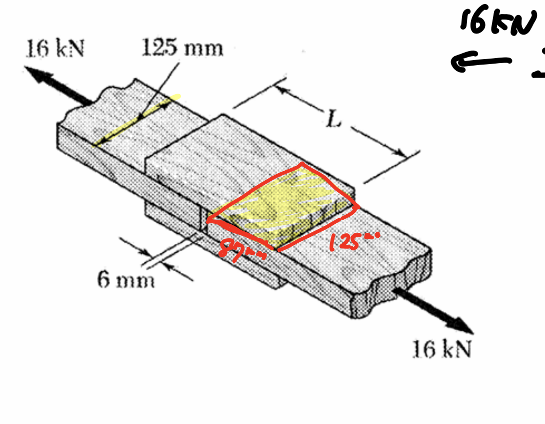
Q1 For the joint and loading of Prob. **Q1**, determine the factor of safety, knowing that the length of each splice is $L = 180$ mm.

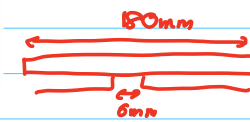
The two wooden members shown, which support a 16-kN load, are joined by plywood splices fully glued on the surfaces in contact. The ultimate shearing stress in the glue is 2.5 MPa and the clearance between the members is 6 mm. Determine the required length L of each splice if a factor of safety of 2.75 is to be achieved.



$P = \frac{16kN}{2} = 8kN$

$= 8000\,N$

Step 1: Length of glued part.



$(180^{mm} - 6^{mm})/2$

$= 87^{mm}$

Step 2: Area of glued part ⇒ $87^{mm} \times 125^{mm} = 10875\,mm^2$

Step 3: Ultimate shear load ⇒ ← P_u $\qquad \tau_u = \frac{P_u}{A}$

Ultimate shear stress ⇒ 2.5 MPa ← τ_u

Area ⇒ $10875\,mm^2$ ← A

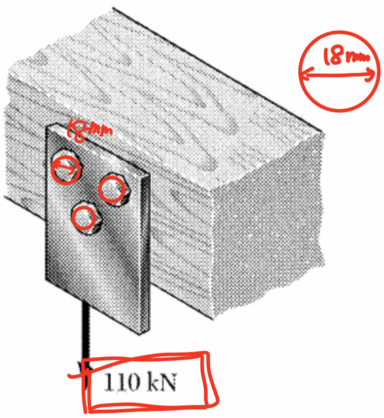
$\tau_u = \frac{P_u}{A} \qquad P_u = \tau_u \cdot A = 2.5^{MPa\,(N/mm^2)} \cdot 10875^{mm^2}$ ultimate load

$= 27187.5\,N$ $\quad P_u$

Step 4: Factor of safety ⇒ $F.S = \frac{P_u}{P} = \frac{27187.5^N}{8000^N} = 3.40$

Factor of Safety is 3.4

Three 18-mm-diameter steel bolts are to be used to attach the steel plate shown to a wooden beam. Knowing that the plate will support a 110-kN load and that the ultimate shearing stress for the steel used is 360 MPa, determine the factor of safety for this design.



Step 1: determine the Area of bolt for each

$\Rightarrow (9^{mm})^2 \cdot \pi = 254.47 mm^2$

$= 254.5 mm^2$

Step 2: Ultimate shearing load (P_u)?

Ultimate shear stress (τ_u) $\Rightarrow$ 360MPa

Area (A) $\Rightarrow 254.5 mm^2$

$\tau_u = \frac{P_u}{A} \Rightarrow P_u \Rightarrow 360^{N/mm^2} \cdot 254.5^{mm^2}$

$\Rightarrow 91,620 N$

$= 91.6 kN$ ← /each bolt.

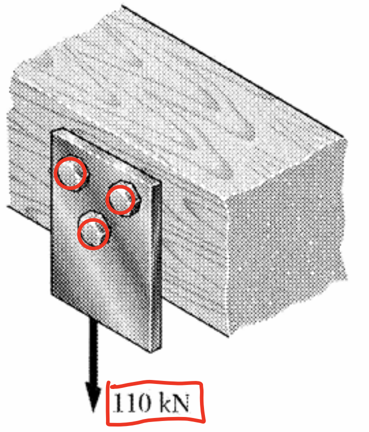
Step3: There are 3bolts, so total Ultimate shear load is

$\Rightarrow 91.6^{kN} \times 3^{bolts} = 274.8^{kN}$

Step4: Factor of safety $F.S = \frac{P_u}{P} = \frac{274.8^{kN}}{110^{kN}} = 2.50$

Factor of safety is 2.5

Three steel bolts are to be used to attach the steel plate shown to a wooden beam. Knowing that the plate will support a 110 kN load, that the ultimate shearing stress for the steel used is 360 MPa, and that a factor of safety of 3.35 is desired, determine the required diameter of the bolts.



Step1: Actual applied on each bolt ... ?

$P = 110^{kN}/3 = 36.67^{kN}$

Step2: Ultimate shear load with F.S as 3.35

$F.S = \frac{P_u}{P}$ (F.S = 3.35, P = 36.67 kN)

$P_u = F.S \times P$

$= 3.35 \times 36.67^{kN}$

$= 122.84^{kN}$

(Ultimate shear stess)

Step3: Area by τ_u and P_u

360^{MPa} $\tau_u = \frac{P_u}{A} = \frac{122.84^{kN}}{A\ mm^2} = \frac{122840^{N}}{A^{mm^2}}$

$A = \frac{P_u}{\tau_u} = \frac{122840^{N}}{360^{N/mm^2}}$

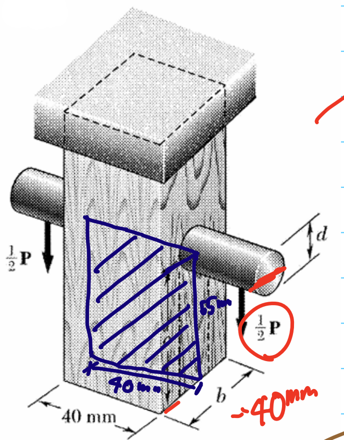
$= 341.22mm^2$

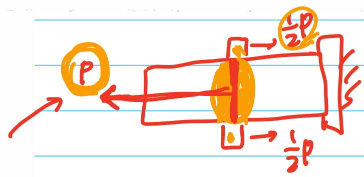
Step4: Get diameter.

$A = \left(\frac{d}{2}\right)^2 \cdot \pi \qquad 341.22 = \left(\frac{d}{2}\right)^2 \pi \qquad 341.22 = \frac{d^2}{4}\pi$

$d = \sqrt{\frac{341.22 \cdot 4}{\pi}} = 20.84^{mm} = 20.8mm$

A load **P** is supported as shown by a steel pin that has been inserted in a short wooden member hanging from the ceiling. The ultimate strength of the wood used is 60 MPa in tension and 7.5 MPa in shear, while the ultimate strength of the steel is 145 MPa in shear. Knowing that $b = 40$ mm, $c = 55$ mm, and $d = 12$ mm, determine the load **P** if an overall factor of safety of 3.2 is desired.





double shear

Step 0: Area of steel bar

$A = (6)^2\pi = 113.1 \text{ mm}^2$

steel bar

Step 1: Ultimate shear load for steel bar

145 MPa

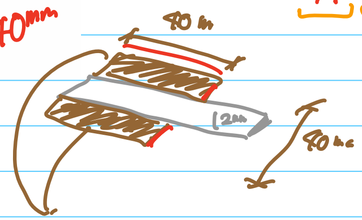
$\tau_u = \frac{P_u}{A} = \frac{P_u}{2}$; $A \leftarrow 113.1 \text{ mm}^2$

$P_u = \tau_u \cdot A \cdot 2$ ← double

$= 145 \text{ N/mm}^2 \cdot 113.1 \text{ mm}^2 \cdot 2$

$= 32799$ N

$\doteq 32.8$ kN



wooden part

Step 2: Determine the Area of wooden part suffered most.

$A \Rightarrow (40^{mm} - 12^{mm}) \cdot 40^{mm} = 1120 \text{ mm}^2$

Normal / axial load

Step 3: Ultimate load for wooden part.

60 MPa

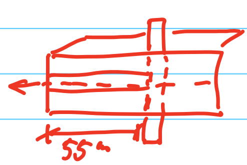
$\sigma_u = \frac{P_u}{A}$; $A \leftarrow 1120 \text{ mm}^2$

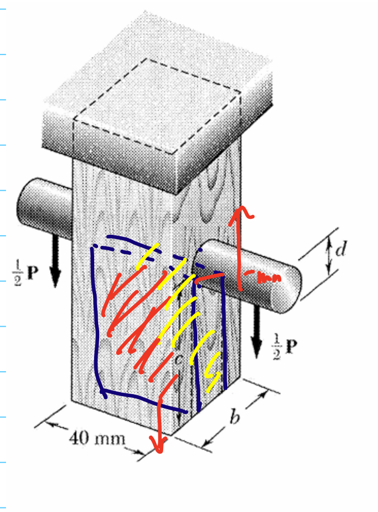
$P_u = 60 \text{ N/mm}^2 \cdot 1120 \text{ mm}^2$

$= 67200$ N

$= 67.2$ kN

Step 4: Shear stress in wooden part





Step4: Shear stress for wooden member

$$Area = 55^{mm} \cdot 40^{mm} = 22000^{mm^2}$$

Step5: Ultimate shear load for wooden member

$$\tau_u = \frac{P_u}{A} \qquad \tau_u = \frac{P_u}{2A} \qquad P_u = 7.5 \cdot 2 \cdot 22000 = 33000^{N} = 33^{kN}$$

(τ_u = 7.5 MPa, A = 22 000 mm^2)

steel bar, wooden member

steel bar	wooden member: Normal	wooden member: Shear
P_u 32.8 kN	67.2 kN	33 kN

Step 5: Use minimum Ultimate load to get allowable load.

$$P = \frac{P_u}{F.S} = \frac{32.8^{kN}}{3.2} \qquad P_{all} = 10.25\ kN$$