Solutions for Chapter 6 - MSEG 302

6-25 **(a)** A force of 100,000 N is applied to a 10 mm × 20 mm iron bar having a yield strength of 400 MPa and a tensile strength of 480 MPa. Determine whether the bar will plastically deform and whether the bar will experience necking.

Solution: First determine the stress acting on the wire:

$\sigma = F/A$ = 100,000 N / (10 mm)(20 mm) = 500 N/mm^2 = 500 MPa

Because σ is greater than the yield strength of 400 MPa, the wire will plastically deform.

Because σ is greater than the tensile strength of 480 MPa, the wire will also neck.

(b) Calculate the maximum force that a 0.2-in. diameter rod of Al_2O_3, having a yield strength of 35,000 psi, can withstand with no plastic deformation. Express your answer in pounds and Newtons.

Solution: $F = \sigma A$ = (35,000 psi)(π/4)(0.2 in.)^2 = 1100 lb

F = (1100 lb)(4.448 N/lb) = 4891 N

6-26 A force of 20,000 N will cause a 1 cm × 1 cm bar of magnesium to stretch from 10 cm to 10.045 cm. Calculate the modulus of elasticity, both in GPa and psi.

Solution: The strain ε is ε = (10.045 cm − 10 cm)/10 cm = 0.0045 cm/cm

The stress σ is σ = 20,000 N / (10 mm)(10 mm) = 200 N/mm^2
= 200 MPa

$E = \sigma/\varepsilon$ = 200 MPa / 0.0045 cm/cm = 44,444 MPa = 44.4 GPa

E = (44,444 MPa)(145 psi/MPa) = 6.44 × 10^6 psi

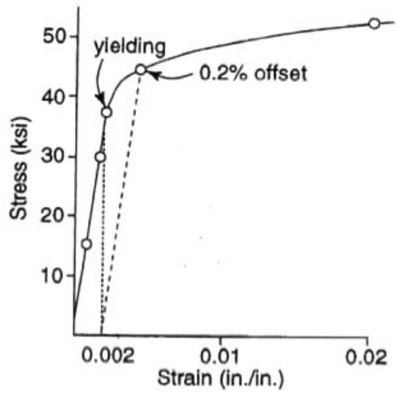
6-33 The following data were collected from a standard 0.505-in.-diameter test specimen of a copper alloy (initial length (ℓ_o) = 2.0 in.):

Load (lb)	Gage Length (in.)	Stress (psi)	Strain (in./in.)
0	2.00000	0	0.0
3,000	2.00167	15,000	0.000835
6,000	2.00333	30,000	0.001665
7,500	2.00417	37,500	0.002085
9,000	2.0090	45,000	0.0045
10,500	2.040	52,500	0.02
12,000	2.26	60,000	0.13
12,400	2.50 (max load)	62,000	0.25
11,400	3.02 (fracture)	57,000	0.51

After fracture, the gage length is 3.014 in. and the diameter is 0.374 in. Plot the data and calculate the 0.2% offset yield strength along with (a) the tensile strength, (b) the modulus of elasticity, (c) the % elongation, (d) the % reduction in area, (e) the engineering stress at fracture, (f) the true stress at fracture, and (g) the modulus of resilience.

Solution: $\sigma = F / (\pi/4)(0.505)^2 = F/0.2$

$\varepsilon = (\ell - 2) / 2$



0.2% offset yield strength = 45,000 psi

(a) tensile strength = 62,000 psi

(b) $E = (30{,}000 - 0) / (0.001665 - 0) = 18 \times 10^6$ psi

(c) % elongation $= \dfrac{(3.014 - 2)}{2} \times 100 = 50.7\%$

(d) % reduction in area $= \dfrac{(\pi/4)(0.505)^2 - (\pi/4)(0.374)^2}{(\pi/4)(0.505)^2} \times 100 = 45.2\%$

(e) engineering stress at fracture = 57,000 psi

(f) true stress at fracture = 11,400 lb / $(\pi/4)(0.374)^2$ = 103,770 psi

(g) From the graph, yielding begins at about 37,500 psi. Thus:

½(yield strength)(strain at yield) = ½(37,500)(0.002085) = 39.1 psi

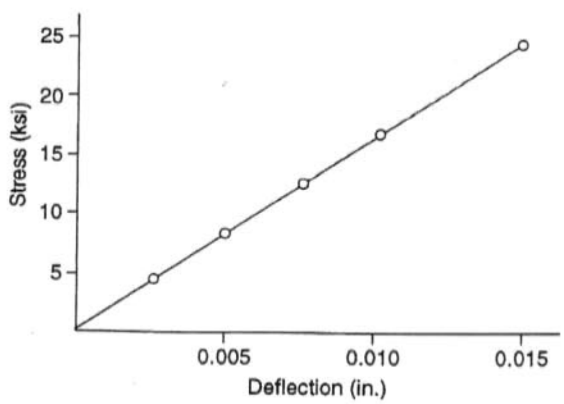
6-39 A bar of Al_2O_3 that is 0.25 in. thick, 0.5 in. wide, and 9 in. long is tested in a three-point bending apparatus, with the supports located 6 in. apart. The deflection of the center of the bar is measured as a function of the applied load. The data are shown below. Determine the flexural strength and the flexural modulus.

Force (lb)	Deflection (in.)	Stress (psi)
14.5	0.0025	4,176
28.9	0.0050	8,323
43.4	0.0075	12,499
57.9	0.0100	16,675
86.0	0.0149 (fracture)	24,768

Solution: stress = $3LF/2wh^2$ (6-15)

$= (3)(6 \text{ in.})F/(2)(0.5 \text{ in.})(0.25 \text{ in.})^2$

$= 288F$



The flexural strength is the stress at fracture, or 24,768 psi.

The flexural modulus can be calculated from the linear curve; picking the first point as an example:

$$\text{FM} = \frac{FL^3}{4wh^3\delta} = \frac{(14.5 \text{ lb})(6 \text{ in.})^3}{(4)(0.5 \text{ in.})(0.25 \text{ in.})^3(0.0025 \text{ in.})} = 40 \times 10^6 \text{ psi}$$