Experimental determination of Young's modulus of aluminium using three point bend test

(AS2100: Basic Aerospace Engineering Lab)

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The three point bend test fig-7 is a classical experiment in mechanics, used to measure the Young's modulus (E) of a material in the shape of a beam. The experiment is performed by hanging a set of known weights at point B and measuring the corresponding deflection(w_0) using a dial gauge. The experiment was performed by 5 different groups using instruments with same precision and each experiment consist of 20 cycles of measurements. Each cycle of measurement in an experiment corresponds to increasing the load from 0 to a maximum value P_{max} in fixed steps of ΔP and decreasing from maximum to 0 with same step size of ΔP. The ΔP and P_{max} values for each group is fixed but different groups can have different values. The applied load (P) and the corresponding dial gauge readings (w_0)are given in the file `P7_ThreePointBending.mat`. The value of L - length of beam, the cross-sectional dimensions a and b are known to be same for each group and known exactly. The beam is made of an aluminium alloy.

Use the following parameters wherever necessary:

- Length of beam, L = 1m
- Height of cross section, a = 0.03m
- Width of cross section, b = 0.03m

The data set `P7_ThreePointBending.mat` contains,

- Applied loads for each experiment in newton (each variable is an array of size 13, as there are 7 sets of weights and each cycle consist of loading and unloading)

  $\Longrightarrow$ `"P_exp1", "P_exp2", "P_exp3", "P_exp4", "P_exp5"`

- Corresponding deflection values (each variable is a 13×20 matrix, as there are 20 cycles for each loads per experiment)

  $\Longrightarrow$ `"w_0exp1","w_0exp2","w_0exp3","w_0exp4""w_0exp5"`

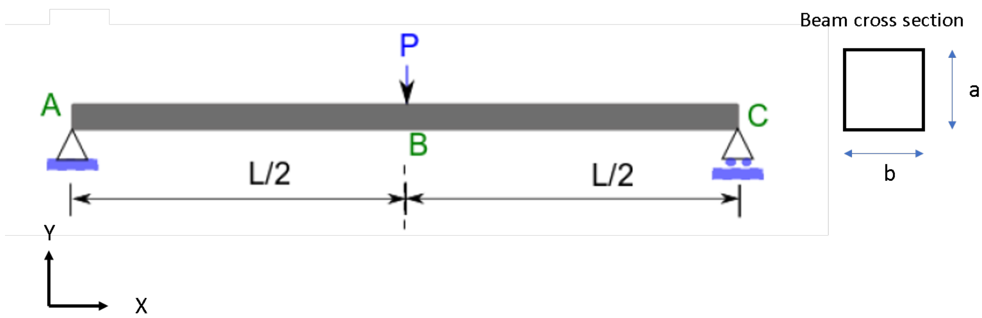

Figure 7: Schematic of three point bend test

1. Explain the theory behind the experiment and outline the experimental procedure.
2. Derive the relation between the applied load (P) and deflection (w_o) for a simply supported beam.
3. What are the possible sources of error in the experiment and how to minimize them?
4. How does changing the number of cycles per experiment affect the mean value of E ? Also does load increment value (ΔP) have any effect in accuracy or precision of the E for a given P_{max}?

5. Using the given dataset `P7_ThreePointBending.mat` make plots of Load (P)vs deflection(w_0) for each experiment for the first cycle and fit a linear curve over these data points. What does the slope of the best fit linear curves represent?

6. Calculate the best estimate of E for each cycle for all the 5 experiment.(i.e, from each experiment you get 20 values for E)

7. Using the values of E obtained in question-6 plot normalised histograms of E for all the 5 experiments. Also plot the smoothened probability density function trends over the histogram plot.

8. Find statistical quantities μ ,σ of E for each experiment and plot Gaussian probability density functions for E using the above obtained quantities and compare with the corresponding smoothened plots in question-7.

9. Basic principles behind the experiment are the Hooke's law and Euler Bernoulli beam theory.Upon careful examination it was concluded that one experiment had violated Hooke' law and Euler Bernoulli beam theory. Which experiment is that? and why ?

10. Find the best estimate of E from all the experiments.(express your final answer inclusive of the associated error in terms of $\pm 1\sigma$). Compare your result with the published value of the Young's modulus of aluminium 2024.

11. What are the short comings of the current experiment? Suggest better experiments to measure Young's modulus of a material

In addition to answers to the above questions each report should also include introduction about the experiment , schematics of the experimental setup, a results and discussion section and a conclusion section.