UNIT II

Lateral load analysis using Approximate methods:-

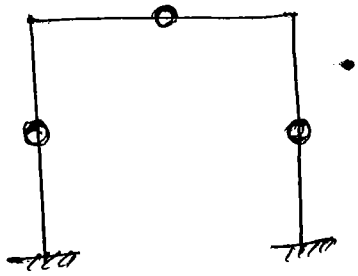
(i) portal method (ii) cantilever method
(iii) factor method (not in the syllabus).
(iv) ⇒ for Vertical loads : Substitute frame method

(i) portal method:-

Assumptions:- 1. point of contra flexure occurs at the middle of all members of frame

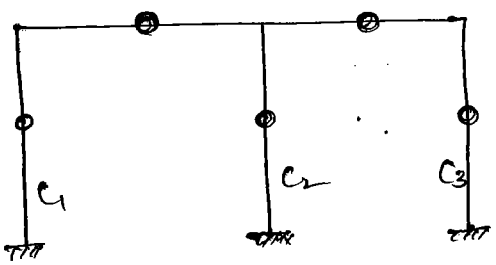
2. Horizontal shear taken by each interior column is double of that taken by exterior column.

The above assumptions will make the frame determinate and this method is proposed by Albert Smith in 1915.



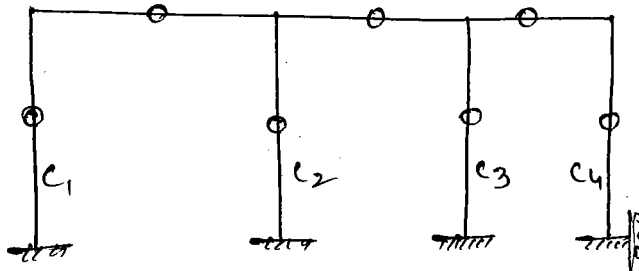
without Hinges
$D_s = 3 - 3 = 0$

No. of Hinges = 3



$D_s = 6$. (without Hinges)
No. of Hinges = 5 (Assmp. 1)
no. of shear relations = 1 (Assmp 2)

$\boxed{V_{c2} = 2V_{c1}}$

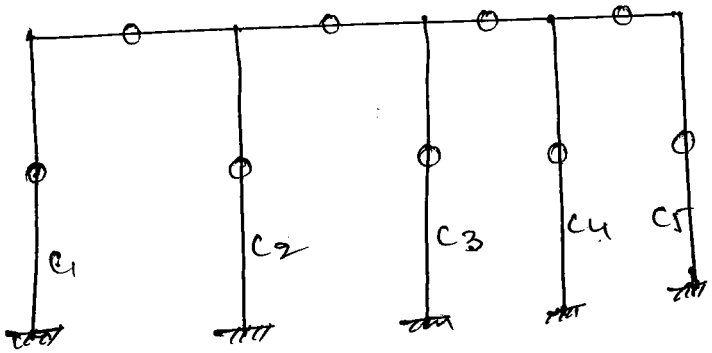


$D_1 = 9$ (without Hinges

no. of Hinges = 7 (Assump. 1)

no of shear relations = 2 (Assump. 2)

$V_{C1} = V_{C2}$; $V_{C4} = V_{C3}$



$D_1 = 12$

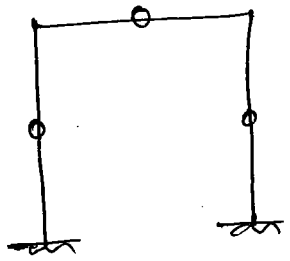
no. of Hinges = 9 (Assump. 1)

no. of Shear relations = 3 (Assump. 2)

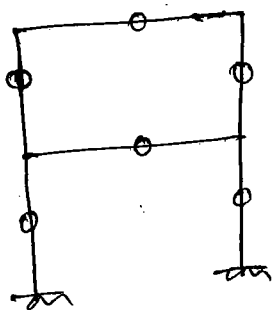
$V_{C2} = 2V_{C1}$

$V_{C3} = 2V_{C1}$

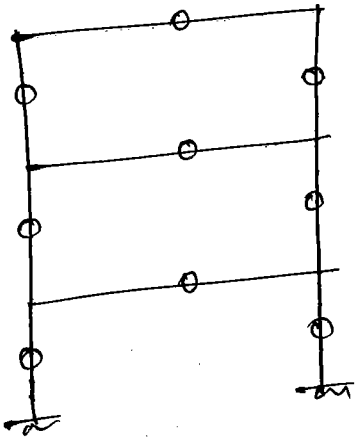
$V_{C4} = 2V_{C1}$



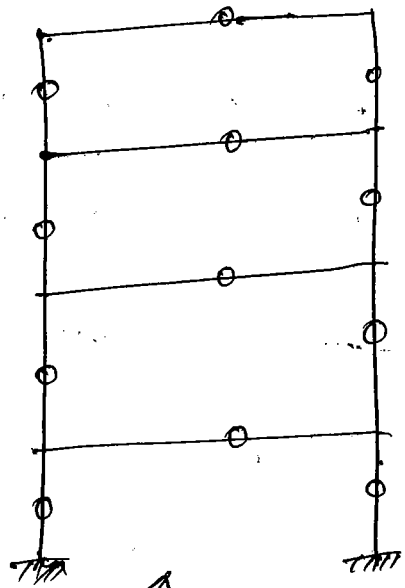
$D_1 = 0 = 3-3$



$D_1 = 6-6 = 0$



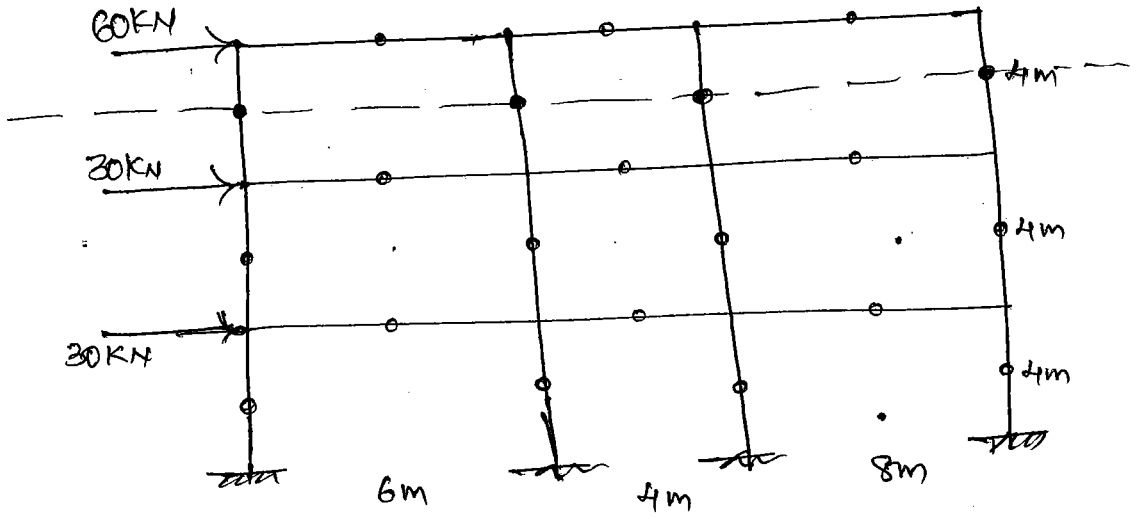
$D_1 = 9-9 = 0$



$D_1 = 12-12 = 0$

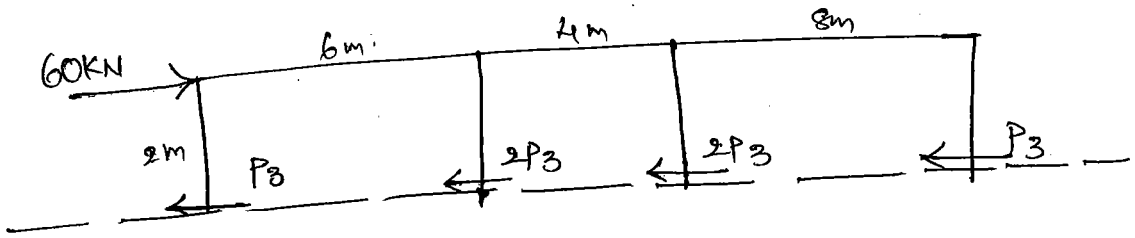
prob:- The following figure shows wind loads transferred to joints at A, D, G are 12 KN, 24 KN and 24 KN. Analyse the frame by portal method?

May-16 prob: Analyse the frame shown below by using portal Method?



Step 1:- column shear.

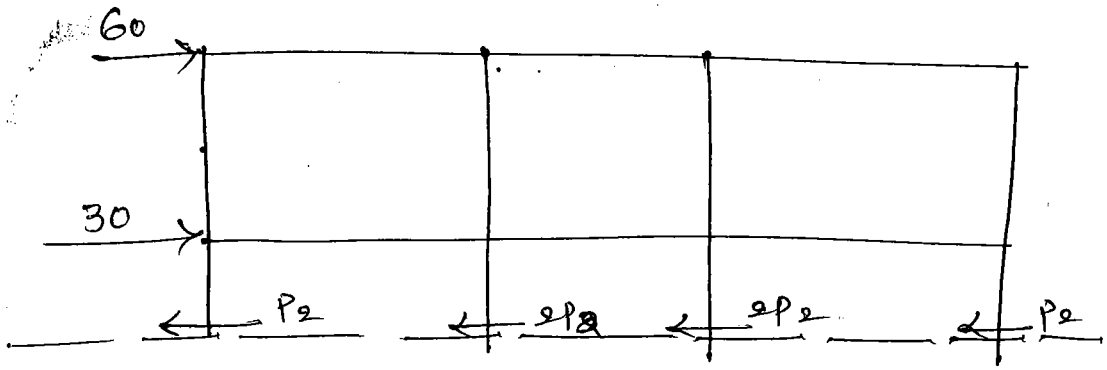
Assumption:- Horizontal shear taken by each interior column is double that of exterior cl.



$$\therefore \quad 60 = P_3 + 2P_3 + 2P_3 + P_3 =$$

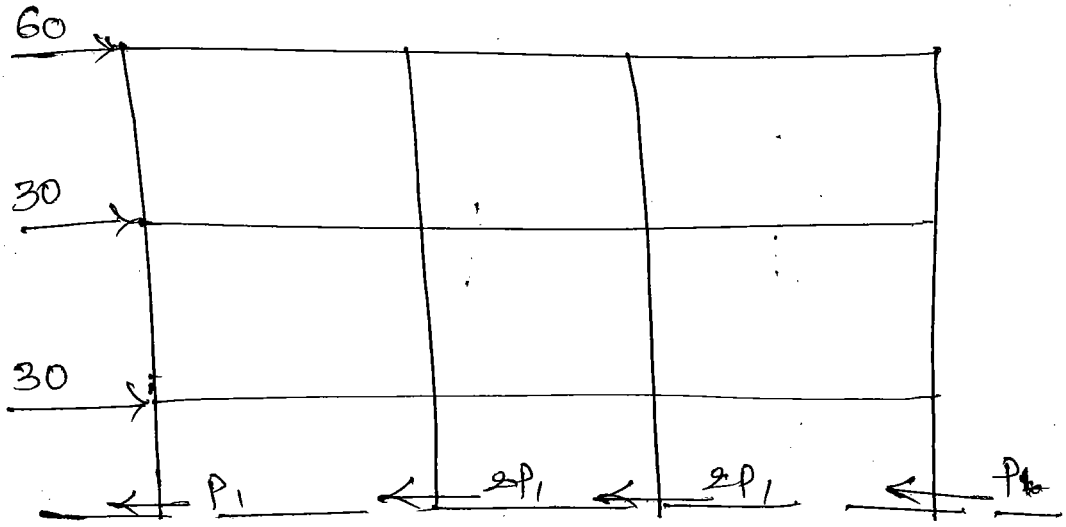
$$60 = 6P_3 \Rightarrow \boxed{P_3 = 10\ KN.}$$

Taking section in the middle of storey. at all storey levels we can calculate Colum Shear



$$60 + 30 = P_2 + 2P_2 + 2P_2 + P_2$$

$$90 = 6P_2 \Rightarrow \boxed{P_2 = 15\ KN}$$



$$60 + 30 + 30 = P_1 + 2P_1 + 2P_1 + P_1$$

$$120 = 6P_1 \Rightarrow \boxed{P_1 = 20\ KN}$$

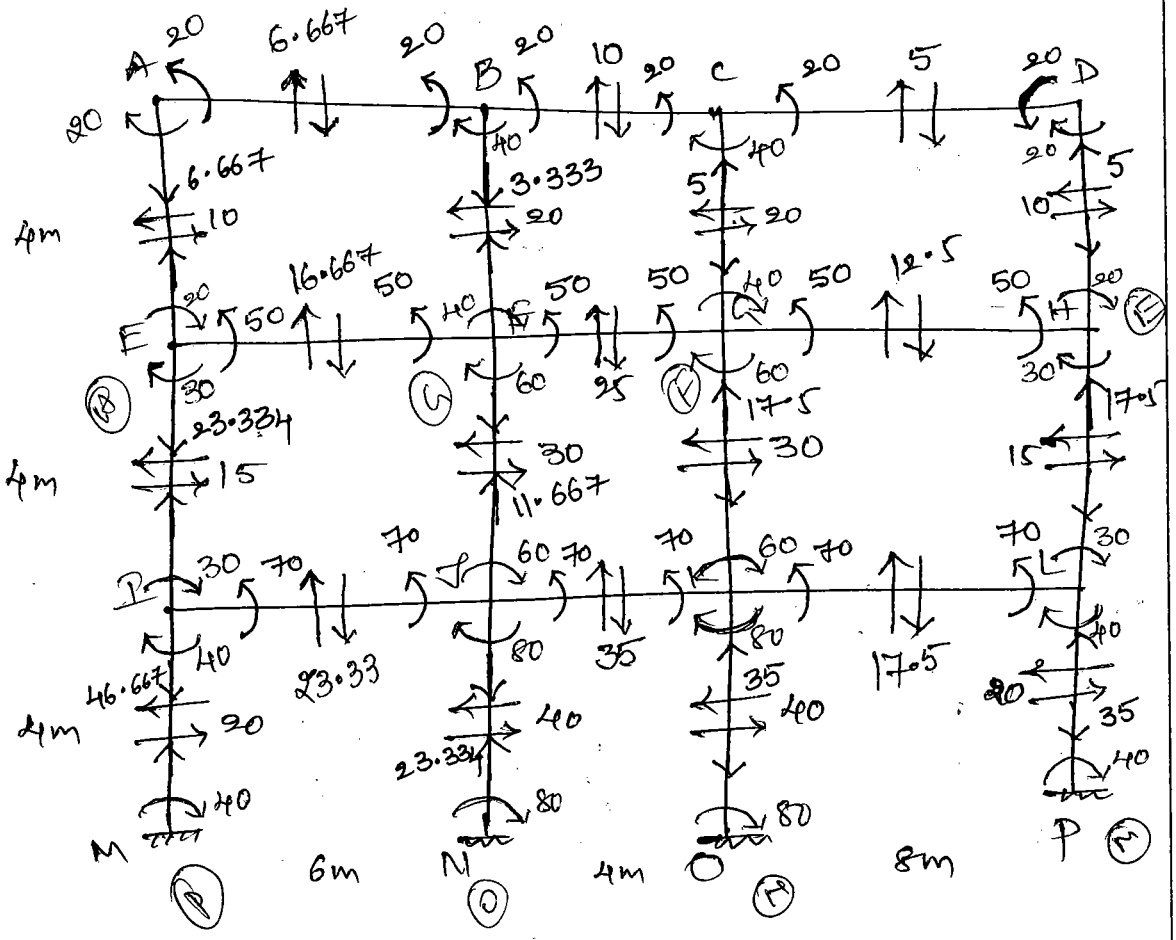
Hence, column shear in

3rd Storey = 10 KN

2nd " = 15 KN

1st " = 20 KN

Step 2:- Column moments



col AE

at A = 10 × 2 = 20 KNm = at E

Ily column DH.

column BF, at B, BM = 20×2 = 40 KNm.

Ily for all the colums. at all storey levels

Step 3:- Beam end moments (Indicated in green Pen)

Beam AB:- end A = $M_{AE} + M_{AB} = 0$

$20 + M_{AB} = 0$

$\therefore M_{AB} = -20$

$\therefore M_{BA} = -20$ KNm.

for Beam BC:- $M_{BA} + M_{BE} + M_{BF} = 0$

$-20 + M_{BC} + 40 = 0$

$M_{BC} = -20$ KNm

for Beam CD:- $M_{CB} + M_{CG} + M_{CD} = 0$

Ily for all Beams $-20 + 40 + M_{CD} = 0$ $\therefore M_{CD} = -20$

Step 4:- Beam shear

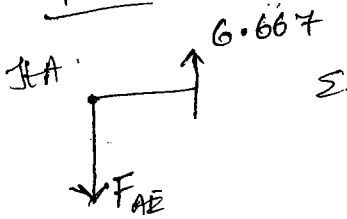
AB:- $BM = 20 = V_{AB} * 3 \Rightarrow V_{AB} = 6.667 KN$

$V_{BC} = \frac{20}{2} = 10 KN$

$V_{CD} = \frac{20}{4} = 5 KN$

Ably for all other beams.

Step 5:- Column axial force



$\Sigma f_y = 0 \quad F_{AE} + 6.667 = 0$

$F_{AE} = 6.667 KN$

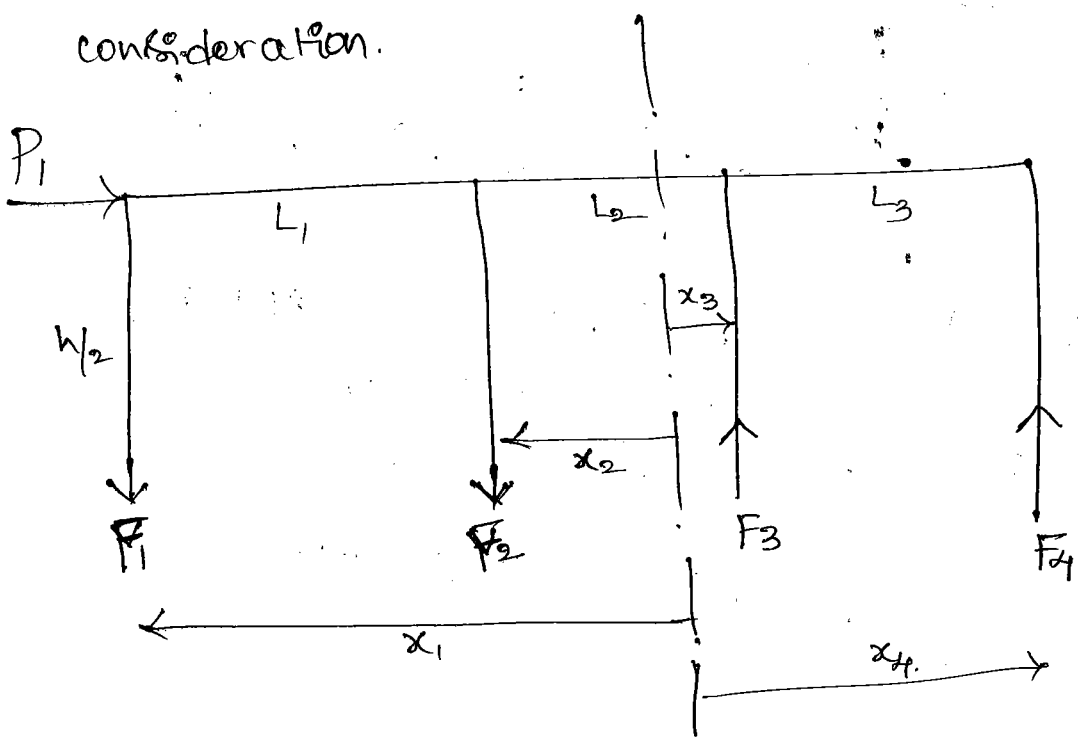
Ably. All other column.

prob:- Analyse a portal frame of two storeyed two bay of 5m bay length each and height @ 5m. A horizontal force of 120 KN is applied at top storey and 240KN is at lower storey. use portal method?

Cantilever method :-

Assumptions :- (1) there is a point of contraflexure at the centre of each member.

(2) Intensity of axial stress in each column of a storey is proportional to the distance of that column from C.G of all columns of the storey under consideration.



$$\frac{\left(\frac{F_1}{a_1}\right)}{x_1} = \frac{\left(\frac{f_2}{a_2}\right)}{x_2} = \frac{\left(\frac{F_3}{a_3}\right)}{x_3} = \frac{\left(\frac{F_4}{a_4}\right)}{x_4} \quad \text{---(1)}$$

Taking moment about the point of contraflexure of the first column

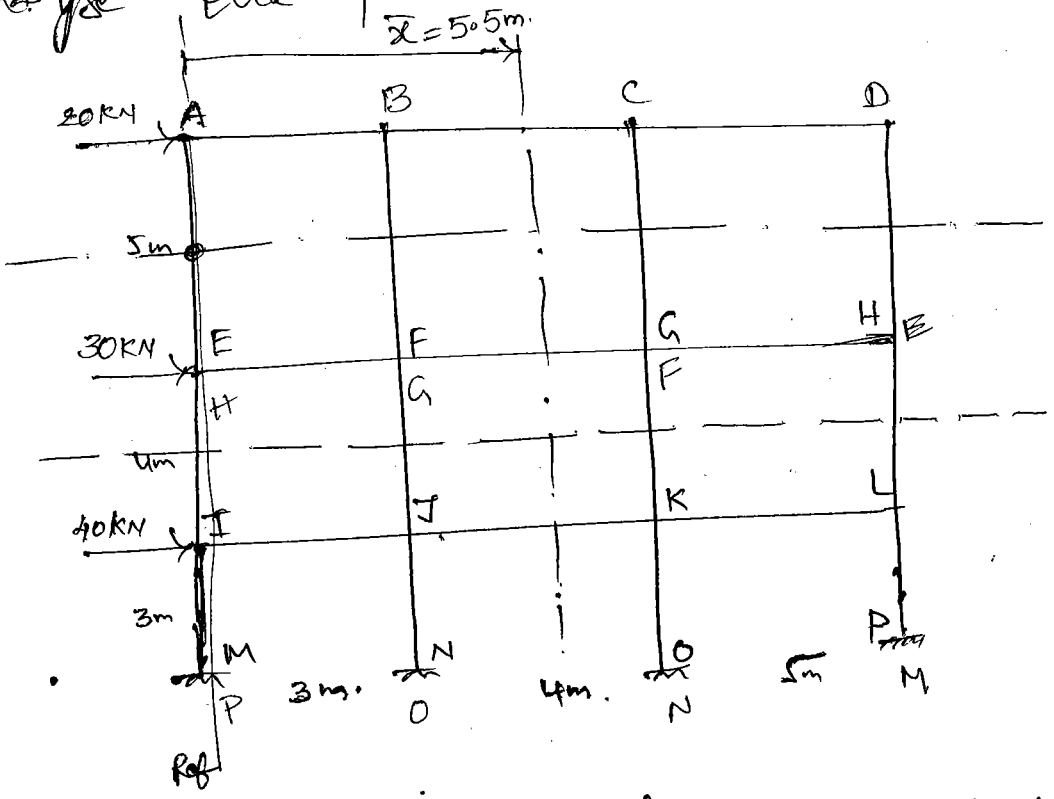
$$P_1\left(\frac{h}{2}\right) = F_2(L_1) - F_3(L_1+L_2) - F_4(L_1+L_2+L_3) \quad \text{---(2)}$$

Using (1) & (2) we can find

F_1, F_2, F_3 & F_4

oct-16 prob:-

Analyse the portal frame by Cantilever Method?



Step 1:- Distance of CG of column AEI is given by

$$\bar{x} = \frac{A_1x_1 + A_2x_2 + A_3x_3 + A_4x_4}{A_1 + A_2 + A_3 + A_4}$$

$$= \frac{0 + a\times 3 + a\times 7 + a\times 12}{a+a+a+a} = \frac{22a}{4a} = 5.5m$$

Assumption

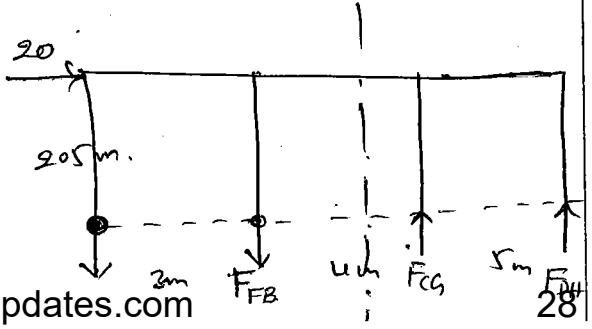
$$\frac{\left(\frac{F_{AE}}{a}\right)}{5.5} = \frac{(F_{FB}/a)}{2.5} = \frac{(F_{CG}/a)}{1.5} = \frac{(F_{DH}/a)}{6.5}$$

$$F_{AE}\times\frac{2.5}{5.5} = F_{FB} \qquad \left(\frac{1.5}{5.5}\right)F_{AE} = F_{CG} \qquad \left(\frac{6.5}{5.5}\right)F_{AE} = F_{DH}$$

$$0.455\,F_{AE} = F_{FB} \qquad 0.273\,F_{AE} = F_{CG} \qquad 1.182\,F_{AE} = F_{DH}$$

Taking moment at mid point of AE,

$$20\times 2.5 + F_{FB}\times 3 - F_{CG}\times 7 - F_{DH}\times 12 = 0$$



$$20\times 2.5 + (0.455\,F_{AE})\times 3 - (0.273\,F_{AE})\times 7 - (1.182\,F_{AE})\times 12 = 0$$

$$50 + [1.365 - 1.911 - 14.184]\,F_{AE} = 0$$

$$F_{AE} = \frac{50}{14.73} = \underline{3.4\ KN}$$

$F_{FB} = 1.55\ KN$; $F_{CG} = 0.93$; $F_{DH} = 4\ KN$

Storey 2:- $\frac{F_{EI}}{5.5} = \frac{F_{FJ}}{2.5} = \frac{F_{GK}}{1.5} = \frac{F_{HL}}{6.5}$

Taking moments about mid point of EI. then

$$20\times 7 + 30\times 2 + F_{FJ}\times 3 - F_{GK}\times 7 - F_{HL}\times 12 = 0$$

$$20\times 7 + 30\times 2 + \left[\frac{2.5\times 3}{5.5} - \frac{1.5}{5.5}\times 7 - \frac{6.5\times 12}{5.5}\right] F_{EI} = 0$$

$$140 + 60 + [1.364 - 1.91 - 14.182]\,F_{EI} = 0$$

$$F_{EI} = \frac{200}{14.728} = 13.58 KN$$

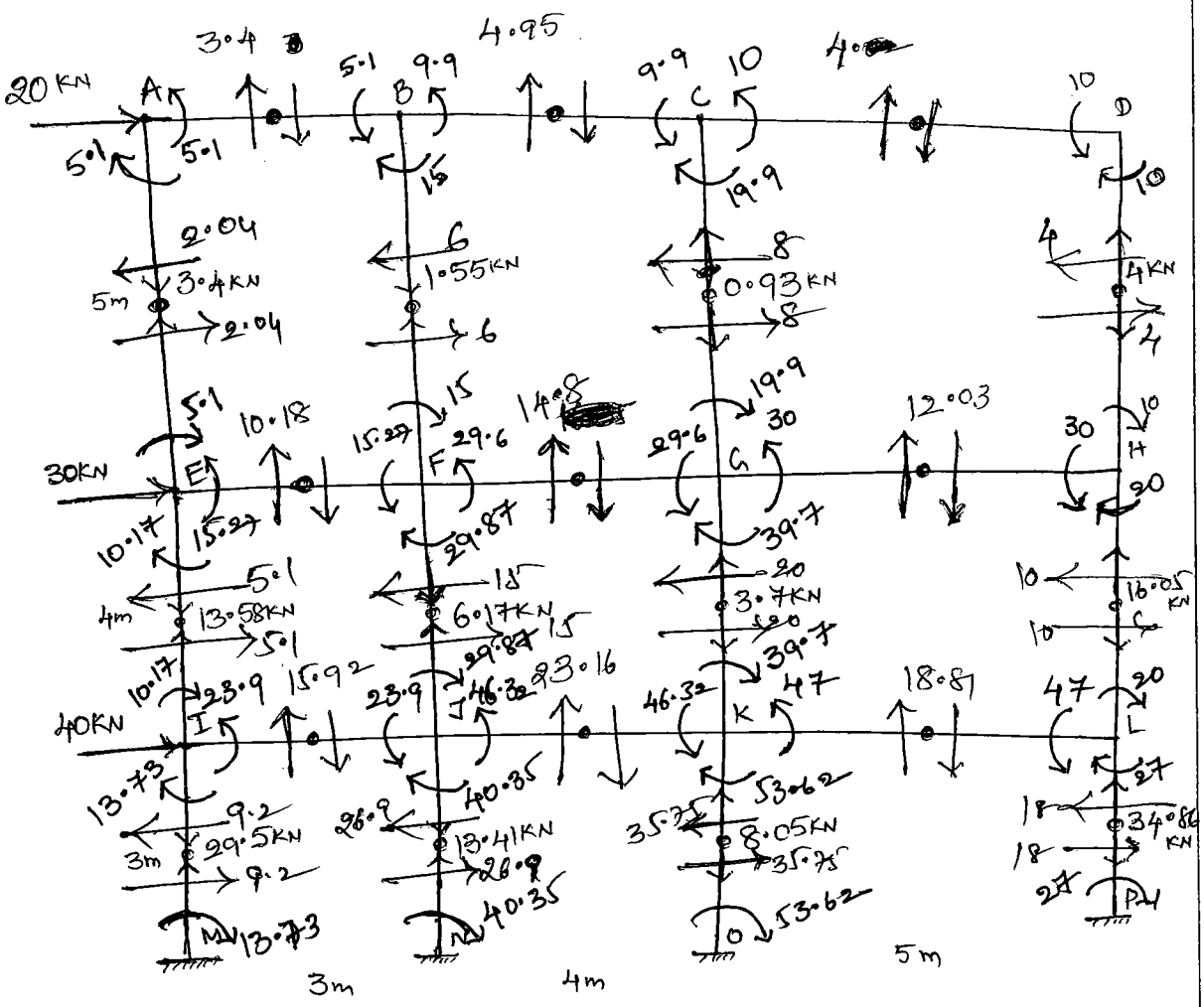
$F_{FJ} = 6.17 KN$; $F_{GK} = 3.7 KN$; $F_{HL} = 16.05\ KN$

Storey 3:- $\frac{F_{IM}}{5.5} = \frac{F_{JN}}{2.5} = \frac{F_{KO}}{1.5} = \frac{F_{LP}}{6.5}$

$$20\times 10.5 + 30\times 5.5 + 40\times 1.5 = 14.728\,F_{IM}$$

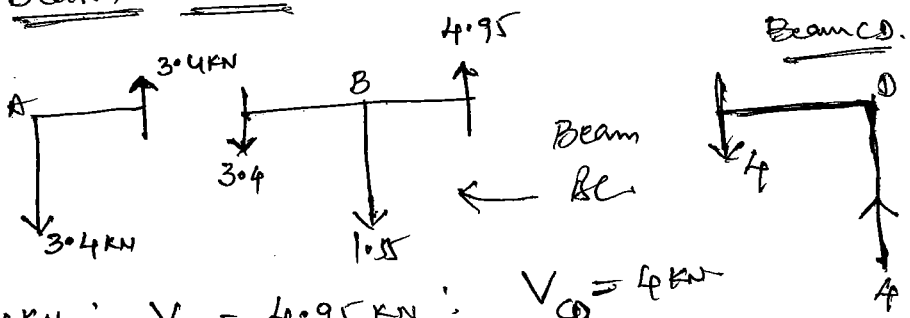
$$F_{IM} = 29.5 KN$$

$F_{JN} = 13.41 KN$; $F_{KO} = 8.05\ KN$; $F_{LP} = 34.86\ KN$



Step 2:- Beam Shear

AB:-



$V_{AB} = 3.4\ KN$; $V_{BC} = 4.95\ KN$; $V_{CD} = 4\ KN$

Hy, for all other beams.

Step 3:- Beam end moments:-

$M_{AB} = 3.4 \times 1.5 = 5.1\ KNm = M_{BA}$

$M_{BC} = M_{CD} = 4.95 \times 2 = 9.9\ KNm$

$M_{CD} = M_{DC} = 4 \times 2.5 = 10\ KNm$

Hy all other beams.

Step 4:- Column moments:-

Colm. AE, $M_{AB} + M_{AE} = 0$

$-5.1 + M_{AE} = 0 \Rightarrow M_{AE} = 5.1$ KNm.

cl. FB, $M_{BA} + M_{BC} + M_{BF} = 0$

$-5.1 + (-9.9) + M_{BF} = 0$ $\quad M_{BF} = 15$ KNm

by for all other Colms.

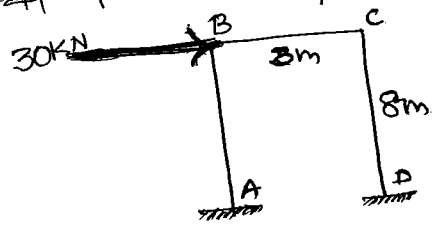
Step 5:- Colm Shear

$V_{AE} = \frac{5.1}{2.5} = 2.04$ KN $\quad V_{BF} = \frac{15}{2.5} = 6$ KN

$V_{CG} = \frac{19.9}{2.5} = 8$ KN $\quad V_{DH} = \frac{10}{2.5} = 4$ KN.

by for all other Colms.

May-15 prob: Analyse the portal frame by using portal method?



Nov-15 Explain the portal method for analyzing a building frame subjected to horizontal forces?

Nov-15 Write the steps involved in portal frame method?