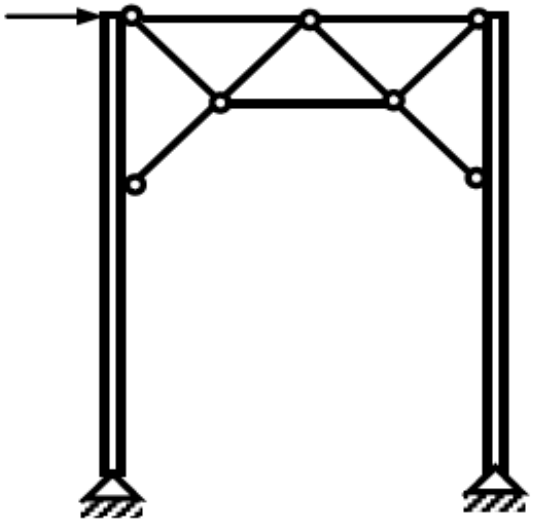
Approximate Analysis of Bridge Portal and Mill Bent

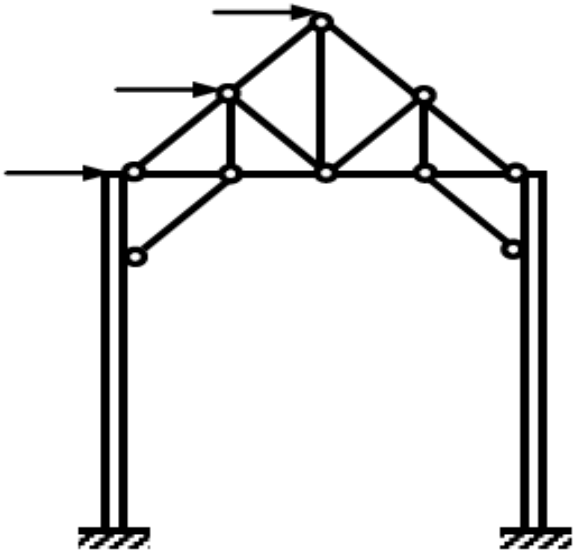
Bridge Portals and Mill Bents

Portals for bridges or bents for mill buildings are often arranged in a manner to include a truss between two flexural members. In such structures, the flexural members are continuous from the foundation to the top and are designed to carry bending moment, shear force as well as axial force. The other members that constitute the truss at the top of the structure are considered pin-connected and to carry axial force only.

Structural Analysis & Design I



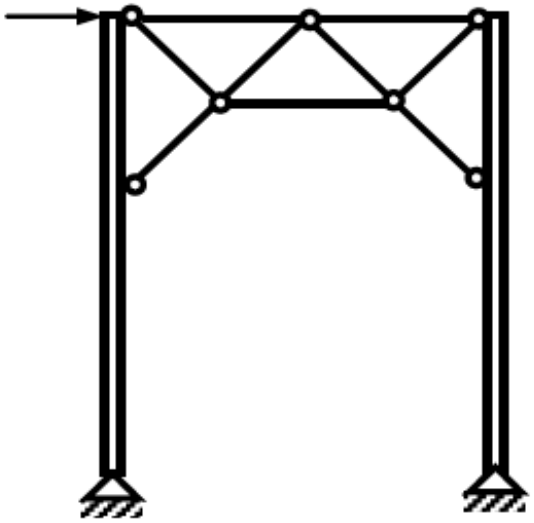
Bridge Portal



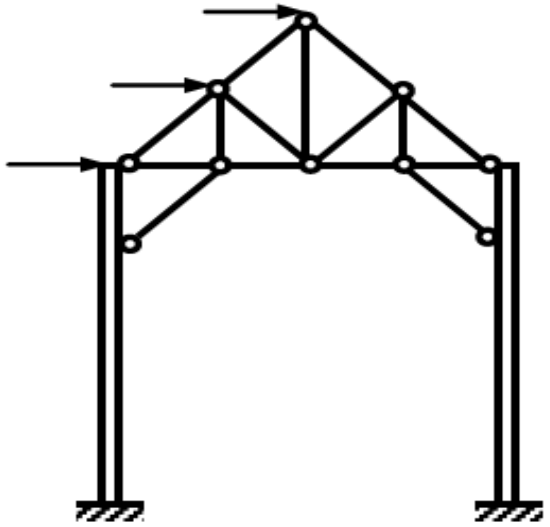
Mill Bent

Such a structure can be statically indeterminate to the first or third degree, depending on whether the supports are assumed hinged of fixed. Therefore, the same three assumptions made earlier for portal frames can be made for the approximate analysis of these structures.

Structural Analysis & Design I



Bridge Portal

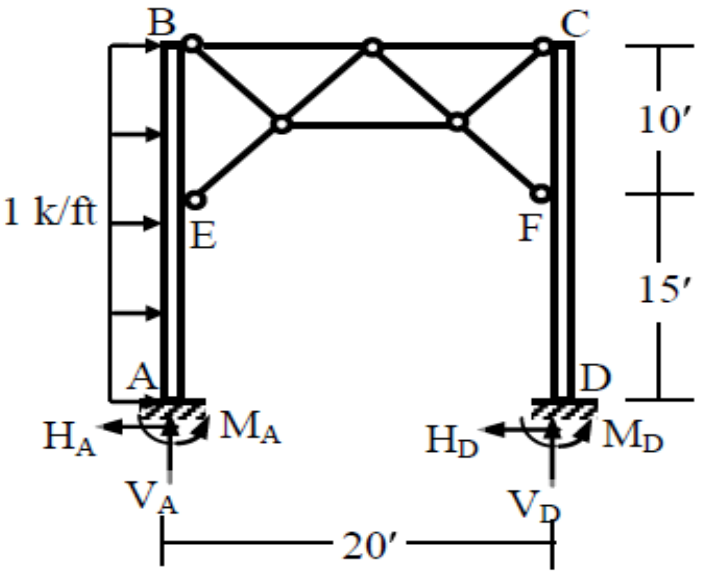


Mill Bent

1. **The horizontal support reactions are equal**
2. **There is a point of inflection at the center of the unsupported height of each fixed based column**

Structural Analysis & Design I

Prob : In the bridge portal loaded as shown below, draw the bending moment diagrams of columns AB and CD.



Assuming the total load to be applied equally (i.e., 25/2 = 12.5 k and 12.5 k) at A and B, the horizontal reactions are $H_A = 12.5 + 12.5/2 = 18.75$ k, $H_B = 12.5/2 = 6.25$ k

Also, BM = 0 at the midpoint of the free height; i.e., at 15/2 = 7.5′ from the bottom.

$\therefore -M_A + 18.75 \times 7.5 - 7.5 \times 7.5/2 = 0 \Rightarrow M_A = 112.5$ k-ft

$-M_D + 6.25 \times 7.5 = 0 \Rightarrow M_D = 46.88$ k-ft

$\therefore \sum M_A = 0 \Rightarrow -112.5 - 46.88 + 25 \times 12.5 - V_D \times 20 = 0$

$\Rightarrow V_D = 7.66$ k

$\therefore \sum F_y = 0 \Rightarrow V_A + V_D = 0 \Rightarrow V_A = -7.66$ k

Also, BM = 0 at the midpoint of the free height; i.e., at 15/2 = 7.5′ from the bottom.

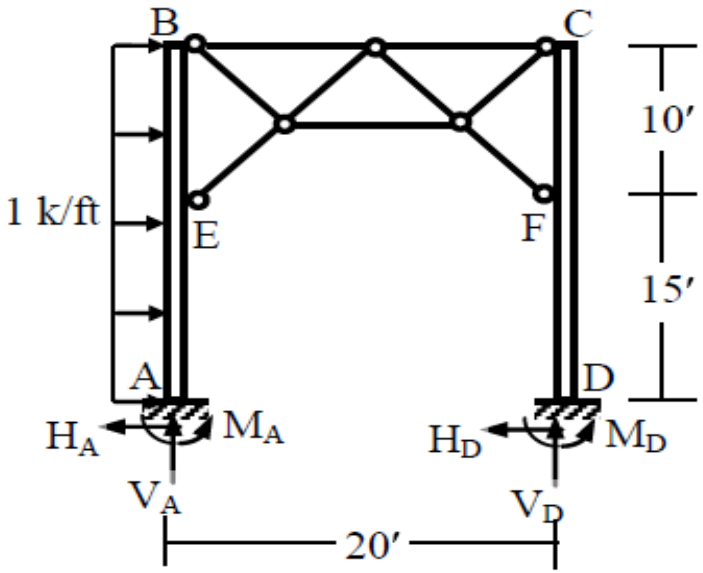
$\therefore -M_A + 18.75 \times 7.5 - 7.5 \times 7.5/2 = 0 \Rightarrow M_A = 112.5$ k-ft

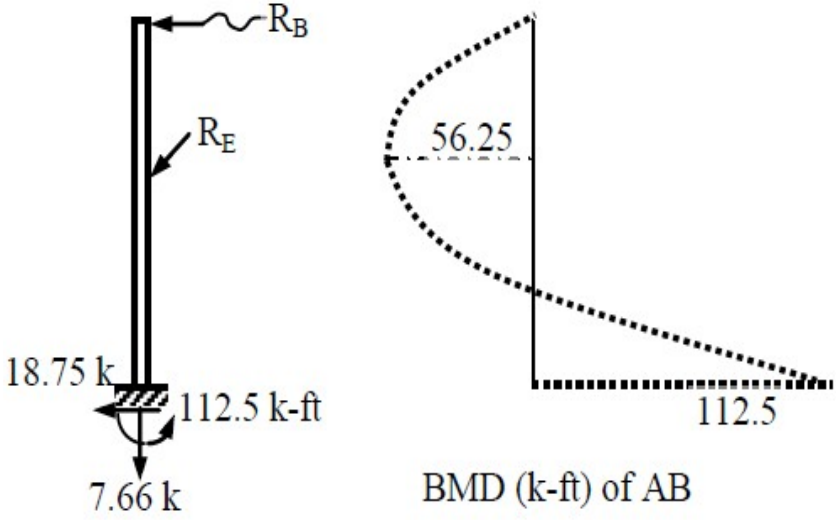
$-M_D + 6.25 \times 7.5 = 0 \Rightarrow M_D = 46.88$ k-ft

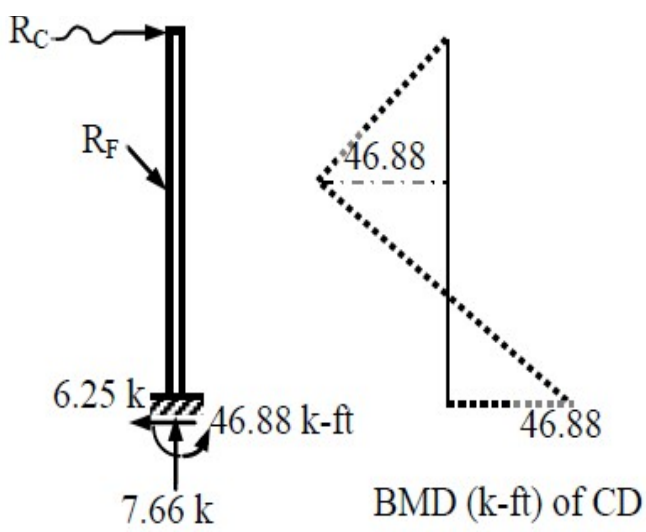
$\therefore \sum M_A = 0 \Rightarrow -112.5 - 46.88 + 25 \times 12.5 - V_D \times 20 = 0$

$\Rightarrow V_D = 7.66$ k

$\therefore \sum F_y = 0 \Rightarrow V_A + V_D = 0 \Rightarrow V_A = -7.66$ k

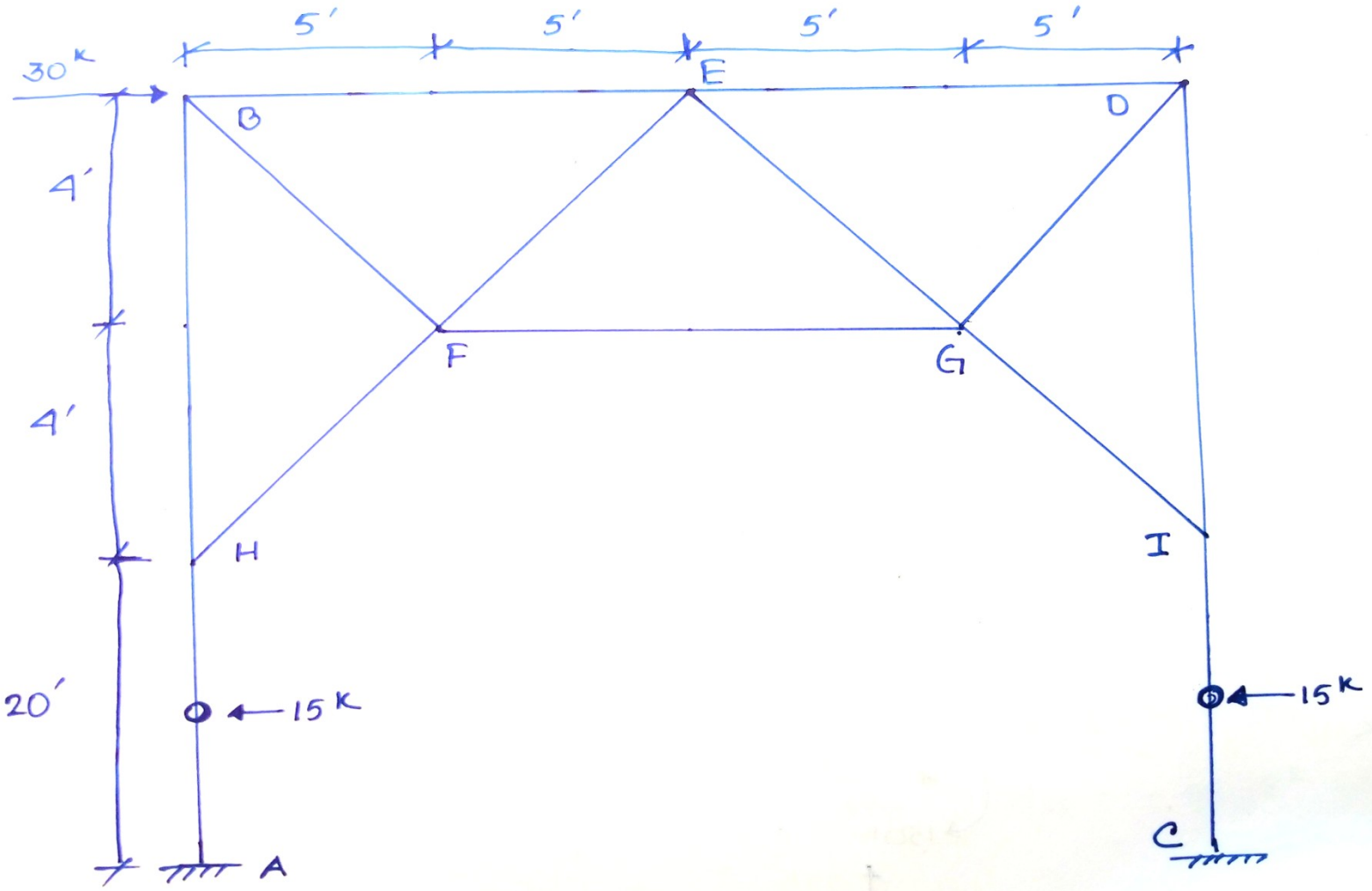




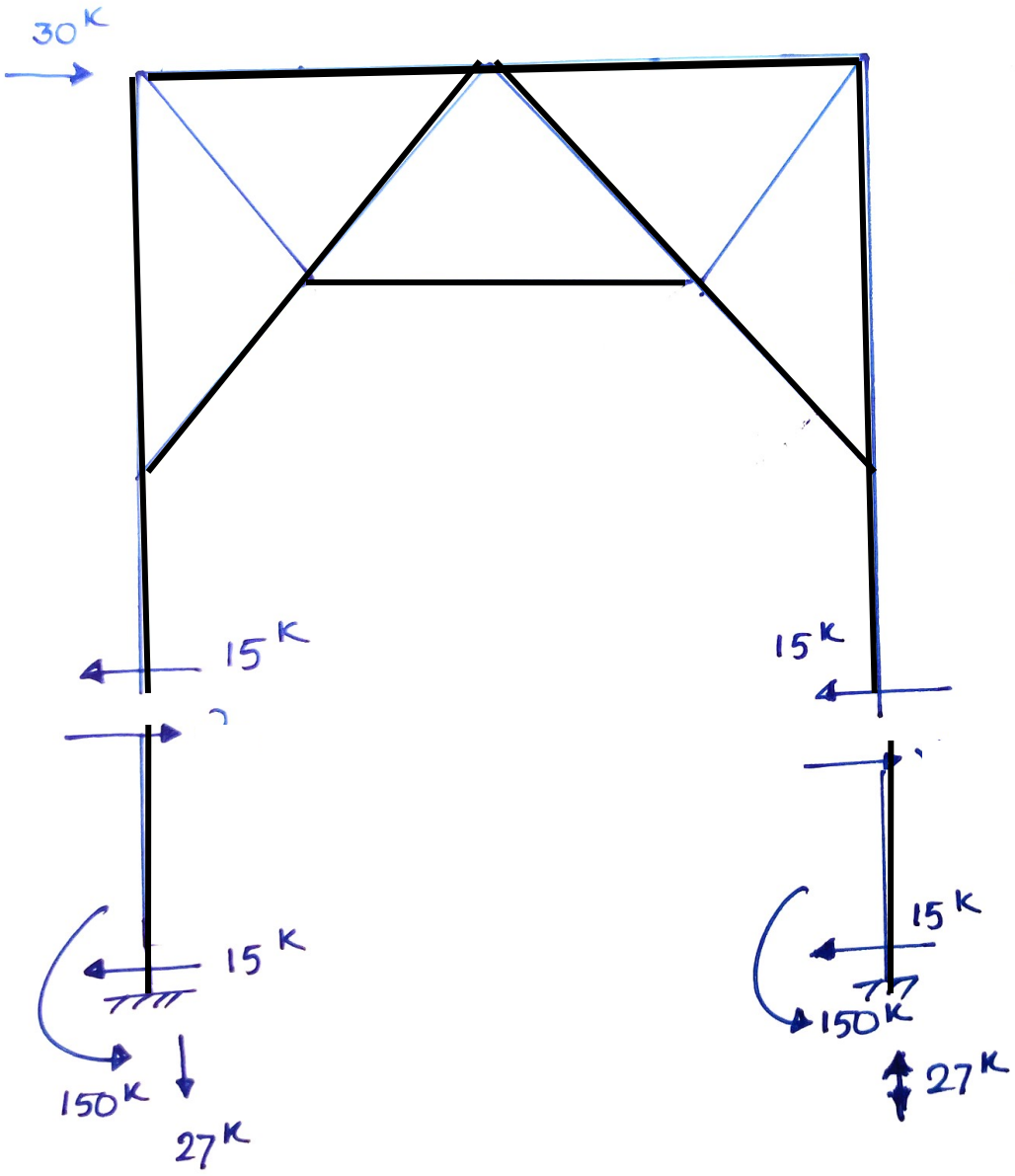


Structural Analysis & Design I

Find out the bar forces of member BF, BE, HF, of bridge portal shown in Fig. Draw AFD, SFD of the left leg due to bar forces



Structural Analysis & Design I

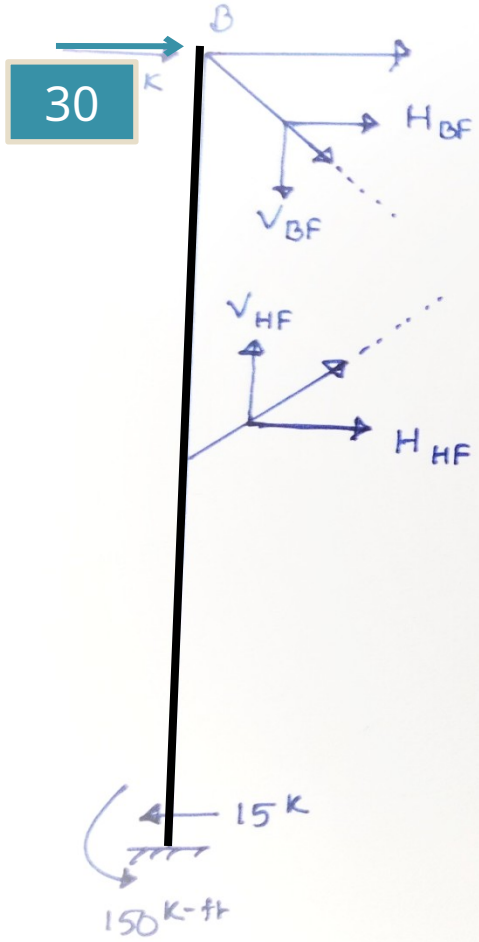


$+\circlearrowleft \Sigma M_b = 0$

$\Rightarrow 30 \times 18 - V_a \times 20 = 0$

$V_a = +27^K \ (\downarrow)$

$V_f = 27^K \ (\uparrow)$



$\circlearrowleft + \quad \Sigma M_B = -H_{HF} \times 18 + 15 \times 28 - 150$

$\therefore \quad H_{HF} = 33.75^{K} (T)$

$V_{HF} = 33.75 \times 4/5 = 27^{K} (T)$

$F_{HF} = 43.22^{K} (T)$

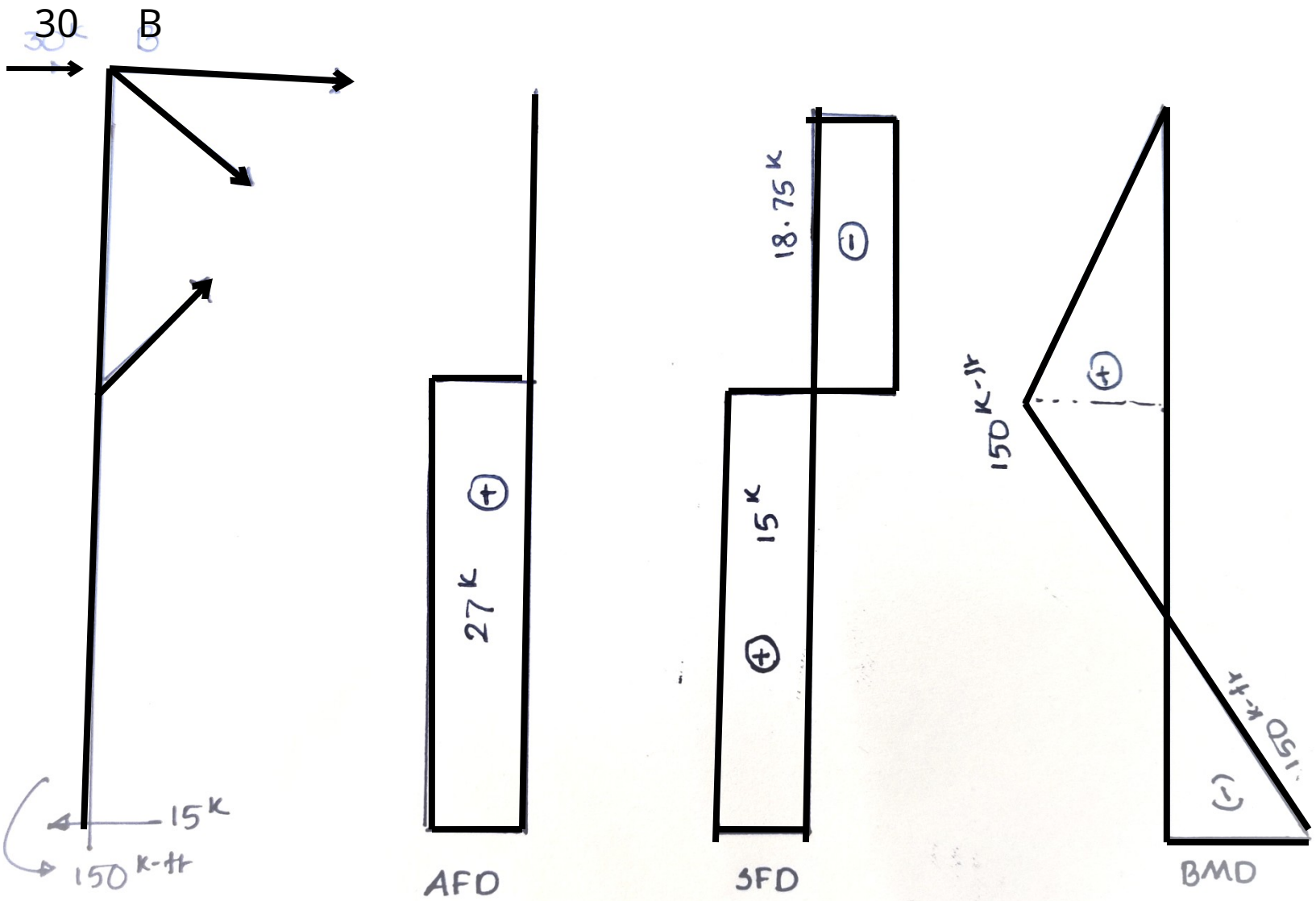
$\Sigma V = 0 \Rightarrow \quad -V_{BF} + 27 - 27 = 0$

$\therefore \quad V_{BF} = 0 \qquad \therefore \quad F_{BF} = 0$

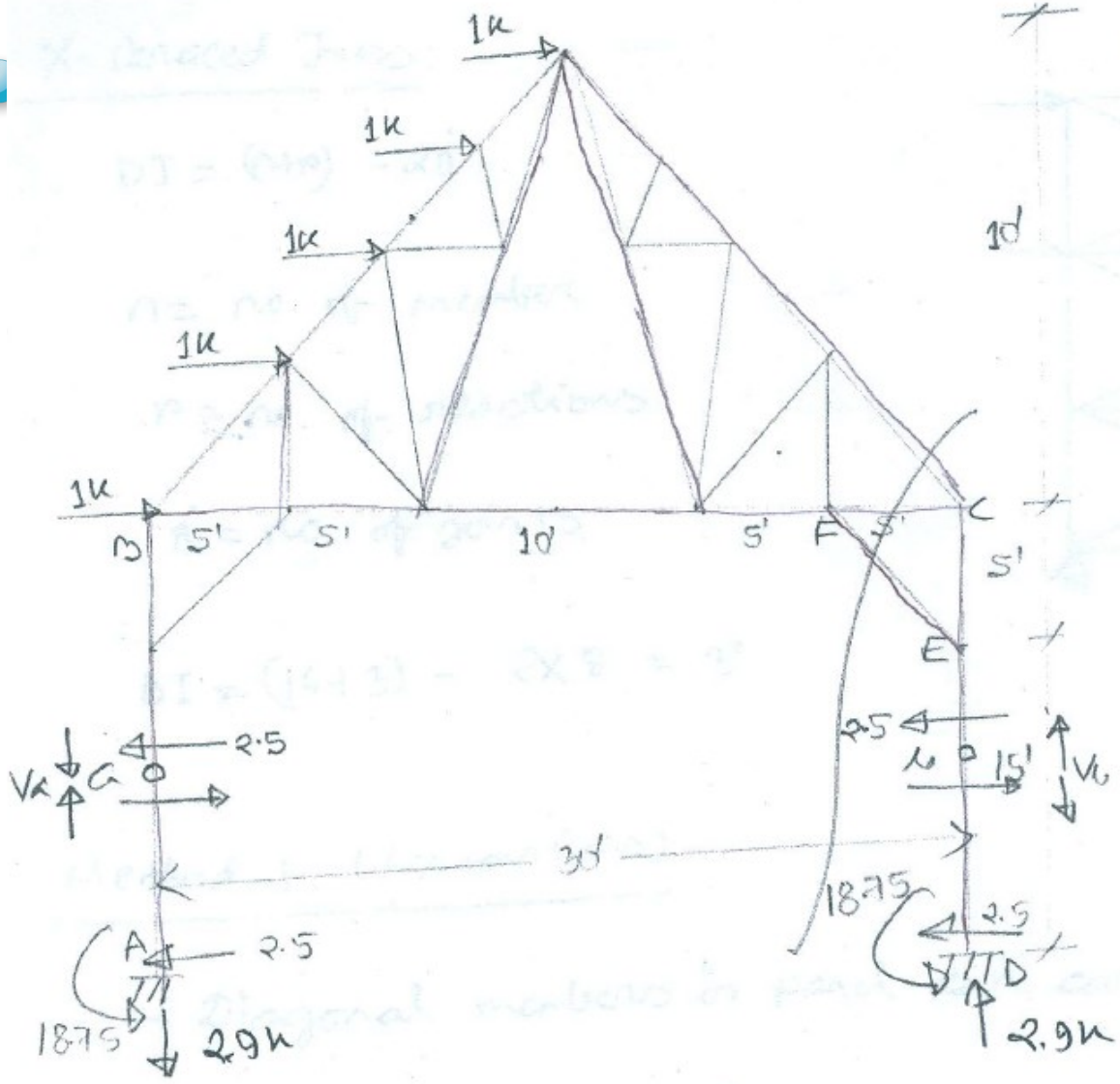
$\Sigma H = 0 \Rightarrow \quad -15 + 33.75 + 30 + H_{BE} = 0$

$\therefore \quad H_{BE} = -48.75^{K} (C)$

Structural Analysis & Design I

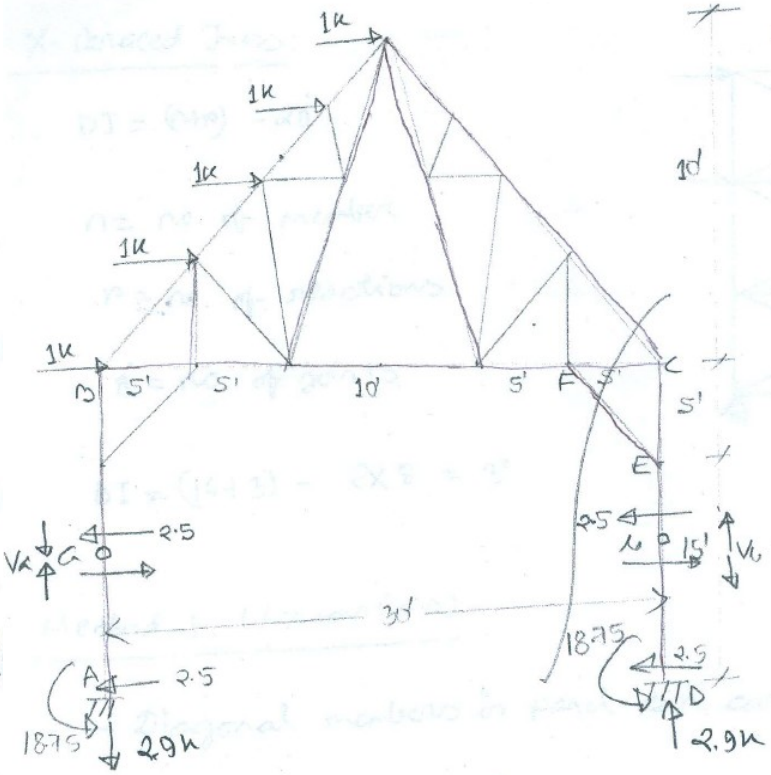


Structural Analysis & Design I



Find out the bar forces of member CE, EF of mill bent shown in fig. Draw AFD, SFD, BMD & sight leg due to these bar forces.

Structural Analysis & Design I



$\oplus \Sigma M_B = 0$

$\Rightarrow 5 \times 17.5 + V_A \times 30 = 0$

$\therefore V_A = +2.9k$

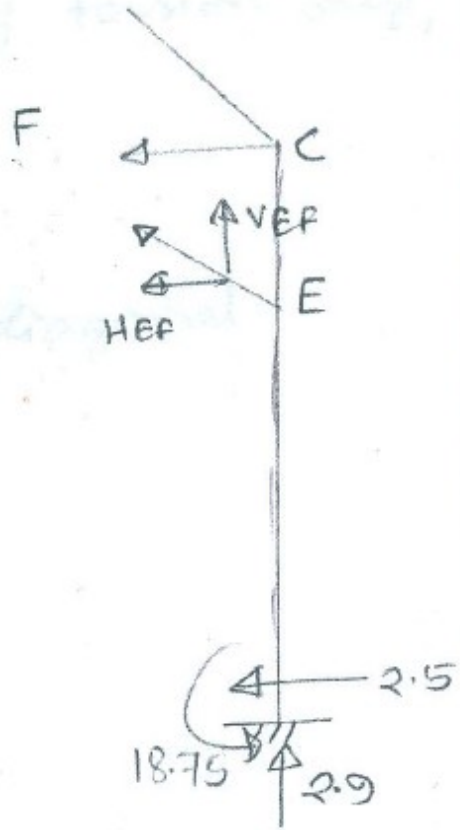
$\therefore V_A = 2.9k\ (\downarrow), \quad V_D = 2.9k$

$M_A = 7.5 \times 2.5 = 18.75k'$

$\oplus \Sigma M_C = -18.75 + 2.5 \times 20 + H_{EF} \times 5 = 0$

$\therefore H_{EF} = -6.25k\ (C)$

$\therefore V_{EF} = -6.25k\ (C)$



$\oplus \Sigma M_B = 0$

$\Rightarrow 5 \times 17.5 - V_A \times 30 = 0$

$\therefore V_A = +2.9K$

$\therefore V_A = 2.9K\ (\downarrow),\quad V_D = 2.9K\ (\uparrow)$

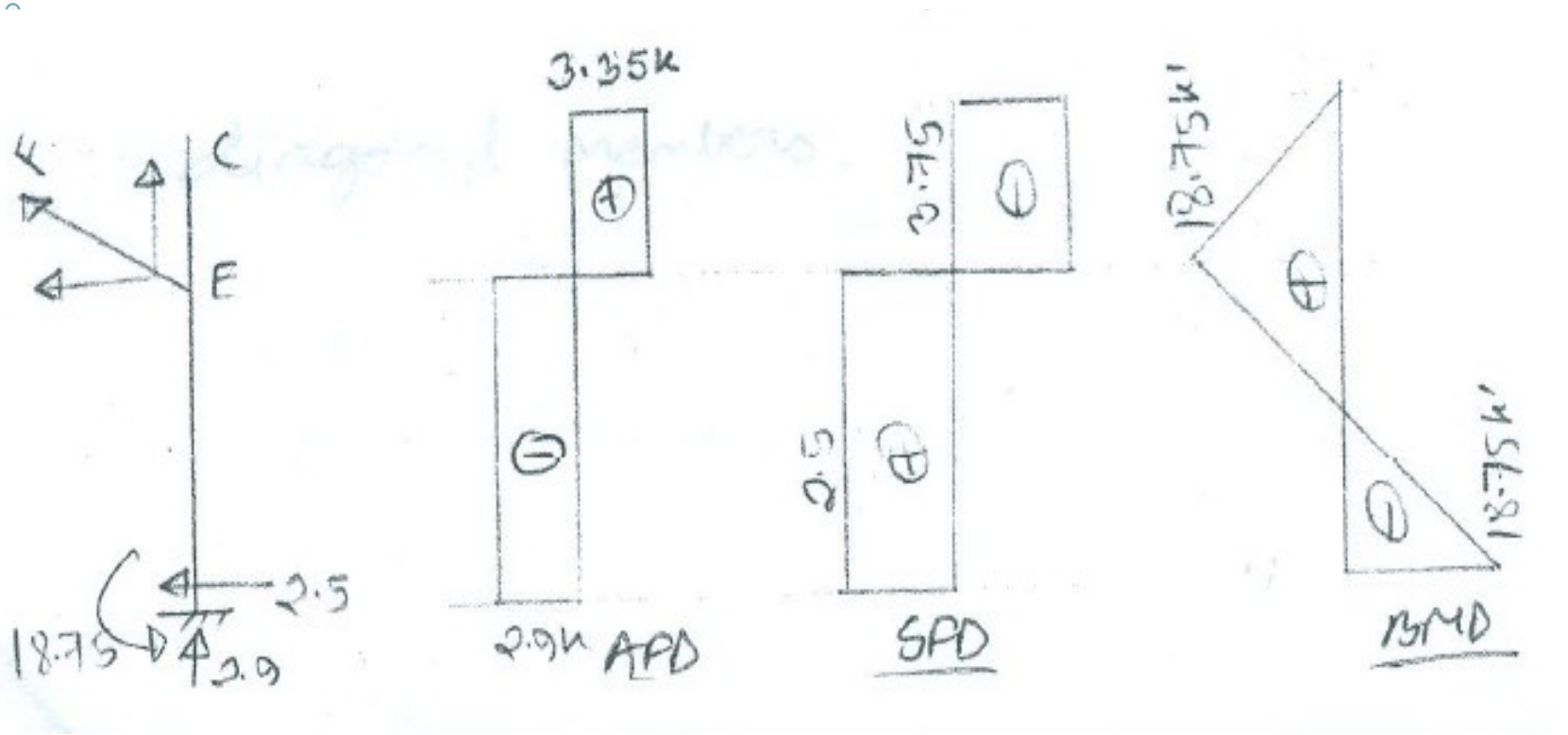
$M_A = 7.5 \times 2.5 = 18.75K'$

$\oplus \Sigma M_C = -18.75 + 2.5 \times 20 + H_{EF} \times 5 = 0$

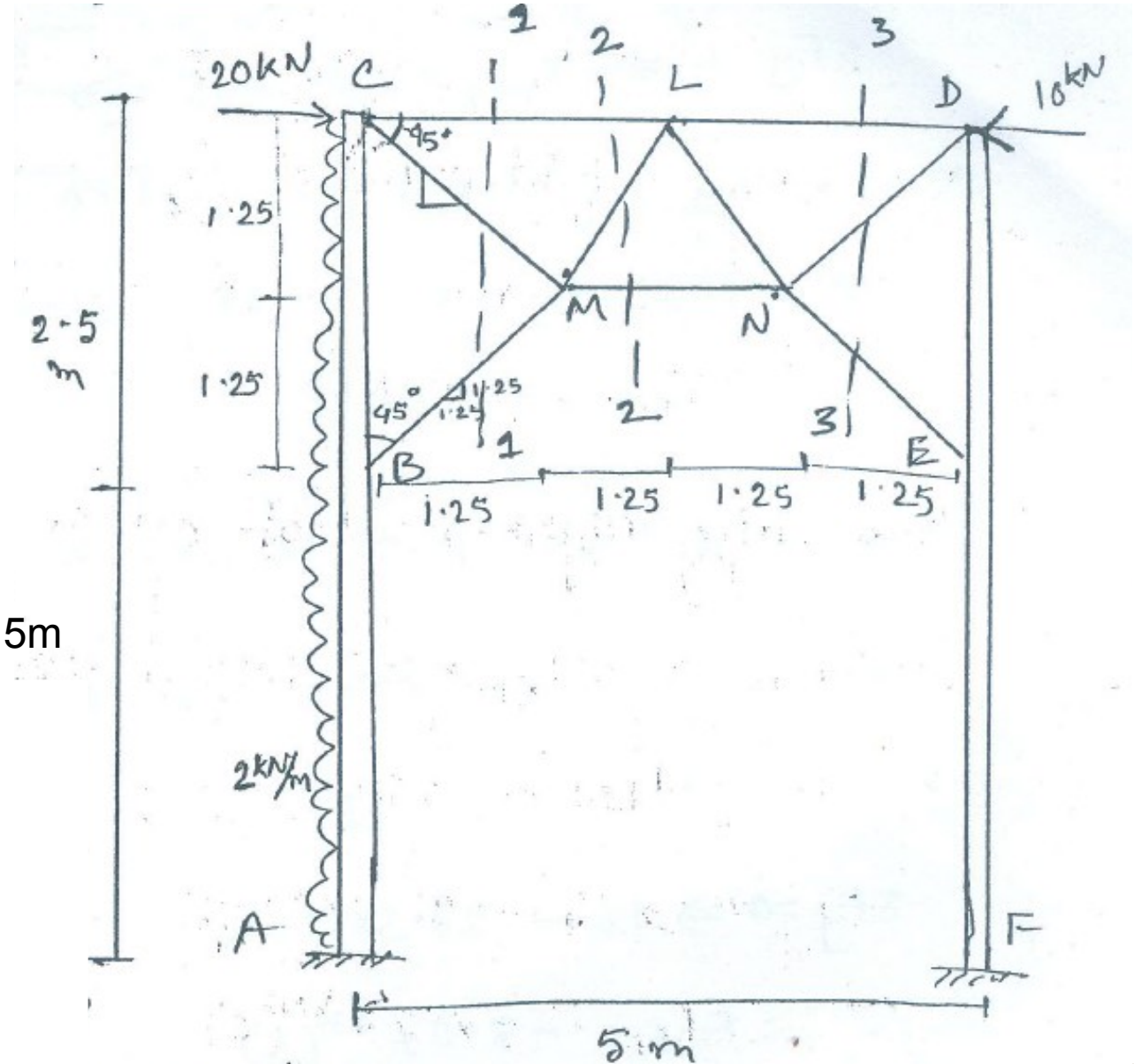
$\therefore H_{EF} = -6.25K\ (C)$

$\therefore V_{EF} = -6.25K\ (C)$

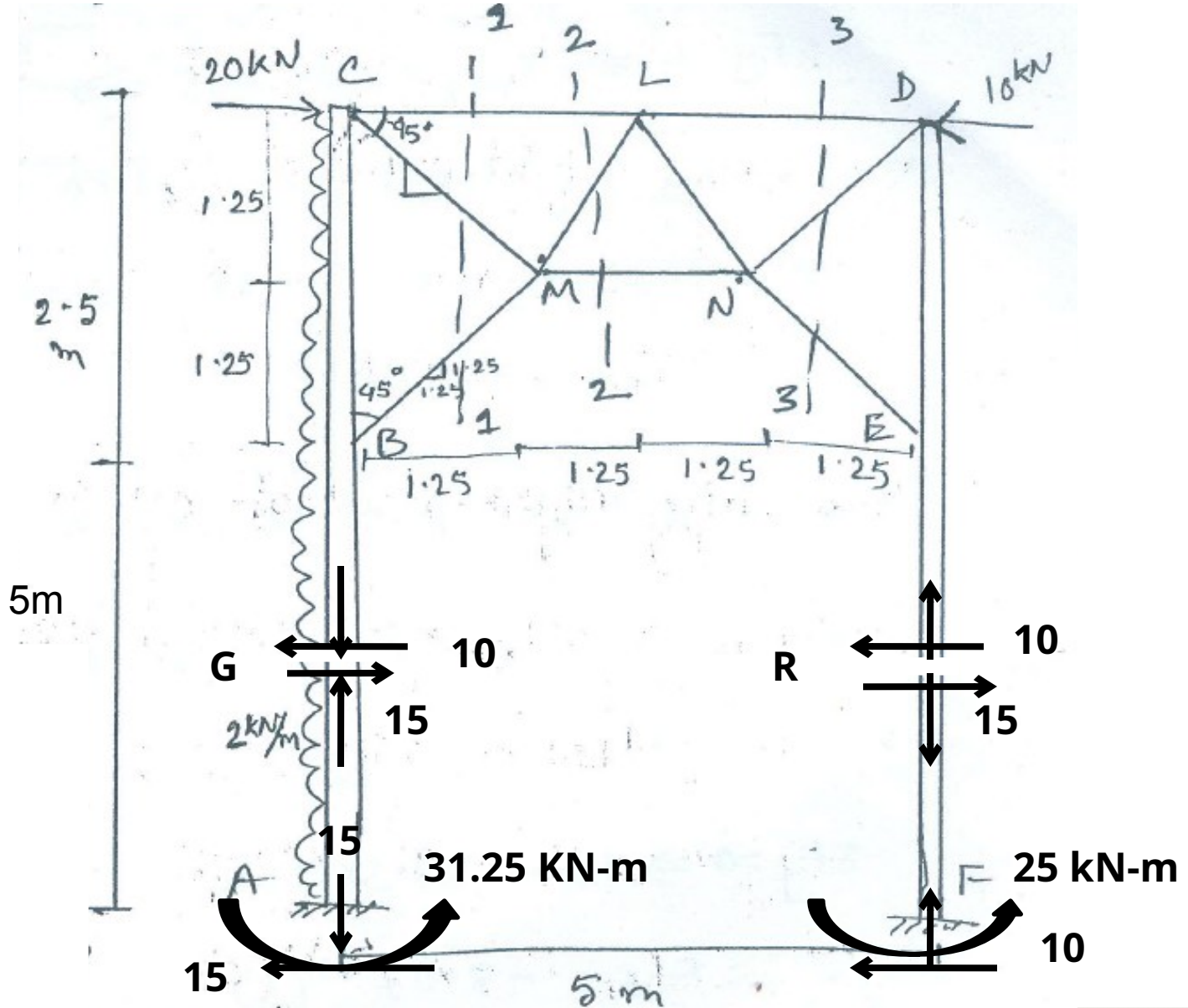
Structural Analysis & Design I



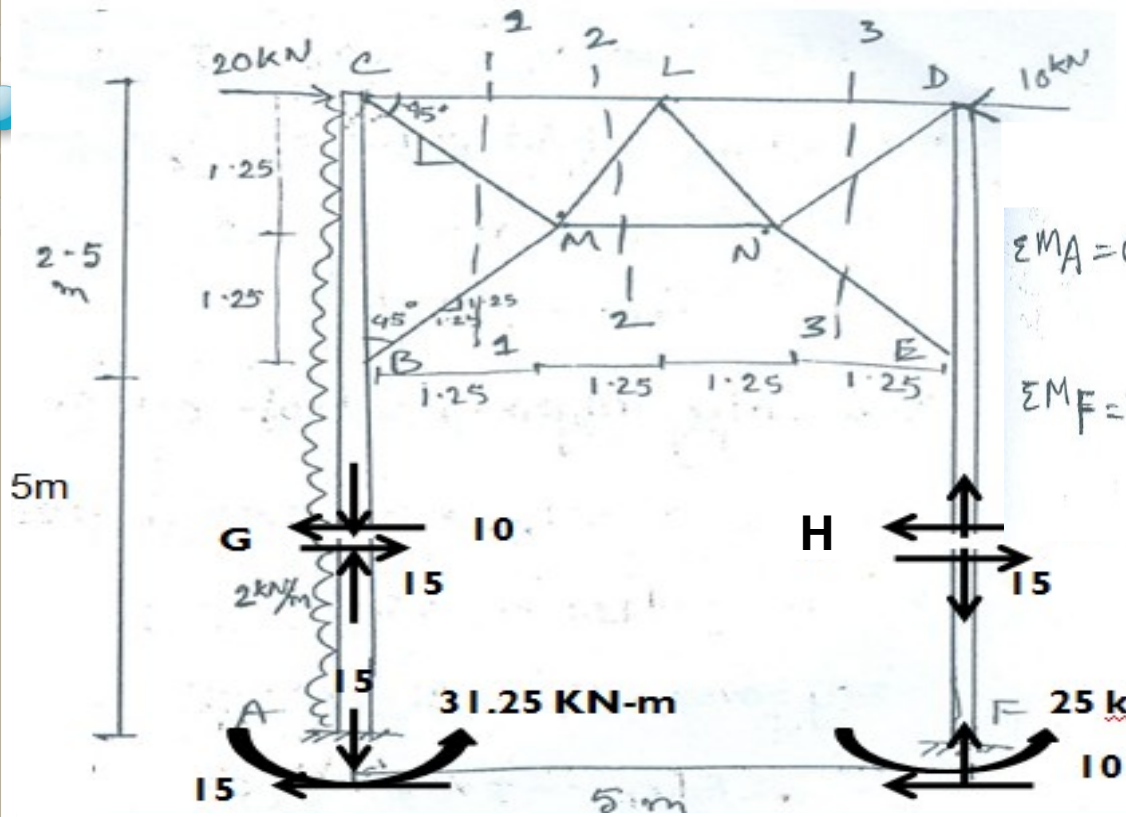
Structural Analysis & Design I



Structural Analysis & Design I



Structural Analysis & Design I



$\Sigma M_A = 0 \Rightarrow 10 \times 2{\cdot}5 + 2 \times 2{\cdot}5 \times \frac{2{\cdot}5}{2} - M_A = 0$

$\therefore M_A = 31{\cdot}25^{k-1}$

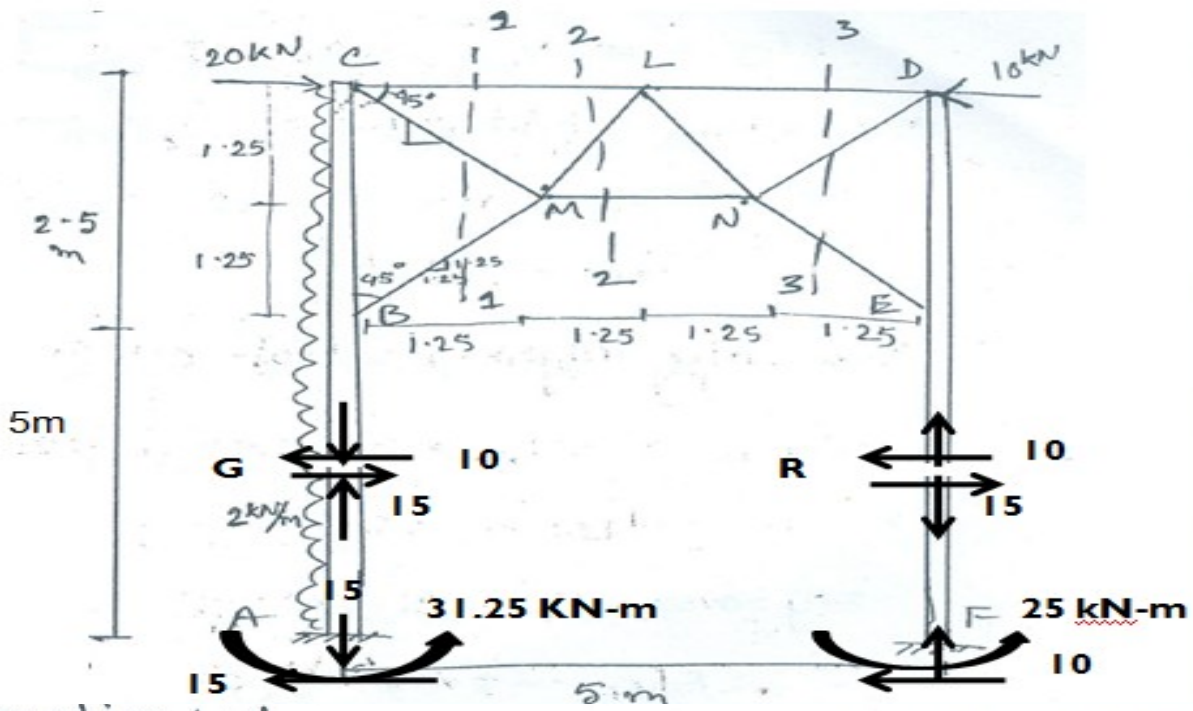
$\Sigma M_F = 0 \Rightarrow 10 \times 2{\cdot}5 - M_F = 0$

$\therefore M_F = 25^{k-1}$

$\Sigma M_G = 0 \Rightarrow 20 \times 5 - 10 \times 5 + 2 \times 5 \times 2{\cdot}5 - R_H \times 5 = 0$

$\therefore R_H = 15\ kN$

Total lateral force $= 20 - 10 + 2 \times 5 = 0 = 20$



Section 1-1

$\Sigma M_C = 0 \Rightarrow -F_{BM}\sin 45 \times 2\cdot5 - 31\cdot25 + 15\times 7\cdot5 - 2\times 7\cdot5 \times \frac{7\cdot5}{2} = 0$

$\therefore F_{BM} = 14\cdot14\ kN\ (T)$

$\Sigma F_y = 0 \Rightarrow -15 + F_{BM}\times \cos 45 - F_{CM}\times \sin 45 = 0$

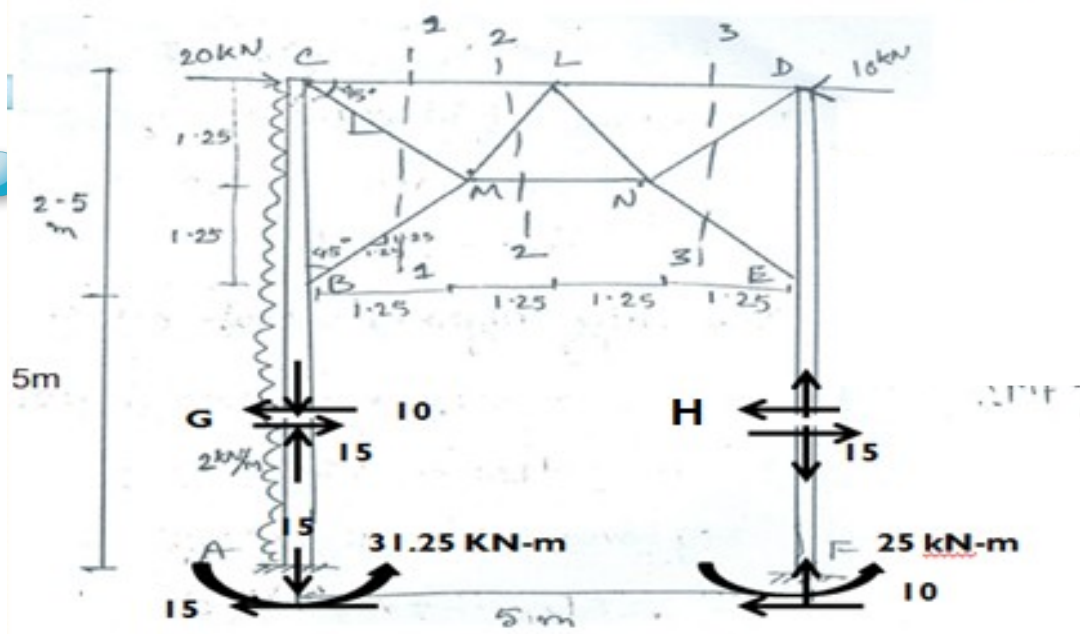
$\therefore F_{CM} = -5\sqrt{2}\ (C)$

$\Sigma F_x = 0 \Rightarrow -15 + F_{BM}\sin 45 + F_{CM}\cos 45 + F_{CL} + 20 + 2\times 7\cdot5 = 0$

$\therefore -15 + 14\cdot14\sin 45 - 5\sqrt{2}\cos 45 + F_{CL} + 2\times 7\cdot5 + 20 = 0$

$\therefore F_{CL} = -25\ kN\ (C)$

Structural Analysis & Design I



considering left part of section 2-2:

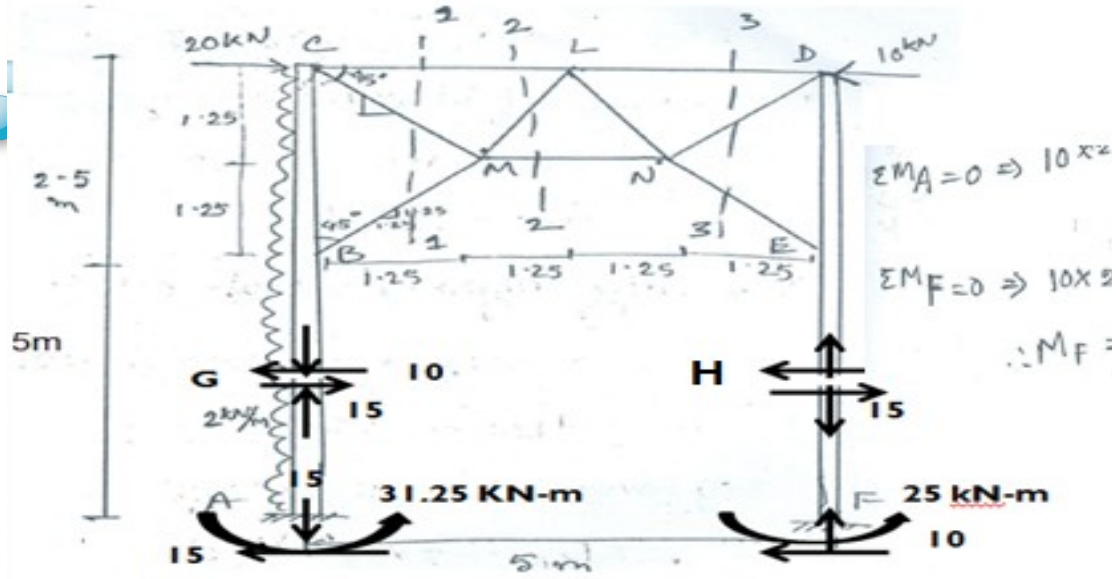
$\Sigma F_y = 0 \Rightarrow F_{ML} \sin 45 - 15 = 0 \Rightarrow F_{ML} = 21.21\ kN\ (T)$

considering right part of section 2-2:

$\Sigma M_L = 0 \Rightarrow F_{MN} \times 1.25 - 25 - 15 \times 2.5 + 10 \times 7.5 = 0$

$\therefore F_{MN} = -10\ kN\ (C)$

Structural Analysis & Design I



Considering right part of section 3-3;

$\Sigma M_D = 0 \Rightarrow F_{EN} \times \cos 45^\circ \times 2.5 - 25 + 10 \times 2.5 = 0$

$\therefore F_{EN} = -28.3\ kN$ (C)

$\Sigma F_y = 0 \Rightarrow 15 - 28.3 \times \cos 45 - F_{DN} \times \cos 45 = 0$

$\therefore F_{DN} = -7.07\ kN$ (C)

$\Sigma F_x = 0 \Rightarrow -10 - 10 + 28.3 \times \cos 45 + 7.07 \times \cos 45 + F_{LD} = 0$

$\therefore F_{LD} = 5\ kN$ (T)

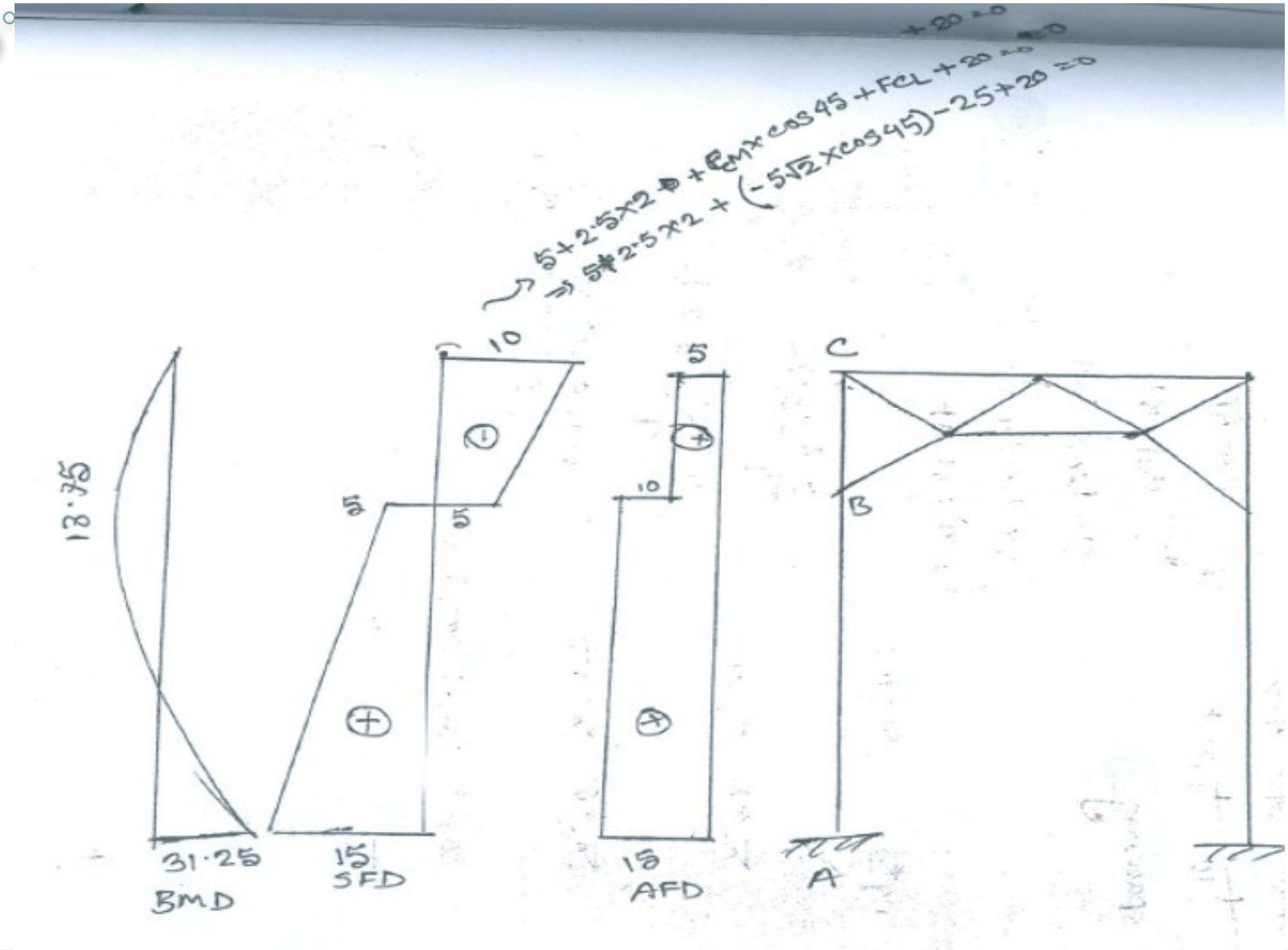
at joint (L)

$\Sigma F_y = 0 \Rightarrow F_{ML} \cos 45 + F_{LN} \cos 45 = 0$

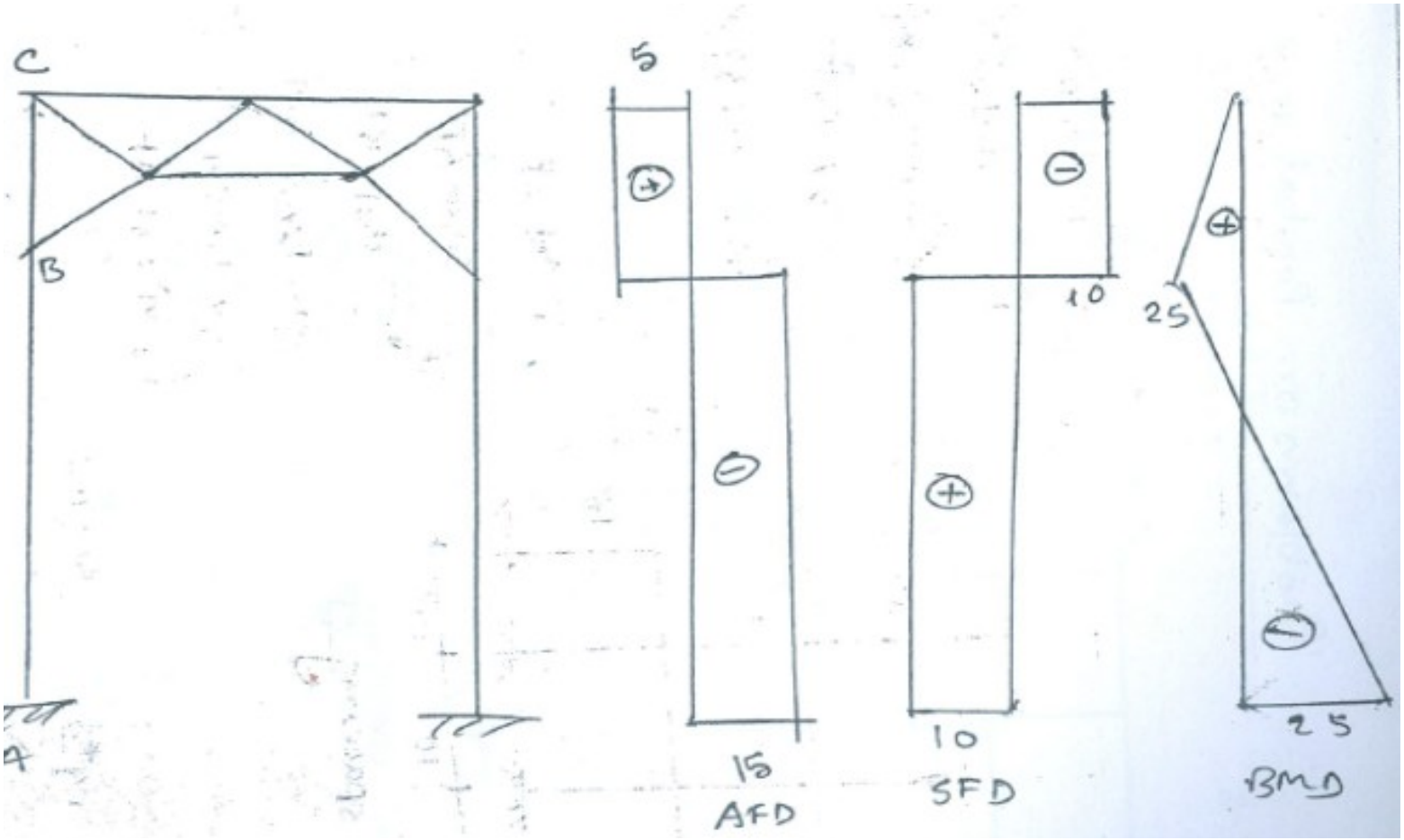
$\therefore F_{LN} = -F_{ML}$

$\therefore F_{LN} = -21.21\ kN$ (C)

Structural Analysis & Design I

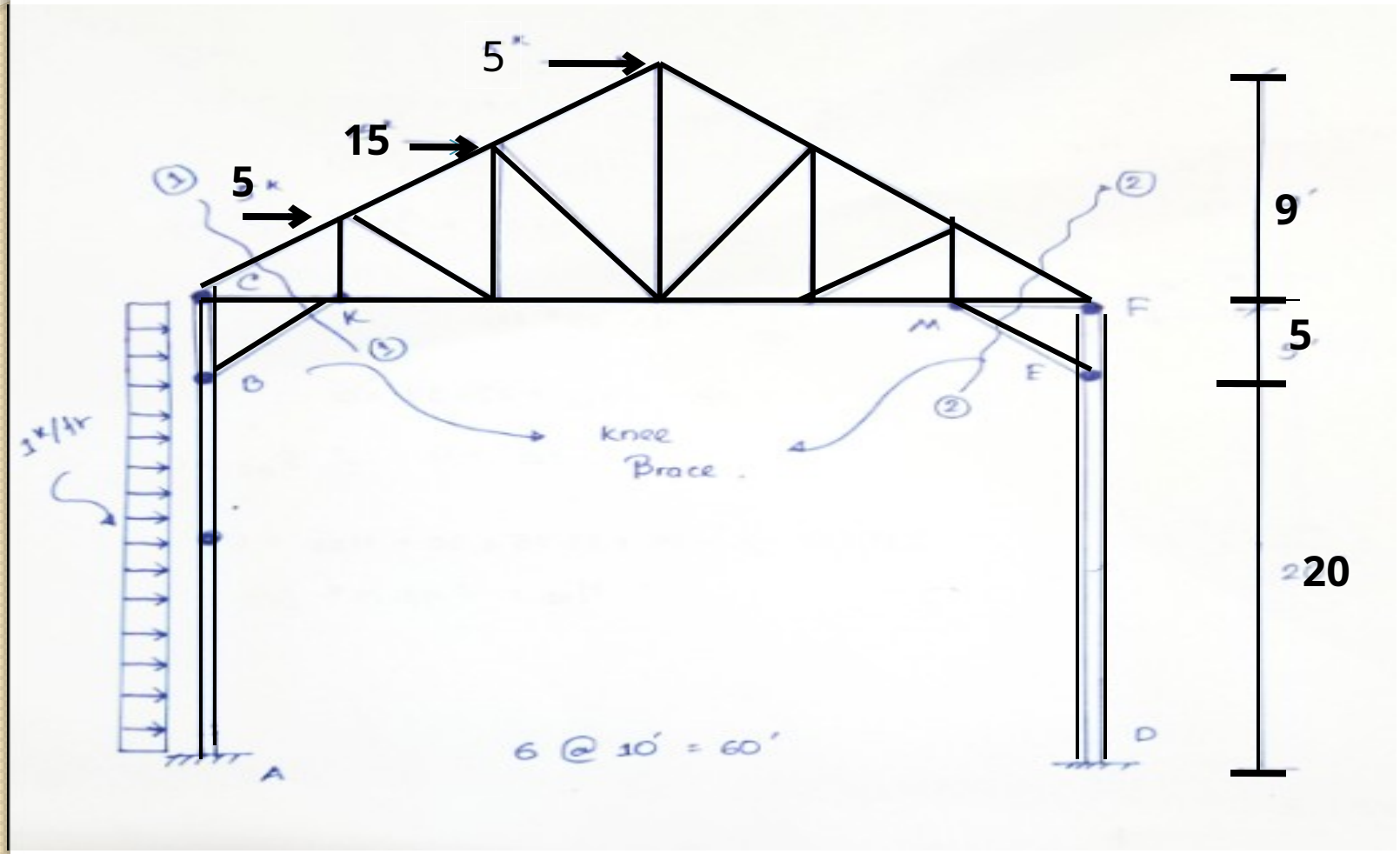


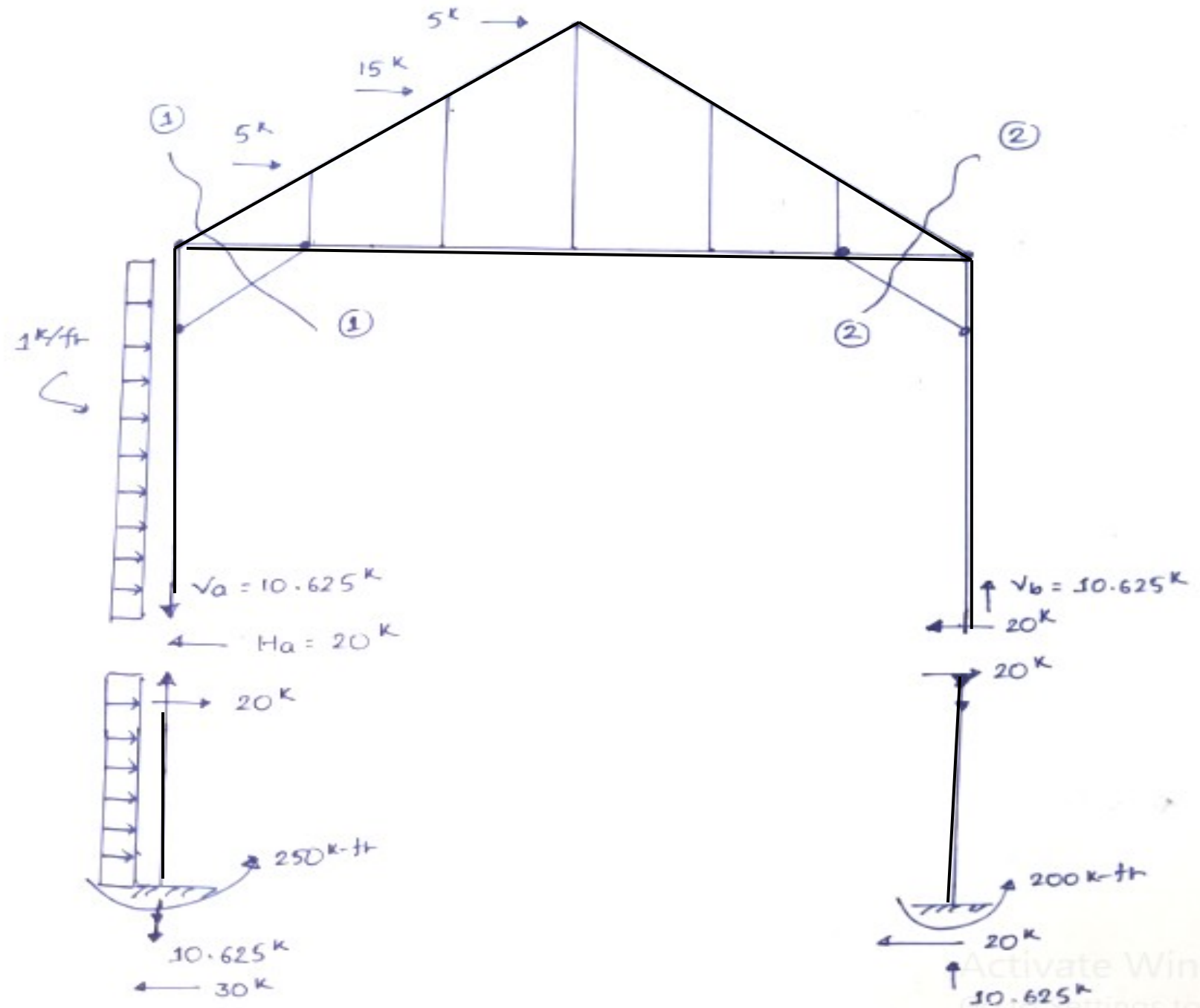
Structural Analysis & Design I



Structural Analysis & Design I

Draw shear force and bending moment diagram for the column ABC of the Mill bent in Fig. and find the bar forces in the knee braces BK and ME




5K
15K
5K
1
2
1
2
1K/ft
Va = 10.625K
Ha = 20K
Vb = 10.625K
20K
20K
20K
250K-ft
200K-ft
10.625K
30K
20K
10.625K

Structural Analysis & Design I

$\Sigma F_H = 15 + 15 + 10 = 40^k$ $\therefore H_a = 20^k$, $H_b = 20^k$

$\Sigma M_b = 0$ (+) $5 \times 24 + 15 \times 21 + 5 \times 18 + 1 \times 15 * 7.5 + V_a * 60 = 0$

$V_a = 10.625^k (\downarrow)$ $V_b = 10.625 (\uparrow)$

(+) ΣM_A

$20 \times 10 + 1 \times 10 \times 5 - M_A = 0$

$\therefore M_A = 250$ k-ft

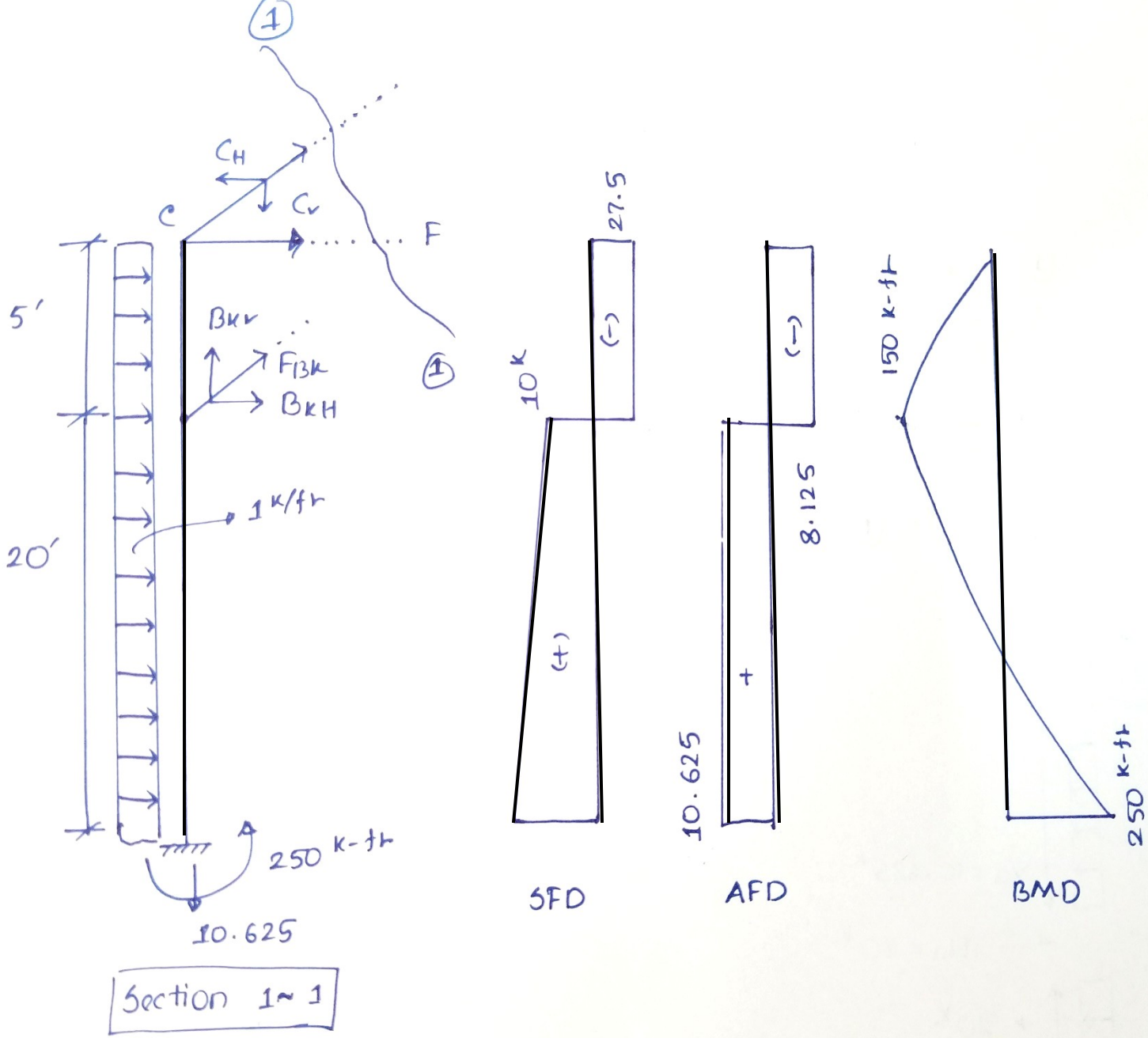
$\circlearrowleft \Sigma M_C = 0$

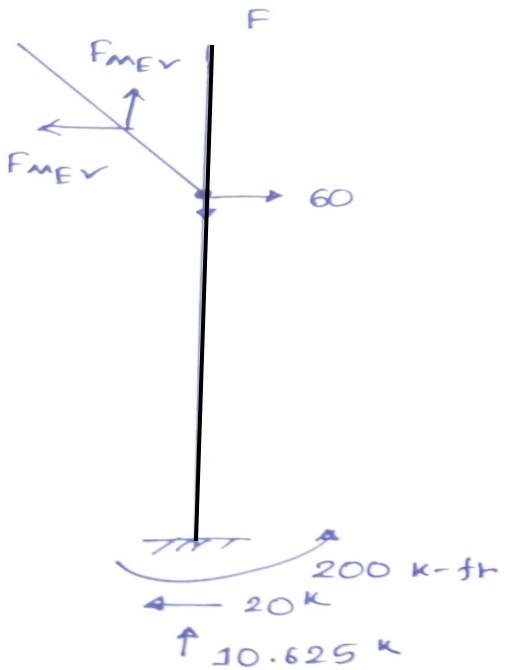
$$30 \times 25 - 250 - 1 * 25 \times 12.5 - F_{BKH} \times 5 = 0$$

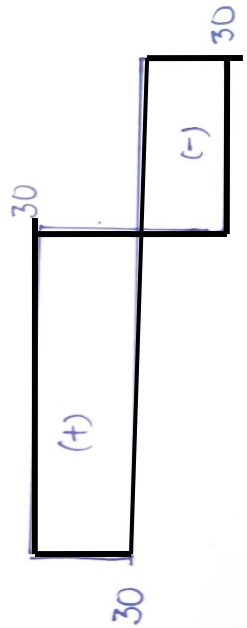
$$F_{BKH} = 37.5^{K} (T)$$

$$F_{BKv} = 37.5 \times \frac{5}{10} = 18.75^{K}$$

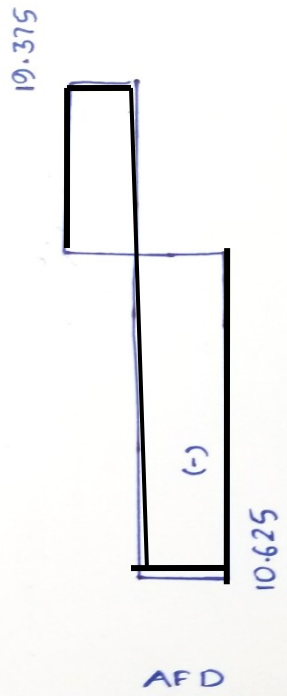
$$F_{BK} = 37.5 * \frac{11.18}{10} = 41.93^{K} (T)$$


1
C_H
C_V
C
F
5'
20'
B_{KV}
F_{BK}
B_{KH}
1
1 K/ft
250 K-ft
10.625
Section 1~1
10 K
27.5
(-)
(+)
SFD
10.625
+
8.125
(-)
AFD
150 K-ft
250 K-ft
BMD

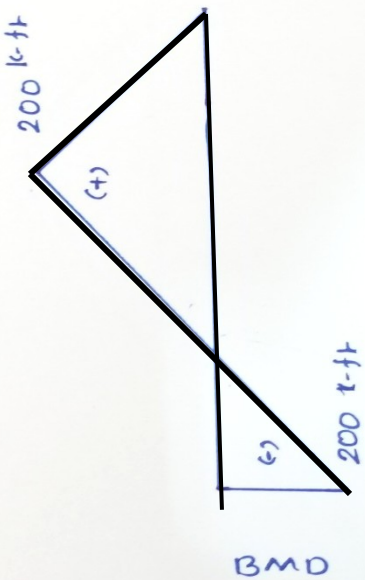




SFD



AFD



BMD

$\overset{+}{\circlearrowleft} \Sigma M_F = 0$

$20 \times 25 - 200 + F_{MEH} \times 5 = 0$

$F_{MEH} = -60^K$

$F_{ME} = 60 \times \frac{11.18}{10} = 67.8$ (C)

$F_{MEV} = 60 \times \frac{5}{10} = 30^K$