} 5 \text{ cycles @ } 80 \text{ ksi} \\ 2 \text{ @ } 90 \text{ ksi} \\ 1 \text{ @ } 100 \text{ ksi} \end{array} \right] \leftarrow \underline{20 \text{ seconds}}$

predict life

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

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

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

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

$$\Rightarrow \underline{b} = \underline{-0.123}$$

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

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

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  $\log_{10} a$ ,  $b$ ,  $S_f$

$$S_f = 80 \text{ ksi} \Rightarrow 9.58 \times 10^4 \text{ cycles} \quad (5)$$

$$90 \Rightarrow 3.67 \times 10^4 \text{ cycles} \quad (2)$$

$$100 \Rightarrow 1.55 \times 10^4 \text{ cycles} \quad (1)$$

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?

$$\frac{1}{0.0001712} \approx 5800 \quad \text{N.B.}$$

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

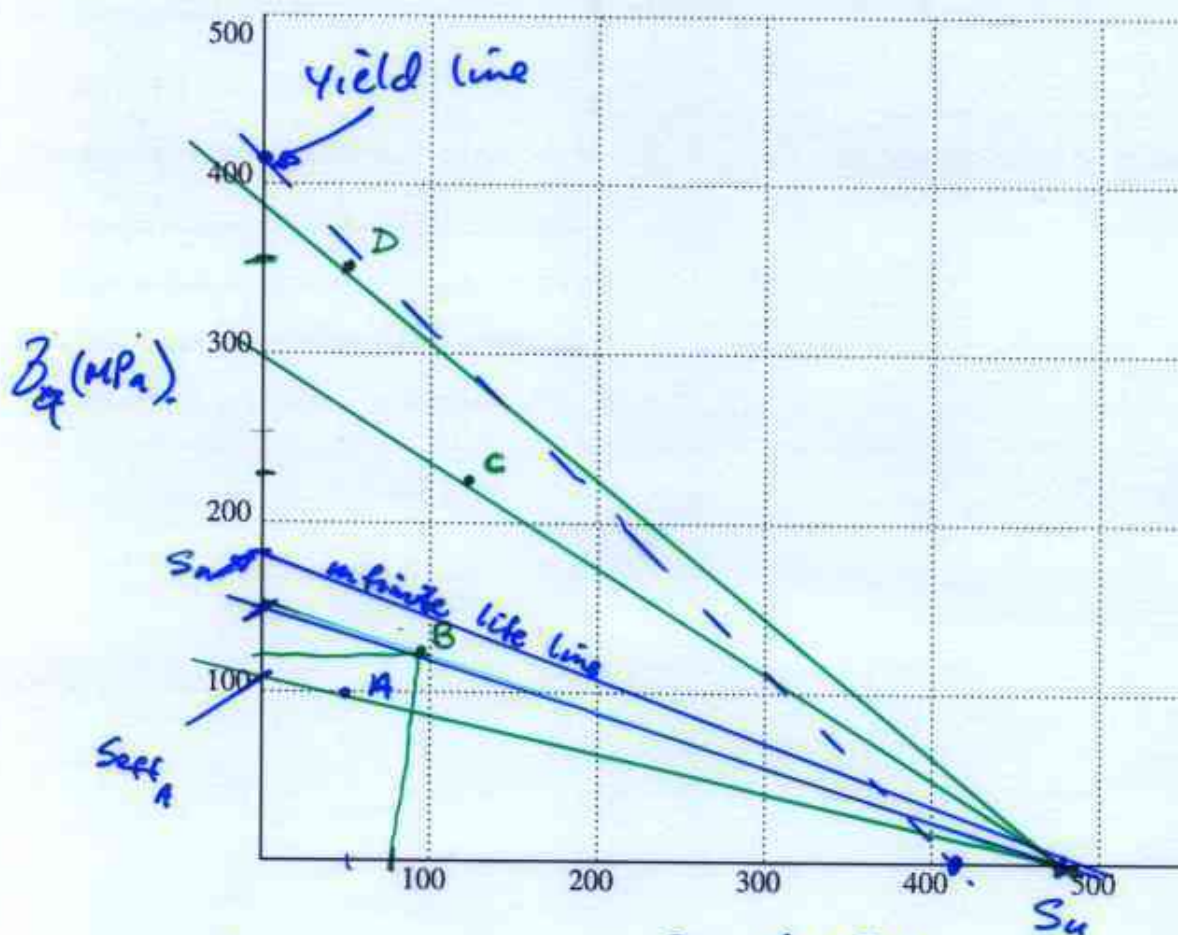
### 10 Sample Problem

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

- A • 2 cycles at  $\sigma_a = 100\text{MPa}$  and  $\sigma_m = 50\text{MPa}$
- B • 4 cycles at  $\sigma_a = 125\text{MPa}$  and  $\sigma_m = 75\text{MPa}$
- C • 2 cycles at  $\sigma_a = 225\text{MPa}$  and  $\sigma_m = 125\text{MPa}$
- D • 1 cycle at  $\sigma_a = 350\text{MPa}$  and  $\sigma_m = 50\text{MPa}$

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

Calculate the expected life of the component.



	$S_{eff}$	
A	100 MPa	} use these to find N (lifetime).
B	150 MPa	
C	300 MPa	
D	390 MPa	

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

$$\left. \begin{array}{l} \log_{10}(450) = 3b + \log_{10}(a) \\ \log_{10}(180) = 6b + \log_{10}(a) \end{array} \right\} \text{Solve}$$

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

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

Subst in  $\left| 110, \right| 150 \left| , 300 \left| , 390 \right|$  for Sf

$N \rightarrow \left| 4 \times 10^7 \right| 4 \times 10^6 \left| 2.13 \times 10^4 \right| 2.943 \times 10^3 \left| \right.$

$\infty \downarrow$   $\infty$  sortg

1 block  $\frac{4}{4 \times 10^6} + \frac{2}{2.127 \times 10^4} + \frac{1}{2.943 \times 10^3} = \sum \frac{n_i}{N_i}$

not important here

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

$$\approx 2299 \text{ blocks} \quad 6 \text{ seconds per block}$$

$$\frac{(2299)(6)}{(60)(60)} = \underline{\underline{\approx 3.8 \text{ hours}}}$$