UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: March 2021

Module Number: ME3206 **Module Name: Strength of Materials**

[Three Hours]

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

(State the assumptions where necessary and correctly states the units)

Q1. a) Briefly describe the failure criterions based on the material types.

[2.0 Marks]

b) State Griffith's criterion for fracture of brittle materials and discuss the relationship of the above mentioned criterion with the 1st law of thermodynamics.

[2.0 Marks]

c) Using above mentioned (Q1.b) criterion; show the fracture strength of a material which is given by,

$$\sigma_f = \sqrt{\frac{8E\gamma_s}{\pi a(1+\upsilon)(1+k)}}.$$

Where,

σ_f - Fracture strength of a material,

a - Crack size

υ - Poisson's ratio

k - Stress intensity factor

E - Modulus of elasticity

γ_s - Specific surface energy of a fractured surface

[3.0 Marks]

d) Theoretical value and actual values of γ_s have a difference. What are the reasons for such a difference and how do you overcome it by correcting the equation?

[2.0 Marks]

e) Establish a relationship between the modulus of elasticity and the bulk modulus of a material (considering volumetric strain).

[3.0 Marks]

Q2. a) Briefly describe the Transgranular and Intergranular Fractures.

[1.5 Marks]

b) Briefly discuss three methods which are used to strengthen the metals.

[1.5 Marks]

c) Explain two methods of reducing stress concentrations.

[2.0 Marks]

d) What is meant by:
   i) The stress concentration factor
   ii) The stress intensity factor (SIF)
   iii) The critical stress intensity factor

[3.0 Marks]

e) A 3 mm thick tension panel 10 cm wide containing an edge crack of 1 mm yielded at a load of 150 kN. However, at a load of 120 kN, another panel of same material cracked into two pieces when the crack was 5 mm long. With this information, calculate the yield stress and fracture toughness of the material. SIF for the edge crack is $K_I = 1.12\,\sigma\sqrt{\pi a}$.

[4.0 Marks]

Q3. a) Define the fatigue damage and briefly describe the step by step process of fatigue crack growth.

[3.0 Marks]

b) What are the roles of the following kinds of stress in fatigue failure?
   i) Compressive stress
   ii) Tensile stress

[2.0 Marks]

c) Differentiate Primary creep, Secondary creep and Tertiary creep of materials.

[3.0 Marks]

d) Suggest and explain a method to perform a creep test for a particular material (Metallic).

[4.0 Marks]

Q4. Consider a Mechanical component under direct load F_1 and F_2 giving rise to stresses σ_y, and σx, vertically, and horizontally as shown in Fig. Q4.

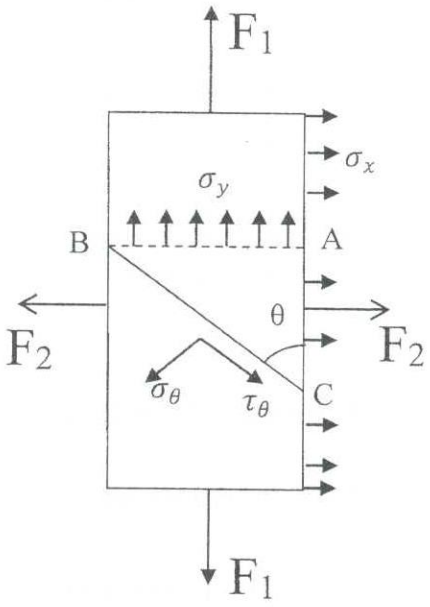

Figure Q4

a) Derive equations to find τ_θ (shear stress along BC plane) and σ_θ (normal stress to BC plane).

[5.0 Marks]

b) By examining the equations, conclude the followings,
- Maximum normal stress,
- Maximum shear stress.

[3.0 Marks]

c) In a popular testing method (mechanical property) sample is loaded as Fig. Q4.

i) What is the test?

[1.0 Mark]

ii) What is the machine we used for this test?

[1.0 Mark]

ii) How could you see the test results of a steel sample?

[2.0 Marks]

iv) How do you transfer one dimensional test results in to three dimension?

[2.0 Marks]

Q5. The state of plane stress at a point is represented by the stress element below (Fig. Q5).

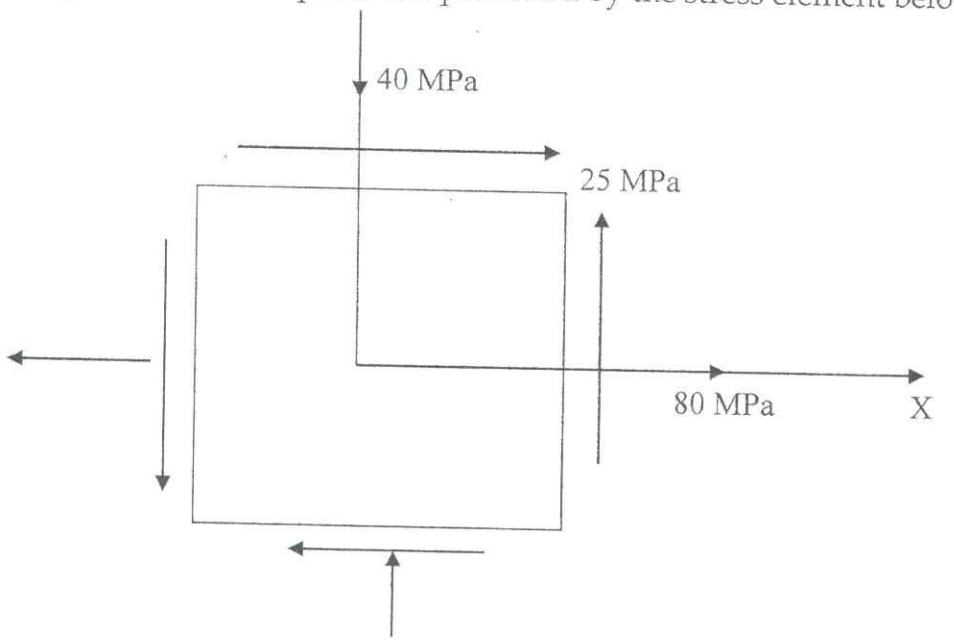

Figure Q5

a) Draw the corresponding Mohr's stress circle for the above stress system.

[4.0 Marks]

b) Find the stresses on an element inclined at 30° clockwise and draw the corresponding stress elements.

[3.0 Marks]

c) Calculate (or find using corresponding Mohr's stress circle) the principal stresses and the planes on which they act.

[2.0 Marks]

d) What would be the effect on these results if owing to a change of both tensile loadings to compressive while shear stresses remain unchanged?

[3.0 Marks]