GLASGOW CALEDONIAN UNIVERSITY

School of Engineering & Built Environment

> ***Note:*** Take E = 210 GN/m^2 and ν = 0.28, and, where applicable, G = 81 GN/m^2

ENGINEERING DESIGN & ANALYSIS 2 (M2H721926)

Tutorial: 2D Strain Analysis

1. A 60° delta strain gauge rosette attached to a steel component gave the readings indicated in Figure Q1.

Determine:

i) the magnitude and direction of the principal stresses;

ii) the maximum shear stress.

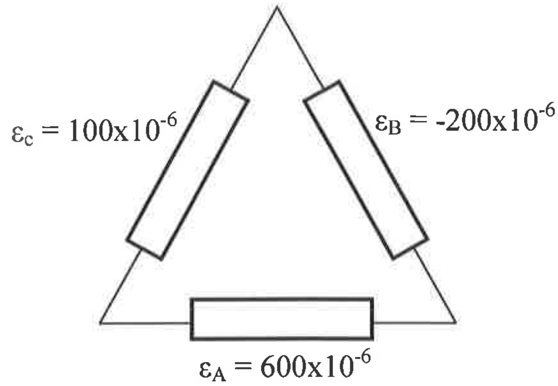

Figure Q1

2. A thin cylinder with closed ends has internal and external diameters of 220 mm and 240 mm respectively. The cylinder is subject to an internal pressure p and an axial torque T. A 60° delta strain gauge rosette attached to the cylinder surface gave the readings indicated in Figure Q2.

Determine:
i) the hoop and longitudinal stresses developed in the cylinder wall;
ii) the internal pressure;
iii) the applied torque;
iv) magnitude of the principal stresses in the cylinder wall.

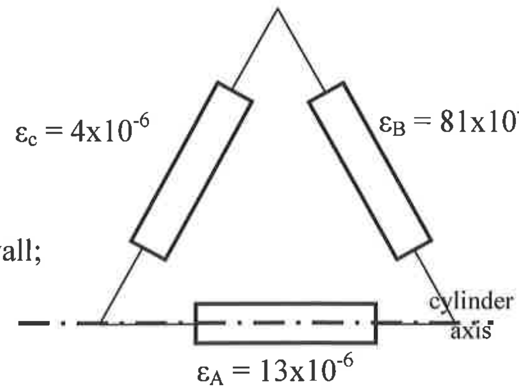

Figure Q2

3. A 60° delta strain gauge rosette attached to a the surface of a steel plate of thickness 10 mm. Under a particular loading, the strain readings are as indicated in Figure Q3.

Determine:

i) the magnitude and nature of the principal stresses;

ii) the inclination of the major principal stress to gauge A;

iii) the change in thickness of the steel plate.

(*Hint:* for 3D strain: $\varepsilon_3 = \frac{1}{E}[\sigma_3 - \nu(\sigma_2 + \sigma_1)]$)

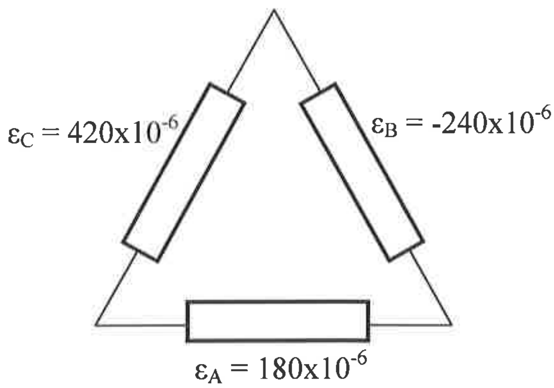

Figure Q3

4. A 120° strain gauge rosette is attached to a steel bar of width 100 mm and thickness 10 mm and the strain readings indicated in Figure Q4 were obtained. The bar is subjected to bending moment 'M' acting in the x-y plane.

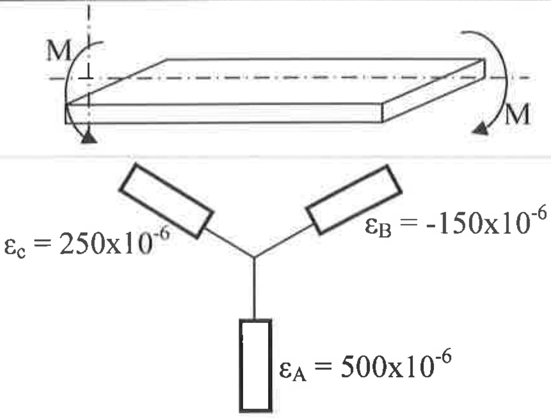

Figure Q4

Determine:

i) the inclination of gauge A to the x-x axis;

ii) the bending moment M.

5. Five strain gauges are attached to the surface of a machine component and the readings are as indicated in Figure Q5.

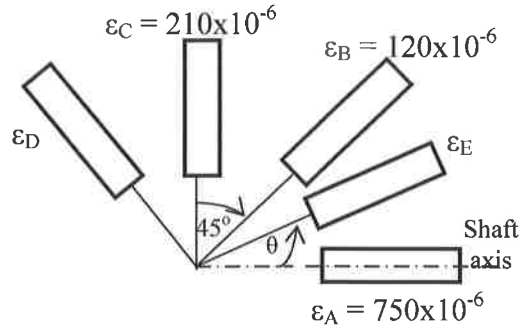

Figure Q5

Determine:

i) the reading on gauge D;

ii) the angle θ such that $\varepsilon_E = 0$;

iii) the magnitude of the principal stresses.

6. A steel shaft 150 mm diameter is subject to a bending moment M and a torque T. A strain gauge rosette attached to the shaft surface gave the readings indicated in Figure Q6.

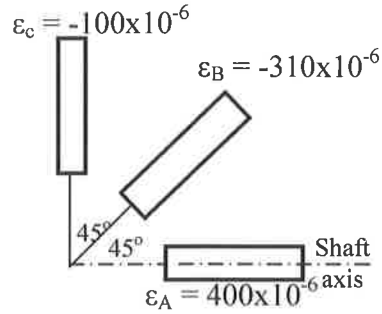

Figure Q6

Determine:

i) the principal strains and their inclination to gauge A;

ii) the principal stresses;

iii) the magnitude of the applied bending moment and applied torque.

Tutorial : 2D Strain Analysis - Answers

1. i) $\sigma_1 = 123$ MN/m^2; $\sigma_2 = -28$ MN/m^2; ii) $\tau_{max} = 76$ MN/m^2
2. i) $\sigma_\theta = 12.7$ MN/m^2; $\sigma_L = 6.35$ MN/m^2; ii) p = 1.15 MN/m^2; iii) T = 6.33 kNm; iv) $\sigma_1 = 17.7$ MN/m^2; $\sigma_2 = 1.6$ MN/m^2
3. i) $\sigma_1 = 97$ MN/m^2 (tensile); $\sigma_2 = -29$ MN/m^2 (comp); ii) 40° to A; iii) $\Delta t = 0.91x10^{-6}$mm
4. i) 18°; ii) M = 200 Nm
5. i) $\varepsilon_D = 1080x10^{-6}$; ii) 19°; iii) $\sigma_1 = 248$ MN/m^2; iii) $\sigma_2 = 32$ MN/m^2
6. i) $\varepsilon_1 = 680x10^{-6}$ at 31° to A; $\varepsilon_2 = -380x10^{-6}$ at 59° to A; ii) $\sigma_1 = 130$ MN/m^2; $\sigma_2 = -43$ MN/m^2; iii) M = 27.8 kNm; T = 50.4 kNm