



College of Engineering, University of Iowa
Department of Civil & Environmental Engineering
53:086 Civil Engineering Materials
Spring Semester, 2008

Homework Assignment #1

due: Tuesday, February 5th, 2008

1. According to the Griffith fracture model, the magnitude of tensile stress at which a small fracture of size “a” will propagate in a stable manner in an isotropic, homogeneous, linearly elastic medium is given by the relation:

$$\sigma_{fract} = \frac{2K_{Ic}}{(\pi a)^{\frac{1}{2}}} = \left(\frac{4G_c E}{\pi a} \right)^{\frac{1}{2}} \quad (1)$$

where: K_{Ic} is the “mode-1 fracture toughness” of the material in question; G_c is the surface energy or “fracture-toughness” of the material in question; E is the Young’s modulus of the material in question; and a is the half-dimension of a planar crack in the material.

Using representative properties for mild steel, hydrated portland cement (mass concrete without any aggregate), and silicon glass, compute and plot on log-log scale the fracture stress σ_{fract} versus fracture size a for $a \in [10^{-7} m, 10^{-3} m]$.

Material	G_c (kJ/m ²)	K_{Ic} (MN/m ^{3/2})	Tensile strength (MPa)
Mild steel	100	150	420 (A36 steel)
Hydrated portland cement paste	0.03	0.20	5 (very approximate)
Silicon glass	0.01	0.83	2,400 (S-glass fiber)

2. Using your results from the preceding question, consider the fracture stress of the three materials above at flaw size $a=10^{-7}m$. Compare and discuss these fracture stresses to the representative values provided of the actual tensile strengths.
3. Equation (1) above establishes that there is an inverse relation between void or flaw size in a material and its fracture strength level. By processing materials as very fine fibers, the void or defect sizes can be made very small, and the strength of the material is greatly improved. Write a one-page summary based on a brief literature review of how a specific type of structural fibers are processed (or spun) into such small diameters. For example, you could consider different types of glass fibers, carbon fibers, or polymer fibers here. Your paper need only treat the processing of one type of fiber.

Bonus: 20 Bonus Points can be earned on this assignment by taking and submitting a photograph (digital preferred) of glass with visible void-like defects. Please provide a few words of explanation with your photograph, explaining exactly what the photograph is of. Have something in the photo of known size that permits one to estimate the size of the voids in comparison.