AML 851 FRACTURE MECHANICS (2008-2009)
Major Test Time 2 hours Marks 100

Answer all the questions

1. Given separately and to be answered **first** on the question paper itself. (30)

2. (a) Derive the size of plastic zone using Dugdale's approach. (6)

   (b) A large structural panel made of high strength Al-alloy (σ_{ys} = 400 MPa) was found to contain an embedded crack of depth 10 mm when inspected by NDE. Find the minimum toughness (K_{IC}) desirable so that it could sustain a stress = 50 % of the yield strength. The depth to length ratio of crack is = 0.1. (6)

3. A load-CMOD diagram is obtained on a pipe line steel (yield strength = 430 MPa) by testing single edge crack specimen in 3-point bending with specimen dimensions as follows: thickness = 15 mm, width = 30 mm, crack size = 15.8 mm, span length = 120 mm. The crack initiation was noticed at a load of 12000N and corresponding elastic CMOD and total CMOD values were 0.1 mm and 0.95 mm respectively. Determine the CTOD initiation toughness. Find the CTOD value at the original crack tip and at the instantaneous crack tip when the crack has further grown by 0.75 mm. Given the initial tearing modulus of steel = 180. The K expression is given as $K_I = (2.25\ SP/BW^2)(\pi a)^{1/2}$ (13)

4. (a) Describe the method for evaluation of J_{IC} fracture toughness using single specimen unloading compliance technique in 3-point bend specimen employing the analysis of J-R curve as per the standard. (9)

   (b) Outline five main differences between level I and level II assessment methods for structural integrity analysis under static loading situation. (6)

5. (a) Find the fatigue crack growth rate (using Foreman equation) in presence of a corner crack (quarter elliptical surface crack) of depth = 5 mm and length = 20 mm at a T junction made of a steel of fracture toughness = 85 MPa $\sqrt{m}$ when the applied stress varies from 100 to 300 MPa. Given, that for a loading of K_{max} = 50 MPa $\sqrt{m}$ and R=0.4, the FCGR=$1.863X10^{-7}$ m/cycle in the above alloy, using Foreman equation. The exponent m in Foreman equation=3.0. (11)

   (b) Define crack growth retardation factor in Wheeler model. (4)

6. A large thick plate of steel containing a through thickness centre crack of length 8 mm oriented at an angle $\beta = 60^o$ with respect to the direction of applied uniaxial tensile stress fractures at a value of σ_C = 1000 MPa. Calculate K_{IC} of steel using the MTS criterion. (15)

Note: ***For corner crack*** $\mathbf{K_I = [1.2\ \sigma\ (\pi a)^{1/2}]/\ \phi}$ **,** ***for embedded crack*** $\mathbf{K_I = [\sigma\ (\pi a)^{1/2}]/\ \phi}$