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WALKING A TIGHT ROPE

Last month, I saw a video where Nik Wallenda walked a 2" diameter wire rope 1,400' long that was 1,500' above the stream bed of a gorge near the Grand Canyon.

To view the video, put your cursor on the link below, press Ctrl and then click on the link to watch Nik walking the tight rope!

http://www.cbsnews.com/video/watch/?id=50149503n

I was intrigued, not so much by his walking ability, but by the layout of the cable across the canyon. I felt that this would be a practical application so I decided to use the Guyline Properties Program on my website and see if I could duplicate the configuration of the cable using the information above.

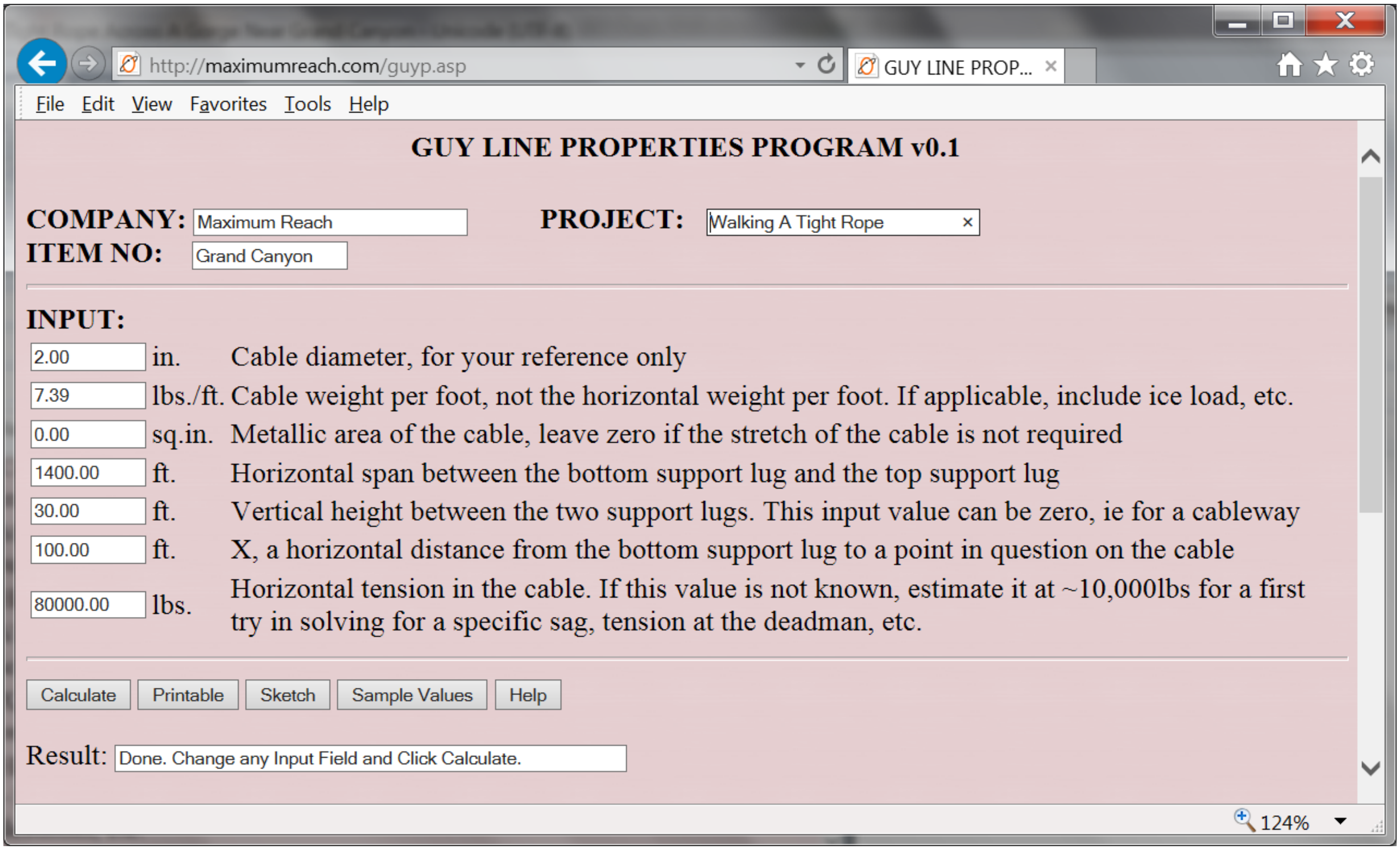
I couldn't tell in the video what kind of anchorage was used, but rock bolts and strand jacks would work very well in a remote area.

Thinking that it would be easier to walk if there wasn't too much sag in the cable and that it would be better to walk down hill if possible, I decided to limit the sag to about 25' and place the upper support 30' above the lower support.

Using 80,000 lbs (36.36 Te) of horizontal tension in the cable provided a sag of 22.64'. In the video, it looked like the cable sloped somewhat from the upper support down to the bottom support.

Note in the guyline properties program print outs below that if the support on the starting side of the canyon is 30' higher than the support on the far side of the canyon (the end of walk side), that the cable is almost all downhill with a small climb up at the end of the walk. Piece of cake.

INPUT DATA



GUY LINE PROPERTIES PROGRAM v0.1

COMPANY: Maximum Reach **PROJECT:** Walking A Tight Rope

ITEM NO: Grand Canyon

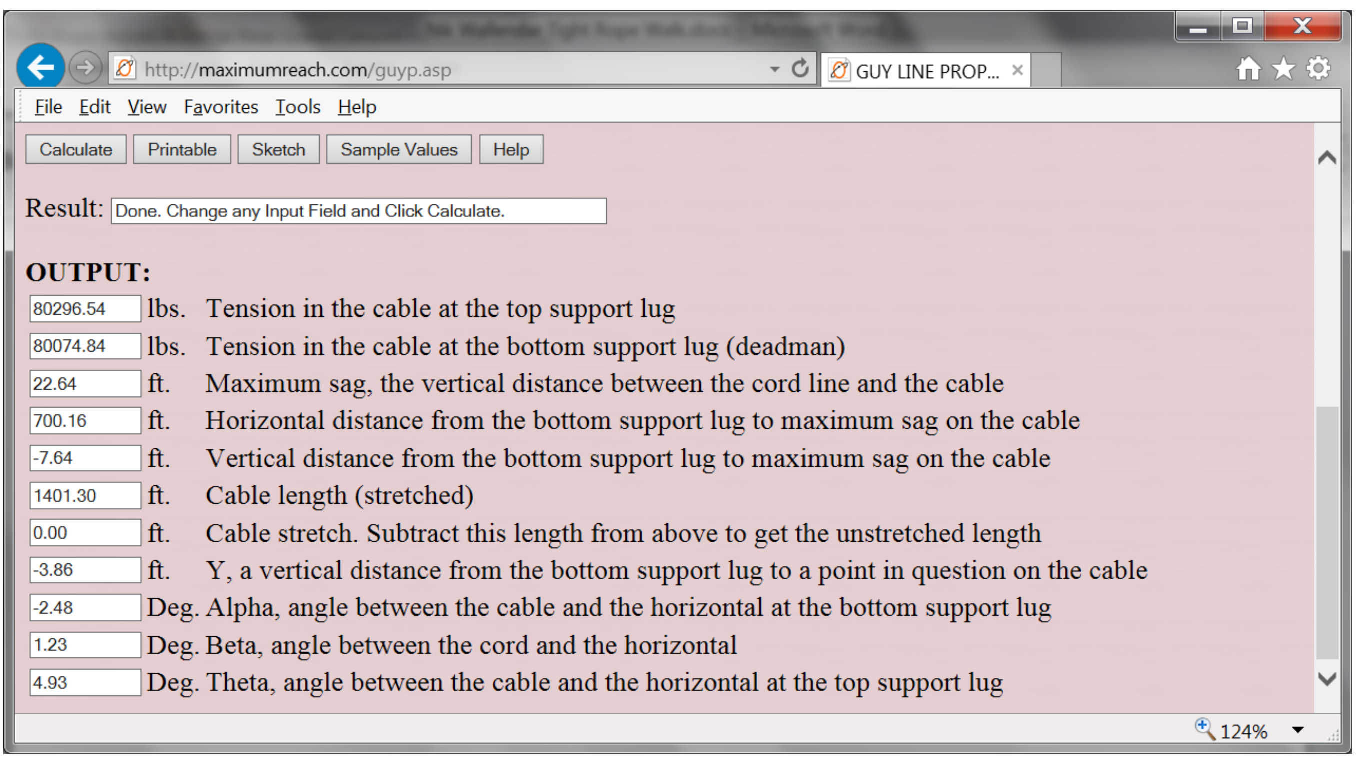
INPUT:

2.00	in.	Cable diameter, for your reference only
7.39	lbs./ft.	Cable weight per foot, not the horizontal weight per foot. If applicable, include ice load, etc.
0.00	sq.in.	Metallic area of the cable, leave zero if the stretch of the cable is not required
1400.00	ft.	Horizontal span between the bottom support lug and the top support lug
30.00	ft.	Vertical height between the two support lugs. This input value can be zero, ie for a cableway
100.00	ft.	X, a horizontal distance from the bottom support lug to a point in question on the cable
80000.00	lbs.	Horizontal tension in the cable. If this value is not known, estimate it at ~10,000lbs for a first try in solving for a specific sag, tension at the deadman, etc.

Calculate | Printable | Sketch | Sample Values | Help

Result: Done. Change any Input Field and Click Calculate.

OUTPUT DATA



Calculate | Printable | Sketch | Sample Values | Help

Result: Done. Change any Input Field and Click Calculate.

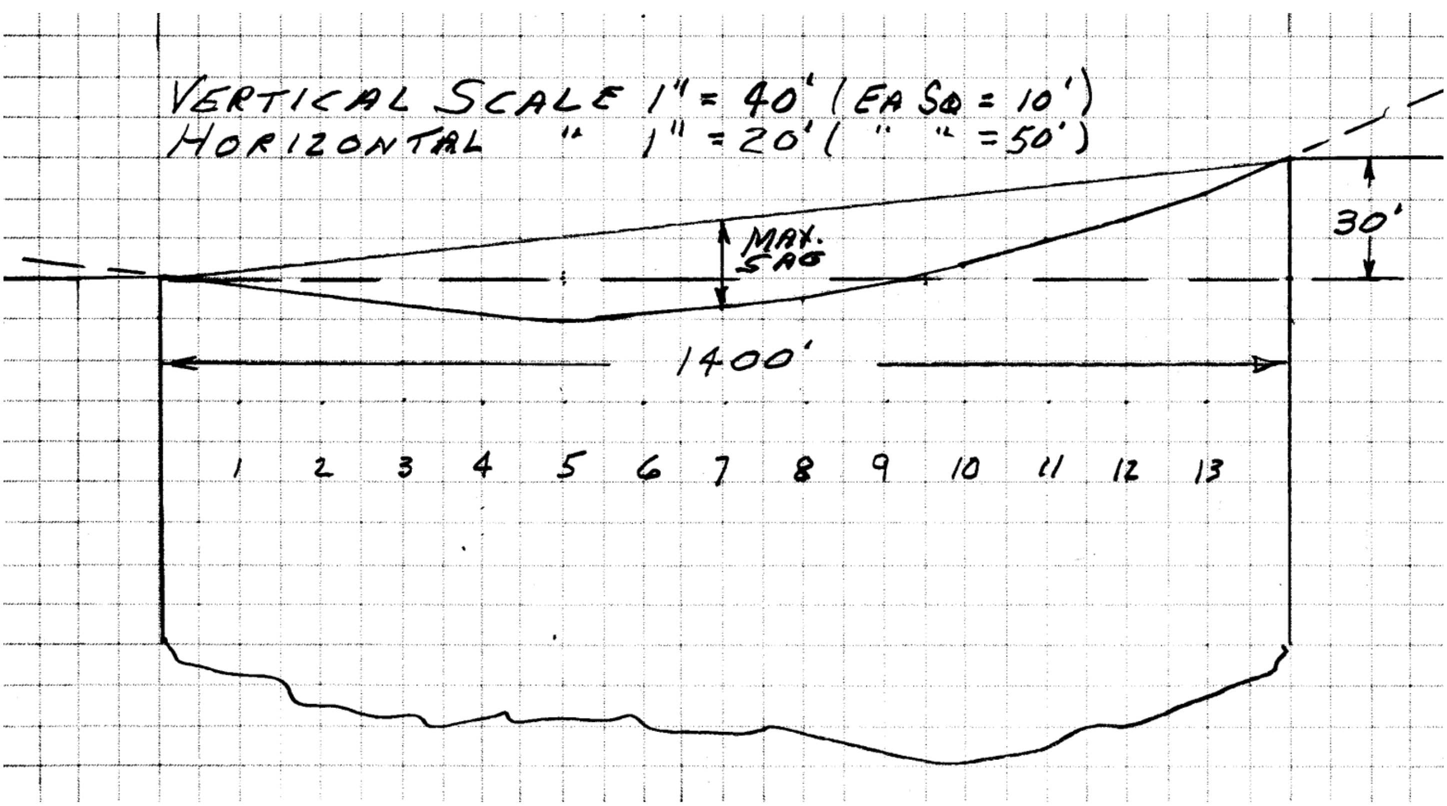
OUTPUT:

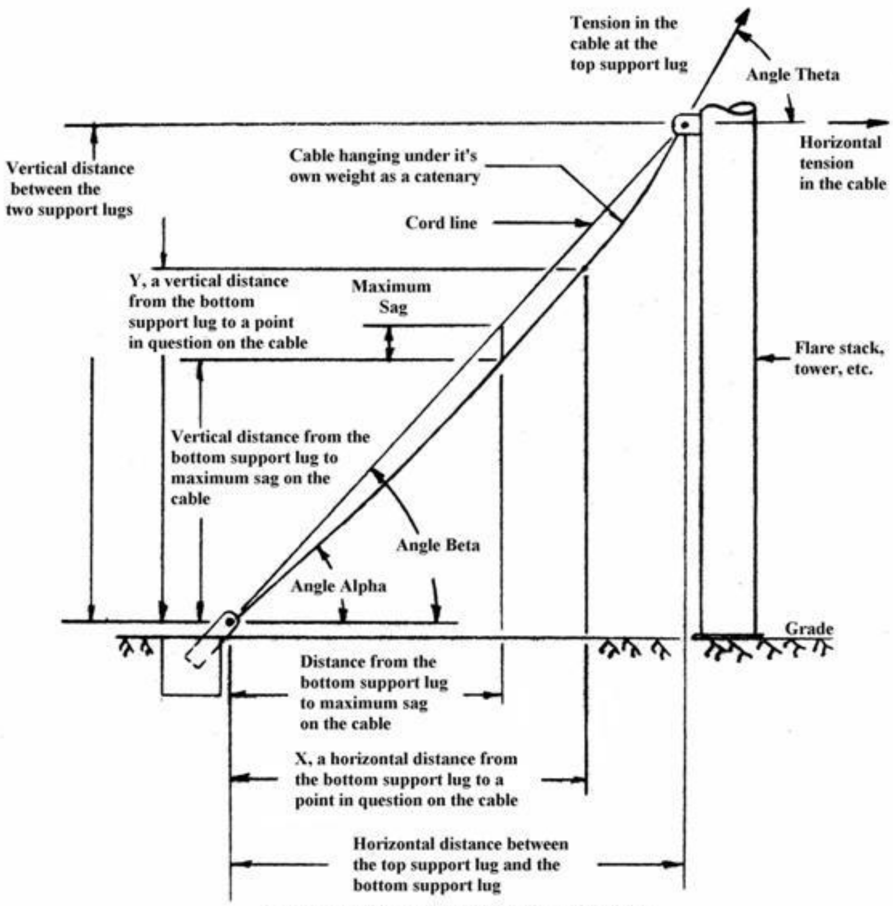
80296.54	lbs.	Tension in the cable at the top support lug
80074.84	lbs.	Tension in the cable at the bottom support lug (deadman)
22.64	ft.	Maximum sag, the vertical distance between the cord line and the cable
700.16	ft.	Horizontal distance from the bottom support lug to maximum sag on the cable
-7.64	ft.	Vertical distance from the bottom support lug to maximum sag on the cable
1401.30	ft.	Cable length (stretched)
0.00	ft.	Cable stretch. Subtract this length from above to get the unstretched length
-3.86	ft.	Y, a vertical distance from the bottom support lug to a point in question on the cable
-2.48	Deg.	Alpha, angle between the cable and the horizontal at the bottom support lug
1.23	Deg.	Beta, angle between the cord and the horizontal
4.93	Deg.	Theta, angle between the cable and the horizontal at the top support lug

By using my program and the input data and using X at 100′ increments, I found that for a:

X = 100′	Y = -3.8′
X = 200′	Y = -6.8′
X = 300′	Y = -8.8′
X = 400′	Y = -9.9′
X = 500′	Y = −10.1′
X = 600′	Y = -9.3
X = 700′	Y = -7.6′
X = 800′	Y = -5.1′
X = 900′	Y = -1.5′
X = 950′	Y = O.6′
X = 1000′	Y = 2.9′
X = 1100′	Y = 8.3′
X = 1200′	Y = 14.6′
X = 1300′	Y = 21.9′
X = 1400	Y = 30.0′

By plotting these values, they show that at the lower support, the cable starts off sloping down at an angle of −2.48 degrees, At about 500′ it bottoms out at 10′ below the lower support and starts sloping up. At about 950′ it crosses the level line from the bottom support. From there it continues to slope up until it is 30′ above the lower support, ie, to the level of the top support.





GUY LINE PROPERTIES SKETCH

I also made a run with the upper support 60' above the lower support. With the horizontal tension still at 80,000 lbs., the sag was about the same but the angle at the bottom was reduced to -1.25 degrees. So the cable was pretty much downhill all the way from the upper support.

The guyline properties program is used to find the properties of a cable hanging under its own weight as a catenary and does not take into account a load placed on it. I used it for the above example as the weight of a 200 lb. walker would not increase the tension in the cable very much due to the flatness of the cable and high tension required to maintain a 22.6' sag.

But a 200 lb. load would increase the tension somewhat. The following steps show how to calculate how much the increase in tension would be by keeping the sag the same as in the printout above. This information came from the United States Steel Handbook, page 46, shown below.

Tiger Brand Wire Rope Engineering Hand Book

United States Steel

Go to the following website to purchase a copy of this handbook:

http://www.ebay.com/itm/USS-TIGER-BRAND-WIRE-ROPE-ENGINEERING-HAND-BOOK-1946-/370622836420

INCLINED SPAN—SINGLE LOAD AT CENTER—ANCHORED

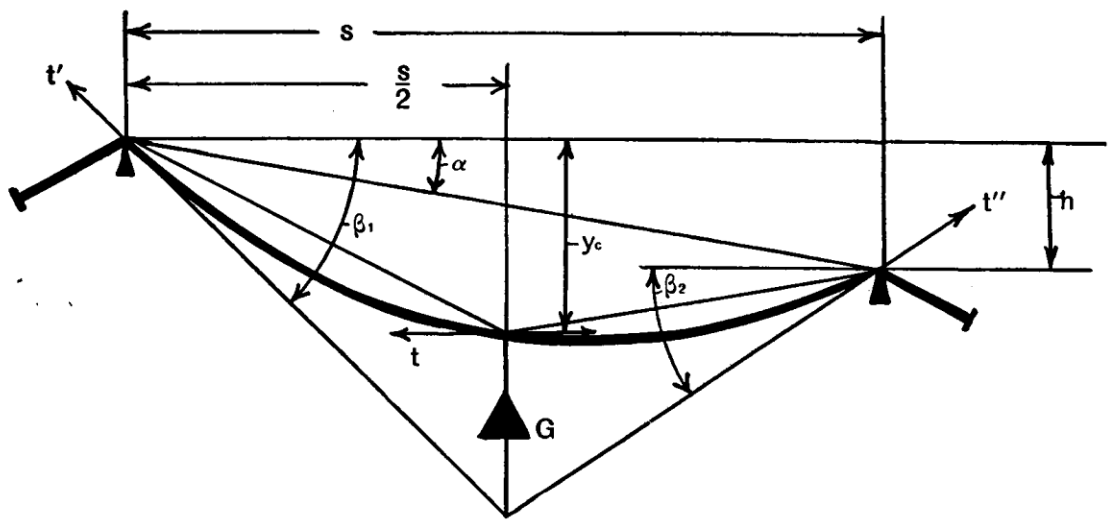


Figure 5

If the chord is inclined, similar to Fig. 5, then the center deflection is found by adding $\frac{h}{2}$ to (26). Then:

$$y_c = \frac{Gs}{4t} + \frac{ws^2}{8t} + \frac{h}{2} = \frac{s\,(2G + ws)}{8t} + \frac{h}{2} \quad (30)$$

$$t = \frac{s\,(2G + ws)}{8y_c - 4h} \quad (31)$$

y_c

$$t' = t \sec \beta_1 \qquad \text{See (28)}$$

$$t'' = t \sec \beta_2 \qquad \text{See (28)}$$

$$\tan \beta_1 = \frac{G + ws}{2t} + \frac{h}{s} \qquad \text{See (29)}$$

$$\tan \beta_2 = \frac{G + ws}{2t} - \frac{h}{s} \qquad \text{See (29)}$$

Reference the drawing and formulas above where the cable has an inclined span and a single load at the center. The tension in the cable is greatest when the load is at the center. Also, the tension in cable is greatest at the upper support. Notice that in the drawing that the horizontal reference line is taken at the upper support, whereas in my sketch it is taken at the lower support.

The horizontal tension T in a cable with a 200 lb. load hanging at the center of the span is:

T = S(2*G+w*S)/(8*Yc-4*H) where

S = the 1,400′ span
G = the 200 lb. load
w = 7.39 lb./ft of 2″ ϕ cable weight
Yc = the 37.6′ vertical distance from the lower support to the upper support + the vertical distance from the lower support to a point down on the cable at the center of the span which = 30′ between supports + 7.6′ from the printout above where X = 700′.
H = the 30′ vertical distance between the lower and upper supports

= 1,400(2*200 + 7.39*1,400)/(8*37.6 – 4*30) = 83,210 lbs.

The angle B1 at the upper support is:

Tan (B1) = (G + wS)/2*/T + H/S

= (200 + 7.9*1,400)/2*83,210 + 30/1,400 = 0.0848

B1 = 4.85° This closely matches the 4.93° found in the printout above

The tension T1 in cable at the upper support is:

T1 = T*Sec(B1) = T/Cos(B1) = 83,509 lbs.

So, the increase in tension due to a 200 lb. walker is 83,509 – 80,296 = 3,213 lbs.

The safe working load (SWl) of a 2″ ϕ EIPS wire rope is:

Breaking strength of a 2″ ϕ EIPS wire rope = 396,000 lbs.
The safety factor for a stationary wire rope ie, a guyline = 3.0:1
The safety factor for a running wire rope, ie, a hoist line = 3.5:1

So being conservative and using the 3.5:1 S.F.

The SWL of the wire rope is 396,000/3.5 ≈ 113,000 lbs.

113,000 lbs. > 83,509 lbs. ===➔ GOOD

It is not clear in the video how the cable is tied off or connected to the anchorage, but the worst case for a reduction in SWL for say using cable clamps would be 0.80 and a best case of 1.0 using spelter sockets.

113,000 lbs. * 0.80 $\approx$ 90,000 lbs. ====➔ STILL GOOD

END OF PRESENTATION