CABLE BOWSTRING BRIDGE

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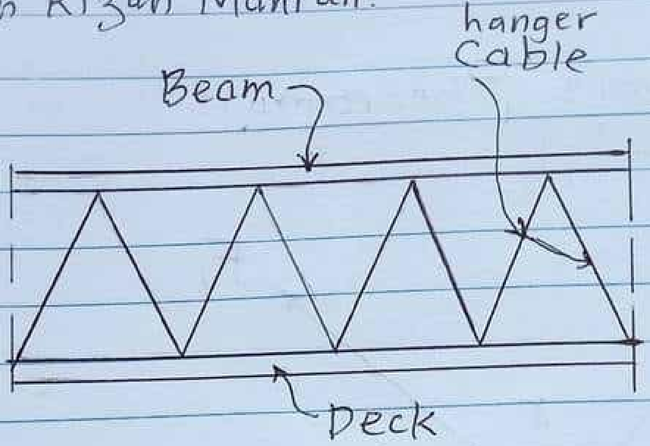
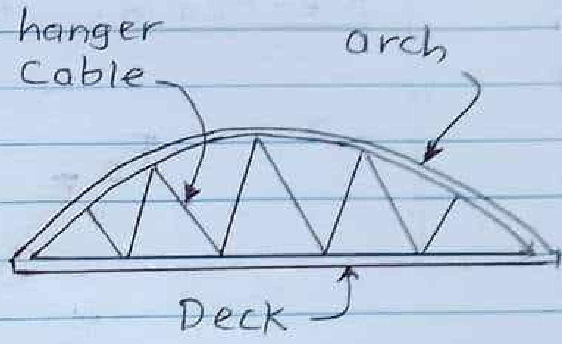
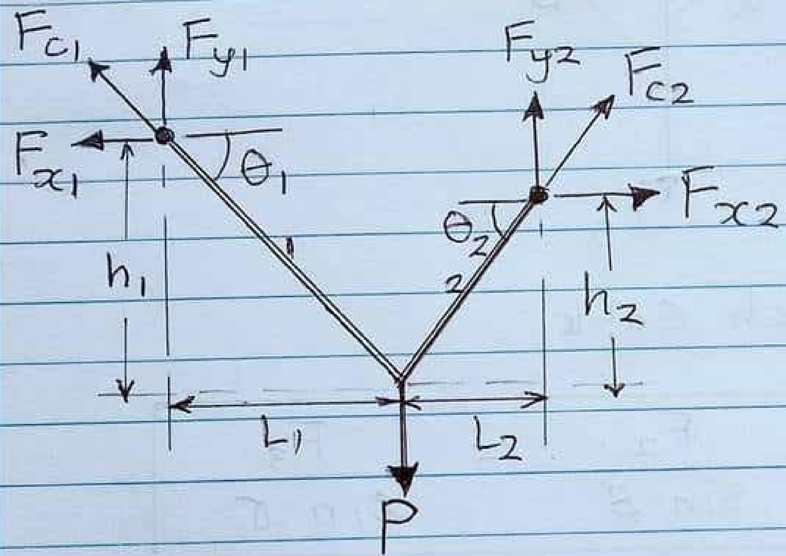
NO DATE

By: Shah Rizan Mahran.





Analysis & Reaction



Method 1:

$$\Sigma F_y \uparrow = \Sigma F_y \downarrow$$

$$F_{y1} = \frac{P \cdot L_2}{(L_1 + L_2)}$$

$$F_{y2} = \frac{P \cdot L_1}{(L_1 + L_2)}$$

$$\Sigma \vec{F_x} = \Sigma \overleftarrow{F_x} \quad F_{x1} = \frac{F_{y1}}{\tan\theta_1} = F_{y1}\left(\frac{L_1}{h_1}\right)$$

$$F_{x2} = \frac{F_{y2}}{\tan\theta_2} = F_{y2}\left(\frac{L_2}{h_2}\right)$$

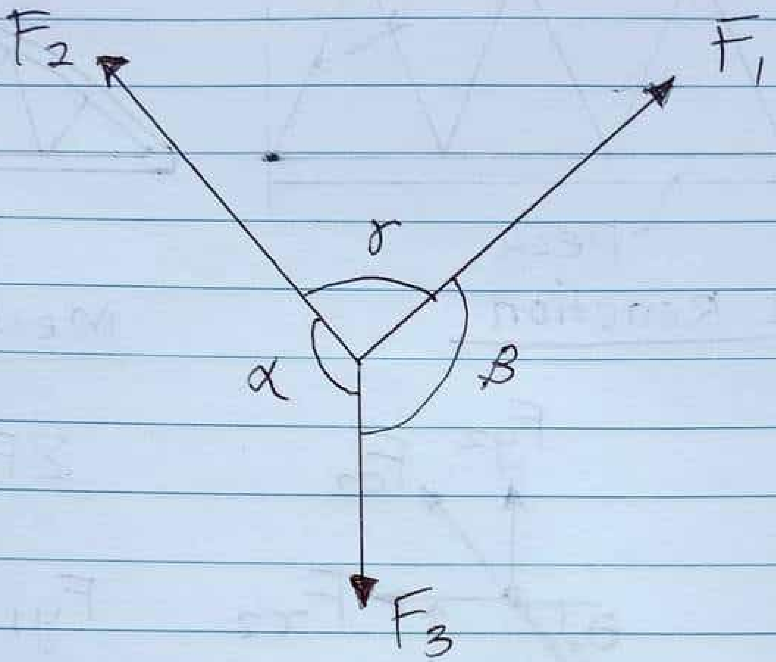
Tensile Force To cable & length :-

$$F_{c1} = \sqrt{F_{x1}^2 + F_{y1}^2} \quad \& \quad L_{c1} = \sqrt{h_1^2 + L_1^2}$$

$$F_{c2} = \sqrt{F_{x2}^2 + F_{y2}^2} \quad \& \quad L_{c2} = \sqrt{h_2^2 + L_2^2}$$

or $F_{c1} = \dfrac{F_{y1} \times L_{c1}}{h_1}$ & $F_{c2} = \dfrac{F_{y2} \times L_{c2}}{h_2}$

Method 2: Lamis Theorom.



Force avery each Cable:

$$\boxed{\frac{F_1}{\sin \alpha} = \frac{F_2}{\sin \beta} = \frac{F_3}{\sin \gamma}}$$

This method only to find & calculate tensile force each cable. Not to use to calculate vertical force & horizontal force, F_y & F_x.

Given F_3:

$$F_1 = F_3 \times \frac{\sin \alpha}{\sin \gamma}$$

$$F_2 = F_3 \times \frac{\sin \beta}{\sin \gamma}$$

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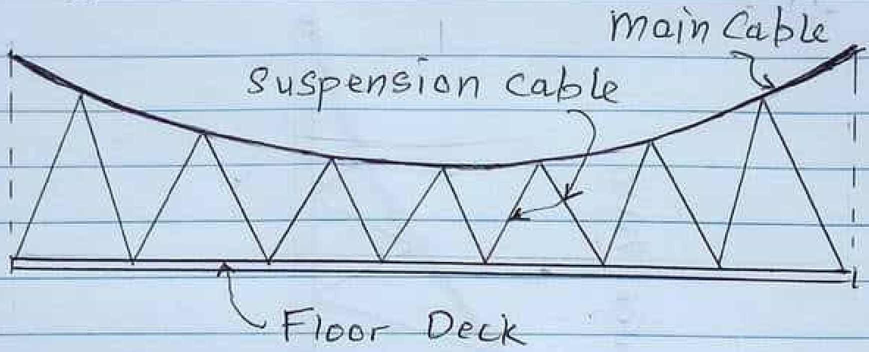
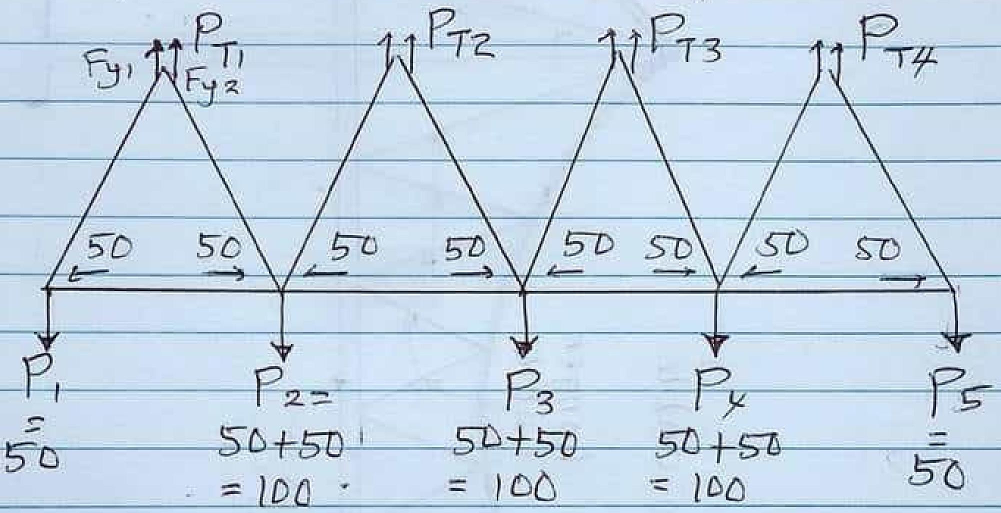


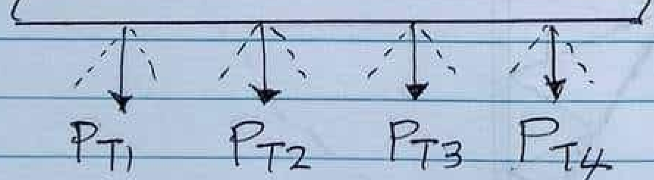
Load transfer from deck to suspension cable:

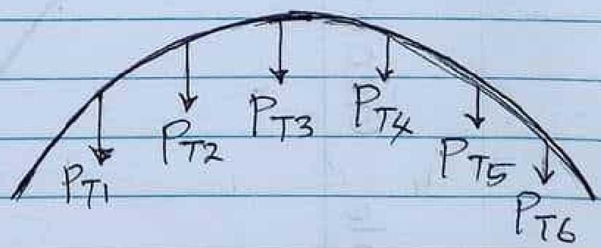


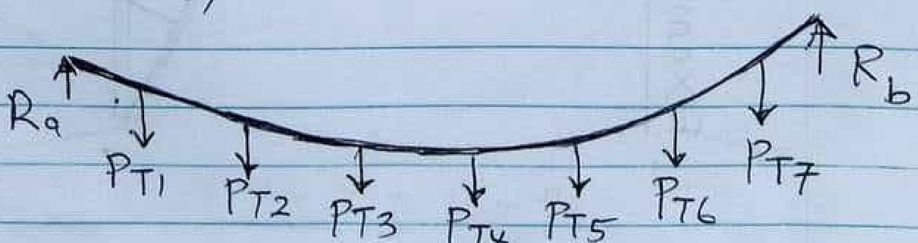
Were: $P_{T1} = F_{y1} + F_{y2}$ $\quad$ $P_{T3} = F_{y5} + F_{y6}$

$P_{T2} = F_{y3} + F_{y4}$ $\quad$ $P_{T4} = F_{y7} + F_{y8}$

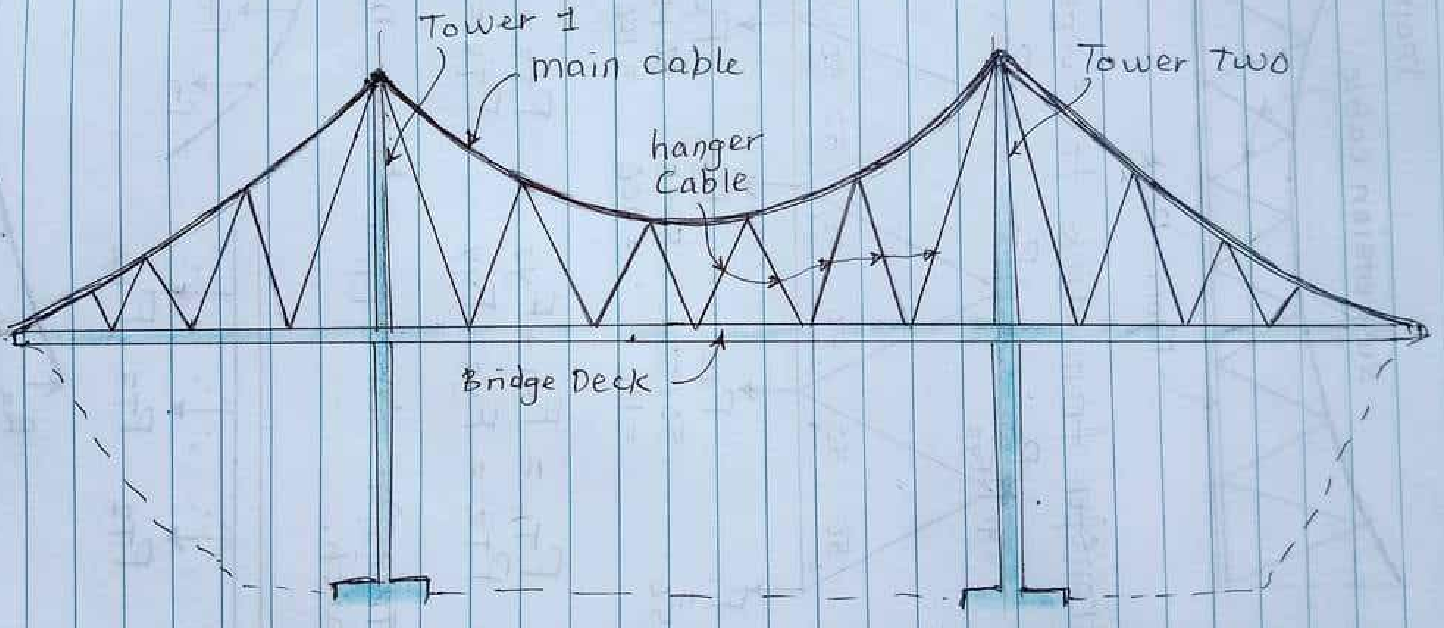
Load Transfer to upper beam, main cable and arch.







Example Geometry



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Cable Mark	load P	L	h	Lc	Reaction		Tensile Force F_c	P_T	Remark
					F_y	F_x			
Total	$\Sigma P = ?$				$\Sigma F_y = ?$	$\Sigma F_x = ?$		$\Sigma P_T = ?$	

Notes: Programme this table into microsoft excel.

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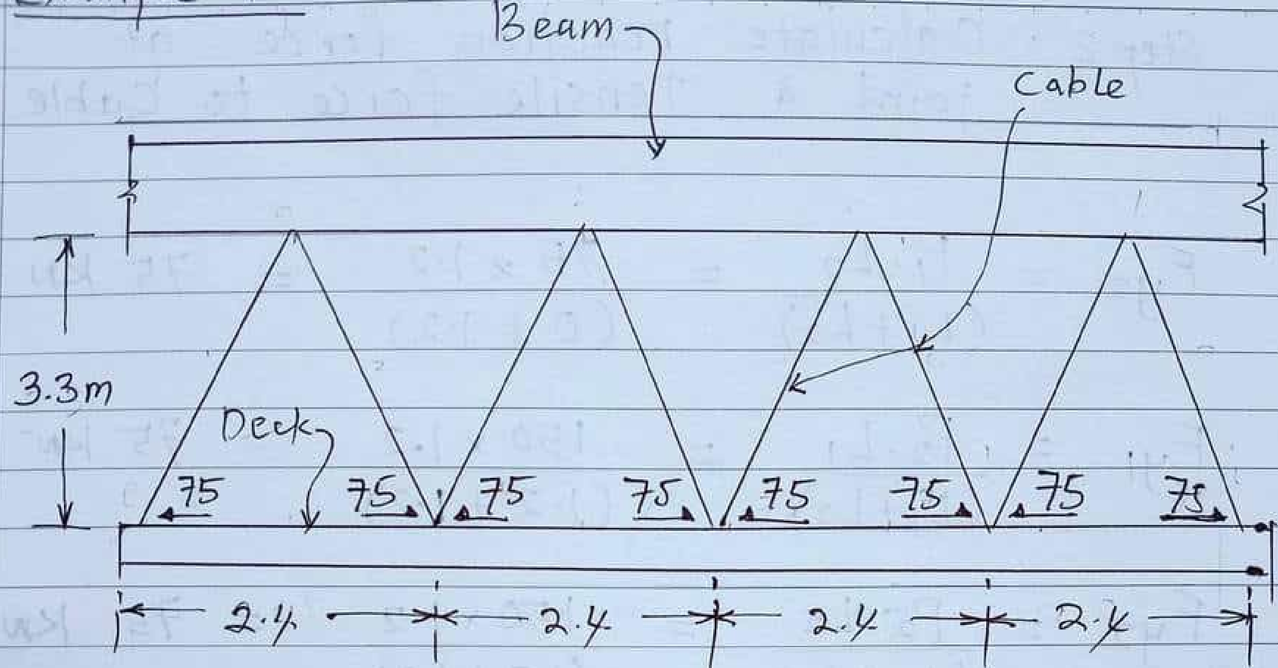
Example 7:



Step 1: Calculate load to suspension cable

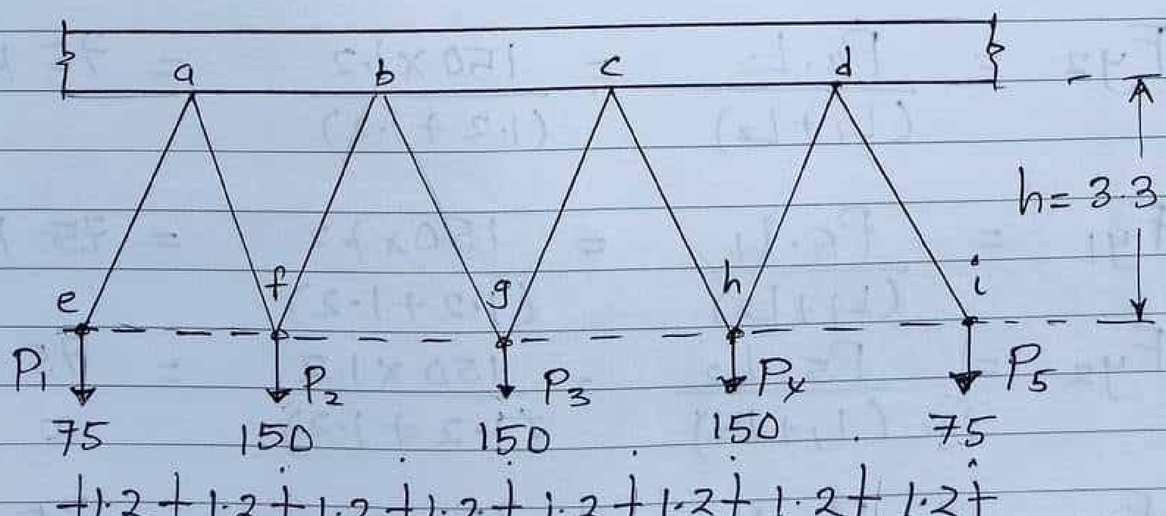
$P_1 = 75$ KN.

$P_2 = 75 + 75 = 150$ KN

$P_3 = 75 + 75 = 150$ KN

$P_4 = 75 + 75 = 150$ KN

$P_5 = 75$ KN



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Step 2 : Calculate reaction force at joint & tensile force to Cable.

$$F_{y2} = \frac{P_1 \cdot L_2}{(L_1 + L_2)} = \frac{75 \times 1.2}{(0 + 1.2)} = 75 \text{ KN}$$

$$F_{y1} = \frac{P_2 \cdot L_1}{(L_1 + L_2)} = \frac{150 \times 1.2}{(1.2 + 1.2)} = 75 \text{ KN}$$

$$F_{y2} = \frac{P_2 \cdot L_2}{(L_1 + L_2)} = \frac{150 \times 1.2}{(1.2 + 1.2)} = 75 \text{ KN}$$

$$F_{y1} = \frac{P_3 \cdot L_1}{(L_1 + L_2)} = \frac{150 \times 1.2}{(1.2 + 1.2)} = 75 \text{ KN}$$

$$F_{y2} = \frac{P_3 \cdot L_2}{(L_1 + L_2)} = \frac{150 \times 1.2}{(1.2 + 1.2)} = 75 \text{ KN}$$

$$F_{y1} = \frac{P_4 \cdot L_1}{(L_1 + L_2)} = \frac{150 \times 1.2}{(1.2 + 1.2)} = 75 \text{ KN}$$

$$F_{y2} = \frac{P_4 \cdot L_2}{(L_1 + L_2)} = \frac{150 \times 1.2}{(1.2 + 1.2)} = 75 \text{ KN}$$

$$F_{y1} = \frac{P_5 \cdot L_1}{(L_1 + L_2)} = \frac{75 \times 1.2}{(1.2 + 0)} = 75 \text{ KN}$$

Tensile force to cable :

$$F_{x2} = F_{y2}\left(\frac{L_2}{h_2}\right) = 75\left(\frac{1.2}{3.3}\right) = 27.2727 \text{ kN}$$

cable 1; $F_{c1} = \sqrt{27.2727^2 + 75^2} = \sqrt{F_{x2}^2 + F_{y2}^2}$

@ $F_{c1} = \dfrac{F_{y2} \cdot L_{c2}}{h_2} = \dfrac{75 \times \sqrt{3.3^2 + 1.2^2}}{3.3}$

$\therefore$ $F_{c1} = 79.8048$ kN

cable 2; $L_c = \sqrt{3.3^2 + 1.2^2} = 3.5114$ m.

$F_c = \dfrac{75 \times 3.5114}{3.3} = 79.8048$ kN.

cable 3; $L_c = \sqrt{3.3^2 + 1.2^2} = 3.5114$ m.

$\therefore F_c = 75 \times 3.5114 / 3.3 = 79.8048$ kN.

cable 4; $L_c = \sqrt{3.3^2 + 1.2^2} = 3.5114$ m.

$\therefore F_c = 75 \times 3.5114 / 3.3 = 79.8048$ kN.

cable 5; $L_c = \sqrt{3.3^2 + 1.2^2} = 3.5114$ m

$\therefore F_c = 75 \times 3.5114 / 3.3 = 79.8048$ kN.

cable 6; $L_c = \sqrt{3.3^2 + 1.2^2} = 3.5114$ m.

$\therefore F_c = 75 \times 3.5114 / 3.3 = 79.8048$ kN.

cable 7; $L_c = 3.5114$ m $F_c = 79.8048$ kN.

cable 8; $L_c = 3.5114$ m $F_c = 79.8048$ kN.

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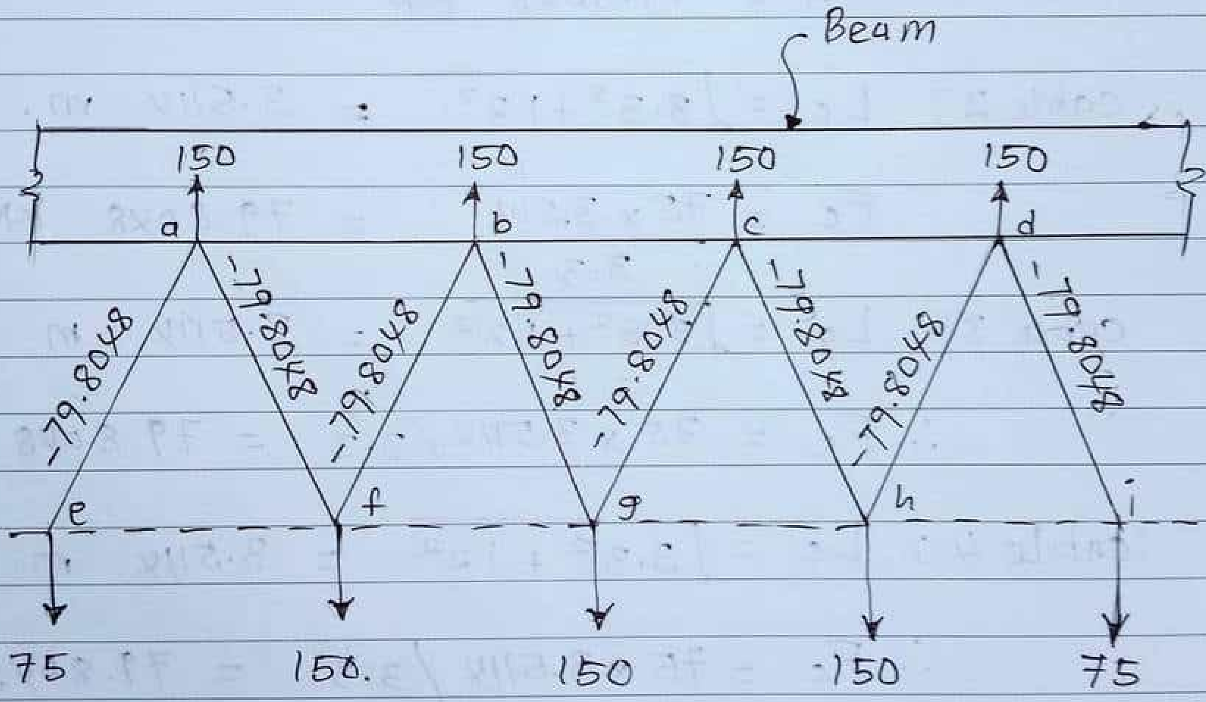
Load transfer to beam :.

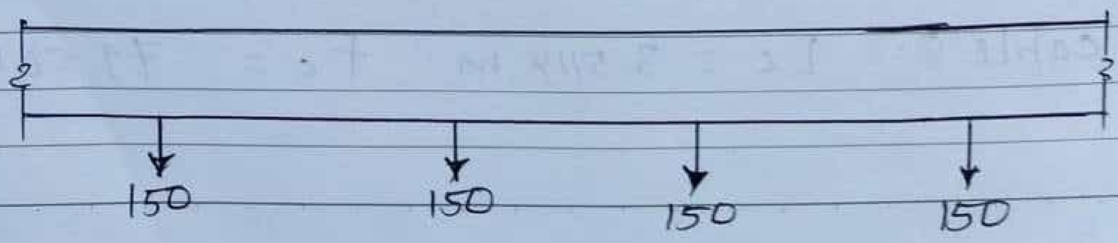
$P_{Ta} = 75 + 75 = 150$ KN.
$P_{Tb} = 75 + 75 = 150$ KN.
$P_{Tc} = 75 + 75 = 150$ KN.
$P_{Td} = 75 + 75 = 150$ KN.

$P_{T\,joint} = F_{y1} + F_{y2}$



- Tensile
+ compression.

After this; calculate shear force & bending moment to beam member. Draw SFD and BMD for Beam structure.



Example 2:

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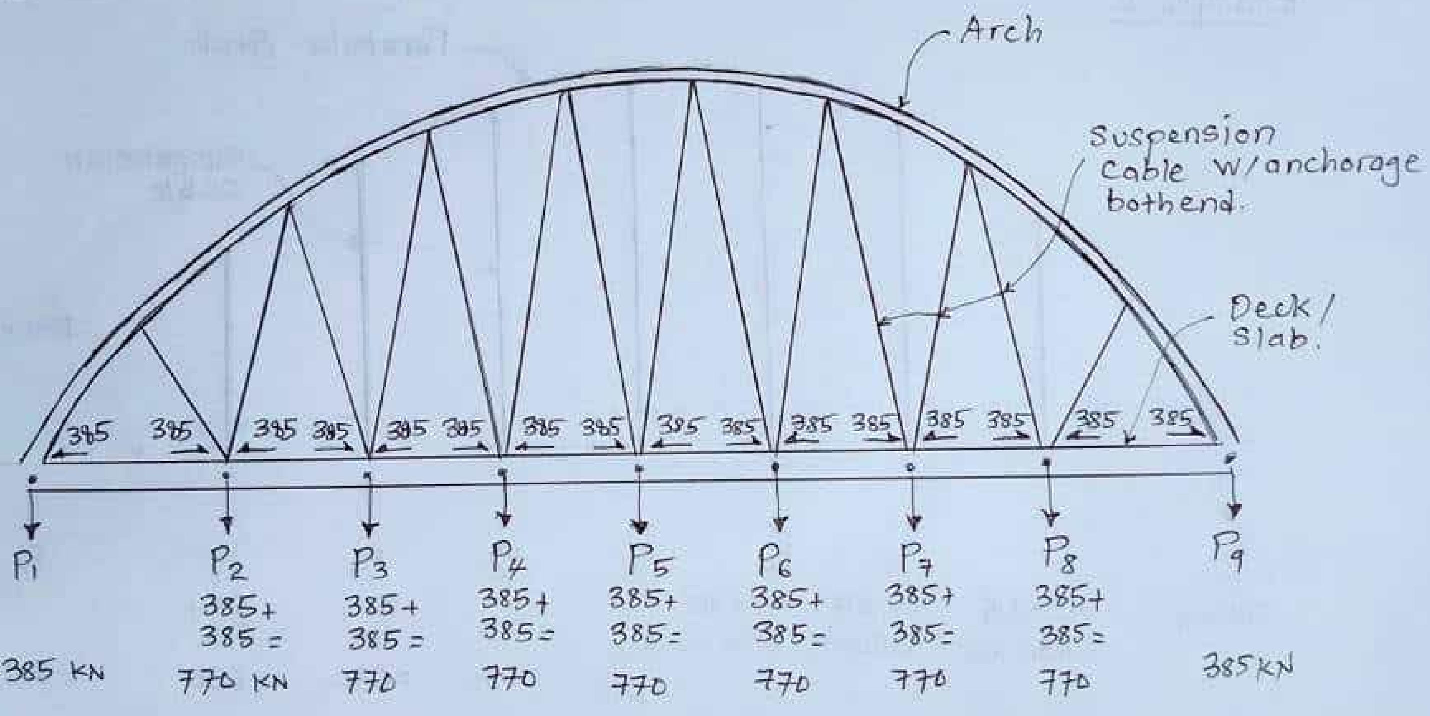
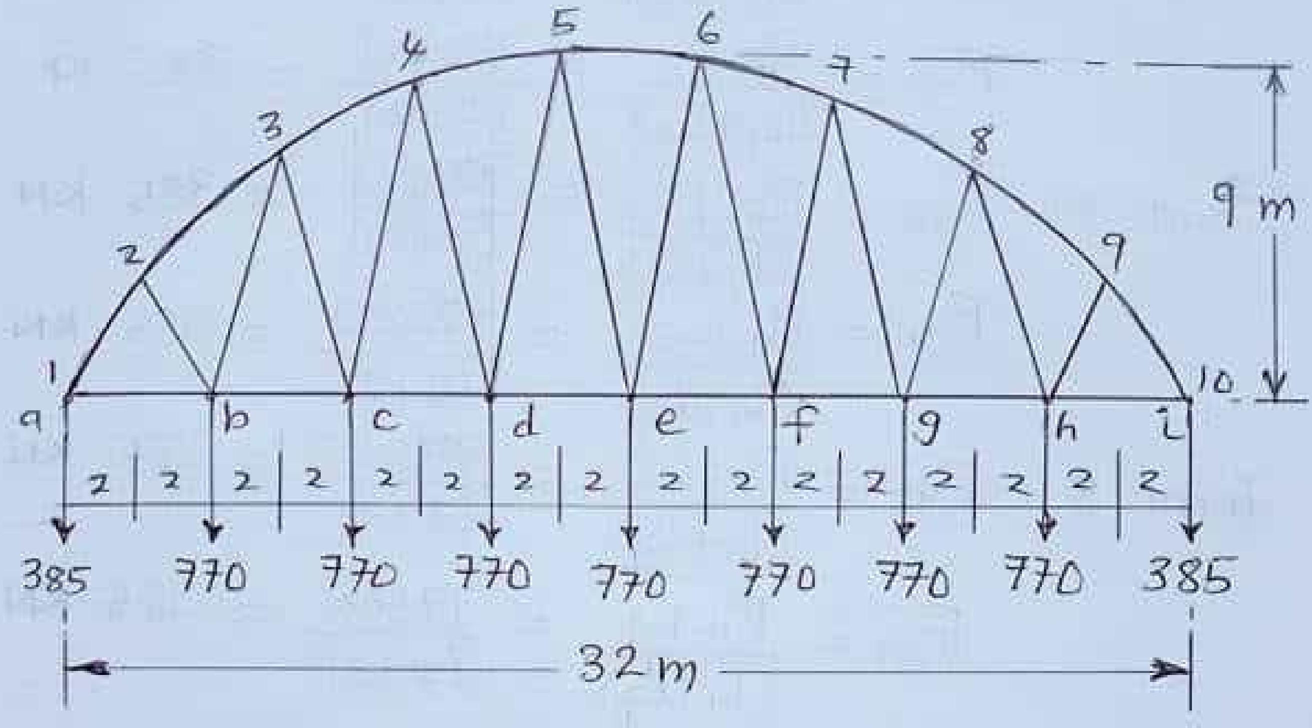


LOAD TRANSFER TO HANGER CABLE



Vertical Force at joint 1, 2, 3, 4, 5, 6, 7, 8, 9 & 10.

Joint 2; $F_{y1} = \dfrac{P_b \cdot L_2}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

Joint 3; $F_{y2} = \dfrac{P_b \cdot L_1}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

$F_{y1} = \dfrac{P_c \cdot l_2}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

Joint 4; $F_{y2} = \dfrac{P_c \cdot L_1}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

$F_{y1} = \dfrac{P_d \cdot L_2}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

Joint 5; $F_{y2} = \dfrac{P_d \cdot L_1}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

$F_{y1} = \dfrac{P_e \cdot L_2}{(L_1 + L_2)} = \dfrac{770(2)}{(2+2)} = 385$ KN

Joint 6; $F_{y2} = \frac{P_e . L_1}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

$F_{y1} = \frac{P_f . L_2}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

Joint 7; $F_{y2} = \frac{P_f . L_1}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

$F_{y1} = \frac{P_g . L_2}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

Joint 8; $F_{y2} = \frac{P_g . L_1}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

$F_{y1} = \frac{P_h . L_2}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

Joint 9; $F_{y2} = \frac{P_h . L_1}{(L_1 + L_2)} = \frac{770(2)}{(2+2)} = 385$ KN

Height h at joint 1, 2, 3, 4, 5, 6, 7, 8, 9 & 10 using equation below:

$$h = y = \frac{4 . y_c}{L^2}(Lx - x^2) \qquad y_c = 9 \text{ m}, \quad L = 32 \text{ m}$$

Joint 1; $h = 0 \qquad = 0.00$ m

Joint 2; $h = \frac{4 \times 9}{32^2}(32 \times 2 - 2^2) = 135/64$ m

Joint 3; $h = \frac{9}{256}(32 \times 6 - 6^2) = 351/64$ m

Joint 4; $h = \frac{9}{256}(32 \times 10 - 10^2) = 495/64$ m

Joint 5; $h = \frac{9}{256}(32 \times 14 - 14^2) = 567/64$ m

Joint 6; $h = \frac{9}{256}(32 \times 18 - 18^2) = 567/64$ m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