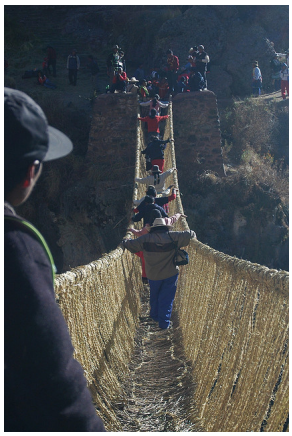
Funicular Form Example:
Incan Grass Bridge
Single Load vs. Distributed Load

THAYER SCHOOL OF ENGINEERING AT DARTMOUTH



Let's look at an Incan suspension bridge made from grass cables. Here is a great video describing the building of an Incan Grass Bridge:

http://www.pbs.org/wgbh/nova/education/ancient/grass-bridge.html

Figures: Q'eswachaka bridge in Peru. Photo by Carlos Díaz https://flic.kr/p/RqfJC
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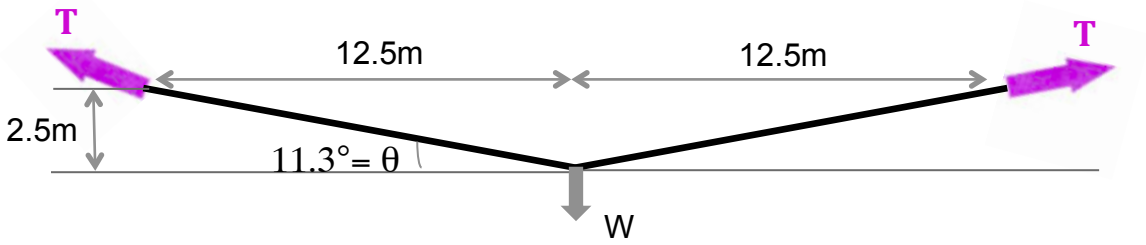
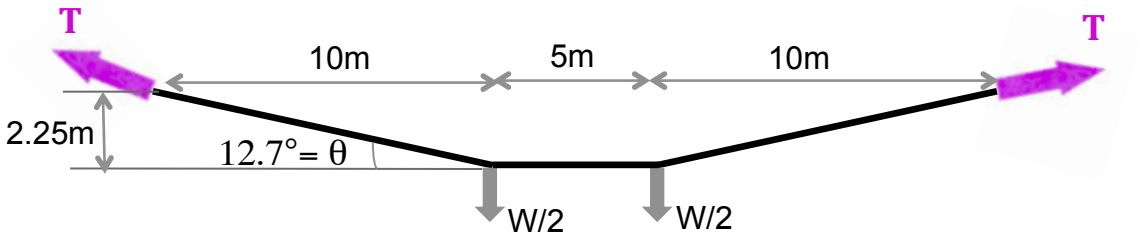
Based on testing done at Cornell University we know that each of the main cables of the bridge can support about 18.5kN: http://www.ce.jhu.edu/perspectives/handouts_unprotected/inca_bridge.pdf

Let's focus on a simple Incan suspension bridge with just one cable. We need to lift a heavy object from below and are planning to use an Incan grass rope. I am wondering if it is better to lift the object from a single point or to distribute the load by lifting it at two points. Knowing that the span of the bridge (25m) and length of the cable (25.5m) will not change we can figure out the geometry for the two scenarios.

Scenario 1:



Scenario 2:



Based on what we've seen from previous problems, we know that the tension in the cable on either side will need to be the same in order to maintain horizontal equilibrium so I'll just call both values T for tension. Using vertical equilibrium we should be able to calculate the tension force in the cable.

Scenario 1:

$\Sigma F_y = T\sin 11.3° + T\sin 11.3° - W = 0$

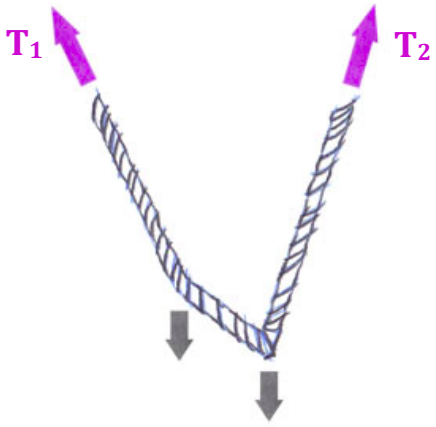
$T_{\text{scenario 1}} = 2.55W$

Scenario 2:

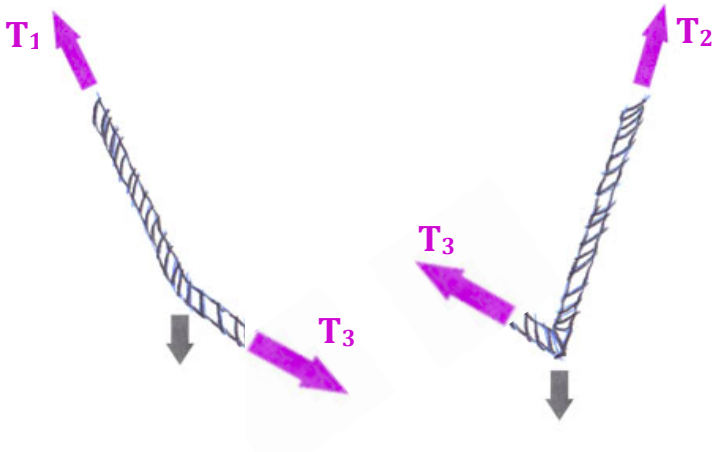
$\Sigma F_y = T\sin 12.7° + T\sin 12.7° - W/2 - W/2 = 0$

$T_{\text{scenario 2}} = 2.27W$

Distributing the load between two locations will result in a smaller tension force in the rope. Because the loading was symmetric and we distributed it evenly we were able to use horizontal and vertical equilibrium much as we had done for a single load on the cable. For uneven or unsymmetric loading you'd need to look at each loading point separately or use rotational equilibrium; I will introduce rotational equilibrium in the suspension bridge example.



Funicular form with uneven loading



Free-body diagrams for funicular form with uneven loading