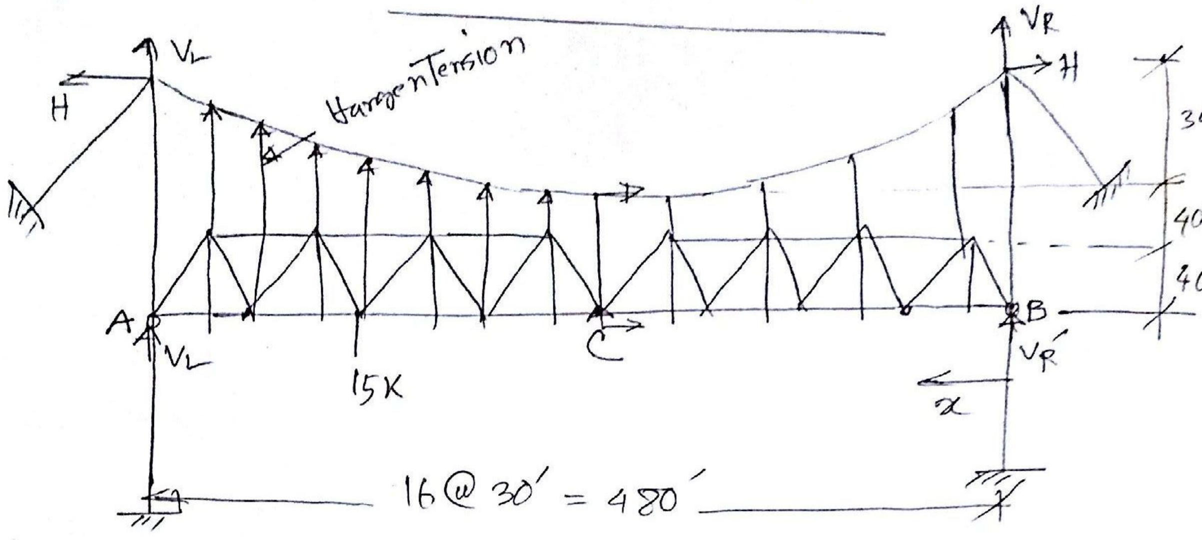
Suspension Cable Bridge

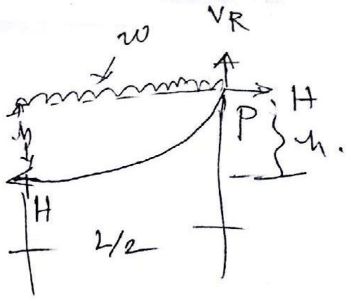


$$\Sigma M_B = (V_L + V_L')\times 480 + H \times 110 - H\times 110 - 15\times 360 = 0$$

$$\Rightarrow \quad V_L + V_L' = 11.25K.$$

$$\Sigma M_c = (V_L + V_L')\times 240 - H\times 110 + H\times 80 - 15\times 120 = 0$$

$$\Rightarrow H = 30K$$



$$\Sigma P = 0$$

$$w\frac{L}{2}\cdot\frac{L}{4} - H\cdot h = 0$$

$$\frac{wl^2}{8} - Hh = 0$$

$$Hh = \frac{wl^2}{8}$$

$$w = \frac{8Hh}{l^2} = \frac{8\times 30\times 30}{480^2} = 0.03125\ k/ft.$$

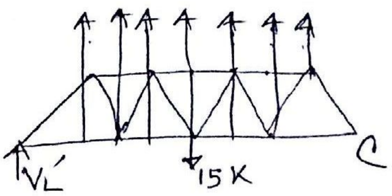
Hanger Tension $= w \times$ Length of the pannel

$$= 0.03125\times 30 = 0.9375\ K.$$

considering the AC portion,

$$\Sigma M_c = 7\times 0.9375\times 120 - 15\times 120 + V_L'\times 240 = 0$$

$$\Rightarrow V_L' = 4.22K$$



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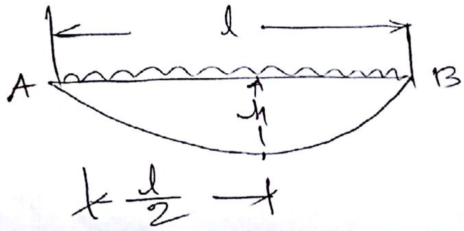
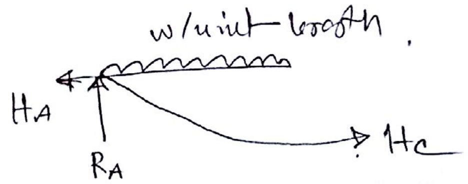
Analysis of Cables under Uniformly Distributed Loads.

(1) Cable suspended from supports at same level. Let h be the dip of the cable at centre c and cable be loaded with uniformly distributed load of intensity w/unit length.

$$H_A = H_B = \frac{wl}{2}$$

Consider equation of half of the cable. Let Hc be horizontal thrust at centre C. $H_A = H_c$,





B.M. at c ~~with~~ will be zero, therefore,

$$R_A \cdot \frac{l}{2} - H_A \times h - \frac{wl}{2} \times \frac{l}{4} = 0.$$

$$\frac{wl}{2} \times \frac{l}{2} - H_A \cdot h - \frac{wl^2}{8} = 0.$$

$$H_A = \frac{wl^2}{8h}, \quad w = \frac{8Hh}{l^2}$$

At centre of cable tension will be horizontal.

Let y be sag at any point X, in the cable at distance x from A

Taking moment about X,

$$R_A x - wx \cdot \frac{x}{2} - H_A \cdot y = 0.$$

$$\frac{wl}{2} \cdot x - \frac{wx^2}{2} - \frac{wl^2}{8h} \times y = 0$$

$$y = \frac{8h}{l^2}\left(\frac{lx}{2} - \frac{x^2}{2}\right)$$

This represents a parabolic equation. Thus ~~takes~~ Cable takes parabolic shape.

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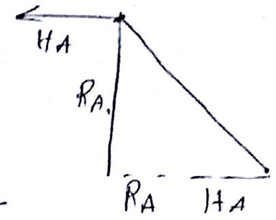
Harger Tension = w x Length of the panel

Maximum tension in the cable Occurs at supports.

$$T_{max} = \sqrt{R_A^2 + H_A^2}$$



$$= \sqrt{\left(\frac{wl}{2}\right)^2 + H^2}$$

$$= \sqrt{\left(\frac{wl}{2}\right)^2 + \left(\frac{wl^2}{8h}\right)^2}$$

$$= \frac{wl}{2}\sqrt{1 + \left(\frac{l}{4d}\right)^2}$$

$$= \frac{wl}{8d}\sqrt{16d^2 + l^2}$$

$$T_{max.} = \frac{wl2}{8d}\sqrt{1 + 16.\cancel{\tan\theta}\,\theta^2}$$

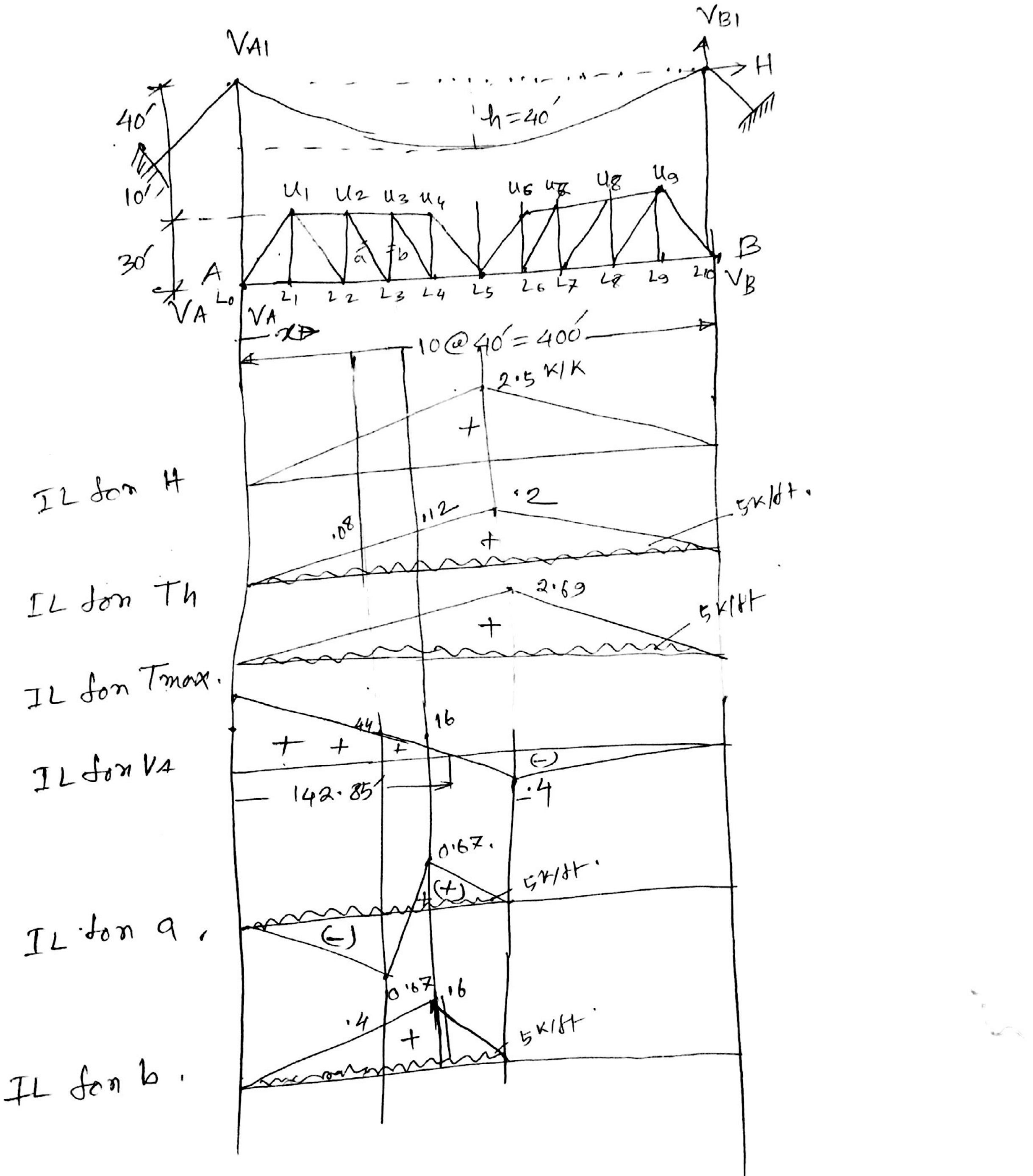
$\theta = \frac{h}{l}.$

$$T_{max} = \frac{wl^2}{8h}\sqrt{1 + 16\theta^2}$$

$$\cancel{T_{max} = H\sqrt{1 + 16\tan\theta}}.$$

T

Deduce influence lines for hanger tension, maximum cable tension and stress in member a and b of the following suspension bridge shown in fig below. Also calculate the maximum force/stress of those members due to uniform load of 5 k/ft.



Considering whole free body diagram

$\Sigma M_B = 0$

$$(V_A + V_{A1}) \times 400 - 1 \times (400 - x) = 0$$

$$(V_A + V_{A1}) = \frac{400 - x}{400}$$

Considering left portion of C

$\Sigma M_c = 0$

$$(V_A + V_{A1}) \times 200 - 1(200 - x) - 80H + 40H = 0$$

$$\Rightarrow \frac{400 - x}{400} \times 200 - (200 - x) = 40H$$

$$\Rightarrow 40H = \cancel{200} - \frac{x}{2} - \cancel{200} + x = \frac{x}{2}$$

$$\Rightarrow H = \frac{x}{80} \quad [0 < x < 200]$$

(i) 1^K at L_0, i,e, $x = 0$, $H = 0$ K/K

1^K at L_1 i,e, $x = 40$ $H = {\cdot}5$ K/K.

1^K at L_5 i,e $x = 200$, $H = 2{\cdot}5$ K/K

(ii) IL for hanger tension

$$H = \frac{wl^2}{8h} = \frac{w \times 400^2}{8 \times 40} =$$

$$\frac{x}{80} = \frac{w \times 400^2}{8 \times 40}, \quad w = \frac{x \times 8 \times 40}{80 \times 400^2} = 2{\cdot}5 \times 10^{-5} x$$

Hanger Tension

$$T_h = w \times \text{panel length} = 2{\cdot}5 \times 10^{-5} \times 40$$

$$\boxed{T_h = {\cdot}001x}$$

when 1^K at L_0. i,e, $x = 0$, $T_h = 0$ K/K,

1^K at L_1 i,e $x = 40$, $T_h = {\cdot}04$ K/K,

1^K at L_5 i, e, $x = 200$ $T_h = {\cdot}2$ K/K

(III) IL for maximum cable tension (T_{max})

We know

$$T_{max} = H\left[1+16\theta^2\right]^{1/2} \qquad \theta = \frac{h}{l}$$

$$= \frac{x}{80}\left[1+16\times\left(\frac{40}{400}\right)^2\right]^{1/2}$$

$$= \cdot 01346x$$

1^K at L_0, $T_{max} = 0$,

1^K at L_5 $T_{max} = 2{\cdot}96$.

(IV) IL for V_A

when Load at L_0, $V_A = 1$;

when unit Load at L_5,

$$T_h = \cdot 001 \times 200 = \cdot 2 \ K/K.$$

$\Sigma M_c = 0$,

$$\cdot 2 \times 40 \times (1+2+3+4) + V_A \times 200 = 0$$

$$\Rightarrow V_A = -0{\cdot}4 \ K/K.$$

when Load at L_{10}, $V_A = 0 \ K/K$.

Alternatively

$\Sigma M_c = 0$

$$V_A \times 200 + T_h \times 40(1+2+3+4) - 1^K(200-x) = 0$$

$$V_A \times 200 + \cdot 001\, x \times 400 - (200-x) = 0$$

$$V_A = \frac{200 - 1{\cdot}4x}{200}$$

$x = 0$, $V_A = 1$

$x = 40$, $V_A = 0{\cdot}72$

$x = 80$ $V_A = 0{\cdot}44$

$x = 120$, $V_A = \cdot 16$.

$x = 200$ $V_A = -0{\cdot}4$

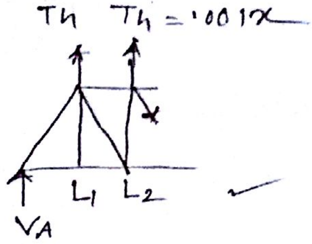
when $V_A = 0$,

$$0 = \frac{200 - 1{\cdot}4x}{200}$$

$$x = 142{\cdot}86'$$

IL for a and ba.

When unit load at A



$V_A = 1$

$a = 0$

When unit Load at L2

$$V_A = \frac{200 - 1.4x}{200}$$

$\Sigma F_y = 0.$

~~2 x .001x + VA (x) − av = 0.~~

$2 \times .001x + V_A - 1 - a_v = 0$

$a_v = 2 \times .001 \times 80 + .44 - 1 = -.4$

$$a = -.4 \frac{\sqrt{30^2 + 40^2}}{30} = -0.67 \ K/K.$$

$a = -0.67.$

When Load at L3, $V_A = .16$, at L3, (120′)

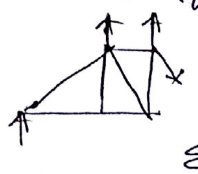
$2 \times .001x + A_v \cancel{(-1)} - a_v = 0.$

$2 \times .001 \times 120 + .16 (-1) - a_v = 0$ X No Need.

~~av = .6.~~ $a_v = .4$

$a = 0.67.$

When Load at L5, $V_A = -.4$, $.001x = .2$



$a = 0.$

$\Sigma F_y = 0.$

$-.4 + 2 \times .2 + a_v = 0$

$a_v = 0.$

when Load at L10,

$a = 0,$

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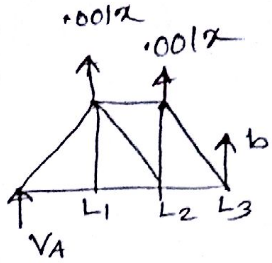
IL for b



Load at L_2, $x = 80$,

$V_A = .44$

$T_h = .08$

$\Sigma F_y = 0$,

$b + .44 + 2 \times .08 - 1 = 0$,

$b = 0.40$ K/K

Load at L_3

$x = 120$

$V_A = .16$

$T_h = .12$

~~Load~~ $\Sigma F_y = 0$, $b + .16 + 2 \times .12 - 1 = 0$

$b = .6$ K/K,

Load at L_5

$x = 200$

$V_A = -.4$

$T_h = .2$

$\Sigma F_y = 0$,

$b + (-.4) + 2 \times (.2) = 0$

$b = 0$

Maximum stress:

Maximum stress for hanger tension $= \left[2 \times \frac{1}{2} \times 200 \times .2\right] \times 5$

$= 200$ Kip.

Maximum stress for maximum cable tension $= \frac{1}{2} \times 200 \times 2.69 \times 2 \times 5$

$= 2690$ Kips.

Maximum stress for a,

positive stress $= \frac{1}{2} \times 100 \times 0.67 \times 5 = 167.50$ Kip.

Negative stress $= \frac{1}{2} \times 100 \times 0.67 \times 5 = 167.50$ kip,

Maximum stress for b $= \frac{1}{2} \times 200 \times .6 \times 5 = 300$ kip.

$$\Sigma M_B = 0.$$

$$(V_L + V_L) \times 480 - x.1 = 0$$

$$V_L + V_L' = \frac{x}{480}$$

$$\Sigma M_c = (V_L + V_L')240 - 1(x - 240) - T \times 120 + T \times 80$$

$$\frac{x}{480} \times 240 - x + 240 - 40T = 0.$$

$$T = \frac{240 \times 480 - 240x}{480 \times 40} = 6 - 0'925x$$

$$w = \frac{8Th}{L^2}$$

$$w_p = \frac{1}{24}\left(6 - \frac{x}{80}\right) =$$

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