Lesson 16: Arches

"As hangs a flexible cable, so, inverted, stand the touching pieces of an arch". Robert Hooke (1635-1703).

Lesson 16: Arches
Monday, October 3, 2016

Lesson Objectives
1. Define an arch.
2. Define and Identify a funicular arch.
3. Determine the geometry for a funicular arch.
4. Compute the internal forces and moments in a determinate (3-pinned) arch or an indeterminate funicular arch.
5. Explain why one could correctly analyze a 3-DOI fixed base arch, treating it as a determinate three-pinned arch analysis IF (and only IF) the arch is funicular.
6. Illustrate why traditional masonry arches are actually made stronger and safer by piling more dirt onto the stone arch.

References: See website powerpoint and supplementary reading.

Homework (Due Wednesday. Standard Homework. Presentation Counts)
0. (On your own. Do not hand in).
   TRUE or FALSE. The structure below is an arch, but it is not a funicular arch.

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1. Whereas Frame A has Arch Action, Frame B does not. Plot the internal moment diagram on the frames shown using the usual sign convention (plot the moment diagram on the compression side of the structure). Then, compare the magnitudes of maximum moment with and without Arch Action.
   Given: Frame A has DOI=1. Consequently, you must be given the horizontal support reactions as follows: $A_x = 7.09$ kips to the right, $E_x = 7.09$ kips to the left.

The arch below has the same height, span, and loads as previous Frame A, but it is funicular. If the arch below is parabolic and (therefore) funicular, answer the following:
   a. Knowing that the arch has a parabolic shape, given in the form of $y = Ax^2$ with the origin and directions shown, determine the constant $A$. 

2. The arch below has the same height, span, and loads as previous Frame A, but it is funicular. If the arch below is parabolic and (therefore) funicular, answer the following:
   a. Knowing that the arch has a parabolic shape, given in the form of $y = Ax^2$ with the origin and directions shown, determine the constant $A$. 

b. Determine the compressive force in the arch at point A. (hint: knowing the equation of the parabola, you can now determine the angle the arch makes at point A).

c. Determine the compressive force in the arch at the origin (midspan).

d. If the cross-section of previous Frame A and this Frame C are both 6”x6” solid shapes, compare the maximum stresses of Frame A and Frame C (remember P/A +/- Mc/I)

3. **IF THE FOLLOWING PROBLEM CAN BE SOLVED WITH STATICS**, determine the maximum stress in member AB. First, determine if the problem can be solved by statics, alone; then, if it can be solved, determine the stress in member AB. Given: fixed foundation supports. The cross-section of the arch consists of a 6”x6” solid, made from timber.

4. **IF THE FOLLOWING PROBLEM CAN BE SOLVED WITH STATICS**, determine the maximum stress in member AB. First, determine if the problem can be solved by statics, alone; then, if it can be solved, determine the stress in member AB. Given: fixed foundation supports. The cross-section of the arch consists of a 6”x6” solid, made from timber.