UNIVERSITI TEKNIKAL MALAYSIA MELAKA	No Dokumen: SB/MMSB2/BMCS2333/3	No Isu./Tarikh 1/12-12-2007
SOLID MECHANICS 2 **Stress-strain analysis of a simple beam**	No Semakan/Tarikh 4/26-03-2013	Jumlah Mukasurat 3

OBJECTIVE

To design and conduct the experiment in order to analyze the strain-stress behaviour of a simply supported beam through stress-strain measurement method by using strain gauges.

LEARNING OUTCOMES (N.B Students **should not include** these as part of their final report)
At the end of this laboratory session the students should be able to

1. Understand and familiarize with the functions of Universal Material Tester, data logger and the applications of strain gauges in measuring the normal strains.
2. Understand the differences between theoretical and experimental (or measurement) data with regard of strain-stress analysis due to bending load.
3. Determine maximum (nominal) bending stress for the simply supported beam by using experimental technique and compare it with the theoretical prediction.
4. Understanding of basic laboratory practice, including design of experiments, write a clear and well-presented technical report, data acquisition, interpretation and analysis, and the relationship between experiments and theory.

THEORETICAL BACKGROUND

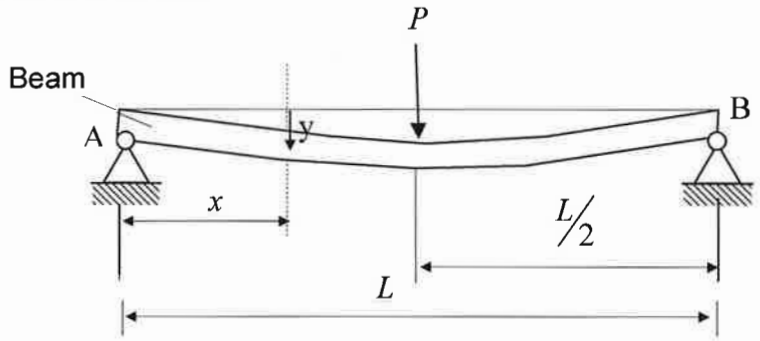

Figure 1 A simply supported beam subjected to three-point loading
y = beam deflection at distance x from point A, L = Length

For a simply supported beam as shown in Figure 1, it can be proved that the nominal or bending stress along the beam may be determined from the general formula of bending theory. Therefore, the Maximum Nominal Stress or Bending Stress in the beam is given by;

$$\sigma_{max} = \frac{M_{max}.c}{I} = \frac{PLh}{8I} \qquad (1)$$

where, I is moment of inertia, h and w are thickness and width of the beam cross-section.

By substituting $I = wh^3/12$ (mm^4) in (1), we will obtain the general equation of ***Maximum Bending Stress*** of the beam when subjected to concentrated load P at its mid-span;

$$\sigma_{max} = \frac{3PL}{2wh^2} \qquad (2)$$

To determine the ***normal strain*** at any distance x, we may apply the Hooke's law and 3D stress-strain relationship as follows;

$$\sigma = E.\varepsilon \qquad \text{and} \qquad \varepsilon_x = \frac{1}{E}\left(\sigma_x - \nu\sigma_y - \nu\sigma_z\right) \qquad (3)$$

with E and ν represents the Young's Modulus and Poisson's ratio of the test material. Equation (3) can be used to determine theoretical value of the ***normal strain*** at any point along the beam. In practice, the measurement of this normal strain at the point of interest is done by using the strain gauge which is fixed / installed at the required location and direction.

Precaution!

In order to avoid yielding at any sections or locations along the test beam, the apply load P cannot be applied greater than its critical value, i.e $P < P_y$, where P_y represents the load that cause initial yield at the upper and lower surfaces of the beam. When $P > P_y$, this may also cause the beam to experience permanent deformation upon unloading and will never return to its initial shape. It may also damage to the strain gauge once we overloaded the beam.

EQUIPMENT & SPECIMEN

- Universal Material Tester & Bending Device / Supports,
- Data logger
- Beam specimen mounted with strain gauges (as shown in Figure 2).

Reminder: For the given beam, the exact position of the installed strain gauges must be measured and recorded.

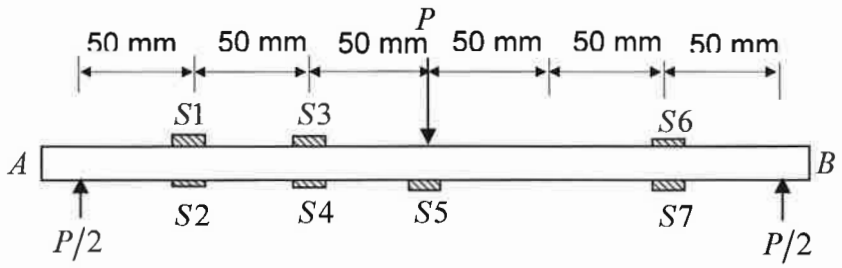

Figure 2 *Free-body diagram* of beam AB where $S1, S2, S3, ..., S7$ represents strain gauges mounted on the upper and lower surfaces of the beam

TASK

- Your experiment must be designed and conducted to investigate the maximum deflection and stress of a simply supported beam and determine the stress-strain distribution at the required locations as the load P is increased to its maximum allowable limit (must be less than its initial yield load, P_y).

- All necessary data and results must be measured, recorded or tabulated systematically to facilitate its analysis and interpretation at the later stage of your work.

- Comparison of experimentally determined results with the theoretical results must also be presented, analyzed and discussed in your report.