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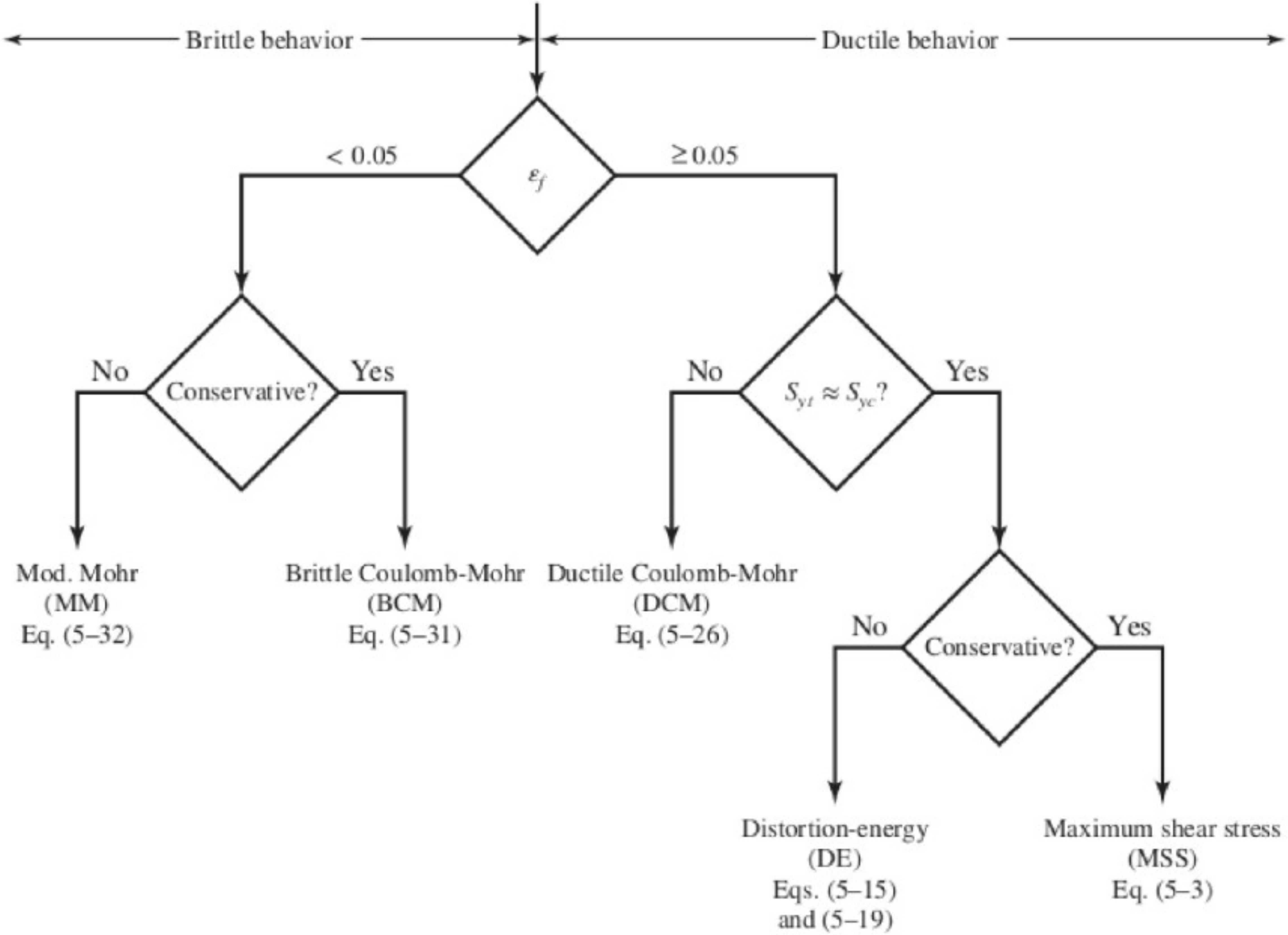

Brittle behavior
Ductile behavior
ε_f
< 0.05
≥ 0.05
Conservative?
No
Yes
$S_{yt} \approx S_{yc}$?
No
Yes
Mod. Mohr (MM) Eq. (5–32)
Brittle Coulomb-Mohr (BCM) Eq. (5–31)
Ductile Coulomb-Mohr (DCM) Eq. (5–26)
Conservative?
No
Yes
Distortion-energy (DE) Eqs. (5–15) and (5–19)
Maximum shear stress (MSS) Eq. (5–3)

A ductile hot-rolled steel bar has a minimum yield strength in tension and compression of 350 MPa. Using the distortion-energy and maximum-shear-stress theories determine the factors of safety for the following plane stress states:

(a) $\sigma_x = 100$ MPa, $\sigma_y = 100$ MPa $\quad \sigma_z = 0$

(b) $\sigma_x = 100$ MPa, $\sigma_y = 50$ MPa

$S_y = 350$ MPa

$\sigma_1 - \sigma_3 \geq S_y$

$\sigma_1 - \sigma_3 = \frac{S_y}{N}$

$100 - 0 = \frac{350}{N} \Rightarrow N = \frac{350}{100} = \boxed{3.5}$ MSS

$$\frac{S_y}{N} = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2}} \geq S_y$$

$$\sqrt{\frac{(100-100)^2 + (100-0)^2 + (100-0)^2}{2}} = \sqrt{\frac{10000 + 10000}{2}} = 100$$

$\frac{S_y}{N} = 100$

$N = \frac{350}{100} = \boxed{3.5}$

DE

A brittle material has the properties $S_{ut} = 30$ kpsi and $S_{uc} = 90$ kpsi. Using the brittle Coulomb-Mohr and modified-Mohr theories, determine the factor of safety for the following states of plane stress.

(a) $\sigma_x = 25$ kpsi, $\sigma_y = 15$ kpsi $\quad \sigma_z = 0$

(b) $\sigma_x = 15$ kpsi, $\sigma_y = -15$ kpsi

$\sigma_A = \frac{S_{ut}}{N}$

BCM MM

$25 = \frac{30}{N} \Rightarrow N = \frac{30}{25} = \boxed{1.2}$

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A ductile hot-rolled steel bar has a minimum yield strength in tension and compression of 350 MPa. Using the distortion-energy and maximum-shear-stress theories determine the factors of safety for the following plane stress states:

(*a*) $\sigma_x = 100$ MPa, $\sigma_y = 100$ MPa

(*b*) $\sigma_x = 100$ MPa, $\sigma_y = 50$ MPa

A brittle material has the properties $S_{ut} = 30$ kpsi and $S_{uc} = 90$ kpsi. Using the brittle Coulomb-Mohr and modified-Mohr theories, determine the factor of safety for the following states of plane stress.

MM: Pg 264

(*a*) $\sigma_x = 25$ kpsi, $\sigma_y = 15$ kpsi

(*b*) $\sigma_x = 15$ kpsi, $\sigma_y = -15$ kpsi

A ductile hot-rolled steel bar has a minimum yield strength in tension and compression of 350 MPa. Using the distortion-energy and maximum-shear-stress theories determine the factors of safety for the following plane stress states:

(a) $\sigma_x = 100$ MPa, $\sigma_y = 100$ MPa

(b) $\sigma_x = 100$ MPa, $\sigma_y = 50$ MPa $\quad \sigma_z = 0 \quad \sigma_1 = 100$ MPa $\quad \sigma_2 = 50$ MPa $\quad \sigma_3 = 0$

$$\frac{S_y}{N} = \sigma_1 - \sigma_3 \qquad \frac{350 \text{ MPa}}{N} = 100 \text{ MPa} \quad \Rightarrow \quad \frac{350}{100} = N = \boxed{3.5} \quad \text{MSS}$$

$$\frac{S_y}{N} = \sqrt{\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}} = \sqrt{\frac{(100-50)^2+(50-0)^2+(0-100)^2}{2}} = \sqrt{\frac{2500+2500+10000}{2}} = \sqrt{7500} = 86.6$$

$$\frac{S_y}{86.6} = \frac{350}{86.6} = \boxed{4.04 = N} \quad \text{DE}$$

A brittle material has the properties $S_{ut} = 30$ kpsi and $S_{uc} = 90$ kpsi. Using the brittle Coulomb-Mohr and modified-Mohr theories, determine the factor of safety for the following states of plane stress.

(a) $\sigma_x = 25$ kpsi, $\sigma_y = 15$ kpsi

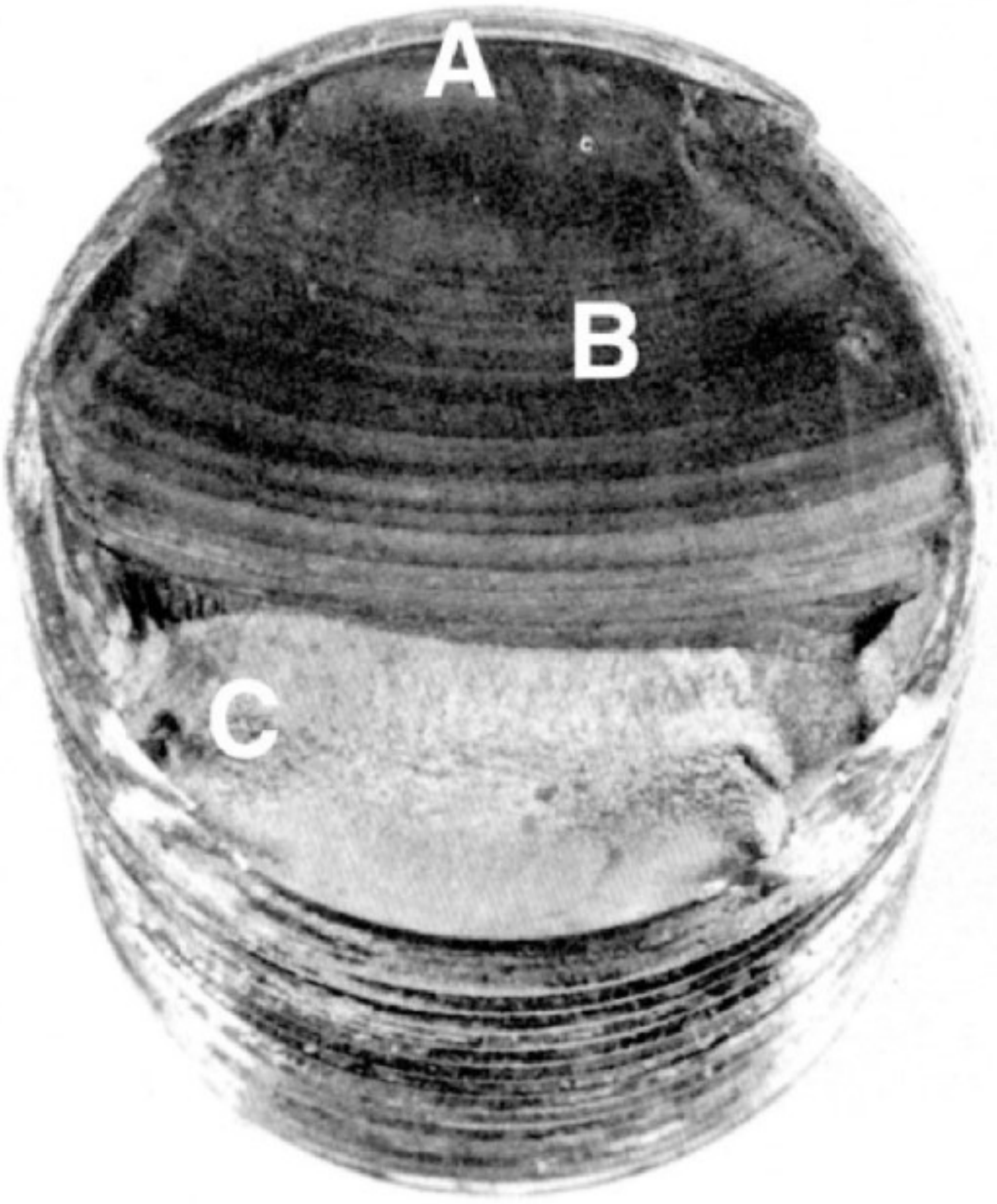
(b) $\sigma_x = 15$ kpsi, $\sigma_y = -15$ kpsi

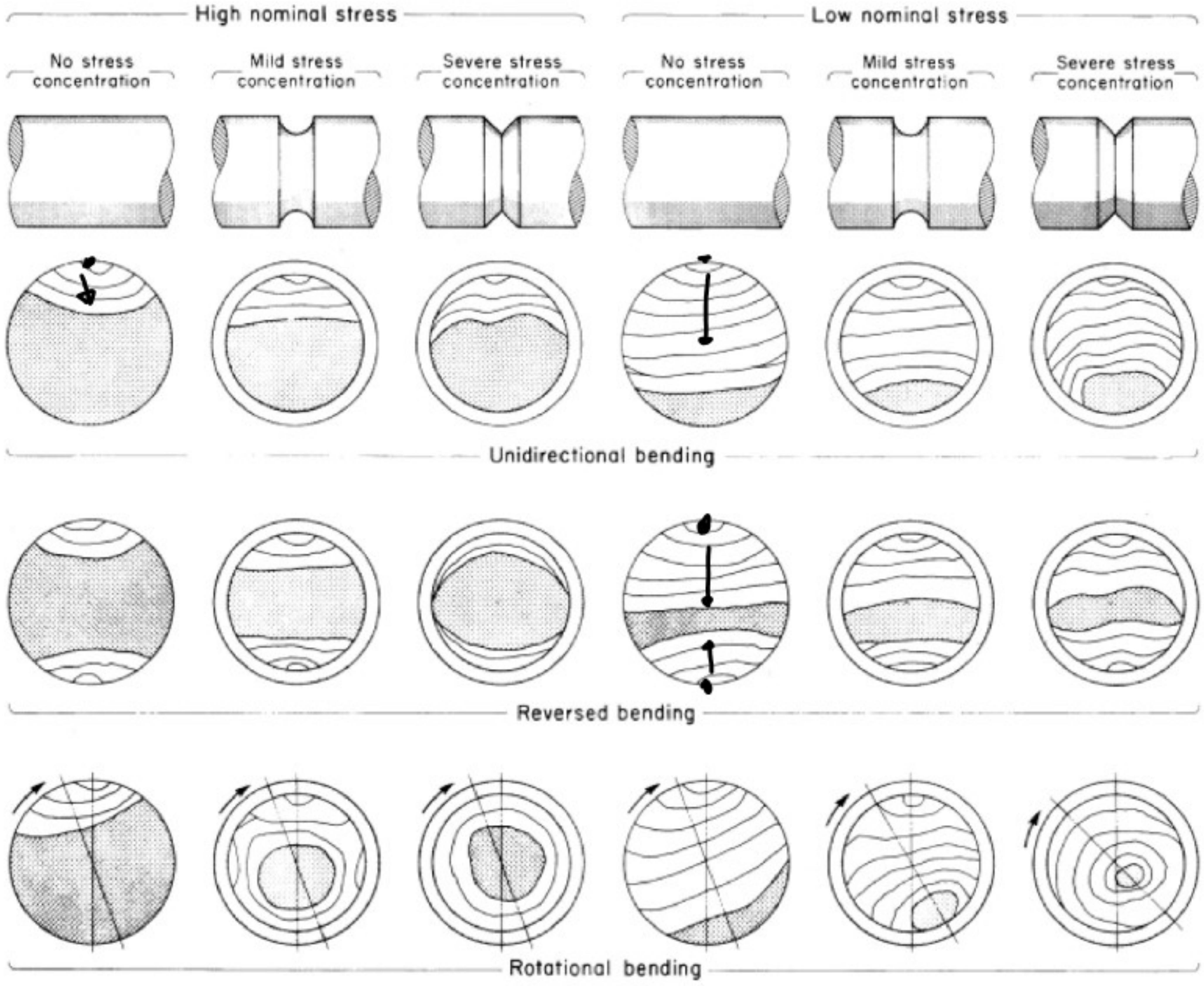
$\sigma_A = 15$ kpsi $\quad \sigma_B = -15$ kpsi

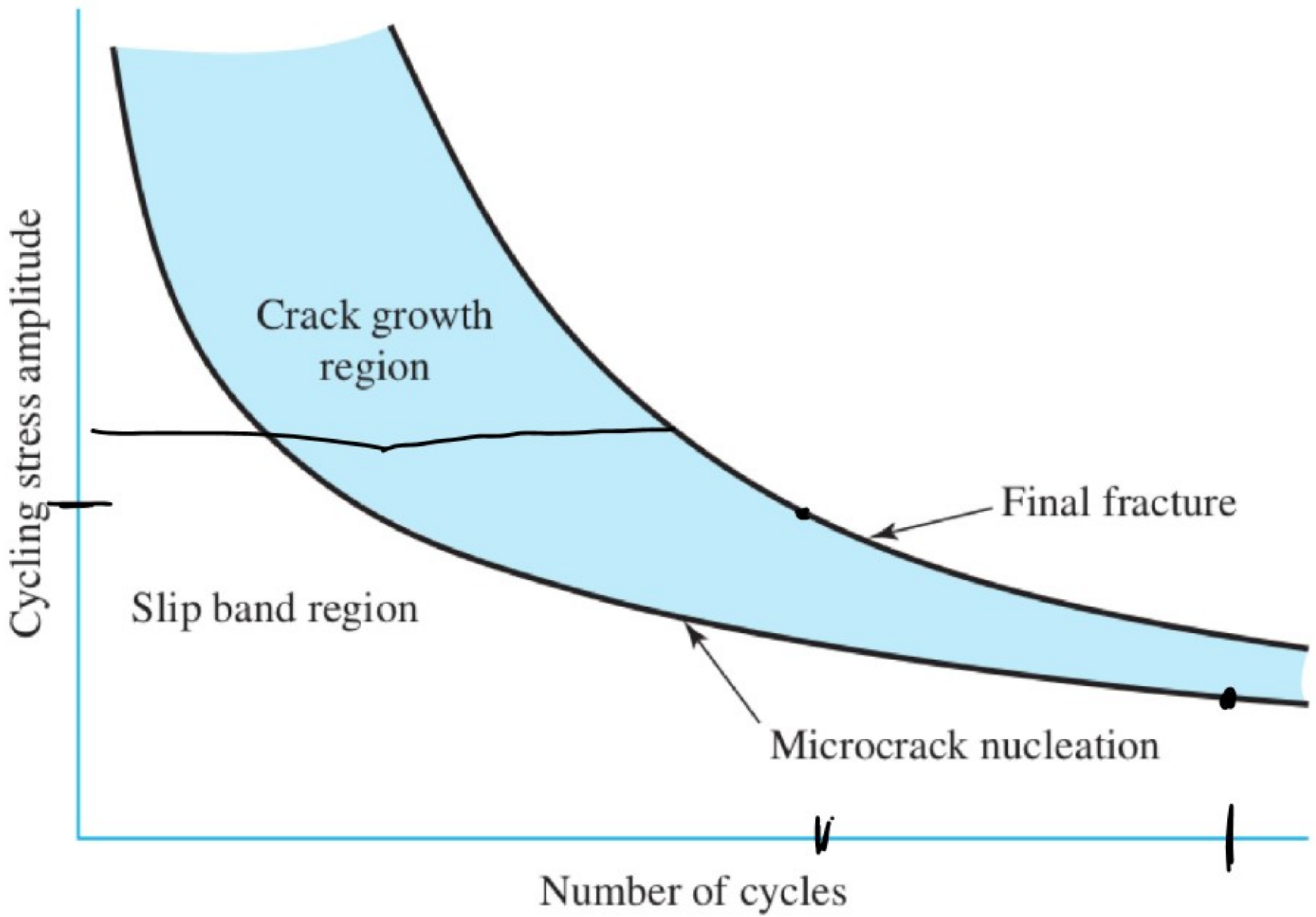
$$\frac{\sigma_A}{S_{ut}} - \frac{\sigma_B}{S_{uc}} = \frac{1}{N} \qquad \frac{15}{30} - \frac{-15}{90} = 0.67 = \frac{1}{N} \Rightarrow N = \frac{1}{0.67} = \boxed{1.5} \text{ BCM}$$

$$\left|\frac{\sigma_B}{\sigma_A}\right| = \left|\frac{-15}{15}\right| = 1 \qquad \sigma_A = \frac{S_{ut}}{N} \qquad 15 = \frac{30}{N} \Rightarrow N = \frac{30}{15} = \boxed{2} \text{ MM}$$

Fatigue




High nominal stress
Low nominal stress
No stress concentration
Mild stress concentration
Severe stress concentration
No stress concentration
Mild stress concentration
Severe stress concentration
Unidirectional bending
Reversed bending
Rotational bending


Crack growth region
Final fracture
Slip band region
Microcrack nucleation
Cycling stress amplitude
Number of cycles

Methods

Stress-life Method

Strain-life Method

LEFM linear elastic fracture mechanics

Design Criteneias

Infinite life design

Safe life design

Fail-safe design

Damage tolerant design

LEFM

Stress fluctuctuating from σ_{min} to σ_{max}

$$\Delta\sigma = \sigma_{max} - \sigma_{min}$$

$$\Delta K_I = \beta \Delta\sigma \sqrt{\pi a}$$

a crack size

β stress intensity modification factor (Pg. 271)

K_I stress intensity

Paris eq'n $$\frac{da}{dN} = C(\Delta K_I)^m$$

C, m constants

N number of cycles

$$\int_0^{N_f} dN = N_f = \frac{1}{C}\int_{a_i}^{a_f} \frac{dA}{(\beta \Delta\sigma \sqrt{\pi a})^m}$$

N_f	number of cycles
a_i	initial crack size
a_f	final crack size