FINAL TERM EXAMINATION

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SECTION	B
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SUBJECT	STRUCTURAL ANALYSIS - I
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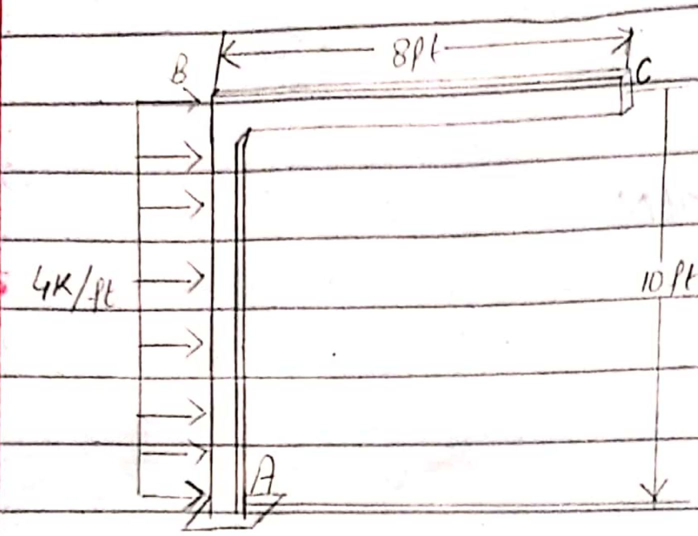
QUESTION No 01

DETERMINE the vertical . . . .
. . . . Use method of Virtual Work?



To Find :~

Virtual work $= \Delta_{ch} = ?$

GIVEN THAT :~

$E = 29(10^3)$ Ksi

$I = 600$ in^4

SOLUTION

As we Know that

For REACTION :-

$\Sigma M_A = 0$

$-4(10)(5) + C_y(8) = 0$

$C_y = 25$ Kips

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

$$25 + A_y = 0$$

$$A_y = -25 \text{ Kip}$$

$$\Sigma F_x = 0 \quad \rightarrow +$$

$$40 - A_x = 0$$

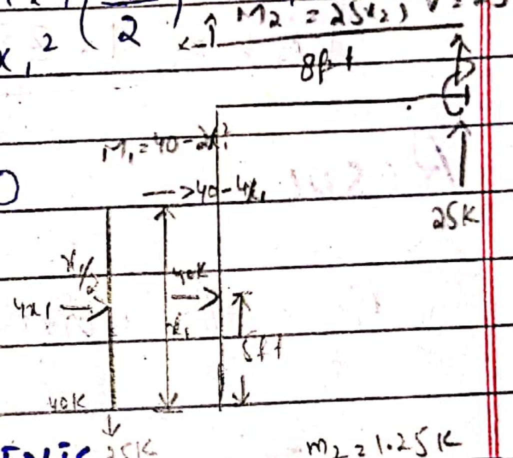
$$A_x = +40 \text{ Kips}$$

REAL MOMENTS :-

$$\Sigma M_1 = 0$$

$$-40 x_1 + 4x_1\left(\frac{x}{2}\right) + M_1 = 0$$

$$M_1 = 40x_1 - 2x_1^2$$



$$-25x_2 + M_2 = 0$$

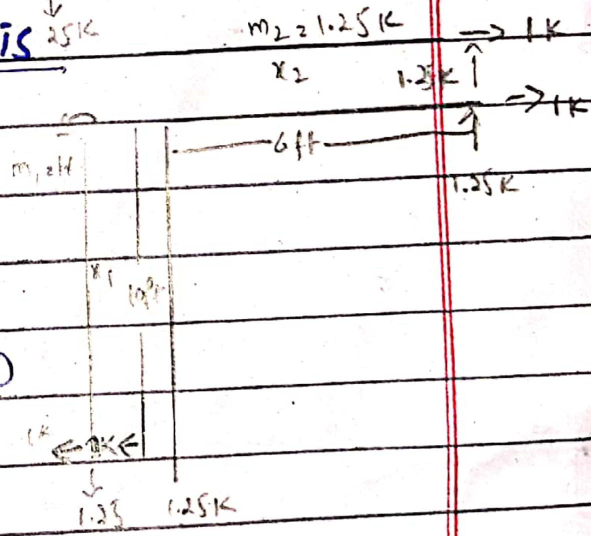
$$M_2 = 25x_2$$

VIRTUAL MOMENTS

$$\Sigma m_1 = 0$$

$$-1(x_1) + m_1 = 0$$

$$m_1 = 1x_1$$



$$-m_2 + 1.25x_2 = 0$$

$$m_2 = 1.25x_2$$

FROM VIRTUAL WORK EQUATION :-

$$1K \cdot \Delta_{ch} = \int_0^l m M dx / EI$$

$$1K \cdot \Delta_{ch} = \int_0^{18} \frac{(40x_1 - 2x_1^2)(1x_1)dx}{EI}$$

$$\Delta_{ch} = \frac{8333.3}{EI} + \frac{5333.3}{EI}$$

$$\Delta_{ch} = \frac{13666.7}{EI} K^2 ft^3$$

$$= \frac{13666.7 K^2 \cdot ft (12^3 in^3 / 1 ft^3)}{(29 \times 10^3 K/in^2)(600)}$$

$$\boxed{\Delta_{ch} = 1.357 \text{ in}}$$

RESULT

Hence the Virtual work = $\Delta_{ch} = 1.357$ in

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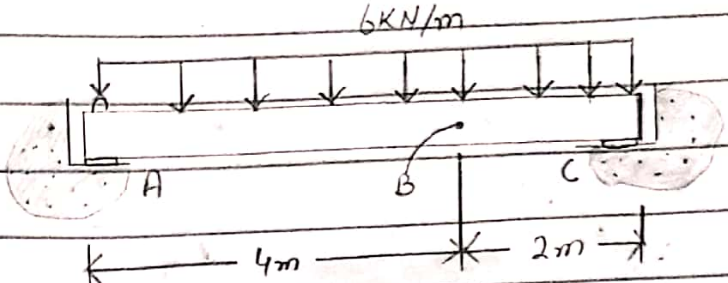
QUESTION No 02

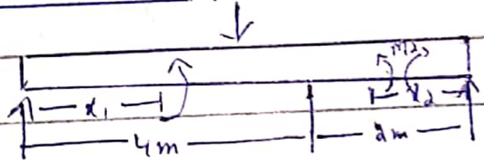
Determine the slope and ......
.... Use Castigliano's Theorem.



To Find :-

We have to find the slope and displacement

SOLUTION :-



$30+0.06667M'$ $30-0.06667M'$

$$M_1 = (30 + 0.06667M')x_1 - 2x_1^2$$

$$M_2 = (30 + 0.06667M')x_2 - 2x_2^2$$

Now

$$\frac{\delta M_1}{\delta M'} = 0.06667x_1 \text{ and}$$

And $$\frac{\delta M_2}{\delta M'} = 0.0667x_2$$

Set $m' = 0$

Now $m_1 = (30x_1 - 2x_1^2)$ K.ft

And

$m_2 = (30x_2 - 2x_2^2)$ K.ft

Thus

$$Q_B = \int_0^L m\left(\frac{\delta m}{\delta m'}\right)\frac{dx}{EI}$$

$$= \int_0^{4m} \frac{(30x_1 - 2x_1^2)(0.06667x_1)\,dx}{EI} \rightarrow$$

$$+ \int_0^{2m} \frac{(30x_2 - 2x_2^2)(0.06667x_2)\,dx_2}{EI}$$

$$= \frac{1}{EI}\left[\int_0^{4m}(2.001x_1^2 - 0.1334x_1^2)\,dx_1 + \int_0^{2m} 2.001x_2^2 - 0.1334x_2^2 \; dx_2\right]$$

$$= \frac{1}{EI}\left[\frac{2001}{3}x_1^2\Big|_0^4 - \frac{0.1334}{4}x_1^3\Big|_0^4 + \frac{2.001}{3}x_2^2\Big|_0^2 - \frac{0.1334x_2^3}{4}\Big|_0^2\right]$$

$$= \frac{1}{EI}\left[0.667x_1^3\Big|_0^4 - 0.03335x_1^4\Big|_0^4 + 0.667x_2^3\Big|_0^2 - 0.03335x_2^4\Big|_0^2\right]$$

$$Q_B \Rightarrow \frac{1}{EI}\left[(42.688 - 8.5376) + (5.336 - 0.5336)\right]$$

$$Q_B = \frac{38.9504}{EI}$$

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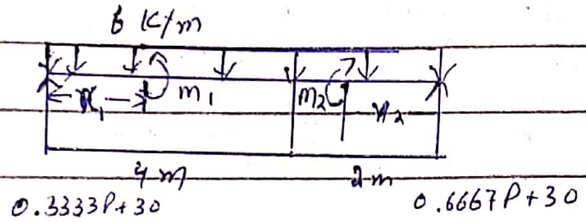
$$\theta_B = \frac{38.9504}{(200\times10^9)(60\times10^6 \text{ in } m^4)}$$

$$\theta_B = \frac{38.9504}{(200\times10^9)(6\times10^{-5})}$$

$$\boxed{\theta_B = 0.03245 \times 10^{-4} \text{ radian}}$$

Now DISPLACEMENT



Now $M_1 = (0.33P+30)\ x_1 - 2x_1^2$

$M_2 = (0.6667P + 30)\ x_2 - 2x_2^2$

Now $\frac{\delta M_1}{\delta P} = 0.3333x_1$

And $\frac{\delta M_2}{\delta P} = 0.6667\,x_2$

Set $P = 0$

$M_1 = (30x_1 - 2x_1^2)$ and $M_2 = (30x_2 - 2x_2^2)$

$$\Delta B = \int_0^l m\left(\frac{\delta m}{\delta P}\right)\frac{dx}{EI}$$

$$\Rightarrow \Delta B = \frac{1}{EI}\left[\int_0^4 (30x_1 - 2x_1^2)\,0.3333x_1\,dx_1 + \int_0^2 (30x_2 - 2x_2^2)\,0.6667\,dx_2\right]$$

$$\Rightarrow \Delta B = \frac{1}{EI}\left[\int_0^4 (9.999x_1^2 - 0.6666x_1^3)\,dx_1 + \int_0^2 (20.001x_1^2 - 1.3334x_1^3)\,dx_2\right]$$

$$\Delta B = \frac{1}{EI}\left[\frac{9.999x_1^3}{3}\Big|_0^4 - \frac{0.6666x_1^4}{4}\Big|_0^4 + \frac{20.001x_2^3}{3}\Big|_0^2 - \frac{1.3334x_2^4}{4}\Big|_0^2\right]$$

$$\Delta B = \frac{1}{EI}\left[(213.33 - 42.6624) + (53.336 - 5.336)\right]$$

$$\Delta B = \frac{218.6676}{(200 \times 10^9)(6 \times 10^{-5})}$$

$$\Delta B = 0.1822 \times 10^{-4} \text{ ft}$$

$$\Delta B = 2.186 \times 10^{-4}$$

Hence

$$\theta_B = 0.03245 \times 10^{-4}$$

$$\Delta B = 2.186 \times 10^{-4}$$

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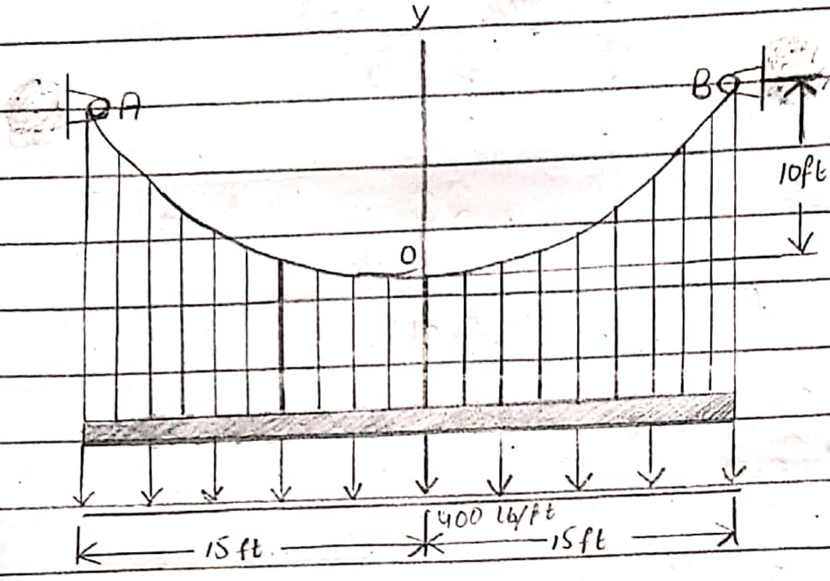
QUESTION No 03

The cable is subjected to the uniform ...... curve and the force in the cable at O & B.



To Find :~

We have to find the equation of the curve and the force in the cable at O and B.

Solution :~

As we know that

$$y = \frac{h x^2}{L^2}$$

$$= \frac{10}{(15)^2} x^2$$

$$y = 0.0444 x^2$$

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AND.

$$T_0 = F_H = \frac{W_o L^2}{2h}$$

$$= \frac{400(15)^2}{2(10)}$$

$$= \frac{400 \times 225}{2(10)}$$

$$= \frac{90000}{20}$$

$$= 4500\, lb$$

$$\boxed{F_H = 4.500 K.lb}$$

Now. As we know that

$$T_H = T_{max} = \sqrt{(F_H)^2 + (W_o L)^2}$$

$$= \sqrt{(4500)^2 + [(400)(15)]^2}$$

$$T_{max} = \sqrt{(4500)^2 + (6000)^2}$$

$$\boxed{T_{max} = 7500\, lb = 7.500\, Klb}$$

Now,

$$T_B = T_{max} = W_o L \sqrt{1 + \left(\frac{L}{2h}\right)^2}$$

$$= 400(15)\sqrt{1 + \left(\frac{15}{2 \times 10}\right)^2}$$

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

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$$= 6000\sqrt{\frac{400 + 225}{400}}$$

$$= 6000\sqrt{\frac{625}{400}}$$

$$= 6000\sqrt{1.5625}$$

$$= 6000(1.25)$$

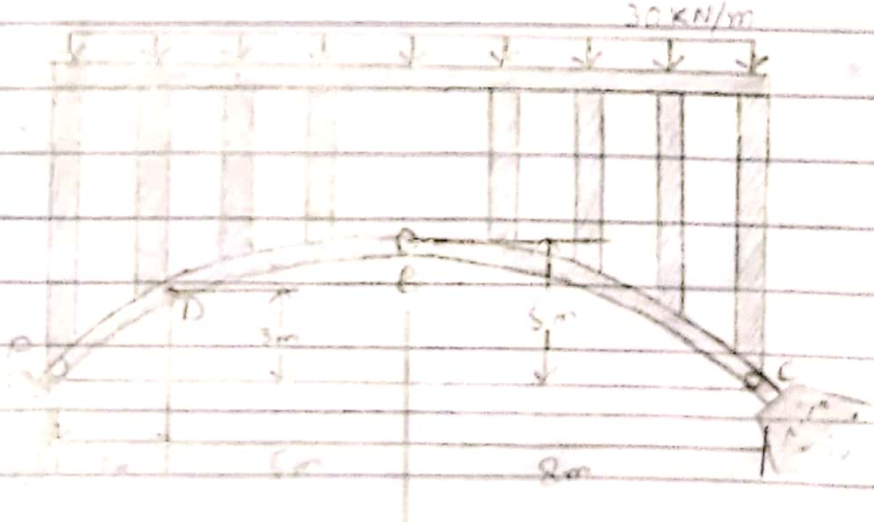
$T_H = T_{max} = 7500\ lb$

OR

$$\boxed{T_H = T_{max} = 7500\ lb = 7.5\ K\ lb}$$

QUESTION No 04

The Three hinged spandrel ....
.... in the arch at point D?



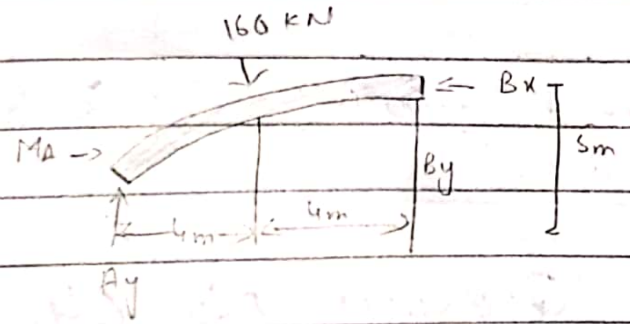
SOLUTION :~

MEMBER AB :~

$$\circlearrowright + \Sigma M_A = 0$$

$$\Rightarrow B_x(5) + B_y(8) - 240(4) = 0$$

$$5B_x + 8B_y = 960$$



MEMBER BC :~

$$\circlearrowright + M_c = 0$$

$$\Rightarrow B_x(5) + B_y(8) + (240)(4 = 0$$

As $B_y = 0$

$$\Rightarrow -5B_x + 0 + 960$$

$$\Rightarrow 5B_x = 960$$

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

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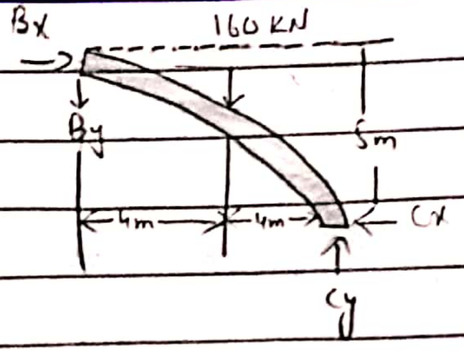

MEMBER BD :-

$$\circlearrowright M_D = 0$$

$$\Rightarrow (B_x)(2) - (150 \times 2.5) - M_D = 0$$

$$\Rightarrow (192 \times 2) - (375) - M_D = 0$$

$$\Rightarrow 384 - 375 - M_D = 0$$

$$\Rightarrow 9 - M_D = 0$$

$$\Rightarrow \boxed{M_D = 9 \text{ KN.m}}$$

RESULT

HENCE $M_D = 9$ KNm

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