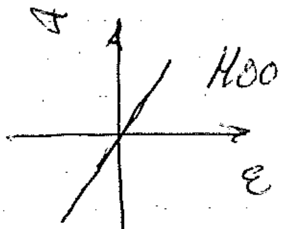
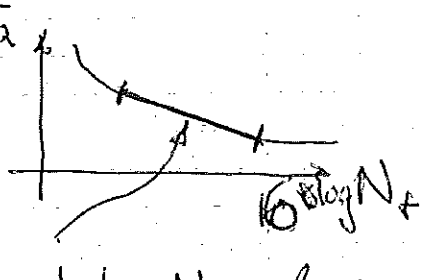
KAP 7 TOTAL LIFE

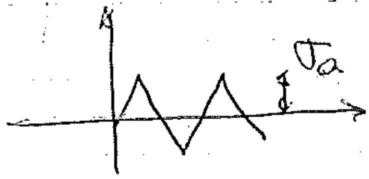
STRESS-LIFE HCF



Hooke: Materialmodell



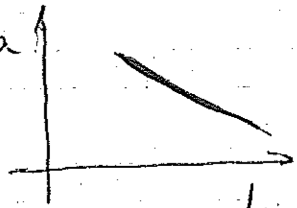
Wöhlerdiagr. $\sigma_m = 0$



$$\sigma_a = k \log N_f + l \qquad k < 0$$

$$\log N_f = \frac{\sigma_a - l}{k} \qquad N_f = 10^{\frac{\sigma_a - l}{k}}$$

Basquin $\sigma_m = 0$ $\sigma_a = \sigma_f'(2N_f)^b$



$$\log \sigma_a = \log \sigma_f' + b \log 2N_f$$

$$\log 2N_f = \frac{\log \sigma_a - \log \sigma_f'}{b}$$

$$N_f = \frac{1}{2} 10^{\frac{\log \sigma_a - \log \sigma_f'}{b}}$$

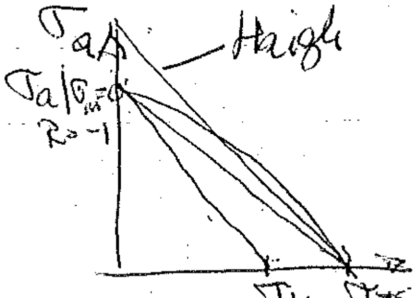
$R = \frac{\sigma_{min}}{\sigma_{max}}$ load ratio

Medelsp

Soderberg $\sigma_a = \sigma_a|_{\sigma_m = 0, R=-1} \left(1 - \frac{\sigma_m}{\sigma_Y}\right)$

Mod Goodman $\frac{\sigma_m}{\sigma_{TS}}$

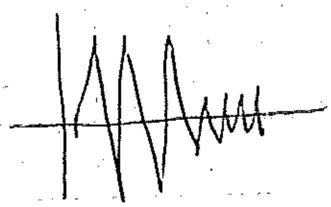
Gerber $\left(\frac{\sigma_m}{\sigma_{TS}}\right)^2$



CONSTANT LIFE DIAGRAMS

MOD Basquin; Morrow $\sigma_a = (\sigma_f' - \sigma_m)(2N_f)^b$

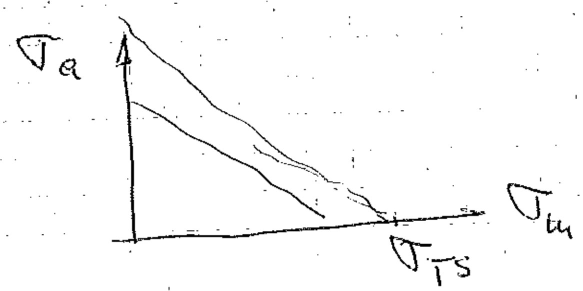
Accumulerad skada Palmgren-Miner



$\sum \frac{n_i}{N_f} = 1$

Utböch: $(\sigma_m \ \sigma_a) \rightarrow (\sigma_m, \sigma_a K_f K_d K_r)$

shot peening
kul bombning



formfaktorn = α

Anvisning $K_f = 1 + q(K_t - 1)$ ← kälkänslighet $q = 0$ ingen notd effekt

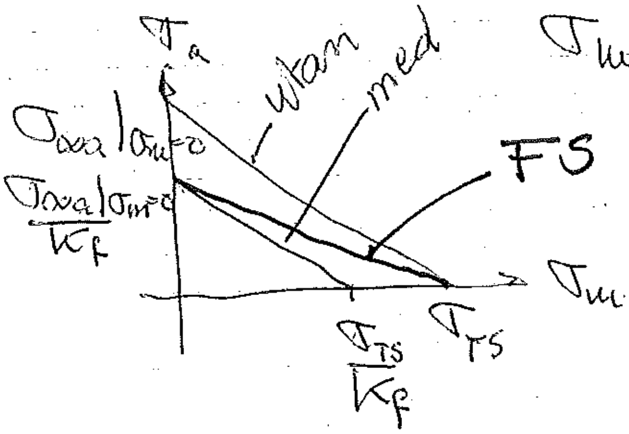
utmattningsf utan anvisn / med

$q = 1$ full

FS: σ_m red inte

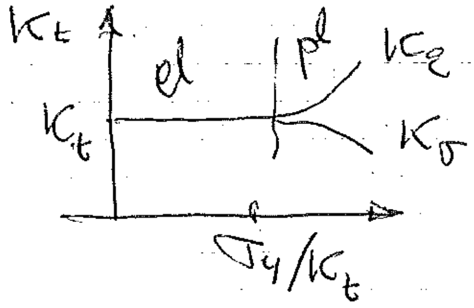
Anvisning + medelsp $\sigma_a = K_f \sigma_{a\infty}$ $\sigma_m = K_f \sigma_{m\infty}$

$\sigma_{max} = K_f \sigma_{\infty max} < \sigma_y$



Fleraxligt: Tex Mises

Notched members LCF Number



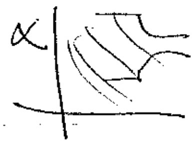
$K_f = \sqrt{K_\sigma K_\varepsilon}$

$K_\sigma = \frac{\sigma_{max}}{\sigma_\infty}$

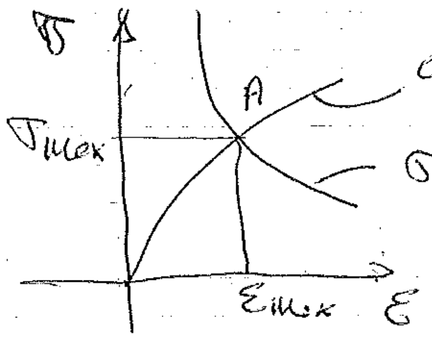
$K_\varepsilon = \frac{\varepsilon_{max}}{\varepsilon_\infty}$

$K_f = 1 + q(K_t - 1)$

↑ formfaktorn α



$$\sigma_{max}\varepsilon_{max} = K_\sigma \sigma_\infty K_\varepsilon \varepsilon_\infty = K_f^2 \sigma_\infty \varepsilon_\infty = \underbrace{\frac{K_f^2 \sigma_\infty^2}{E}}_{konst}$$



cyklisk σ-ε kurva

$\sigma \cdot \varepsilon = \frac{K_f^2 \sigma_\infty^2}{E} \Rightarrow \sigma_{max}, \varepsilon_{max}$

Se Morrow $\varepsilon_a = \varepsilon_{max} = \frac{\sigma_f' - \sigma_m}{E}(2N_f)^b + \varepsilon_f'(2N_f)^c$

$\Rightarrow N_f =$

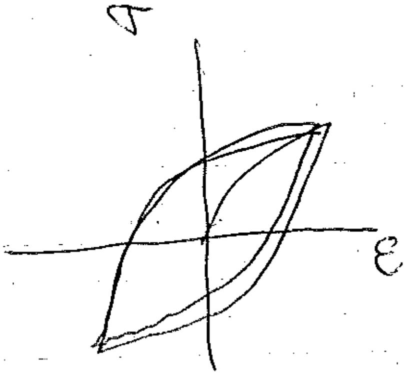
Hysteresis-loop

$$\begin{cases} \Delta\sigma \, \Delta\varepsilon = \frac{K_f^2 (\Delta\sigma_\infty)^2}{E} \\ \Delta\varepsilon = \frac{\Delta\sigma}{E} + 2\left(\frac{\Delta\sigma}{2A'}\right)^{1/n'} \end{cases}$$

Start i A $\sigma_C = \sigma_A - \Delta\sigma$

$\varepsilon_C = \varepsilon_A - \Delta\varepsilon$

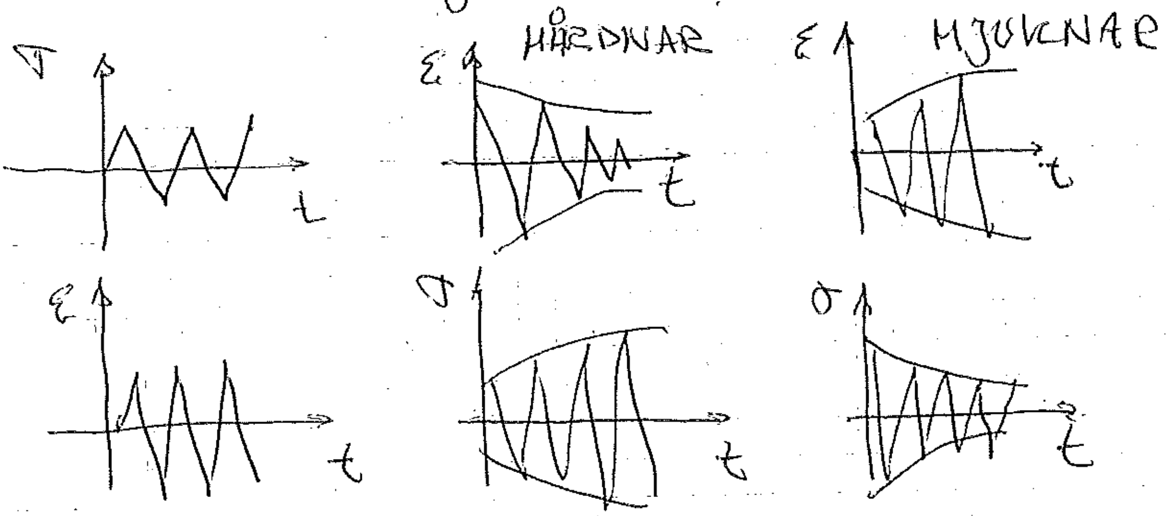
KAP 8 TOTAL LIFE
STRAIN-LIFE LCF

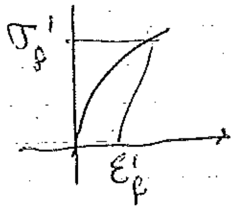


Materialmodell Ramberg-Osgood

Monotont $\varepsilon = \varepsilon_e + \varepsilon_p = \frac{\sigma}{E} + \left(\frac{\sigma}{A}\right)^{1/n}$

Cykliskt $\varepsilon_a = \varepsilon_{ae} + \varepsilon_{ap} = \frac{\sigma_a}{E} + \left(\frac{\sigma_a}{A'}\right)^{1/n'}$



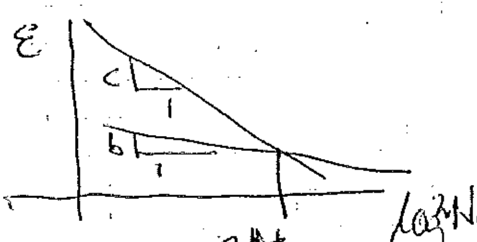


Coffin-Manson (jfr Basquin $\sigma_a = \sigma_f'(2N_f)^b$)

$\varepsilon_a = \varepsilon_f'(2N_f)^c \quad b < c$

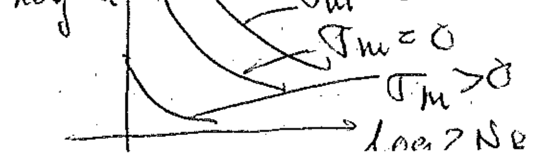
$\varepsilon_a = \varepsilon_{ae} + \varepsilon_{ap} = \frac{\sigma_a}{E} + \varepsilon_f'(2N_f)^c = \frac{\sigma_f'}{E}(2N_f)^b + \varepsilon_f'(2N_f)^c$

HCF LCF

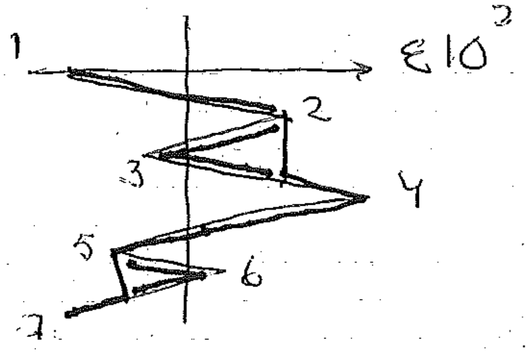


N_t = transition life

Mittspänning: Morrow $\varepsilon_a = \frac{\sigma_f' - \sigma_m}{E}(2N_f)^b + \varepsilon_f'(2N_f)^c$



Variabel ampl. Rainflow count



	ε_{max}	ε_{min}	$\Delta\varepsilon$
1-7	5	-3	8
2-3	3	-1	4
5-6	+1	-2	3

Morrow $\varepsilon_a = \frac{\Delta\varepsilon}{2} = \frac{\sigma_f' - \sigma_m}{E}(2N_f)^b + \varepsilon_f'(2N_f)^c$

$\Rightarrow N_f$

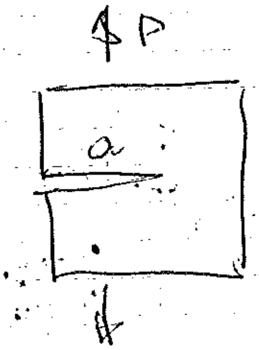
Sum: $\sum \frac{n_i}{N_f} = 1$

DAMAGE TOLERANS
SKADETOLERANT SYN

KAP 9 BROTTMEKANIK

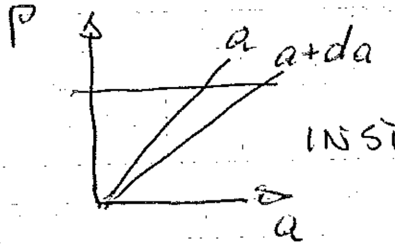
LEFM

EPFM

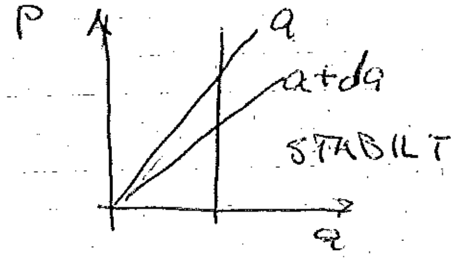


MODUS I

LASTSTYRT

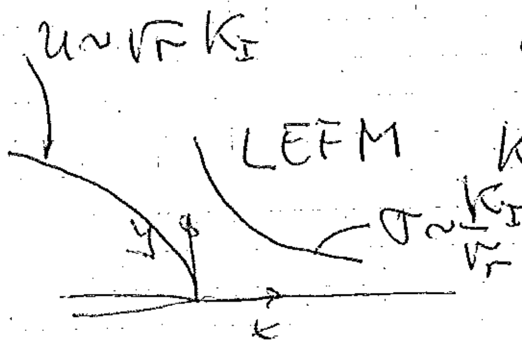


FÖRSKJSTYRT



$$\mathcal{G} = \frac{P^2}{2}\frac{dC}{dA} = \mathcal{G}_c$$

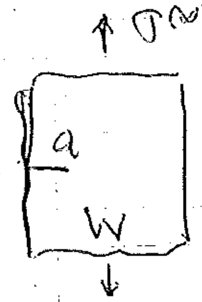
Energy release rate



$$K_I = \lim_{x \to 0} \sqrt{2\pi x}\, \sigma_{yy}\big|_{\theta=0}$$

$$K_I = K_{Ic}$$

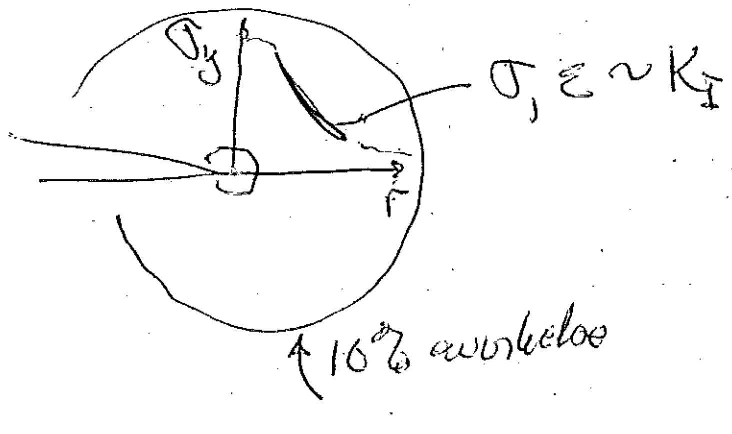
$K_I = K_I$(geometri)

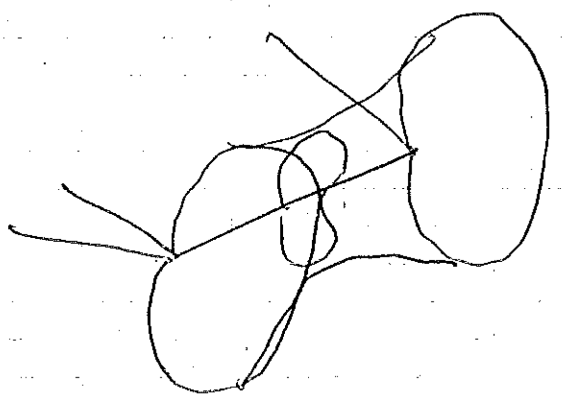


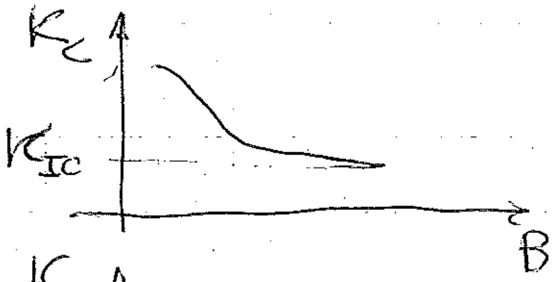
$$K_I = \sigma_\infty \sqrt{\pi a}\, f_g\left(\frac{a}{W}\right)$$

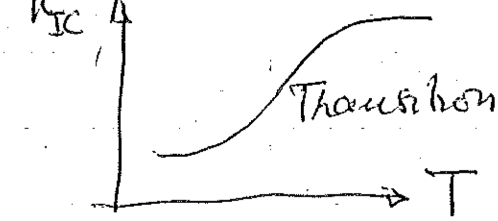
$\to 1.12$, $a/W \to 0$

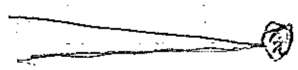
K dominans





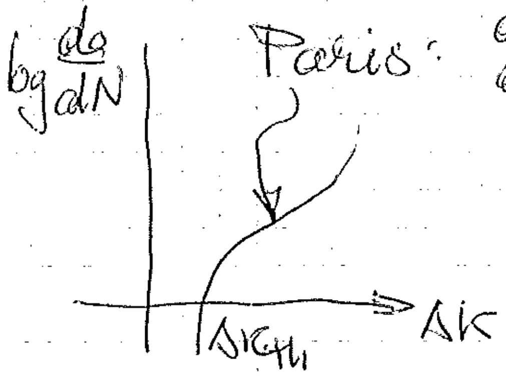






ASTM: LEFM om $a, > 2.5 \frac{1}{3\pi}\left(\frac{K_I}{\sigma_y}\right.$

Inrius plastiske zon



Paris: $\frac{da}{dN} = C\Delta K^m$

$\Delta K = K_{I\,max} - K_{I\,min} =$

$= (\sigma_{nom\,max} - \sigma_{nom\,min})\sqrt{\pi a}\, f(a)$

$$\int_{a_0}^{a_1} \frac{da}{C\Delta K^m} = \int_0^N dN = N$$

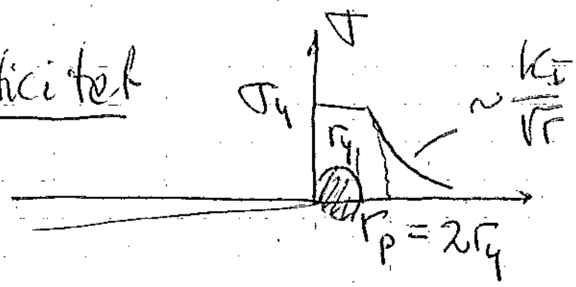
LEFM: $\sigma \lesssim 0.4 - 0.5\, \sigma_{ys}$

2 mött; $G = \frac{K_I^2}{E}$ plan sp

$G = \frac{K_I^2(1-\nu^2)}{E}$ plan töjn

$$G = \frac{1-\nu^2}{E}(K_I^2 + K_{II}^2) + \frac{1+\nu}{E} K_{III}^2$$

Plasticitet

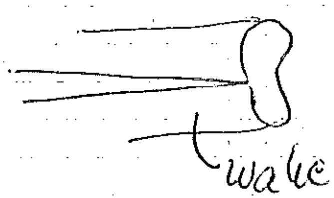


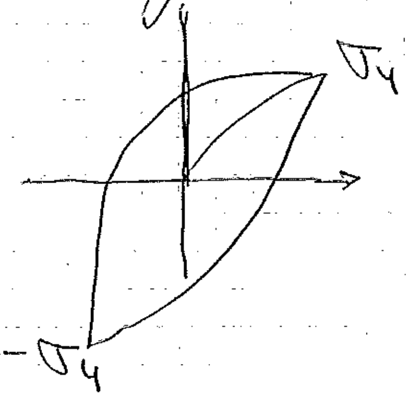
$a_{eff} = a + r_y > a$

$K_{eff} = \sigma^\infty \sqrt{\pi a_{eff}}$

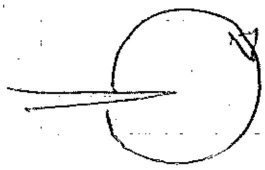
Irwin ⇒ ASTM

EPFM J HRR CTOD J dominans





Brott $J = J_c$



$$J = \int_\Gamma \left(W dy - \sigma_{ij} n_j \frac{\partial u_i}{\partial x} ds \right) \qquad W = \int_0^\varepsilon \sigma_{ij} d\varepsilon_{ij}$$

Hook LEFM $J = \frac{(1+\nu)(\kappa+1)}{4E} \left(K_I^2 + K_{II}^2 + \frac{4}{\kappa+1} K_{III}^2 \right)$ $\kappa = 3-4\nu$ pd, $\kappa = \frac{3-\nu}{1+\nu}$ ps

EPFM Ramberg-Osgood $\varepsilon = \frac{\sigma}{E} + \left(\frac{\sigma}{A'}\right)^{1/n'} = \frac{\sigma}{E} + \left(\frac{\sigma}{A'}\right)^n$

$$\Rightarrow \sigma_{ij} = C_I \left(\frac{J}{r}\right)^{\frac{1}{n+1}} f(\theta, n)$$

$$\varepsilon_{ij} = C_{II} \left(\frac{J}{r}\right)^{\frac{n}{1+n}} g(\theta, n)$$

$$u_i \sim C_{III} \left(\frac{J}{r}\right)^{\frac{n}{n+1}} r^{\frac{1}{n+1}} h(\theta, n)$$

Hook, LEFM: K_I definierar amplituden

Ramberg Osgood EPFM: J

9.7 J-dominans

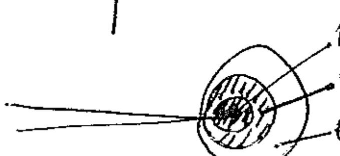
I plastiska zonen: HRR-singulariteten $\sigma_{ij} \sim \left(\frac{J}{r}\right)^{\frac{1}{n+1}}$

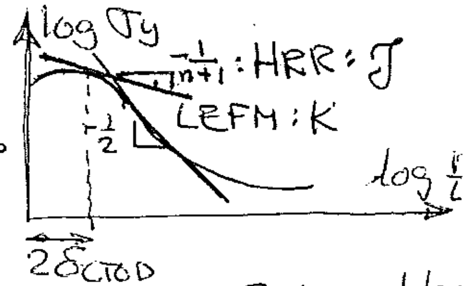
$\varepsilon_{ij} \sim \left(\frac{J}{r}\right)^{\frac{n}{n+1}}$

Elastiskt: $n=1$, σ_{ij};

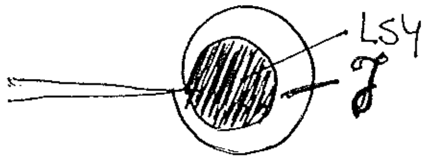
Båda ger ∞ sp. töjn. då $r \to 0$. I verkligheten blir,

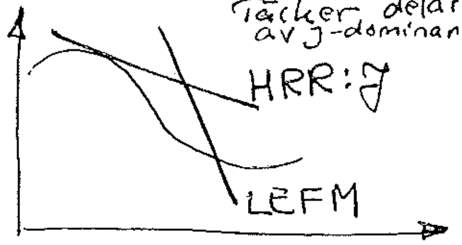
SSY: K och J



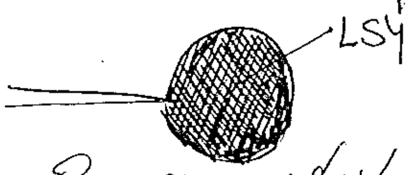


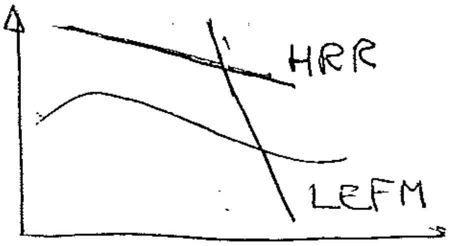
ELASTISK-PLASTISK: J och CTOD





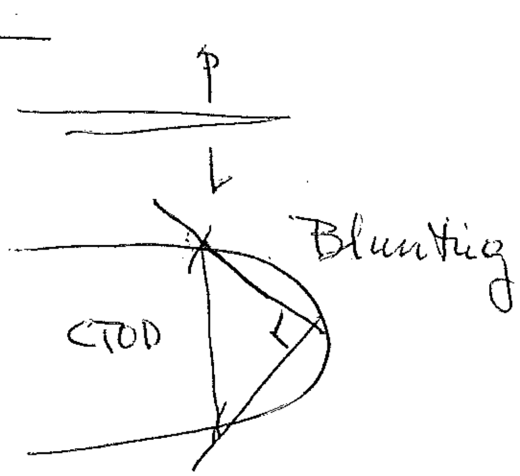
LARGE SCALE YIELDING



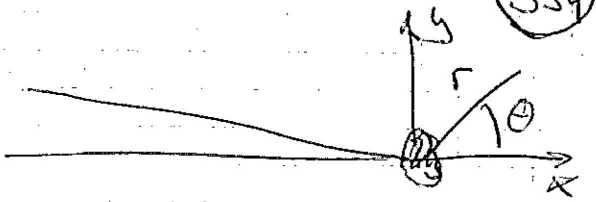


Enparameterlösningar gälla ej

CTOD:



TVÅ PARAMETRAR T, Q



(SSY) $\sigma_{ij} = \frac{K_I}{\sqrt{2\pi r}} f_{ij}(\theta) + T\delta_{1i}\delta_{1j}$

(LSY) $\sigma_{ij} \approx (\sigma_{ij})_{T=0} + Q\sigma_y\delta_{ij}$

↑ treaxlighet

KAP 13 Fretting