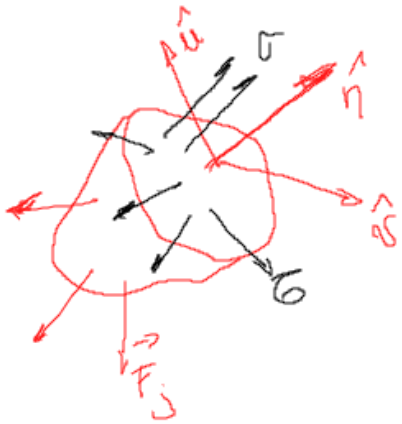
Tensão -



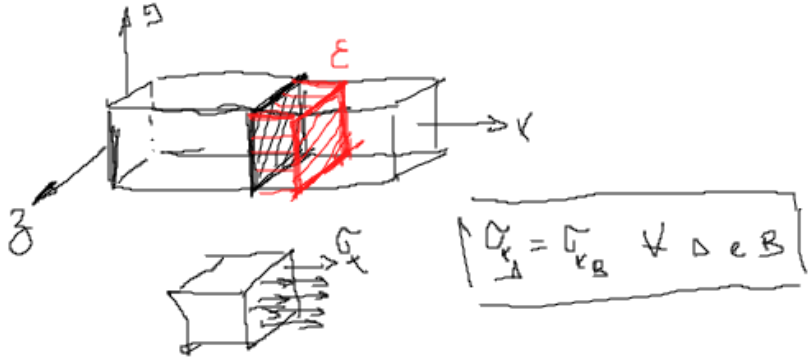
Normal σ

Cisalhamento τ

Tensão ⇒ deformação

Tensão normal uniforme - para todos os pontos da secção considerada a tensão normal tem a mesma intensidade.

- Deformação é tal que a S.T deformada é paralela a S.T não deformada.

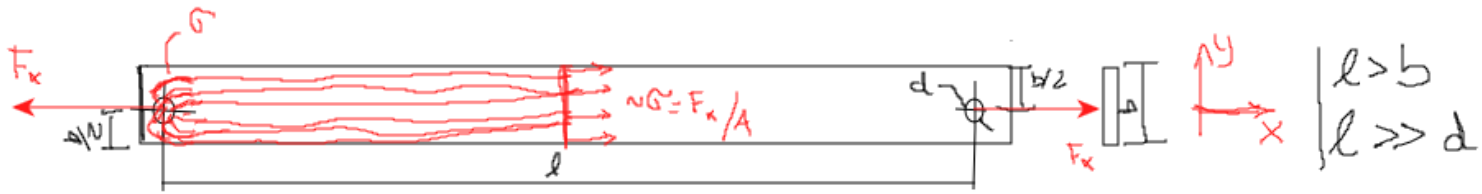


$\sigma_{x_A} = \sigma_{x_B} \quad \forall A \in B$

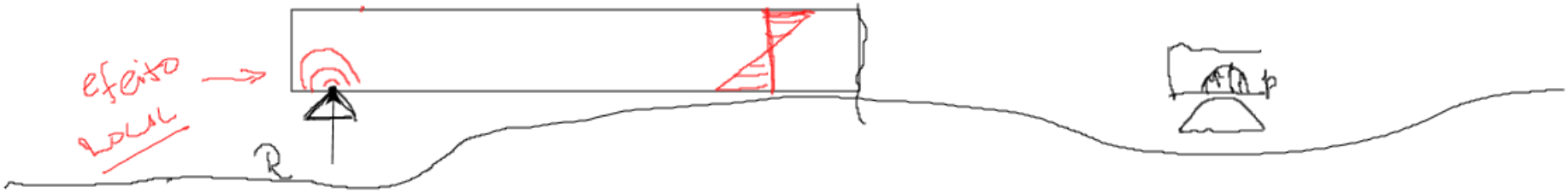
- Elástico Linear
- Uniforme

F_x = força na direcção x (normal)

$$F_x = \int_A \sigma_x \, dA \quad \Rightarrow \quad F_x = \sigma_x \int_A dA \quad \Rightarrow \quad \boxed{\sigma_x = F_x / A}$$



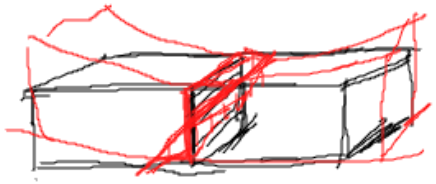
- Desprezando efeitos locais
  Considerando a distribuição
  das tensões "longe" dos pontos de aplicação de carregamento

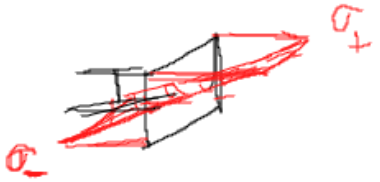


Flexão – (Não considero σ)

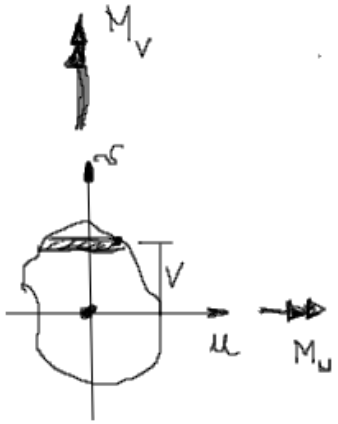
Mudança de raio de curvatura

ST plana permanece plana - Rotação da ST em torno de um eixo (linha neutra)





$$\sigma = E\varepsilon$$



$$dM_u = \vec{v} \wedge \sigma \cdot dA \cdot \hat{n}$$

$$\sigma_n = \frac{M_u v}{I_{uu}} + \frac{M_v \cdot u}{I_w}$$

I_u = Mom. Inercia da área eixo u

Eixos Principais de inércia

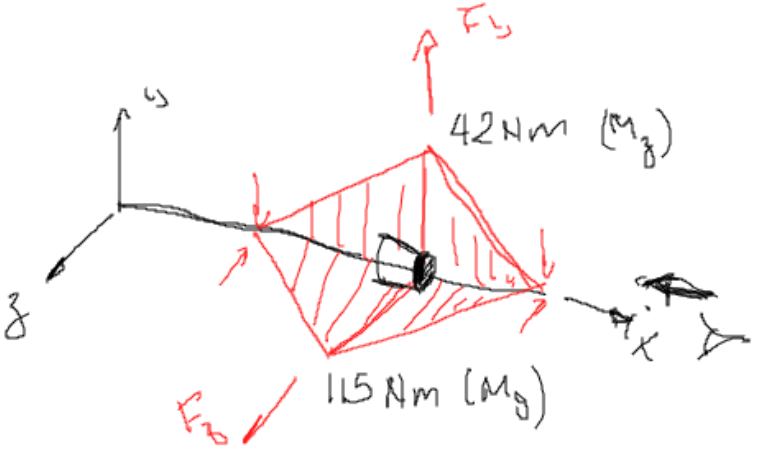
Flexão

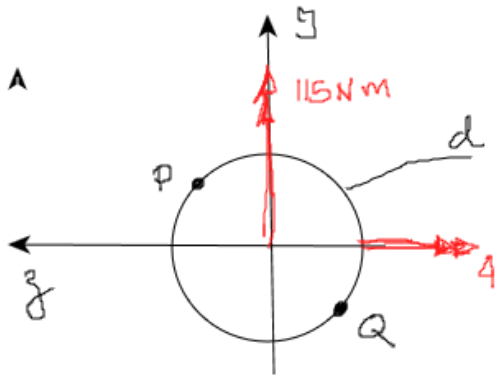
$$\sigma = \frac{M_u \cdot v}{I_{uu}} + \frac{M_v \cdot u}{I_{vv}}$$

u e v eixos Principais de inércia

- Vigas curvas - Vigas cujo raio de curvatura é da mesma ordem de grandeza que o comprimento

- gancho





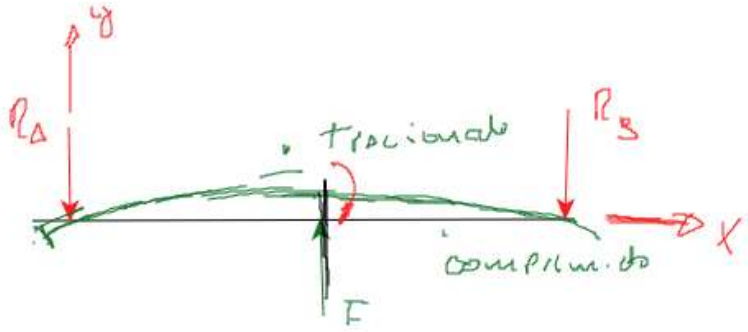
$$I_{zz} = I_{yy} = \frac{\pi d^4}{64}$$

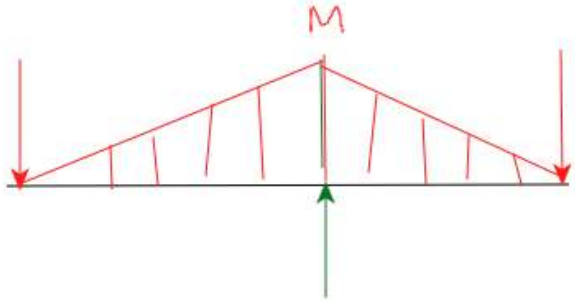
$d = 25\,mm$

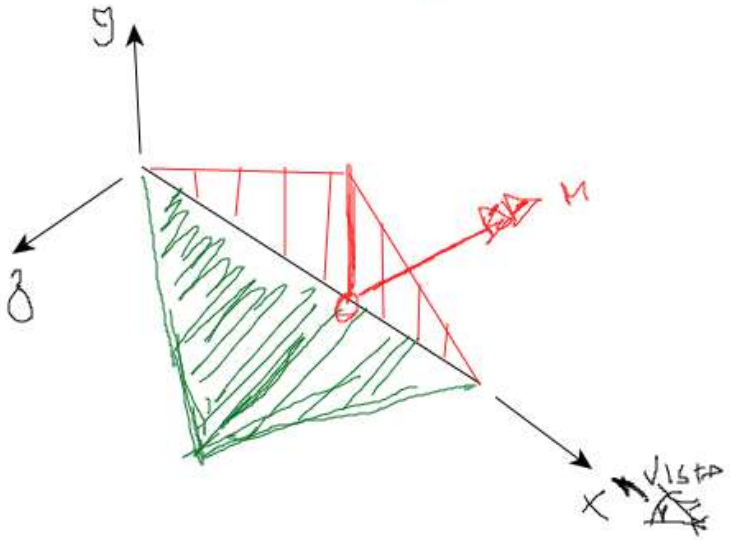
conv. R.H.

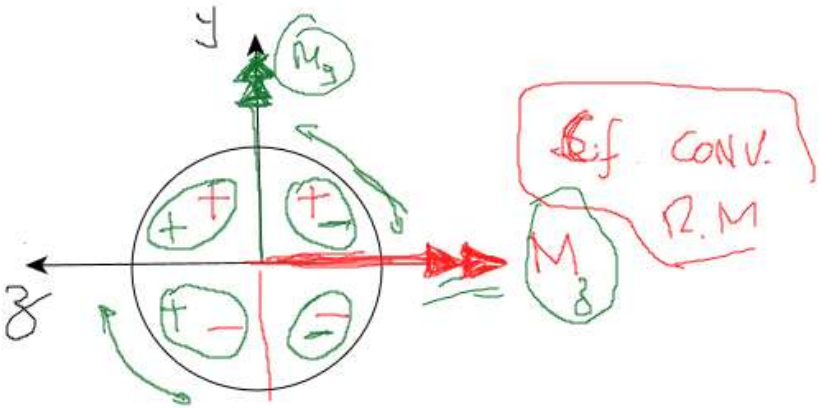
$$\sigma_P = \frac{42 \cdot y_P}{I_{zz}} + \frac{115 \cdot z_P}{I_{yy}}$$

$$\sigma_Q = \frac{42\, y_Q}{I_{zz}} + \frac{115\, z_Q}{I_{yy}}$$


y
R_A
traccionado
R_B
x
comprim.do
F

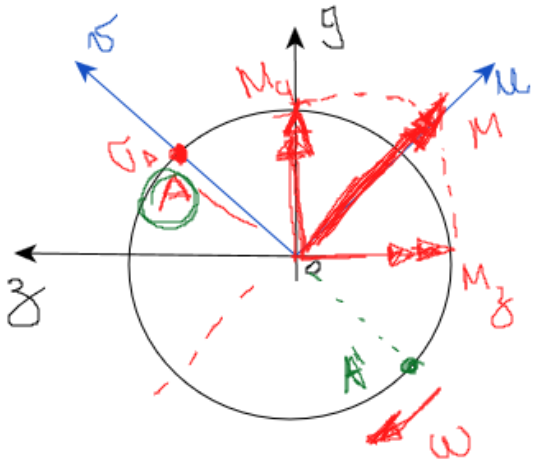

M


y
M
z
x
vista


y
M_y
C.f CONV.
R.M
M_z
z

Qual a máxima tensão normal?

Apenas para eixo S.T. Circular



η, ζ – eixos principais

ξ, ψ – eixos principais

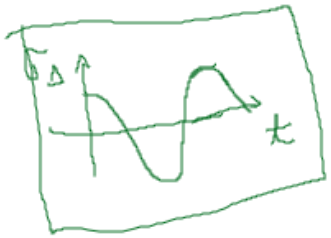
$$M = \sqrt{M_\zeta^2 + M_\eta^2}$$

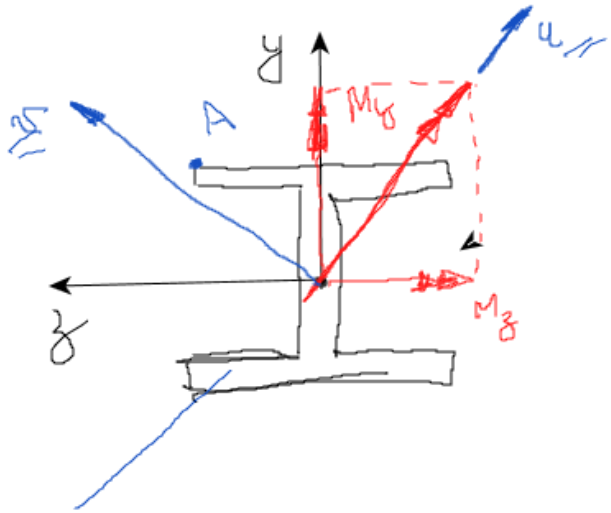
σ_Δ = Máxima Tensão normal

$$\sigma_\Delta = \frac{M}{I_{\mu\mu}} \cdot \frac{d}{2}$$

$$I_{\mu\mu} = \frac{\pi d^4}{64}$$

$$\sigma_\Delta = \frac{32\,M}{\pi d^3}$$





$$\sigma_\Delta = \frac{M_z}{I_{zz}} \cdot y_\Delta + \frac{M_y}{I_{yy}} \cdot z_\Delta$$

σ_{max}

Não Fazer!

$$M = \sqrt{M_y^2 + M_z^2} \Rightarrow$$

$$\sigma_\Delta = \frac{M}{I_{uu}} \cdot \eta_\Delta$$

$I_{uu} = ?$

I_{zz} e I_{yy} → Tabelados

Cálculo rápido

Exemplo $M_y = 42\ Nm$ $d = 25\ mm$

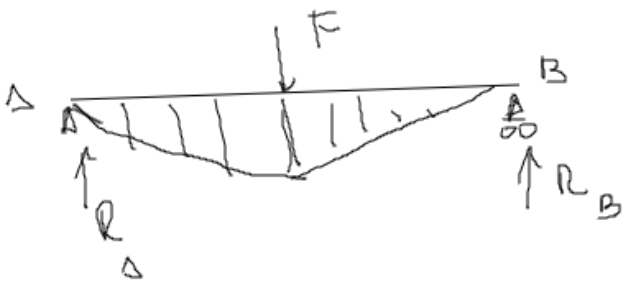
$M_z = 115\ Nm$

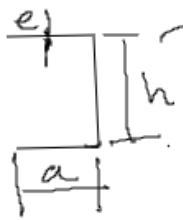
$$M = \sqrt{42^2 + 115^2} = 122{,}5\ Nm = 122{,}5 \cdot 10^3\ N \cdot mm$$

$$\sigma_{Max} = \frac{32\,M}{\pi\, d^3} \Rightarrow \sigma_{max} = \frac{32 \cdot 122{,}5 \cdot 10^3}{\pi\,(25)^3} \simeq 80\ N/mm^2$$

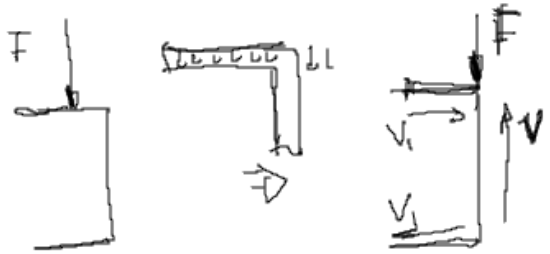
$1\ N/mm^2 = 1\ MPa$

$$\boxed{\sigma_{Max} = 80\ MPa}$$





S.T. Perfil aberto
Paredes finas
$e \ll a$
$e \ll h$



Flexão + Torcional

Lá não há eq. no cisalhamento

Centro de Torção ou Centro de Cisalhamento