Engineering Fracture Mechanics

Assignment # 4

Stress Intensity Factor Evaluation, Plastic Zone Modelling, Fracture Testing

1. The stress function referred with respect to the centre of crack as the origin, subjected to two wedge loads of *P* N/m acting symmetrically is given as:

$$Z_I = \frac{2Pz(a^2 - s^2)^{\frac{1}{2}}}{\pi(z^2 - s^2)(z^2 - a^2)^{\frac{1}{2}}}$$

Determine the SIF using the definition of SIF based on stress function.

2. Which of the cracks shown in Fig. 2 is critical? Justify your answer.

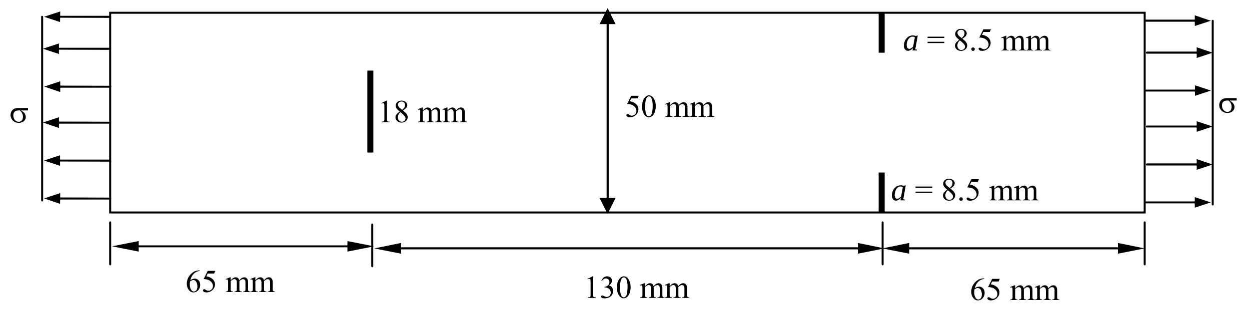

Fig. 2

3. Using the method of superposition, estimate the SIF of evenly spaced collinear cracks in an infinite strip subjected to internal pressure.

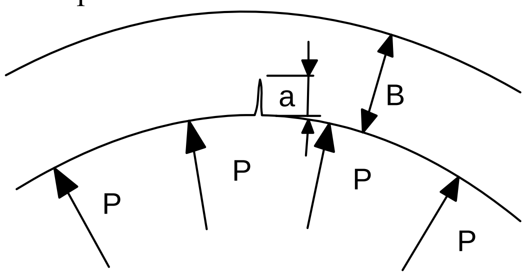

Fig. 3

4. Does the value of SIF for an elliptical flaw remain constant over its periphery?

5. Why do you think that the study of elliptical flaws is important in fracture?

6. Discuss the range of LEFM/EPFM with suitable sketches.

7. What do you understand by small scale yielding?

8. Discuss the basis on which the thickness of the specimen for fracture toughness experiments is arrived at.

9. Illustrate with neat sketches the evidence of slip planes in plane stress.

10. What is a Chevron Notch? What is its role in a fracture experiment?

11. The candidate fracture toughness obtained in a plane strain fracture toughness test is $K_Q = 55$ MPa(m)$^{1/2}$. The yield stress of the material is 680 MPa and the specimen thickness is 13.2 mm. Is the test valid? What is the maximum K_{IC} that could be measured with the specimen?

12. A three-point bend specimen (σ_{ys} = 1200 MPa, E = 210 GPa) was tested according to the ASTM E399 procedure. The specimen dimensions were S = 300 mm, W = 80 mm, and B = 40 mm. The specimen was tested at a loading rate of 105 kN/min. A Chevron starter notch was machined and the specimen was subjected to 30,000 cycles at P_{max} = 46 kN and P_{min} = 0. The final stage of fatigue crack growth was conducted for 50, 000 cycles at P_{max} = 32 kN and P_{min} = 0. The maximum load and the secant load of the test record were measured as P_{max} = 85 kN and P_Q = 80kN. The fractured specimen was carefully measured to get the Crack profile which is as follows

    a_1 = 39.95 mm ; a_2 = 40.08 mm ; a_3 = 39.98 mm;

    a (surface 1) = 39.16 mm ;

    a (surface 2) = 39.53 mm ;

    Determine K_Q. Can it be taken as K_{IC} ?

    Hint: Verify whether the test meets the requirements of a fracture test

13. Using Feddersen's approach, establish a complete residual strength diagram for a 450 mm wide centre cracked panel made of Aluminium alloy. The thickness of the panel is 16 mm. The toughness of the specimen material is 87.5 MPa(m)$^{1/2}$ and yield stress is 400 MPa. Table the specific residual strengths for crack lengths of 50 mm, 100 mm and 150 mm. Determine the minimum panel width to perform a valid plane stress test.