UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2017

Module Number: ME 3304 **Module Name: Strength of Materials**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

(State your assumptions clearly)

Q1. a) Derive an expression for the theoretical fracture strength of a material.

[3.0 Marks]

b) Modulus of elasticity of an alloy is 210×10^{10} Pa. Calculate the theoretical fracture strength of this alloy.

[1.0 Mark]

c) Actual fracture strength of above mentioned alloy (Q1 b)) is 180×10^{7} Pa. Is there any difference between actual and theoretical fracture strength values of the alloy? If it is so, what are the reasons for that?

[1.0 Mark]

d) Which of the two plates shown in Figures Q1-d-i, and ii, will exhibit a greater stress concentration on the x-axis? The diameter of the circular hole (Figure Q1-d-i) is equal to the major diameter of the elliptical hole (Figure Q1-d-ii).

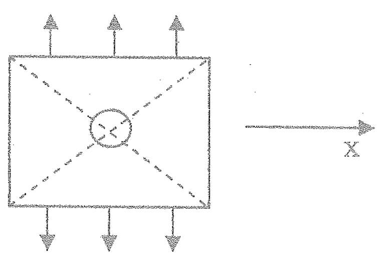

Figure Q1-d-i

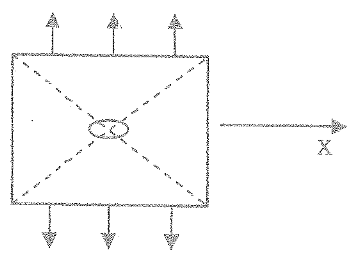

Figure Q1-d-ii

[2.0 Marks]

e) What do you understand by Stress Intensity Factor and Critical Stress Intensity Factor (Fracture toughness)?

(Clue- $K_I = \sigma\sqrt{\pi a}\, f(\alpha, a)$)

[2.0 Marks]

f) An edge cracked plate as shown in Figure Q1-f has dimensions w=100 mm, t=5 mm, h=300 mm, and a remote tensile load of 100 kN is applied. Calculate,

i) Stress intensity factor K_I for a crack length of 15 mm.

ii) Critical crack length, a_c, for fracture if the material of the plate is AISI 4130 steel which has fracture toughness (K_{IC}) of 100 MPa $m^{1/2}$.

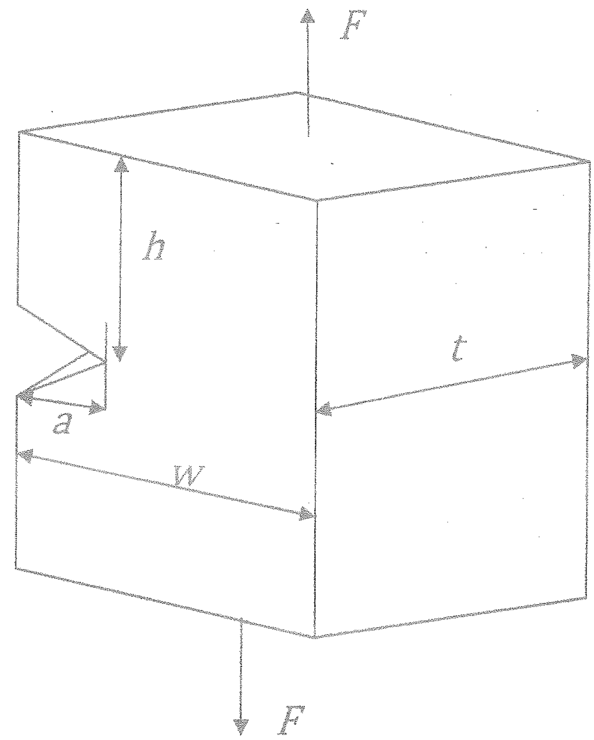

Figure Q1-f

[3.0 Marks]

Q2. a) Are elongation and necking indicators of ductility or brittleness? Explain your answer with neat sketches.

[3.0 Marks]

b) What do you mean by the Hook's law and why it is modified to the Generalized Hook's law? Explain your answer with an example calculation.

[4.0 Marks]

c) Rotating shaft can be manufactured using a ductile or brittle material. Which material is expected to have a longer fatigue life? Explain your answer.

[3.0 Marks]

d) Describe the step by step process of the ductile failure with neat sketches.

[2.0 Marks]

Q3. a) Explain the cumulative damage theory to explain fatigue failure.

[2.0 Marks]

b) What is the significance of Goodman and Gerber relationships?

[2.0 Marks]

c) Explain stage wise fatigue crack growth and final failure of metallic materials.

[3.0 Marks]

d) What are the roles of the following stresses in fatigue failure?

i) Compressive stress

ii) Tensile stress

iii) Shear stress

[3.0 Marks]

e) Which of the two shafts shown in Figures Q3-i, and ii will have a longer fatigue life? Explain your answer.

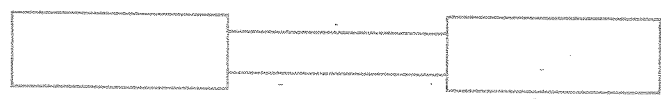

Figure Q3-i

Figure Q3-ii

[2.0 Marks]

Q4. a) For the state of plane stress as shown in the Figure Q4, determine the followings using the transformation equations.

i) The principle planes.

[1.5 Marks]

ii) The principle stresses.

[1.5 Marks]

iii) The maximum shearing stress and the corresponding normal stress.

[1.5 Marks]

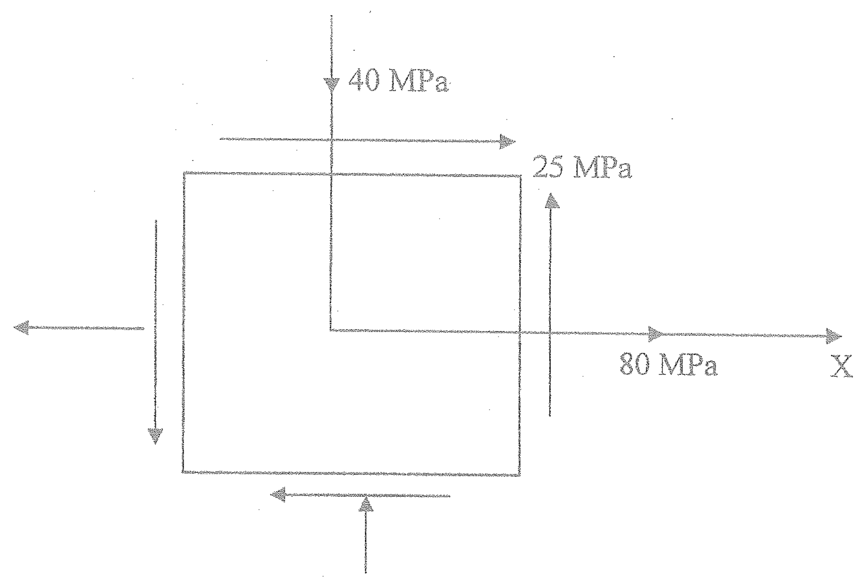

Figure Q4

b) Draw the Mohr's circle for the above (Q4 a)) state of stresses and mark the corresponding points and planes of the Q4 a) i), ii) and iii).

[4.5 Marks]

c) What are the new magnitudes and directions (Q4 a) i), ii) and iii)) when the 40 MPa compressive stress is changes to a tensile with same magnitude while other stresses are remained same.

[3.0 Marks]

Q5. A square element is distorted under the action of a plane stress field, resulting in the strains shown in Figure Q5. Determine the followings.

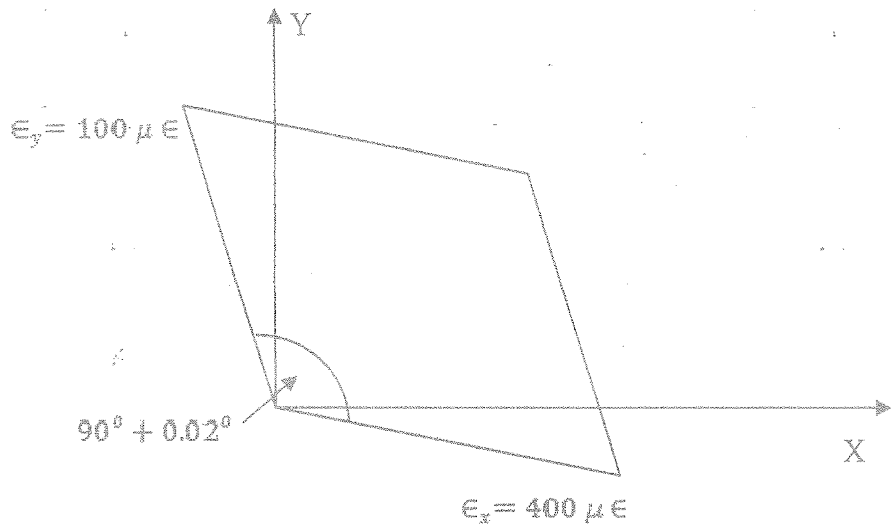

Figure Q5

b) The principle strains.

[2.0 Marks]

c) Directions of the principal strain axes.

[2.0 Marks]

d) The magnitudes of the principal stresses.
Elastic Modulus (E) = 200 GN/m^2
Poisson's ratio (μ) = 0.3.

[5.0 Marks]

e) Which one is more practical to measure stress or strain? Describe your answer with two methods available to measure.

[3.0 Marks]