

SE104 Homework 13

1. Fractography analysis – study of fracture surfaces – can provide useful information about fracture properties of materials. By examining the fracture surfaces of a steel, it was observed that the surfaces were fibrous; i.e. fracture occurred through dimple (microvoids) formation. The average dimple size was around $10\ \mu\text{m}$. It is known that the strength of the steel is about 300 MPa. (a) Assess its fracture toughness; (b) What is the critical crack-tip opening displacement (CTOD)? Hint: The stiffness of all steels is around 210 GPa; the work to form a single dimple is around $\sigma_y V$, where σ_y is the yield strength and V is the dimple volume.
2. The stiffness, strength, and toughness of a material are 200 GPa, 400 MPa, and $80\ \text{MPa}\cdot\text{m}^{1/2}$, respectively. (a) What is the critical precrack size that would reduce the failure strength (σ_f) to below the yield strength (σ_y)? (b) Plot the failure strength as a function of the precrack size. Assume $Y = 1$.
3. Describe in detail how a metallic material may be brittle if a large precrack exists.
4. Describe what is a crack-tip plastic zone, and how to assess its size.