ENGN1300: Structural Analysis

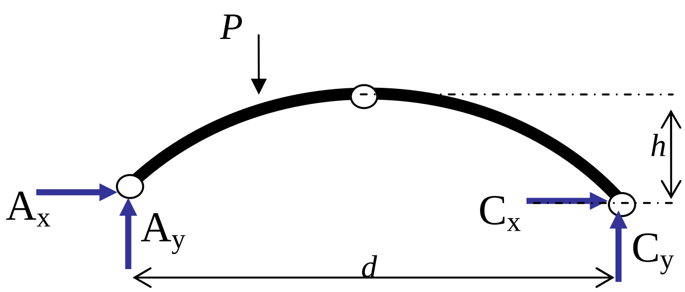
Homework 7
Due Friday April 9, 2010

Division of Engineering
Brown University

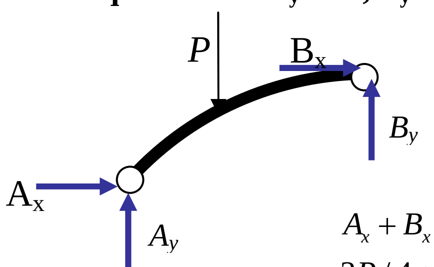
1. Recall the Salginotabel Bridge (d=90m, h=13m) from the previous problem set. The bridge was designed to carry a live load of 350 kg/m^2, which when multiplied by the width of 3.5 m, gives 12 kN/m. In designing the bridge, the live load must be applied in the worst case scenario. Although distributing the live load uniformly over the bridge gives rise to the highest axial forces, higher internal moments may be generated if the span is only partially loaded. To simplify the analysis, we represent the distributed live load by 3 equal concentrated loads, each separated by a distance equal to the quarter span. The magnitude P of these loads is equal to the load over a quarter span, multiplied by a reduction factor of 0.9, due to the more severe effects of a concentrated load. Thus,

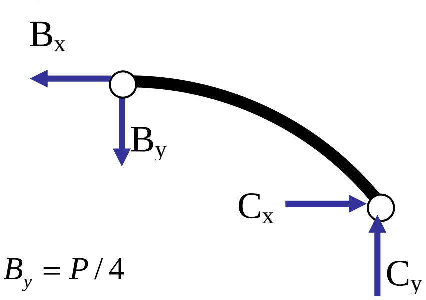
$$P=0.9\times(12\text{kN/m})\times(90\text{m}/4)=244\text{ kN}$$

   a. Calculate and plot the internal moments due to the live load when the bridge is partially loaded with a single load P at quarter span



Global equilibrium: $C_y=P/4$, $A_y=3P/4$, $C_x=-A_x$,





$$A_x+B_x=0$$

$$3P/4+B_y=P\Rightarrow B_y=P/4$$

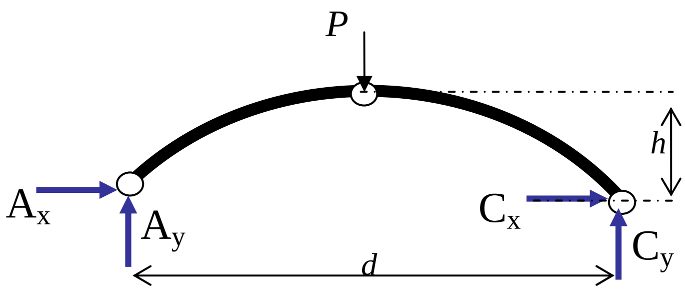
$$-P\frac{d}{4}-B_xh+B_y\frac{d}{2}=0\Rightarrow$$

$$B_x=-\frac{Pd}{8h},\quad A_x=\frac{Pd}{8h}=-C_x$$

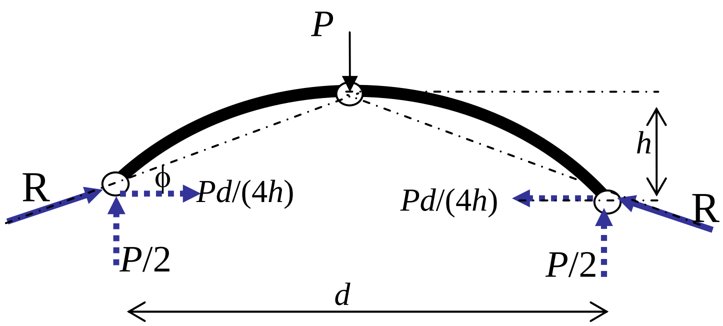
Moments:

$$M(x) = 3\frac{P}{4}x - \frac{Pd}{8h}y(x) \ (0 < x < d/4)$$
$$M(x) = 3\frac{P}{4}x - P(x - d/4) - \frac{Pd}{8h}y(x) \ (d/4 < x < d/2)$$
$$M(x) = \frac{P}{4}(d - x) - \frac{Pd}{8h}y(x) \ (d/2 < x < d)$$

b. Calculate and plot the internal moments due to the live load when the bridge is partially loaded with a single load *P* at midspan.

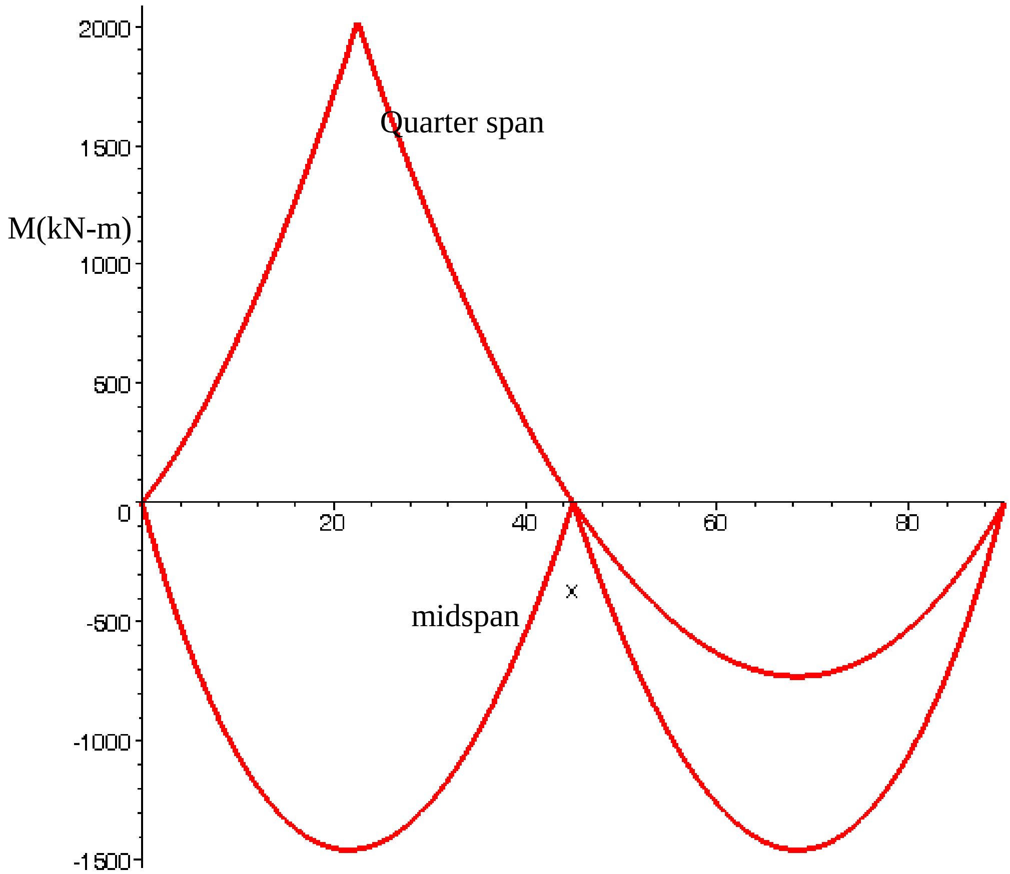


Members AB and BC are two-force members and so the force lines of action pass through AB and BC, respectively. By symmetry, the forces are the same.
$A_y=C_y=R\sin\phi=P/2$. $R=P/(2\sin\phi)$, $\phi=\tan^{-1}(h/2d)$ $A_x=-C_x=R\cos\phi=Pd/(4h)$



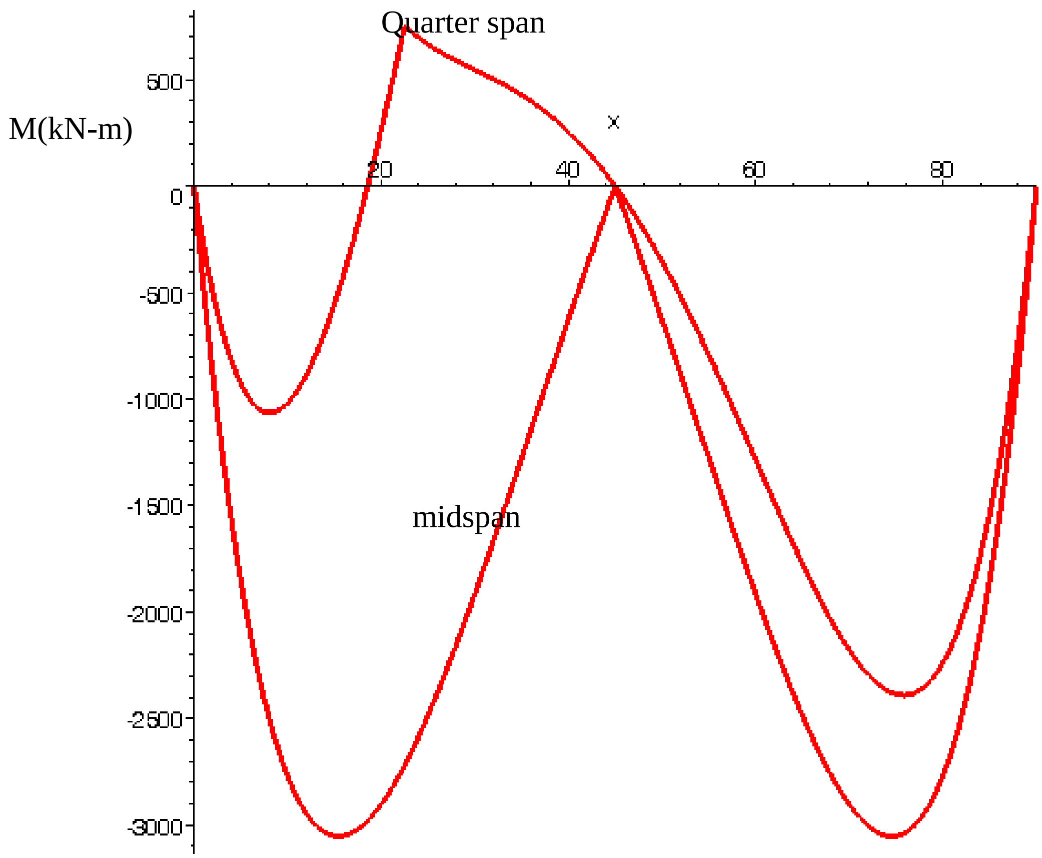
Moments:

$$M(x) = \frac{P}{2}x - \frac{Pd}{4h}y(x) \ (0 < x < d/2)$$
$$M(x) = \frac{P}{2}(d - x) - \frac{Pd}{4h}y(x) \ (d/2 < x < d)$$



c. Which of these two live load situations gives the highest moment when the 7500kN dead load of the bridge is included? You can use the estimate for the moments due to dead load arrived at in problem 3a of problem set 6.

See graph:



Quarter span
M(kN-m)
500
0
-500
-1000
-1500
-2000
-2500
-3000
20
40
60
80
x
midspan