MEMORIAL UNIVERSITY OF NEWFOUNDLAND
FACULTY OF ENGINEERING AND APPLIED SCIENCE
MEMORIAL UNIVERSITY
Newfoundland & Labrador, Canada

Engineering: 5312 **Mechanics of Solids II**

Lab Test #1 – Steel Beam Deflection

OBJECTIVES:

1. To measure deflections and strains in a simply supported steel beam.
2. To compare the analytical and experimental values of strains in the beam.
3. To use measured deflections and theory to evaluate the Young's modulus of the material.
4. To note the source of errors in a typical simply supported beam experiment.

TEST SPECIMEN

A simply supported steel beam with square tube cross-section, instrumented with strain gages.

EQUIPMENT

1. Structural testing frame with hydraulic loading ram.
2. Data acquisition unit connected to a personal computer (PC)
3. Linear potentiometric displacement transducer (LPDT)
4. Measuring instruments as required, callipers, etc.

PROCEDURE

1. Set the beam up as shown in Fig. 1. Identify strain gauges (s_1, s_2, etc.) and note down the type, length, resistance and calibration constants, if any. Note the calibration constant for the load cell, its type and range, etc.
2. Using the appropriate instruments, measure the length, width, depth and thickness of the beam. See if you can get the radius of the corners as well. Take four readings of each at different locations. Note that the accuracy needed for the length is less than that for width and depth. Explain why. Measure the distance between the supports and the

locations of the load point, strain gauges, LPDT, etc., from the supports. Estimate the accuracy of these measurements. Note the type of the support. Note if the contact points with the supports move from the original location on the beam during loading.

3. Check the data acquisition system, the personal computer and driving software. Familiarize yourself with their operation.
4. Start the data acquisition (DA) program and create an electronic file on the computer hard drive for data logging. Using the DA program, set the initial values of strains and deflection to zero at no load. Put the DA program on "monitoring mode".
5. Load the beam (gently) in 100 lb increments up to a maximum of 1000 lbs using a hand-operated hydraulic actuator. Note that the pump is very sensitive and very little pump stroke is actually needed to increase the load by 100 lb.
6. Keep an accurate manual record of the total applied load at each loading increment for later synchronization with the data in the log file.
7. After reaching the maximum load release the load from the beam, in gradual ***decrements*** until all load is removed. Again log the strain gauge and LVDT readings for each ***decrement***.
8. Copy the electronic file that contains the results to your own memory stick.
9. Turn off all equipment, and tidy up.

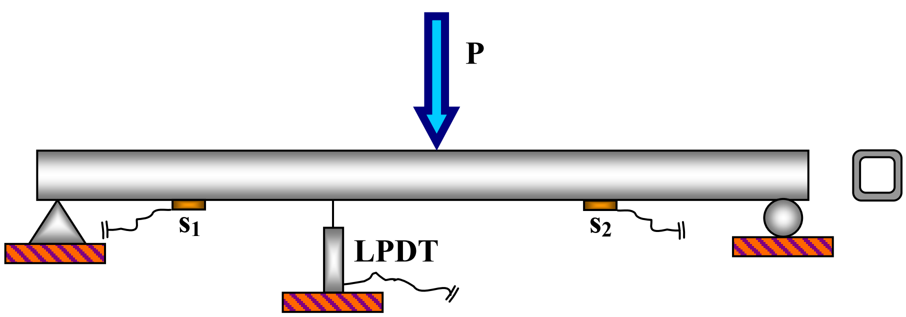

Fig. 1 Lab Setup For Steel Beam Test

CALCULTIONS

1. Find the moment of inertia of a hollow square tube cross section using the measured data. Try to include the corner radii in the calculation. You need to use the parallel axis theorem to do this.

2. The theoretical values of strain can be determined from the flexural formula:

   $$\sigma = \frac{Mc}{I} \qquad (1)$$

   Where,

   σ = Normal stress

   M = Bending moment at the location of the measurement of strains

   c = Distance from N.A. to the extreme fibres ($c = h/2$ for rectangular cross-section)

   I = Moment of inertia

   For this set-up, explain the direction of the above stress and why.

3. Using the measured strains, ε, the experimental values of stress, σ, can be determined from:

   $$\sigma = E\,\varepsilon \qquad (2)$$

   Where, E is the elastic Young's modulus. Use TWO manufacturer values for Young's modulus of 200,000 MPa and 210,000 MPa. Repeat the calculations later with the Young's modulus obtained from deflection measurements.

4. Derive the theoretical value of deflection (δ) for the beam by integrating:

   $$EI\frac{d^2v}{dx^2} = M_x \qquad (3)$$

   where, x = Distance measured along the beam from either one of the support points.

ANALYSIS

1. Produce plots of measured strains vs. applied load for all the strain gauges. It is not enough to simply plot the results. Comment on the comparisons and expected behaviour.
2. Compare the theoretical and experimental values of stress at the strain gage locations. Comment. Produce statistical parameters for the errors (mean, standard deviation, etc.). Determine the maximum stress in the beam and compare it with the yield strength of structural steel. What is the factor of safety?
3. Obtain Load-Deflection graph (P on the vertical axis) from the experimental data. Comment on the linearity of P-δ relationship (or the lack of it). Approximately measure

the slope (the ratio P/δ) of the P-δ line from the graph. Compute the theoretical slope from the deflection equation and compare.

Using the deflection equation and the measured deflections (LPDT readings), find the Young's modulus value. Plot the calculated Young's modulus (for each deflection) and obtain the average value. Use this for calculating the stress values. Explain the variations in the measured values for E and the manufacturers recommended values.

4. Prepare a report according to the given guidelines. Include all calculations made under "Preliminary Calculations" 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

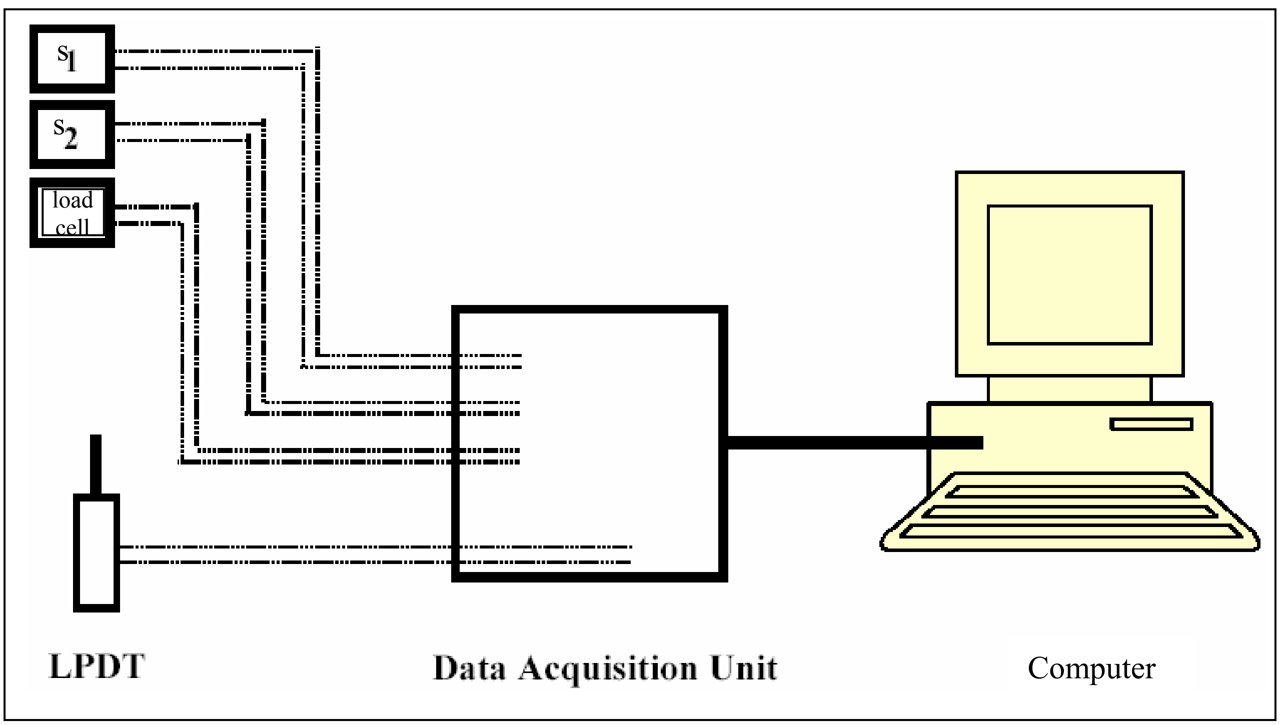

Fig. 2 Schematic for the data acquisition system