Buckling of Slender Members

Objective:

- To determine the l critical loads of slender members.
- To observe the load-deflection behavior of slender members under compressive load.

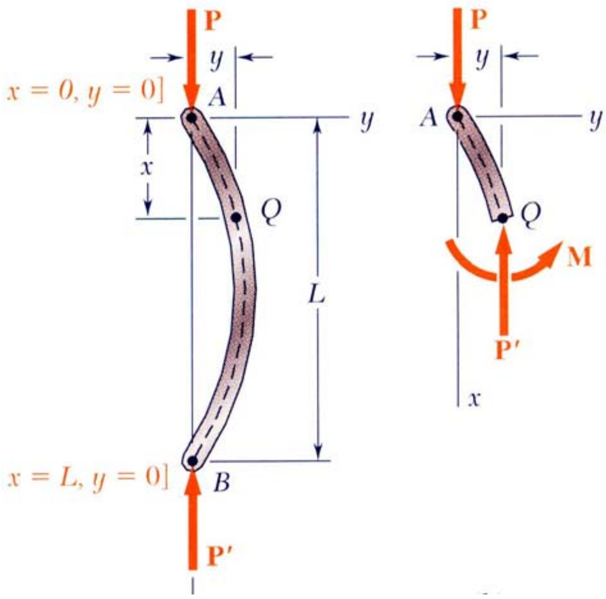
Preparation: (i) Loading frame, (ii) Load cell, (iii) LVDT, (iv) DC power supply, (v) LVDT signal conditioner, (vi) PC and data acquisition system

Background:

If a short member is subjected to compressive load, failure will occur by yielding of the material. However, if the member is relatively long a different type of behavior will be observed. When the compressive load reaches a critical value the lateral deflection will become significant. This behavior is called "buckling" and can occur even though the maximum stress in the column is less than the yield stress of the material. The critical load is affected by material properties, member length, cross section, and boundary conditions.

Consider an axially loaded beam with both ends pinned. After a small perturbation, the system reaches an equilibrium configuration such that

$$\frac{d^2y}{dx^2}=\frac{M}{EI}=-\frac{P}{EI}y$$



$$\frac{d^2y}{dx^2} + \frac{P}{EI}y = 0$$

Solution with assumed configuration can be obtained if

$$P = P_{cr} = \frac{\pi^2 EI}{L^2}$$

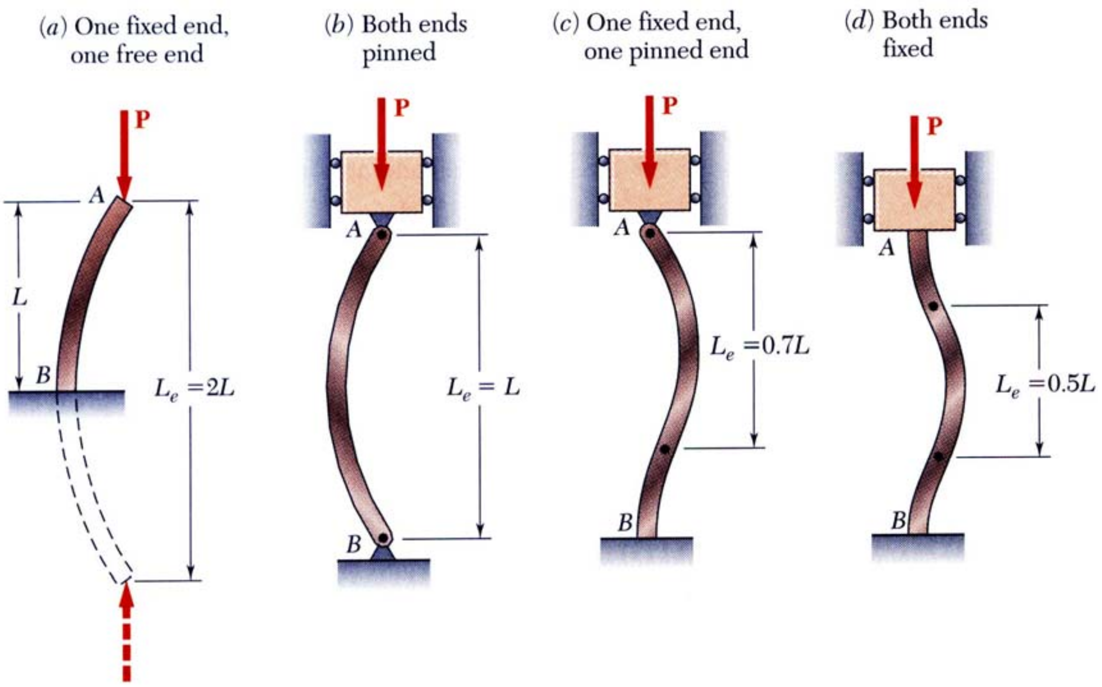
The value of stress corresponding to the critical load,

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 E\left(Ar^2\right)}{L^2 A} = \frac{\pi^2 E}{\left(L/r\right)^2} = critical\ stress$$

where $r = (I / A)^{1/2}$ is the radius of gyration and

$$\frac{L}{r} = slenderness\ ratio$$

For members with other boundary conditions, the effective length L_e are summarized in the figure below:



Procedure:

1. Calibrate LVDT.
2. Tighten the load cell on the cross head of the loading machine. Adjust the position of the cross head to fit the length of the specimen. Place the test specimen in the testing machine.
3. Measure the dimension of the cross section for the specimen. Check to see if the specimen is bowed to one side. Measure the distance between the grips.
4. Connect the LVDT to measure the displacement of the cross head.
5. Slowly apply a compressive load while recording both displacement and load. Carefully watch the bar to see when lateral deflection starts. Continue until the bar buckles.
6. Repeat for the other specimens.

Report:

1. Record the dimension and material properties of the specimens.
2. Plot the measured load-displacement curve and identify the buckling load P_{cr} .
3. Use the effective length L_e of the specimens to calculate the theoretical critical loads.
4. Plot theoretical curves of *critical stress* vs. *slenderness ratio*. Plot the "raw" data on the same plot.
5. Discuss the results and draw appropriate conclusions.