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Section : B

Subject : Steel Structure

Department : BS. civil

Submitted To : Engr. Amjed Islam

Question No: 1 :-

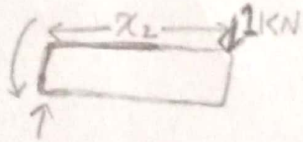
Sol:-

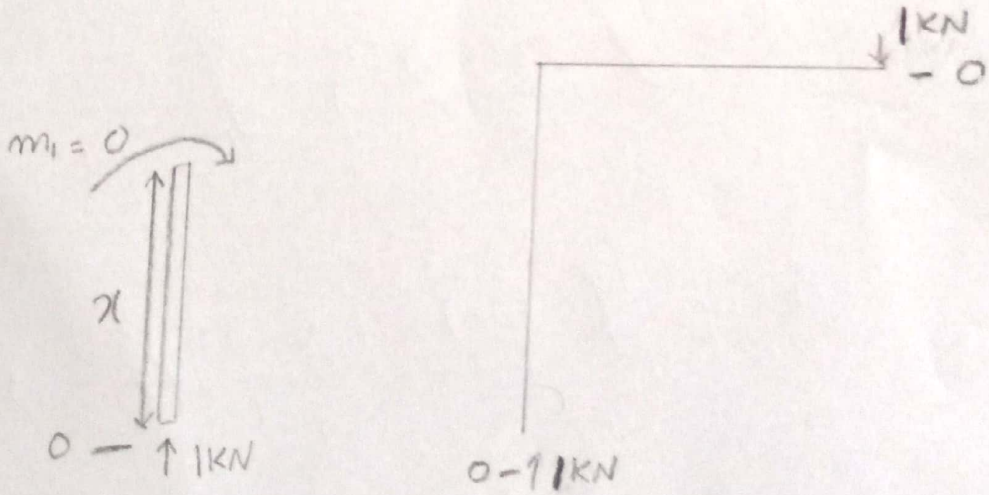
Virtual Moment:-

For convenience the co-ordinates x_1 and x_2 as shown in fig. will be used.

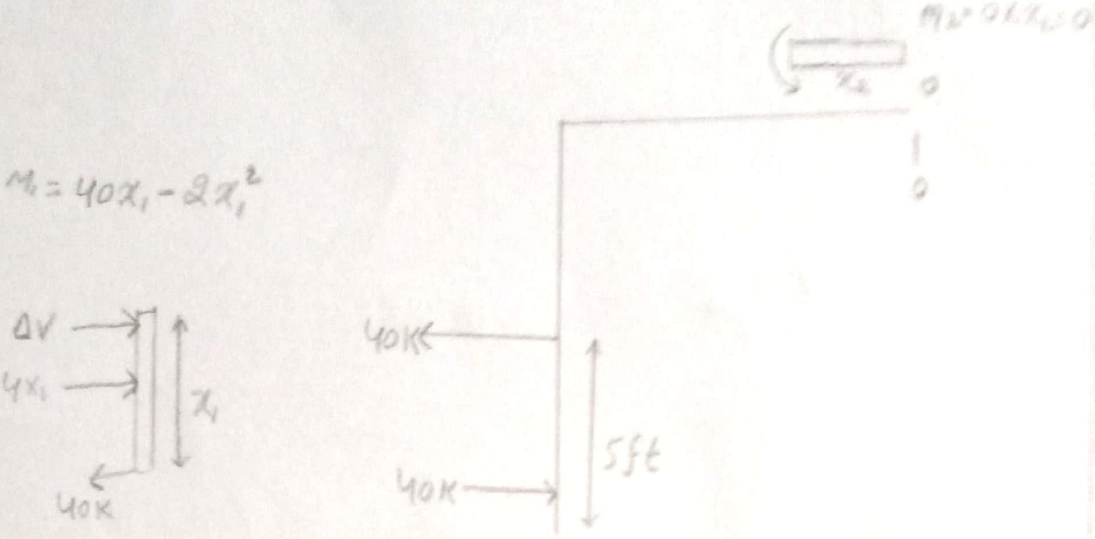
A vertical unit load is applied at C.

$m_2 = x_2$





Real moments :-



Now,

Using virtual work equation

$$\Delta_C = \int_0^L \frac{mM}{EI}\, dx$$

$$\Delta_C = \int_0^{10} \frac{m_1 M_1\, dx}{E_1} + \int_0^8 \frac{m_2 M_2}{E_1}\, dx_2$$

$$\Delta_C = \int_0^{10} \frac{(0x) \times 40x_1 - 2x_1^2)\, dx_1}{E_1} +$$

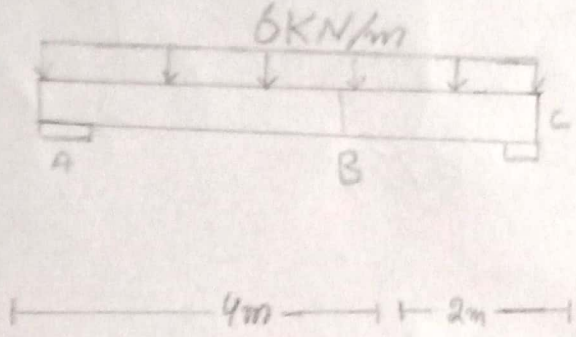
$$\int_0^8 \frac{1x_2 \times (0)}{E_1}\, dx_2$$

$$\Delta_C = 0 + 0$$

$$\boxed{\Delta_C = 0}$$

Question NO: 2 :-

Given :-



$E = 200\ GPa$

$I = 60(10)^6\ mm^4$

To Find :-

$\theta = ?$

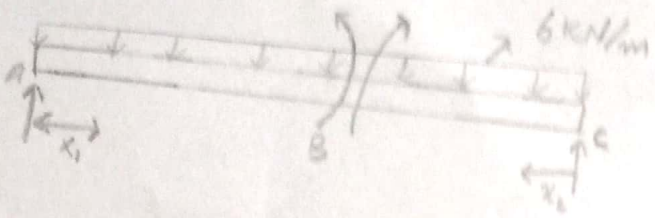
$\Delta = ?$ at Poin B

Sol :-

External couple Moment M :-

Since the Slope at 'B' is to be determined, an external couple M is Placed on the beam at this Point.

Internal Moment:-



$V_A = 18 + 0.1667M'$ $\qquad V_2 = 18 - 0.1667m'$

As $\curvearrowright + M_c = 0$

So

$$V_A \times 6 - (6 \times 6) \times 3 - M' = 0$$

$$V_A = \frac{108 + M'}{6}$$

$$V_A = 18 + 0.1667M'$$

Similarly:-

$$N_B = 18 - 0.1667M'$$

For x:-

$$M_1 = (18 + 0.1667M')x_1 - 3x_1^2$$

$$\frac{dM_1}{dM'} = 0.1667x_1$$

For x_2 =

$$\Sigma M = 0$$

$$M_2 = (18 - 0.1667M')x_2 - 3x_2^2$$

$$\frac{dM_2}{dM'} = -0.1667x_2$$

For Slope:-

$$\theta_B = \int_0^3 \frac{M_2 M}{2M'} \frac{dV}{EI}$$

$$\theta_B = \int_0^4 \frac{(18 - 3x_1^2) \times 0.1667x_1}{EI} +$$

$$\int_0^2 \frac{(18 - 3x_2^2) \times 0.1667x_2}{EI} dx$$

$$\theta_B = \int_0^4 \frac{(3x^2 - 0.5x^3)}{EI} dx +$$

$$\int_0^2 \frac{(-3x^2 + 0.5^3)}{EI} dx$$

$$\theta_B = \left[\frac{3x^3}{3} - \frac{0.5x^4}{4}\right]_0^4 + \left[\frac{-3x^3}{3} + \frac{0.5x^4}{4}\right]_4^2$$

$$\theta_B = \frac{32 - 6}{EI}$$

$$\theta_B = \frac{26\ KN/m^2}{EI}$$

$$\theta_B = \frac{26}{200 \times 10^6 \times \frac{60 \times 10^6}{1000^4}}$$

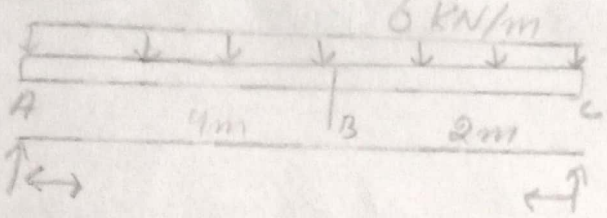
$$\theta_B = 0.00216\ rad$$

For displacement:-

External Force:-

A vertical force P is placed on the beam at 'B'.

Internal Moments:-



18+0.333P

18+0.333P

For x_1 :-

$$\Sigma M = 0$$

$$M_1 = (18 + 0.333P) \times x_1 - 3x_1^2$$

$$\frac{dM_1}{dP} = 0.33x_1$$

For x_2 :-

$$\Sigma M = 0$$

$$M = (18 + 0.667P)\, x_2 - 3x_2^2$$

$$\frac{dM_2}{dP} = 0.667x_2$$

Set $P = 0$

$M_2 = 18 - 3x_1^2$ KN.m²

$M_2 = 18x_2 - 3x_2^2$ KN.m²

Now for displacement:-

$$\Delta_B = \int M \left(\frac{dM}{dP}\right) \frac{dx}{EI}$$

$$\Delta_B = \int_0^4 \frac{(18 - 3x_1^2) \times 0.33x_1 \, dx}{EI} + \int_0^2 \frac{(18 - 3x_1^2) \times 0.66x_2}{EI}$$

$$\Delta_B = \int_0^4 \frac{5.94x_1^2 - x^3}{EI} dx \int_0^2 \frac{12x_2^3 - 2x_3^3}{EI} dx$$

$$\Delta_B = \left(\frac{5.94x^3}{3} - \frac{x^4}{4} \right)_0^4 + \left(\frac{12x^3}{3} - \frac{2x^4}{4} \right)_0^2$$

$$\Delta_B = \frac{62.72 + 24}{EI}$$

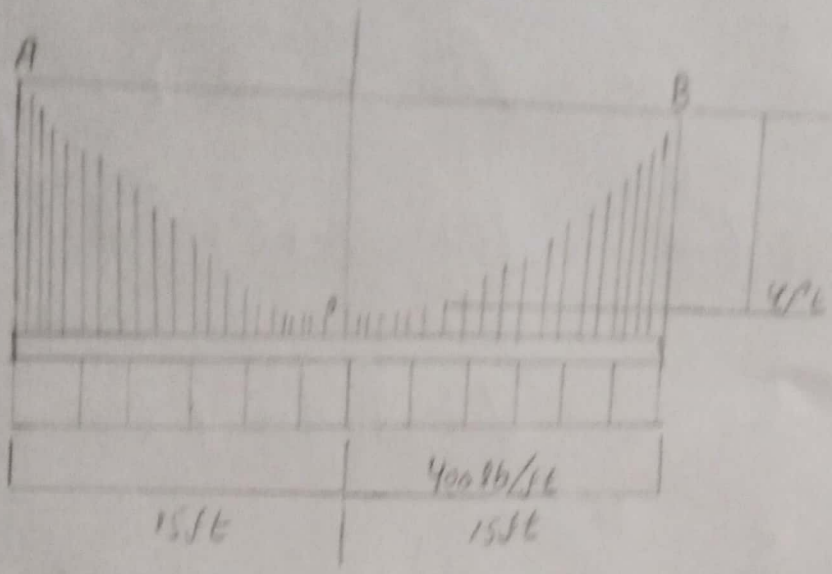
$$\Delta_B = \frac{86.72}{EI} \text{ KN.m}^2$$

$$\Delta_B = \frac{86 \cdot 72}{200 \times 10^6 \times \frac{60 \times 10^6}{10^2}}$$

$$\Delta_B = 0.00722\,m$$

$$\boxed{\Delta_B = 0.00722\,m}$$

Q No: 3 :-



Sol:- From eq/ : 5.9

$$y = \frac{n}{L^2} x^2 = \frac{10}{15^2} x^2$$

$$y = 0.0444 x^2$$

From eq 5-8

$$T_o = F_4 = \frac{w_o L^2}{2h} = \frac{400(15^2)}{2(10)}$$

T_o = 4500 lb ÷ing by 1000

T_o = 4.5K

From eq 5-10:

$$T_B = T_{Max} = \sqrt{Fu^2 + (w_o L)^2}$$

$$T_B = T_{Max} = \sqrt{(4500)^2 + (400)^2 (15)^2}$$

$$T_B = T_{Max} = \sqrt{20250000 + (400 \times 15)^2}$$

$$T_B = T_{Max} = 7500 lb \text{ divided by } 1000$$

$$T_B = T_{Max} = 7.5K$$

Also from eq 5-11

$$T_B = T_{Max} = w_o L \sqrt{1 + \left(\frac{L}{2n}\right)^2}$$

$$T_B = T_{Max} = (400)(15) \sqrt{1 + \left(\frac{15}{20}\right)^2}$$

$$T_B = T_{Max} = 6000 \sqrt{1 + \frac{225}{400}}$$

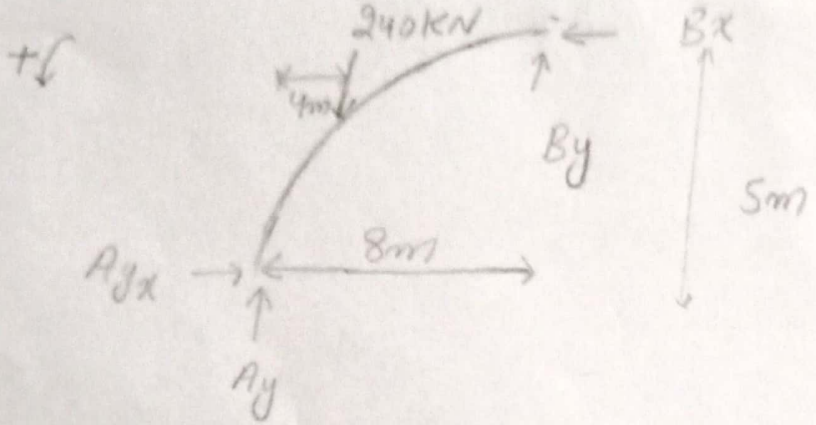
$$T_B = T_{Max} = 6000 (1.25)$$

$T_B = T_{MAX}$ = 7500lb divided by 1000

$T_B = T_{MAX} = 7.5K$

Question No: 4:

(i) Member AB:-

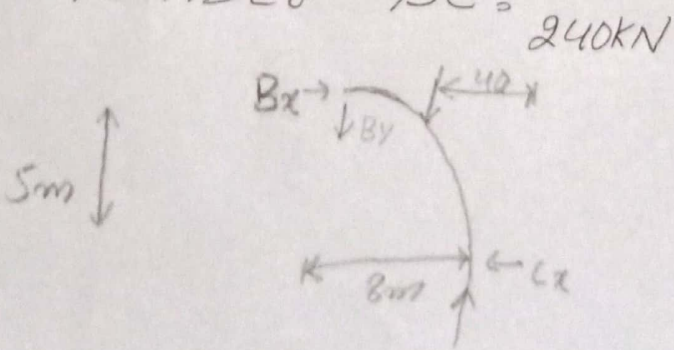


$+\zeta M_A = 0$

$Bx \times 5 + By \times 8 - (30 \times 8 \times 8/2)$

$5Bx + 8By = 960 \rightarrow (1)$

(ii) Member BC:-



$\downarrow + \Sigma M_C = 0$

$-Bx + 5 + By \times 8 + 30 \times 8 \times 8/2 = 0$

$-5B_x + 8B_y = -960 \rightarrow (ii)$

Subtracting eq (ii) from (i)

$$5B_x + 8B_y = 960$$
$$\mp 5B_x \pm 8B_y = \mp 960$$
$$10B_x = 1920$$

$$\boxed{B_x = 192\ KN}$$

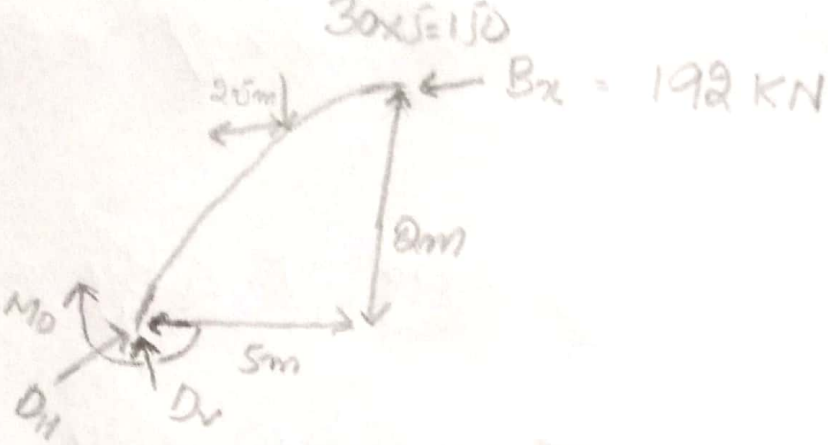
from eq (i)

$$5(192) + 8B_y = 960$$

$$8B_y = 960 - 960$$

$$\boxed{B_y = 0\ KN}$$

Segment DB :-



$$\downarrow + \Sigma M_D = 0$$

$$-M_D + 192 \times 2 - (30 \times 5) \times 2.5 =$$

$$\boxed{M_D = +9\,KN\text{-}m}$$