

Pb - 104

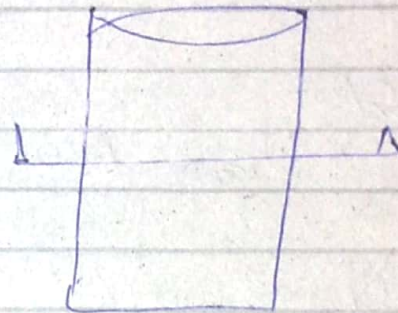
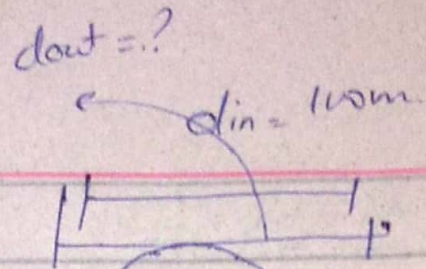
Given data

$$\sigma = 120 \text{ MPa}$$

$$d_{in} = 100 \text{ mm}$$

$$d_{out} = ?$$

$$P = 400 \text{ kN}$$



Sol:- Since;

$$\sigma = \frac{P}{A}$$

$$A = \frac{P}{\sigma}$$

$$\frac{\pi}{4} (D_{out}^2 - D_{in}^2) = \frac{400 \times 10^3}{120}$$

$$\pi (D_{out}^2 - (100)^2) = 13333.33$$

$$D_{out}^2 = 14246.28$$

$$D_{out} = 119.35 \text{ mm} \quad \text{Ans}$$

Pb-105

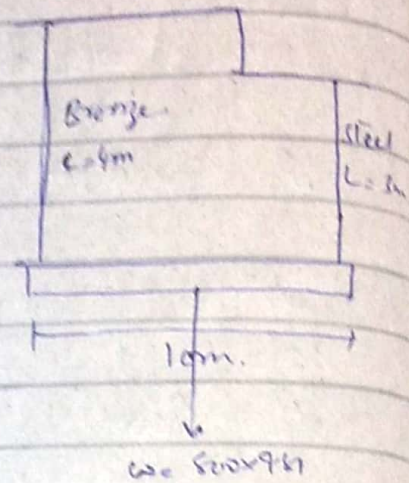
Bar $W = 800 \text{ kg}$

Area = ?

9 each cable

$\sigma_{Br} = 90 \text{ MPa}$

$\sigma_{St} = 120 \text{ MPa}$



$$= 7848$$

Soln

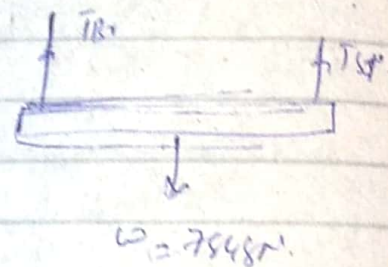
Draw FBD of beam.

$$\sum F_y = 0$$

$$T_{Br} + T_{St} = 7848 \rightarrow (1)$$

↺

$$\sum M_B = 0$$



$$T_{St}(10) - 7848(5) = 0$$

$$T_{St} = 2934 \text{ N}$$

$$\sigma_{St} = \frac{T_{St}}{A_{St}}$$

$$A_{St} = \frac{T_{St}}{\sigma_{St}}$$

$$A_{St} = \frac{2934}{120 \times 10^6}$$

$$A = 32.7 \text{ mm}^2$$

Q0

$$T_{Br} = 4914 \text{ N}$$

$$\text{or } A_{Br} = \frac{4914}{90}$$

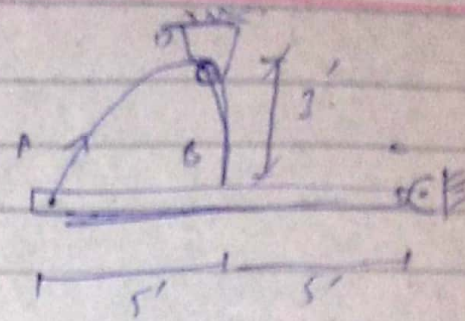
$$A_{Br} = 54.6 \text{ mm}^2$$

Prob - 106

Cable $d = 0.6$ in.

bar $W = 6000$ lb.

$\delta = ?$ in cable.



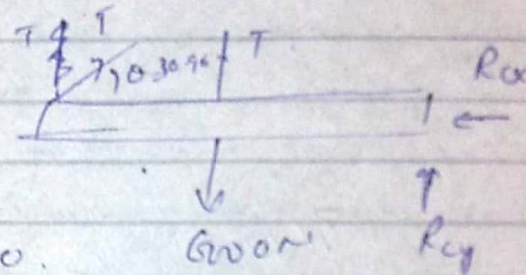
Sol:-

$$A_3 \quad \delta = \frac{P}{A} \rightarrow \text{①}$$

Draw FBD

At

$$\sum M_c = 0$$



$$T(\sin 30.96)(10) - 6000(5) = 0$$

$$+T(5) \quad T(5.144) = 6000(5)$$

$$T = 5831 \quad T = 2957.4 \text{ lb}$$

$$\delta = \frac{T}{A}$$

$$= \frac{2957.4}{\frac{\pi (0.6)^2}{4}}$$

$$\boxed{\delta = 10465.01 \text{ Psi}}$$

Ans

$$\delta = 10.465 \text{ Kpsi} \quad \text{Ans}$$

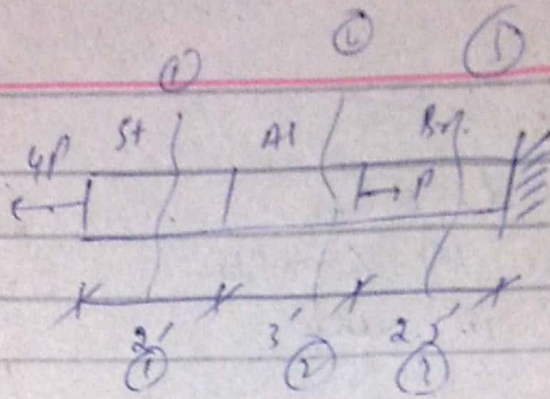
Pb # 107

Given data,

$$P = 3000 \text{ lb}$$

$$A = 0.5 \text{ in}^2$$

σ in each section = ?

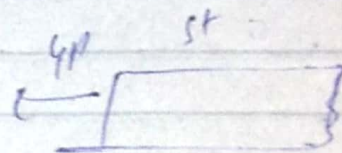


Sol:- Section 1-1

$$\sigma_{st} = \frac{4P}{A}$$

$$= \frac{4(3000)}{0.5}$$

$$= 24 \text{ ksi}$$

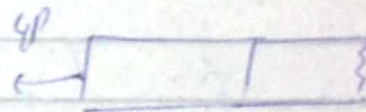


(Tension)

Section 2-2

$$\sigma_{al} = \frac{4P}{0.5}$$

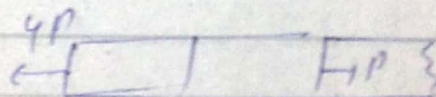
$$= 24 \text{ ksi}$$



(Tension)

Section 3-3

$$= \frac{3 \times 3000}{0.5}$$



$$F = 3P$$

Tension

$$\boxed{\sigma_{st} = 18 \text{ ksi}} \quad \text{Ans}$$

Pb-108

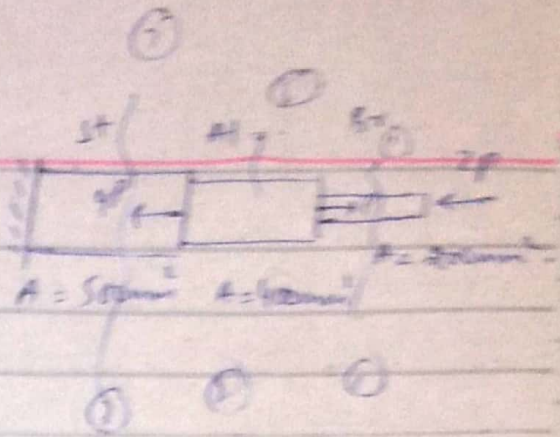
Given data,

$$\sigma_{st} = 140 \text{ MPa}$$

$$\sigma_{al} = 90 \text{ MPa}$$

$$\sigma_{br} = 100 \text{ MPa}$$

$$P = ?$$



Solution:-

Section (1)-(1)

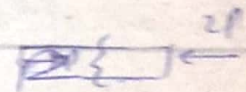
$$\sigma_{br} = \frac{2P}{A}$$

$$P = \sigma_{br} (A)$$

$$= 100 (200)$$

$$= 20000 \text{ N}$$

$$P_{br} = 20 \text{ kN}$$



Net Force = P
Compression

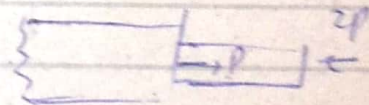
Section 2-2

$$\sigma_{al} = \frac{P_{al}}{A_{al}}$$

$$P_{al} = \sigma_{al} A_{al}$$

$$= 90 (400)$$

$$P_{al} = 36 \text{ kN}$$



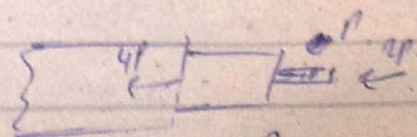
$2P - P = P$
comp

Section 3-3

$$\sigma_{st} = \frac{P}{A}$$

$$= \frac{140 \times (500)}{1}$$

$$= 14 \text{ kN}$$



$P = 5P$
Compression

So we will take maximum safe value of P i.e. smallest one of 10100

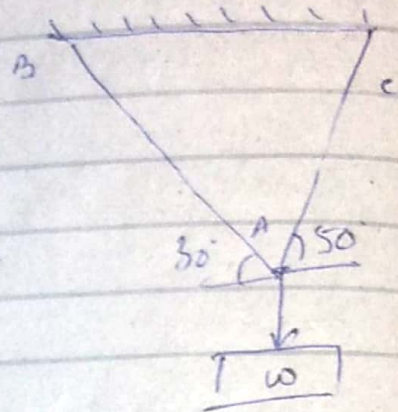
Pb-109

Given data:

σ in either wire = 30 Ksi

$$A_{AB} = 0.4 \text{ in}^2$$

$$A_{AC} = 0.5 \text{ in}^2$$



Draw FBD

Soln First find T_{AB} , $\{T_{AC} = ?\}$

$$\sigma_{AB} = \frac{T_{AB}}{A}$$

$$T_{AB} = 30 \times 10^3 (0.4)$$

$$T_{AB} = 12000 \text{ lb. or } 12 \text{ Kips.}$$

$$T_{AC} = 30 \times 10^3 (0.3) = 9000 \text{ lb or } 9 \text{ Kips.}$$

Now;

$$\frac{\sin \alpha}{a} = \frac{\sin \beta}{b} = \frac{\sin \gamma}{c}$$

$$\frac{\sin 100}{W} = \frac{\sin 130}{T_{AB}} = \frac{\sin 120}{T_{AC}}$$

Comparing, two

$$\frac{\sin 100}{W} = \frac{\sin 180}{T_{AB}}$$

$$W = \frac{\sin 100 \times T_{AB}}{\sin 180}$$

$$W = \frac{18.4 \text{ kips}}{1} = 18.4 \text{ kips}$$

Now compare with other;

$$\frac{\sin 100}{W} = \frac{\sin 120}{T_{AC}}$$

$$W = \frac{\sin 100 \times 9000}{\sin 120}$$

$$W = 10.23 \text{ kN}$$

We will take smallest value of load i.e. $W = 10.23 \text{ kN}$

Ans
2.

Prob-110
 $P = ?$

$$\sigma_w = 1800 \text{ Psi}$$

$$\sigma_c = 650 \text{ Psi}$$

Soln-

For Concrete;

$$\sigma_c = \frac{P_c}{A_c}$$

$$\sigma_c A_c = P_c$$

$$P_c = 650 (12 \times 12)$$

$$= 93600 \text{ lbs}$$

For wooden block.

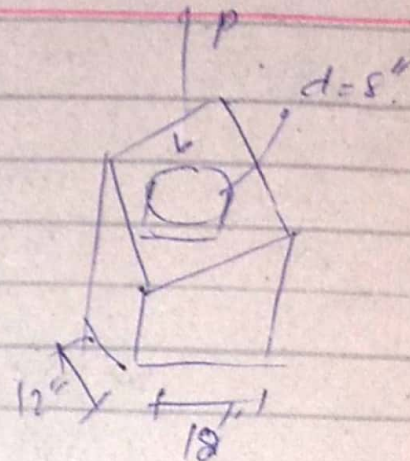
$$\sigma_w = \frac{P_w}{A_w}$$

$$P_w = 1800 \left(\frac{\pi}{4} (8)^2 \right)$$

$$P_w = 90432 \text{ lb}$$

So the max. safe load is

$$\frac{1}{2} \times 90432 \text{ lb} \times \frac{A_w}{2}$$



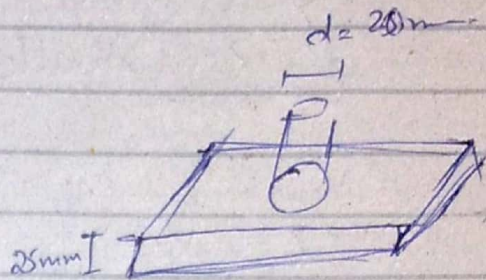
Q115:-

$$d = 20 \text{ mm}$$

$$t_L = 25 \text{ mm}$$

$$\sigma = 350 \text{ MPa}$$

$$P = ?$$



As we know that,

$$\sigma = \frac{P}{A}$$

$$P = \sigma A$$

$$\therefore \sigma = 350 \text{ MPa}$$

$$\Sigma A = \pi D (t_L)$$

$$P = 350 (1570)$$

$$= 3.14 (20) (25)$$

$$= 1570 \text{ mm}^2$$

$$P = 549,500 \text{ N}$$

or

$$P = 550 \text{ kN}$$

Pb - 116

$$V = \sigma = 40 \text{ ksi}$$

$$\sigma_c = 50 \text{ ksi}$$

$$a) \text{ Thickness} = t = ?$$

$$d = 2.5 \text{ in}$$

Sol: A_1

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

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

$$\sigma = \frac{P}{A}$$

$$\pi T(D) = \frac{V}{T} \Rightarrow$$

$$P = 50 (\pi / 4) (2.5)^2$$

$$T = \frac{243.3}{\pi(D)} = \frac{243.3}{3.14(2.5)(40)} \quad V = P = 243.3$$

$$T = 0.781 \text{ in}$$

(b) $t_L = 0.25 \text{ in}$
 $d = ?$ (Smallest hole that can be punched?)

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

$$A = \pi D t$$

$$D = \frac{V}{\tau (\pi t)} = \frac{245.3}{(40)(3.14)(0.25)}$$

$$D =$$

$$V = \tau A$$

$$= \frac{\tau (\pi D^2)}{4}$$

(b) Smallest diameter that can be punched
 Since, $\frac{P}{A} = \delta \Rightarrow P = V = \delta A \rightarrow (1)$

$$\Rightarrow P = \delta \left(\frac{\pi}{4} D^2 \right) \rightarrow (2)$$

Also,

$$\tau = \frac{V}{A} \Rightarrow V = (\pi D t) \tau \rightarrow (3)$$

By comparing;

$$\pi D t (\tau) = \frac{\pi}{4} (\delta D^2)$$

$$D = \frac{4 t (\tau)}{\delta} \Rightarrow \frac{4(0.25)(40)}{50} = 0.8 \text{ in}$$

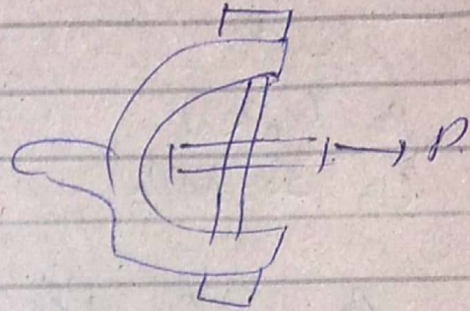
(117):-

2

$$d = ?$$

$$P = 400 \text{ kN}$$

$$\tau = 300 \text{ MPa}$$



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

$$\tau = \frac{P}{2A}$$

∴ As resistance is offered by two areas. So;

$$A = \frac{P}{2\tau} \Rightarrow \frac{4P}{2(\tau)(\pi)(D)} = D^2$$

$$D^2 = \frac{4(400 \times 10^3)}{2(300 \times 10^6)(3.14)}$$

$$D = 29.14 \text{ mm}$$

Pb-118:-

Diameter of pulley = $d = 200\text{mm}$

Diameter of shaft = 60mm

Key length = 70mm

$T = 2.2\text{KNm}$

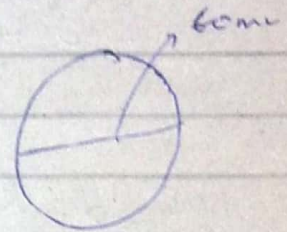
$\tau = 60\text{MPa}$

$b = ?$ (width)

Sol:-

As we know that,

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



$$V = \tau(A)$$

$$= 60(\pi)(w)$$

$$= 60(70)w$$

$$V = 4200w \rightarrow (1)$$

$$r = \frac{60}{2} = 30\text{mm}$$

As, $T = r \times F(V)$

$$V = \frac{T}{r} = \frac{2.2 \times 10^3 \text{ Nm}}{0.030 \text{ m}}$$

$$V = 73.33 \text{ kN}$$

Put in eq (1).

$$73.33 = 4200w \Rightarrow w = 17.46 \text{ mm}$$

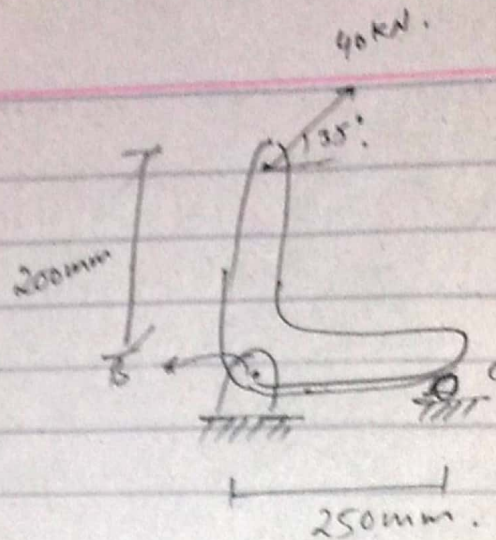
We get value in m
to convert it we multiply by 1000. Ans

Pb-119

Given data:

Pin dia = 20mm

$\delta_B = ?$



As,

$$\delta_B = \frac{R_B}{2A} \rightarrow 0$$

Find $R_B = ?$

$$R_B = \sqrt{(B_y)^2 + (B_x)^2} \quad (2)$$

$$\sum F_y = 0$$

$$40 \sin 35^\circ + B_y + C_y = 0 \rightarrow (1)$$

$$\sum M_C = 0$$

$$-B_y(250) + 40 \sin 35^\circ (250) + 40 \cos 35^\circ (200) = 0$$

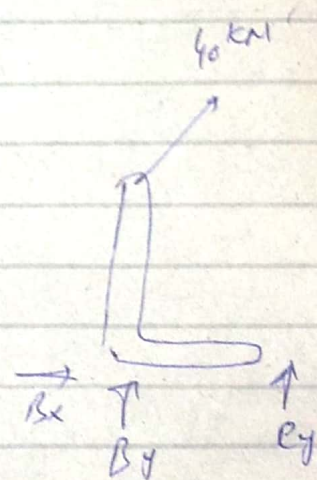
$$8191.52 + 4588.61 = B_y(250)$$

$$B_y = 51.12 \text{ kN}$$

$$\sum F_x = 0$$

$$-B_x + 40 \cos 35^\circ = 0$$

$$B_x = 32.76$$



$$P_B = \frac{\sqrt{(32.766)^2 + (51.12)^2}}{2 - \left(\frac{1}{4}(20)^2\right)}$$

$$= 59.1 \text{ kN}$$

$$\frac{1}{2}(20)^2$$

$$\tau = \frac{P_B}{A} = 94.1 \text{ MPa}$$

[Pb-120]

Given data:

Weight of member = 200 lb/ft.

Smallest diameter at pin A = ?

$\tau = 5000 \text{ psi}$ (Assume single shear).

Sol:-

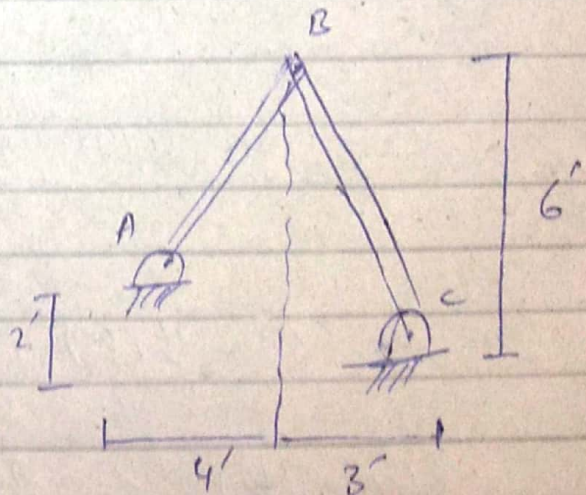
Length of AB = ?

$$(AB)^2 = (4)^2 + (4)^2$$

$$AB = 5.66'$$

Now weight of AB.

$$= 5.66(200 \text{ lb/ft})$$



$$W_{AB} = 1131.4 \text{ lb}$$

$$\sum M_B = 0$$

$$1131.4(2) - A_y(4)$$

$$\sum M_A = 0$$

$$-1131.4(2) + B_y(4) + B_x(4) = 0$$

$$B_x + B_y = 565.7 \rightarrow (1)$$

Now find length of BC.

$$(BC)^2 = (6)^2 + (3)^2$$

$$BC = 6.71'$$

$$\text{Weight of BC} = 6.71(200)$$

$$BC W_{\text{right}} = 1341.6 \text{ lb}$$

Now draw FBD of BC.

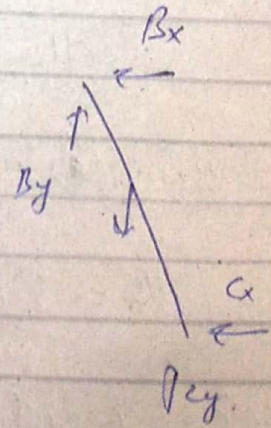
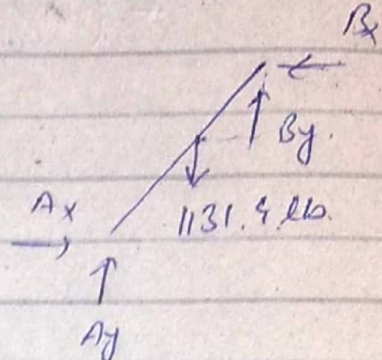
$$\sum M_C = 0$$

$$B_x(6) - B_y(3) + 1341.6(1.5) = 0$$

$$6B_x - 3B_y = -2012.46$$

$$\Rightarrow 2B_x - B_y = -670.8 \rightarrow (2)$$

Draw FBD of beam AB.



Add eq ① & ②

$$B_x + B_y = 567.7$$

$$\oplus 2B_x - B_y = -670.8$$

$$3B_x = -103.12$$

$$\boxed{B_x = -34.4 \text{ lb}}$$

$$B_y = 602.07 \text{ lb}$$

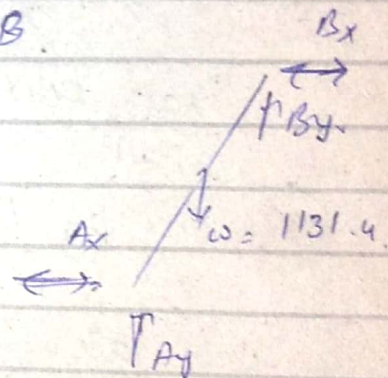
Now Take FBD of bar AB

$$\sum F_x = 0$$

$$A_x = 34.4$$

$$B_y + A_y - 1131.4 = 0$$

$$A_y = 529.3$$



$$P = \sqrt{(A_y)^2 + (A_x)^2}$$

$$= \sqrt{280186.58 + 1183.36}$$

$$P = 530.44$$

$$D = \frac{(530.44)^4}{\pi(5000)}$$

$$\boxed{D = 0.367''} \quad \text{Ans}$$

Pb-121

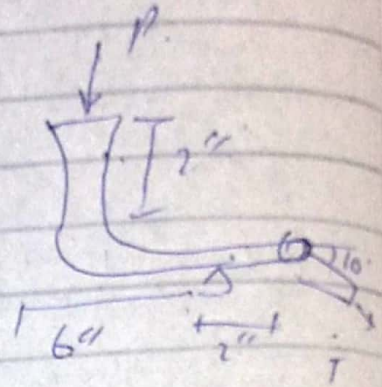
Given data;

Shearing strength at B
 $= \bar{\tau} = 4000 \text{ Psi}$

Axial stress $= \sigma = 5000 \text{ psi}$

$d = 0.25 \text{ in.}$

$d = \text{for control rod} = 0.5$
 $P = ?$



Sol:-

2 Draw FBD of fig

$\sum M_B = 0$ on basis of axial stress

To get value of P.

$$P(6) - T \sin 10^\circ (2) = 0$$

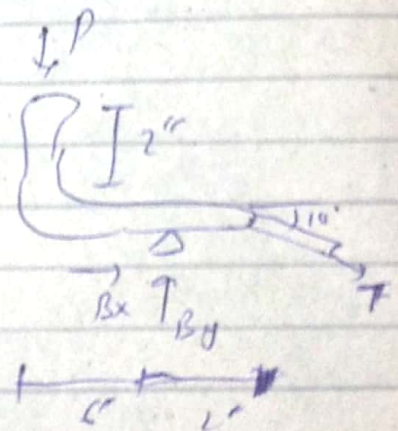
$$6P = 0.3473T \rightarrow (1)$$

$$P = 0.058T$$

$$P = 0.058 \left(\frac{\pi}{4} D^2 \right)$$

$$= 0.058 (5000) \left(\frac{\pi}{4} \right) (0.5)^2$$

$$P = 56.91 \text{ lb}$$



$$\begin{aligned} \sigma &= \frac{P}{A} \\ \sigma &= \frac{P}{A} \\ T &= F_2 \sigma A \\ T &= \end{aligned}$$

also on basis of shearing strength.

$$A_2, \quad \sum F_y = T \sin 10^\circ (2)$$

$$P = \frac{1}{2} T \sin 10^\circ \rightarrow (2)$$

$$\sum F_x = 0$$

$$B_x + T \cos 10^\circ = 0$$

$$B_x = -T \cos 10^\circ$$

$$= T = \frac{3P}{\sin 10^\circ}$$

$$B_x = -\frac{3P}{\sin 10^\circ} \cos 10^\circ$$

$$= -3P \cot 10^\circ \rightarrow (3)$$

$$\sum F_y = 0 \quad (+)$$

$$B_y - P - T \sin 10^\circ = 0$$

$$B_y = P + T \sin 10^\circ$$

$$= P + \frac{3P}{\sin 10^\circ} \sin 10^\circ \rightarrow \frac{P \sin 10^\circ + 3P}{\sin 10^\circ}$$

$$B_y = \frac{3.1736P}{0.1736} \Rightarrow B_y = 18.25P$$

$$R_B = \sqrt{(B_x)^2 + (B_y)^2}$$

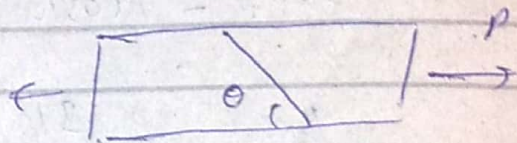
$$= \sqrt{(-3P \cot 10)^2 + (18.25P)^2}$$

Prob - 122.

Prove that $\tau = \frac{P \sin 2\theta}{2A}$

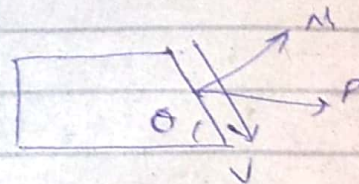
As;

$$\tau = \frac{V}{A'} \Rightarrow (1)$$

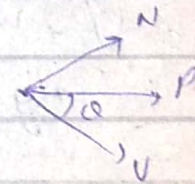


From similarity of Δ s.

$$\frac{A'}{A} = \frac{f}{\sin \theta}$$

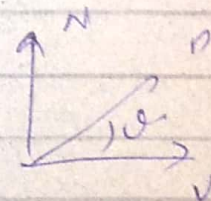


$$A' = \frac{A}{\sin \theta}$$



$$\therefore V = P \cos \theta$$

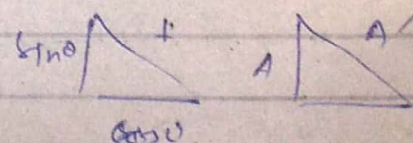
$$= \frac{P \cos \theta}{A / \sin \theta}$$



$$N = P \sin \theta$$

$$V = P \cos \theta$$

$$\tau = \frac{P \sin 2\theta}{2A} \quad \text{(Proved)}$$



Pb-123:-

$$A = 100 \times 50$$

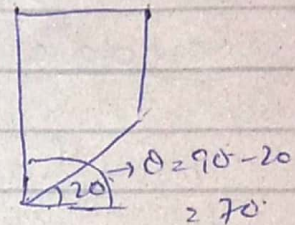
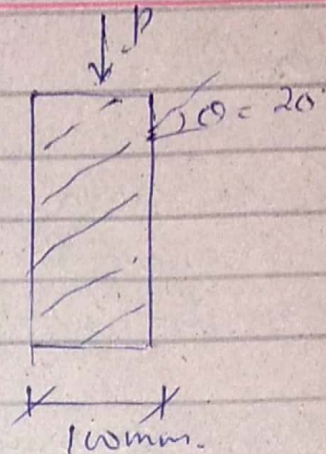
$$P = ?$$

$$\theta = 20^\circ$$

$$\sigma = 20 \text{ MPa}$$

$$\tau = 5 \text{ MPa}$$

On basis of shearing stress;



$$\tau = \frac{P \sin 2\theta}{2A}$$

$$P = \frac{2A\tau}{\sin 2\theta} \Rightarrow \frac{2(100 \times 50)(5)}{\sin 40^\circ}$$

$$P = 77.78 \text{ kN}$$

On basis of compressive stress.

$$\sigma = \frac{P \sin^2 \theta}{A} \Rightarrow P = \frac{\sigma A}{\sin^2 \theta}$$

$$= \frac{20(100 \times 50)}{(\sin 20^\circ)^2} = \frac{100,000}{0.883}$$

$$= 120048.0 \text{ N}$$

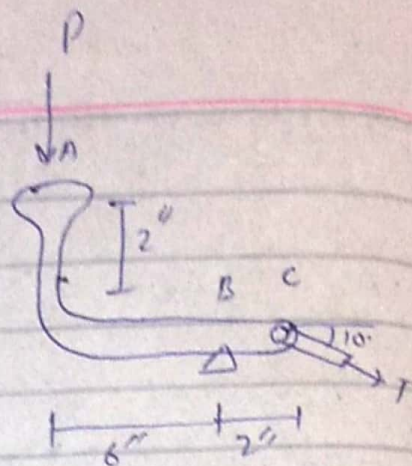
$$P = 120 \text{ kN}$$

So we will check $P = 77.78 \text{ kN}$

Pb-121

Given data:

Shearing stress at
Pin B = 4000 Psi.



Axial stress at C = 5000 Psi

$D_B = 0.25 \text{ in.}$

$D_C = 0.5 \text{ in.}$

Req. data; $P = ?$

Sol:-

2 We have to find P on basis of shear stress & axial stress as both values are given.

On basis of axial stress.

→ Draw FBD of Fig.



$$\sum M_B = 0$$

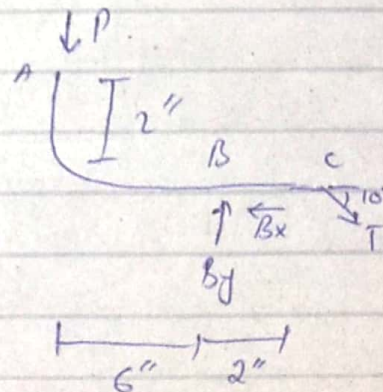
$$P(6) - T_C(2) \sin 10^\circ = 0$$

$$6P = 2T_C \sin 10^\circ$$

$$6P = 2(981.25) \sin 10^\circ$$

$$P = 327.08(0.1736)$$

$$\boxed{P = 56.79 \text{ lb.}}$$



As at C stress is,

$$\sigma_c = P/A$$

$$\sigma_c = T_C/A$$

$$T_C = \sigma_c A$$

$$= 5000 \left(\frac{\pi}{4} (0.5)^2 \right)$$

$$T_C = 981.25$$

Now on basis of shearing stress.

$$\tau = \frac{R(V)^{or}}{A} \rightarrow (1)$$

$$R = \sqrt{(B_x)^2 + (B_y)^2} \rightarrow (2)$$

At from $\sum M_B = 0$

$$6P = 2T \sin 10^\circ$$

$$P = \frac{1}{3} T \sin 10^\circ \rightarrow (3)$$

$$\therefore T \sin 10^\circ = 3P$$

$$\sum F_x = 0 \quad B_x + T \cos 10^\circ = 0$$

$$\Rightarrow T = \frac{3P}{\sin 10^\circ}$$

$$B_x = -T \cos 10^\circ \Rightarrow -3P \cot 10^\circ$$

$$B_x = -3P \cot 10^\circ \rightarrow (4)$$

$$\sum F_y = 0 (+)$$

$$B_y - P - T \sin 10^\circ = 0$$

$$B_y = P + T \sin 10^\circ$$

$$\therefore P = \frac{27P \cot 10^\circ}{\sin 10^\circ}$$

$$= 6P = 2T \sin 10^\circ$$

$$T = \frac{3P}{\sin 10^\circ}$$

$$B_y = 3P + P$$

$$B_y = 4P \rightarrow (5)$$

$$3P = T \sin 10^\circ$$

$$\text{Eq (2)} \Rightarrow R = \sqrt{(-3P \cot 10^\circ)^2 + (4P)^2}$$

$$R = \sqrt{289P^2 + 16P^2}$$

$$R = \sqrt{305.46 P^2}$$

$$R = 17.477 P \rightarrow$$

$$P = \frac{1}{17.477} R \rightarrow \textcircled{6}$$

$$= \frac{1}{17.477} \left(\frac{\pi}{4} (0.25)^2 (4000) \right)$$

Shear stress
at B

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

$$P = 11.22 \text{ lb}$$

$$R_b = \tau A$$

$$= \tau \left(\frac{\pi}{4} D^2 \right)$$

We will take small
value (that more safe)

So

$$P = 11.22 \text{ lb} \quad \text{Ans}$$

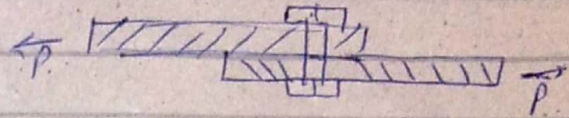
Pb-125:-

$$d = 20 \text{ mm}$$

$$\sigma = 120 \text{ MPa}$$

$$\tau = 60 \text{ MPa}$$

$$\tau = 60 \text{ MPa}$$



- (a) Minimum thickness of each plate = ?
(b) Largest average tensile force = ?

soln- As,

shearing stress = ?

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

$$V = ?$$

$$V = \tau A = \tau \left(\frac{\pi}{4} D^2 \right)$$

$$V = 60 \left(\frac{\pi}{4} (20)^2 \right)$$

$$V = 18840 \text{ N} \rightarrow \text{①}$$

As, from bearing stress,

$$\sigma = \frac{V}{A} = \frac{V}{d(t)}$$

$$t = \frac{V}{d \cdot \sigma} = \frac{18840 \text{ N}}{(20)(120)}$$

$$\boxed{t = 7.85 \text{ mm}}$$

(b) Largest average tensile force = ?

$$\sigma = \frac{P}{A}$$

$$P = \sigma A$$

$$A = l \times t$$

or

$w \times \text{thickness}$

$$= 7.85 (110 - 20)$$

$$P = 2 (706.5)$$

$$= 706.5$$

$$\sigma = \frac{18840}{706.5}$$

$$\sigma = 26.67 \text{ MPa}$$

Pb-126:-

$n = 4$ rivets.

$d = \frac{3}{4}$ inches

$P = ?$

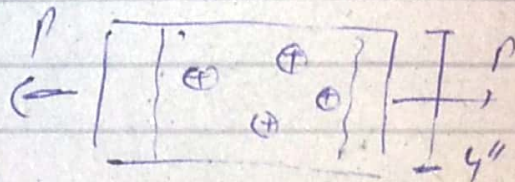
$\tau = 14 \text{ ksi}$

$\sigma = 18 \text{ ksi}$

Sol:-

Since,

Based on shearing stress,



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

$$V = \tau \left(\frac{\pi}{4} D^2 \right)$$

$$= 14 \left(\frac{\pi}{4} \left(\frac{3}{4} \right)^2 \right) \Rightarrow$$

$$V = 24.72 \text{ kips}$$

Based on bearing stress:

Since:

$$\sigma = \frac{V}{4A} \Rightarrow V = 4\sigma A \Rightarrow \sigma (4d_b t_p)$$

$$= 18 \left(\frac{3}{4} \right) \left(\frac{7}{16} \right) (4)$$

$$P = 47.25 \text{ Kips}$$

So the max safe load is 24.72 Kips.

Pb - 27

$$P = 14 \text{ Kips}$$

$$\tau = 12 \text{ ksi}$$

$$\sigma = 20 \text{ ksi}$$

$$d = ?$$

$$t_{\text{plate}} = ?$$

Sol:- (a) Diameter:-

$$\tau = \frac{P}{2A}$$

$$A = \frac{P}{2\tau} \Rightarrow \frac{\pi}{4} D^2 = \frac{P}{2\tau} \Rightarrow D^2 = \frac{4P}{2\pi\tau}$$

$$= \frac{4(14)}{3.14(12)(2)} \Rightarrow \boxed{d = 0.862 \text{ mm}}$$

(b) Thickness:-

$$\sigma = \frac{P}{2A} \Rightarrow t = \frac{P}{\sigma(d)} \Rightarrow \boxed{0.406 \text{ mm} = t}$$

176-129

Given data;

$$d_b = 7/8 \text{ inch}$$

$$\text{dat root} = 0.701 \text{ in}$$

$$\text{Tensile stress} = 18 \text{ Ksi}$$

Shearing stress at head of bolt, τ in thread.

$$\text{diameter of washer} = d_w = ?$$

$$\text{inside di} = 9/8 \text{ in}$$

$$\sigma = 800 \text{ Psi}$$

Sol:-

Since we know that;

$$\sigma = P/A \Rightarrow P = \sigma (\pi/4 D^2)$$

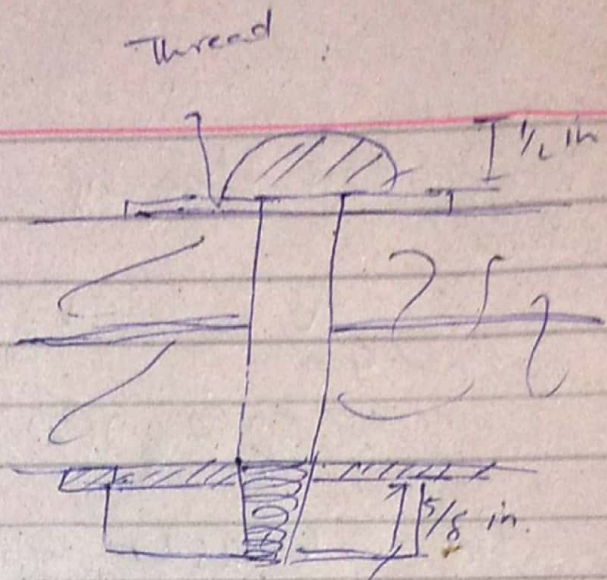
$$P = 18 (\pi/4 (7/8)^2)$$

$$P = 10.82 \text{ Kips}$$

shearing stress at head.

$$\tau = \frac{V}{A} \Rightarrow \frac{10.82}{\pi (7/8) (1/2)}$$

$$\tau = 7.875 \text{ Ksi}$$



$$11 \left(\frac{T_B(6)}{AE} \right) - 7 \left(\frac{T_A(4)}{AE} \right) - 4 \left(\frac{T_C(6)}{AE} \right) = 0$$

$$66T_B - 28T_A - 24T_C = 0 \rightarrow (2)$$

$$\downarrow$$

$$\sum M_A = 0$$

$$-600(4) + T_B(4) + T_C(6) = 0$$

$$4T_B + 6T_C = 2400$$

$$T_B = -\frac{3}{2}T_C + 600 \rightarrow (3)$$

Σ (2) ⇒

$$66 \left(-\frac{3}{2}T_C + 600 \right) - 28T_A - 24T_C = 0$$

$$-99T_C + 39600 - 28T_A - 24T_C = 0$$

$$-125T_C - 28T_A + 39600 = 0$$

$$T_C + 0.224T_A = 316.8 \rightarrow (4)$$

Put eq (3) in eq (1)

$$T_A + \left(-\frac{3}{2}T_C + 600 \right) + T_C = 600$$

$$T_A - \frac{1}{2}T_C = 0 \rightarrow (5)$$

$$0.112T_A + \frac{1}{2}T_C = 158.4$$

$$T_A = 142.44 \text{ kN}$$

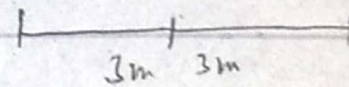
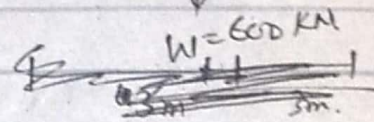
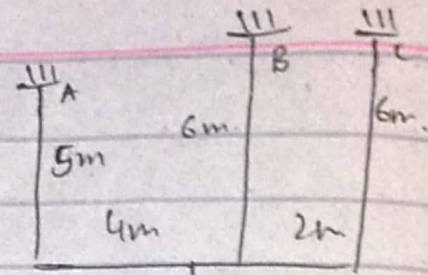
1pb-155

$$W = 600 \text{ kN}$$

Load in each rod = ?

Sol:-

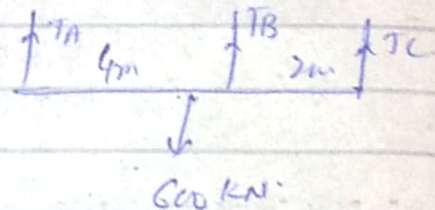
Draw FBD.



$$\sum F_y = 0 \quad \uparrow +$$

$$T_A + T_B + T_C = 600 \rightarrow (1)$$

$$\sum M_A = 0$$



$$- 600(3) + T_B(4) + T_C(6) = 0$$

$$4T_B + 6T_C = 1800 \rightarrow (2)$$

$$T_B = \frac{1800 - 6T_C}{4}$$

$$T_B = 450 - \frac{3T_C}{2} \rightarrow (3)$$

eq (1) $\Rightarrow$

$$T_A + 450 - \frac{3T_C}{2} + T_C = 600$$

$$T_A - \frac{1}{2}T_C = 600 - 450$$

$$T_A - \frac{1}{2}T_C = 150 \rightarrow (4)$$

$$-\frac{3}{2} + 1 = -\frac{1}{2}$$

$$\frac{3}{2} + 1 = \frac{5}{2}$$

Now when load is applied.

From similarity
of Δs .

$$\frac{\delta_B - \delta_A}{4} = \frac{\delta_C - \delta_A}{6}$$

$$\delta_B - \delta_A = \frac{2\delta_C - 2\delta_A}{3}$$

$$\delta_B - \delta_A + \frac{2\delta_A}{3} - \frac{2\delta_C}{3} = 0$$

$$-\frac{1}{3}\delta_A + \delta_B - \frac{2}{3}\delta_C = 0 \rightarrow (5)$$

$$-\frac{1}{3}\delta_A + 450 - \frac{3}{2}T_C = 0$$

$$-\frac{1}{3}TA(5) + TB(6) - \frac{2}{3}TC(6) = 0$$

$$-\frac{5}{3}TA + 6TB - 4TC = 0 \rightarrow (6)$$

Put eq (3) in eq (6).

$$-\frac{5}{3}TA + 6\left(450 - \frac{3}{2}TC\right) + TC = 0$$

$$-\frac{5}{3}TA + 2700 - 9TC + TC = 0$$

$$\frac{5}{3}TA + 8TC = 2700 \rightarrow (2)$$

$$TA + 4 \cdot 8TC = 1620 \rightarrow (3)$$

$$\begin{array}{r} + \\ \ominus \end{array} TA - \begin{array}{c} 1 \\ \oplus \end{array} 8 \cdot 5TC = 150$$

$$6 \cdot 3 TC = 1470$$

$$TC = 277.35$$

$$TA - 0.5TC = 150$$

$$16TA - 8TC = 1200$$

$$\frac{5}{3}TA + 8TC = 2700$$

$$\left(\frac{5}{3} + 16\right) TA = 3900$$

$$\frac{5+48}{3} TA = 3900$$

$$TA = 220.7$$

(b) Shearing stress in thread.

$$\bar{c} = \frac{V}{A} = \frac{10.87}{\pi(7/8)(0.731)}$$

(b) shearing stress in thread.

$$\bar{c} = \frac{V}{A} = \frac{10.87}{\pi(0.731)(5/8)}$$

$$\bar{c} = 7.57 \text{ Kbi}^{-1}$$

(c) Outer diameter of washer.

$$\delta = \frac{P}{A} \Rightarrow \delta = \frac{P}{\frac{\pi(D_{out}^2 - D_{in}^2)}{4}}$$

$$\Rightarrow \frac{\pi(D_{out}^2 - D_{in}^2)}{4} = \frac{P}{\delta}$$

$$D_{out}^2 = \frac{4P}{\delta\pi} + D_{in}^2$$

$$= \frac{4(10.87)}{800(3.14)} + \left(\frac{9}{8}\right)^2$$

or

$$10.82 = 800\left(\frac{\pi}{4}(D_{out}^2 - D_{in}^2)\right)$$

Pb - 205:-

Proved that:

$$\delta = \frac{\rho g L^2}{2E}$$

Q

$$\delta = \frac{MgL}{2AE}$$

Sol:-

$$0 \leq y \leq L$$

We have find change
in elongation (Total)
as general

As we know that;

$$W = mg$$

$$= \rho V g$$

$$\therefore \rho = \frac{m}{V}$$

$$m = \rho V$$

$$W = \rho \times g \times A dy \rightarrow (1)$$

From fig.

Since

$$\delta = \frac{PL}{AE}$$

$$V = A dy$$

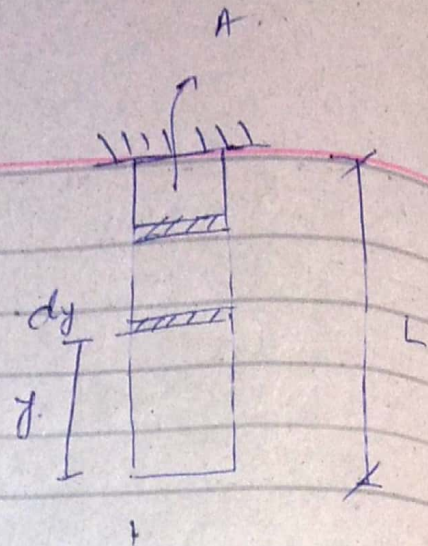
$$\text{Here } P = W \text{ \& } L = dy$$

So,

$$d\delta = \frac{W dy}{AE}$$

$$d\delta = \frac{\rho g A y dy}{AE}$$

Put W
value



$$d\delta = \frac{\rho g y dy}{E}$$

$$\int d\delta = \frac{\rho g}{E} \int y dy$$

$$\delta = \frac{\rho g}{E} \left(\frac{y^2}{2} \right) \Big|_0^L \Rightarrow \delta = \frac{\rho g (y^2)}{E \cdot 2} \Big|_0^L$$

$$y = L$$

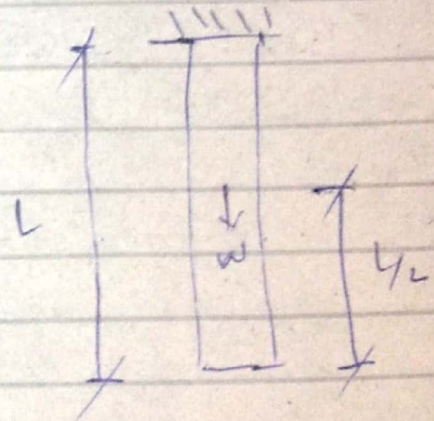
$$\delta = \frac{\rho g L^2}{E \cdot 2}$$

(b)

Since

$$\delta = \frac{\rho g L^2}{2E}$$

$$\delta = \frac{M g L^2}{A L \cdot 2E}$$



$$\boxed{\delta = \frac{M g L}{2 A E}}$$

Proved

Since $P = \frac{M}{L}$

$$P = \frac{M}{A L}$$

Pb-266

$$A = 300 \text{ mm}^2$$

$$L = 150 \text{ m}$$

$$P = 20 \text{ kN}$$

$$\text{Unit mass of steel} = 7850 \text{ kg/m}^3$$

$$E = 200 \times 10^3 \text{ MPa}$$

$$\delta = ?$$

$$\therefore m = 7850 \times 150 \times 300 \times 10^{-6}$$

$$m = 353.25$$

$$W = 353.25 \times 9.81$$

$$W = 3465.38 \text{ N}$$

Soln- As we know that;

$$\delta = \frac{PL}{AE} \rightarrow \text{①}$$

Here elongation due to its own weight also due to load applied.

As;

$$\delta_{\text{total}} = \delta_L + \delta_W \rightarrow \text{②}$$

$$\delta_L = \frac{PL}{AE} \Rightarrow \frac{20 \times 10^3 (150)}{(300 \times 10^6) (200 \times 10^3 \times 10^9)}$$

$$\delta_L = 0.05 \text{ m}$$

$$\delta_L = 50 \text{ mm} \quad (\text{Due to load})$$

$$\delta_W = \frac{WL}{AE} = \frac{3465.38 (150)/2}{(300 \times 10^6) (200 \times 10^3)}$$

$$\boxed{\delta_W = 4.33 \text{ mm}}$$

$$\delta_{\text{total}} = \delta_L + \delta_W$$

$$\therefore 50 + 4.33 = \boxed{54.33 \text{ mm} = \delta_{\text{total}}}$$

Ans
2

Pb- 202:-

$$l = 30'$$

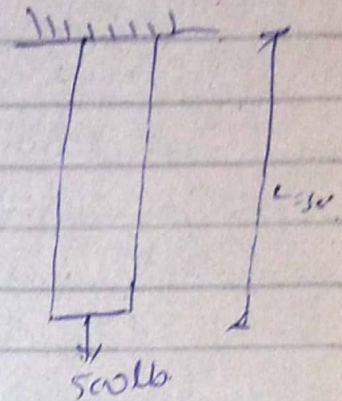
$$P = 500 \text{ lb.}$$

$$d = ?$$

$$S = 20 \text{ ksi}$$

$$\delta = 0.20 \text{ in (elongation)}$$

$$E = 29 \times 10^6 \text{ psi}$$



Sol: Based on stress.

$$\sigma = P/A \Rightarrow \pi/4 D^2 = P/\sigma$$

$$D = \sqrt{\frac{4P}{\pi \sigma}} \Rightarrow \sqrt{\frac{4 \times 500}{3.14 \times 20 \times 10^3}}$$

$$\boxed{D = 0.178 \text{ in}}$$

Based on elongation.

$$\delta = \frac{PL}{AE}$$

$$A = \frac{PL}{E\delta} \Rightarrow \frac{\pi D^2}{4} = \frac{4PL}{\pi E\delta}$$

$$D^2 = 0.03957$$

$$\boxed{D = 0.198 \text{ in}}$$

So, $\boxed{D = 0.198 \text{ in}}$ is bigger diameter.

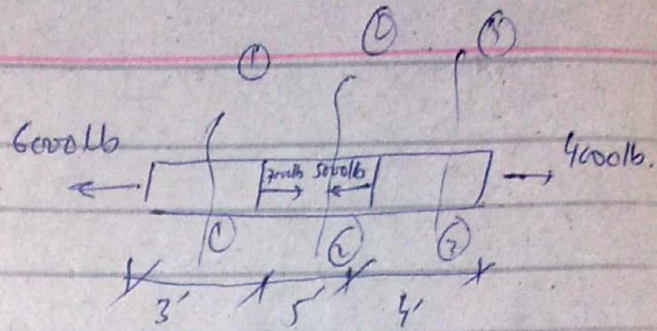
Pb-209:-

Given data:

$$A = 0.5 \text{ in}^2$$

$$\delta = ?$$

$$E = 10 \times 10^6 \text{ psi}$$



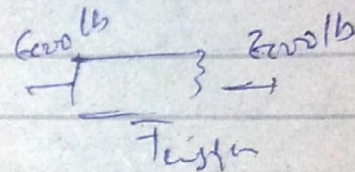
Sol:-

$$\delta_{\text{total}} = \delta_1 + \delta_2 + \delta_3 \rightarrow \text{①}$$

Take section 1-1

$$P = 4000 \text{ lb}$$

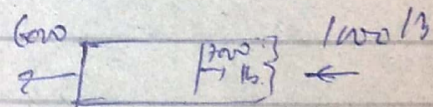
$$L = 3' = 3 \times 12$$



$$\delta_1 = \frac{PL}{AE} = \frac{4000(36)}{(0.5)(10 \times 10^6)}$$

$$\delta_1 = 0.0432 \text{ in}$$

Take section 2-2



$$\delta_2 = \frac{1000(5 \times 12)}{0.5(10 \times 10^6)} = 0.012 \text{ in}$$

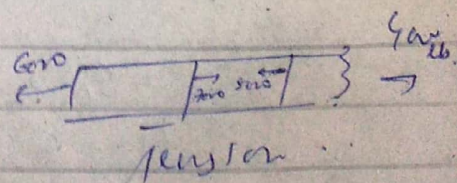
Contraction

$$P = 1000$$

Take section 3-3

$$\delta_3 = \frac{4000(4 \times 12)}{0.5(10 \times 10^6)}$$

$$\delta_3 = 0.0384 \text{ in}$$



$$\delta_{\text{total}} = 0.0432 - 0.012 + 0.0384$$

$$\delta_{\text{total}} = 0.069 \text{ in}$$

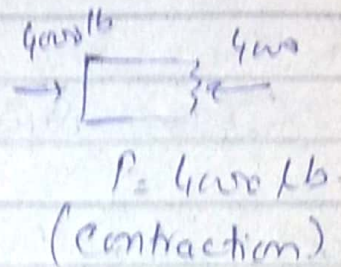
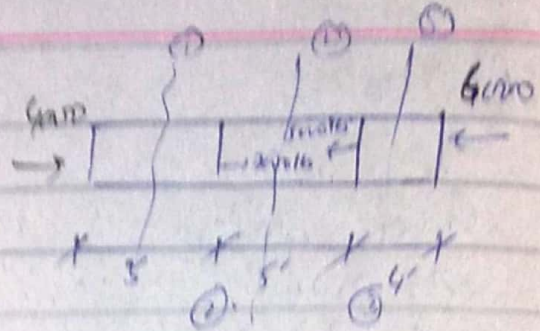
Prob 210-

$$\delta_{total} = -\delta_1 - \delta_2 - \delta_3$$

Take section 1-1

$$\begin{aligned} \delta_1 &= \frac{PL}{AE} \\ &= \frac{4000(3 \times 12)}{0.5(10 \times 10^6)} \end{aligned}$$

$$\delta_1 = 0.0288 \text{ in.}$$



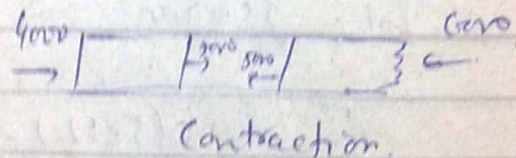
Take section 2-2

$$\begin{aligned} \delta_2 &= \frac{PL}{AE} \\ &= \frac{(1100)(5 \times 12)}{0.5(10 \times 10^6)} \end{aligned}$$

$$\delta_2 = 0.0132$$

Take section 3-3

$$\begin{aligned} \delta_3 &= \frac{6000(4 \times 12)}{0.5 \times 10 \times 10^6} \\ &= 0.0576 \text{ in.} \end{aligned}$$



$$\begin{aligned} \delta_T &= -\delta_1 - \delta_2 - \delta_3 \\ &= -0.0288 - 0.0132 - 0.0576 \end{aligned}$$

$$|\delta_T| = 0.0996 \text{ in.} \quad \text{Reduce its length.}$$

Pb-211:-

Given data;

$$\delta_{\text{total}} = 3 \text{ mm}$$

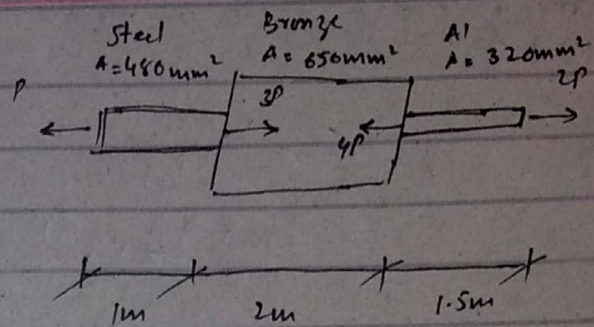
$$\sigma_{\text{st}} = 140 \text{ MPa}$$

$$\sigma_{\text{br}} = 120 \text{ MPa}$$

$$\sigma_{\text{al}} = 80 \text{ MPa}$$

$$E_{\text{st}} = 200 \text{ GPa}$$

$$E_{\text{al}} = 70 \text{ GPa} \quad \& \quad E_{\text{br}} = 83 \text{ GPa}$$



Max value of $P = ?$

Sol:- Based on stresses:-

$$\sigma_{\text{st}} = \frac{P}{A_{\text{st}}} \Rightarrow P = \sigma_{\text{st}} (A) = (140 \times 480) = 67200 \text{ N} = 67.2 \text{ kN}$$

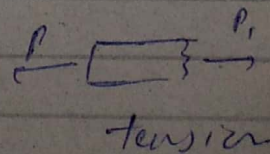
$$\sigma_{\text{br}} = \frac{2P}{A_{\text{br}}} \Rightarrow 2P = \frac{120}{2} (650) = 39000 \text{ N} = 39 \text{ kN}$$

$$\sigma_{\text{al}} = \frac{2P}{A_{\text{al}}} = 2P = \frac{80}{2} (320) = 12800 \text{ N} = 12.8 \text{ kN}$$

Based on deformation:

$$\text{Since } \delta_{\text{tot}} = \delta_1 + \delta_2 + \delta_3$$

Take Section 1-1.



$$\delta_1 = \frac{P(1 \times 10^3)}{(480)(200)}$$

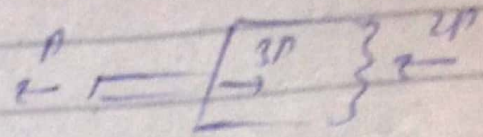
$$\delta_1 = 0.0104 P = 1.042 \times 10^{-5} P$$

Take Section 2-2

$$\delta_2 =$$

$$= \frac{2P(2000)}{(650)(83 \times 10^3)}$$

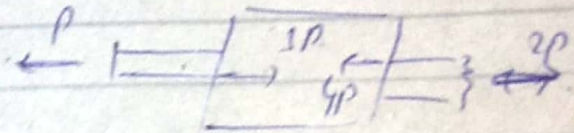
$$\delta_2 = 7.41 \times 10^{-5} P$$



Contraction

Take Section 3-3

$$\delta_3 = \frac{2P(15)}{(320)(70)}$$



Contraction

$$\delta_3 = 1.34 \times 10^{-4} P$$

Tension

$$\delta_{total} = +\delta_1 - \delta_2 - \delta_3$$

$$= (1.042 \times 10^{-3} - 7.41 \times 10^{-5} + 1.34 \times 10^{-4}) P$$

$$P_2 = 15181.52 \text{ N}$$

$$\boxed{P_2 = 15.18 \text{ KN}}$$

So max. safe load is ~~8.8 KN~~ 12.8 KN

Pb-212

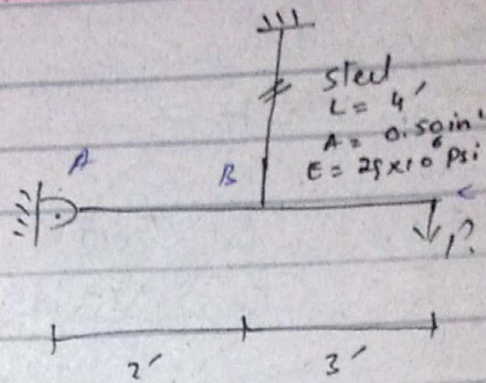
Given data:

$P = ?$

$\sigma_{st} = 30 \text{ ksi}$

vertical movement

$\Delta_c = 0.1 \text{ inch}$



Sol:- Based on max. stress.

$\sum MA = 0$

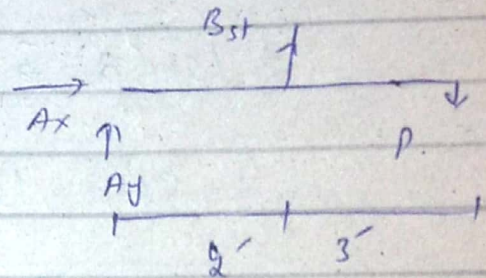
$$P_{st}(2 \times 12) - P(5) = 0$$

$$\text{BO } P = 24 P_{st}$$

$$\text{BO } P = 24 (\sigma_{st} A_{st})$$

$$= 24 (30 \times 10^3) (0.5)$$

$$P = 1800 \text{ lb} \Rightarrow 1.8 \text{ kips}$$



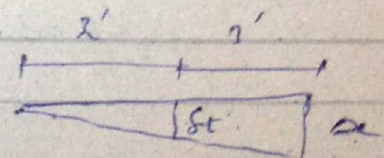
Now on based on deformation;

As after load is applied

From similarity of Δ s

$$\frac{\Delta_c}{5} = \frac{\delta_{st}}{2}$$

$$\Rightarrow \delta_{st} = \frac{2}{5} (0.1) = 0.04 \text{ in}$$



$$\delta = \frac{P \Delta L}{AE}$$

$$0.04 = \frac{P_{st} (4 \times 12)}{(0.5) (29 \times 10^6)}$$

$$P_{st} = 12083.3 \text{ lb}$$

$$A_B \text{ from } \sum M_A = 0$$

$$+ P_{st}(8) - P(5) = 0$$

$$5P = P_{st}(2)$$

$$P = \frac{2}{5} (12083.3)$$

$$P = 4833.33 \text{ lb}$$

$$P = 4.83 \text{ kips}$$

So the smallest value of P is
4.83 kips. $\frac{Ans}{2}$

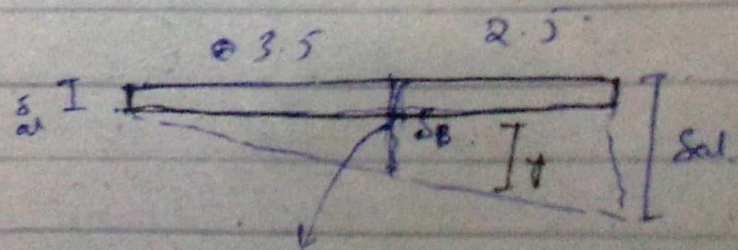
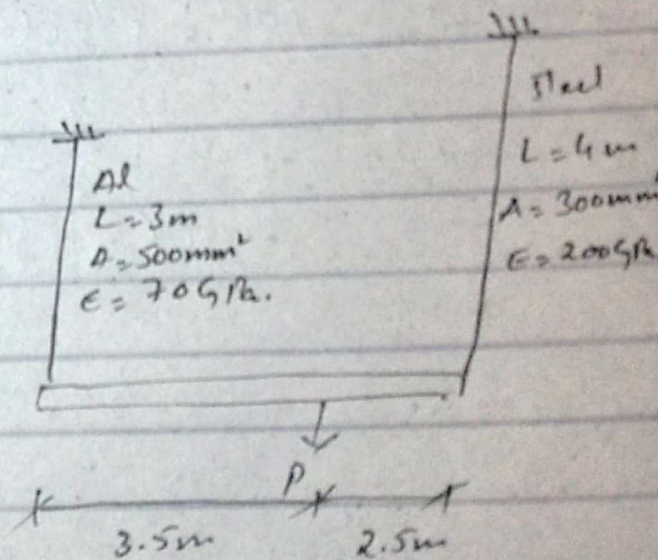
Pb-213:-

Given data:
 $P = 50 \text{ kN}$.

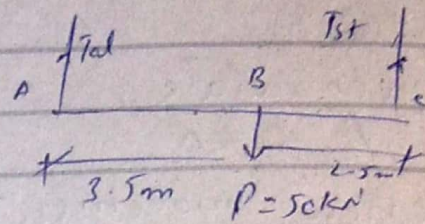
Required data:
 Vertical movement
 at B?

Soln After load is applied
 deform shape is;

First we have
 to find δ_A
 & δ_B .



As from FBD of fig.
For Al:
 $\sum M_B = 0$



$$-T_{al}(6) + P(2.5) = 0$$

$$(6) T_{al} = 125$$

$$T_{al} = 20.83 \text{ kN}$$

$$\delta_{al} = \frac{T_{al} L}{AE} \Rightarrow \frac{20.83 \times 10^3 (3 \times 10^3)}{(500)(70 \times 10^3)}$$

$$\boxed{\delta_{al} = 1.78 \text{ mm}}$$

Now for steel.

$$+\sum M_A = 0$$

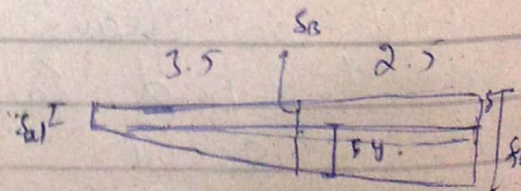
$$-50(3.5) + T_{st}(6) = 0$$

$$6T_{st} = 175 \Rightarrow T_{st} = 29.17 \text{ kN}$$

$$\delta_{st} = \frac{T_{st} (L)}{AE} \Rightarrow \frac{(29.17 \times 10^3)(4 \times 10^3)}{(300)(200 \times 10^3)}$$

$$\boxed{\delta_{st} = 1.94 \text{ mm}}$$

Now Using fig. 2 dycom
when load is applied.
from similarity of Δ_s .



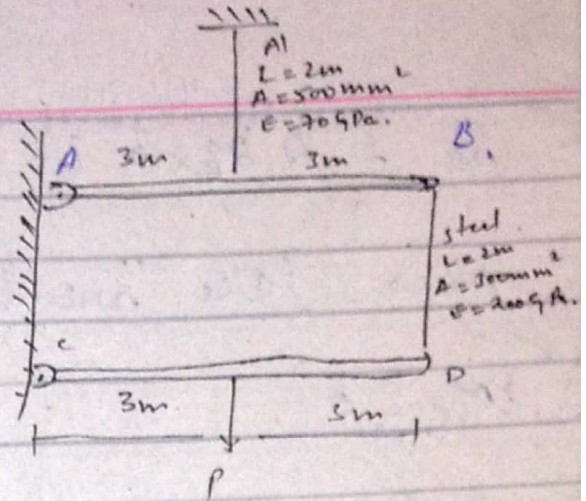
Pb-219:-

Given data:

$$P = ?$$

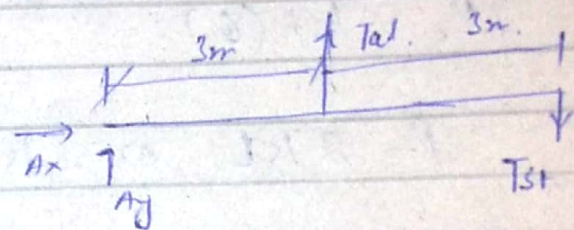
Vertical movement

$$\delta_c = \delta_p = 5 \text{ mm}$$



Sol:- Draw FBD of AB bar.

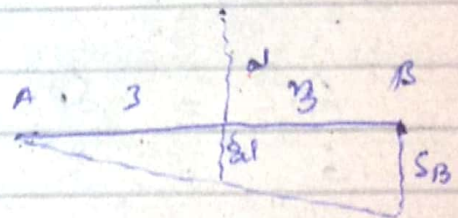
$$\sum M_A = 0$$



$$T_{al}(3) - T_{st}(6) = 0$$

$$T_{al} = 2T_{st} \rightarrow \text{①}$$

As load is applied consider only bar AB.



From similarity of Δs .

$$\frac{\delta_B}{6} = \frac{\delta_{al}}{3}$$

$$\delta_B = 2\delta_{al}$$

$$\delta_{al} = \frac{P_{al}(L)}{AE}$$

$$= 2 \left(\frac{T_{al}(2 \times 10^3)}{(500 \text{ mm}^2)(70 \times 10^3)} \right)$$

$$\delta_B = 1.1428 \times 10^{-4} T_{al}$$

$$T_{al} = 2T_{st}$$

$$\delta_B = 2(1.1428 \times 10^{-4}) T_{st}$$

$$\delta_B = 2.28 \times 10^{-4} T_{st} \rightarrow (2)$$

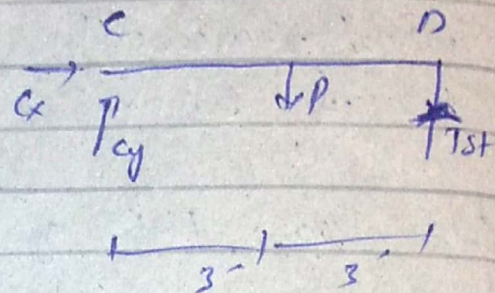
Now take member CD.

Draw FBD $\downarrow$

$$\sum M_C = 0$$

$$T_{st}(6) - P(3) = 0$$

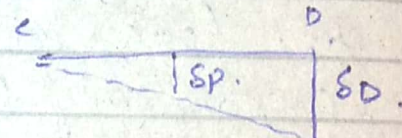
$$3P = T_{st}(6)$$



$$P = 2T_{st} \text{ or } T_{st} = \frac{1}{2}P \rightarrow (3)$$

Also when load is applied
the deform shape will be
rod CD.

$$\frac{\delta_D}{6} = \frac{\delta_P}{3}$$



$$\delta_{st} + \delta_B = 2\delta_P$$

$$\delta_D = \delta_{st} + \delta_B$$

$$\delta_{st} + 2.28 \times 10^{-4} T_{st} = 2\delta_P$$

$$\frac{P T_{st}(2)}{(300)(200)} + 2.28 \times 10^{-4} T_{st} = 2\delta_P$$

$$\delta_P = 5$$

$$3.33 \times 10^{-5} T_{st} + 2.28 \times 10^{-4} T_{st} = 2(5)$$

$$3.33 \times 10^{-5} \left(\frac{1}{2} P \right) + 2.28 \times 10^{-4} \left(\frac{1}{2} P \right) = 10$$

$$P (3.33 \times 10^{-5} + 2.28 \times 10^{-4}) = 20 \Rightarrow \frac{10P}{P} = 2.61 \times 10^4$$

$$P = 26100$$

$$\frac{\delta}{3.5} = \frac{\delta_{st} - \delta_{al}}{6}$$

$$\delta = \frac{3.5(1.94)}{6}$$

$$\delta = 0.093 \text{ mm}$$

~~Now Again from similarity of Δ s~~

~~or~~ Δ from fig

$$\delta_B = \delta_{al} + \delta$$

$$= 1.78 \text{ mm} + 0.093$$

$$\boxed{\delta_B = 1.87 \text{ mm}} \quad \text{vertical deflection.}$$

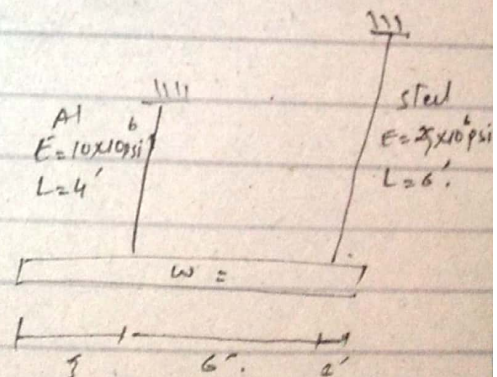
Pb-215:-

Required data:
Ratio of areas of rods.

Sol:- For slab to remain level.

$$(\delta_{al}) = (\delta_{st})$$

$$\left(\frac{PL}{AE} \right)_{al} = \left(\frac{PL}{AE} \right)_{st}$$



$$\frac{P_{al}(4 \times 12)^3}{A_{al}(10 \times 10^6)} = \frac{P_{st}(-6 \times 12)^3}{A_{st}(25 \times 10^6)}$$

$$\frac{P_{al}}{A_{st}} = \frac{P_{al}(4 \times 12) \cancel{A_{st}}(25 \times 10^6)}{P_{st}(26 \times 12) \cdot 10 \times 10^6}$$

$$\frac{A_{al}}{A_{st}} = \frac{1.93 P_{al}}{P_{st}} \rightarrow (1)$$

We have to P_{al} & $P_{st} = ?$

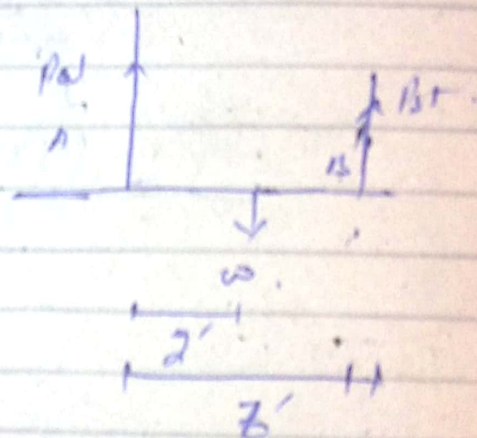
from fs FBD

$$\sum M_A = 0$$

$$P_{st}(6) - w(2) = 0$$

$$P_{st} = \frac{w}{3} \rightarrow (2)$$

$$\sum M_B = 0$$



$$P_{al}(6) - w(4) = 0$$

$$P_{al} = \frac{2}{3} w \rightarrow (3)$$

eq (1) & (2)

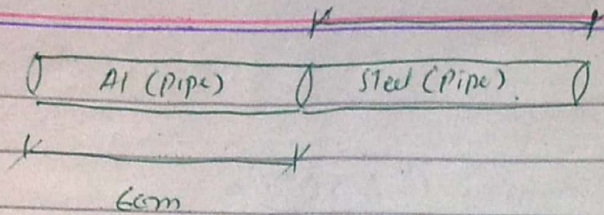
$$\frac{A_{al}}{A_{st}} = \frac{1.93(2/3 w)}{1/3 w} =$$

$$\boxed{\frac{P_{al}}{A_{st}} = 3.87}$$

$$t = 10^\circ\text{C}$$

$$(60 + 0.005) \text{ m}$$

Pb :-



Required data:

At what temperature will aluminum pipe be 15mm longer than steel pipe

$$\alpha_{al} = 23 \times 10^{-6} / ^\circ\text{C}$$

$$\alpha_{st} = 12 \times 10^{-6} / ^\circ\text{C}$$

Pb-222:-

A solid cylinder of diameter d carries an axial load P . show that change in diameter

$$\frac{4 P \nu}{\pi E d}$$

Sol:- since we know

$$\nu = - \frac{\epsilon'}{\epsilon}$$

$$\epsilon' = -\nu \epsilon$$

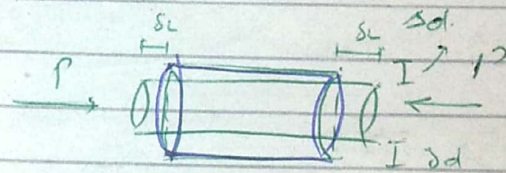
$$\frac{\Delta d}{d} = - \frac{\nu \delta}{E}$$

$$\Delta d = - \nu \left(\frac{P}{A} \right) \frac{d}{E}$$

$$= + \nu \frac{P}{\frac{\pi}{4} d^2} \frac{d}{E}$$

$$\Delta d = \frac{4 P \nu}{\pi E d}$$

Proved



∴ From Hooke's law

$$\text{Stress} = E (\text{strain})$$

$$\sigma = E (\epsilon)$$

$$\epsilon = \frac{\delta}{E}$$

$$\therefore \sigma = \text{Stress} = \frac{P}{A}$$

$$\therefore A = \frac{\pi d^2}{4}$$

∴ -ve sign convention as length will decrease

Pb-225.

Given data:

$$d = 1.2 \text{ m}$$

$$P = 1.5 \text{ MPa}$$

$$t = 10 \text{ mm}$$

$$\nu = 0.30$$

$$\Delta d = ?$$

$$E = 200 \text{ GPa}$$

Soln

As we know

$$\Delta d = \frac{4PV}{\pi E d} \Rightarrow \frac{4(1.5 \times 10^6)(0.3)}{(2.14)(200 \times 10^9)(1.2)}$$

$$\Delta d = 2.388 \times 10^{-6} \text{ m}$$

$$\Delta d = 2.388 \times 10^{-6} \cdot 10^3 \text{ mm}$$

$$\Delta d = 2.388 \times 10^{-3} \text{ mm}$$

Pb-226

Given data:

$$d = 2"$$

$$\text{thickness, } t = 0.05"$$

$$\text{Tangential Stress} = \sigma_x = ?$$

$$P_c = 3140 \text{ lb}$$

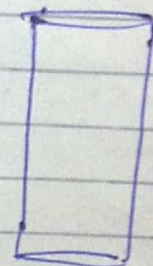
$$\nu = 0.30$$

Soln

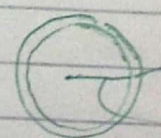
As given that no buckling occur. So change in length (deformation) will be zero.

$$\Delta x = \frac{\sigma_x}{E} - \frac{\sigma_y \nu}{E}$$

$$0 = \frac{\sigma_x}{E} - \frac{\sigma_y \nu}{E}$$



↓ Top view



$$t = 0.05"$$

$$d = 2"$$

$$\frac{\delta x}{E} = \nu \frac{\delta y}{E}$$

$$\delta x = \nu \delta y \rightarrow (1)$$

$$\delta y = \frac{P}{A} \Rightarrow \frac{P}{\pi(\text{thickness})(\text{Diameter})}$$

$$= \frac{3140}{\pi(2)(0.05)}$$

$$\delta y = 10,000 \text{ psi}$$

$$\text{At } (1) \quad \delta x = \nu \delta y$$

$$\delta x = 0.3(10,000)$$

$$\boxed{\delta x = 3000 \text{ psi}}$$

Prob 227:

Given data:

$$L = 150 \text{ mm}$$

$$d = 80 \text{ mm}$$

$$t = 3 \text{ mm}$$

$$P = 4 \text{ MPa}$$

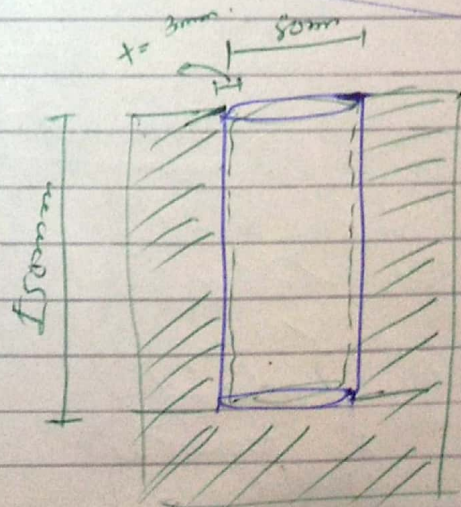
$$E = 83 \text{ GPa}$$

$$\nu = 1/3$$

$$\delta x = ? \text{ (tangential stress)}$$

Sol: 0

As we know tangential stress is;



$$\sigma_y = \frac{Pd}{4t} = \frac{(4 \times 10^6)(80)}{4(3)}$$

$$= \frac{80 \times 10^6}{3}$$

$$\sigma_y = 26.67 \times 10^6 \text{ Pa}$$

$$\sigma_y = 26.67 \text{ MPa}$$

The strain in x-direction is,

$$\epsilon_x = \frac{\sigma_x}{E} - \frac{\nu \sigma_y}{E}$$

Since the tube is fixed so no strain will be produced.

$$\frac{\sigma_x}{E} = + \nu \frac{\sigma_y}{E}$$

$$\sigma_x = + \frac{1}{3} (26.67)$$

$$\boxed{\sigma_x = 8.89 \text{ MPa}} \text{ Ans}$$

Prob:- 2281-

Given data:

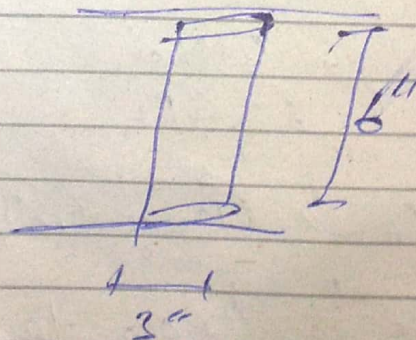
$$P = 600 \text{ Psi}$$

$$\nu = 1/3$$

$$E = 12 \times 10^6 \text{ Psi}$$

Required data:

$$\sigma_y = ? \quad \epsilon_x = ?$$



Soln - As we know that;

$$\epsilon_x = \frac{\sigma_x}{E} - \nu \frac{\sigma_y}{E}$$

Since $\epsilon_x = 0$ ~~there~~ as no deformation will produce but of fixed support.

$$\frac{\sigma_x}{E} = \frac{\nu \sigma_y}{E}$$

$$\sigma_x = \nu \sigma_y \rightarrow (1)$$

$$\sigma_y = \text{tangential stress} = \frac{Pd}{2t}$$

$$= \frac{600(3)}{2(0.1)} = 9000 \text{ Psi}$$

longitudinal stress =

$$\sigma_x = \frac{1}{2}(9000)$$

$$\sigma_x = 3000 \text{ Psi} \quad \text{Ans}$$

Pb-233:-

Given data;

$E_{\text{iron}} = 100 \text{ GPa.}$

$E_{\text{st}} = 200 \text{ GPa.}$

$\delta = 0.8 \text{ mm.}$

Required data = $P = ?$

Soln
2 Draw FBD.

$\uparrow \sum F_y = 0$

$P_{\text{cast}} + P_{\text{st}} = P.$

$P = P_{\text{cast iron}} + P_{\text{st}} \rightarrow \textcircled{1}$

Since;

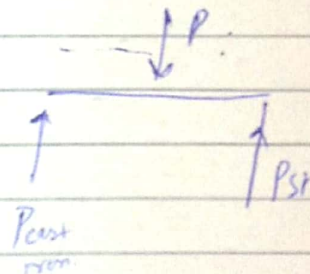
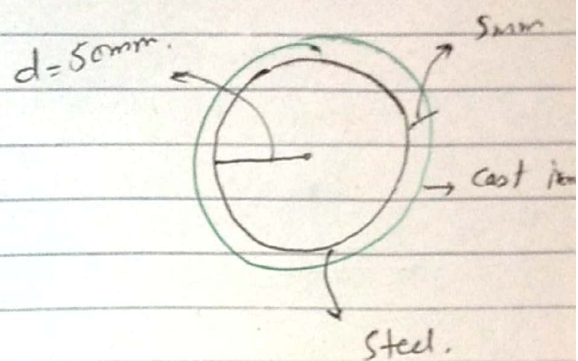
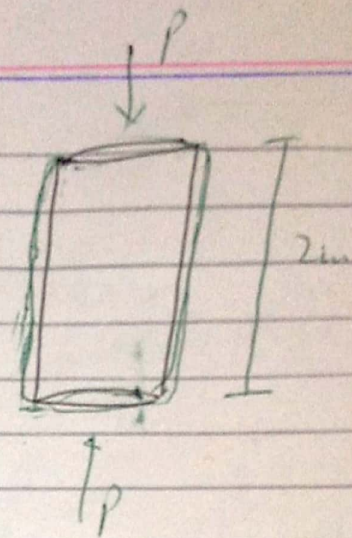
$\delta = \frac{PL}{AE}$

$0.8 = \frac{P_{\text{st}}(2000)}{\frac{\pi}{4}(50)^2(200 \times 10^3)}$

$P_{\text{st}} = 157000 \text{ N.}$

~~$P_{\text{cast iron}} = P_{\text{cast iron}}$~~

$0.8 = \frac{P_{\text{cast iron}}(2000)}{\frac{\pi}{4}(60^2 - 50^2)(200 \times 10^3)}$
 $P_{\text{cast iron}} = 34540 \text{ N.}$



$\therefore 1 \text{ GPa} = 10^9 \text{ Pa}$
 But

Diameter in mm
 $i.e. 10^6 \text{ mm}^2$
 $10^3 \times 10^{-6} = 10^3$

Put values in $\textcircled{1}$

$P = 157000 + 34540$

$P = 191540 \text{ N.}$

$\boxed{P = 191.54 \text{ kN}}$

Pb-234

Given data:

$$d = 200 \text{ mm}$$

$$P = 300 \text{ kN}$$

$$\sigma_{\text{con}} = 6 \text{ MPa}$$

$$\sigma_{\text{st}} = 120 \text{ MPa}$$

$$E_{\text{con}} = 14 \text{ GPa}$$

$$E_{\text{st}} = 200 \text{ GPa}$$

Required data:

Area for steel = ?

Sol:-

Draw FBD

$$\epsilon_{\text{ty}} = 0$$

$$P = P_{\text{st}} + P_{\text{con}} \rightarrow \text{①}$$

From method of compatibility:

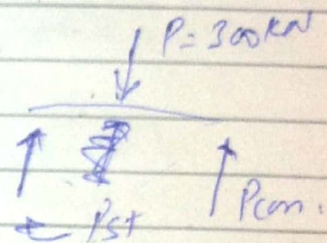
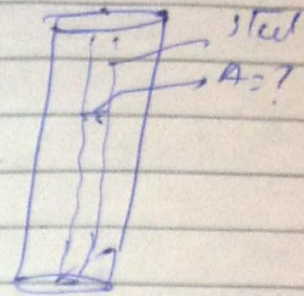
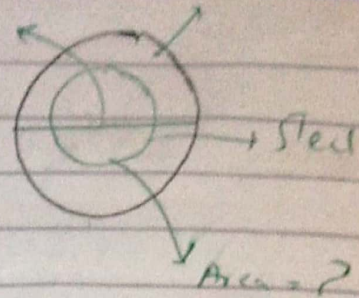
$$\Delta_{\text{con}} = \Delta_{\text{st}}$$

$$\left(\frac{PL}{AE} \right)_{\text{con}} = \left(\frac{PL}{AE} \right)_{\text{st}}$$

$$\frac{\sigma_{\text{con}} L}{(E)_{\text{con}}} = \frac{\sigma_{\text{st}} L}{(E)_{\text{st}}} \Rightarrow \sigma_{\text{con}} = \sigma_{\text{st}} \frac{(E)_{\text{con}}}{(E)_{\text{st}}}$$

$$\sigma_{\text{con}} = \sigma_{\text{st}} \left(\frac{14}{200} \right) \Rightarrow \sigma_{\text{con}} = 0.07 \sigma_{\text{st}} \rightarrow \text{②}$$

$d = 200 \text{ mm}$ Concrete



When $\sigma_{st} = 120 \text{ MPa}$.

Ex ① $\Rightarrow$

$$\sigma_{con} = 0.07 (120)$$

$$\sigma_{con} = 8.4 \text{ MPa} > 6 \text{ MPa}.$$

When ~~$\sigma_{con} = 14 (0.07)$~~

When $\sigma_{con} = 6 \text{ MPa}$.

$$\sigma = 0.07 \sigma_{st}$$

$$\sigma_{st} = 85.71 < 120 \text{ MPa}$$

Thus second assumption is right.

$$\text{So, } \sigma_{con} = 6 \text{ MPa}, \sigma_{st} = 85.71 \text{ MPa}$$

Ex ② $\Rightarrow$

$$P = 300 \text{ kN} = P_{st} + P_{con}$$

$$300 \text{ kN} = \sigma_{st} A_{st} + \sigma_{con} A_{con}$$

$$= 85.71 (A_{st}) + 6 \left(\frac{\pi}{4} (200)^2 - A_{st} \right)$$

$$300 \times 10^3 = 85.71 A_{st} - 6 A_{st} + 188400$$

$$111600 = 79.71 A_{st}$$

$$A_{st} = 1400 \text{ mm}^2 \quad \text{Ans}$$

Pb - 235:-

Given data:

$$\text{width} = 8 \text{ in.}$$

$$P = 300 \text{ kips.}$$

$$\sigma_T = 1200 \text{ Psi}$$

$$\sigma_{st} = 20 \text{ ksi}$$

$$E_T = 1.5 \times 10^6 \text{ Psi}$$

$$E_{st} = 29 \times 10^6 \text{ Psi.}$$

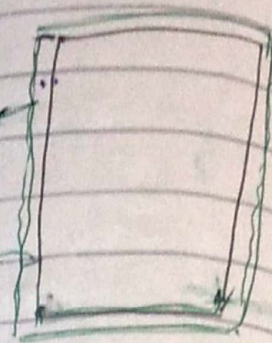
Required data:

Thickness of steel = ?

steel

t = ?

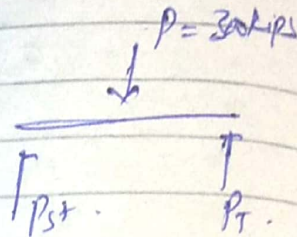
$$P = 300 \text{ kips}$$



Sol:-

2 Draw FBD

$$P_{st} + P_T = 300 \rightarrow (1)$$



Using method of compatibility,

$$\Delta_{st} = \Delta_T.$$

$$\left(\frac{PL}{AE} \right)_{st} = \left(\frac{PL}{AE} \right)_T.$$

$$\therefore \frac{P}{A} = \sigma.$$

$$\frac{\sigma_{st} L}{E_{st}} = \frac{\sigma_T L}{E_T}.$$

$$\sigma_{st} = \frac{\sigma_T \times E_{st}}{E_T} \Rightarrow \frac{\sigma_T (29 \times 10^6)}{1.5 \times 10^6}$$

$$\sigma_{st} = 19.33 \sigma_T \rightarrow (2)$$

When $\sigma_{st} = 20 \text{ ksi}$

$$20 \times 10^3 = 19.33 \sigma_T$$

$$\sigma_T = 1034.5 \text{ Psi} < 1200 \text{ MPa}$$

For $\sigma_T = 1200 \text{ Psi}$

$$\sigma_{st} = 19.33(1200)$$

$$\sigma_{st} = 23196 \text{ Psi} > 20,000 \text{ Psi}$$

So our first assumption is correct.

$$\begin{aligned} \sigma_{st} &= 20 \times 10^3 \text{ Psi} & \sigma_T &= 1034.5 \text{ Psi} \\ \sigma_{st} &= 20 \text{ Ksi} & \sigma_T &= 1.034 \text{ Ksi} \end{aligned}$$

$$\Rightarrow P_{st} + P_T = 300$$

$$(\sigma_{st} A_{st}) + (\sigma_T)(A_T) = 300$$

$$20(484) + 1.034(8 \times 8) = 300$$

$$(8)(80) \overset{\text{Thick}}{\sigma_{st}} = 300 - 66.176$$

$$\sigma_{st} = \frac{233.824}{80(8)}$$

$$\sigma_{st} = 0.36535 \text{ Ksi} \quad \text{Ans}$$

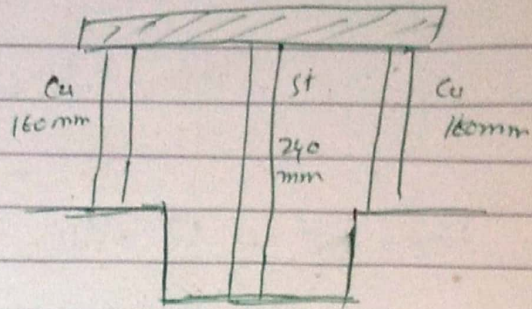
Pb-236:-

Given data:

$$A_{cu} = 900 \text{ mm}^2$$

$$E_{cu} = 120 \text{ GPa}$$

$$\sigma_{cu} = 70 \text{ MPa}$$



$$A_{st} = 1200 \text{ mm}^2$$

$$E_{st} = 200 \text{ GPa}$$

$$\sigma_{st} = 140 \text{ MPa}$$

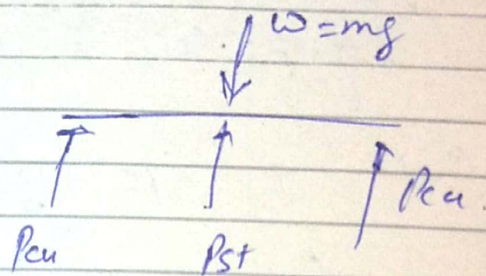
Required data:

Mass that be supported = ?

Sol:- Draw FBD:-

$$\sum F_y = 0 \quad (\uparrow +)$$

$$2P_{cu} + P_{st} = W$$



$$2(\sigma A)_{cu} + (\sigma A)_{st} = W$$

$$\therefore \sigma = P/A$$

$$\therefore P = \sigma A$$

①.

From method of compatibility:

$$\Delta_{st} = \Delta_{cu}$$

$$\left(\frac{PL}{AE} \right)_{st} = \left(\frac{PL}{AE} \right)_{cu}$$

$$\frac{\sigma_{st} L_{st}}{E_{st}} = \frac{\sigma_{cu} L_{cu}}{E_{cu}}$$

$$\frac{\sigma_{st} (240)}{200} = \frac{\sigma_{cu} (160)}{120}$$

$$\sigma_{st} = 1.11 \sigma_{cu} \rightarrow \textcircled{1}$$

When $\sigma_{st} = 140 \text{ MPa}$.

$$1.11 \cdot \sigma_{cu} = 140$$

$$\sigma_{cu} = 126.126 \text{ MPa} > 70 \text{ MPa} = \sigma_{cu}$$

Neglect

Now

for $\sigma_{cu} = 70 \text{ MPa}$

eq (2) $\Rightarrow$

$$\sigma_{st} = 70(1.11)$$

$$\sigma_{st} = 77.7 \leq 140 \text{ MPa} = \sigma_{st}$$

Use it.

So, $\sigma_{st} = 77.7 \text{ MPa}$ when $\sigma_{cu} = 70 \text{ MPa}$.

eq (1) $\Rightarrow 2(70)(900) + 77.7(1200) = W$

$$126000 + 93240 = W$$

$$W = 219,240$$

$$W = mg = 219240$$

$$m = \frac{219240}{9.81}$$

$$\boxed{m = 22348.6 \text{ Kg}} \quad \text{Ans}$$

$$P_b = 238$$

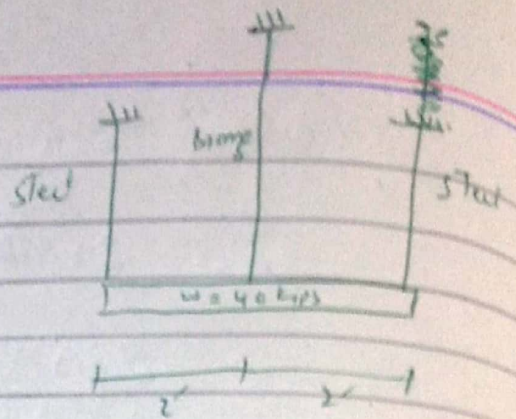
Given data;

$$W = 40 \text{ kips}$$

$$\text{Length}_{st} = L_{st} = 3'$$

$$A_{st} = 1 \text{ in}^2$$

$$E_{st} = 29 \times 10^6 \text{ psi}$$



$$(A_{br})_{br} = 1.5 \text{ in}^2$$

$$(E)_{br} = 12 \times 10^6 \text{ psi}$$

Required data;

- (a) length of bronz bar so that load on each steel bar twice the load on bronz bar

Sol:- As given that;

$$P_{st} = 2P_{br}$$

Step #1

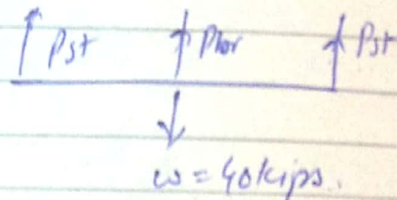
Draw FBD.

$$2P_{st} + P_{br} = 40$$

$$2(2P_{br}) + P_{br} = 40$$

$$4P_{br} + P_{br} = 40$$

$$P_{br} = 8 \text{ kips}$$



Step #2.

Using method of compatibility.

$$\Delta_{br} = \Delta_{st}$$

$$\left(\frac{PL}{AE}\right)_{br} = \left(\frac{PL}{AE}\right)_{st}$$

$$\frac{P_{br} L_{br}}{(1.5)(12 \times 10^6)} = \frac{P_{st}(3 \times 12)}{(1)(29 \times 10^6)}$$

$$\therefore 3' = 3 \times 12'' = 36''$$

To convert into inches

$$\frac{P_{br}}{18} L_{br} = \frac{2P_{st} (24)}{29}$$

$$L_{br} = \frac{2(24)(18)}{29}$$

$$L_{br} = 44.689"$$

$$1 \text{ ft} = 12"$$

$$L_{br} = \frac{44.689}{12}$$

$$L_{br} = 3.72 \text{ ft}$$

(b) The length of bronze that will make steel stress twice the bronze stress.
Given condition;

$$\sigma_{st} = 2\sigma_{br} \rightarrow (1)$$

$$\text{Since; } 2P_{st} + P_{br} = 40.$$

$$\sigma = \frac{P}{A}$$

$$P = \sigma A$$

$$2(\sigma A)_{st} + (\sigma A)_{br} = 40.$$

$$2(2\sigma_{br} A_{st}) + \sigma_{br} A_{br} = 40.$$

$$4(\sigma_{br})(1) + \sigma_{br}(1.5) = 40.$$

$$\sigma_{br} = 7.2727 \text{ Ksi} \rightarrow (2)$$

$$\text{So } \sigma_{st} = 2(7.2727)$$

$$\sigma_{st} = 14.54 \text{ Ksi} \rightarrow (3)$$

Step #2 Using method of compatibility:

$$\delta (D)_m = (D)_{st}$$

$$\delta \left(\frac{PL}{AE} \right)_{br} = \left(\frac{PL}{AE} \right)_{st}$$

$$\frac{\delta_{br} L_{br}}{E_{br}} = \frac{\delta_{st} L_{st}}{E_{st}}$$

$$L_{br} = \frac{\delta_{st} L_{st}}{E_{st}} \times \frac{E_{br}}{\delta_{br}}$$

$$L_{br} = \frac{(14.54)(3 \times 12)}{29} \times \frac{12}{7.2727}$$

$$L_{br} = 29.29"$$

$$L_{br} = \frac{29.29}{12}$$

$$L_{br} = 2.48 \text{ ft}$$

At this length stress in steel
twice bronze steel.

238

To reach its allowable limit.

$$\delta_{cu} = \delta_{st}$$

$$\frac{\delta_{cu} L_{cu}}{E_{cu}} = \frac{\delta_{st} L_{st}}{E_{st}}$$

$$L_{cu} = \frac{\delta_{st} L_{st} E_{cu}}{\delta_{cu} E_{st}}$$

$$L_{cu} = \frac{(140)(240)(120)}{70(200)}$$

$$L_{cu} = 288 \text{ mm}$$

Pb-238

$$W = 40 \text{ kips.}$$

$$L_{st} = 3'$$

$$A_{st} = 1 \text{ in}^2$$

$$E = 29 \times 10^6 \text{ psi}$$

$$L_{br} = ?$$

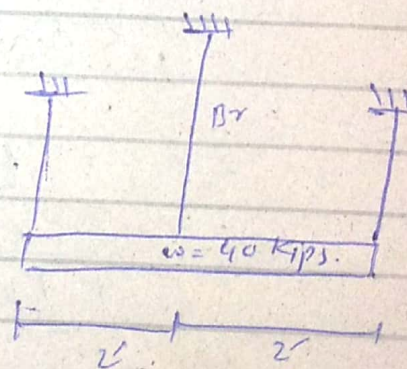
$$A_{br} = 1.5 \text{ in}^2$$

$$E = 12 \times 10^6 \text{ psi}$$

a) Length of bronze bar so that load on each steel bar is twice the load on bronze.

$$P_{st} = 2P_{br}$$

$$2P_{st} + P_{br} = 40 \rightarrow \textcircled{1}$$



$$2P_{st} + P_{br} = 60$$

$$2P_{st} = 60$$

$$2(2P_{br}) + P_{br} = 60$$

$$5P_{br} = 60$$

$$P_{br} = 12 \text{ kips}$$

From method of compatibility,

$$\Delta_{br} = \Delta_{st}$$

$$\frac{P_{br}(L_{br})}{A_{br} E_{br}} = \frac{P_{st} L_{st}}{A_{st} (E_{st})}$$

$$\frac{P_{br}(L_{br})}{(1.5)(12)} = \frac{2P_{br}(3000)}{(1)(25)}$$

$$L_{br} = 44.55"$$

$$L_{br} = 3.72 \text{ ft}$$

⑤ The length of bronze bar must be
shorter than bronze steel

$$P_{st} = 2P_{br} \rightarrow \text{①}$$

$$A_s \quad \sum F_y = 0$$

$$2P_{st} + P_{br} = 60$$

$$2(\sigma_{st} A_{st}) + (\sigma_{br} A_{br}) = 40.$$

$$2(2 \sigma_{br} A_{st}) + \sigma_{br} A_{br} = 40.$$

$$4 \sigma_{br} (1) + \sigma_{br} (1.5) = 40.$$

$$\sigma_{br} = 7.273 \text{ Ksi} \rightarrow \text{OK}$$

$$\sigma_{st} = 14.54 \text{ Ksi} \rightarrow \text{OK}$$

$$\sigma_{st} = \sigma_{br}.$$

$$\frac{\sigma_{st} L_{st}}{A E} = \frac{\sigma_{br} L_{br}}{A E}.$$

$$L_{br} = \frac{\sigma_{st} L_{st} A E}{A E \cdot \sigma_{br}}.$$

$$= \frac{14.54 (3 \times 12) (1) (\cancel{A})}{(\cancel{A}) (7.273)}.$$

$$L_{br} = 29.78''$$

$$\boxed{L_{br} = 2.5'}$$

Pb- 239:-

Given data:

$$Length = l_{st} = 250 \text{ mm}$$

$$l_{al} = 249.90 \text{ mm}$$

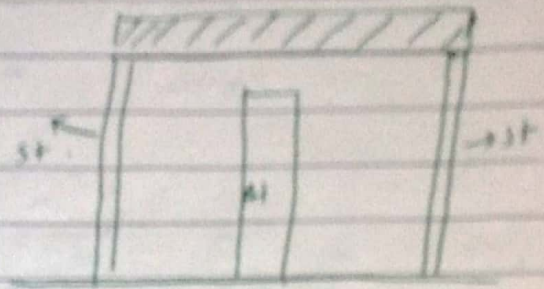
$$P = 400 \text{ kN}$$

$$A_{st} = 1200 \text{ mm}^2$$

$$E_{st} = 200 \text{ GPa}$$

$$A_{al} = 2400 \text{ mm}^2$$

$$E_{al} = 70 \text{ GPa}$$



Required data:-

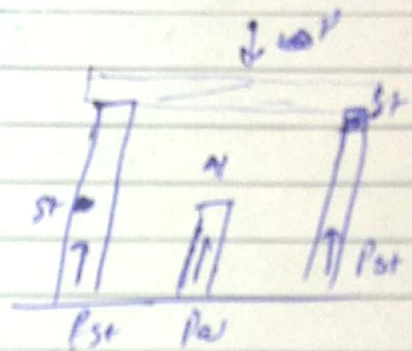
σ_{al} = Stress in aluminum bar = ?

Soln: Step #1

Draw the FBD & fig

$$\sum F_y = 0 \quad (\uparrow +)$$

$$2P_{st} + P_{al} = 400 \times 10^3 \text{ N}$$



$$2(\sigma A)_{st} + (\sigma A)_{al} = 400 \times 10^3$$

$$\therefore \sigma = P/A$$

$$2\sigma_{st} A_{st} + \sigma_{al} A_{al} = 400 \times 10^3 \rightarrow \text{①} \quad P = \sigma A$$

Step #2

Using Compatibility eqn

$$\Delta + (\Delta)_{al} = (\Delta)_{st}$$

$$0.1 + \left(\frac{PL}{AE} \right)_{al} = \left(\frac{PL}{AE} \right)_{st}$$

= As In case of

compression

$$\Delta = \Delta_{st} + \Delta_{al}$$

$$\Delta_{st} = \Delta - \Delta_{al}$$

$$\therefore \Delta = 250 - 249.9 = 0.1 \text{ m}$$

$$\therefore \delta = P/A$$

$$0.1 + \frac{\delta_{al}(249.9)}{70 \times 10^3} = \frac{\delta_{st}(250)}{200 \times 10^3}$$

$$\therefore \text{As } GPa = 10^9 Pa$$

$$\delta_{st} = \left(0.1 + \frac{\delta_{al}}{70 \times 10^3} \right) \frac{200 \times 10^3}{250}$$

> But when we have given calculation in mm so we write 10^3 in place of GPa

$$\delta_{st} = 80 + 2.856(\delta_{al}) \quad \hookrightarrow (2)$$

Put in eq (1)

$$2(80 + 2.856(\delta_{al}))(1200) + \delta_{al}(2400) = 400 \times 10^3$$

$$192000 + 6854.4 \delta_{al} + 2400 \delta_{al} = 400 \times 10^3$$

$$9254.4 \delta_{al} = 208000$$

$$\delta_{al} = 22.47 \text{ MPa} \quad \text{Ans}$$

240 & 241 not included

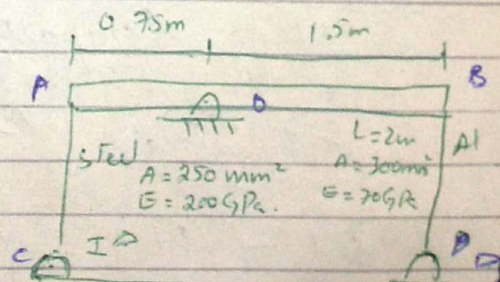
Pb-242

Given data;

$$\Delta = 5 \text{ mm}$$

Required data;

Compute stress in aluminum rod when lower end of steel

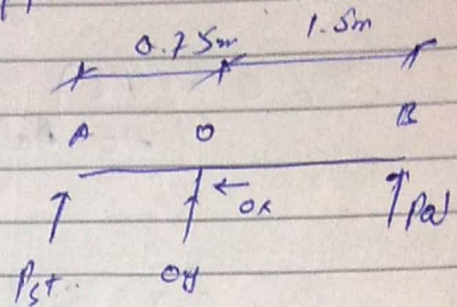


rod is attached to support.

Solution:-

Step #1

Draw FBD of fig.



~~Fig. 1~~

$$\sum M_O = 0$$

$$-P_{st}(0.75) + P_{al}(1.5) = 0$$

$$P_{al}(1.5) = 0.75(P_{st})$$

$$P_{st} = 2P_{al} \rightarrow (1)$$

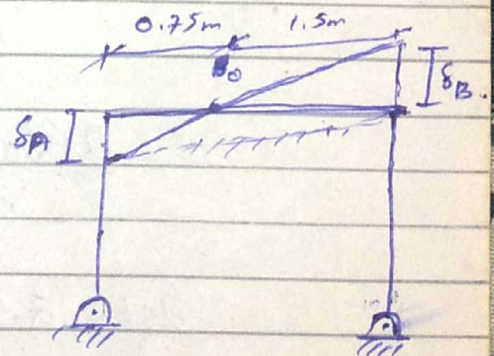
Step #2

In order to bring the steel rod to pin support we have to apply Tension (tensile) force as a result Tension will also produced in aluminum rod as shown.

Using Similarity of Δs

$$\frac{\delta_A}{0.75} = \frac{\delta_B}{1.5}$$

$$\delta_A = 0.5 \delta_B \rightarrow (2)$$



Step #3

In case of Tension we know that;

$$\Delta = \delta_{al} + \delta_{st} \rightarrow (3)$$

Put (2) in (3).

$$\Delta = 0.5 \delta_{al} + \delta_{st}$$

$$\therefore \Delta = \delta$$

$$\delta = 0.5 \left(\frac{PL}{AE} \right)_{al} + \left(\frac{PL}{AE} \right)_{st}$$

$$\therefore \frac{P}{A} = \delta$$

$$\delta = 0.5 \left(\frac{\delta_{al} L}{E} \right) + \left(\frac{\delta_{st} L}{E} \right)_{st}$$

$$\delta = 0.5 \left(\frac{\delta_{al} (2000)}{70 \times 10^3} \right) + \left(\frac{\delta_{st} (2000 - \delta)}{200 \times 10^3} \right)$$

$$\delta = 0.0143 \delta_{al} + 9.975 \times 10^{-3} \delta_{st} \rightarrow (4)$$

As,

$$\text{Eq (1)} \Rightarrow P_{st} = 2 P_{al}$$

$$\therefore \delta = \frac{P}{A}$$

$$\delta_{st} A_{st} = 2 \delta_{al} A_{al}$$

$$\Rightarrow \delta A = P$$

$$\delta_{st} = \frac{2 \delta_{al} A_{al}}{A_{st}}$$

$$= \frac{2 (\delta_{al}) (300)}{250}$$

$$\delta_{st} = 2.4 \delta_{al} \rightarrow (5)$$

Put in Eq (4)

$$\delta = 0.0143 \delta_{al} + 9.975 \times 10^{-3} (2.4 \delta_{al})$$

$$\delta = 0.0143 \delta_{al} + 0.02394 \delta_{al}$$

$$0.03824 \sigma_{al} = 5$$

$$\sigma_{al} = 130.75 \text{ MPa}$$

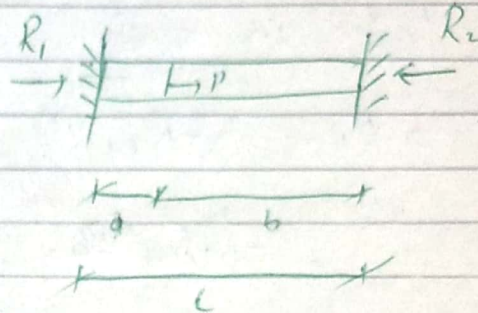
Ans. diff becz error in notes (solution) of Mos.

Pb-243

Required:

$$R_1 = \frac{Pb}{L}$$

$$R_2 = \frac{Pa}{L}$$



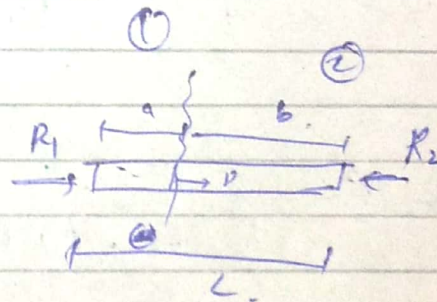
Solution:-

Step # 1.
Draw FBD.

$$\sum F_x = 0 \quad (\rightarrow)$$

$$R_1 + R_2 = P$$

$$R_2 = P - R_1 \quad \text{--- (1)}$$



Step # 2

Apply method of Compatibility.

$$\Delta_1 = \Delta_2$$

$$\left(\frac{PL}{AE} \right)_1 = \left(\frac{PL}{AE} \right)_2$$

$$\frac{R_1(a)}{AE} = \frac{R_2(b)}{AE}$$

As same material & Area.

$$a R_1 = b R_2 \rightarrow (2)$$

$$\text{eq (1)} \Rightarrow R_1 = -R_2 + P.$$

$$R_2 = -R_1 + P. \rightarrow (3)$$

Put in eq (2).

$$a R_1 = b(-R_1 + P)$$

$$= -R_1 b + Pb.$$

$$R_1 a + R_1 b = Pb.$$

$$R_1(a+b) = Pb.$$

$$\because a+b=L.$$

$$R_1 = \frac{Pb}{L}$$

eq (3)

$$R_2 = -R_1 + P.$$

$$= -\frac{Pb}{L} + P$$

$$= \frac{-Pb + PL}{L}$$

$$= \frac{P(L-b)}{L}$$

$$\because L-b=a.$$

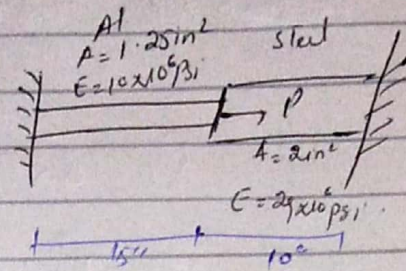
From fig

$$R_2 = \frac{Pa}{L}$$

Problem 245

Given data:

load, $P = 50 \text{ kips}$.



Required data:-

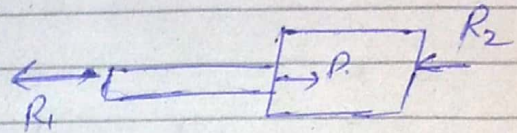
stress in each material. = ?

Solution:-

Step #1

Draw FBD of bar

$$\sum F_x = 0 \quad (\rightarrow)$$



$$R_1 + R_2 = P$$

$$R_2 = P - R_1 \rightarrow (1)$$

Step #2

Using method of Compatibility.

$$(\Delta)_{al} = (\Delta)_{st}$$

$$\left(\frac{PL}{AE}\right)_{R_1} = \left(\frac{PL}{AE}\right)_{R_2}$$

$$\frac{R_1(15)}{(1.25)(10 \times 10^6)} = \frac{R_2(10)}{2(29 \times 10^6)}$$

$$R_1 = 0.144 R_2 \rightarrow (2)$$

Using eq (1).

$$R_1 = 0.144(P - R_1)$$

$$R_1 + 0.144 R_1 = 0.144(50 \times 10^3)$$

$$\frac{1}{144} \\ \cancel{0.556} R_1 = 7200$$

$$R_1 = 6293.7 \text{ lb.}$$

$$\sigma_{al} = \frac{R_1}{A} = \frac{6293.7}{1.25}$$

$$\boxed{\sigma_{al} = 5034.96 \text{ Psi}}$$

$$e_1 \Rightarrow R_1 = P - R_2$$

$$R_2 = P - R_1$$

$$= 50000 - 6293.7$$

$$R_2 = 43706.3 \text{ lb.}$$

$$\sigma_{st} = \frac{R_2}{A} = \frac{43706.3}{2}$$

$$\boxed{\sigma_{st} = 21853.15 \text{ Psi}} \quad \frac{\text{Ans}}{2}$$

Pb-246

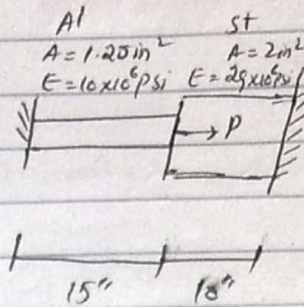
Given data:

$$\sigma_{al} = 10 \text{ ksi}$$

$$\sigma_{st} = 18 \text{ ksi}$$

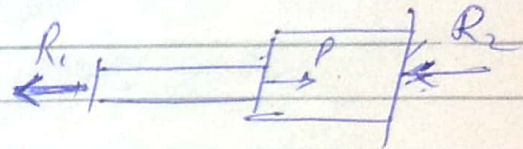
Required data:

$$P = ?$$



Solution:- Step 1
Draw FBD of fig

$$\sum F_x = 0 \quad (\rightarrow)$$



$$R_1 + R_2 = P$$

$$\text{Since } \frac{R}{A} = \frac{\sigma}{A}$$

$$(\sigma A)_{al} + (\sigma A)_{st} = P \rightarrow \textcircled{1}$$

$$R = \sigma A$$

Step #2

Using method of Compatibility,

$$(\Delta)_{st} = (\Delta)_{al}$$

$$\left(\frac{PL}{AE} \right)_{st} = \left(\frac{PL}{AE} \right)_{al}$$

$$\left(\frac{\sigma L}{E} \right)_{st} = \left(\frac{\sigma L}{E} \right)_{al}$$

$$\frac{\sigma_{al}(15)}{10 \times 10^6} = \frac{\sigma_{st}(10)}{29 \times 10^6}$$

$$\sigma_{al} = 0.23\sigma_{st} \rightarrow \textcircled{1}$$

Case #1

when $\sigma_{st} = 18 \text{ ksi}$

$$\sigma_{al} = 0.23(18)$$

$$= 4.13 \text{ ksi} < 10 \text{ ksi} = \sigma_{al}$$

(it is right)

Case #2

when $\sigma_{al} = 10 \text{ ksi}$

$$\frac{10}{0.23} = \sigma_{st}$$

$$\sigma_{st} = 43.48 \text{ ksi} > \sigma_{st} = 18 \text{ ksi}$$

(Discarded)

so we have $\sigma_{st} = 18 \text{ ksi} \leq \sigma_{al} = 4.13 \text{ ksi}$

$$\textcircled{1} \Rightarrow (4.13)(1.25) + 18(2) = P$$

$$5.1625 + 36 = P$$

$$\boxed{P = 41.16 \text{ kips}} \quad \text{Ans}$$

2.

Pb-247:-

Given data;

$$P_1 = 150 \text{ kN}$$

$$P_2 = 90 \text{ kN}$$

Required data;

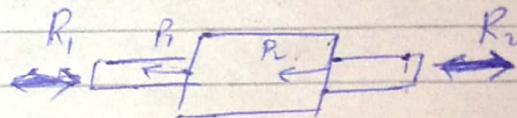
Stress in each member = ?

Sol:-

Step #1

Draw FBD of bars.

$$\sum F_x = 0$$



$$R_1 + R_2 = P_1 + P_2$$

$$R_1 + R_2 = 240 \rightarrow \textcircled{1}$$

$$\text{or } R_2 = 240 - R_1 \rightarrow \textcircled{1}$$

Step #2

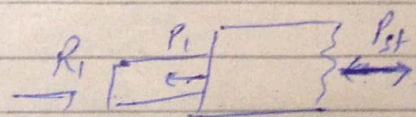
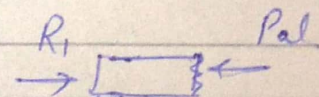
Draw FBD of each segment separately;

$$\sum F_x = 0 \Rightarrow P_{Al} = R_1 \rightarrow \textcircled{3}$$

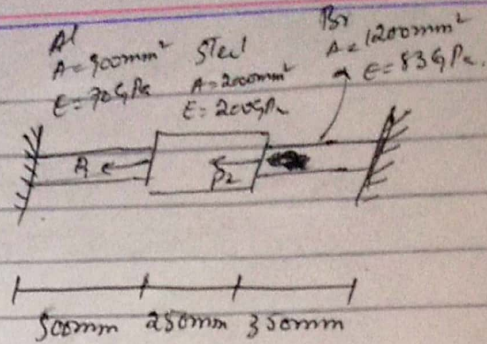
$$R_1 = P_1 - P_2$$

$$P_{St} = P_1 - R_1$$

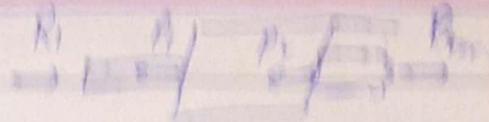
$$P_{St} = 150 - R_1 \rightarrow \textcircled{2}$$



AB in Steel Tension



$$P_{st} = R_2 = 240 = R_1$$



Step #3

Using method of compatibility

$$\Delta_{total} = \Delta_{st} + \Delta_{br}$$

$$\Delta_{total} = \Delta_{st} + \Delta_{br}$$

As rigid

$$\Delta_{total} = 0$$

$$\left(\frac{PL}{AE}\right)_{st} = \left(\frac{PL}{AE}\right)_{st} + \left(\frac{PL}{AE}\right)_{br}$$

$$\frac{R_1(500)}{(900)(70 \times 10^3)} = \frac{(150 - R_1)250}{(2000)(200 \times 10^3)} + \frac{(240 - R_1)(350)}{(1200)(833 \times 10^3)}$$

$$7.94 \times 10^6 R_1 = (150 - R_1)6.25 \times 10^7 + (240 - R_1)3.5 \times 10^8$$

$$7.94 \times 10^6 R_1 + 6.25 \times 10^7 R_1 + 3.5 \times 10^6 R_1 = (8.43 \times 10^9) + 9.375 \times 10^9$$

$$1.2065 \times 10^5 R_1 = 9.375 \times 10^9$$

$$R_1 = 76.64 \text{ kN}$$

$$P_{st} = R_1 = 76.64 \text{ kN}$$

$$P_{st} = 150 - 76.64 = 72.36 \text{ kN}$$

$$P_{br} = 240 - 76.64 = 163.36 \text{ kN}$$

$$\sigma_{st} = \frac{R_1}{A} = \frac{76.64 \times 10^3}{900} = 55.15 \text{ MPa}$$

$$\sigma_{br} = \frac{P_{st}}{A} = \frac{72.36 \times 10^3}{2000} = 36.18 \text{ MPa}$$

$$\delta_{br} = \frac{P_{br}}{A_{br}} = \frac{163.364 \times 10^3}{1200}$$

$$\delta_{br} = 136.13 \text{ MPa} \quad \text{Ans}$$

$$P_b = 248$$

Given data:

$$P_1 = 150 \text{ kN}$$

$$P_2 = 90 \text{ kN}$$

$$\Delta = 0.80 \text{ mm}$$

Sol: Step #1

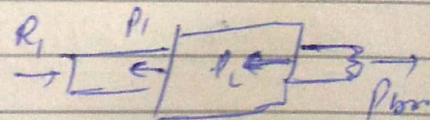
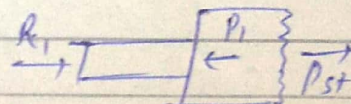
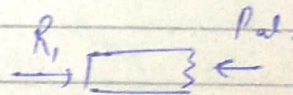
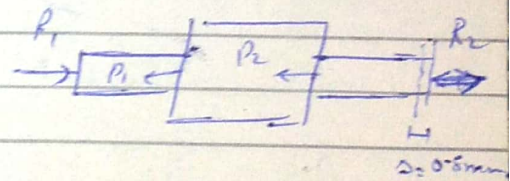
Draw FBD of bars.

Now take each segment.

$$R_1 = P_1$$

$$P_{st} = 150 - R_1$$

$$P_{br} = 240 - R_1$$



Step #2

Using method of compatibility,

$$\delta_{Total} = \delta_{al} + \delta_{st} + \delta_{br}$$

$$\delta_{al} = \delta_{st} + \delta_{br} + \delta_{Total}$$

$$\left(\frac{PL}{AE}\right)_{al} = \left(\frac{PL}{AE}\right)_{st} + \left(\frac{PL}{AE}\right)_{br} + 0.8$$

There is
Tension in
steel & brass
i.e. why +ve
& Compression
in aluminum
So -ve

$$\frac{R_1(500)}{900(70 \times 10^3)} = \frac{(150 - R_1)(200)}{(200 \times 200 \times 10^3)} + \frac{(240 - R_1)(350)}{(1200)(83 \times 10^3)} + 0.8$$

$$7.94 \times 10^{-6} R_1 + 2.5 \times 10^{-7} R_1 + 3.51 \times 10^{-6} R_1 = 9.375 \times 10^{-5} + 8.43 \times 10^{-4} + 0.8$$

$$1.2075 \times 10^{-5} R_1 = 9.371 \times 10^{-4}$$

$$1.2075 \times 10^{-5} R_1 = 0.80093$$

$$R_1 = 66.33 \text{ kN}$$

$$R_1 = P_{al} = 66.33 \text{ kN}$$

$$P_{st} = 150 - 66.33 = 83.67 \text{ kN}$$

$$P_{br} = 240 - 66.33 = 173.67 \text{ kN}$$

$$\delta_{al} = \frac{66.33 \times 10^3}{900} \quad \left. \begin{array}{l} \delta_{st} = \frac{83.67 \times 10^3}{200} \\ \delta_{br} = \frac{173.67 \times 10^3}{1200} \end{array} \right\}$$

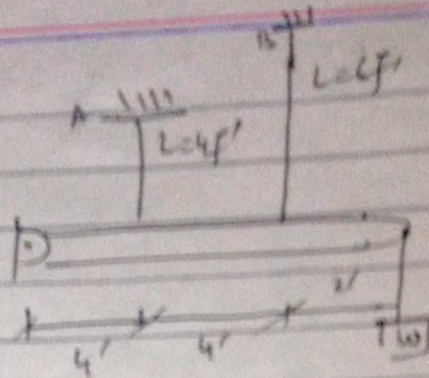
$$\boxed{\delta_{al} = 7.37 \text{ MPa}} \quad \left. \begin{array}{l} \delta_{st} = 41.8 \text{ MPa} \\ \delta_{br} = 144.7 \text{ MPa} \end{array} \right\}$$

Ans
2

Pb-251

Given data:

$$w = 6600 \text{ lb}$$



Required data:

Load in each rod = ?

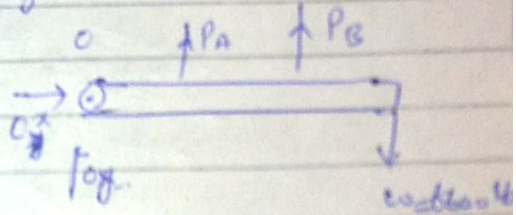
Sol:-

2

Step #1

Draw FBD & fig.

$$\sum M_0 = 0$$



$$P_A(4) + P_B(8) - w(10) = 0$$

$$4P_A + 8P_B = 6600$$

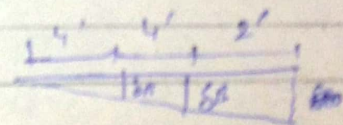
$$P_A + 2P_B = 1650 \rightarrow (1)$$

Divide by 4.

Step #2

When load is applied.

By similarity of Δ s



$$\frac{\delta_A}{4} = \frac{\delta_B}{8}$$

$$\delta_A = \frac{4}{8} (\delta_B)$$

$$\delta_A = 0.5 \delta_B$$

$$\left(\frac{PL}{AE} \right)_A = (0.5) \left(\frac{PL}{AE} \right)_B$$

$$\frac{P_A(t)}{AE} = \frac{0.5 P_B(t)}{AE}$$

$\therefore P_A = P_B$
 A_1 identical.
 $E_A = E_B$

$$4P_A = 3P_B$$

$$P_A = \frac{3}{4} P_B \rightarrow (2)$$

Using eq (1).

$$\frac{4P_B}{3} + 2P_B = 16500$$

~~$$\frac{4P_B + 6P_B}{3} = 16500$$~~

~~$$10P_B = 49500$$~~

~~$$P_B =$$~~

$$0.75P_B + 2P_B = 16500$$

$$2.75P_B = 16500$$

$$P_B = 6000 \text{ lb}$$

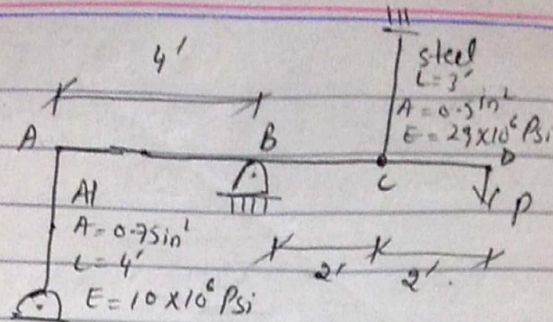
$$\text{eq (2)} \Rightarrow P_A = \frac{3}{4} (6000)$$

$$P_A = 4500 \text{ lb} \quad \text{Ans}$$

Pb-252

Given data:

load, $P = 20 \text{ kips}$



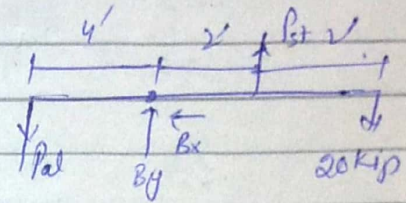
Required data:

Stress in each rod = ?

Solution:- Step #1

Draw FBD of bar.

$$\sum M_B = 0$$



$$P_{al}(4) + P_{st}(2) - 20(4) = 0$$

$$4P_{al} + 2P_{st} - 80 = 0$$

$$2P_{st} + 4P_{al} = 80$$

$$P_{st} + 2P_{al} = 40 \rightarrow (I)$$

$$\rightarrow A_s \quad P_{st} = \sigma_{st} A_{st}$$

$$\rightarrow P_{al} = \sigma_{al} A_{al}$$

Using these eqs in eq (I)

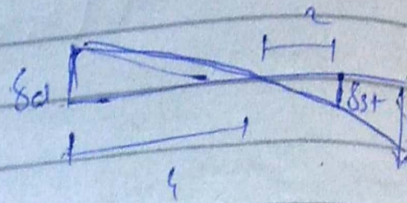
$$\sigma_{st} A_{st} + 2(\sigma_{al} A_{al}) = 40$$

$$\sigma_{st}(0.5) + 2(\sigma_{al}(0.75)) = 40$$

$$(0.5)\sigma_{st} + 1.5\sigma_{al} = 40$$

$$\sigma_{st} + 3\sigma_{al} = 80 \text{ kip} \rightarrow (II)$$

Step #2
When load is applied
Using similarity of Δs



$$\frac{\delta_{st}}{2} = \frac{\delta_{al}}{4}$$

$$\delta_{st} = 0.5 \delta_{al}$$

$$\left(\frac{PL}{AE}\right)_{st} = 0.5 \left(\frac{PL}{AE}\right)_{al} \quad \because \delta = \frac{PL}{AE}$$

~~By~~

$$\frac{\delta_{st} L_{st}}{E_{st}} = 0.5 \frac{\delta_{al} L_{al}}{E_{al}}$$

$$\frac{\delta_{st}(3)}{29 \times 10^6} = \frac{0.5(\delta_{al})(4)}{10 \times 10^6}$$

$$\delta_{st} = 1.933 \delta_{al} \rightarrow (2)$$

$$eq (1) \Rightarrow \delta_{st} + 3 \delta_{al} = 80 -$$

$$\delta_{st} = 80 - 3 \delta_{al} \rightarrow (3)$$

Comparing eq (2) & (3)

$$80 - 3 \delta_{al} = 1.933 \delta_{al}$$

$$4.933 \delta_{al} = 80$$

$$\delta_{al} = 16.217 \text{ Ksi}$$

$$eq (1) \Rightarrow \delta_{st} = 1.933(16.217) \Rightarrow \delta_{st} = 31.348 \text{ Ksi}$$

Pb-283

Given data:

$$W = 50 \text{ kips}$$

Required data:

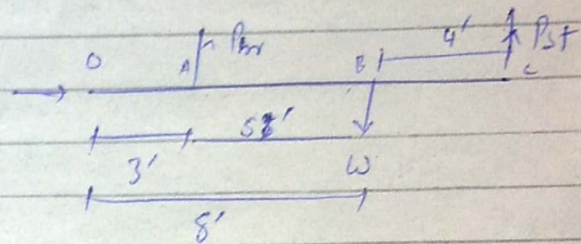
Vertical movement of $W = ?$

Sol:-

Step #1

Draw FBD

$\sum M_0 = 0$



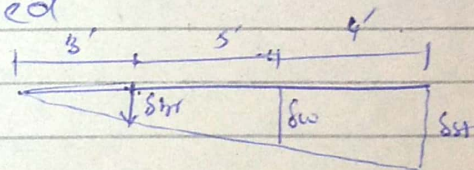
$$P_{br}(3) - 50(8) + P_{st}(12) = 0$$

$$3P_{br} + 12P_{st} = 400 \rightarrow \textcircled{1}$$

Step #2

When load is applied

By similarity of Δs



$$\frac{\delta_{st}}{12} = \frac{\delta_{br}}{3}$$

$$\delta_{st} = 4 \delta_{br}$$

$$\delta = \frac{PL}{AE}$$

$$\left(\frac{PL}{AE} \right)_{st} = 4 \left(\frac{PL}{AE} \right)_{br}$$

$$\frac{P_{st}(10)}{0.5(29 \times 10^6)} = 4 \left(\frac{P_{br}(3)}{2(12 \times 10^6)} \right)$$

$$(0.6896) P_{st} = \frac{12 P_{br}}{24}$$

$$P_{st} = 0.725 P_{br} \rightarrow (2)$$

eq (1) =

$$3 P_{br} + 12 P_{st} = 400$$

$$3 P_{br} + 12(0.725) P_{br} = 400$$

$$11.7 P_{br} = 400$$

no need

$$P_{br} = 34.18 \text{ Kip}$$

$$\delta_{br} = \frac{34.18}{2} = 17.09 \text{ Ksi}$$

$$\delta_{br} = \frac{P_{br}(3)}{2 \times 12 \times 10^6}$$

$$\therefore \delta = \frac{PL}{AE}$$

$$= \frac{34.18 \times 10^3 \left(\frac{3 \times 12}{3 \times 12} \right)}{2 \times 12 \times 10^6}$$

$$r_f = 1 \times 12''$$

$$\delta_{br} = 0.01527 \text{ in}$$

Now $P_{st} = ?$

$$\text{eq (2)} \Rightarrow P_{st} = 0.725 (P_{br})$$

$$P_{st} = 0.725 (34.18) \Rightarrow P_{st} = 24.78 \text{ Kip}$$

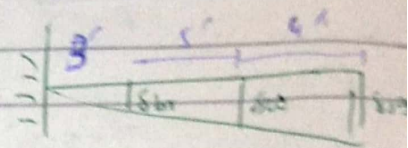
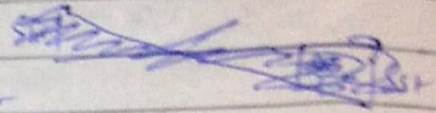
$$\delta_{st} = \frac{P_{st} L}{AE} \Rightarrow \frac{(24.78 \times 10^3)(10 \times 12)}{(0.5)(29 \times 10^6)}$$

$$\delta_{st} = 0.2051 \text{ in.}$$

Now Considering diagram

Comparing δ_{br} & δ_w

$$\frac{\delta_w}{8} = \frac{\delta_{br}}{3}$$



$$\delta_w = \frac{8}{3} \delta_{br}$$

$$\delta_w = \frac{8}{3} (0.01527)$$

$$\delta_w = 0.04072 \text{ in}$$

Now Comparing δ_w & δ_{st}

$$\frac{\delta_{st}}{12} = \frac{\delta_w}{8}$$

$$\delta_w = \frac{8}{12} (\delta_{st})$$

$$= \frac{2}{3} (0.2051)$$

$$\delta_w = 0.1367 \text{ in}$$

Pb-254

Given data:

$$\sigma_{st} = 180 \text{ MPa}$$

$$\sigma_{br} = 70 \text{ MPa}$$

Required data:
 $P = ?$

Sol:-

Step #1 Draw FBD.

$$\sum M_0 = 0$$

$$P(2) - P_{st}(1.5) - P_{br}(3) = 0$$

$$P_{st}(1.5) + 3P_{br} = 2P$$

$$\sigma_{st} A_{st}(1.5) + 3\sigma_{br} A_{br} = 2P$$

$$(\sigma_{st}) 900(1.5) + 3\sigma_{br}(300) = 2P$$

$$2P = 1350\sigma_{st} + 900\sigma_{br}$$

$$P = 675\sigma_{st} + 450\sigma_{br} \rightarrow (1)$$

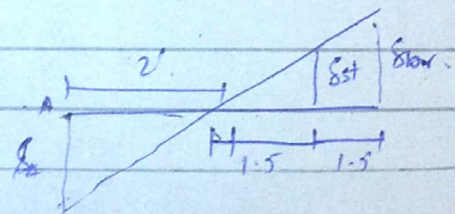
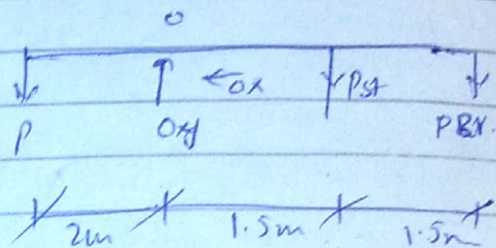
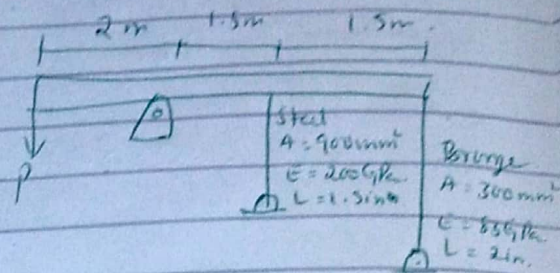
Step #2

When load is applied

$$\frac{\sigma_{st}}{1.5} = \frac{\sigma_{br}}{3}$$

$$\sigma_{st} = 0.5\sigma_{br} \rightarrow (2)$$

Put in eq



$$\sigma_{st} = \frac{\sigma_{br}}{2}$$

$$\frac{P}{A_{st}} \frac{L_{st}}{E_{st}} = 0.5 \left(\frac{\sigma_{br}}{E_{br}} \right) \frac{L_{br}}{A_{br}}$$

$$\frac{\sigma_{st} (200 \times 10^3)}{200 \times 10^3} = 0.5 \left(\frac{\sigma_{br}}{83 \times 10^3} \right) (1.5)$$

$$\cancel{4.5 \sigma_{st}} = \cancel{1.8675 \sigma_{br}}$$

$$\sigma_{br} = 0.6225 \sigma_{st} \rightarrow (2)$$

When $\sigma_{br} = 70 \text{ MPa}$
 $\Rightarrow \sigma_{st} = 112.44 < 150 \text{ MPa} = \sigma_{st}$
 O.K. (right)

When $\sigma_{st} = 150 \text{ MPa}$
 $\Rightarrow \sigma_{br} = 0.6225(150)$

$$\sigma_b = 93.37 \text{ MPa} > 70 \text{ MPa} = \sigma_{st}$$

Discarded.

So,

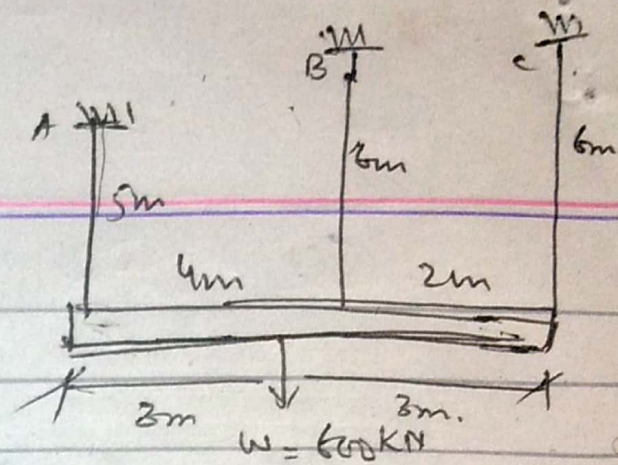
$$\begin{aligned} \Rightarrow P &= 675 \sigma_{st} + 450 \sigma_{br} \\ &= 675(112.44) + 450(70) \end{aligned}$$

$$P = 103,397 \text{ N}$$

$$\boxed{P = 103.39 \text{ kN}}$$

Ans
 2

Pb-2⁵:-



Given data;

Same area & material i.e.

E & $A =$ same for all.

Required data;

load in each rod.