B. E. Part IV (8th Semester) Examination, April-May, 2013

Fracture Mechanics and Failure Analysis (MT 805/1)

Full marks: 70 **Time: 3h**

Write question number 6 and any three from the rest. All the questions carry equal marks.

1. (a) Explain brittleness in terms of lattice resistance and microstructural stress intensity factor as proposed by Cottrell.
   (b) Establish smith's model for microcrack formation at the grain boundary carbide.

2. (a) Explain compliance and singularity.
   (b) Describe plasticity correction under plane stress condition.

3. (a) Explain the limit load model for void instability.
   (b) Express the correlation between the fracture stress and size of the triggering particle of a Griffith crack.

4. (a) Compare the applicability of Basquine and Coffin-Manson relationship.
   (b) Schematically show the superposition of elastic and plastic strain life.

5. (a) Briefly state the different stages of the fatigue process.
   (a) Explain the effect of variation of limiting range of strain (σ_{max} - σ_{min}) on mean stress.

6. Write any two
   (a) A cylindrical pressure vessel with a radius (r) of 1m and a wall thickness (t) of 1 cm is made of steel (Young's modulus 210 GPa) with a (mode-I) fracture toughness of 47 MPa $m^{1/2}$. Inspection reveals a crack of 7cm length running in the circumferential direction. What is the maximum internal pressure (p) allowable, assuming a safety factor of 2? [Hint: Axial stress= p.r/t].

(b) Calculations based on the cohesion force suggest that the tensile strength of glass should be 10 GPa. However, a tensile strength of only 1.5 % of this value is found experimentally. Griffith supposed that this low value was due to the presence of cracks in the glass. Calculate the size 2a of a crack normal to the tensile direction in a plate. Given: Young's modulus E = 70 GPa, Surface tension γ= 0.5 J/m^2.

(c) A plate of maraging steel has a tensile strength of 1900 MPa. Calculate the reduction in strength caused by a crack in this plate with a length 2a= 3 mm oriented normal to the tensile direction. Given: Young's modulus E= 200 GPa, Surface tension γ = 2 J/m^2, Plastic energy per unit crack surface area γ_p= 2×10^4 J/m^2, Critical stress intensity factor $K_c = \sigma_c(\pi a)^{1/2}$.

(d) A large sheet containing a 50 mm long crack fractures when loaded to 500 MPa. Determine the fracture load of a similar sheet with a 100 mm crack.