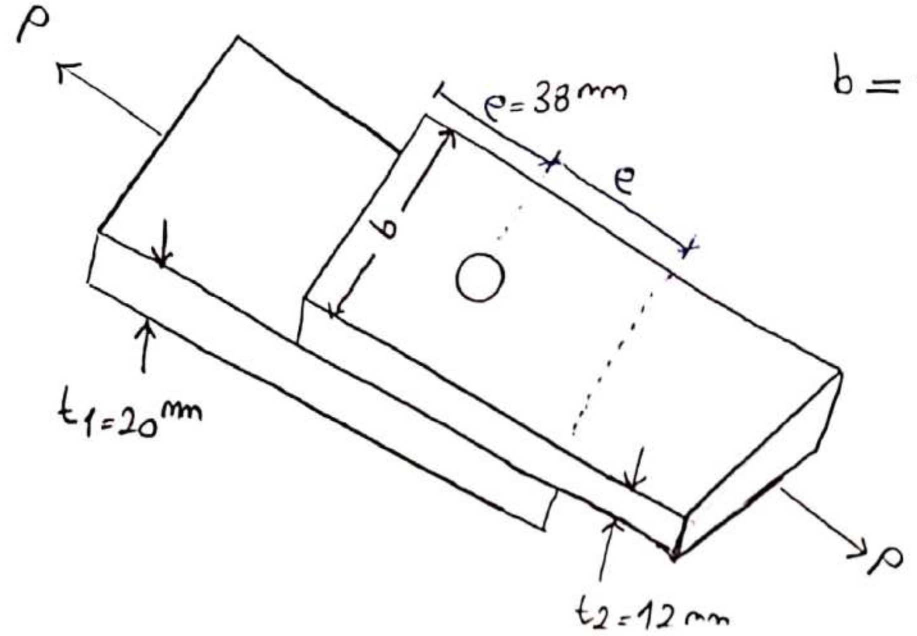
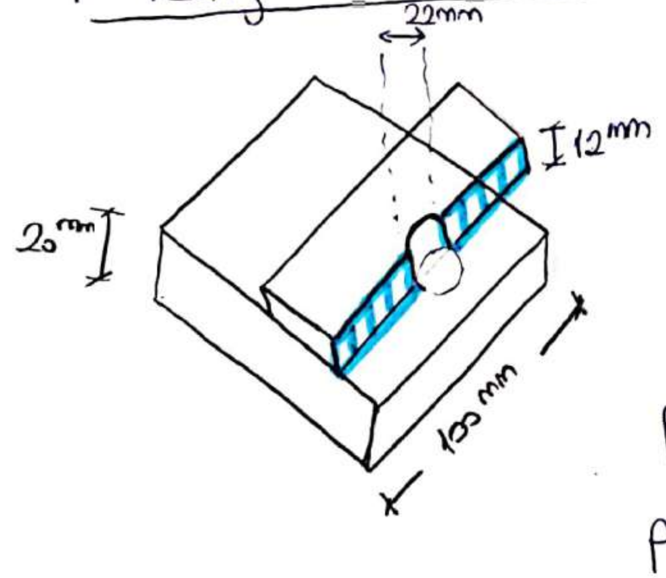
## Example:




$b = 100^{mm}$

Determine the largest "P" load that can be applied to the plates of the lap joint shown in the figure. The bolt has a diameter of 22 mm. Each plate has an allowable tensile and compressive (bearing stress) of 140 MPa and 280 MPa, respectively ($\sigma_{allow}$) ($\hat{\sigma}_{allow}$) and $\tau_{allow} = 100$ MPa.

### 1– Tearing of the plate:




$$A_1 = (b - d)t$$

$$A_1 = (100 - 22)^{mm} \cdot 12^{mm}$$

$$A_1 = 936 \text{ mm}^2$$

$$P_1 \leq (\sigma_{allow})(A_1)$$

$$P_1 \leq (936^{mm^2} * 140^{MPa}) \leq 131 \times 10^3 \text{ N}$$

$$P_1 \leq 131 \text{ kN}$$

2- Shearing of the bolt: For the single shear, the area of the bolt subjected to shear is calculated as:

$$P_2 \le \tau_{allow} \cdot A_1$$

$$P_2 \le 100^{MPa} \cdot \underbrace{(\pi \cdot r^2)}_{380\ mm^2} \qquad r \to 11^{mm}$$

$$P_2 \le 38 \times 10^3 N$$

$$P_2 \le 38\ kN$$

3- Crushing of the rivet (bolt):

$$t_{min} = \min[\overset{20^{mm}}{t_1}, \overset{12^{mm}}{t_2}] \Rightarrow \text{minimum thickness}$$

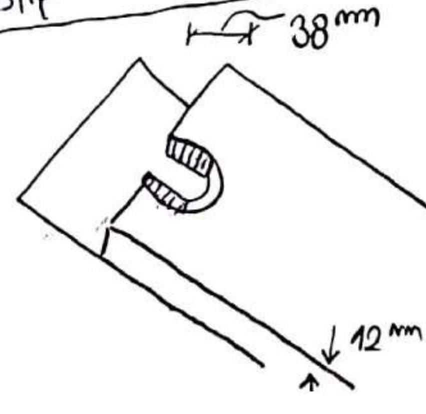
the area of cross-section $A_3 = t_{min} \cdot d$

$$P_3 \le (t_{min} \cdot d)(\sigma_{allow})$$

$$\le (12^{mm})(22^{mm})(280\ MPa)$$

$$P_3 \le 74\ kN$$

4- Slip on the edge of plate hole:




$$A_4 = 2(38 * 12)$$

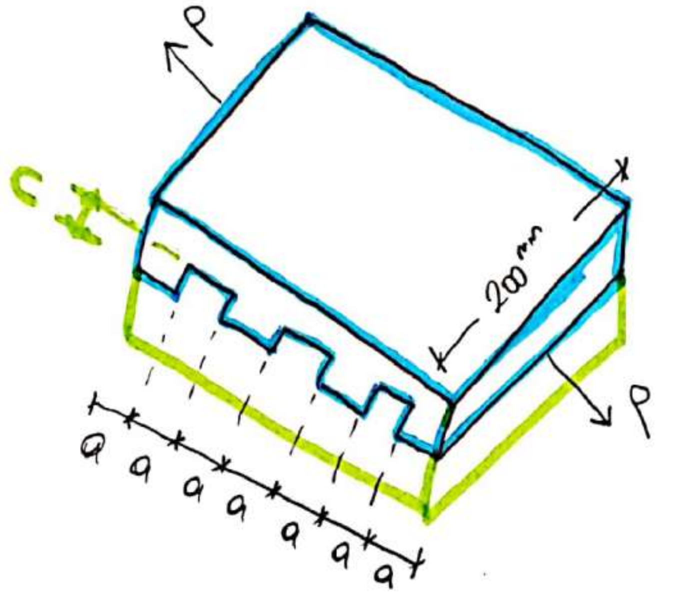
$$A_4 = 912\ mm^2$$

$$P_4 \le 912 * (\overset{\tau_{allow}}{100})$$

$$P_4 \le 91,2\ kN$$

$$\boxed{P \leq 38 \text{ kN}}$$

Example: Determine the largest "P" load that can be apelled to the joint shown in Figure. An allowable compressive (bearing) stress of 12 MPa, an allowable shear stress of 2 MPa.




$a = 120$ mm

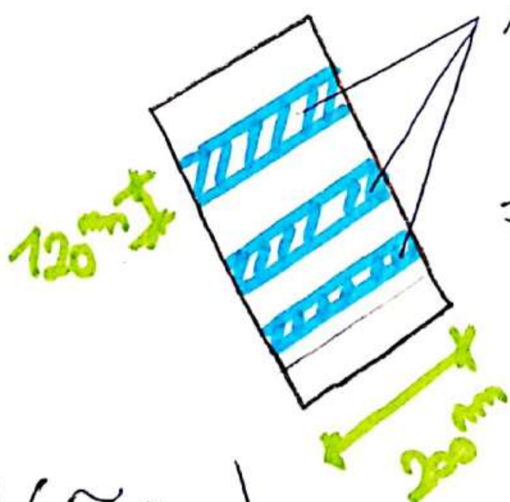
$c = 60$ mm

The number of parts under shear

→ 4 in the upper piece

→ $\boxed{3 \text{ in the below piece}}$

So the calculations are performed with respect to the **weakest** piece.




$A_{shear} = 200 \times 120$
$= 240$ cm$^2$

Faces subjected to shear are shaded.

$$P \leq (3 * A_{shear})(\tau_{allow})$$

$$P \leq 144 \times 10^3 \text{ N} \; ; \; \leq \underline{\underline{144 \text{ kN}}}$$

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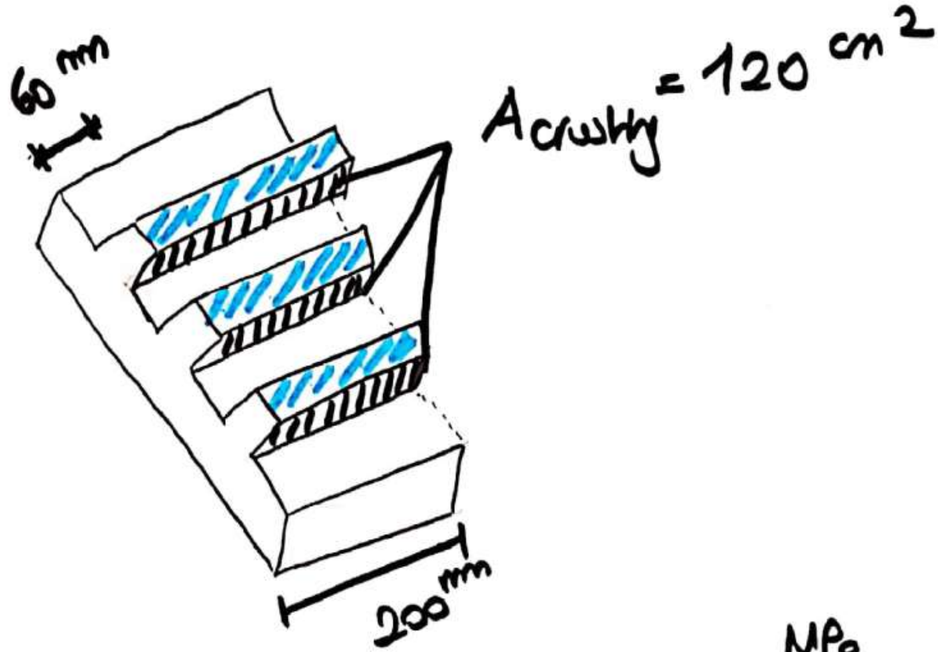
Faces subjected to crushing are shaded as follows:



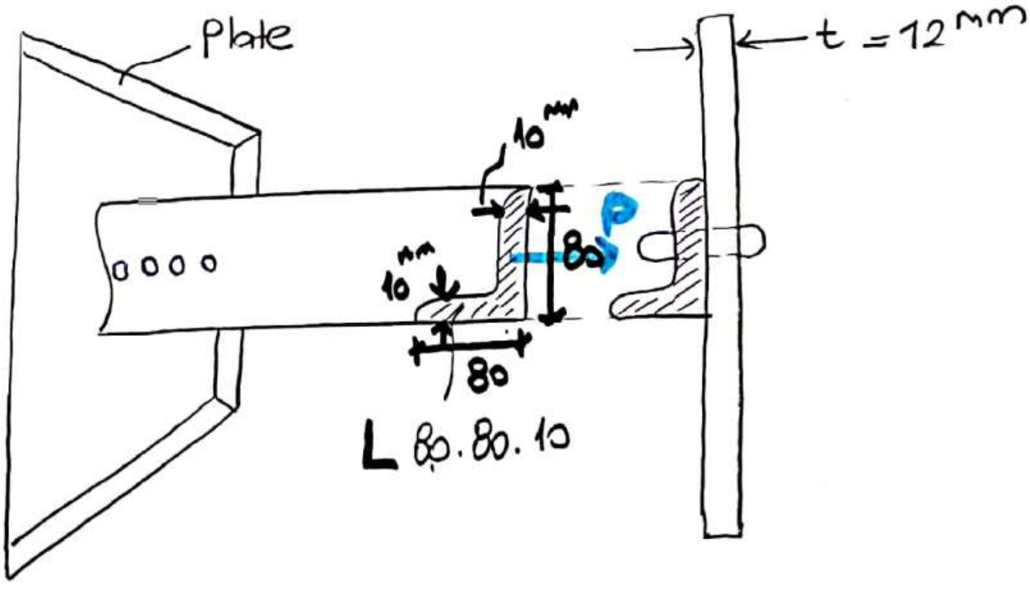

$$P \le (6 * 12000^{mm^2})\underbrace{(12)}_{\hat{\sigma}_{allow}}^{\sim MPa}$$

$$P \le 864 \times 10^3 \ N$$

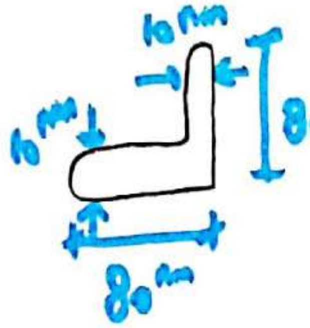
$$P \le \underline{\underline{864 \ kN}}$$

$$\underline{\underline{P_{max} \le 144^{kN}}}$$

Example:



The figure shows a tension bar connected to the plate using 4 numbers of rivets with 18 mm diameter. The thickness of the plate is $t = 12^{mm}$. If the allowable shear stress and compressive stress are $\boxed{140}$ mpa and 280 mpa, respectively and the load $P = 120$ kN, check possible failure conditions.




$80.80.10^{mm}$

1- Shearing of the rivet : " Single shear"

$$P_{shear} \leq \tau_{allow} \cdot A \quad \pi r^2 ; \pi d^2/4$$

$$P_{shear} \leq (14^{kN/cm^2}) \left( \frac{\pi . 1,8^2}{4} \right)$$

$$\boxed{P_{shear} \leq 35,6 \text{ kN}}$$

2- Crushing of the rivet :

$$t_{min} = \min \left[ \begin{matrix} t_{plt}, & t_{(L\ section)} \\ 12^{mm}, & 10^{mm} \end{matrix} \right] = 10^{mm}.$$

$$P_{crushing} \leq t_{min} \cdot d \cdot \hat{\sigma}_{allow}$$

$$\leq (1^{cm}) (1,8^{cm}) (28)^{kN/cm^2}$$

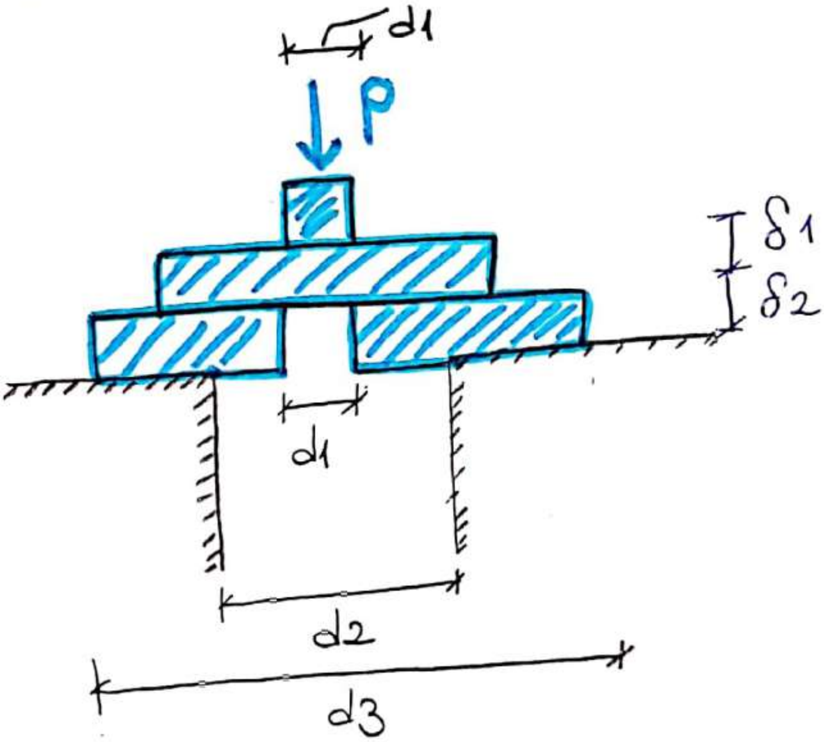
$$\boxed{P_{crushing} \leq 50,4 \text{ kN}}$$

4 rivets for the Joint ;

$$4 * 35,6 = 142,4 \text{ kN} > P = 120 \text{ kN}$$

there is no need to add rivets for this Joint.
The number of rivets is enough

Example:

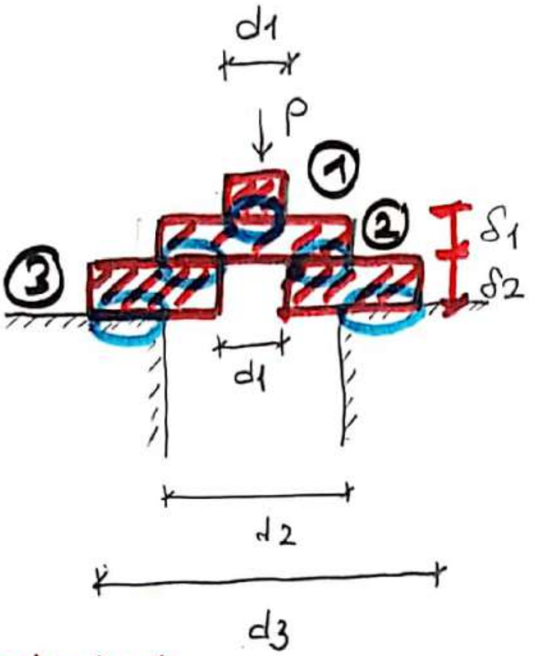



$\tau_{allow} = 80$ mPa
$\hat{\sigma}_{allow} = 180$ mPa

$P = 250$ kN
$d_1, d_2, d_3$ and $\delta_1, \delta_2 = ?$

For the arrangement shown in figure, 3 cylinders are positioned.
The cylinder on the bottom has an hole with a diameter d1.
This arrangement is under the effect of P load ; P = 250 kN

HW:




$P = 250$ kN

$\tau_{allow} = 80$ MPa

$\sigma_{allow} = 180$ MPa

the (red colored / hatched) parts

Shear: For the $2^{nd}$ : $(\pi \cdot \delta_1 \cdot d_1)(\tau_{allow})$

$\hookrightarrow P \leq (\pi \cdot d_1 \cdot \delta_1)\, \tau_{allow}$

$$\frac{250}{\pi \cdot \delta_1 \cdot d_1} \leq 8 \quad \cdots (1)$$

For the $3^{rd}$ : $P \leq (\pi \cdot d_2 \cdot \delta_2)\, \tau_{allow}$

$$\frac{250}{\pi \cdot \delta_2 \cdot d_2} \leq 8 \quad \cdots (2)$$

blue parts

Crushing: $1^{st}$ : $\dfrac{250}{\pi \cdot d_1^2/4} \leq 18$ ; $d_1 \geqslant 4{,}21$ cm (3)

$2^{nd}$ : $\dfrac{250}{\pi (d_2^2 - d_1^2)/4} \leq 18$ $d_2 \geqslant 5{,}95$ cm (4)

(1)

$3^{rd}$ : $\dfrac{250}{\pi \dfrac{(d_3^2 - d_2^2)}{4}} \leq 18$ ; $d_3 \geqslant 7,29$ cm (5)

$$\left.\begin{aligned} \delta_1 &\geqslant 2,37 \text{ cm} \\ \delta_2 &\geqslant 1,67 \text{ cm} \end{aligned}\right\} \text{From (1) and (2)}$$