[30|10|17]

Note:

① While finding out the rotation factor (or) the distribution factor consider finding the relative stiffness

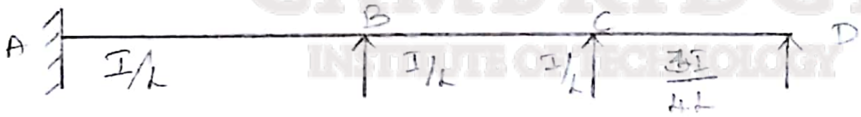
i.e Relative stiffness of a member with far end fixed $= \frac{I}{L}$

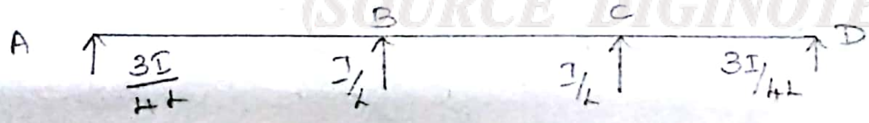
Relative stiffness for a member with far end hinged $= \frac{3I}{4L}$

Joint	member	Relative stiffness	Total stiffness	DF	RF

② For Beams having Internal supports to be simply supported (or) hinged (or) roller

Eg:- In the member ABCD as shown below support 'B' and 'C' [Internal] are simply supported but the relative stiffness of the members BC & CB should be considered as the relative stiffness for a member for far end fixed. $\left[\frac{I}{L}\right]$





③ If the moment of Inertia of the member is 2I, 3I, any constand x I has to be considered as the total moment of Inertia of the member (I)

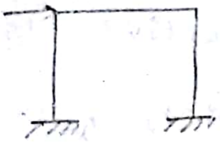
Kani's method is also called as

Rotation Contribution method

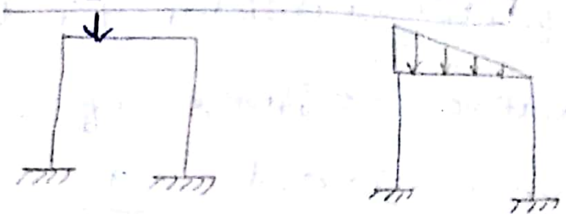
Kani's method for portal frames with sway.

sway — Horizontal load

Case (i)

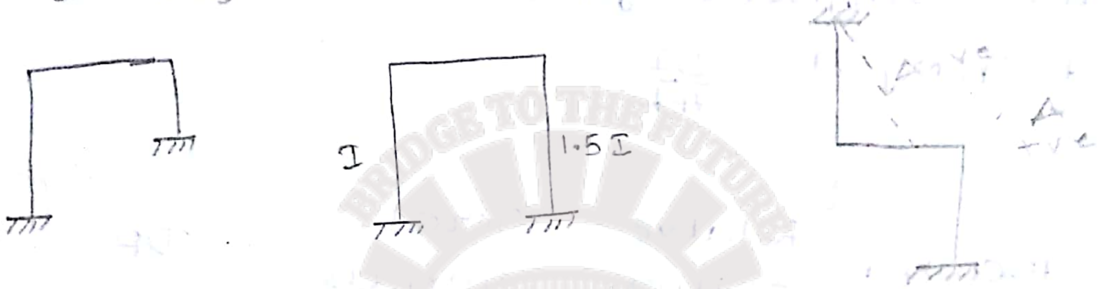


Case (ii) Unsymmetrical loading

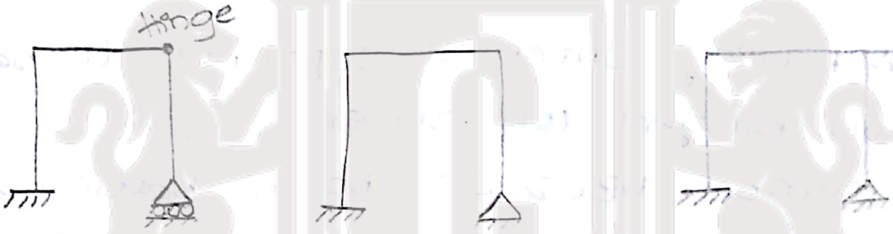


Case (iii) Unsymmetrical supports

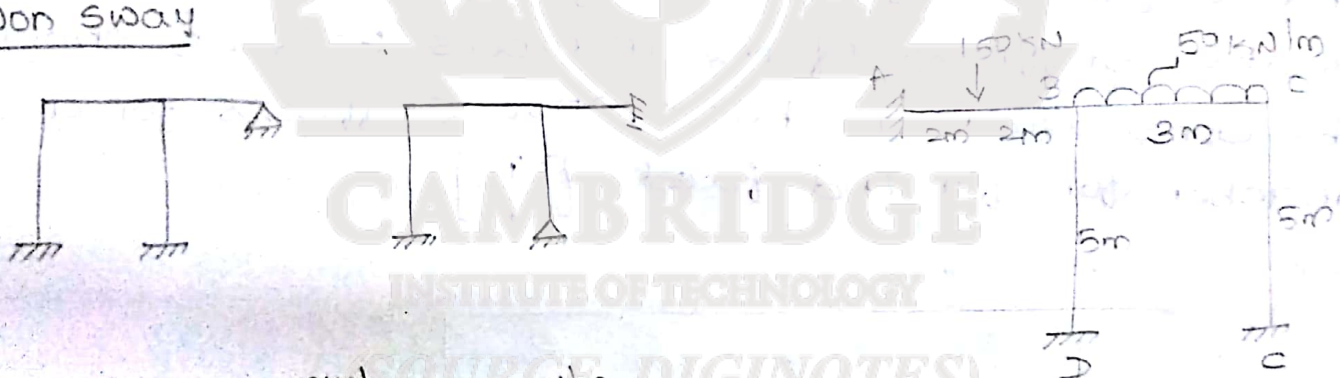
(or) unsymmetrical columns



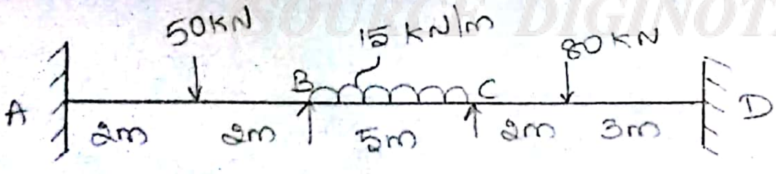
Case (iv) Hinged support / Roller.



Non sway



(1)



Step (1): FEM's

$M_{FAB} = -\frac{WL}{8} = -25$ kN-m

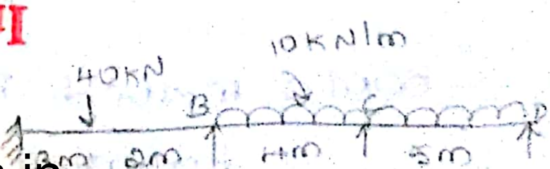
$M_{FBA} = 25$ kN-m

$M_{FBC} = -\frac{wL^2}{12} = -31.25$ kN-m

$M_{FCB} = 31.25$ kN-m

$M_{FCD} = -57.6$ kN-m

$M_{FDC} = 38.4$ kN-m



Step ②:-

Joint	Member	Relative Stiffness	Total Stiffness	DF
B	BA	$K = \frac{I}{L} = 0.25I$	$0.45I$	0.56
	BC	$K = 0.2I$		0.44
C	CB	$K = \frac{I}{L} = 0.2I$	$0.4I$	0.5
	CD	$K = 0.2I$		0.5

A	B		C		D
	0.56	0.44	0.5	0.5	
-25	25	-31.25	31.25	-57.6	58.4
	3.5	2.75	13.17	13.17	
1.75		6.58	1.375		6.58
	-3.68	-2.89	-0.68	-0.68	
-1.84		-0.34	-1.44		-0.34
	0.19	0.14	0.72	0.72	
0.095		0.36	0.07		0.36
	-0.20	-0.158	-0.035	-0.035	
-0.1		-0.0175	-0.079		-0.0175
	0.0098	0.0077	0.039	0.039	

$M_{AB} = -25.095$ kN-m

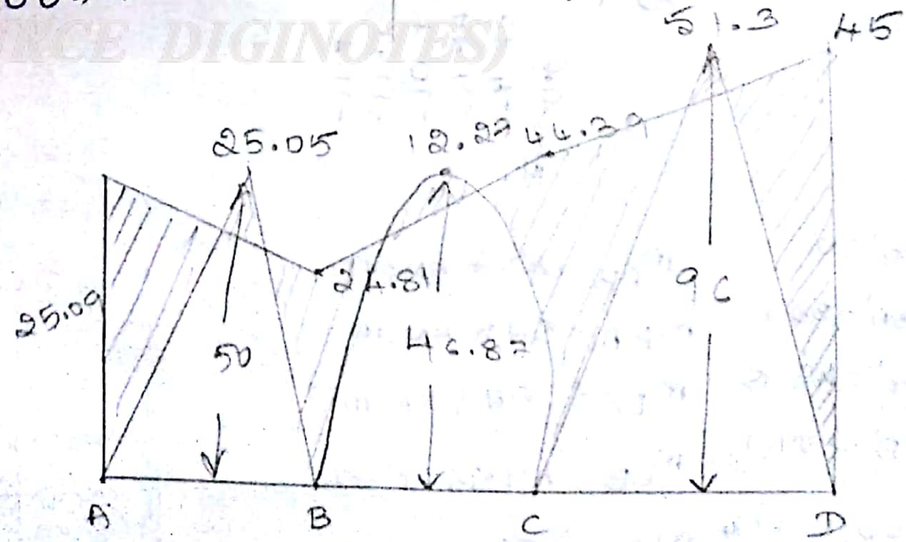
$M_{BA} = 24.81$ kN-m

$M_{BC} = -24.81$ kN-m

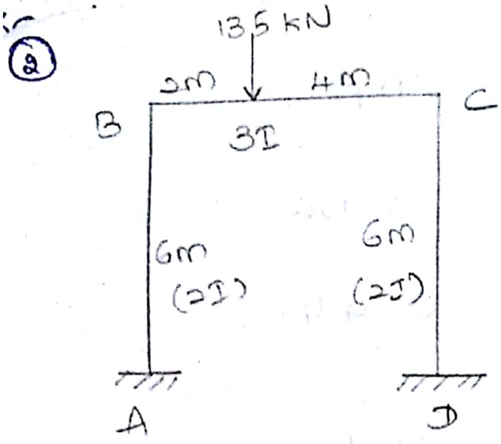
$M_{CB} = 44.39$ kN-m

$M_{CD} = -44.39$ kN-m

$M_{DC} =$ ~~24.182~~ 45 kN-m



②



FEM's

$M_{FAB} = M_{FBA} = M_{FCD} = M_{FDC} = 0$

$M_{FBC} = -120$ kN-m

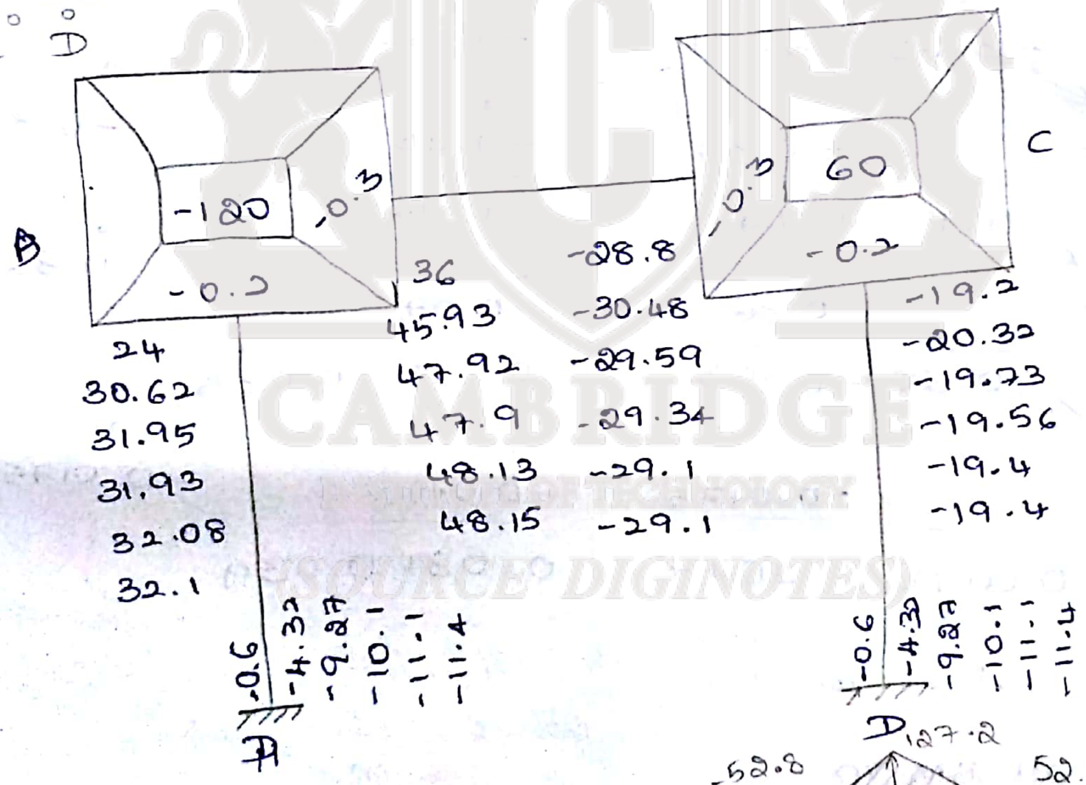
$M_{FCB} = 60$ kN-m

(only for co

$-1.5 \times D$

Joint	member	Relative Stiffness	Total stiffness	DF	RF	ΔF
B	BA	$I/L = 0.33 I_0$	$0.83 I_0$	0.4	-0.2	-0.6
	BC	$I/L = 0.5 I_0$		0.6	-0.3	
C	CB	$I/L = 0.5 I_0$	$0.83 I_0$	0.6	-0.3	
	CD	$I/L = 0.33 I_0$		0.4	-0.2	-0.6

0 0.2 0.6 0 0
A B C D



$M_{AB}' = 0$ $\quad$ $M_{AB} = 20.7$ kN-m

$M_{BA}' = 32.1$ $\quad$ $M_{BA} = 52.8$ kN-m

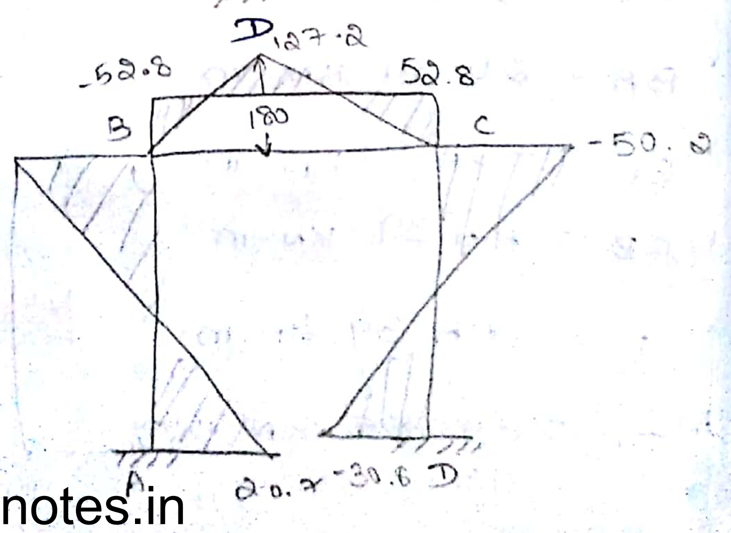
$M_{BC}' = 48.15$ $\quad$ $M_{BC} = -52.8$ kN-m

$M_{CB}' = -29.1$ $\quad$ $M_{CB} = 49.95$ kN-m

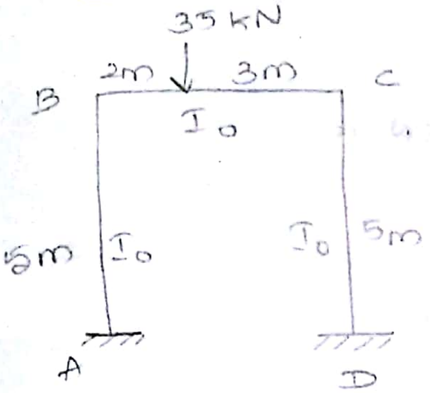
$M_{CD}' = -19.4$ $\quad$ $M_{CD} = -50.2$ kN-m

$M_{DC}' = 0$ $\quad$ $M_{DC} = -30.8$ kN-m

52.8



Frames with sway



FEM's

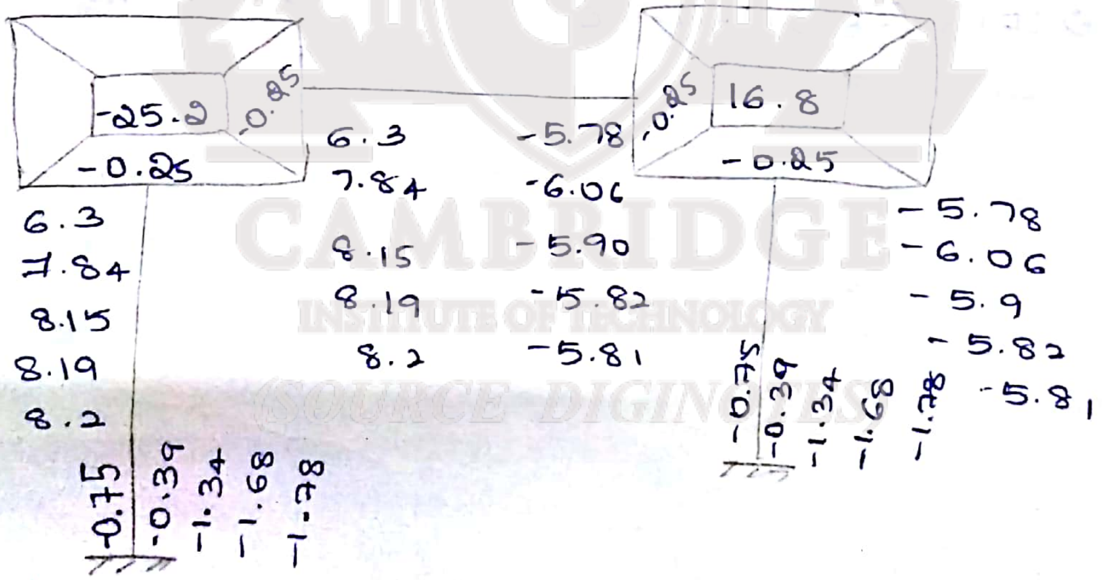
$M_{FAB} = M_{FBA} = M_{FCD} = M_{FDC} = 0$

$M_{FBC} = \frac{-wb^2a}{L^2} = -25.2$ kN-m

$M_{FCB} = 16.8$ kN-m

Joint	member	Relative stiffness	Total stiffness	DF	RF	CF
B	BA	$I/L = 0.2I_0$	$0.4I_0$	0.5	-0.25	-0.75
	BC	$I/L = 0.2I_0$		0.5	-0.25	
C	CD	$I/L = 0.2I_0$	$0.4I_0$	0.5	-0.25	-0.75
	CB	$I/L = 0.2I_0$		0.5	-0.25	

Resultant Restraint moments.



$M'_{AB} = 0$

$M'_{BA} = 8.2$ kN-m

$M'_{BC} = 8.2$ kN-m

$M'_{CB} = -5.81$ kN-m

$M'_{CD} = -5.81$ kN-m

$M'_{DC} = 0$

$M''_{AB} = M''_{BA} = -1.78$ kN-m

$M''_{CD} = M''_{DC} = -1.78$ kN-m

KN 13.5 kN

Final moments:-

Primavera
M S Project

$M_{AB} = M_{FAB} + 2M'_{AB} + M'_{BA} + M''_{AB}$

$= -0.\cancel{75} + 2(0) + 8.2 + (-1.78) = 6.42 \text{ kN-m}$

$M_{BA} = M_{FBA} + 2M'_{BA} + M'_{AB} + M''_{BA}$

$= 2(8.2) + (-1.78) = 14.62 \text{ kN-m}$

$M_{BC} = M_{FBC} + 2M'_{BC} + M'_{CB}$

$= -25.2 + 2(8.2) + (-5.81) = -14.61 \text{ kN-m}$

$M_{CB} = M_{FCB} + 2M'_{CB} + M'_{BC} + 0$

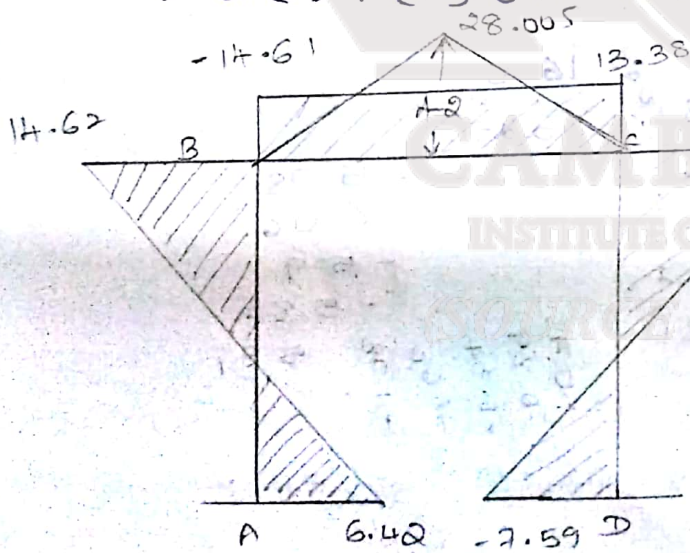
$= 16.8 + 2(-5.81) + 8.2 = 13.38 \text{ kN-m}$

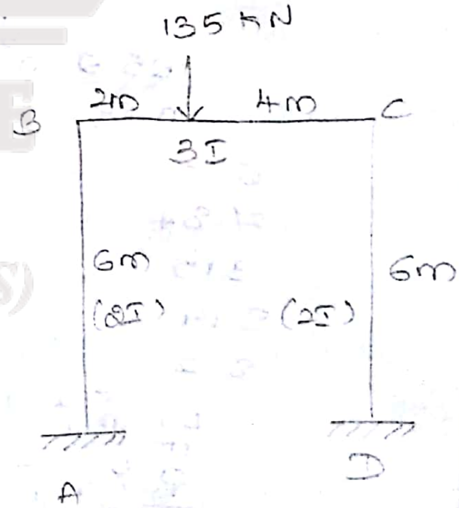
$M_{CD} = M_{FCD} + 2M'_{CD} + M'_{DC} + M''_{CD}$

$= 2(-5.8\cancel{8}) + (-1.78) = -13.4 \text{ kN-m}$

$M_{DC} = M_{FDC} + 2M'_{DC} + M'_{CD} + M''_{DC}$

$= 2(0) + (-5.81) - 1.78 = -7.59 \text{ kN-m}$





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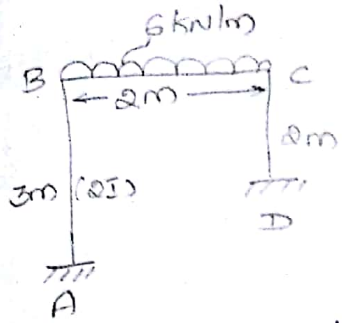
Case ② Unequal Column Height.

① Draw the BMD & sketch the deflected shape of the frame as shown in the figure.



Step①: FEM's

$$M_{FAB} = M_{FBA} = M_{FCD} = M_{FDC} = 0$$

$$M_{FBC} = -2\ kN\text{-}m$$

$$M_{FCB} = 2\ kN\text{-}m$$

Joint	member	Relative stiffness	Total stiffness	DF	RF	ΔF (Displacement factor)
B	BA	$K = I/L$, $K = 0.67I$	$1.167I$	0.57	-0.285	
	BC	$K = I/L$, $K = 0.5I$		0.43	-0.215	
C	CB	$K = I/L$, $K = 0.5I$	I	0.5	-0.25	
	CD	$K = 0.5I$		0.5	-0.25	

Step③: Displacement factor

$$D_{BA} = \frac{-1.5\, C_{BA} \cdot K_{BA}}{C_{BA}^2 K_{BA} + C_{CD}^2 K_{CD}} \qquad D_{CD} = \frac{-1.5\, C_{CD}\, K_{CD}}{C_{BA}^2 K_{BA} + C_{CD}^2 K_{CD}}$$

$h_r = 3m$ → consider higher value only ~~$h_r = 2m$~~

$$C_{BA} = \frac{h_r}{h_{BA}} \qquad C_{CD} = \frac{h_r}{h_{CD}}$$

$$\boxed{C_{BA} = \frac{3}{3} = 1} \qquad \boxed{C_{CD} = \frac{3}{2} = 1.5}$$

$$\cancel{C_{CD} = \frac{h_r}{h_{CD}} = \frac{2}{2}, \quad C_{CD} = 1} \qquad \cancel{C_{BA} = \frac{h_r}{h_{BA}} = \frac{2}{3}, \quad C_{BA} = 0.67}$$

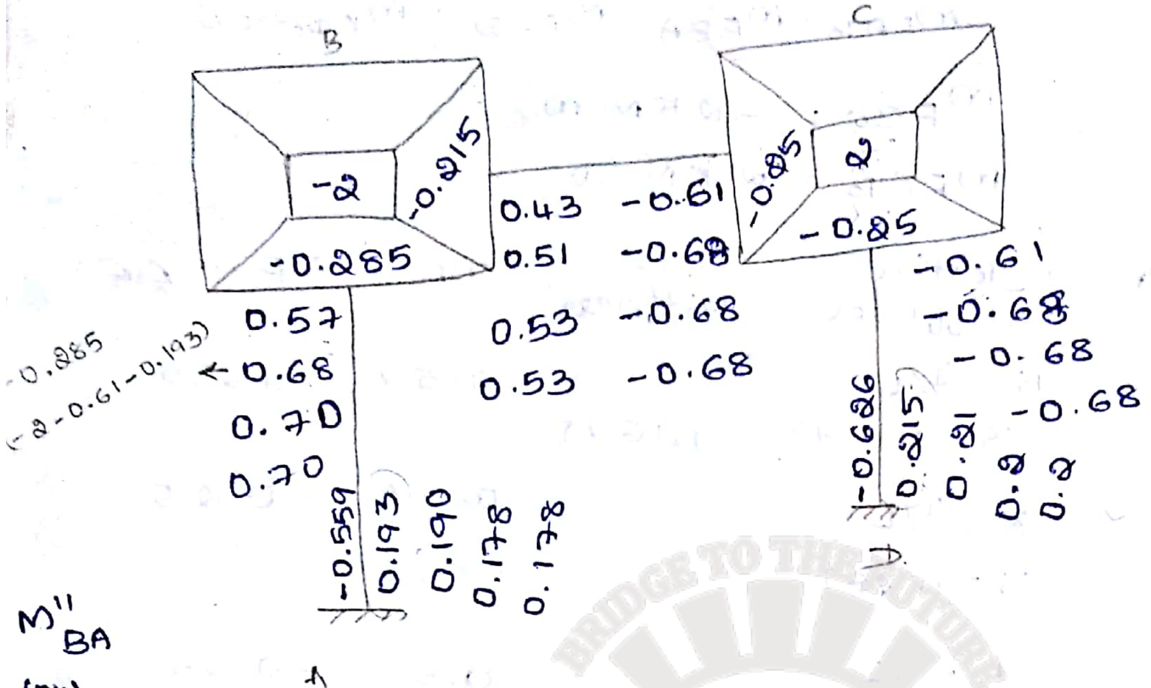
$$D_{BA} = \frac{-1.5 \times 1 \times 0.67I}{0.67I + 1.5^2 \times 0.5I} = -\frac{1.005I}{1.795I}$$

$$\boxed{D_{BA} = -0.559}$$

$$D_{CD} = \frac{-1.5 \times 1.5 \times 0.5I}{0.67I + 1.5^2 \times 0.5I} = -\frac{1.125I}{1.795I}$$

$$\boxed{D_{CD} = -0.626}$$

Step ④: Resultant Restraint moments



M''_{BA}

(or)

$$M''_{AB} = -0.559 \times [C_{BA}(M'_{AB} + M'_{BA}) + C_{CD}(M'_{CD} + M'_{DC})]$$

$$= -0.559 [1(0.57) + 1.5(-0.51)] = 0.193$$

$$M''_{CD} \text{ (or) } M''_{DC} = -0.626 \times [C_{BA}(M'_{AB} + M'_{BA}) + C_{CD}(M'_{CD} + M'_{DC})]$$

$$= -0.626 [1(0.57) + 1.5 \times (-0.61)] = 0.215$$

$$M_{AB} = M_{FAB} + 2M'_{AB} + M'_{BA} + M''_{AB}$$

$$M_{AB} = 0 + 2(0) + 0.7 + 0.193 = 0.893 \text{ kN-m}$$

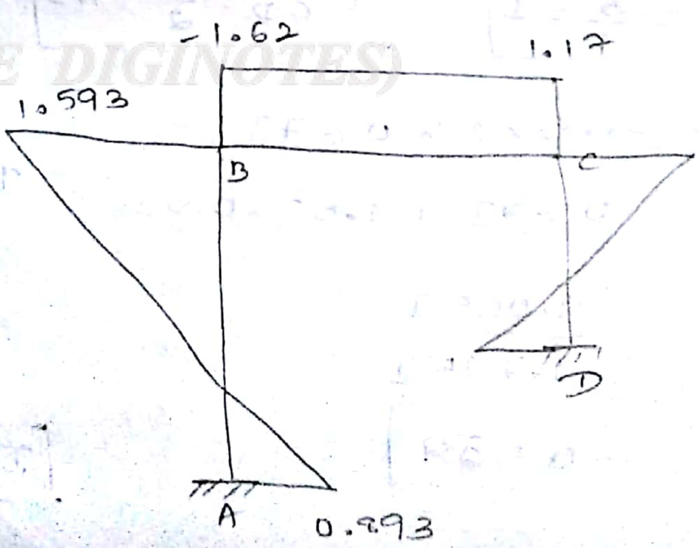
$M_{BA} = 1.593$ kN-m

$M_{BC} = -1.62$ kN-m

$M_{CB} = 1.17$ kN-m

$M_{CD} = -1.17$ kN-m

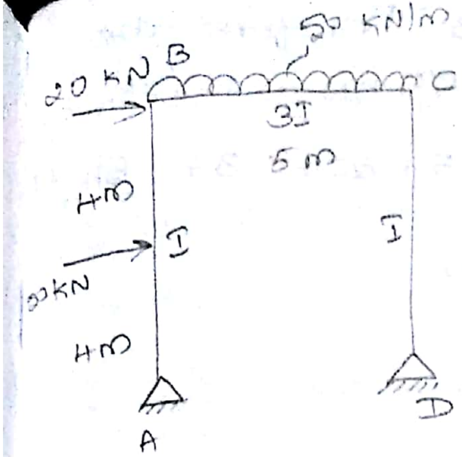
$M_{DC} = -0.49$ kN-m



Type -

① Analyse the frame shown in fig by Kani's metho

Draw the BMD, SFD & Elastic curve.



Fixed End moments

$M_{FAB} = -50$ kN-m

$M_{FBA} = 50$ kN-m

$M_{FBC} = -104.16$ kN-m

$M_{FCB} = 104.16$ kN-m

$M_{FCD} = M_{FDC} = 0$

Joint	member	Relative stiffness	Total stiffness	DF	RF
B	BA	$k = 3I/4L$, $k = 0.09$	0.69	0.13	-0.065
	BC	$k = I/L$, $k = 0.6$		0.87	-0.435
C	CB	$k = 0.6$	0.69	0.87	-0.435
	CD	$k = 0.09$		0.13	-0.065
A	AB	$k = 0.09I$	0.09I	1	-0.5
D	DC	$k = 0.09I$	0.09I	1	-0.5

$C_{CD} = C_{BA} = 1$

step ③ Displacement factor

$$D_{BA} = \frac{-1.5\, C_{BA} \cdot k_{BA}}{C_{BA}^2 \cdot k_{BA} + C_{CD}^2 k_{CD}} \qquad D_{CD} = \frac{-1.5 \times C_{CD} \times k_{CD}}{C_{BA}^2 k_{BA} + C_{CD}^2 k_{CD}}$$

$$C_{BA} = \frac{h_r}{h_{BA}} = \frac{8}{8} = 1 = C_{CD}$$

$M = F d$

$F = \frac{M}{d}$

$D_{BA} = -0.75$

$D_{CD} = -0.75$

step ④: storey moment (M_r)

Top shear P_h is calculated as follows.

The concentrated load at the centre 50kN is distributed as 25kN at the top & 25kN at the bottom. Also at the top their is horizontal load of 20kN. The support A is hinged & hence the moment should be zero. To make the moment zero at the support the moment is released

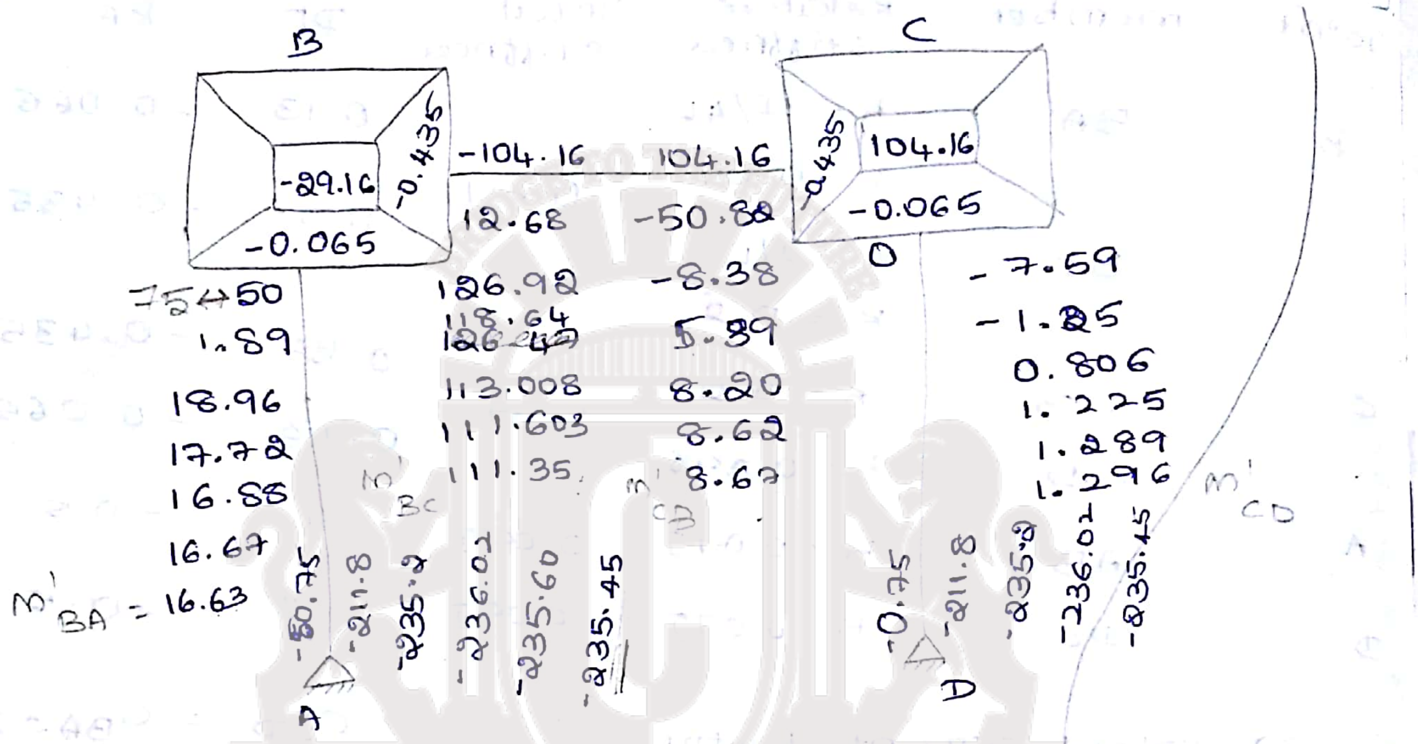
& half of the moment is carried over to B. Therefore the Shear at the top due to the End moment. 75 kN-m is $(75 \div 8)$. Hence the total shear force will be $P: 25 + 20 + 9.37 = 54.375\,kN$

$$M_{r} = \frac{P h_r}{3} = \frac{54.375 \times 8}{3} = 145\ kN\text{-}m$$

$\frac{75}{8}$; 3 → members (AB, BC, CD) ; $\frac{M_{FBA}}{h_r}$

$M''_{AB} = 2 \times \Delta_{BA} \left[M_r + \frac{1}{1.5} (\ldots) \right]$

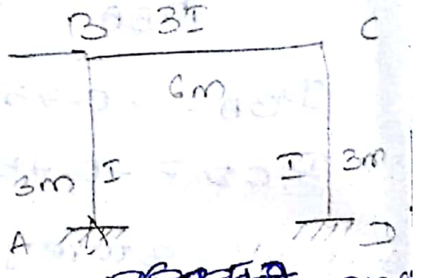
Step⑤: Resultant Restraint moments



$$M''_{AB} = 2\Delta_{AB}\left[\frac{C_{BA}}{1.5}(\cancel{M'_{AB}} + M'_{BA}) + \frac{C_{CD}}{1.5}(M'_{CD} + \cancel{M'_{DC}}) + M_r\right]$$

$$= 2(-0.75)\left[1(145) + \frac{1}{1.5}(1.89) + \frac{1}{1.5}(-7.59)\right]$$

$M''_{AB} = -211.8\ kN\text{-}m$



$M_{AB} = M_{FAB} + 2M'_{AB} + M'_{BA} + M''_{AB} = 0$

$M_{AB} = -50 + 2(0) + 16.63 + (-235.45) = -218.82$

$M_{BA} = -152.19$

$M_{BC} = -108.24$

$M_{CB} = -2.6$

$M_{CD} = -232.85$