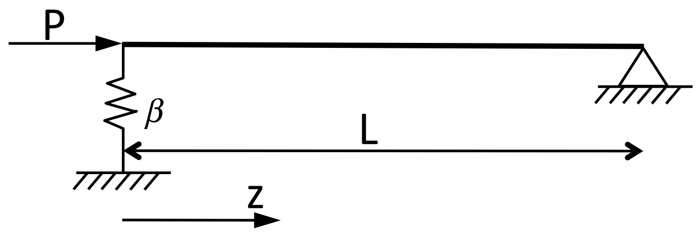
Exam No. 1 CE 579: Structural stability Due: November 14, 2014

Problem no. 1 (25)

Consider the case of a column that is pinned at one end, and braced at the other end by an elastic brace with stiffness equal to beta (β). Assume that the differential equation for column flexural buckling governs, and the solution is of the form:

$$v = A + Bz + C\sin(kz) + D\cos(kz)$$



where,

z is the location along the length of the column,

k = $\sqrt{P / EI}$

P = applied axial force

EI = elastic flexural stiffness of column

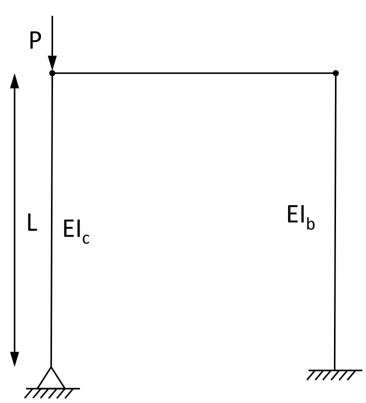
Assume that the braced end is located at z=0.

Substitute the boundary conditions, and develop the eigenvalue problem for buckling analysis. Show all your work and calculations, and then answer the following questions:

Q1. What are the two buckling modes and loads that are possible? Develop a plot to show the variation of the buckling loads (and modes) as the spring stiffness β is increased.

Q2. What is the minimum value of the brace stiffness (β) so that column flexural buckling mode governs?

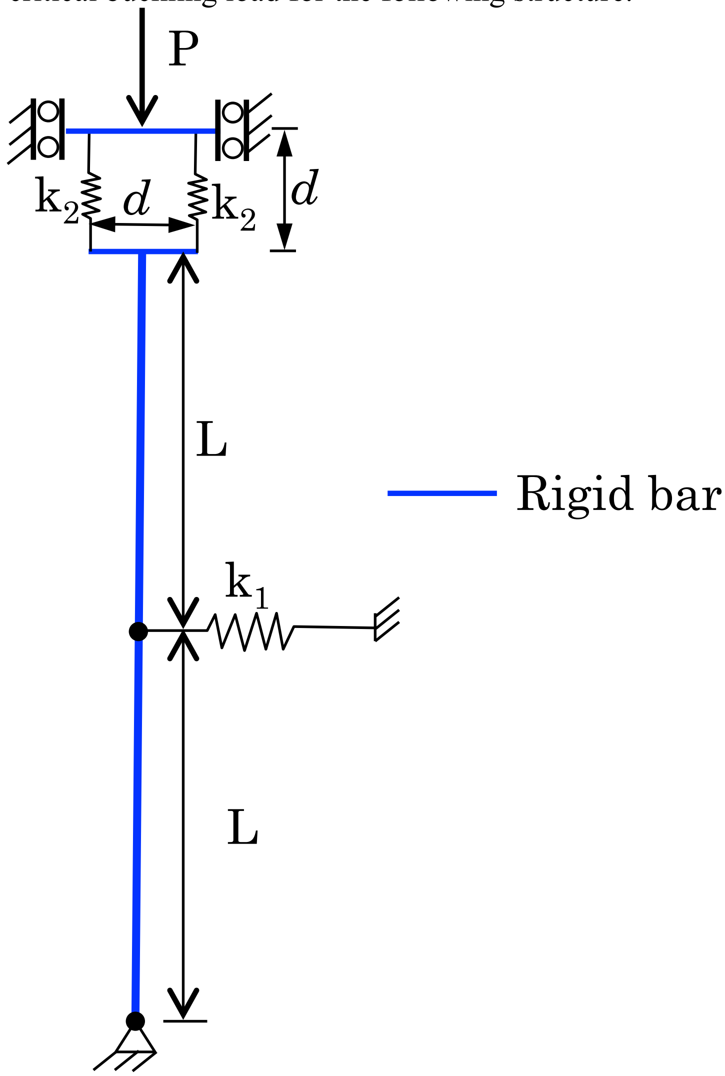
Q3. What is more important for design: brace required strength, or brace required stiffness?



Q4. Consider the simple frame shown above. The member on the right braces the column subjected to axial force P. What is the required stiffness (EI_b) of the bracing member on the right so that column flexural buckling governs?

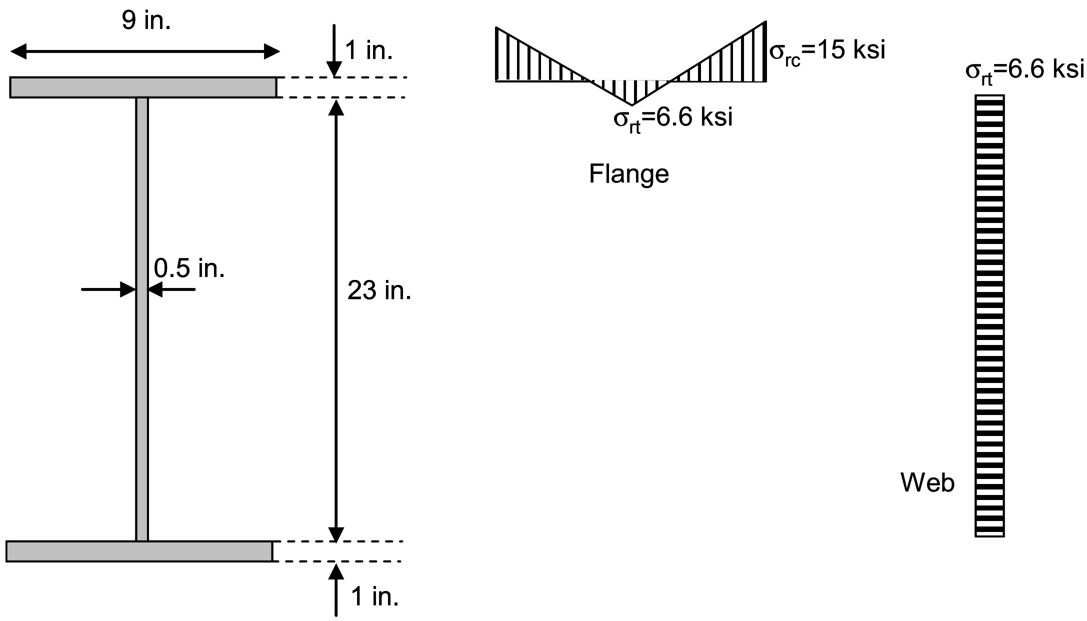
Problem No. 2 (15)

Calculate the critical buckling load for the following structure.



Problem No. 3 (40)

Consider the steel column cross-section shown below. The dimensions are indicated in the figure. Assume that the steel material is elastic-perfectly plastic with yield stress σ_y=50 ksi. The residual stress pattern for the column shape is also shown below. If needed, adjust the value of the tensile residual stress to achieve zero force from integrating residual stresses over the cross-section.



Develop an algorithm and implement it using software tools to numerically develop and report using tables and charts (as needed):

(a) The stub column σ–ε curve for this column cross-section in compression

(b) The column-buckling curves accounting for elastic and inelastic buckling about the x and y-axes and the effects of residual stresses.

(c) The column curves must be plotted on the same graph with λ on the x-axis and σ_{cr}/σ_Y on the y-axis.

(d) Plot the AISC LRFD column curve on the same graph as the column-buckling curves for the given cross-section. How does the LRFD curve compare?

Problem No. 4 (20 points)

As an engineer you are required to design a steel column made from A992 (50 ksi steel) to carry a dead load of 200 kips and a live load of 800 kips. The column has an unsupported length of 14 ft. For buckling about the major axis, the column is fixed at the base and **only** restrained against rotation at the top. For buckling about the minor axis, the column is pinned at the top and bottom. Use the design K values given in AISC – LRFD.

Upon construction of the structure, the site engineer calls to tell you that some mistakes were made in the fabrication and erection process:

(a) You had specified a hot-rolled steel column, but due to market fluctuations, your specified shape could not be obtained. Instead, a welded built-up column was fabricated. The column was fabricated with universal mill steel plates that had dimensions close to the specified rolled shape. The plate dimensions were to nearest 1/8 in. of the rolled shape dimensions.

(b) During erection, the column was constructed with a pin connection at the base for buckling about the major axis!

(c) The certified mill test report for the steel plates came in at an average value of 49 ksi.

As the engineer of record, you need to make a decision regarding the adequacy of the column that has been built. Is the implementation of your design going to be ok? How will you check it? Explain your reasoning with design calculations.