Homework #2: Arches

Given: Class #4
Due: Class #7

1) As the structural guru in Gehry's office, you must propose a system for carrying column loads over a truck loading zone in the basement of a new building. The inclined columns carry the weight of five stories above and this load must be transferred over an open space as illustrated in Figure 1. Each column carries an axial load of 400 kips and is inclined at a slope of 4:1 from the vertical as shown.

a) Label the problem using Bow's notation to facilitate a graphical solution.

b) On a separate piece of paper, draw the load line for the problem using the loads given in Figure 1. (You may choose to draw the force polygon at a convenient scale.)

c) Using graphic statics, propose a structural solution in axial compression for the problem which does not interfere with the zone marked by a dashed line in Figure 1. Your arch must be supported on the granite foundation beneath the building and should be horizontal at the crown of the arch. Sketch your design on Figure 1. (Note: you may wish to experiment with several trial pole locations before deciding on the final form.)

d) Based on the force polygon for this problem, which element of the arch carries the highest load? Using concrete with an allowable stress of 3,000 psi (3 kips/in^2), what is the minimum required cross-sectional area?

e) Based on the results of (d), propose a suitable cross-section for this part of your arch.

f) In terms of construction, name one advantage and one disadvantage to your proposed system.

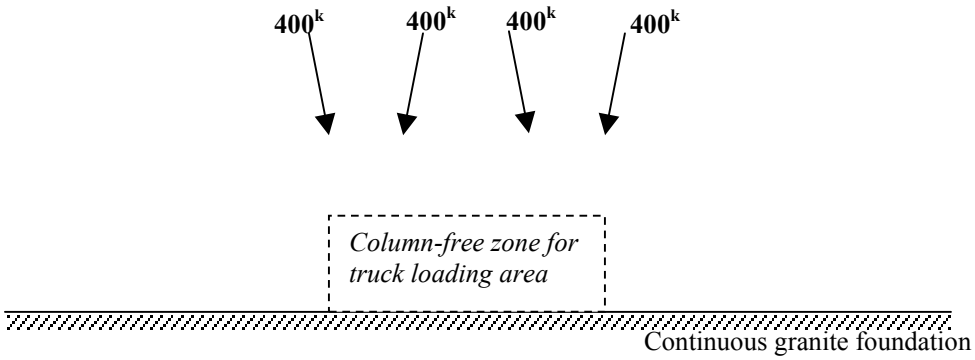

Figure 1

-over-

2) You are designing an arch pedestrian bridge over a canal in Lowell. The span of the bridge is 80 feet and the bridge must support its own weight of 1.5 kips/foot along the length of the bridge. The deck will be suspended from the arch by a vertical cable every 10 feet, so that the arch is loaded with eight vertical loads of 15 kips each. (Note: We have converted the uniform load on the bridge to a point load acting at each cable.) In other words, the arch will be located above the deck and the roadway will *hang* from the arch. Due to poor soil conditions, the thrust of the arch must be resisted by a horizontal tension member contained within the bridge deck.

a) Label the problem using Bow's notation.

b) On a separate piece of paper, draw the load line for the problem using the loads given in Figure 2. (Again, you should choose a convenient scale.)

c) Using graphic statics, propose an arch design with a maximum compression force of 120 kips. Sketch your solution on Figure 2.

d) What is the magnitude of tension force in the deck for your arch design?

e) The analysis above assumes that a single arch in the center of the deck supports all of the load. It is also possible to support the bridge with two parallel arches (one on either side of the deck), which share the load equally so that each arch supports half of the load. If two parallel arches were used, and the maximum compression force in any element is still 120 kips, how does the geometry of the arch change? Draw this new solution on a separate piece of paper.

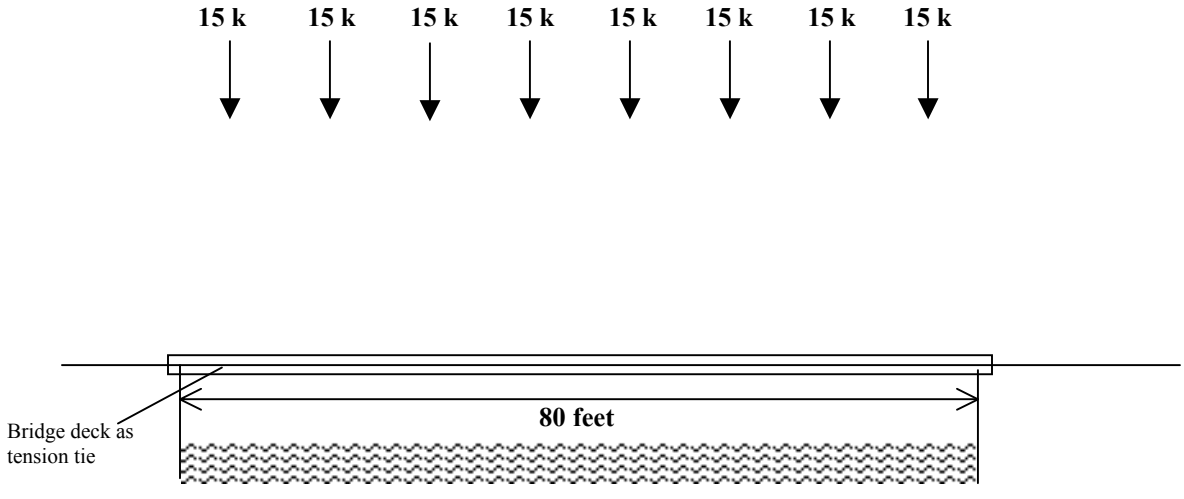

Figure 2