AM2540

Strength of Materials Lab

Code **F**

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Measurement of Bending Stress using a Strain Gauge

1 Aim

The objective of this experiment is to measure the tensile bending stress at the root of a cantilever beam subjected to tip transverse loading using a strain gauge.

2 Apparatus

The apparatus consists of a strain gauge, a strain gauge indicator (model P 3500), an alluminium specimen bar, a bar holder with a provision for loading and a multimeter.

3 Theory

A strain gauge is a device used to measure the strain in any component. The most common example of a strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the component by a suitable adhesive.

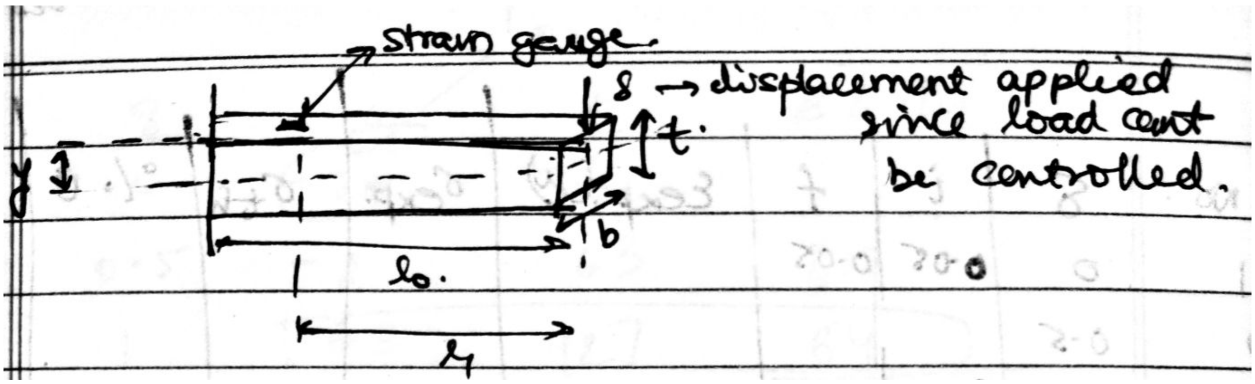
A strain gauge takes advantage of the physical property of electrical conductance and its dependence on not only on the electrical conductivity which is a property of the material, but also on the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity such that it does not break or permanently deform, it will become narrower and longer. This causes a change in its electrical resistance end-to- end. Conversely, on compression, the conductor becomes broader and shorter, and once again brings about a change in its electrical resistance properties. This can be explained by the fact that the electrical resistance in a piece of wire is directly proportional to the length and inversely proportional to the area of the cross section.

The relation of resistance to length and area is given by

$$R = \rho \frac{L}{A}$$

where R is the resistance, ρ is the resistivity of the material, L is the length of the conductor and A is the cross-sectional area of the conductor.

4 Diagram



5 Equations

5.1 Experimental Stress(σ_{exp})

$$\sigma_{exp} = E \cdot \epsilon_{exp}$$

where E is the Young's Modulus of the material of the specimen, ϵ_{exp} is the experimental strain.

NOTE: The specimen used here is a cantilever beam made of aluminium. The modulus of elasticity of aluminium is $70GPa$.

5.2 Deflection in a Cantilever Beam

$$\delta = \frac{PL_0^3}{3EI}$$

where P is the load applied at the tip of the beam, L is the length of the beam, E is the Young's Modulus of the material of the specimen and I is the moment of inertia of the beam.

5.3 Moment of the Applied Load

$$M = PL_1$$

where L_1 is the distance of the point of application of the load from the strain gauge along the beam.

5.4 Flexural Equation

The equation for calculating theoretical stress at a point in a beam is given by

$$\sigma_{th} = \frac{M}{I} \cdot y$$

where M is the moment of the applied load, I is the moment of inertia of the beam and y is the distance of the point at which the stress is to be calculated from the neutral axis of the beam.

6 Calculations

For $\delta = 1mm,\ original\ intial\ value = -2(\mu),\ current\ final\ value\ = 127(\mu)$

$$\epsilon_{exp} = current\ final\ value - original\ intial\ value = 129(\mu) = 129 \times 10^{-6}$$

$$\sigma_{exp} = 70 \times 10^{9} \times 129 \times 10^{-6} = 9.03MPa$$

In this case

$$y = \frac{t}{2}$$

where t is the thickness along y-axis of the beam.

Combining the relation from 3.2, 3.3 and 3.4, we get

$$\sigma_{th} = \frac{3 \cdot \delta \cdot E \cdot L_1 \cdot t}{2 \cdot L_0^3}$$

given

$$L_0 = 25.4cm, L_1 = 24.6cm, t = 6mm$$

$$\sigma_{th} = 9.4575MPa$$

$$\%Error = \frac{9.4575 - 9.03}{9.4575} \times 100 = 4.520222046\%$$

7 Table

Sl. No.	Deflection (mm)	Initial Display Value	Final Display Value	Experimental Strain (µ)	Experimental Stress (MPa)	Theoretical Stress (MPa)	% Error
1	0.5	-2	63	65	4.55	4.72875	3.780068729
2	1	63	127	129	9.03	9.4575	4.520222046
3	1.5	124	189	191	13.37	14.18625	5.753810908
4	2	190	255	257	17.99	18.915	4.890298705
5	2.5	250	319	321	22.47	23.64375	4.964314036
6	3	319	380	382	26.74	28.3725	5.753810908
7	3.5	380	445	447	31.29	33.10125	5.47184774
8	4	445	506	508	35.56	37.83	6.000528681
9	4.5	503	569	571	39.97	42.55875	6.082767938
10	5	569	628	630	44.1	47.2875	6.740681998

8 Sources of Error

- The strain gauge may not be perfectly aligned with the neutral axis of the beam.
- The weight of the cantilever beam has not been accounted for.
- There will be a considerable variation in the resistance of the strain gauge due to temperature effects.
- Resistance of the wire has been neglected.
- There is an uncertainty of 10^{-5} for the micrometer and zero error is possible in the multimeter.
- A 1% error in the measurement of the gauge factor should be expected.