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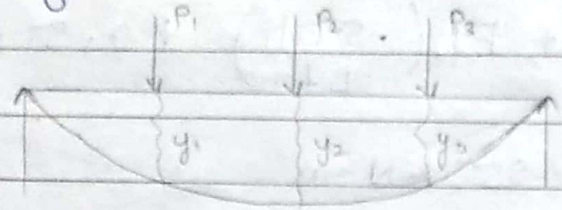
Unit 3 Strain Energy Method

* castiglinous theorem

The partial derivative of the total strain energy w.r.t any load at any point gives the deflection at that point in the direction of load



Here $\frac{\partial u_1}{\partial P_1} = y_1$; where u = strain energy stored due to bending

$\frac{\partial u_2}{\partial P_2} = y_2$

$\frac{\partial u_3}{\partial P_3} = y_3$

$$u = \int \frac{m^2}{2EI} dx$$

$$\frac{\partial u}{\partial R} = \int \frac{2m}{2EI} \frac{\partial u}{\partial R} dx$$

$$\frac{\partial u}{\partial R} = \int \frac{m}{EI} \frac{\partial u}{\partial R} dx$$

OR $$\frac{\partial u}{\partial H} = \int \frac{m}{EI} \frac{\partial u}{\partial H} dx$$

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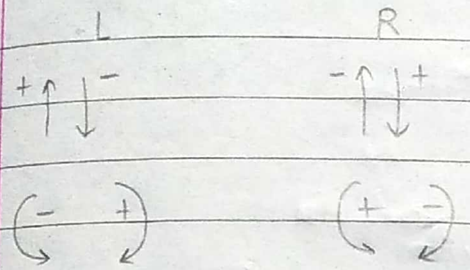
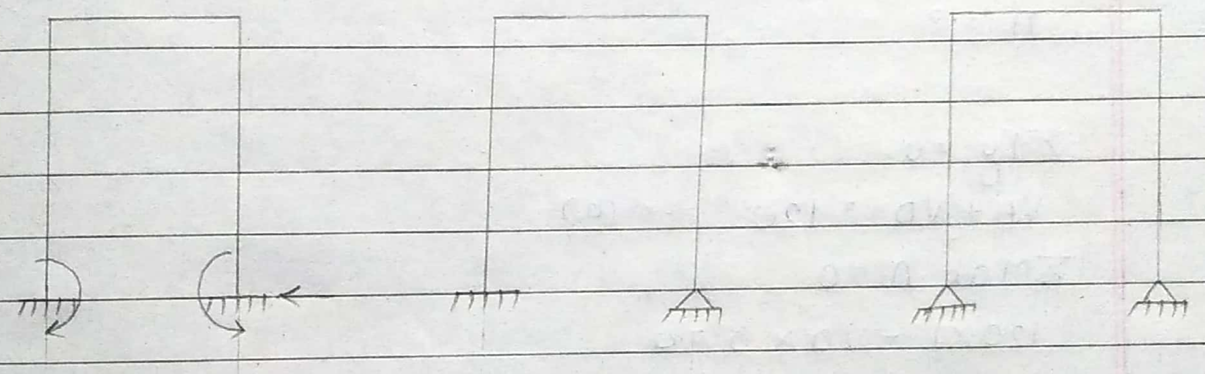
* standard sign conventions *



* standard cases for DOSI *



DOSI = 6-3 = 3

DOSI = 5-3 = 2

DOSI = 4-3 = 1

* Numericals *

S-16 Q For the partal frame as shown in fig, find the redundant reactions and draw the BMD by using strain energy method Take EI as constant for all the members

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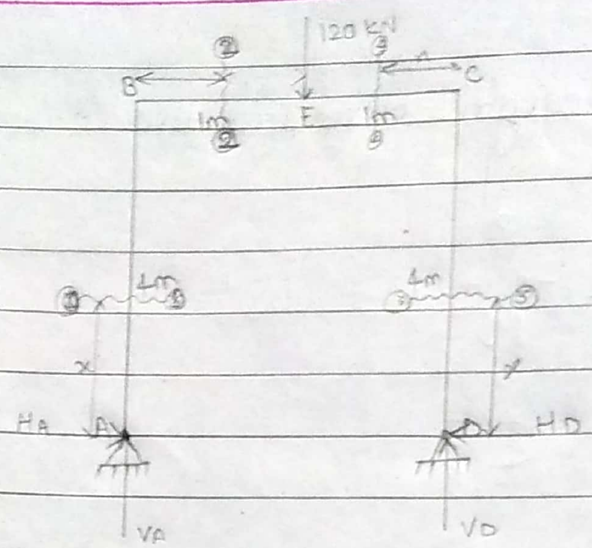


DOST = 4-3 = 1

H = 2

$\Sigma Fy = 0$

$VA + VD = 120 \quad \ldots (a)$

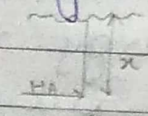
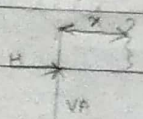
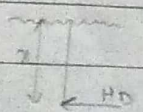
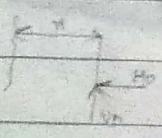
ΣM at $A = 0$

$120 \times 1 - VD \times 3 = 0$

$VD = 40$ KN

$VA = 80$ KN

Apply castiglianos theorem for given

Diagram	Portion	Origin	limit	EI	M	$\partial u/\partial H$
	AB	A	0-4	EI	$-Hx$	$-x$
	BE	B	0-1	EI	$8x-4H$	-4
	DC	D	0-4	EI	$-Hx$	$-x$
	CE	C	0-2	EI	$40x-H4$	-4

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$$\int \frac{M}{EI} \frac{\partial u}{\partial H} dx$$

$$= \int_0^4 \frac{-Hx}{EI}(-x)\,dx + \int_0^1 \frac{80x-4H}{EI}(-4)\,dx + \int_0^4 \frac{-Hx}{EI}(-x)\,dx$$
$$+ \int_0^2 \frac{40x-4H}{EI}(-4)\,dx$$

$$= \frac{H}{EI}\left[\frac{x^3}{3}\right]_0^4 + \frac{1}{EI}\left[-320\frac{x^2}{2} + 16Hx\right]_0^1 + \frac{H}{EI}\left[\frac{x^3}{3}\right]_0^4$$
$$+ \frac{1}{EI}\left[-160\frac{x^2}{2} + 16Hx\right]_0^2$$

$$= \frac{H}{EI}\frac{64}{3} - \frac{320}{2EI} + \frac{16H}{EI} + \frac{64H}{3EI} - \frac{160\times4}{2EI} + \frac{16H(2)}{EI}$$

$$= \frac{64H}{3EI} + \frac{64H}{3EI} - \frac{320}{2EI} - \frac{320}{EI} + \frac{32H}{EI} + \frac{16H}{EI}$$

$$= \frac{H}{EI}\left[\frac{64}{3} + \frac{64}{3} + 32 + 16\right] - \frac{1}{EI}\left[\frac{320}{2} + 320\right]$$

$$= 90.67\frac{H}{EI} - 480$$

$$90.67\frac{H}{EI} = \frac{480}{EI}$$

$$H = \frac{480}{90.67}$$

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$H = 5.29\,m$

$BM_A = 0$

$BM_B = -H_A \cdot x$

$= 5.29 \times 4$

$= -21.16$ kN-m

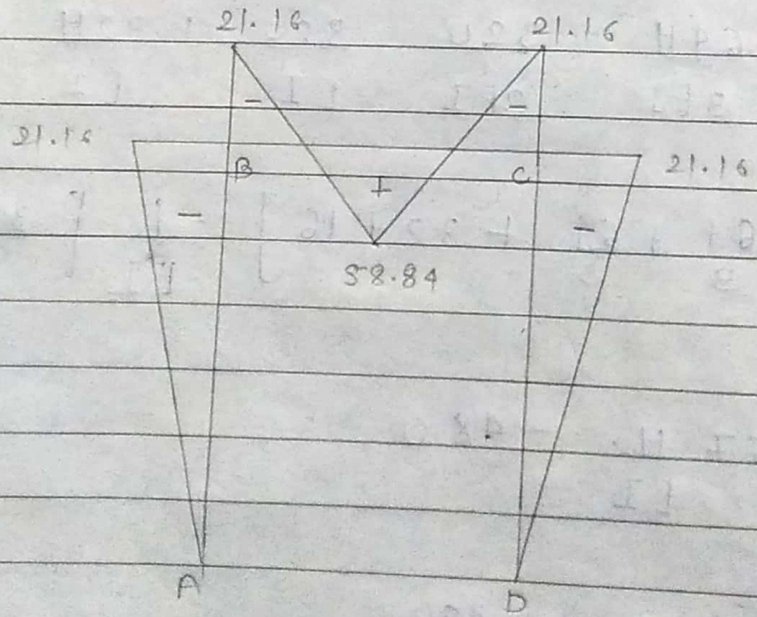
$BM_C = -H_A x = -5.29 \times 4 = -21.16$ kN-m

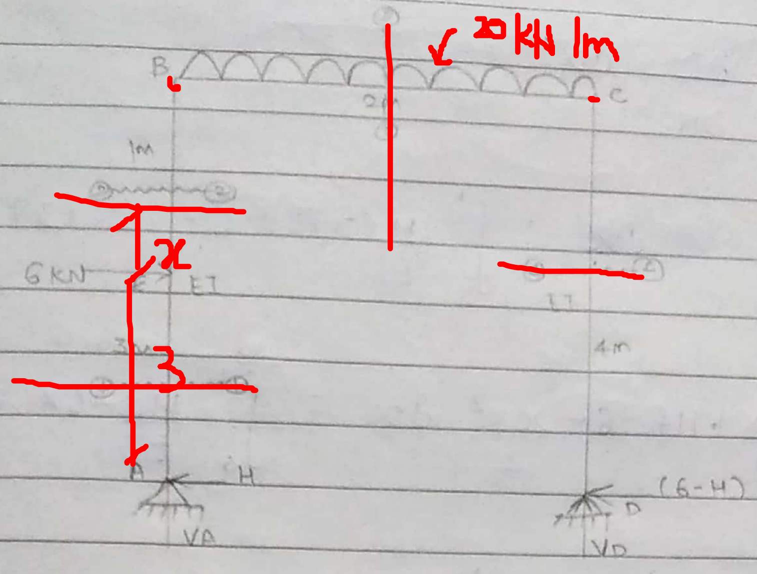
$BM_D = 0$

$BM_E = 40x - H4$

$= 40 \times 1 - 5.29 \times 4$

$= 58.84$ kN-m





DOSI = 4-3 = 1

Reactions

$V_A + V_D = 40\,kN$

$\Sigma M @ A = 0$

$(20 \times 2 \times 1) + 6 \times 3 - V_D \times 2 = 0$

$V_D = 29\,kN$

$V_A = 11\,kN$

Apply castiglianous theorem

Origin	Portion	limit	EI	M	$\partial M / \partial H$
A	AE	0-3	EI	Hx	x
E	EB	0-1	EI	$H(x+3) - 6x$	$(x+3)$
B	BC	0-2	2EI	$11x + H \times 4 - 6 \times 1 - \frac{20x^2}{2}$	4
D	DC	0-4	EI	$-(6-H)x$ $-6x + Hx$ or $Hx - 6x$	x

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$$= \int \frac{M}{EI} \frac{\partial M}{\partial H} dx$$

$$= \int_0^3 \frac{Hx}{EI} x \, dx + \int_0^1 \frac{H(x+3) - 6x}{EI} \cdot (x+3) \, dx +$$

$$\int_0^2 \frac{11x + H4 - 6 - 20x^2}{EI \quad\quad 2} dx + \int_0^4 \frac{Hx - 6x}{EI} \cdot x \, dx$$

$$= \frac{H}{EI} \int_0^3 x^2 \, dx + \frac{H}{EI} \int_0^1 Hx + 3H - 6x^2 - 18x \, dx + \frac{4}{EI}$$

$$\int_0^2 11x - 6 - 10x^2 + 4H \, dx + \frac{1}{EI} \int_0^4 Hx^2 - 6x^2 \, dx$$

$$= \frac{H}{EI} \left[\frac{x^3}{3}\right]_0^3 + \frac{1}{EI} \left(H\left[\frac{x^2}{2}\right]_0^1 + 3H - 6\left[\frac{x^3}{3}\right]_0^1 \right) - 18 \frac{x^2}{2} \, d + \frac{4}{EI}$$

$$\left[11\frac{x^2}{2} - 6 - 10\frac{x^3}{3} + 4H \right]_0^2 + \frac{1}{EI} \left[H\frac{x^3}{3} - 6\frac{x^3}{3} \right]_0^4$$

$$= \frac{H}{EI} \left[\frac{(3)^3}{3}\right] + \frac{1}{EI} \; H\left[\frac{1^2}{2}\right] + 3H - 6 \times \frac{1^3}{3} - 18\left(\frac{1^2}{2}\right) + \frac{4}{EI}$$

$$\left(11 \times \frac{2^2}{2} - 6 - 10\frac{2^3}{3} + 4H \right) + \frac{1}{EI} \left(H\left(\frac{4^3}{3}\right) - 6\left(\frac{4^3}{3}\right) \right)$$

$$= \left(\frac{H}{EI} \times \frac{27}{3}\right) + \left(\frac{1}{EI} \times \frac{H}{2} + 3H - \frac{6}{3} - \frac{18}{2}\right) + \left(\frac{4}{EI} \times \frac{44}{2} - 6 - \frac{80}{3}\right.$$

$$\left. + 4H \right) + \left(\frac{1}{EI} \times \frac{64H}{3} - \frac{384}{3} \right)$$

$$= \frac{H}{EI} \times 9 + \left(\frac{1}{EI} \left(\frac{7H}{2}\right) - 2 - 9 \right) + \left(\frac{4}{EI} \times 22 - \frac{98}{3} \right) + 4H$$

$+ \frac{1}{EI} \times 21.33H - 128$

$= 9H + 3.5H - 11 + 88 - 32.66 + 4H + 21.33H - 128$

$= 9H + 3.5H + 4H + 21.33H - 83.66$

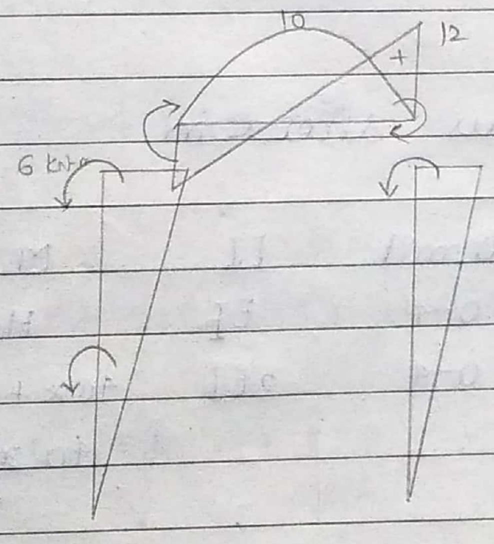
$= 37.83H - 83.66$

$H = 2.98$ kN

BMD @ B = + 6 KNm

C = + 12 KN-m

E = 9 KN-m



Q Analyzed the given portal frame as shown in fig and determine the redudant ratios, plot the BMD using strain energy method

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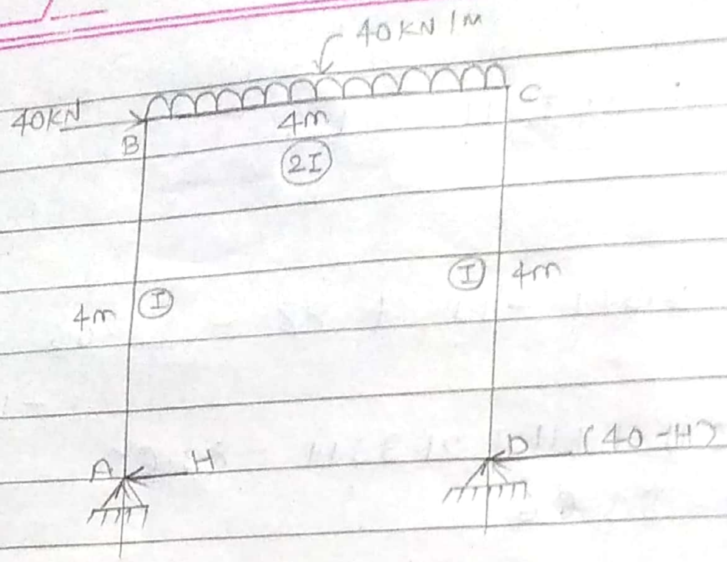


DOSI = 4 - 3 = 1

$V_D + V_A = 160$ KN

$\Sigma M @ A = 0$

$(40 \times 4 \times 2) + (40 \times 4) - V_D \times 4 = 0$

$V_D = 120$ KN

$V_A = 40$ KN

Apply castiglinous theorem

Origin	Portion	Limit	EI	M	$\partial M/\partial H$
A	AB	0-4	EI	Hx	x
B	BC	0-4	2EI	$40x + H\times 4 - 40\frac{x^2}{2}$	4
D	DC	0-4	EI	$(40-H)x - 40x + Hx$	x

$$= \int \frac{M}{EI} \frac{\partial M}{\partial H} dx$$

$$= \frac{H}{EI}\int_0^4 x \, dx + \frac{1}{2EI}\int_0^4 (40x + H\times 4 - 20x^2) \times 4 \, dx$$

$$+ \frac{1}{EI}\int_0^4 (-40x + Hx)\, x \, dx$$

$$= \frac{H}{EI}\left[\frac{x^2}{2}\right]_0^4 + \frac{1}{2EI}\left[40\times\frac{x^2}{2} + 4H - 20\times\frac{x^3}{3}\right]_0^4 \times 4$$

$$+ \frac{1}{EI}\left(-40\times\frac{x^3}{3} + H\frac{x^3}{3}\right]_0^4 \times \frac{x^2}{2}\,dx$$

$$= \frac{H}{EI}\left[\frac{4^2}{2}\right] + \frac{1}{EI}\left[40\times\frac{4^2}{2} + 4H - 20\times\frac{4^3}{3}\right]\times 2$$

$$+ \frac{1}{EI}\left(-40\times\frac{4^3}{3} + H\frac{4^3}{3}\right]$$

$$= \frac{8H}{EI} + \frac{1}{EI}\left[40\times 8 + 4H - 20\times 21.33\right]2 + \frac{1}{EI}$$

$$(-40\times 21.33 + 21.33H)$$

$$= \frac{8H}{EI} + \frac{1}{EI}\left[640 + 32H - 853.2\right] + \frac{1}{EI}(-18.67 + 21.33H)$$

$$= 8H + 640 + 8H - 853.2 - 18.67 + 21.33H$$

$$= \frac{21.33H}{E2} + \frac{640}{EI} + \frac{32H}{EI} - \frac{853.33}{EI} - \frac{853.33}{EI} + \frac{21.33H}{EI}$$

$$= \frac{74.66H}{EI} - \frac{1066.66}{EI}$$

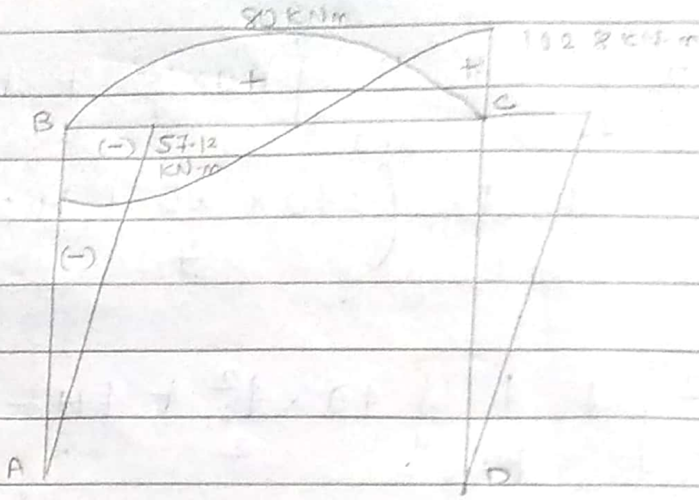
$H = 14.29$

BM @ A = 0

BM @ D = 0

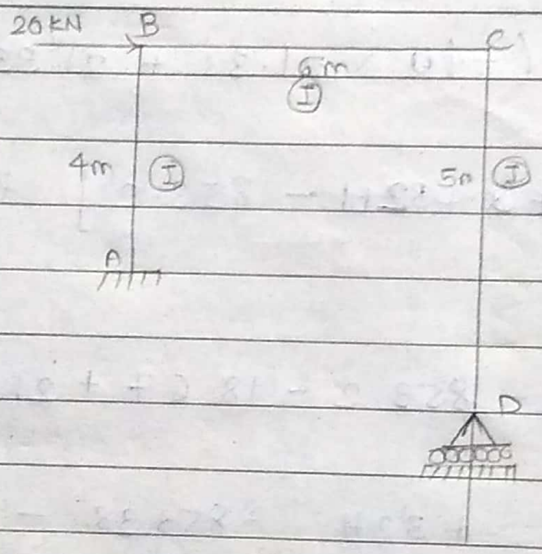
BM @ B = 57.12 KN-m

BM @ C = 102.8 KN-m



Case II

W-14 Q Analyzed the given portal frame as
S-14 shown in fig and draw the BMD
W-16 using strain energy method.
W-18



DOSI = 4 − 3 = 1

Origin	Portion	Limit	EI	M	∂M/∂V
D	DC	0−5	EI	0	0
C	CB	0−6	EI	VD×x	x
B	BA	0−4	EI	VD×6 − 20×x	6

$$\int \frac{M}{EI}\frac{\partial M}{\partial V}\,dx$$

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$$= \int_0^5 \frac{0}{EI} dx + \int_0^6 \frac{V_D x \cdot x\, dx}{EI} + \int_0^4 \frac{6V_D - 20x \cdot 6\, dx}{EI}$$

$$= \int_0^6 \frac{V_D}{EI} x^2\, dx + \int_0^4 \frac{36V_D x - 120x}{EI} dx$$

$$= \frac{V_D}{EI}\left[\frac{x^3}{3}\right]_0^6 + \frac{V_D}{EI}\left[36 \times 4 - 120 \times \frac{x^2}{2}\right]_0^4$$

$$= \frac{V_D}{EI} \times \frac{6^3}{3} + \frac{V_D}{EI}\left(144 - 120 \times \frac{4^2}{2} \times 6\right)$$

$$= \frac{V_D}{EI} 72 + \frac{V_D}{EI}(24 \times 8)$$

$$= \frac{V_D}{EI} 72 + \frac{144 V_D}{EI} - \frac{960}{EI}$$

$$= 216 V_D - 960$$

$$960 = 216 V_D$$

$$V_D = 4.44 \text{ KN}$$

BM @ D = 0

BM @ C = 0

BM @ B = 4.44×6 = 26.4 KN-m

BM @ A = -4.44 × 6 + 20 × 4 = 53 KN-m

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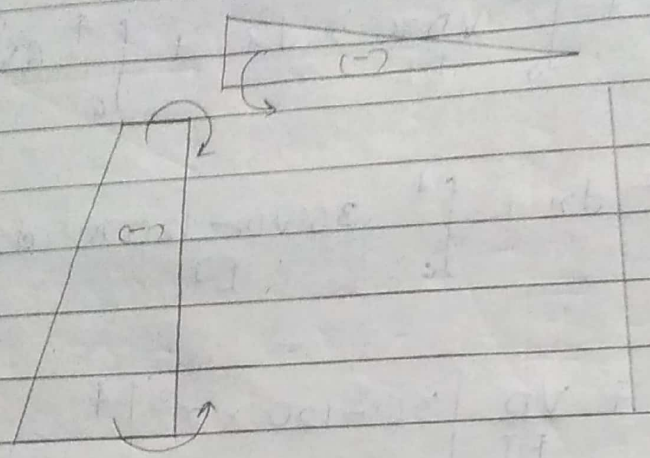
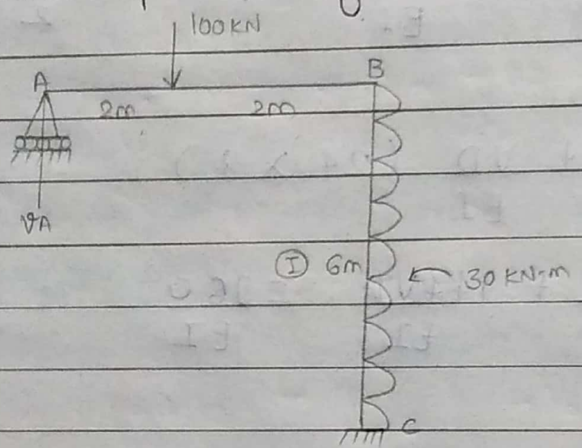


Q Analyzed the portal frame



DOSI = 4 - 3 = 1

Origin	Portion	Length	EI	M	$\partial M / \partial V_A$
A	AE	0-2	EI	$VA \times x$	x
E	EB	0-2	EI	$VA \times (2+x) - 100x$	$2+x$
B	BC	0-6	EI	$VA \times 4 - 200 - \frac{30x^2}{2}$	4

$$= \int \frac{M}{EI} \frac{\partial M}{\partial VA} \, dx.$$

$$= \int_0^2 VA\,x \cdot x + \int_0^2 [VA\,(x+2)] - 10x \;(x+2) \; + \int_0^6 \left(VA \times 4 - 200 - 30\frac{x^2}{2}\right) \times 4$$

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$$= \int_0^2 VA\, x^2 + \int_0^2 (VA\,x + 2VA - 100x)(x+2) + \int_0^6 16VA - 800 - 120\frac{x^2}{2}$$

$$= \int_0^2 VA\,x^2 + \int_0^2 VA\,x^2 + 2VA\,x - 100x^2 + 2VA\,x + 4VA - 200x + \int_0^6 16VA - 800x - 120\frac{x^2}{2}$$

$$= \int_0^2 VA\frac{x^3}{3} + \int_0^2 VA\frac{x^3}{3} + 2VA\frac{x^2}{2} - 100\frac{x^3}{3} + 2VA\frac{x^2}{2} + 4VA\,x - 200\frac{x^2}{2}$$

$$+ \int_0^6 16VA\,x - 800\times 6 - 60x^3$$

$$= VA\left(\frac{2^3}{3}\right) + VA\left(\frac{2^3}{3}\right) + 2VA\left(\frac{2^2}{2}\right) - 100\left(\frac{2^3}{3}\right) +$$

$$2VA\times\left(\frac{2^2}{2}\right) + 4VA\times 2 - 200\times\frac{2^2}{2} + 16VA\times 6 - 800\times 60\times\frac{6^3}{3}$$

$$= 2.67\,VA + 2.67\,VA + 4\,VA - 266.67 + 4\,VA + 8\,VA + 96\,VA - 4800 - 4320$$

$$= 117.34\,VA + 9786.67$$

$$\therefore VA = 83.40\ KN$$

Final BM after calculations of VA

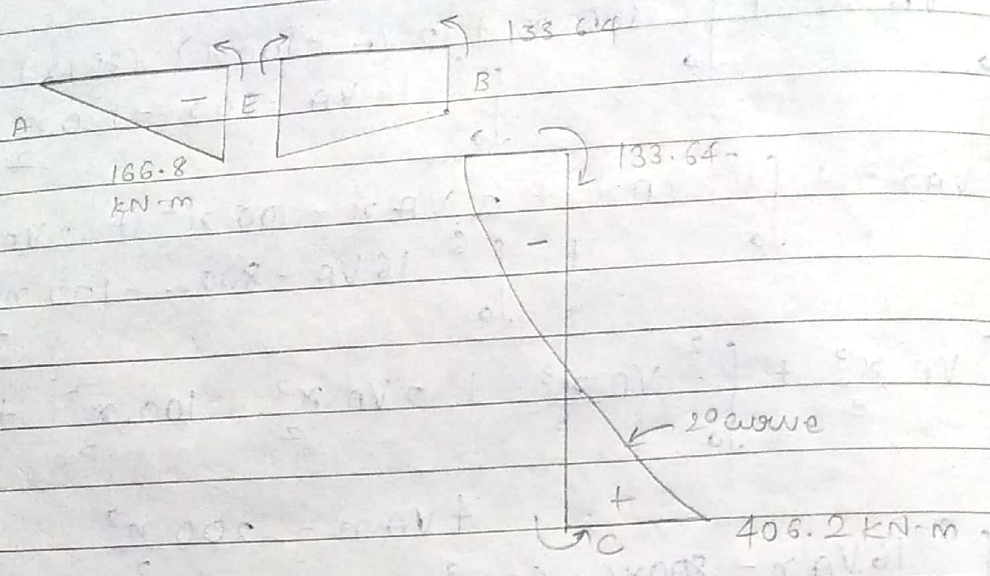
BM @ A = 0

BM @ E = 83.4 × 2 = 116.8 KN-m

BM @ B = 83.4 × 4 − 100 × 2 = 133.6 KN-m

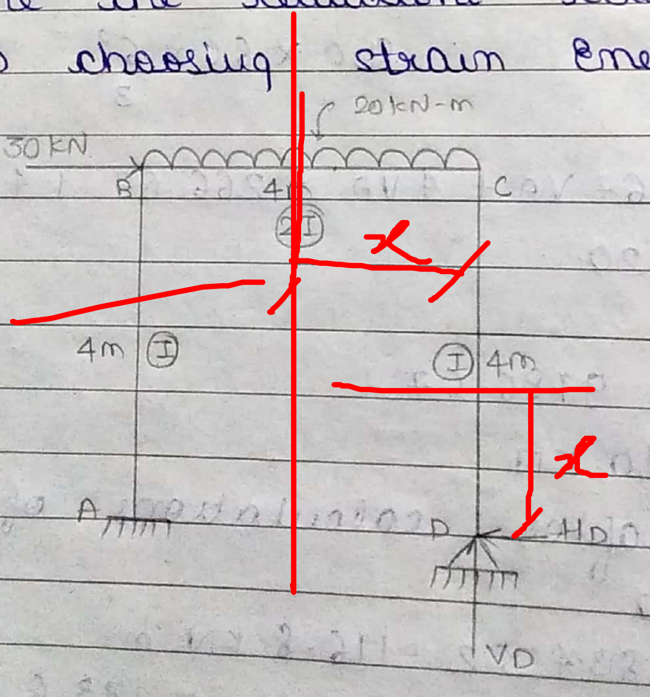
BM @ C = 83.4 × 4 − 100 × 2 − 30 × 6 × $\frac{6}{2}$

= −406.4 KN-m



* Portal frame with double degree of in-determinance

W-19 Q For the portal frame as shown in fig Determine the redudant reaction and draw the BMD choosing strain Energy method



DOSI = 5 - 3 = 2

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Origin	Portion	Length	EI	M	$\partial M/\partial H_D$	$\partial M/\partial V_D$
D	DC	0-4	EI	$-H_D \cdot x$	$-x$	0
C	CB	0-4	2EI	$-H_D 4 + V_D \times x - \frac{20x^2}{2}$	-4	x
B	BA	0-4	EI	$-H_D(4-x) + V_D \times 4 - 30x + 20\frac{4^2}{2} \times 4$	$-(4+x)$	4

$$\int \frac{M}{EI} \frac{\partial M}{\partial H_D} dx$$

$$= \int_0^4 -H_D(x) \cdot x \, dx + \int_0^4 \left(-H_D 4 + V_D \cdot x - \frac{20x^2}{2}\right) - 4 +$$

$$\int_0^4 -H_D 4 + H x x + 4V_D - 30x + 20\left(\frac{4^2}{2}\right) \cdot (-4+x)$$

$$= \int_0^4 16H_D - 4V_D x - \frac{80x^2}{2} + \int_0^4$$

$$= \int_0^4 H_D x^2 + \int_0^4 16H_D - 4V_D x + 40x^2 + \int_0^4 - 4H_D x + H_D x^2 +$$

$$4V_D x - 30x^2 - 160x + 16H_D - 4H_D x - 16V_D + 120x + 640$$

$$= \int_0^4 H_D \frac{x^3}{3} + \int_0^4 16\frac{H_D \times x}{2} - 4\frac{V_D x^2}{2\times 2} + \frac{40x^3}{2\times 3} +$$

$$\int_0^4 - 4H_D\frac{x^2}{2} + H_D\frac{x^3}{3} + 4V_D\frac{x^2}{2} - 30\frac{x^3}{3} - 160\frac{x^2}{2}$$

$$+ 16H_D x - 4H_D\frac{x^2}{2} - 16V_D x + 120\frac{x^2}{2} + 640x$$

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$BM_D = 0$

$BM_C = 10.085 \times 4 = 40.34$ kN·m

$BM_B = -57.5 \times 4 + 20 \times 4 \times 2 = -71.6$ kN·m

$BM_A = 30 \times 4 + 10.085 \times 4 = 160.34$ kN·m

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$$H_D \times \frac{4^3}{3} + 16\frac{H_D}{2}\times 4 - \frac{4V_D}{2}\times\frac{4^2}{2} + \frac{40\times 4^3}{2\times 3} - 4H_D\times\frac{4^2}{2} +$$

$$H_D \times \frac{4^3}{3} + 4V_D \times \frac{4^2}{2} - 30\times\frac{4^3}{3} - 160\times\frac{4^2}{2} + 16H_D\times 4 - 4H_D\times\frac{4^2}{2}$$

$$-16V_D\times 4 + 120\times\frac{4^2}{2} + 640\times 4$$

$$21.33H_D + 32H_D - 16V_D + 426.67 - 32H_D + 21.33H_D$$

$$+32V_D - 640 - 1280 + 64H_D - 32H_D - 64V_D + 960 + 2560$$

$$74.66H_D - 48V_D = -2026.67 \quad \text{—(1)}$$

$$\int \frac{M}{EI}\frac{\partial m}{\partial V_d}\,dx$$

$$= \int_0^4 (-4H_D + V_D x - 10x^2)\times x + \int_0^4 (-4H_D + H_D x + 4V_D$$

$$-30x - 160)\times 4$$

$$= \int_0^4 -4H_D x + V_D x^2 - 10x^3 + \int_0^4 -16H_D + 4H_D x + 16V_D$$
$$-120x - 640$$

$$= \int_0^4 -\frac{4H_D}{2}\times\frac{x^2}{2} + \frac{V_D}{2}\frac{x^3}{3} - \frac{10x^4}{2\times 4} + \int_0^4 -16H_D x + 4H_D\frac{x^2}{2}$$

$$+16V_D x - 120\frac{x^2}{2} - 640x$$

$$= -4H_D\left(\frac{4^2}{2\times 2}\right) + V_D\left(\frac{4^3}{2\times 3}\right) - \frac{10(4)^4}{2\times 4} - 16H_D\times 4 + 4H_D\left(\frac{4^2}{2}\right)$$

$$+16V_D\times 4 - 120\times\frac{4^2}{2} - 640\times 4$$

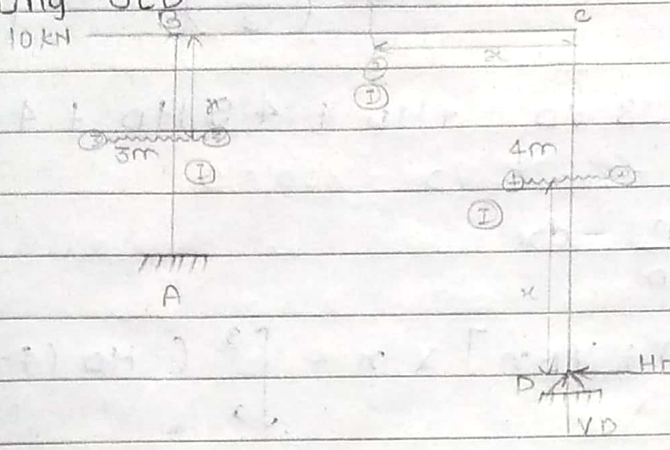
$$= -16H_D + 10.67V_D - 320 - 64H_D + 32H_D + 64V_D - 960$$
$$-2560$$

$$= -48H_D + 74.67V_D = +3840$$

$$= 48H_D - 74.67V_D = -3840 \quad \text{—(2)}$$

$$\therefore H_D = 10.085 \text{ kN}$$
$$V_D = 57.9 \text{ kN}$$

Q Analyse the given portal frame as shown in fig. The end A is fixed D is hinged. Draw BMD using SED



DOSI = 5 − 3 = 2

Portion	Origin	EI	Limit	M	$\partial M/\partial V_D$	$\partial M/\partial H_D$
DC	D	EI	0-4	$-H_D x$	−	$-x$
CB	C	EI	0-4	$-H_D \times 4 + V_D \times x$	x	-4
BA	B	EI	0-3	$-H_D(4-x) + V_D \times 4$ $-10x$	$+4$	$-4+x$

$$\int \frac{M}{EI} \frac{\partial M}{\partial V_D} dx$$

$$\int_0^4 (-4H_D) + V_D x \cdot x \cdot (-4) + \int_0^3 -H_D \times 4 + xH_D + 4V_D - 10x \cdot 4 \cdot (-4+x)$$

$$\int_0^4 16xH_D + (-4x^2 V_D) + \int_0^3 -4H_D + xH_D + 4V_D - 40x \cdot (-4+x)$$

$$\int_0^4 16xH_D - 4x^2 V_D + \int_0^3 -4H_D + xH_D + 4V_D + 160x - 40x^2$$

$$16\left(\frac{x^2}{2}\right)_0^4 H_D - 4\left(\frac{x^3}{3}\right) V_D + (-4H_D) + \left(\frac{x^2}{2}\right)_0^3 H_D + 4V_D - 160\left(\frac{x^2}{2}\right)_0^3 - 40\left(\frac{x^3}{3}\right)_0^3$$

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$$16\left(\frac{4^2}{2}\right) H_D - 4\left(\frac{4^3}{3}\right) V_D - 4H_D + \left(\frac{8^2}{2}\right) H_D + 4V_D$$

$$-160\left(\frac{3^3}{3}\right) - 40\left(\frac{3^3}{3}\right)$$

$$128 H_D - 85.33 V_D - 4H_D + 4.5 H_D + 4V_D - 1440 - 360$$

$$128.5 H_D - 81.33 V_D - 1800 = 0$$

$$\int \frac{M}{EI} \frac{\partial m}{\partial V_D} dx$$

$$\int_0^4 [(-H_D \times 4) + V_D x] \times x + \int_0^3 (-H_D(4-x) + V_D 4 - 10x) \times 4$$

$$\int_0^4 -4H_D x + V_D x^2 + \int_0^3 (-4H_D + H_D x + 4V_D - 10x) \times 4$$

$$\int_0^4 -4H_D x + V_D x^2 + \int_0^3 -16H_D + 4H_D x + 16V_D - 40x$$

$$\int_0^4 -4H_D \frac{x^2}{2} + V_D \frac{x^3}{3} + \int_0^3 -16H_D \times x + 4H_D \frac{x^2}{2} + 16V_D x - 40x^2/2$$

$$-4H_D \times \frac{4^2}{2} + V_D \times \frac{4^3}{3} - 16H_D \times 3 + 4H_D \times \frac{3^2}{2} + 16V_D \times 3 - 40\frac{3^2}{2}$$

$$-32H_D + 21.33V_D - 48H_D + 18H_D + 48V_D - 180$$

$$-62H_D + 69.33V_D = 180 \quad —(1)$$

$$\int \frac{M}{EI} \frac{\partial M}{\partial H_D} dx$$

$$= \int_0^4 -H_D x \times (-x) + \int_0^4 (-4H_D + V_D x)(-4) + \int_0^3 (-4H_D + H_D x + 4V_D - 10x) \times (-4 + x)$$

$$\int_0^4 H_D x^2 + \int_0^4 16H_D - 4V_D x + \int_0^3 16H_D - 4H_D x - 16V_D + 40x$$

$$-4H_D x + H_D x^2 + 4V_D x - 10x^2$$

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$$\int_0^4 H_D \frac{x^3}{3} + \int_0^4 16 H_D x - 4V_D \frac{x^2}{2} + \int_0^3 16 H_D x - 4 H_D \frac{x^2}{2} - 16 V_D$$

$$+ 40\frac{x^2}{2} - 4H_D \frac{x^2}{2} + H_D \frac{x^3}{3} + 4V_D \frac{x^2}{2} - 10\frac{x^3}{3}$$

$$H_D \times \frac{4^3}{3} + 16 H_D \times 4 - 4V_D \times \frac{4^2}{2} + 16 H_D \times 3 - 4H_D \times \frac{3^2}{2}$$

$$-16 V_D \times 3 + 40 \times \frac{3^2}{2} - 4H_D \times \frac{3^2}{2} + H_D \times \frac{3^3}{3} + 4V_D \times \frac{3^2}{2} - 10 \times$$

$$21.33 H_D + 64 H_D - 32 V_D + 48 H_D - 18 H_D - 48 V_D$$

$$+ 180 - 18 H_D + 9 H_D + 18 V_D = -90$$

$$106.33 H_D - 62 V_D = -90$$

$$-106.33 H_D + 62 V_D = 90 \quad -(2)$$

$H_D = 1.38$ KN

$V_D = 3.84$ KN

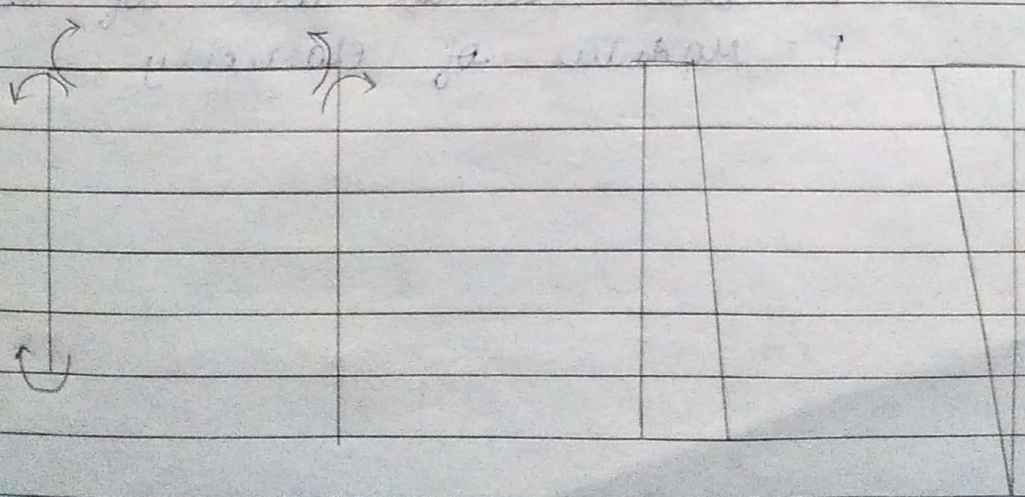
$BM_D = 0$

$BM_C = 1.38 \times 4 = 5.56$ KN-m

$BM_B = -3.84 \times 4 + 1.38 \times 4 = -9.82$ KN-m

$BM_A = -3.84 \times 4 + 1.38 \times 4 + 10 \times 3$

$= 20.02$ KN-m



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* Analysis of Trusses using strain energy method

* Determination of deflection of truss by Williot - Mohr's Diagram

The deflection of load of the truss can be calculated as

$$\boxed{\delta = \frac{TUL}{AE}}$$

$\left\{ P = K\Delta \therefore \Delta = \frac{P}{K} \right\}$

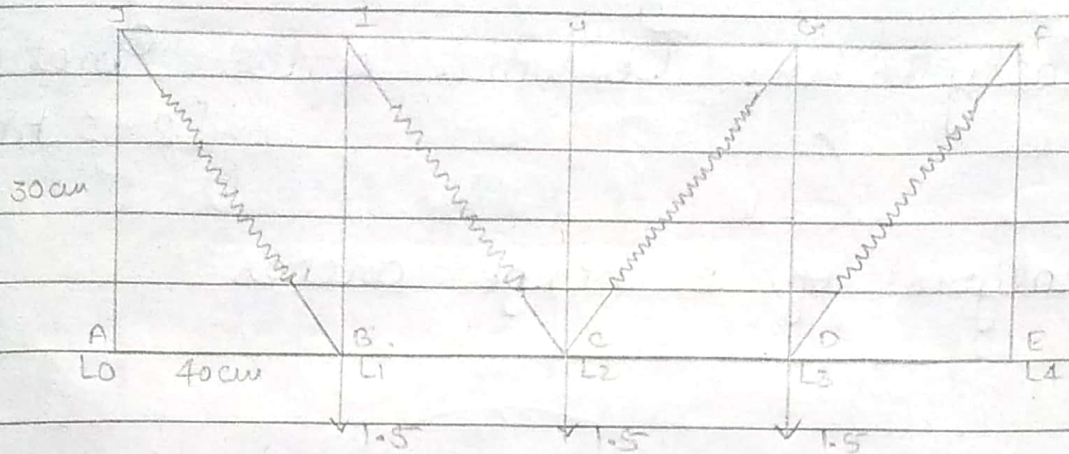
where T = Forces in the any member under the given load

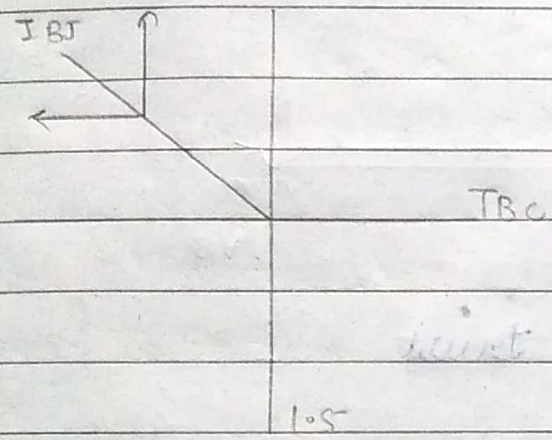
U = Forces in any member under the unit load at the point at which the deflection is required (The unit load act when the load on the truss has been removed and in the direction in which the deflection is required)

L = Length of member

A = cross - sectional area of member

E = Modulus of elasticity


J
I
H
G
F
30 cm
A
B
C
D
E
L0
40 cm
L1
L2
L3
L4
1.5
1.5
1.5


TBJ
TBC
1.5