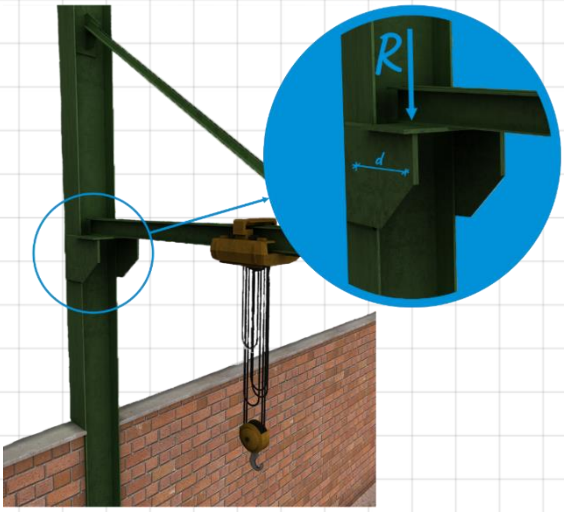
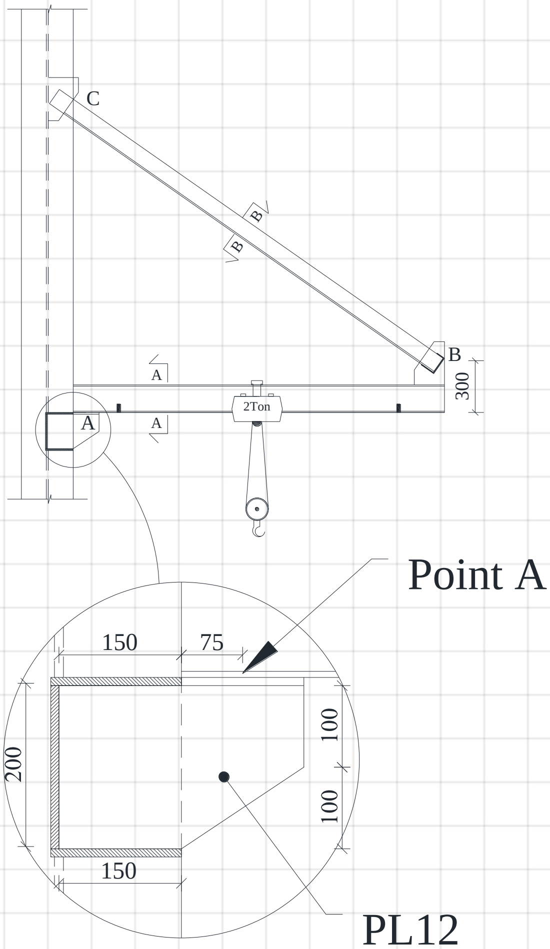
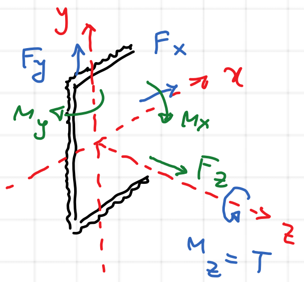
How to calculate the stresses on the critical point of the weld?



The previous videos on calculating weld properties and transferring the applied actions on the centroid of the weld were just a warmup. It is time to go one step further to calculate the stresses on the critical points of the weld.

This video will use multiple examples of calculating shear and normal stresses. These stresses can be caused by a torsional, bending moment, or normal and shear forces.





F_x & F_y → planar forces → Shear stresses (τ)

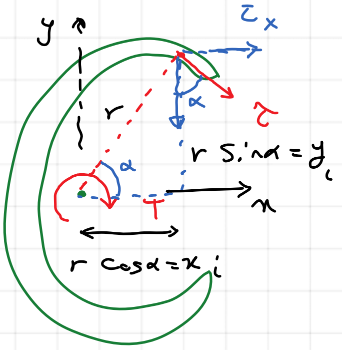
F_z → tension/compression → Axial action (σ)

M_x & M_y → Bending moments around planar axis → (σ)

T → Moment about perpendicular axis → shear stress → (τ)

$$\sigma_{(z)} = \frac{F_z}{A_w} \quad , \quad \sigma_{(z)} = \frac{M_x \, y_i}{I_x} \quad , \quad \sigma_{(z)} = \frac{M_y \, x_i}{I_y}$$

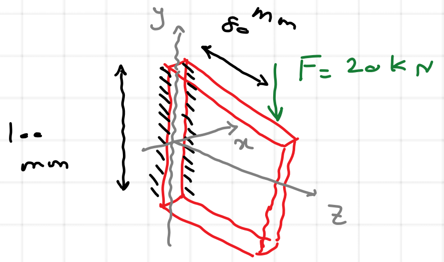
$$\tau_x = \frac{F_x}{A_w} \quad , \quad \tau_y = \frac{F_y}{A_w}$$



$$\tau = \frac{T\,r}{I_p}$$

$$\tau_x = \tau \sin\alpha = \frac{T\,r \sin\alpha}{I_p} = \frac{T \cdot y}{I_p}$$

$$\tau_y = \tau \cdot \cos\alpha = \frac{T \cdot r \cdot \cos\alpha}{I_p} = \frac{T\,x}{I_p}$$



$$F_y = 20\ kN \quad (\downarrow)$$

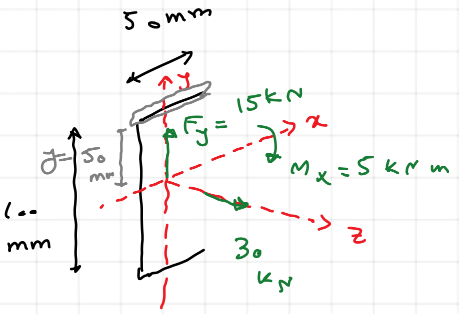
$$M_x = 20kN \times 0.08\ m = 1.6\ (kN \cdot m)$$

$$A_w = 2 \cdot t \cdot 100^{mm} = 200\ t \quad (mm^2)$$

$$I_x = \frac{2 \times t \times (100\ mm)^3}{12} = 1.67 \times 10^5\ t \quad (mm^4)$$

$$\tau_{(F_y)} = \frac{20000\ (N)}{200\ t\ (mm^2)} = \frac{100}{t} \quad (MPa)$$

$$\sigma_{(M_x)} = \frac{1.6 \times 10^6\ (N \cdot mm)}{1.67 \times 10^5\ t\ (mm^4)} = \frac{9.6}{t} \quad (MPa)$$



$$A_w = (50\ mm \times 2 + 100\ mm) \cdot t = 200\ t \quad (mm^2)$$

$$I_x = 2\left(0 + 50\ mm \times t \times (50\ mm)^2\right) + \frac{t \times (100\ mm)^3}{12} = 3.33 \times 10^5\ t \quad (mm^4)$$

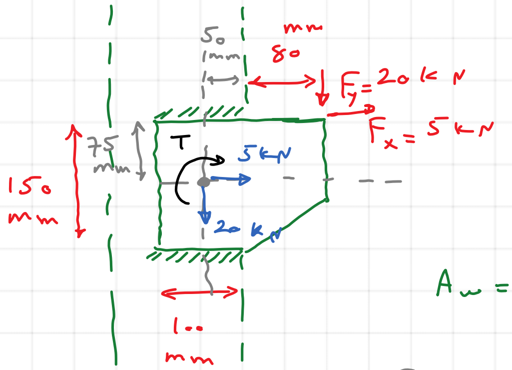
$$\tau_y = \frac{F_y}{A_w} = \frac{15000\ N}{200\ t\ (mm^2)} = \frac{75}{t} \quad MPa \quad (\uparrow)$$

$$\sigma_{(F_z)} = \frac{F_z}{A_w} = \frac{30000\ N}{200\ t\ (mm^2)} = \frac{150}{t} \quad (MPa) \quad (T)$$

max tension → $y = 50$ mm

$$\sigma_{(M_x)} = \frac{M_x\, y_1}{I_x} = \frac{5\ kN \cdot m\ \ y}{3.33 \times 10^5\ t} = \frac{15}{t} \cdot y \quad (MPa) = \frac{750}{t} \quad (MPa) \quad (T)$$

$$\tau_y = \frac{75}{t} \quad (MPa)\ (\uparrow) \qquad \sigma_z = \frac{150}{t} + \frac{750}{t} = \frac{900}{t} \quad (MPa) \quad (T)$$



$$T = 20\,kN \times 130\,mm + 5\,kN \times 75\,mm = 6.6\,kN\,m$$

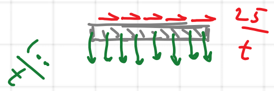
$$A_w = 2 \times 100\,mm \times t = 200\,t \quad (mm^2)$$

$$I_x = 2 \times \left(0 + 100\,mm\; t \times (75\,mm)^2\right) = 1125000\,t \quad (mm^4)$$

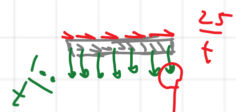
$$I_y = 2 \times \left(t \times (100\,mm)^3 / 12 \right) = 1.67 \times 10^5\,t \quad (mm^4)$$

$$I_p = I_x + I_y = 1.12 \times 10^6\,t \quad (mm^4)$$

$$F_x = 5\,kN \rightarrow \quad \tau_x = \frac{F_x}{A_w} = \frac{5000\,N}{200\,t\,mm^2} = \frac{25}{t} \quad (MPa) \rightarrow$$

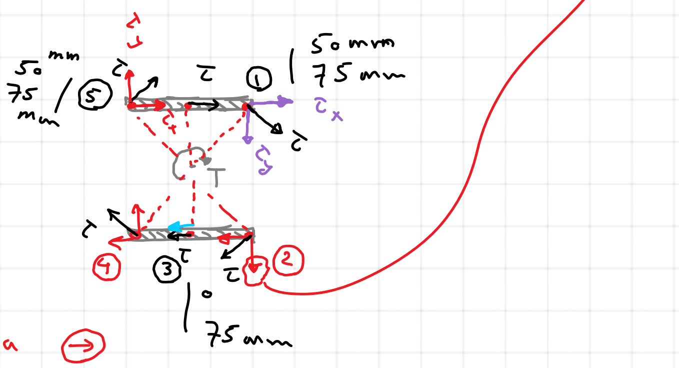


$$F_y = 20\,kN \rightarrow \quad \tau_y = \frac{F_y}{A_w} = \frac{20000\,N}{200\,t\,mm^2} = \frac{100}{t} \quad (MPa) \downarrow$$



$$\tau_x = \frac{T\,y}{I_p} \qquad \tau_y = \frac{T\,x}{I_p} \qquad \begin{cases} T = 6.6\,kN\cdot m \\ I_p = 1.12 \times 10^6\,t \quad (mm)^4 \end{cases}$$

$$\begin{cases} \tau_{x\,(T)} = \frac{5.9}{t} \cdot y \\ \tau_{y\,(T)} = \frac{5.9}{t} \cdot x \end{cases}$$



$$① \rightarrow \quad \tau_x = \frac{5.9 \times 75\,mm}{t} = \frac{442.5}{t} \quad MPa \; (\rightarrow)$$

$$\tau_y = \frac{5.9 \times 50\,mm}{t} = \frac{295}{t} \quad MPa \; (\downarrow)$$

$$\tau_x = \tau_{x(F_x)} + \tau_{x(T)} = \frac{25 + 442.5}{t} = \frac{467.5}{t} \quad (MPa)$$

$$\tau_y = \tau_{y(F_y)} + \tau_{y(T)} = \frac{100 + 295}{t} = \frac{395}{t} \quad (MPa)$$