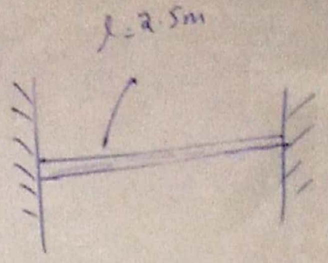
MOS

Problem:- 258.

Given data;



length = $l = 2.5m$

$t_1 = 20°C$

$t_2 = -20°C$

t_1

$\sigma = ?$

$A = 1200mm^2$.

$\alpha = 11.7 \times 10^{-6}$ /°C

$-20 - 20$
$= -40$

$E = 200 GPa$

$\delta = ?$

Since; $\varepsilon_T = \alpha \Delta T$

$= (11.7 \times 10^{-6})(-40)$

$\varepsilon_T = -4.68 \times 10^{-4}$

Since; $\sigma = E(\varepsilon_T)$

$200 \times 10^9 (+4.68 \times 10^{-4})$

$\sigma = 936 MPa$.

Part (b)

If the other end is consider free.

Since we know that

$\delta_{total} = \delta_T - \delta_P$

$= \delta_T = \delta_{Tot} + \delta_P$

$(\alpha \Delta T) L = \frac{\sigma L}{E} + 0.05$

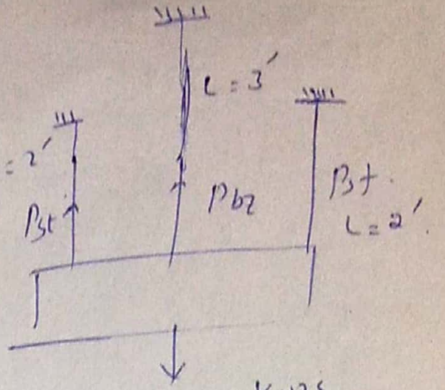
$(11.7 \times 10^{-6})(-40)(2.5 \times 1000) = \frac{\sigma (2.5 \times 1000)}{200 \times 10^9} + 0.5$

$2.34 \times 10^{11} = \sigma (2500) + 1 \times 10^{11}$

$1.34 \times 10^{11} = \sigma (2500)$

$\sigma = 53600000 =$ [illegible] $MPa = \sigma$

Pb-259



Given data;

Area of St = $3/4$ in².

Area of bz = 1.5in².

Toughness :-

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

$E_{bz} = 12 \times 10^6$ Psi

$\alpha_{st} = 6.5 \times 10^{-6} / ^\circ F$

$\alpha_{bz} = 10 \times 10^{-6} / ^\circ F$

$T_1 = 0^\circ F$

$T_2 = 100^\circ F$

Stress in rod? each.

$\uparrow^+ \Sigma F_y = 0$

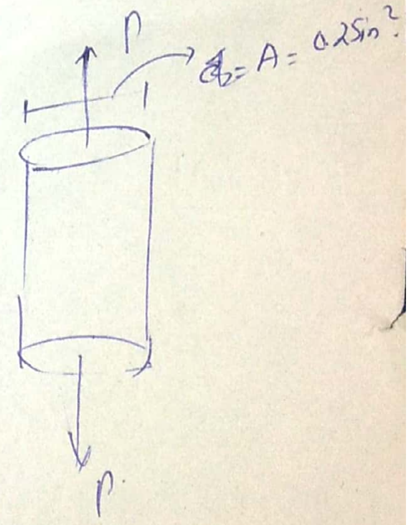
$2P_{st} + P_{bz} = 12000 \text{ lb} \rightarrow (1)$

| Pb - 259 | Geometric relation = ?

(Pb - 260)

| Pb - 261 |

Given data;



A = 0.25 in².

P = 1200 lb.

$T_1 = 70^\circ F$.

$\delta = ?$

$T_2 = 0^\circ F$

$T = ?$ at $\delta = 0$

$\alpha = 6.5 \times 10^{-6} / ^\circ F$ $E = 29 \times 10^6$ psi

~~$\delta = (\alpha \Delta T) L$~~

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

Pb-261

As we know that;

$\delta_{Total} = \delta_T - \delta_P$

$\frac{\delta L}{E} = \alpha \Delta T L + \frac{PL}{AE}$

$\Delta T = G - 70$

$2 - 70$

$\delta = \alpha \Delta T E + \frac{P}{A}$

$\delta = (6.5\times10^{-6})(70)(29\times10^{6}) - \frac{1200}{6.5}$

$\boxed{\delta = 15595 Psi}$

For temp that cause zero stress?

$\delta_T = 0$

$\delta_T = \delta_b$ $\delta_T = \delta_T - \delta_b$

$\alpha \Delta T L = \frac{PL}{AE}$

$\Delta T = \frac{1200}{(0.25)(29\times10^{6})(6.5\times10^{-6})}$

$T - 70 = 25.46$

$T = 70 + 25.46$

$\boxed{T = 95.46\ F}$ / Ans

Pb-263

$P = 5000N$

$T_1 = 20°C$

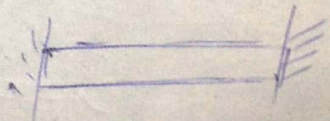
$\delta = 130MPa$

$T_2 = -20°C$

$d = ?$

$\alpha = 11.7\times10^{-6}/°C$

$E = 200GPa$



Sol:- Since; $\delta_{H} = \delta_T + \delta_P$

$\frac{\delta L}{E} = \alpha \Delta t L + \frac{PL}{AE}$

$$\frac{PL}{AE} = \frac{\delta L}{E} - \alpha \Delta T L$$

$$\frac{AE}{P} = \frac{E}{\delta} - \frac{1}{\alpha \Delta T}$$

$$\frac{(\pi/_4 D^2) E}{P} = \frac{E}{\delta} - \frac{1}{\alpha \Delta T}$$

$\Delta T = 40°c$

$$\pi/_4 D^2 = \frac{P}{\delta} - \frac{P}{\alpha \Delta T E}$$

$$D = \sqrt{4\left(\frac{P}{\delta} - \frac{P}{\alpha \Delta T E}\right)}$$

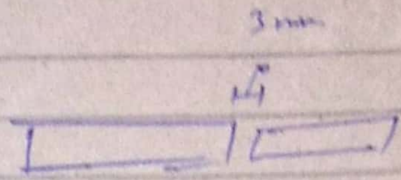
$$= \sqrt{4\left(\frac{5000}{130 \times 10^6} - \frac{5000}{(11.7 \times 10^{-6})(40)(200 \times 10^9)}\right)}$$

$$= 2\left(\sqrt{3.84 \times 10^{-5} + 5.3418 \times 10^{-5}}\right.$$

10mm.

$\frac{D}{h} - 263$

Pb-263:-



~~$l = 7m$~~

$l = 10m$

$D = 3mm$

$t_i = 15°c$

at what temp rail will just touch?

Sol:- As we know that;

Free expansion due to temp change is;

$$\delta_T = \alpha \Delta T L$$

$$\Delta T = \frac{\delta_T}{\alpha L} \Rightarrow 25.64°C$$

$$T_f = 25.64° + 15° \Rightarrow 40.64°c$$

(b) What stress would be induced if there no initial clearance.

As; $\delta = \delta_T - \delta_P$.

Since $\delta = 0$. No clearance

$$\delta_P = \delta_T$$

$$\frac{\sigma L}{E} = \alpha \Delta T L$$

$$\sigma = E \alpha \Delta T$$

$$\sigma = \alpha E (T_f - T_i)$$

$$\sigma = (11.7 \times 10^{-6})(200 \times 10^3)(40.64 - 15)$$

$$\boxed{\sigma = 60 MPa}$$ Ans

Pb-264:-

$l = 3'$

$A = 0.25 in^2$

$P = 1200 lb$

$t_i = 40°F$

$E = 29 \times 10^6 psi$

$\alpha = 6.5 \times 10^{-6} /°F$

(a) Temp at which stress in bar will be 10 ksi

As;

we know That;

$\delta_{Total} = \delta_T \pm \delta_p$

Here $\delta_{Total} = 0$ Since rigid support

$\delta_p = \delta_T \Rightarrow \frac{\sigma \cancel{L}}{E} = \alpha \Delta T \cancel{L}$

$\Delta T = \frac{10 \times 10^3}{29 \times 10^6 (6.5 \times 10^{-6})}$

$\Delta T = 53°C \Rightarrow T_f = 53°C - 40°$

$\boxed{T_f = 13°C}$

(b) Temp at which stress will be zero.

So; Simply;

$\delta_T = \delta_p$

$\frac{P\cancel{L}}{AE} = \alpha \Delta T \cancel{L} \Rightarrow \Delta T = \frac{P}{AE\alpha}$

$\Delta T = 25.64$ $T_f =$

Scanned with CamScanner

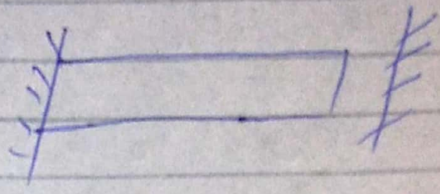
Pb-265:-

$l = 3m$

$A = 320 mm^2$

$T_i = 20°C$

$\delta = 25mm$



25mm

T_f at which Compressive stress in bar will be 35MPa.

$\sigma = 35MPa$

$E = 80GPa$ & $\alpha = 18\times10^{-6}/°C$

Sol:- As we know

$$\delta = \delta_T \mp \delta_P \quad \text{(As Temp decrease)}$$

$$25 = \alpha\Delta TL \mp \frac{PL}{AE} \Rightarrow \alpha\Delta TL - \frac{\sigma L}{E}$$

$$25 \mp \frac{35\times10^6(3\times10^3)}{80\times10^9} = 18\times10^{-6}(3\times10^3)\Delta T$$

$$2.5 \mp 1.3125 =$$

$$\cancel{26.31} = 0.054\,\Delta T$$

$$\Delta T = \cancel{487.22}\ 70.6°C$$

$$T_f = \cancel{487.22}\ 70.6 \mp 20$$

$$\boxed{T_f = \cancel{507.22C}}$$

$$50.6°C$$

Note:-

In case of expansion. —— (T↑)

$$\delta = \delta_T + \delta_P$$

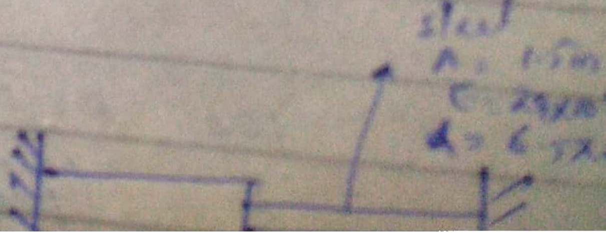
In case of contraction (Temp ↓)

$$\delta = \delta_T - \delta_P$$

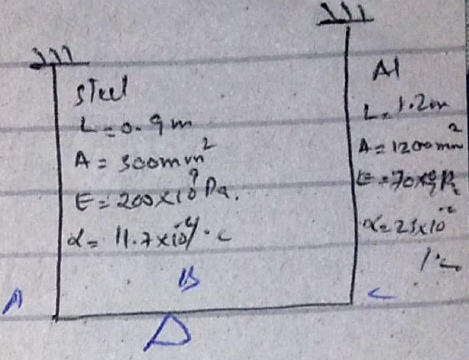
Pb-266:-

$\delta = ?$ (Each Segment)

$\Delta T = 100^\circ c$



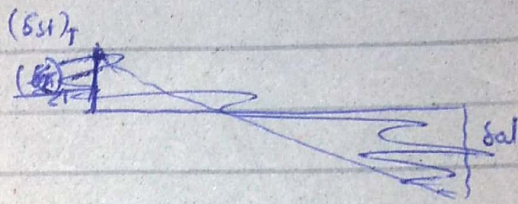
Pb - 268:-

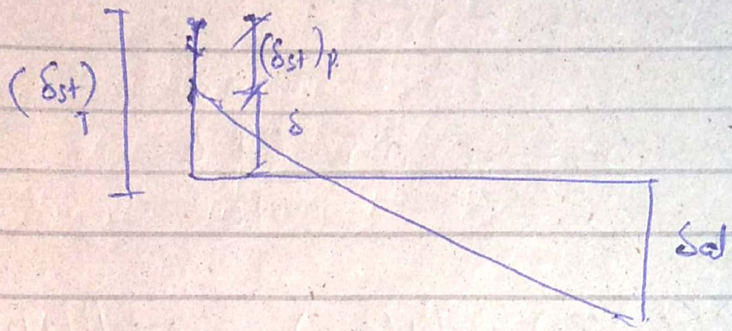


Temp decrease of steel to 40°C

$\delta_{al} = ?$

Sol:- As temp decrease.



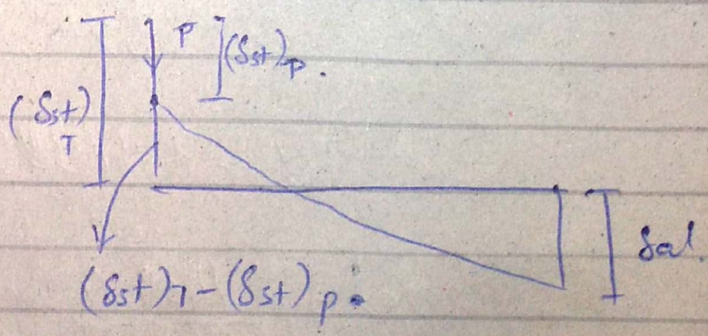


$(\delta_{st})_T - (\delta_{st})_p = \delta_{al}$.

$(\delta_{st})_p + \delta_{al} = (\delta_{st})_T$.

From similarity of Δs.

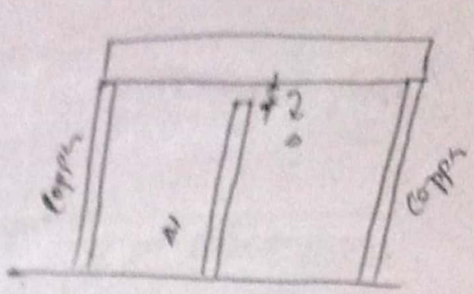
$\dfrac{(\delta_{st})_T - \delta_{st}}{0.6} = \dfrac{\delta_{al}}{1.2}$



$(\delta_{st})_T - (\delta_{st})_p = 0.5\,\delta_{al} \longrightarrow (1)$.

Scanned with CamScanner

Pb. 269:-



given data;

$t = 10°C$

$\Delta =$ gap $= 0.18$ mm

Required data;

Calculate stress in each

rod if temperature increased

$T = 95°C$

For copper bar

$A = 500 \text{ mm}^2$

$E = 120$ GPa

$\alpha = 16.5 \times 10^{-6}/°C$

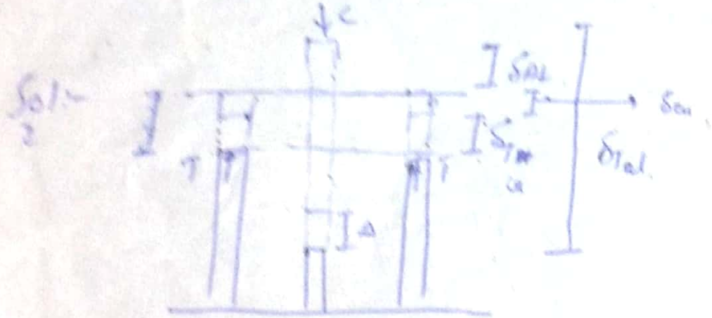
For aluminum bar

$A = 400 \text{ mm}^2$

$E = 70$ GPa

$\alpha = 23.1 \times 10^{-6}/°C$

Sol:-



From above fig.

By Compatability;

$$\delta_{T al} = \Delta + \delta_{T cu} + \delta_{cu} + \delta_{al} \longrightarrow ①$$

~~$\delta_{T al} = \alpha_{al}\,\Delta T \ldots$~~

~~$= (23.1\times10^{-6})(85)(750)$~~

$\delta_{T al} =$

Since;

$\delta_{Tal} = \alpha_{al} \Delta T_{al} L_{al}$

$= (23.1\times10^{-6})(95-10)(750-0.18)$

$\boxed{\delta_{Tal} = 1.472\text{ mm}}$ change in length in aluminum due to increase of Temp.

$\delta_{Tcu} = \alpha_{cu} \Delta T_{cu} L_{cu}$

$= (16.8\times10^{-6})(95-10)(750)$

$\boxed{\delta_{Tcu} = 1.071\text{ mm}}$

eq (1) =>

$\delta_{Tal} = \Delta + \delta_{Tcu} + \delta_{cu} + \delta_{al}$

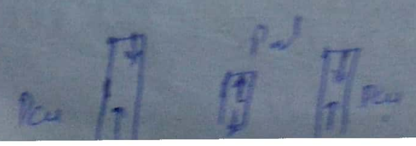
$1.472 = 0.18 + 1.071 + \left(\frac{PL}{AE}\right)_{cu} + \left(\frac{PL}{AE}\right)_{al}$

$0.221 = \frac{P_{cu}(750)}{(400)(70\times10^{3})} + \frac{P_{al}(750-0.15)}{(500)(120\times10^{3})}$

$0.221 = 2.67\times10^{-5} P_{cu} + P_{al}(1.249\times10^{-5})$

$P_{al} = 17,684.2 - 2.13877 P_{cu} \rightarrow (1)$

Draw FBD



$\Sigma F_y = 0 (\uparrow +)$

$P_{cu} + P_{cu} - P_{al} = 0.$

$2P_{cu} - P_{al} = 0$

$2P_{cu} - (17684.2 - 2.1377 P_{cu}) = 0.$

$2P_{cu} - 17684.2 + 2.1377 P_{cu} = 0.$

$4.1377 P_{cu} = 17684.2.$

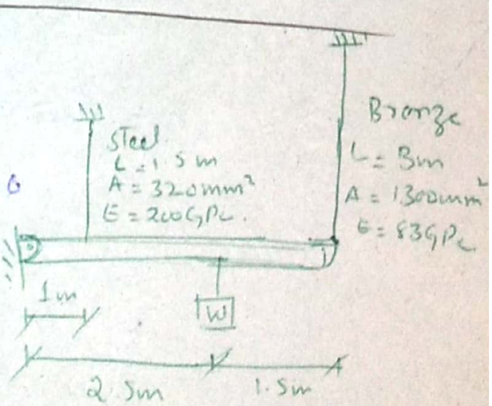
$P_{cu} = 4273.91$

$P_{al} = 8547.819$

$\delta_{al} = \frac{8547.819}{400} = \boxed{21.36 MPa}$

$\delta_{cu} = \frac{4273.91}{500} = \boxed{\delta_{cu} = 8.5 MPa}$

P6 - 271



Given data;

Weight $W = 80kN$.

Stress in steel $= \delta_{st} = 55 MPa$

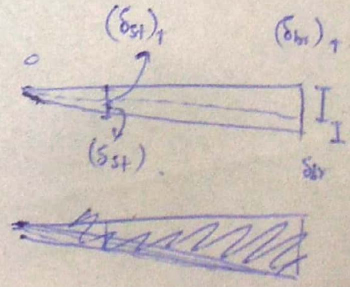
$\alpha_{st} = 11.7 \times 10^{-6}/°c$

$\alpha_{br} = 18.9 \times 10^{-6}/°c$

Required $\Delta T = ?$

Sol:-

Draw diagram when temp change let suppose increases. Then draw when load is applied



Using similarity of triangle

$$\frac{(\delta_{st})_T + \delta_{st}}{1} = \frac{(\delta_{br})_T + \delta_{br}}{4}$$

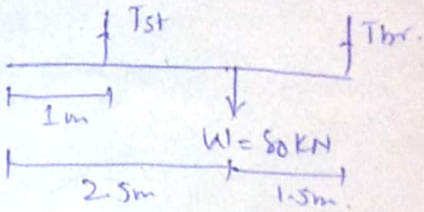
$$(\delta_{st})_T + \delta_{st} = \frac{(\delta_{br})}{4} + \frac{\delta_{br}}{4} \rightarrow ①$$

Since;

$$\cancel{(\delta_{st})_T} = \sigma_{st} = 55 MPa \rightarrow ①$$

For $\sigma_{br} = ?$

$$\sum M_0 = 0$$



$$T_{st}(1) + 4T_{br} - W \times 2.5 = 0$$

$$T_{st} + 4T_{Br} = (80 \times 10^3)(2.5)$$

$$T_{st} + 4T_{Br} = 2 \times 10^5 \rightarrow ②$$

$$\sigma_{st} A_{st} + 4(\sigma_{br} A_{br}) = 2 \times 10^3$$

$$\Rightarrow T_{st} = \sigma_{st} A_{st}$$

$$T_{br} = \sigma_{br} A_{br}$$

$$(55)(320) + 4(\sigma_{br})(1300) = 2 \times 10^5$$

$$\sigma_{br} = 35.0769\ MPa$$

eq ① =>

$$(\delta_{st})_T + \delta_{st} = \frac{(\delta_{br})_T}{4} + \frac{\delta_{br}}{4}$$

$$(\alpha \Delta T L)_{st} + \left(\frac{PL}{AE}\right)_{st} = 0.25\left((\alpha \Delta T L)_{br} + \left(\frac{PL}{AE}\right)_{br}\right)$$

$$(\alpha \Delta T L)_{st} - 0.25(\alpha \Delta T L)_{br} = 0.25\left(\left(\frac{\delta L}{E}\right)_{br}\right) - \left(\frac{\delta_{st} L}{E}\right)$$

$$(11.7\times10^{-6})\Delta T(1500) - 0.25(18.9\times10^{-6})(\Delta T)(3000)$$

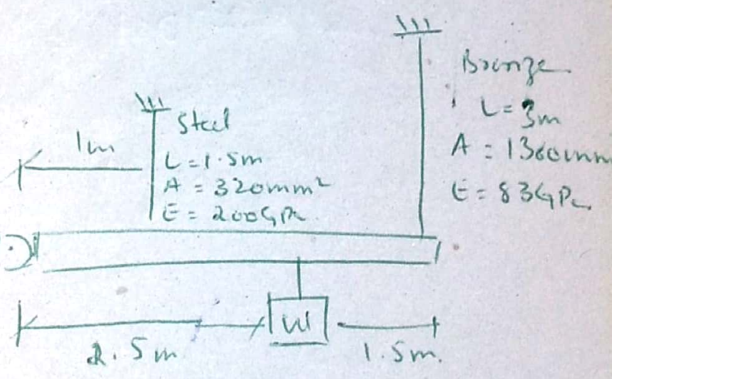
$$= \frac{0.25(35.08\times10^{6})(3000)}{83\times10^{9}} - \frac{55\times10^{6}(1500)}{200\times10^{9}}$$

$$\Delta T(0.01755 - 0.014175) = 0.31698 - 0.4125$$

$$= \frac{-0.09552}{3.375\times10^{-3}}$$

$$\boxed{\Delta T = -28.3^\circ C}$$ Ans.

Pb-272:-



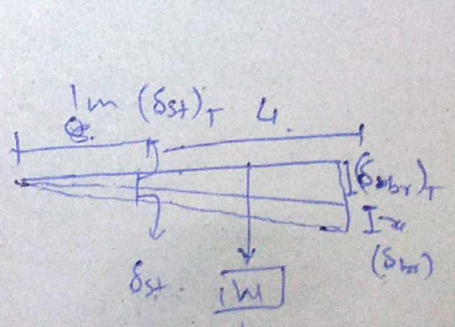
Given data;

W = 120KN.

$\Delta T = 30^\circ C$.

Find stresses in each rod = ?

Sol:- As we know that; after apply load the beam will deform mean inclined.



Using similarity of triangle.

$\delta_{st} + (\delta_{st})_T$ ...

$$(\delta_{st})_T + \delta_{st} = 0.25\left((\delta_{br})_T + \delta_{br}\right)$$

$$(\delta_{st})_T = \alpha \Delta T$$

$$(\alpha \Delta T L)_{T_{st}} + \left(\frac{PL}{AE}\right)_{st} = 0.25\left((\alpha \Delta T L)_{br} + \left(\frac{PL}{AE}\right)_{br}\right).$$

$$(11.7\times10^{-6})(30)(1500) + \frac{\delta_{st}(1500)}{200\times10^{3}} = 0.25(18.9\times10^{-6})(30)(3000) + 0.25\frac{(\delta_{br}(3000))}{83\times10^{3}}$$

$$0.5268 + 7.5\times10^{-3}\,\delta_{st} = 0.4252 + 9\times10^{-3}\,\delta_{br}.$$

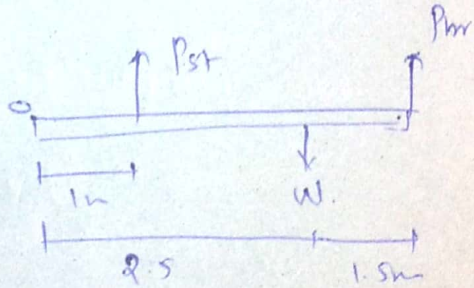
$$0.1013 + 7.5\times10^{-3}\,\delta_{st} = 9\times10^{-3}\,\delta_{br}$$

$$7.5\times10^{-3}\,\cancel{0.0103}\,\delta_{st} = 9\times10^{-3}\,\delta_{br} - 0.1013.$$

$$\delta_{st} = 1.2\,\delta_{br} - 13.5066 \longrightarrow (1)$$

Draw FBD of fig:-

$$\overset{\curvearrowleft}{\Sigma} M_O = 0$$



$$P_{st}(1) + P_{br}(4) - 120\times10^{3}(2.5) = 0$$

$$P_{st} + 4P_{br} - 300000 = 0$$

$$\delta_{st}(A_{st}) + 4(\delta_{br} A_{br}) - 300000 = 0.$$

$$\delta_{st}(320) + 4(\delta_{br}(1300)) - 300000 = 0.$$

$$320\,\delta_{st} + 5200\,\delta_{br} - 300000 = 0$$

$$\delta_{st} = 937.5 - 16.25\,\delta_{br} \longrightarrow (2)$$

Comparing eq (1) & (2)

$1.2\sigma_{br} - 13.5066 = 937.5 - 16.25\sigma_{br}$

$\cancel{1.25}$

$1.2\sigma_{br} - 13.5 - 937.5 + 16.25\sigma_{br} = 0.$

$17.45\sigma_{br} - 951 = 0.$

$$\sigma_{br} = \frac{951}{17.45}$$

$$\boxed{\sigma_{br} = 54.5\ MPa}$$

$\sigma_{st} = 1.2\sigma_{br} - 13.5066.$

$= 1.2(54.5) - 13.5066.$

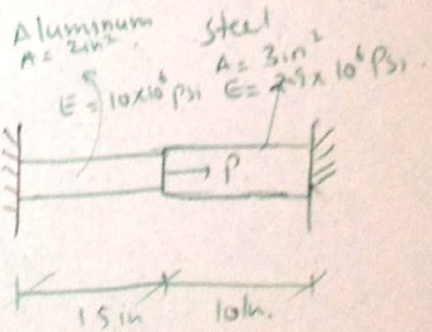
$\sigma_{st} = 65.398 - 13.5066.$

$$\boxed{\sigma_{st} = 51.89\ MPa}$$

R Sol. answer is wrong.

Pb:- 273

The composite bar.



Given data;

$P = 50\ kips$

$T_1 = 60°F.$

$T_2 = 120°F.$

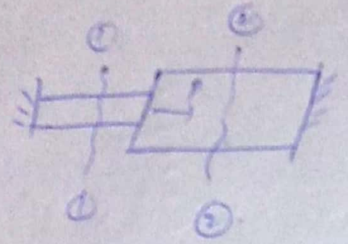
stress in each member = ?

$\alpha_{st} = 6.5\times10^{-6}/°F$

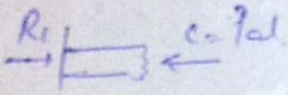
$\alpha_{al} = 12.8\times10^{-6}/°F$

Solution:-

Divide each section into Two Parts, i.e

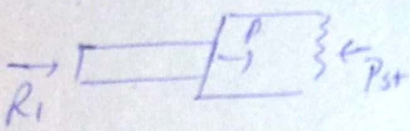


Take Section 1-1.



$R_1 = P_{al}$

section - 2-2.



$R_1 + P = P_{st}$

$P_{st} = R_1 + P \longrightarrow (1)$

From rough work sketch.

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

$$(\alpha \Delta T L)_{T_{st}} + (\alpha \Delta T L)_{T_{al}} = \left(\frac{PL}{AE}\right)_{st} + \left(\frac{PL}{AE}\right)_{al}$$

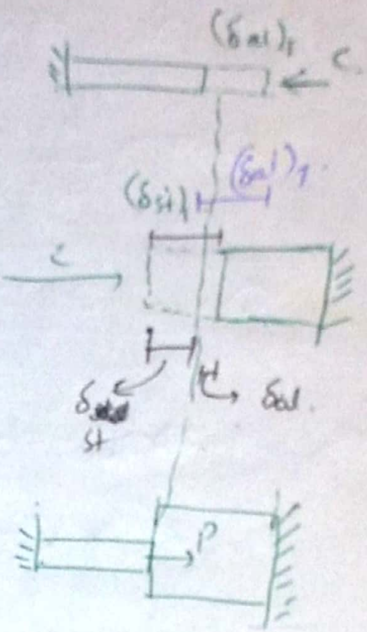
$$\Rightarrow (6.5\times10^{-6})(60)(10) + (12.8\times10^{-6})(60)(15) = \frac{P_{st}(10)}{3(2.9\times10^{6})} + \frac{P_{al}(15)}{2(10\times10^{6})}$$

$$3.9\times10^{-3} + 0.0115\,m = (1.15\times10^{-7})P_{st} + 7.5\times10^{-6}P_{al} \longrightarrow (1)$$

Rough Work

As Temp Increase so each segment will increase its length.

For Aluminium



Find position

Since,

$P_{al} = R_1$

& $P_{st} = R_1 + P$

Using these eqn in eq (2)

$0.0154 = (1.15\times10^{-7})(R_1+P) + 7.5\times10^{-6}(R_1)$

$= (1.15\times10^{-7})(R_1+50\times10^{3}) + 7.5\times10^{-6} R_1$

$0.0154 = 1.15\times10^{-7} R_1 + 5.75\times10^{-3} + 7.5\times10^{-6} R_1$

$\cancel{0.01539}\ 9.65\times10^{-3} = 7.615\times10^{-6} R_1$

$\boxed{R_1 = 1267.23\,lb}$

$P_{al} = R_1 = 1267.23\,lb$

$P_{st} = R_1 + 50000 = 51267.23\,lb$

Stress in steel:-

$\sigma_{st} = \frac{51267.23}{3}$

$\boxed{\sigma_{st} = 17089.1\ psi}$

Stress in Al:-

$\sigma_{al} = \frac{1267.23}{2}$

$\boxed{\sigma_{al} = 633.617\ Psi}$