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Subject Structural Analysis I

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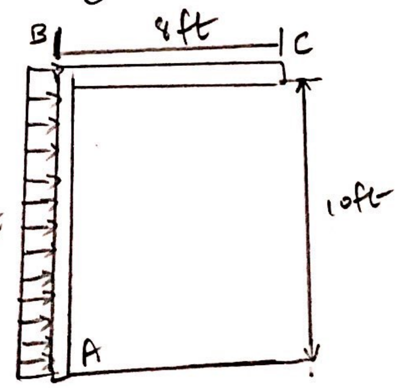
FINAL TERM PAPER

Q 1) Determine the vertical displacement of free end point C on the frame shown in fig

$E = 29(10)^3$ ksi

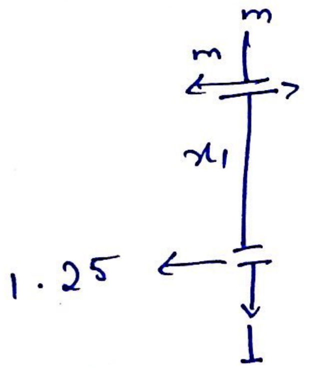
$I = 600 \, in^4$

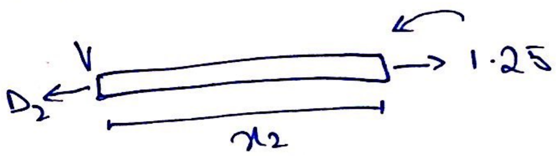


Required:-
Vertical displacement

Solution:-

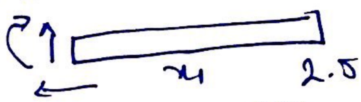
Now virtual moment



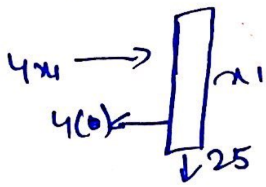


$m_2 = 1.25x$

For real moment



$m_2 = 25x_2$



$$m'' = 40x_1 - \frac{1}{2}x_1(x_2)$$

$$40x_1 - 2x_1^2$$

Now by virtual work equation

$$\Delta c = \int_0^c m \frac{M}{E} dx$$

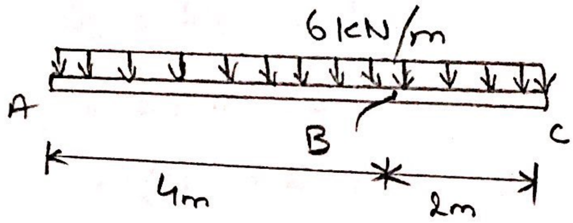
$$\Delta c = \int_0^{10} \frac{(1x_1)(40x_2 - 2x^2)\, dx}{E} + \int_0^{8} \frac{(1.25x_2)(25x_2)}{EI}$$

$$\Delta c = \frac{1}{EI} \left| \frac{40x^3}{3} - \frac{2x^3}{4} \right|_0^{10} + \left| \frac{31.25x_2^3}{3} \right|_0^{8}$$

$$\boxed{\Delta C = 10.64mm}$$

Q NO 2)

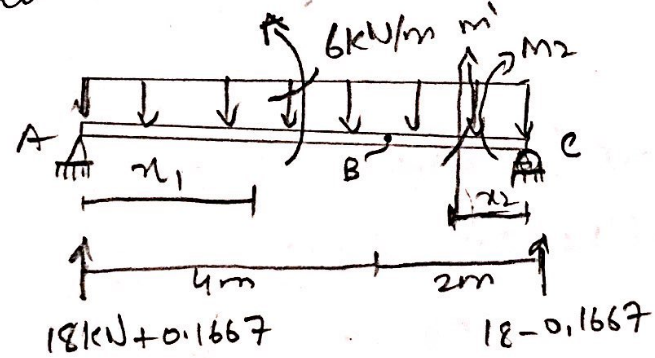
Determine the slope and displacement at point B. Assume the support at A is a pin and C is a roller. Take $E = 200\,GPa$, $I = 60(10)^6\,mm^4$. Use Castigliano's Theorem.



Required

Slope displacement at point B

Solution:-



(a)

$R_1 + R_2 = 0$ — (1)

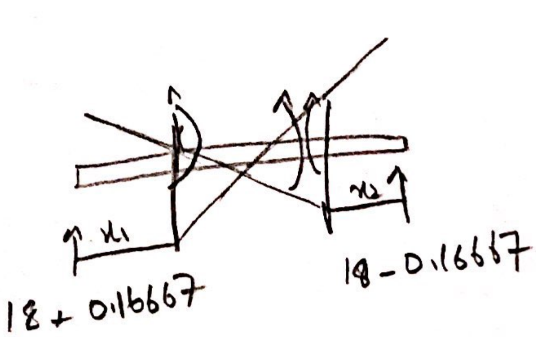
$\Sigma M_A = 0$ ↺+

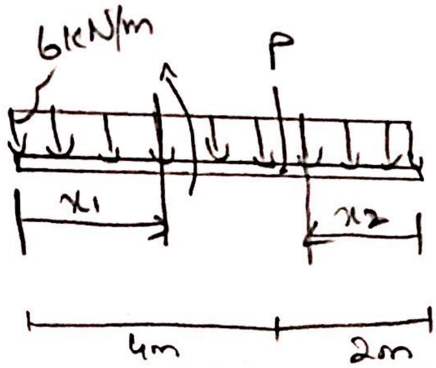
$1 + R_2(6) = 0$

⟹ -0.16667 put in (1)

$R_1 + (-0.16667) = 0$

$R_1 = 0.16667\ kN$





(b)

$R_1 + R_2 = 1$

$\circlearrowright + \Sigma M_A = 0$

$-(1)(4) + R_2(6) = 0$

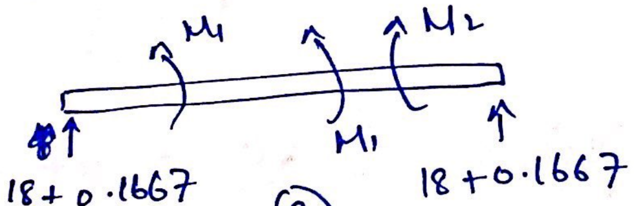
$R_1 = 0.6667\,kN$

$R_2 = 1 - 0.6667\,kN$

$R_2 = 0.333\,kN$

2) $M_1 = (18 + 0.1667)\,x_1 - 2x_1^2$

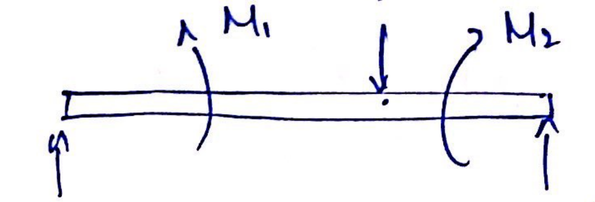
$M_2 = (18 - 0.1667M')\,x_2 - 2x_2^2$



(a)

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

$M_2 = (0.667P + 18)\,x_2 - 2x_2^2$



(b)

The displacement functions shown in the figure "a"

$$\frac{\partial M_1}{\partial M_1} = 0.16667x_1 \text{ and } \frac{\partial M_2}{\partial M'} = 0.1667x_2, \text{ set } M' = 0$$

then

$$M_1 = (18 + 0.1667(0))x_1 - 2x_1^2$$

$$\rightarrow M_1 = (18x_1 - 2x_1^2)$$

$$\rightarrow M_2 = (18x_2 - 2x_2^2)$$

$$\phi_B = \int_0^2 M\left(\frac{\partial M}{\partial M_1}\right)\frac{dx}{EI} = \int_0^4 \frac{(18x_1 - 2x_1^2)(0.1667x_1)\,dx_1}{Ei} +$$

$$\int_0^2 \frac{(18x_2 - 2x_2^2)(0.1667x_2)\,dx_2}{EI}$$

$$\phi_B = \frac{42.65}{EI} + \frac{6.66}{EI}$$

$$\phi_B = \frac{49.31}{EI}$$

$$\phi_B = \frac{49.31}{(200\times10^6\,kpa)(0.00006}$$

$$\boxed{\phi_B = 0.4411 \text{ rad}}$$

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⇒ For the displacement functions shown in fig "b"

$\frac{\partial M_1}{\partial M_p} = 0.333x_1$ and $\frac{\partial M_2}{\partial p} = 0.6667x_2$ also set $P = 0$

then $M_1 = (18x_1 - 2x_1^2)$ KN-m

$M_2 = (18x_2 - 2x_2^2)$ KN-m

Thus

$$\Delta_B = \int_0^L M\left(\frac{\partial M}{\partial p}\right)\frac{dx}{EI}$$

$$\Delta_B = \int_0^4 \frac{(30x_1 - 2x_1^2)(0.333x_1)\,dx}{EI} + \int_0^2 \frac{(30x_2 - 2x_2^2)(0.6667x_2)\,dx}{EI}$$

$$\Delta B = \frac{218.5}{EI} = \frac{218.5}{(200\times10^6)(0.0006)}$$

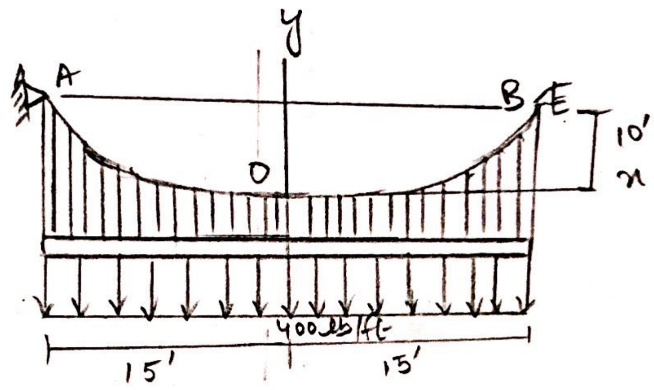
$= 0.018m$

or

$= 18mm$

Q NO. 3)

The cable is subjected to the uniform loading - - - - - - - - - - - -



Solution:-

$$y = \frac{h}{L^2}x^2 = \frac{8}{(15)^2}x^2$$

$$y = 0.0356x^2$$

Now we know that

$$T_o = F_B = \frac{w_o L^2}{2h}$$

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

$$= 4500 \text{ lb} \Rightarrow \frac{4500}{1000}$$

$$\boxed{T_o = 4.5K}$$

Now

determining force at B

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

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

$$= 7500\ lb$$

$$\boxed{T_B = 7.5K}$$

T_B can also be found by this equation

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

Put values

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

$$T_B = 7500\ lb$$

or

$$\boxed{T_B = 7.5K}$$

Q NO 4 The three hinged spandrel arch

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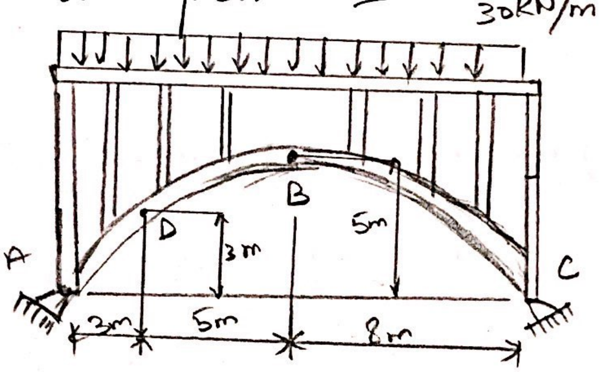
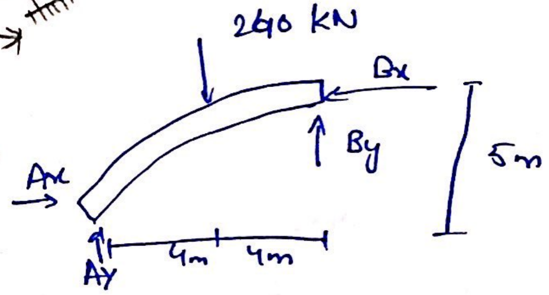
Determine the internal moment in the arch at point D



Solution:-

Member AB:-



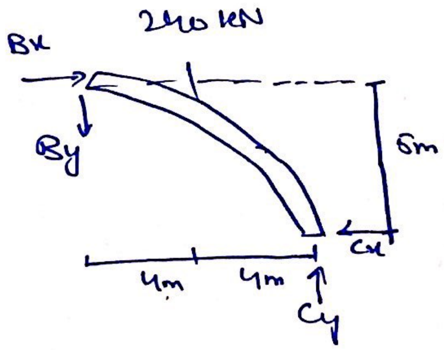
$\circlearrowleft^+ \sum M_A = 0$

$Bx(5) + By(8) - 240(4) = 0$

$= 5Bx + 8By - 960 = 0$ — (A)

Now

Member BC:-



$\circlearrowleft^+ \sum M_C = 0$

$-Bx(5) + By(8) + 240(4) = 0$

$= -5Bx + 8By + 960 = 0$ — (B)

Solving equation A & B for Bx and By

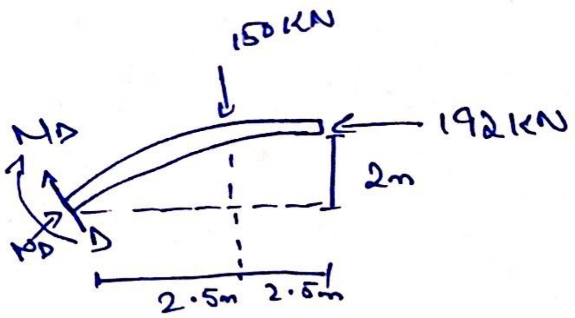
$$5B_x + 8B_y - 960 = 0$$
$$+ \quad -5B_x + 8B_y + 960 = 0$$
$$16B_y = 0$$

$$\boxed{B_y = 0}$$

Put the value of By in eq (A)

$$5B_x + 8(0) - 960 = 0$$
$$5B_x = 960$$
$$\boxed{B_x = 192\,kN}$$

Segment DB



$$\circlearrowleft + \quad \Sigma M_D = 0$$
$$= 192(2) - 150(2.5) - M_D = 0$$
$$= 384 - 375 = M_D$$
$$\boxed{M_D = 9\,KN\text{-}m}$$ internal moment at "D"