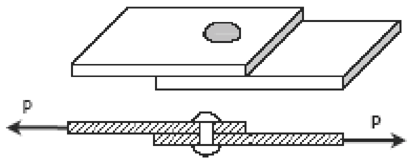
Shearing Stress

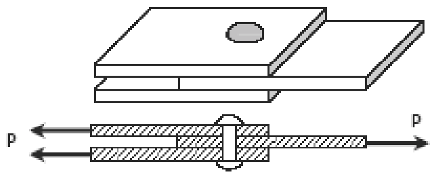
Forces parallel to the area resisting the force cause shearing stress. It differs to tensile and compressive stresses, which are caused by forces perpendicular to the area on which they act. Shearing stress is also known as tangential stress.

$$\tau = \frac{V}{A}$$

where (V) is the resultant shearing force which passes which passes through the centroid of the area A being sheared.



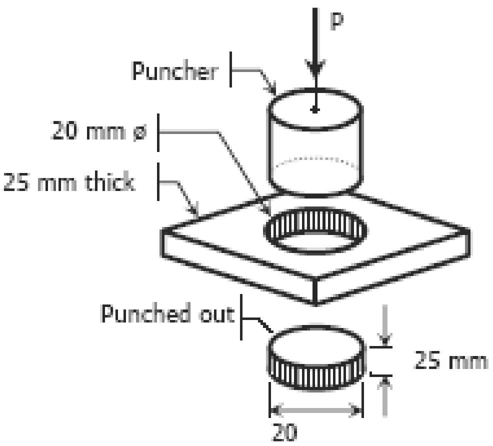
Single Shear



Double Shear

Problem 1: What force is required to punch a 20-mm-diameter hole in a plate that is 25 mm thick? The shear strength is 350 MN/m^2.

Solution:



The resisting area is the shaded area along the perimeter and the shear force *V* is equal to the punching force *P*.

$$V = \tau A$$

$$P = 350[\pi(20)(25)]$$

$$= 549\ 778.7\ \text{N}$$

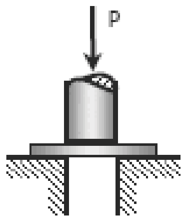
$$= \mathbf{549.8\ kN}$$

Problem 2: As in Fig, a hole is to be punched out of a plate having a shearing strength of 40 ksi. The compressive stress in the punch is limited to 50 ksi.

(**a**) Compute the maximum thickness of plate in which a hole 2.5 inches in diameter can be punched.

(**b**) If the plate is 0.25-inch-thick, determine the diameter of the smallest hole that can be punched.

Solution:



(a) Maximum thickness of plate:

Based on puncher strength:

$P = \sigma A$

$= 50[\frac{1}{4}\pi(2.5^2)]$

$= 78.125\pi$ kips → Equivalent shear force of the plate

Based on shear strength of plate:

$V = \tau A$ → V = P

$78.125\pi = 40[\pi(2.5t)]$

$t = 0.781$ inch

(b) Diameter of smallest hole:

Based on compression of puncher:

$P = \sigma A$

$= 50(\frac{1}{4}\pi d^2)$

$= 12.5\pi d^2$ → Equivalent shear force for plate

Based on shearing of plate:

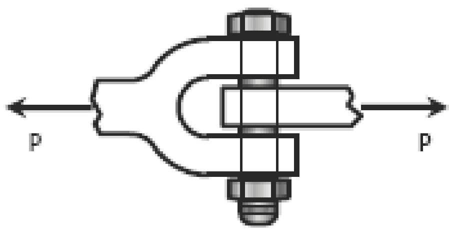
$V = \tau A$ → V = P

$12.5\pi d^2 = 40[\pi d(0.25)]$

$d = 0.8$ **in**

Problem 3: Find the smallest diameter bolt that can be used in the clevis shown in Fig if P = 400 kN. The shearing strength of the bolt is 300 MPa.

Solution:



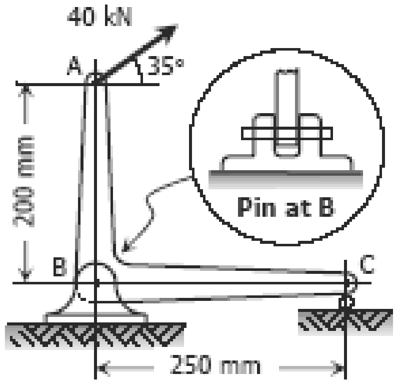
The bolt is subject to double shear.

$V = \tau A$

$400(1000) = 300[2(\frac{1}{4}\pi d^2)]$

$d = 29.13$ mm

Problem 4: Compute the shearing stress in the pin at B for the member supported as shown in Fig. P-119. The pin diameter is 20 mm.



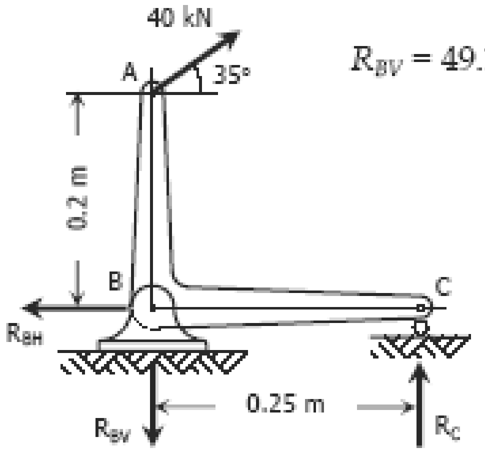
Solution

From the FBD:

$\Sigma M_C = 0$

$0.25R_{BV} = 0.25(40 \sin 35°) + 0.2(40 \cos 35°)$

$R_{BV} = 49.156$ kN



Free Body Diagram

$\Sigma F_H = 0$

$R_{BH} = 40 \cos 35°$

$= 32.766$ kN

$R_B = \sqrt{R_{BH}^2 + R_{BV}^2}$

$= \sqrt{32.766^2 + 49.156^2}$

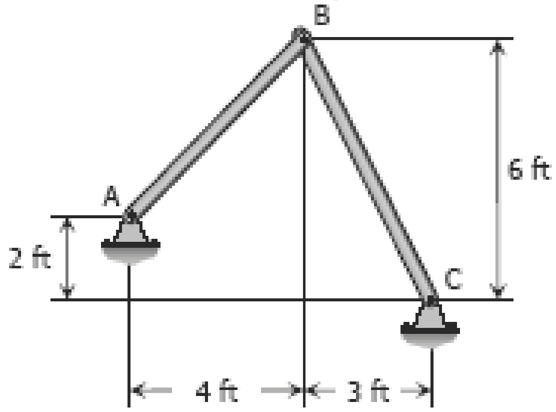
$= 59.076$ kN → shear force of pin at B

$V_B = \tau_B A$ → double shear

$59.076\,(1000) = \tau_B \{2[\frac{1}{4}\pi(20^2)]\}$

$\tau_B = 94.02$ **MPa**

Problem 5: The members of the structure in Fig weigh 200 lb/ft. Determine the smallest diameter pin that can be used at A if the shearing stress is limited to 5000 psi. Assume single shear.



Solution:

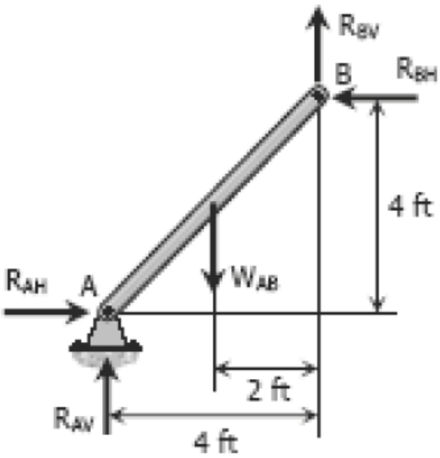
For member AB:

Length, $L_{AB} = \sqrt{4^2 + 4^2}$

$= 5.66$ ft

Weight, $W_{AB} = 5.66(200)$

$= 1132$ lb



FBD of member

$\Sigma M_A = 0$

$4R_{BH} + 4R_{BV} = 2W_{AB}$

$4R_{BH} + 4R_{BV} = 2(1132)$

$R_{BH} + R_{BV} = 566 \quad \rightarrow (1)$

For member BC:

Length, $L_{BC} = \sqrt{3^2 + 6^2}$

$= 6.71$ ft

Weight, $W_{BC} = 6.71(200)$

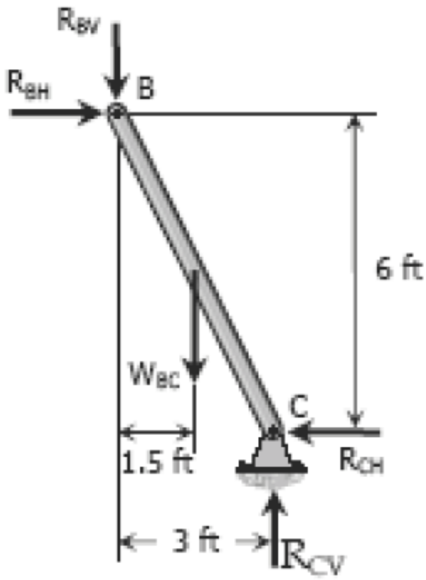
$= 1342$ lb

$\Sigma M_C = 0$

$6R_{BH} = 1.5W_{BC} + 3R_{BV}$

$6R_{BH} - 3R_{BV} = 1.5(1342)$

$2R_{BH} - R_{BV} = 671 \quad \rightarrow (2)$



FBD of member BC

Add equations (1) and (2)

$$R_{BH} + R_{BV} = 566 \quad \rightarrow (1)$$

$$2R_{BH} - R_{BV} = 671 \quad \rightarrow (2)$$

$$3R_{BH} = 1237$$

$$R_{BH} = 412.33 \text{ lb}$$

From equation (1):

$$412.33 + R_{BV} = 566$$

$$R_{BV} = 153.67 \text{ lb}$$

From the FBD of member *AB*

$$\Sigma F_H = 0$$

$$R_{AH} = R_{BH} = 412.33 \text{ lb}$$

$$\Sigma F_V = 0$$

$$R_{AV} + R_{BV} = W_{AB}$$

$$R_{AV} + 153.67 = 1132$$

$$R_{AV} = 978.33 \text{ lb}$$

$$R_A = \sqrt{R_{AH}{}^2 + R_{AV}{}^2}$$

$$= \sqrt{412.33^2 + 978.33^2}$$

$$= 1061.67 \text{ lb} \quad \rightarrow \text{shear force of pin at A}$$

$$V = \tau A$$

$$1061.67 = 5000(\tfrac{1}{4}\pi d^2)$$

$$\mathbf{d = 0.520 \text{ in}}$$