2 Statically Determinate Beams and Frames.

2.1 Introduction:

Equations of equilibrium are sufficient to analyze these type of problem.

For 3D:

$\Sigma F_x = 0$ $\quad \Sigma M_x = 0$

$\Sigma F_y = 0$ $\quad \Sigma M_y = 0$

$\Sigma F_z = 0$ $\quad \Sigma M_z = 0$

For 2D:

$\Sigma F_x = 0$ $\quad \Sigma M_z = 0$

$\Sigma F_y = 0$

2.2 Procedure:

StepI: Calculate DSI. If it is zero then equations of equilibrium are sufficient to analyze the structure.

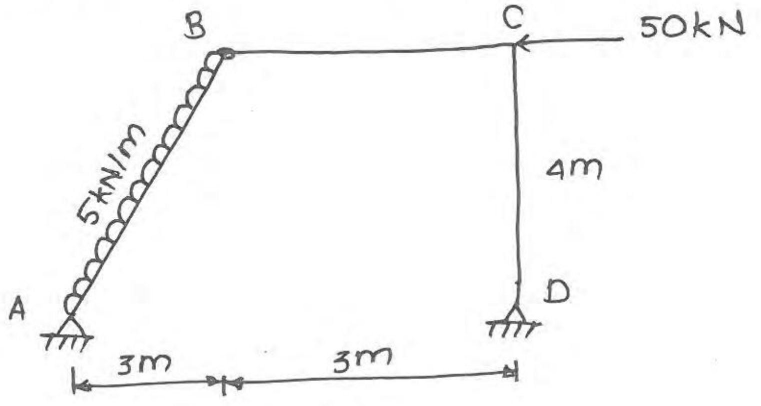
StepII: Draw FBD of entire structure.

StepIII: Formulate equations in terms of unknown forces.

Step IV: Solve simultaneous equations of stepIII and calculate unknown forces.

StepV: Draw BMD.

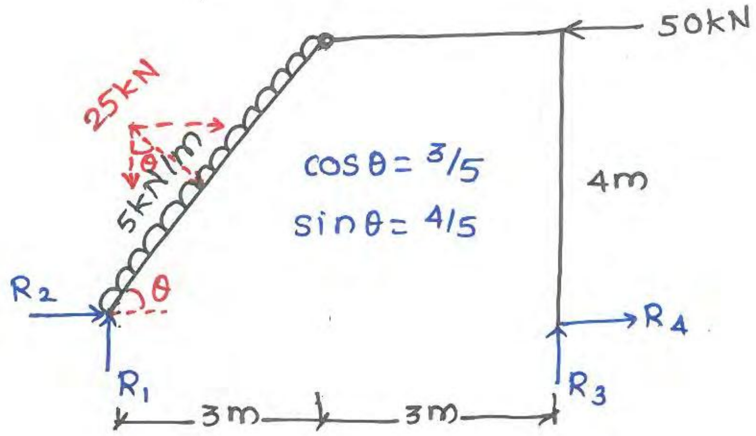
Ex. Analyze the frame given below.



→ Step I: DSI = 0

Step II: FBD

FBD:



Step III:

$$\Sigma F_x = 0$$

$$\Rightarrow R_2 + R_4 - 50 + 25 \sin\theta = 0 \quad \text{---- (i)}$$

$$\Sigma F_y = 0$$

$$\Rightarrow R_1 + R_3 - 25 \cos\theta = 0 \quad \text{-------- (ii)}$$

$$\Sigma M_z = 0$$

$$\Rightarrow \Sigma M_A = 0$$

$$\Rightarrow 25 \times \frac{5}{2} - 50 \times 4 - R_3 \times 6 = 0 \quad \text{---- (iii)}$$

$M_B = 0$ (RHS)

$$-R_3 \times 3 + R_4 \times 4 = 0 \quad \text{--- (iv)}$$

Step IV:

From eq^n (i) to (iv)

$R_1 = 37.91 \text{ kN}$

$R_2 = 12.81 \text{ kN}$

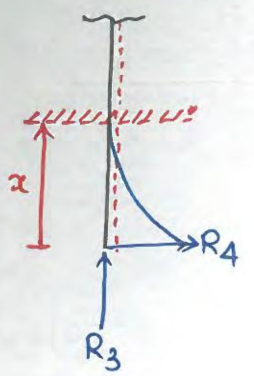
$R_3 = -22.91 \text{ kN}$

$R_4 = 17.18 \text{ kN}$

Step V: BMD.

Assuming outerface as ref. face.

For DC:



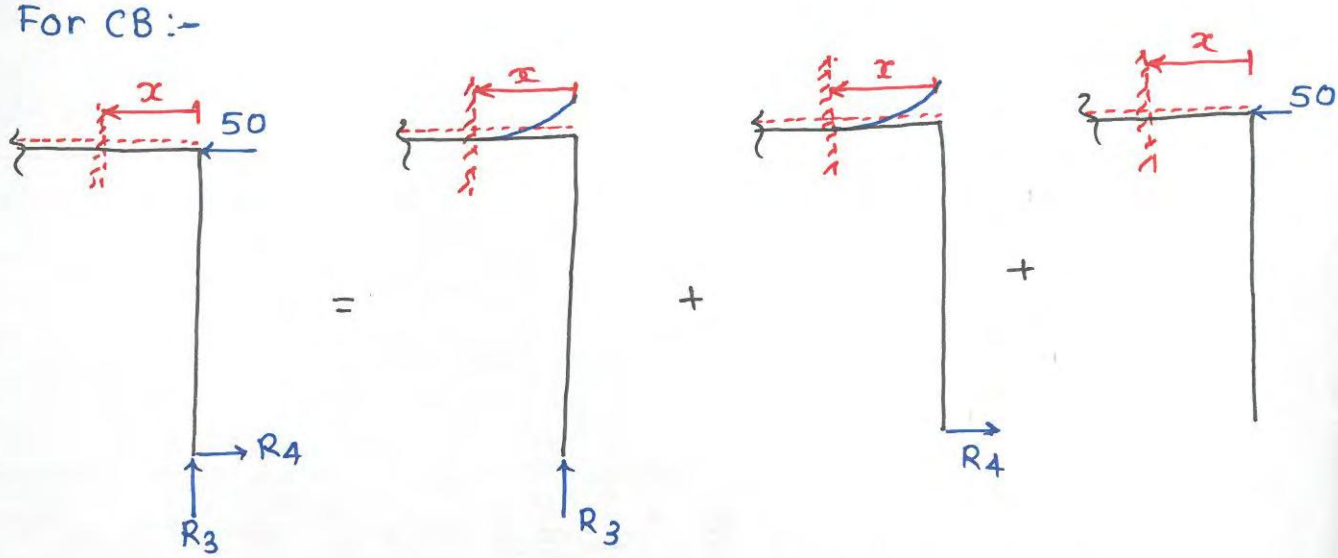
$BM_x = R_4 \cdot x$ (+ve becoz compression on ref face)

$= 17.18\,x$

At $x = 0$, $BM = 0$

$x = 4m$, $BM = 68.72$ kN·m.

For CB :-



$BM_x = R_3 x + R_4 \times 4$ (+ve becoz compression on reference face)

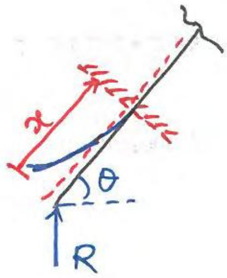
$= -22.91\,x + 17.18 \times 4$

At $x = 0$, $BM = 68.72$ kN·m

$x = 3m$, $BM = 0$

Concept :-

How to write BM at any section in inclined and curved member?

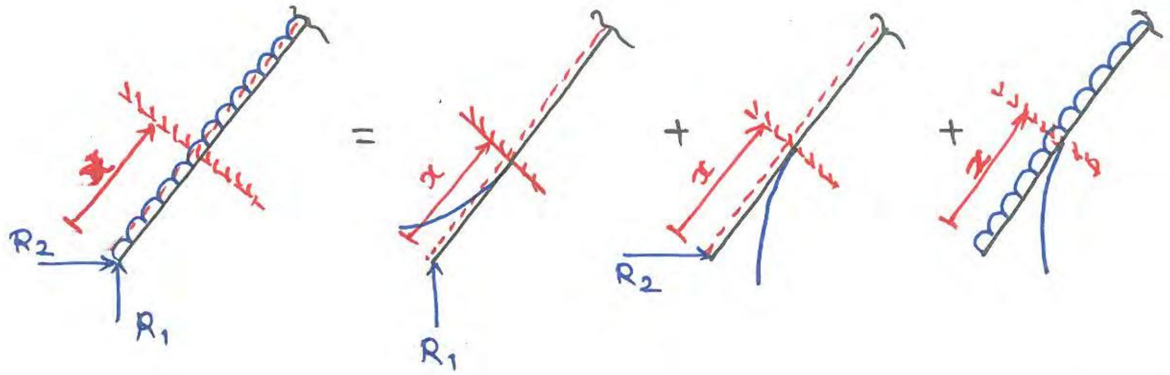


$BM_x = (R\cos\theta) \cdot x$ (+ve becoz comp. on ref. face.)

$= R\,(x\cos\theta)$

= Force × $\perp^{lar}$ distance b/w force and section.

For AB:-



$$BM_x = R_1 x\cos\theta - R_2 x\sin\theta - \frac{wx^2}{2}$$ (+ve if comp on ref face)

$$= 37.91 \times x \times \frac{3}{5} - 12.81 \times x \times \frac{4}{5} - \frac{5}{2}x^2$$

At $x = 0$, BM $= 0$

$x = 5$, BM $= 0$

For maximum BM:-

$$\frac{d(BM_x)}{dx} = 0$$

$$\Rightarrow 37.91 \times \frac{3}{5} - 12.81 \times \frac{4}{5} - 5x = 0$$

$x = 2.5m$

At $x = 2.5m$, BM $= 15.61$ kNm.

BMD:-