GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

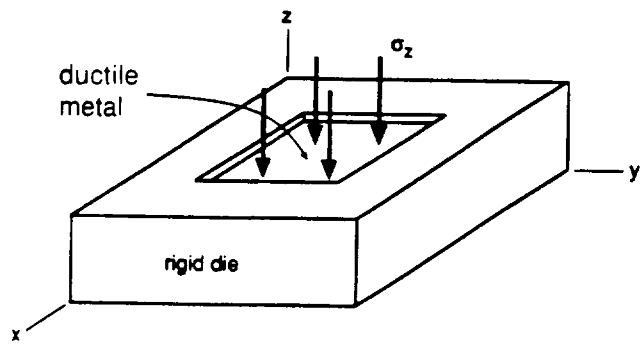
Ph.D. Qualifiers Exam - Spring Quarter 1996

MECHANICS OF MATERIALS
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

-- **Please sign your name on the back of this page** --

A piece of a ductile metal is confined on all four sides by a rigid die as shown in the figure. A uniform compressive stress σ_z is applied to the surface of the metal. It may be assumed that there is no friction between the metal and the die. Please determine the value of σ_z necessary to cause yielding in terms of the uniaxial yield strength σ_{ys} and the elastic constants of the metal.



A specimen (initially a cube) is placed in uniaxial tension. It displays linear response to failure with no necking.
Given

$A_i = 100\ mm^2$	(initial area)
$A_f = 98.01\ mm^2$	(area at failure)
$P_f = 40{,}000\ N$	(load at failure)
$L_i = 10\ mm$	(initial gauge length)
$\delta = 0.2mm$	(elongation at failure)

Write the equation then calculate

engineering stress at failure

true stress at failure

engineering strain at failure

true strain at failure

Young's modulus

Poisson's ratio

ultimate tensile strength

fracture strength

% elongation

% reduction in area

resilience

tensile toughness

A cylindrical pressure vessel 8 m long, 4 m in diameter exploded at an internal pressure of 10 Mpa. The vessel is made of 20 mm-thick steel with the following properties:

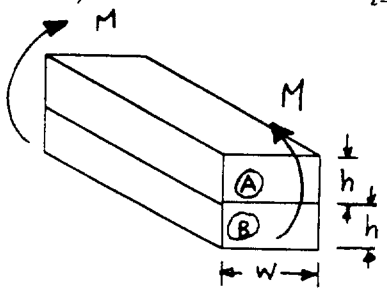
$E = 210$ GPa
$\sigma_y = 1.2$ GPa
$G = 120$ k J/m^2

Did the vessel fail due to exceeding of the yield stress or as a result of surface defects (cracks)? What is the minimum size crack that could account for the failure? Would these be longitudinal or transverse cracks?

A composite beam with constant cross-section is subjected to pure bending as shown in the figure below. The stress-strain relationships for each material are given by:

$\sigma = E\varepsilon$ *for A*

$\sigma = \left(A\left(|\varepsilon| + \varepsilon_c\right)^n - A\varepsilon_o^n\right)\mathrm{sgn}\,\varepsilon$ *for B where* $\lim_{\varepsilon \to 0} \frac{d\sigma}{d\varepsilon} = E$



(a) Outline all necessary steps to determine the stress variation over the cross section (small strain theory). Explore the regimes n > 1 and 0 < n < 1.

(b) Where is the bending strain maximum? Why?

(c) List assumptions which are necessary to invoke simple beam theory.

(d) Which quantitites are continuous across the A - B interface?

stress? ______
strain? ______
displacement? ______
strain energy density? ______