EM 388F: Fracture Mechanics

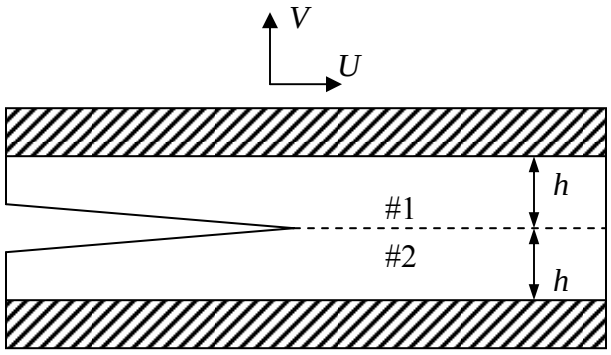
HW#6 (due Wednesday, April 16, 2008)

29. A straight crack is cut in a material with a diamond saw. The material is loaded with a mixture of K_I and K_{II}, and the crack kinks. Plot the initial kink angle as a function of the mode mix defined by $\psi = \tan^{-1}(K_{II}/K_I)$, using the maximum hoop stress criterion.

30. Liechti and Chai (J. Appl. Mech. 59, 295-304, 1992) developed a bimaterial interfacial fracture specimen that is capable of measuring the interface toughness over a wide range of mode mixity. A schematic of their specimen is shown below. The length of the specimen is long compared to the thickness h. The bottom of the specimen is rigidly held and the top is attached to a rigid grip, subjected to a biaxial in-plane displacement in horizontal and vertical directions, U and V. The complex stress intensity factor of a semi-infinite crack at the interface is given by

$$K_I + iK_{II} = \frac{\sqrt{2}\mu_1\mu_2 h^{-1/2-i\varepsilon} e^{i\omega}(cV + iU)}{(1-\beta^2)^{1/2}(\mu_1+\mu_2)^{1/2}[\mu_1(1-\nu_2)+\mu_2(1-\nu_1)]^{1/2}}$$

where $c = \sqrt{\dfrac{2(\mu_1+\mu_2)}{\mu_1(1-2\nu_2)/(1-\nu_2)+\mu_2(1-2\nu_1)/(1-\nu_1)}}$, $\varepsilon = \dfrac{1}{2\pi}\ln\left(\dfrac{1-\beta}{1+\beta}\right)$, ω is a real quantity, and β is the second Dundur's parameter.



(a) Determine the phase angle of mode mix ψ with an arbitrary length l.

(b) For an epoxy(#1)/glass(#2) interface, E_1 = 2.07GPa, E_2 = 68.9GPa, ν_1 = 0.37, ν_2 = 0.20, h = 12.7mm, ω = 16°. The measured interface toughness as a function of mode mix with length l = 127μm is approximately given by $\Gamma(\psi) = G_0\left[1+(1-\lambda)\tan^2\psi\right]$, where G_0 = 3.2 J/m^2 and λ = 0.5. Determine the maximum vertical displacement V (let U = 0) before the interface crack propagates.

(c) Plot the interface toughness as a function of mode mix defined with a different length l = 12.7mm.