Engineering: 5312 **Mechanics of Solids II**

Lab Test #3 – Buckling of Columns

OBJECTIVES:

1. To observe the buckling behaviour of columns and estimate their buckling loads
2. To measure the lateral deflection of the columns during axial compression
3. To compare the analytical and experimental values of buckling loads of columns
4. To obtain the deflection behaviour of columns with slight initial bent shape
5. To find he effects of material properties and end restraint on column behaviour

TEST SPECIMENS

A set of compression members made of different materials and end conditions.

EQUIPMENT

1. Structural testing frame for applying compression fitted with appropriate (hinge-hinge) end restraints, loading screw and load cell
2. Data acquisition unit connected, if available
3. Dial gauge and/or Linear potentiometric displacement transducer (LPDT) for measuring displacements
4. Measuring instruments (callipers, etc.) as required

PROCEDURE

1. The set-up for this experiment is shown in Figure 1.
2. Using the appropriate instruments, measure the length, width and height of the specimens from (sharp) end to (sharp) end. Note the type of material and the shape of the ends of each of the specimens. Record the material properties of the specimens as supplied by the manufacturer.

3. Mount the specimen in the set-up such that the specimen is snug (with any gap and without any appreciable initial load). Make sure that the loading screw has sufficient 'travel' to apply the load. Measure the location of LPDT along the column. Do you notice any crookedness in the specimen? Is it theoretically straight? Why is this important? What is the general order of the crookedness in such columns, if it exists? How would you take care of the crookedness, if present?
4. Check the data acquisition system, the personal computer and driving software, if you are using one. Familiarize yourself with their operation.
5. Set the initial values of load, axial displacement and lateral displacement to zero.
6. Load the column (gently) in increments of as explained by the TA or the Technician. After placing each load increment, allow the system to stabilize before logging the data.
7. Load until the lateral displacement becomes noticeable or until instructed to stop. Do you think that you observed 'sudden buckling'? If it is not sudden buckling, what would be the reason for 'gradual buckling'? Ideally, at what point would you stop loading? Do you consider this as elastic buckling? Explain why (or why not). After reaching the maximum load, release the load in the same decrements as in the loading stage. Again log the deflections for each ***decrement***. Do you still consider this as elastic buckling even after you unload the specimen?
8. ***Repeat the experiment with the available specimens***.

Theoretical Derivations

1. Derive the theoretical formula for the buckling of perfectly straight columns for the end conditions that you noted on the specimens. It should be in the form of the Euler formula:

$$P_{cr} = \frac{\pi^2 EI}{(kL)^2} \tag{1}$$

Explain why the length of the specimen should be measured from the tapered tip. Does the fact that the tapered tip has smaller moment of inertia compared to the rest make a difference to the buckling calculation?
2. Derive, if you can, the formula for the deflection of an initially bent column. The governing equation would be:

$$\frac{d^2 v}{dx^2} + \frac{P}{EI}(v + v_0) = 0$$

where, v_0 is an approximate initial shape. For convenience, this shape can be taken as a half sine curve with a maximum initial deflection of e at mid height if the column. This shape will then be, $v_0 = e \sin \frac{\pi x}{L}$.

ANALYSIS

1. Produce plots of measured displacements vs. applied load. Overlay this with theoretical displacements. Comment on the comparisons. Note that the Load should always be on the vertical axis. Using the measured lateral displacements, could you guess the value of initial bent displacement "*e*" of the column?
2. From the plots of experimental displacements, locate the buckling loads and compare it with the theoretical values. Comment on the accuracy of using the manufacturer's recommended value of the Young's modulus. If you were to guess the Young's modulus from the experimental results, what would it be?
3. Comment on the behaviour of specimens with different materials and end conditions.
4. Explain why the specimens should buckle instead of simply shortening under the influence of axial compressive load.
5. Prepare a report according to the given guidelines. Include all calculations made under "Preliminary Calculations" placed in an Appendix.

Note: Make all calculations (hand written or typed on a computer) legible and professional looking with sufficient margins, titles and good amount of "white space." The report must be produced the same way as you would a work term report. You may include photographs as well.

REFERENCE

R.C. Hibbeler "Mechanics of Materials," Prentice-Hall

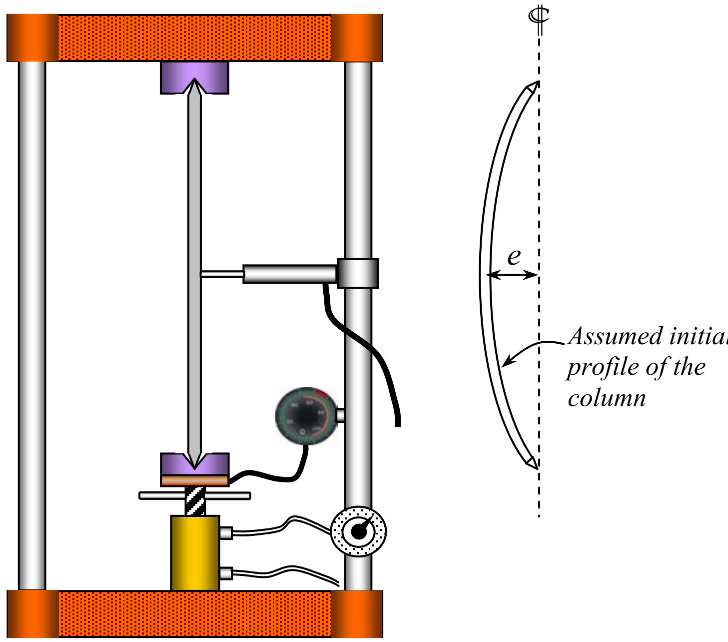

Figure 1 Column test set-up schematic