$F_{ad} + 0.243\ F_{cd} = -6.667 - 42.16 \times 0.316$

$F_{ad} = -20 - 0.243\ F_{cd}$ ——————— 4

Resolving vertically

$F_{cd} \sin \alpha_2 + F_{ed} \sin \alpha_1 = 10$

$F_{cd} = 10/0.97 + 42.16 \times 0.949/0.97$

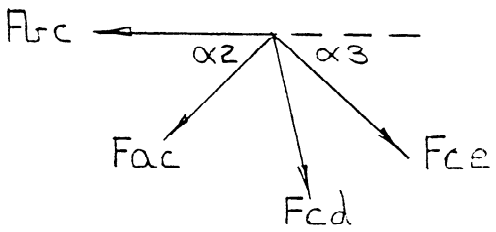
$F_{cd} = 51.55$ kN (tensile) ——————— 5

Substitute 5 into 4

$F_{ad} = -32.5$ kN (compressive)

Joint C

Resolving vertically



$F_{ac} \sin \alpha_2 + F_{cd} \sin \alpha_2$

$+ F_{ce} \sin \alpha_3 = 0$

$0.97\ F_{ac} + 51.55 \times 0.97 + 22.36 \times 0.447$

$F_{ac} = -61.85$ kN (compressive)

Resolving horizontally

$F_{bc} + F_{ac} \cos \alpha_2 = F_{cd} \cos \alpha_2 + F_{ce} \cos \alpha_3$

$F_{bc} = +61{,}85 \times 0.243 + 51.55 \times 0.243 + 22.36 \times 0.894$

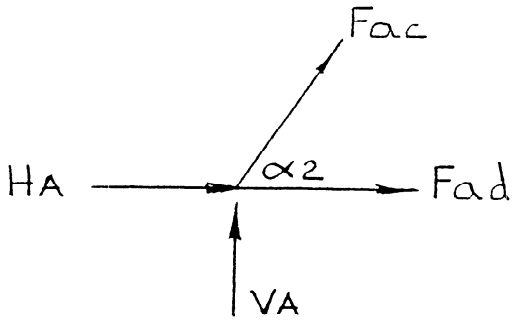
$F_{bc} = 47.5$ kN (tensile)

Reactions

Joint B

$H_B = F_{bc} = 47.5$ kN

Joint A



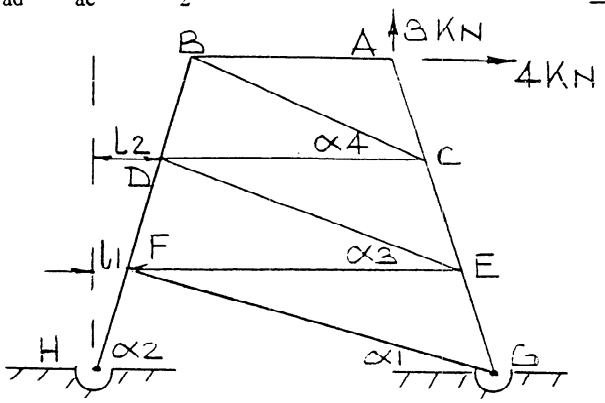
Resolving vertically

$V_A = -F_{ac} \sin \alpha_2 = 60$ kN

Resolving horizontally

$\underline{H_4} = - F_{ad} - F_{ac} \cos \alpha_2 = 32.5 + 61.85 \times 0.243 = \underline{47.5 \text{ kN}}$

7.



$$\alpha_2 = \tan^{-1} \left(\frac{7.5 \times 3}{3.75} \right) = 80.538°$$

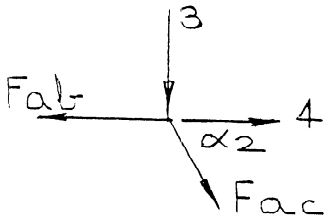
$$\ell_1 = \frac{7.5}{\tan \alpha_2} = 1.25 \text{ m}$$

$\ell_2 = 2.5$ m

$$\alpha_1 = \tan^{-1} \frac{7.5}{(15 - 1.25)} = 28.6°$$

$$\alpha_3 = \tan^{-1} \frac{7.5}{(15 - 3.75)} = 33.69°$$

$$\alpha_4 = \tan^{-1} \frac{7.5}{(15 - 3.75 - 2.5)} = 40.60°$$



Joint A

Resolving vertically

$3 + F_{ac} \sin \alpha_2 = 0$

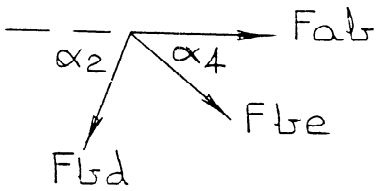
$\underline{F_{ac} = -3/0.986 = - 3.04 \text{ kN}}$ (compressive)

Resolving horizontally

$F_{ab} = F_{ac} \cos \alpha_2 + 4$

$\underline{F_{ab} = + 3.5 \text{ kN}}$ (tensile)

Joint B



Resolving vertically

$F_{bd} \sin \alpha_2 + F_{bc} \sin \alpha_4 = 0$

$0.986\ F_{bd} = -\ 0.651\ F_{bc}$

$F_{bd} = -0.66\ F_{bc}$ ——— 1

Resolving horizontally

$F_{bd} \cos \alpha_2 = F_{ab} + F_{bc} \cos \alpha_4$

$0.164\ F_{bd} = 3.5 + 0.759\ F_{bc}$ ——— 2

Substitute 1 into 2

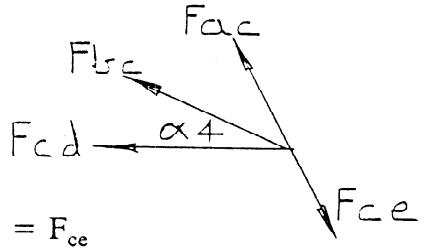
$(0.759 + 0.108)\ F_{bc} = -\ 3.5$

$F_{bc} = -\ 4.04$ kN (compressive) ——— 3

Substitute 3 into 1

$F_{bd} = 2.66$ kN (tensile)

Joint C



Resolving horizontally

$F_{cd} + F_{bc} \cos \alpha_4 + F_{ac} \cos \alpha_2 = F_{ce}$

$F_{cd} = 4.04 \times 0.759 + 3.04 \times 0.164 + F_{ce} \times 0.164$

$F_{cd} = 3.565 + 0.164\ F_{ce}$ ——— 4

Resolving vertically

$F_{ac} \sin \alpha_2 + F_{bc} \sin \alpha_4 = F_{ce} \sin \alpha_2$

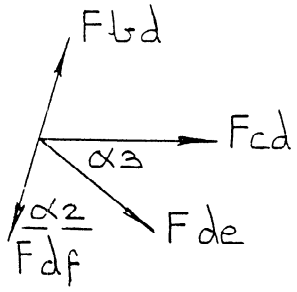
$0.986\ F_{ac} + 0.651\ F_{bc} = 0.986\ F_{ce}$

$F_{cc} = -5.617/0.986 = -5.7$ kN (compressive) ——— 5

Substitute 5 into 4

$F_{cd} = 2.63$ kN (tensile)

Joint D



Resolving vertically

$F_{bd} \sin \alpha_2 = F_{de} \sin \alpha_3 + F_{df} \sin \alpha_2$

$2.66 \times 0.986 = F_{de} \times 0.555 + 0.986\ F_{df}$

$F_{df} = 2.66 - 0.563\ F_{de}$ ——— 6

Resolving horizontally

$F_{bd} \cos \alpha_2 + F_{cd} + F_{de} \cos \alpha_3 = F_{df} \cos \alpha_2$

$0.164 \times 2.66 + 2.63 + 0.832\ F_{de} = 0.164\ F_{df}$ ——— 7

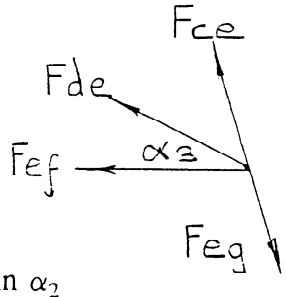
Substituting 5 into 6

$0.436 + 2.63 = F_{de} (-0.832 - 0.092) + 0.436$

$F_{de} = -2.84$ kN (compressive) ——— 8

Substitute 8 into 6

$F_{df} = 4.26$ kN (tensile)



Joint E

Resolving vertically

$F_{de} \sin \alpha_3 + F_{ce} \sin \alpha_2 = F_{eg} \sin \alpha_2$

$- 2.84 \times 0.555 - 5.7 \times 0.986 = 0.986\ F_{eg}$

$F_{eg} = -7.3$ kN (compressive)

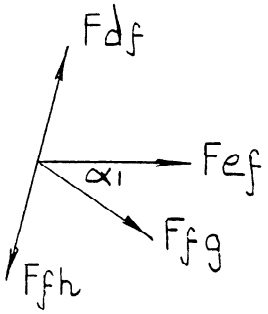
Resolving horizontally

$F_{ef} + F_{de} \cos \alpha_3 + F_{ce} \cos \alpha_2 = F_{eg} \cos \alpha_2$

$F_{ef} = - 0.164 \times 7.3 + 0.832 \times 2.84 + 0.164 \times 5.7$

$F_{ef} = 2.1$ kN (tensile)

Joint F



Resolving vertically

$F_{df} \sin \alpha_2 = F_{fg} \sin \alpha_1 + F_{fh} \sin \alpha_2$

$4.26 \times 0.986 = F_{fg} \times 0.479 + F_{fh} \times 0.986$

$F_{fh} = 4.26 - 0.486\ F_{fg}$ ——— 9

Resolving horizontally

$F_{df} \cos \alpha_2 + F_{ef} + F_{fg} \cos \alpha_1 = F_{fh} \cos \alpha_2$

$4.26 \times 0.164 + 2.1 = 0.164 \times F_{fh} - 0.878\ F_{fg}$ ——— 10

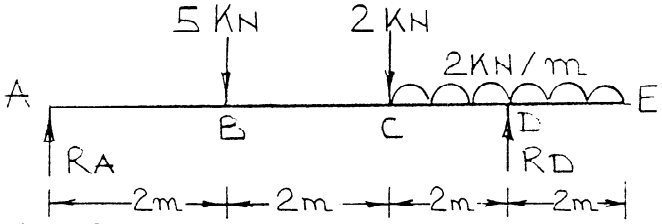
Substituting 10 into 9

$F_{fg} = -2.19$ kN (compressive) ——— 11

Substituting 11 into 9

$F_{fh} = 5.33$ kN (tensile)

8.



Moments about D

$R_A \times 6 = 5 \times 4 + 2 \times 2$

$= 24$

$R_A = 4$ kN

Resolving vertically

$R_A + R_D = 5 + 2 + 2 \times 4$

$R_D = 15 - 4$

$R_D = 11$ kN

Bending moments (M)

$M_A = 0$

$M_B = R_A \times 2 = 8$ kNm

$M_C = R_A \times 4 - 5 \times 2 = 6$ kNm

$M_D = R_A \times 6 - 5 \times 4 - 2 \times 2 - 2 \times 2 \times 1 = -4$ kNm

$M_E = 0$

Shearing forces (F)

$F_A = 4$ kN

$F_{B-} = 4$ kN; $F_{B+} = 4 - 5 = -1$ kN

$F_{C-} = 4 - 5 = -1$ kN

$F_{C+} = 4 - 5 - 2 = -3$ kN

$F_{D-} = 4 - 5 - 2 - 2 \times 2 = -7$ kN

$F_{D+} = 4 - 5 - 2 - 2 \times 2 + R_D = 4$ kN

$F_E = 0$

9. Bending moments (M)

$M_A = 3$ kNm

$M_{B-} = 3$ kNm

$M_{B+} = 3 - 5 = -2$ kNm

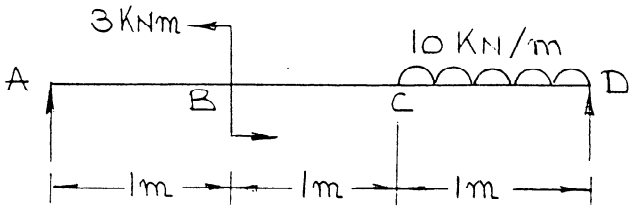
$M_{C-} = 3 - 5 = -2$ kNm

$M_{C+} = 3 - 5 + 2 = 0$

Shearing Forces (F)

$F_A = F_B = F_C = F_D = 0$

10.



Moments about D

$R_A \times 3 = 3 + 10 \times 1 \times 0.5$

$R_A = 2.667$ kN

Resolving vertically

$R_A + R_D = 10 \times 1$

R_D = 7.333 kN

Bending moments (M)

$M_A = 0$

$M_{B-} = R_A \times 1 = 2.667$ kNm

$M_{B+} = 2.667 - 3 = -0.333$ kNm

$M_C = R_A \times 2 - 3 = 2.33$ kNm

$M_D = 0$

Shearing Forces (F)

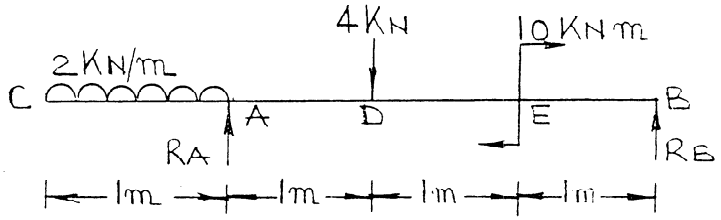
$F_A = R_A = 2.667$ kN

$F_B = 2.667$ kN

$F_C = 2.667$ kN

$F_D = -R_D = -7.333$ kN

11.



Moments about B

$R_A \times 3 + 10 = 2 \times 1 \times 3.5 + 4 \times 2$

$R_A = 1.667$ kN

Resolving vertically

$R_A + R_B = 2 \times 1 + 4$

$R_B = 4.333$ kN

Bending moments (M)

$M_C = 0$

$M_A = -2 \times 1 \times 0.5 = -1$ kNm

$M_D = -2 \times 1 \times 1.5 + R_A \times 1$

$M_D = -3 + 1.667 = -1.333$ kNm

$M_{E-} = -2 \times 1 \times 2.5 + R_A \times 2 - 4 \times 1 = -5.667$ kNm

$M_{E+} = -5.667 \times 10 = 4.333$ kNm

$M_B = 0$

Shearing Forces (F)

$F_C = 0$

$F_{A-} = -2 \times 1 = -2$ kN

$F_{A+} = -2 + R_A = -0.333$ kN

$F_{D-} = -0.333$ kN

$F_{D+} = -0.333 - 4 = -4.333$ kN

$F_E = -4.333$ kN

$F_B = -R_B = -4.333$ kN

12. $2a + 2b = 6$

$a + b = 3$ 1

$$w_a = \frac{a}{a+b} = \frac{a}{3}$$

$$R = \frac{a+b}{2} = 1.5$$

$$M_A = a \times \frac{a}{6} \times \frac{a}{3} = \frac{a^3}{18}$$

$M_{central} = \frac{1}{2} \times 3 \times 1 \times 1 - 1.5 \times b = 1.5 - 1.5\,(3 - a)$

$M_A = M_{central}$

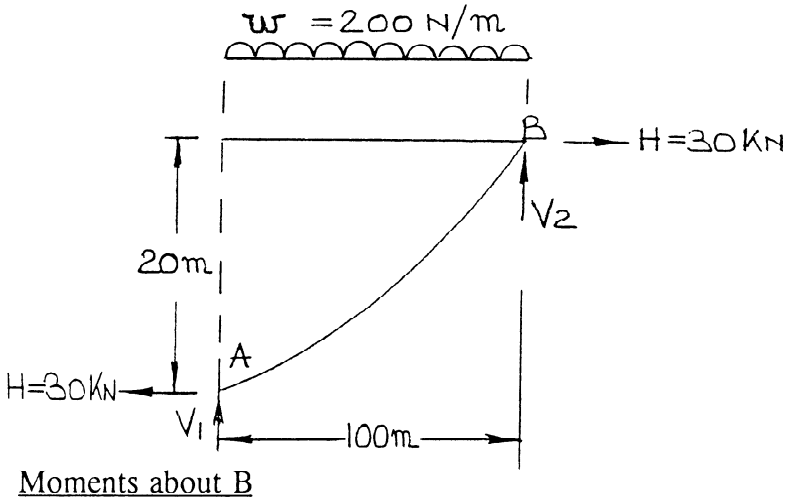
$$\frac{a^3}{18} = -\frac{3}{2} + \frac{3}{2}(3 - a)$$

$$\frac{a^3}{18} = -1.5 + 1.5 \times 3 - 1.5a$$

$a^3/18 + 1.5\,a = 3$

$\underline{a = 1.788 \text{ m}}$

13.



Moments about B

$H \times 20 + V_1 \times 100 = 200 \times 100 \times 50$

$$V_1 = \frac{1E6 - 0.6E6}{100}$$

$\underline{V_1 = 4 \text{ kN}}$

Resolving vertically

$V_1 + V_2 = 200 \times 100$

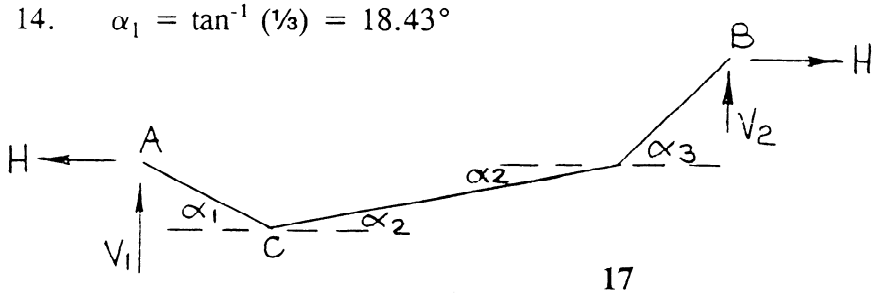
$\underline{V_2 = 16 \text{ kN}}$

To find maximum tension

$T_A = \sqrt{[V_1^2 + H^2]} = 30.27 \text{ kN}$

$\underline{T_B = \sqrt{[V_2^2 + H^2]} = 34.0 \text{ kN}}$ (maximum tension)

14. $\alpha_1 = \tan^{-1}(1/3) = 18.43°$



$\alpha_2 = \tan^{-1}\left(\frac{20}{50}\right) = 21.8°$

$\alpha_3 = \tan^{-1}(1) = 45°$

Joint C

Resolving horizontally

$T_1 \cos \alpha_1 = T_2 \cos \alpha_2$

$T_1 = 0.979\ T_2$ ———— 1

Resolving vertically

$T_1 \sin \alpha_1 + T_2 \sin \alpha_2 = 20$

$0.316\ T_1 + 0.371\ T_2 = 20$ ———— 2

Substituting 1 into 2

$0.680\ T_2 = 20$

$T_2 = 29.4$ kN ———— 3

Substituting 3 into 1

$T_1 = 28.78$ kN

Joint A

Resolving horizontally

$H = T_1 \cos \alpha_1 = 27.3$ kN ———— 4

Resolving vertically

$V_1 = T_1 \sin \alpha_1$

$V_1 = 9.09$ kN

Joint D

Resolving horizontally

$T_3 \cos \alpha_3 = T_2 \cos \alpha_2$