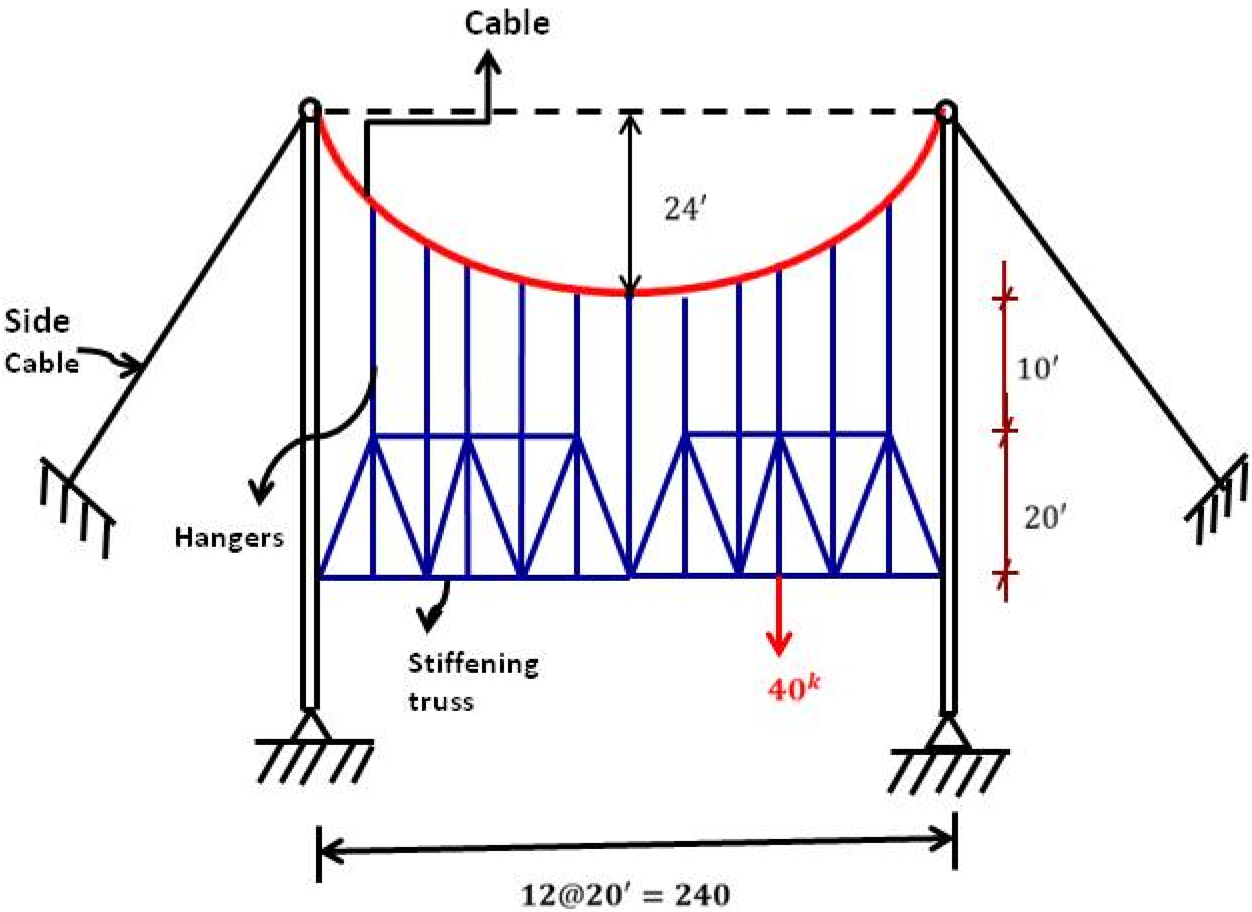
Statically Determinate Suspension Bridge

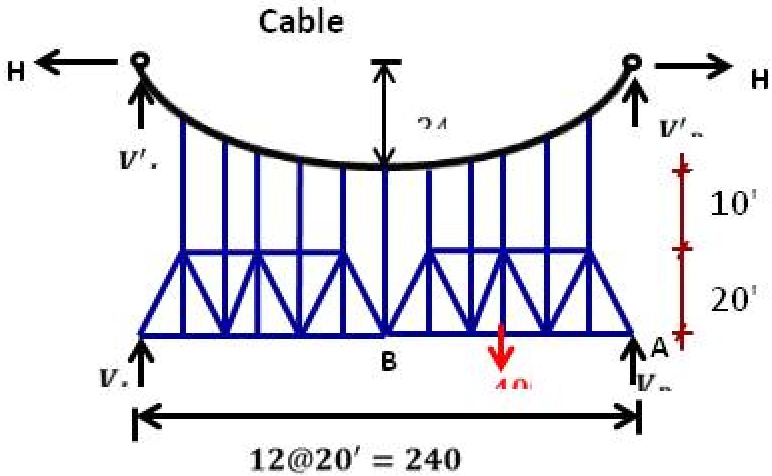
Elastic Theory of Suspension Bridge:

Assumption:

- ❑ Hangers are assumed to take equal tension
- ❑ Cable subjected to uniform load per horizontal feet.
- ❑ Hinge placed in the stiffening truss/girder makes the structure statically determinate.
- ❑ Cable remains parabolic



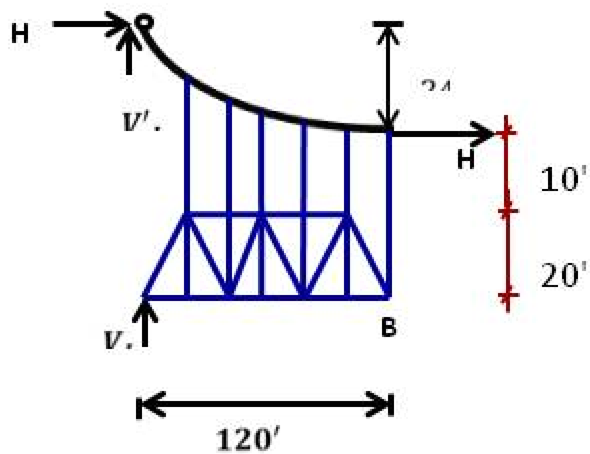
Cable
24′
Side
Cable
10′
20′
Hangers
Stiffening
truss
40^k
12@20′ = 240

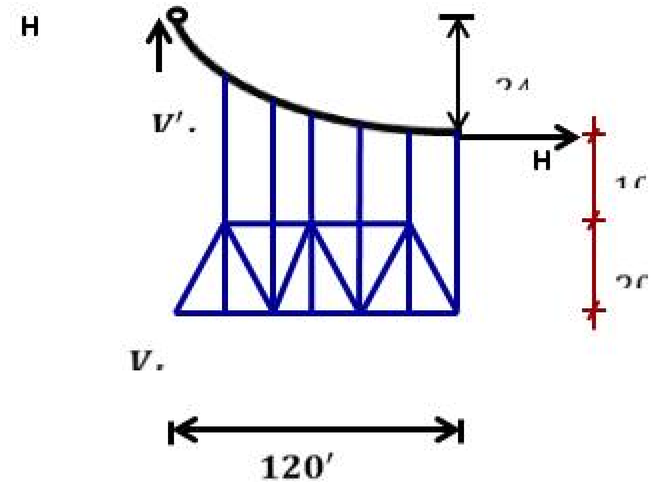


$$\sum M = 0 \quad @A$$

$$(V_L + V'_L) \times 240 - 40 \times 60 = 0$$

$$V_L + V'_L = 10^k$$





$$\sum M = 0 \qquad @B$$

$$(V_L + V'_L) \times 120 + H \times 30 - H \times 54 = 0$$

$$10 \times 120 - H \times 24 = 0$$

$$H = 50^k$$

T_{max} occurs at ends.

For a horizontal cable chord:

$$T_{max} = H((1 + 16\theta^2)^{1/2}$$

$$= 50\left[1 + 16\left(\frac{24}{240}\right)^{1/2}\right]$$

$$= 53.85^k$$

Tension in Hangers

Let tension in each hanger= x

Equivalent uniform load on cable $= \frac{x}{hanger\ sapcing}$

$$= \frac{x}{20} k/ft$$

Appling G.C.T

$H = \frac{wL^2}{8h}$ where $w = \frac{x}{20}$

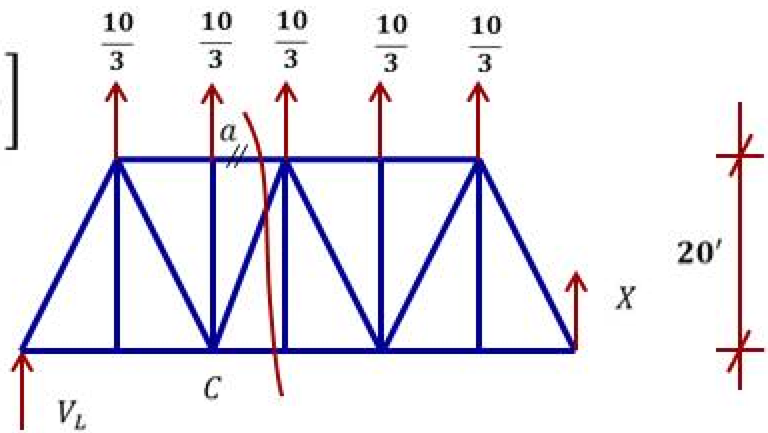
Or, $50 = \frac{x}{20} . \frac{240^2}{8 \times 24}$

$x = \frac{10}{3}\ kips$

$$\sum M = 0 \qquad @B$$

$$V_L = \frac{l}{120}\left[\frac{10}{3} \times (100 + 80 + 60 + 40 + 20)\right]$$

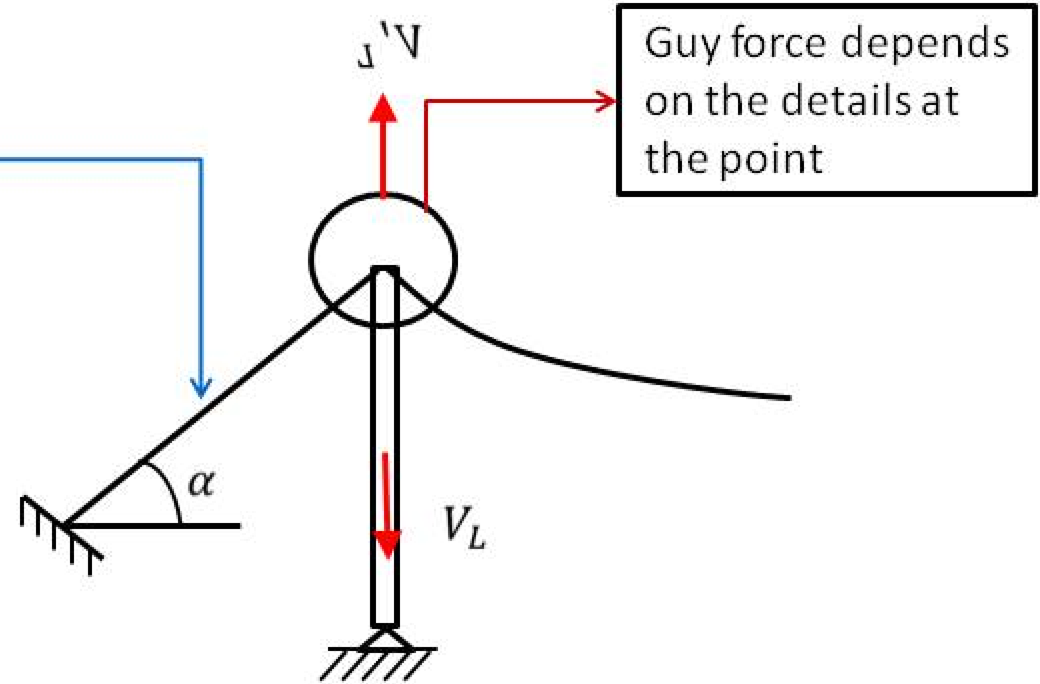
$$= \frac{25}{3}\ Kips \downarrow$$



Now truss member forces can be obtained in the usual manner. Verify that :$F_a = 13.33^k(+)$

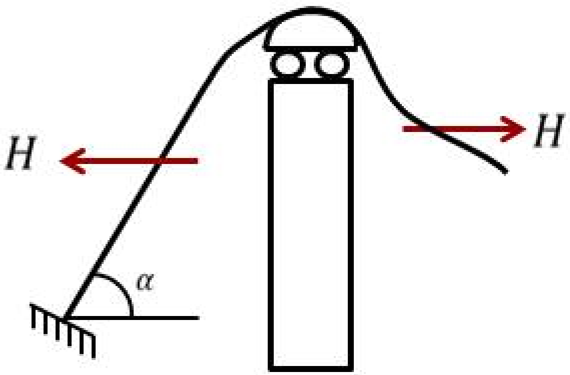
Side Span Cable

- Carries no suspended load
- Acts as guy to the tower



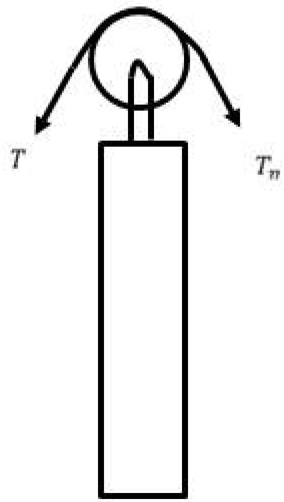
Three Possible Alternatives

(i) Saddle on rollers



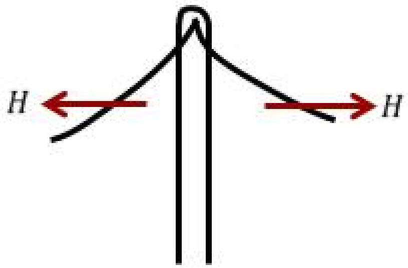
- H same in side and center spans
- T different .
- T in side span= $\frac{H}{\cos\alpha}$

$(ii) Pully$



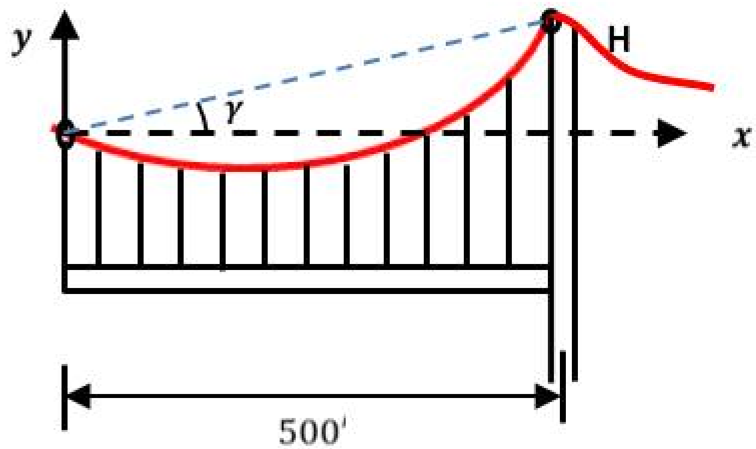
- Tension same in side span and end of center span
- $T_{in\ side\ span} = T_{max}$

(iii) Pins



$$T = \frac{H}{\cos \alpha}$$

Prob 10.2. Side-span Suspension Cable



$E = 27 \times 10^6\ psi$

$\tan\gamma = 0.7$

$w = 1000\frac{lb}{hor.ft}$(distributed hanger loads)

Sag ratio$= \frac{h}{L} = \frac{1}{40}$

Find:

(a) Max.slope of cable$\left(\frac{dy}{dx}\right)_{max}$

(b) T_{max}

(c) S

(d)Unstressed length

(a) Max.slope of cable $\left(\frac{dy}{dx}\right)_{max}$

$$y = \frac{4hx}{L^2}(x - L) + x\tan\gamma$$

$$\frac{dy}{dx} = \frac{8hx}{L^2} - \frac{4h}{L} + \tan\gamma$$

$$= \frac{8 \times 1 \times x}{40 \times 500} - 4 \times \frac{1}{40} + 0.7$$

$$= 0.0004x + 0.6$$

$\frac{dy}{dx}$ **is max. at** $x = max$ **i.e** $x = 500$

$$\left(\frac{dy}{dx}\right)_{max} = 0.0004 \times 500 + 0.6$$

$$= 0.8\ (An$$

(b) $T_{max} = ?$

Max. cable tension occurs where $\frac{dy}{dx}$ is maximum

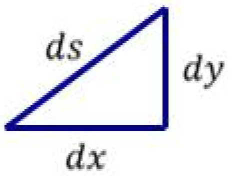
$$T_{max} = H.\frac{ds}{dx}$$

$$= H\sqrt{1 + \left(\frac{dy}{dx}\right)^2_{max}}$$

But $ds = \sqrt{(dx)^2 + (dy)^2}$

$$= \sqrt{1 + (\frac{dy}{dx})^2}.dx$$

Or $\frac{ds}{dx} = \sqrt{1 + (\frac{dy}{dx})^2}$



By G.C.T $H = \frac{wL^2}{8h}$

$w = 1^{k/ft}$

$= \frac{w \times L \times 40}{8}$

$\frac{h}{L} = \frac{1}{40}$

$= \frac{1 \times 500 \times 40}{8}$

$= 2500^k$

$T_{max} = 2500\sqrt{1 + 0.8^2}$

$= 3200^k (Ans)$

(c) S

$$S = \frac{L\sec\gamma}{2}\left(1+\frac{16\theta^2}{\sec^4\gamma}\right)^{1/2} + \frac{L\sec^3\gamma}{8\theta}\ln\left[\frac{4\theta}{\sec^2\gamma} + \left(1+\frac{16\theta^2}{\sec^4\gamma}\right)^{1/2}\right]$$

$$= \frac{500\times 1.22}{2}\left(1+\frac{16}{40^2\times 1.22^4}\right)^{1/2} + \frac{500\times 1.22^3}{8}\ln\left[\frac{4}{40^2\times 1.22^2} + \left(1+\frac{16}{40^2\times 1.22^4}\right)^{\frac{1}{2}}\right]$$

$$= 610.787\ ft \simeq 611\ ft$$

(d) Compute, to the nearest foot, the unstressed length of this cable

Cable stretch: $\Delta S = \frac{HL}{AE}\left[1 + \frac{16}{3}\theta^2 + tan^2\gamma\right]$

$$= \frac{2500 \times 500}{50 \times 27 \times 10^3}\left[1 + \frac{16}{3} \times \frac{1}{40^2} + 0.7^2\right]$$

$$= 1.38\ ft.$$

Unstressed length of cable= $Stressed\ \ length - Cable\ stretch$

$$= 610.787 - 1.38$$

$$\simeq 609\ ft$$