Date: _____ ①

Question :- 01

Given that :-

Factor of safety = 2

$E = 10.3 \times 10^6$ psi

Length = 6ft

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

Condition, One End Hinged and One End fixed

So, $L_e = 0.7L$

Required :-

Safe Central Load = ?

Solution :-

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

$$P_{cr} = \frac{\pi^2 E A r^2}{L_e^2} - ① \quad \because I = Ar^2$$

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

te: _____

$$r = \sqrt{\frac{bb^3}{12}}$$

$$bh$$

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

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

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

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

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

Now, we will find Crippling load

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

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

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

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

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

$P_{cr} = 2.7979\ ksi$

For P_{safe} :-

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

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

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

Question :- 02

Given Data :-

Load = 20 kips = 2.4×10^5 psi

Length = L = 10 ft

$E = 29 \times 10^6$ psi

Required Data :-

Length of each side = ?

Solution :-

As we know that

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

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

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

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

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

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

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

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

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 :-

$$I = Ar^2$$

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

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

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

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

$$h = 11.77$$

te:_____ (8)

Question :- 03

Given Data :-

Load = 20 kips = 2.4×10^5 psi

Length = L = 10 ft

E = 1.6×10^6 psi

Required Data :-

Length of Each Side = ?

Solution :-

As we know that

$$\frac{Le}{r} = \sqrt{\frac{\Lambda^2 E}{6_p}}$$

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

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

$$= \sqrt{65.730}$$

e: _____ (9)

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

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

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

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

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

1st Method :-

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

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

$$b^2 = (14802)^2 \times 12$$

$$b^2 = 2629.190$$

$\sqrt{b^3} = \sqrt{2629.190}$

$b = 51.275$

2nd Method :-

$I = Ar^2$

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

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

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

$h^2 = 12r^2$

$h^2 = 2629.190$

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

$h = 51.275$

Question :- 04

Given Data :-

Column = 356mm x 45mm
$E = 200 \times 10^9$ pa
$\sigma_p = 240 \times 10^6$ pa
$L = 12m$
factor of safety = 2.5

Required Data :-

(a) $l_{min} = ?$
(b) $\sigma_{safe} = ?$

Solution :-

As we know that

$$\sigma_p = \frac{E\pi^2}{(Le/r)^2}$$

$$\frac{Le}{r} = \sqrt{\frac{E\pi^2}{\sigma_p}}$$

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

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

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,

$$L = L_e$$

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

(PART B)

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

$$P_{cr} = \frac{(3.14)^2 (200 \times 10^9)(13950)(12.99)^2}{(12 \times 1000)^2}$$

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

Now,

for $P_{safe} \Rightarrow$

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

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

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