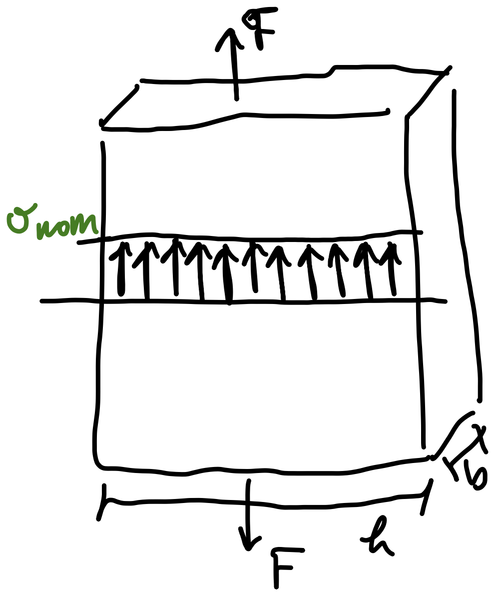
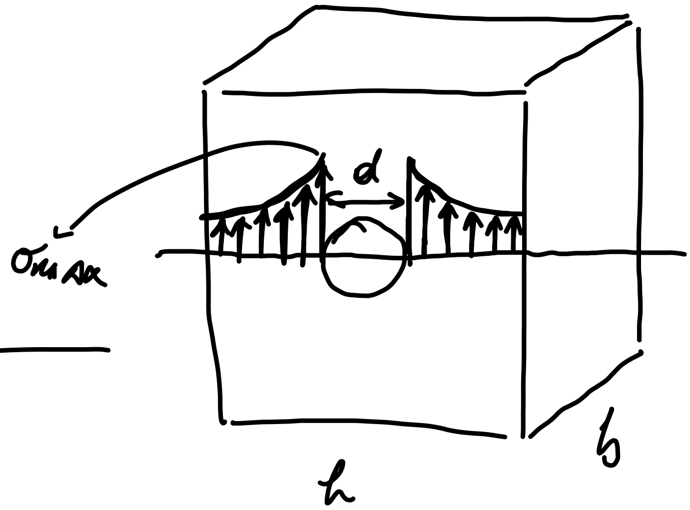
Esercitazione 11 - Intaglio



$$\sigma_{nom} = \frac{F}{A} = \frac{F}{h \cdot b}$$



$$\sigma_{nom} = \frac{F}{A} = \frac{F}{(h-d)d}$$

Con il foro la sezione diminuisce

→ Normale perché stiamo stipulando che siano tutti uguali

Il coefficiente d'intaglio ci corregge questa stipulazione e ci da σ_{max}

$$k_T = \frac{\sigma_{MAX}}{\sigma_{MIN}} = f(\text{geometria, azioni interne}$$

Quando faremo le verifiche statiche faremo:

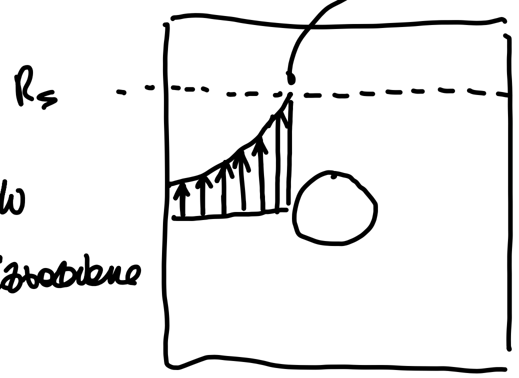
$\sigma_{nom} k_T = \sigma_{max}$ non calcoleremo σ_{max} useremo direttamente k_T

Consideriamo:

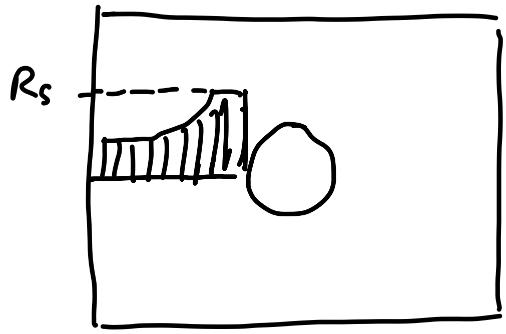
inizia a plasticizzare

Questo punto è a R_s, il resto del materiale non è plastificato, aumentando però, si sviluppa una regione plastificata

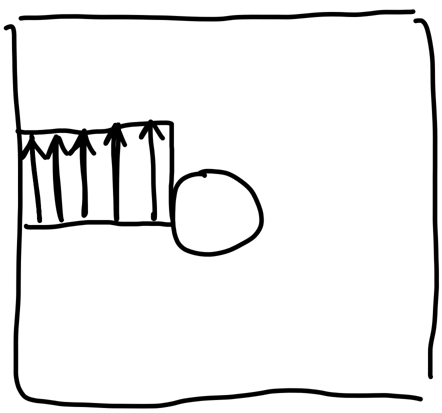
Prima di Plasticizzazione



si usa $\sigma_{MAX} = \sigma_{nom} \cdot k_T$



Aumentando di più:



Si ha plasticizzazione totale

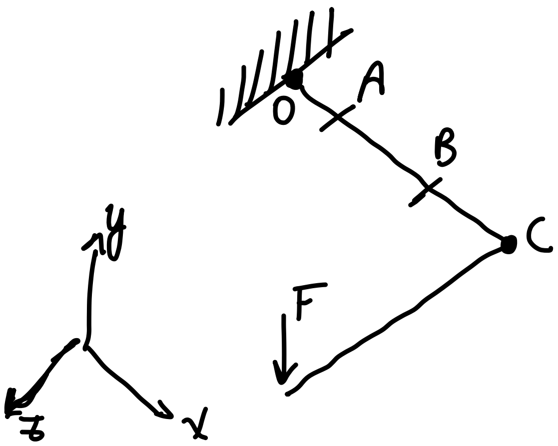
si usa σ_{nom}, perchè $\sigma_{nom} = \sigma_{MAX}$

$$\rightarrow \frac{\sigma_{MAX}}{\sigma_{nom}} = k_T = 1$$

A parità di geometria si ha lo stesso k_T, azioni interne diverse hanno coefficienti d'intaglio diversi.

Come leggere i diagrammi di k_T

Esercizio 1



$\overline{OA} = 50mm$

$\overline{AB} = 300mm$

$\overline{BC} = 50\ mm$

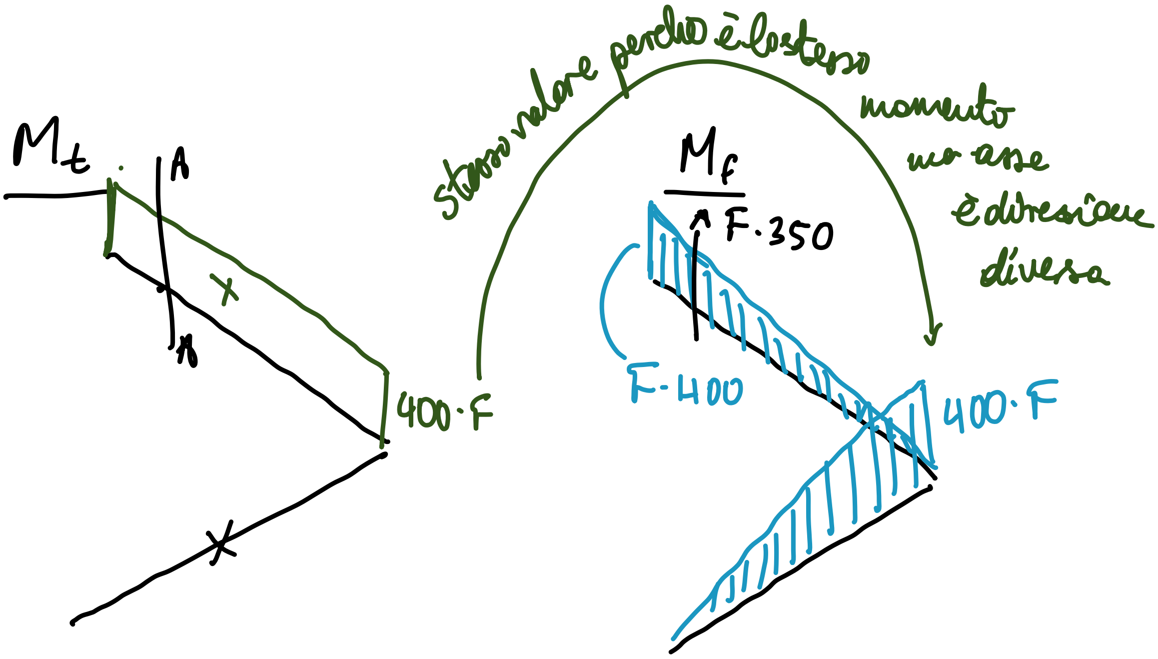
$CD = 400\ mm$

$R_s = 460 MPa$

$D_{OA} = 40mm$

$d_{AB} = 25mm$

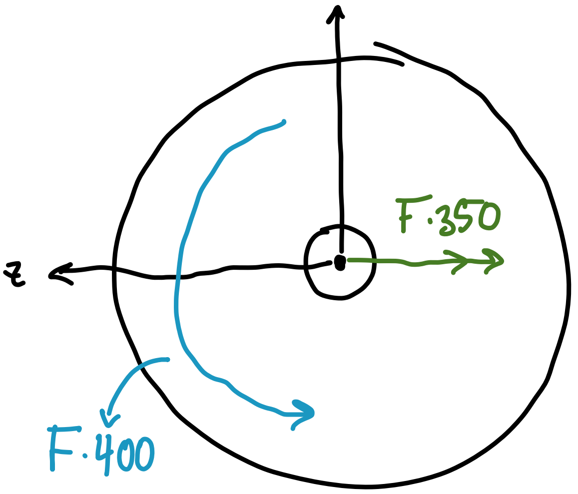
$r_A = 3mm$



Anche se a O gli sforzi nominali sono i più alti quello massimo potrebbero essere ad A

A-A

y



$$\frac{R}{d} = 0{,}12$$

$$\frac{D}{d} = 1{,}6$$

Intaglio, flettente

$k_{t,f} = 1{,}7$

$k_{t,t} = 1{,}35$

Intaglio, torsione

Verifica di sforzi in A

$$\sigma_n = \frac{32 M_f}{\pi d_{AB}^3} = \qquad \tau_M = \frac{16 M_t}{\pi d_{AB}^3} =$$

Mettendo il diametro piccolo stiamo analizzando il caso peggiore possibile

Usiamo GT per è più conservativo

Usiamo σ_{sn} per plasticizzazione totale

$$PT)\ \sigma_{GT}^{a} = \sqrt{\sigma_n^2 + 4\tau_n^2} = 0{,}35\, F = \sigma_{sn}$$

Plasticizzazione

Vogliamo $\eta = 1$ per la plasticizzazione

$\Rightarrow F = 1328N$

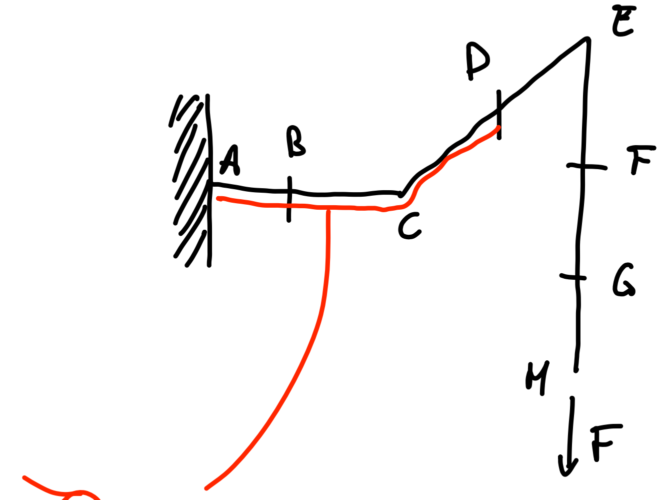
Usiamo σ_{MAX} per prima plasticizzazione

$$PP)\ \sigma_{GT}^{a} = \sqrt{\sigma_{MAX}^2 + 4\tau_{MAX}^2} = \sqrt{(k_{t,f}\,\sigma_n)^2 + 4(k_{t,t}\,\tau_n)^2} = 0{,}52\, F = \sigma_{sn}$$

Prima Plasticizzazione

anche qui $\eta = 1 \Rightarrow F = 878N$

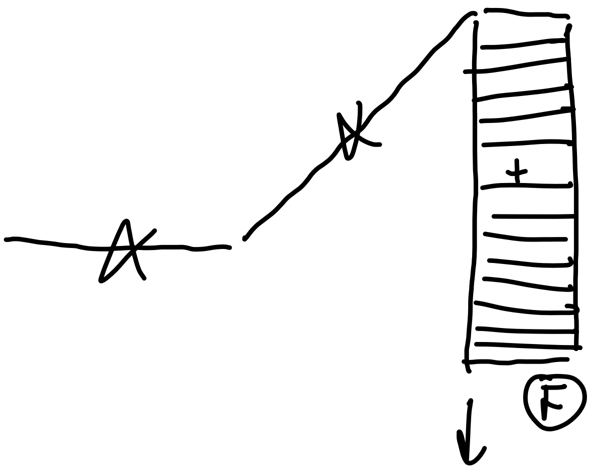
↳ serve forza minore tale che si rompe, è più conservativo



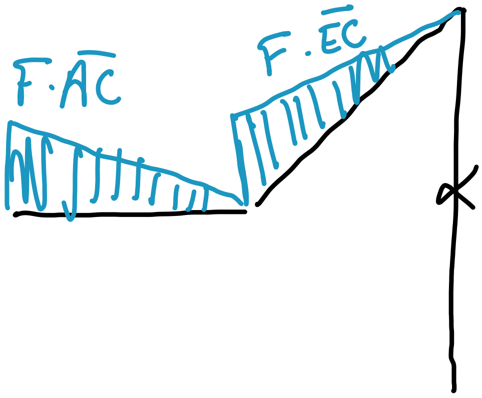
$R_s = 230 \text{ MPa}$

Ghisa grigia $R_u = 250 \text{ MPa}$

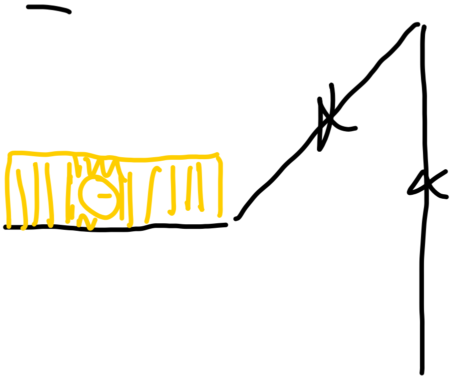
N



M_f

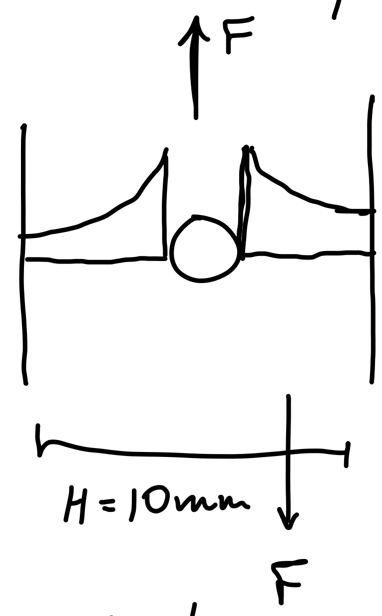


M_t



G-G

$\phi = 4\,mm \quad s = 6\,mm$



$$\frac{d}{H} = 0,4 \Rightarrow k_T = 2,25$$

$$\sigma_n = \frac{F}{(h-d)s} =$$

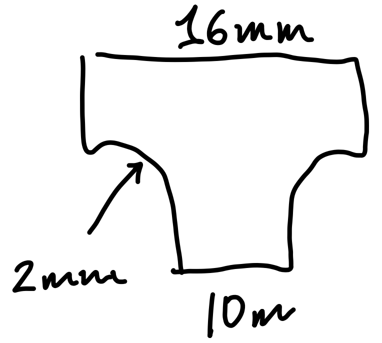
ci limitiamo a PP perché è il caso più conservativo

$PP) \quad \sigma^*_{\sigma T PP} = k_T \sigma_n \le \frac{R_s}{\eta}$ dove prendiamo σ_{su} come σ_{lim} invece a PT dovremmo prendere σ_r come σ_{lim}

Vogliamo F che causi il cedimento $\Rightarrow \eta = 1$

$\Rightarrow F_{lim,G} = 3680\ N$

F-F



$$\sigma = \frac{F}{A} = \frac{F}{60}$$

$$\frac{H}{h} = 1,6 \quad \frac{r}{h} = 0,2$$

$s = 6\,mm$

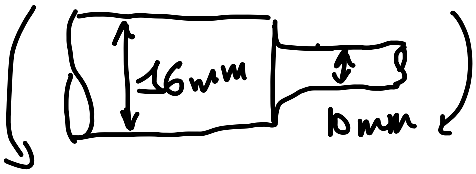
$k_t = 1,74$

PT perché

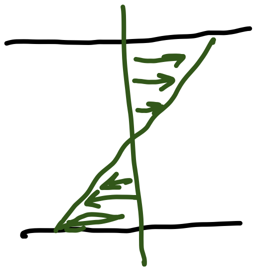
$\sigma \le \frac{R_s}{\eta}$ di minore cedimento $\eta = 1$

$$\sigma = \frac{F}{60} = R_s \Rightarrow F_{lim\,PT} = 60 R_s = 13800\, N$$

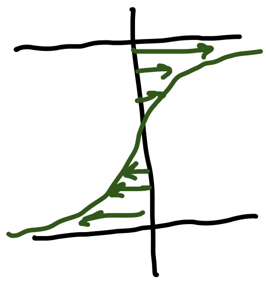
D-D



Normale



Con intaglio, integrale degli sforzi deve esser uguale



$$\sigma_n = \frac{32 M_f}{\pi (10)^3} = 84 MPa \qquad M_f = F \cdot \frac{\overline{CE}}{2}$$

$$\frac{r}{d} = 0,1 \qquad \frac{D}{d} = 1,6 \Rightarrow k_t = 1,76$$

$$F = 150 N \Rightarrow M_f = 8250\, N \cdot m$$

$$\sigma_I = k_t \sigma_n = 147,9\, MPa$$

Per i materiali plastici non c'è differenza tra PT e PP appena si arriva a σ_r c'è cedimento totale

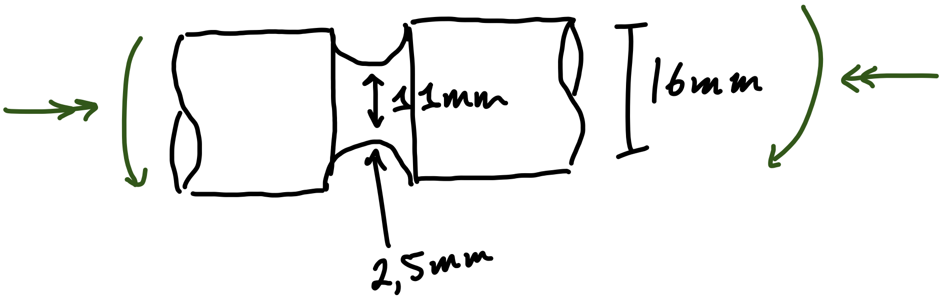
$$\eta = \frac{R_m}{\sigma_I} = 1,69 < 3$$

Verifica non passata, bi cambiare materiale

B-B

$M_t = F \cdot \overline{EC} = 16,5\ Nm$

$M_f = F \cdot \overline{CB} = 12\ Nm$



$\frac{r}{d} = 0,23 \qquad \frac{D}{d} = 1,45$

$\Rightarrow k_{t,f} = 1,6 \qquad k_{t,t} = 1,3$

$\sigma_n = \frac{32 M_f}{\pi d^3} = 91,83\ MPa \qquad \sigma_{MAX} = k_{t,f}\, \sigma_n = 146,93\ MPa$

$\tau_n = \frac{16 M_t}{\pi d^3} = 63,14\ MPa \qquad \tau_{MAX} = k_{t,t} \cdot \tau_n = 82,08\ MPa$

$\sigma_I = \frac{\sigma_{MAX}}{2} + \sqrt{\left(\frac{\sigma_{MAX}}{2}\right)^2 + \tau_{MAX}^2} = 183,6\ MPa$

$\sigma_{II} = \frac{\sigma_{MAX}}{2} - \sqrt{\left(\frac{\sigma_{MAX}}{2}\right)^2 + \tau_{MAX}^2} = 36,6\ MPa$

$|\sigma_I| > |\sigma_{II}|$ quindi ci basta verificare quello per questo materiale fragile

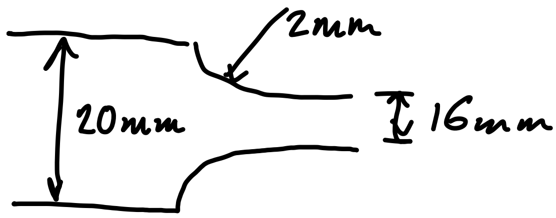
$$\eta = \frac{R_m}{\sigma_I} = 1{,}36 < 3 \times$$

↳ Anche in questo caso la verifica è fallita

A-A

$$M_f = F \cdot \overline{AC} = 19{,}5\ Nm$$

$$M_t = F \cdot \overline{EC} = 16{,}5\ Nm$$



$$\frac{r}{d} = 0{,}125$$

$$\frac{D}{d} = 1{,}25$$

$$k_{t,f} = 1{,}6$$

$$k_{t,t} = 1{,}3$$

$$\sigma_{MAX} = k_{t,f} \cdot \frac{32 M_f}{\pi d^3} = 77{,}6\ MPa$$

$$\tau_{MAX} = k_{t,t} \cdot \frac{16 M_t}{\pi d^3} = 26{,}67\ MPa$$

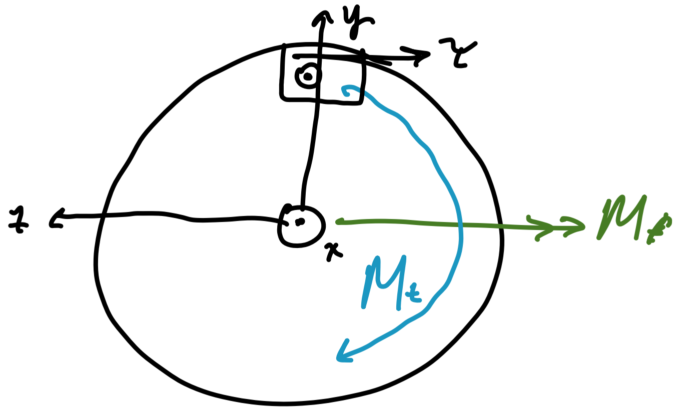
$$\sigma_I = \frac{\sigma_{MAX}}{2} + \sqrt{\left(\frac{\sigma_{MAX}}{2}\right)^2 + \tau^2} =$$

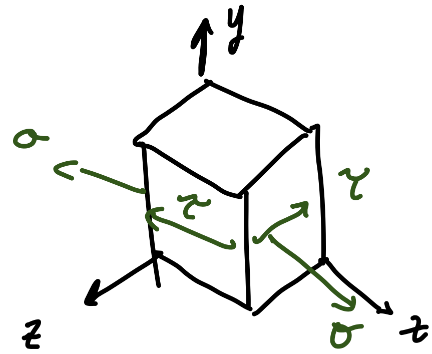
$$\sigma_{II} = \frac{\sigma_{MAX}}{2} - \sqrt{\left(\frac{\sigma_{MAX}}{2}\right)^2 + \tau^2} =$$

Non aveva fatto i conti

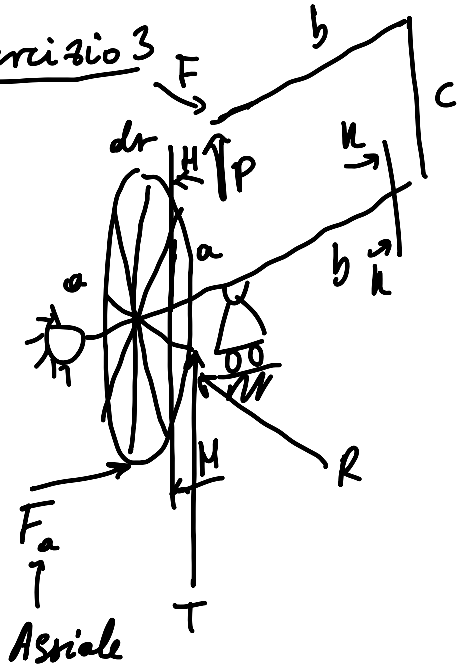
$$\eta = \frac{R_m}{\sigma_I} = 2{,}9 < 3$$

↳ Fallisce anche qui la verifica





Esercizio 3



$T = 1500 N$

$P = 500 N$

$a = 200 \ mm$

$b = 350 \ mm$

$c = 300 \ mm$

$dr = 500 \ mm$

$d = 30 \ mm$

$R_s = 680 MPa$

$K_{t,f}^{M-M} = 1,75$ $\quad K_{t,t}^{M-M} = 1,38$

$K_{t,f}^{K-K} = 1,5$ $\quad K_{t,t}^{K-K} = 1,4$

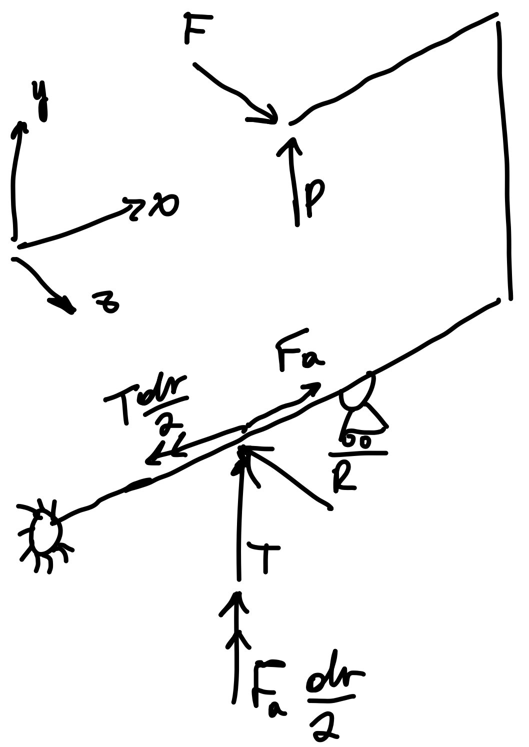
$\alpha = 20°$

$\beta = 45°$

F e P sono fisse per l'albero

F_a, T e R sono rotanti (per l'albero) perché rimangono nello stesso punti (per la loro natura come forze di interazione tra ruote dentate)

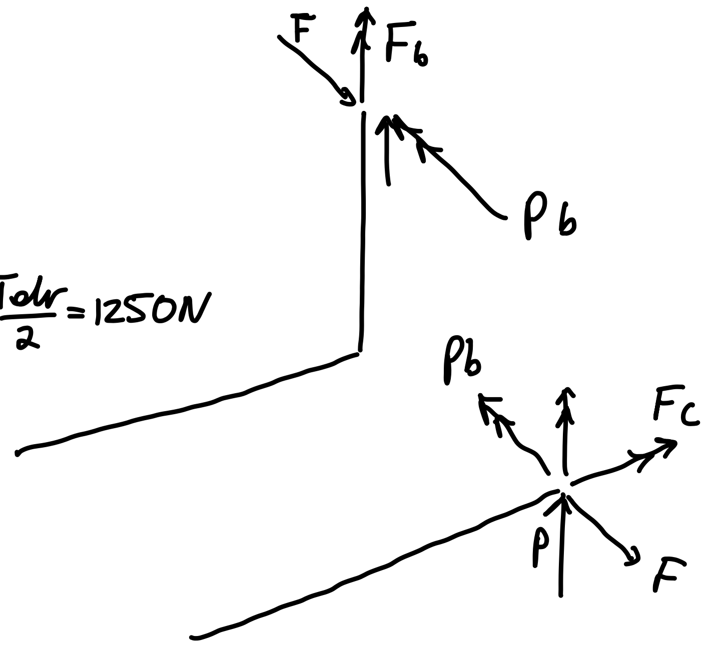
T genera M_t , forza assiale genera momento flettente



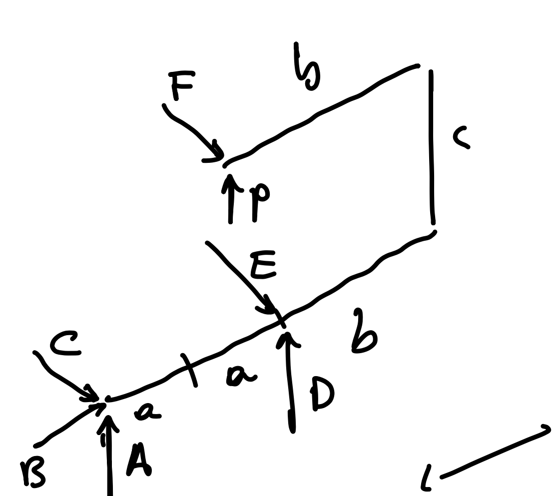
$$R = \frac{T}{\cos\beta} \cdot \tan\alpha = 772\,N$$

$$F_a = T \tan\beta = 1500\,N$$

$$\sum M_x = 0 = \frac{T d_r}{2} - F c \Rightarrow F = \frac{T d_r}{2} = 1250\,N$$



FF → Forze Fisse per l'albero



$$\sum F_x = 0 = B$$

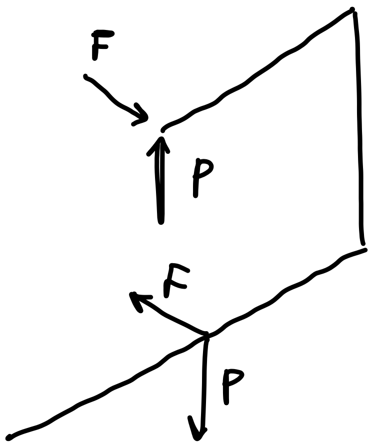
$$\sum F_y = 0 = P + D + A \Rightarrow D = -P$$

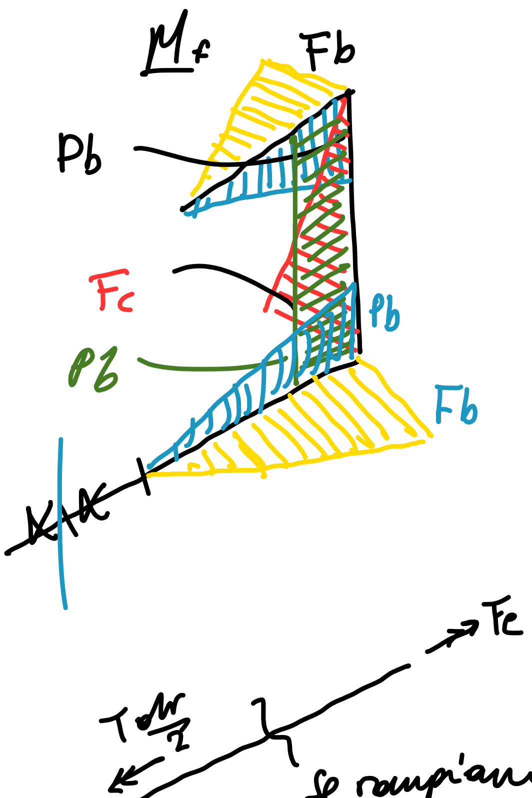
$$\sum F_z = 0 = F + E + C \Rightarrow E = -F$$

$$\sum M_y = 0 = F b - F b + C\,2a \Rightarrow C = 0$$

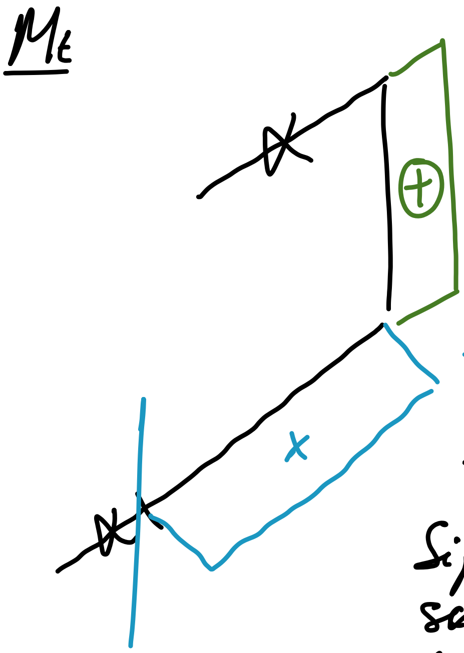
Intorno al carello ↳ Più opportuno ⟵ $\sum M_z = 0 = -A \cdot 2a + Pb - Pb \Rightarrow A = 0$

Azioni Interne





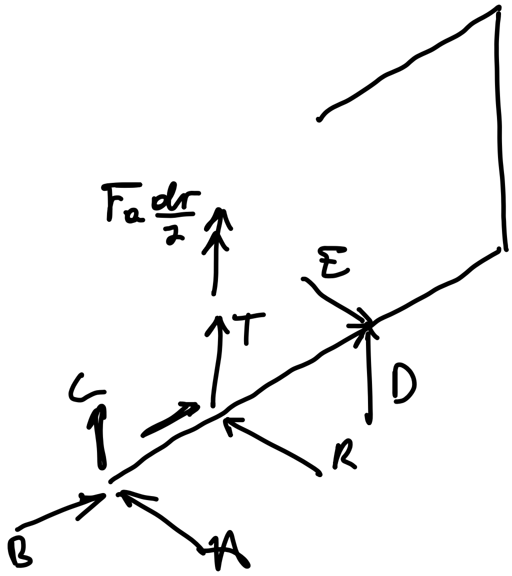
Se rompiamo l'asta a qualsiasi punto troviamo solo lo stesso momento, devono esser contro rotanti se no si sommerebbero



$\frac{Tdr}{2} = M_{Fc}$

Si potrebbe scrivere anche hai momenti rotanti

Forze Rotanti FR



$$\sum F_x = 0 = B + F_a \Rightarrow B = -F_a$$

$$\sum F_y = 0 = T + A + D \Rightarrow D = T - A = -750N$$

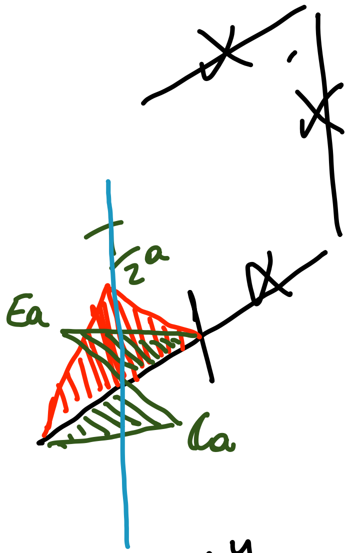
$$\sum F_z = 0 = E + C - R \Rightarrow E = -1210{,}5N$$

$$\sum M_y = 0 = C\,2a - Ra + F_a \frac{dr}{2}$$

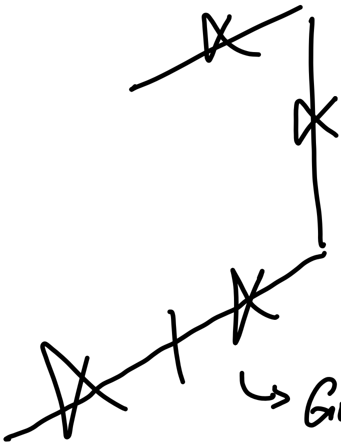
$$\Rightarrow C = 664{,}5N$$

$$\sum M_z = 0 = -A \cdot 2a - Ta \Rightarrow A = 750N$$

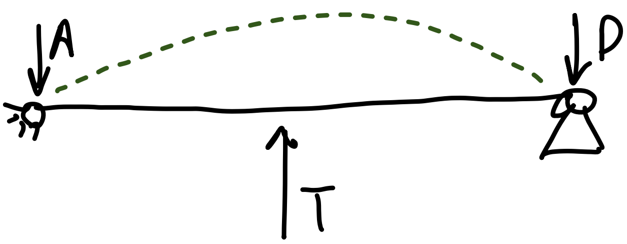
$\underline{M_f}$

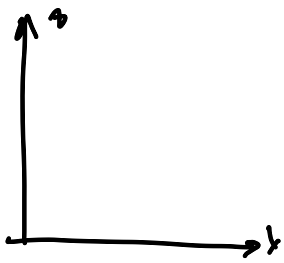


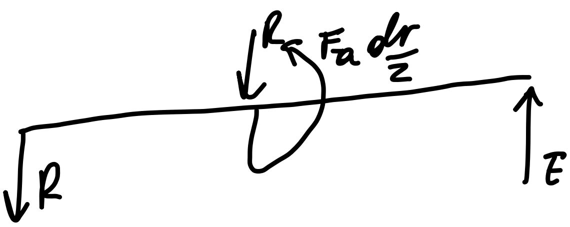
$\underline{M_t}$



↳ Già disegno nelle forze ferme

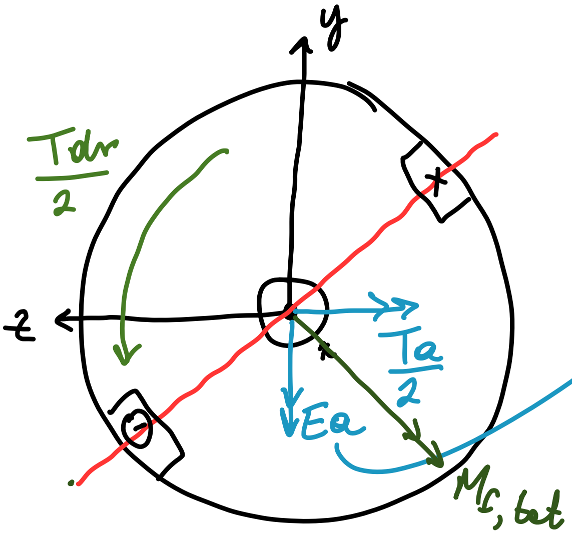






Analisi delle Sezioni

H-H



Ea > Ca e vogliamo sempre analizzare il caso peggiore

$$M_{f,tot} = \sqrt{\left(\frac{T}{2}a\right)^2 + (Ea)^2}$$

$$\sigma_{nom} = \frac{32 M_{f,tot}}{\pi d^3}$$

$$\tau_{nom} = \frac{16 M_{t,tot}}{\pi d^3}$$

$$\sigma_{GT}^{*} = \sqrt{\left(K_{t,f}^{H-H}\,\sigma_n\right)^2 + 4\left(K_{t,t}^{H-H}\,\tau_n\right)^2}$$