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,

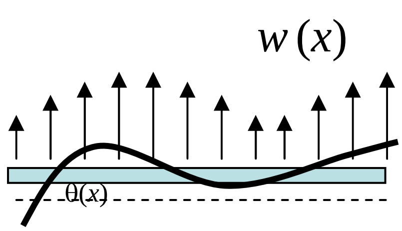
$$P=0.9\times(12\text{kN/m})\times(90\text{m}/4)=244\text{ kN}$$

   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. (Do not include the dead load)

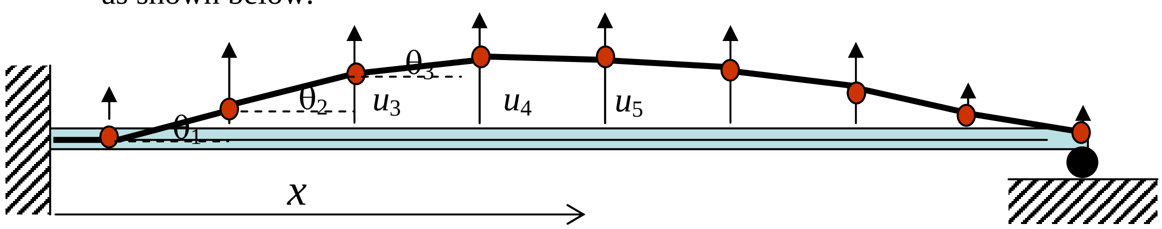
   b. Calculate and plot the internal moments due to the live load when the bridge is partially loaded with a single load *P* at midspan. (Do not include the dead load)

   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.

2. In this problem, you will set up an Excel spreadsheet that will calculate the deflections and moments in a beam subject to loading *w*(*x*) using energy minimization.



As described in class, divide a beam of length L_0 into N segments, each of length s as shown below.



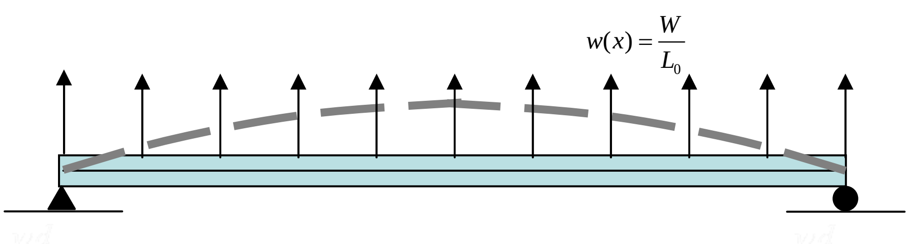
The beam deflections are determined by the angles θ_i:

$$u_1 = s\sin\theta_0, \quad u_2 = u_1 + s\sin\theta_1 \;\; .... \;\; u_i = u_{i-1} + s\sin\theta_{i-1}$$

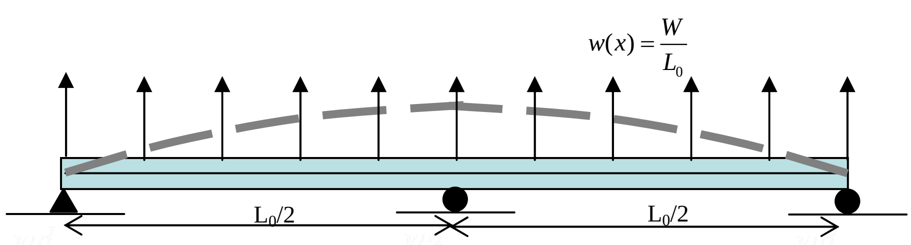
and the curvature at point i is $\kappa_i=(\theta_i-\theta_{i-1})/s$. The elastic energy due to bending is computed at node i as $V_i = \frac{s}{2}EI\kappa_i^2$. The load at node i is $W_i=w(x_i)s$ (i=1,2,…N-1), $W_0=w(0)s/2$, $W_N=w(L_0)s/2$, and so the associated energy is $W_i u_i$. The total energy for the beam is the sum of elastic and load energy: $V = \frac{1}{2}EIs\sum_{i=1}^{N}\frac{(\theta_i-\theta_{i-1})^2}{s^2} - \sum_{i=0}^{N}W_i u_i$. Use the solver to minimize V by varying the angles θ_i subject to constraints introduced by the boundary conditions. Calculate the internal bending moment at each node point.

Run the following cases. In each case, normalize by setting EI=1, W=1, and L_0=1 and plot the moment and deflection. For case (a) plot the beam theory deflection and moment (from your ENGN0310 book or elsewhere) along with the Excel prediction.

a)



b)



c)