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Question :- Q1

Given that :-

Factor of safety = 2

$E = 10.3 \times 10^6$  psi

Length = 6 ft

$b = 3/4$  inch,  $h = 2$  inch

Condition, One End Hinged and One End fixed

So,  $L_e = 0.7L$

Required :-

Safe Central Load = ?

Solution :-

$$P_{cr} = \frac{\pi^2 EI}{L_e^2}$$

$$P_{cr} = \frac{\pi^2 E A r^2}{L_e^2} \text{ --- (1) } \therefore I = A r^2$$

Now,  $r = \sqrt{\frac{I}{A}}$

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(2)

$$r = \sqrt{\frac{hb^3}{12}} \div \frac{bk}{12}$$

$$= \sqrt{\frac{b^2}{12}}$$

$$= \frac{b}{2\sqrt{3}}$$

$$= \frac{3/4}{2\sqrt{3}}$$

$$= \frac{0.75}{3.46}$$

$$r = 0.216 \text{ in}$$

Now, we will find crippling load

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$$\text{So, } P_{cr} = \frac{\pi^2 EA}{(Le/r)^2}$$

$$= \frac{(3.14)^2 (10.3 \times 10^6) (1.5 \text{ in}^2)}{(0.7L/r)^2}$$

$$= \frac{(9.8596) \times 15.45 \times 10^6}{\left(\frac{0.7 \times 72}{0.216}\right)^2}$$

$$P_{cr} = \frac{152.33}{54444.4}$$

$$P_{cr} = 2.7979 \times 10^3 \text{ psi}$$

$$P_{cr} = 2.7979 \text{ ksi}$$

For  $P_{safe}$  :-

$$P_{safe} = \frac{P_{cr}}{\text{factor of safety}}$$

$$P_{safe} = \frac{2.7979}{2}$$

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$$P_{safe} = 1.3989 \text{ ksi}$$

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Question :- Q2

Given Data :-

$$\text{Load} = 20 \text{ kips} = 2.4 \times 10^5 \text{ psi}$$

$$\text{Length} = L = 10 \text{ ft}$$

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

Required Data :-

Length of each side = ?

Solution :-

As we know that

$$\frac{l_e}{r} = \sqrt{\frac{\pi^2 E}{6p}}$$

$$\frac{l_e}{r} = \sqrt{\frac{(3.14)^2 \times (29 \times 10^6)}{2.4 \times 10^5}}$$

$$\frac{l_e}{r} = \sqrt{1.19 \times 10^3}$$

$$\frac{l_e}{r} = 34.5$$

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$$r = \frac{L_e}{34.5}$$

$$r = \frac{10 \times 12}{34.5}$$

$$r = \frac{120}{34.5}$$

$$r = 3.4 \text{ inch}$$

1st Method :-

$$r = \sqrt{\frac{b^2}{12}}$$

$$r^2 \times 12 = b^2$$

$$b^2 = (3.4)^2 \times 12$$

$$b^2 = 138.72$$

$$\sqrt{b^2} = \sqrt{138.72}$$

$$b = 11.77$$



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2nd Method :-

$$I = Ar^2$$

$$A = \frac{I}{r^2}$$

$$h^2 = \frac{b^4}{10} / r^2$$

$$1 = \frac{b^2}{10r^2}$$

$$h^2 = 10r^2$$

$$h = 11.77$$

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Question :- 03

Given Data :-

$$\text{Load} = 20 \text{ kips} = 2.4 \times 10^5 \text{ psi}$$

$$\text{Length} = L = 10 \text{ ft}$$

$$E = 1.6 \times 10^6 \text{ psi}$$

Required Data :-

Length of each side = ?

Solution :-

As we know that

$$\frac{L_e}{r} = \sqrt{\frac{\pi^2 E}{6p}}$$

$$\frac{L_e}{r} = \sqrt{\frac{(3.14)^2 \times (1.6 \times 10^6)}{2.4 \times 10^5}}$$

$$\frac{L_e}{r} = \sqrt{\frac{9.8596 \times 1.6 \times 10^6 \times 10^{-5}}{2.4}}$$

$$= \sqrt{65.730}$$



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$$l_e = 8.107$$

$$r = \frac{l_e}{8.107}$$

$$r = \frac{10 \times 12}{8.107}$$

$$r = \frac{120}{8.107}$$

$$r = 14.802 \text{ inch}$$

1st Method :-

$$r = \sqrt{\frac{b^2}{12}}$$

$$r^2 \times 12 = b^2$$

$$b^2 = (14.802)^2 \times 12$$

$$b^2 = 2629.190$$



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(b)

$$\sqrt{b^2} = \sqrt{2629.190}$$

$$b = 51.275$$

2nd Method :-

$$I = Ar^2$$

$$A = \frac{I}{r^2}$$

$$h^2 = \frac{h^4}{12} / r^2$$

$$1 = \frac{h^2}{12r^2}$$

$$h^2 = 12r^2$$

$$h^2 = 2629.190$$

$$\sqrt{h^2} = \sqrt{2629.190}$$

$$h = 51.275$$

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Question:-04

Given Data :-

$$\text{Column} = 36\text{mm} \times 45\text{mm}$$

$$E = 200 \times 10^9 \text{ pa}$$

$$G_p = 240 \times 10^6 \text{ pa}$$

$$L = 12\text{m}$$

$$\text{Factor of safety} = 2.5$$

Required Data :-

(a)  $L_{\min} = ?$

(b)  $\beta_{\text{safe}} = ?$

Solution :-

As we know that

$$G_p = \frac{EA^2}{(L_e/r)^2}$$

$$\frac{L_e}{r} = \sqrt{\frac{EA^2}{G_p}}$$

$$\frac{L_e}{r} = \sqrt{\frac{(3.14)^2 \times (200 \times 10^9)}{240 \times 10^6}}$$



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$$\frac{L_e}{r} = 90.64$$

Now,

$$r = \sqrt{\frac{b^2}{12}}$$

$$r = \sqrt{\frac{(45)^2}{12}}$$

$$r = 12.99 \text{ mm}$$

Now,

$$L_e = 90.64 \times 12.99$$

$$L_e = 1177.44 \text{ mm}$$

Now for pin Hinge,

$$L = L_e$$

$$L_{\text{mm}} = 1177.44 \text{ mm}$$



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(PART B)

$$P_{cr} = \frac{\pi^2 E A r^2}{L_e^2}$$

$$P_{cr} = \frac{(3.14)^2 (200 \times 10^9) (13950) (12.99)^2}{(2 \times 1000)^2}$$

$$P_{cr} = 32.2343 \text{ GN}$$

Now,

for  $P_{safe} \Rightarrow$

$$P_{safe} = \frac{P_{cr}}{\text{factor of safety}}$$

$$P_{safe} = \frac{32.2343 \text{ GN}}{2.5}$$

$$P_{safe} = 12.8937 \text{ GN}$$