questions

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TS or UTS σ

3.1 A tensile test uses a test specimen that has a gage length of 50 mm and an area = 200 mm^2. During the test the specimen yields under a load of 98,000 N. The corresponding gage length = 50.23 mm. This is the 0.2 percent yield point. The maximum load of 168,000 N is reached at a gage length = 64.2 mm. Determine (a) yield strength, (b) modulus of elasticity, and (c) tensile strength. (d) If fracture occurs at a gage length of 67.3 mm, determine the percent elongation. (e) If the specimen necked to an area = 92 mm^2, determine the percent reduction in area.

3.2 A test specimen in a tensile test has a gage length of 5 cm and an area = 3.125 cm^2. During the test the specimen yields under a load of 14515 kg. The corresponding gage length = 5.1 cm. This is the 0.2 percent yield point. The maximum load of 27215 kg is reached at a gage length = 6.6 cm. Determine (a) yield strength, (b) modulus of elasticity, and (c) tensile strength. (d) If fracture occurs at a gage length of 7.4 cm, determine the percent elongation. (e) If the specimen necked to an area = 1.56 cm^2 determine the percent reduction in area.

3.3 During a tensile test in which the starting gage length = 125.0 mm and the cross-sectional area = 62.5 mm^2, the following force and gage length data are collected (1) 17,793 N at 125.23 mm, (2) 23,042 N at 131.25 mm, (3) 27,579 N at 140.05 mm, (4) 28,913 N at 147.01 mm, (5) 27,578 N at 153.00 mm, and (6) 20,462 N at 160.10 mm. The maximum load is 28,913 N and the final data point occurred immediately prior to failure. (a) Plot the engineering stress strain curve. Determine (b) yield strength, (c) modulus of elasticity, and (d) tensile strength.

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$L_o = 50mm$ $A_o = 200 mm^2$

$F_y = 98000N \rightarrow L = 50.23mm$

$F_{max} = 168000N \rightarrow L = 64.2mm$

a) $\sigma_e = \frac{F}{A_o} = \frac{98000N}{200 mm^2} = 490 MPa$

b) $\sigma_e = Ee$ $= 490 = E \times 4.6\times10^{-3}$

$E = 106521.7$ MPa

$e_{\text{at yield}} = \frac{\Delta L}{L_o} = \frac{50.23-50}{50} = 4.6\times10^{-3}$

c) TS or UTS $= \frac{F_{max}}{A_o} = \frac{168000}{200} = 840$ MPa.

d) $EL\% = \frac{\Delta L}{L_o} \times 100\%$

$\frac{67.3-50}{50} \times 100\% = 34.6\%$

e) $AR = \frac{A_o - A_{f\,(\text{unit})}}{A_o}$ $\frac{200-92}{200} \times 100\% = 54\%$

*What is maximum true stress? *

$\sigma = \frac{F_{max}}{A_i \text{ at final neck}} = \frac{168000}{92} = 1826.87 MPa$

Flow Curve

3.4 In Problem 3.3, determine the strength coefficient and the strain-hardening exponent in the flow curve equation. Be sure not to use data after the point at which necking occurred.

3.5 In a tensile test on a metal specimen, true strain = 0.08 at a stress = 265 MPa. When true stress = 325 MPa, true strain = 0.27. Determine the strength coefficient and the strain-hardening exponent in the flow curve equation.

3.6 During a tensile test, a metal has a true strain = 0.10 at a true stress = 255 MPa. Later, at a true stress = 380 MPa, true strain = 0.25. Determine the strength coefficient and strain-hardening exponent in the flow curve equation.

3.7 In a tensile test a metal begins to neck at a true strain = 0.28 with a corresponding true stress = 345.0
MPa. Without knowing any more about the test, can you estimate the strength coefficient and the strain-hardening exponent in the flow curve equation?

3.8 A tensile test for a certain metal provides flow curve parameters: strain-hardening exponent is 0.3 and strength coefficient is 600 MPa. Determine (a) the flow stress at a true strain = 1.0 and (b) true strain at a flow stress = 600 MPa.

3.9 The flow curve for a certain metal has a strain-hardening exponent of 0.22 and strength coefficient of 372 MPa. Determine (a) the flow stress at a true strain = 0.45 and (b) the true strain at a flow stress = 275 MPa.

3.5:

$\varepsilon = 0.08$ $\sigma_t = 265$ MPa.

$\varepsilon = 0.27$ $\sigma_t = 325$MPa

K, n?

$\sigma = K\varepsilon^n$.

$\frac{325 = \cancel{K} \times 0.27^n}{265 = \cancel{K} \times 0.08^n} = 1.23 = (3.375)^n$

$\ln 1.23 = n \ln 3.375$

$\boxed{n = 0.17}$

$265 = K \times 0.08^{0.17}$

$K = 407.11$ MPa.

3.7: $\varepsilon = 0.28$ (neck) $\sigma = 345.0$MPa

$\sigma = K\varepsilon^n$.

at necking $\varepsilon = n$ so: $345 = K \times 0.7$

$\boxed{K = 492 \text{ MPa}}$

Find UTS? *

$\sigma_t = \sigma_e(1+e)$

$\varepsilon = \ln(1+e)$

$e^{0.28} = e^{\ln(1+e)}$

$e^{0.28} = 1+e$

$e = 0.32$

3.10 A metal is deformed in a tension test into its plastic region. The starting specimen had a gage length = 3.125 cm². and an area = 5 cm. At one point in the tensile test, the gage length = 6.25 cm, and the corresponding engineering stress = 165 MPa; at another point in the test prior to necking, the gage length = 8 cm, and the corresponding engineering stress = 193 MPa. Determine the strength coefficient and the strain-hardening exponent for this metal.

$L_0 = 3.125$ cm $A = 5$ cm^2

$L = 6.25$ cm $\rightarrow \sigma_e = 165$ MPa

$L = 8$ cm $\rightarrow \sigma_e = 193$ MPa

K, n?

$\sigma_t = K\varepsilon^n$

$\sigma_t = \sigma_e(1+e)$

$\varepsilon = \ln(1+e)$

$e = \frac{\Delta L}{L_0} = \frac{8-3.125}{3.125} = 1.56.$

$\sigma_e = \frac{F}{A_0} =$

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Compression

3.18 A metal alloy has been tested in a tensile test with the following results for the flow curve parameters: strength coefficient = 620.5 MPa and strain-hardening exponent = 0.26. The same metal is now tested in a compression test in which the starting height of the specimen = 62.5 mm and its diameter = 25 mm. Assuming that the cross section increases uniformly, determine the load required to compress the specimen to a height of (a) 50 mm and (b) 37.5 mm.

3.18: $K = 620.5$ MPa $n = 0.26$.

$h_0 = 62$ mm $d = 25$ mm

a) $h = 50$ mm.

$\sigma_e = \frac{F}{A_0} = 335.55 = \frac{F}{490.87}$ $\boxed{F = 164710.23\,N}$

$A_0 = \pi r^2 = \pi \times \left(\frac{25}{2}\right)^2 = 490.87$ mm^2.

$e = \frac{\Delta h}{h_0} = \frac{62-50}{50} = 0.24.$

$\sigma_t = K\varepsilon^n$ $\varepsilon = \ln(1+0.24) = 0.215.$

0.26

3.19 The flow curve parameters for a certain stainless steel are strength coefficient = 1100 MPa and strain- hardening exponent = 0.35. A cylindrical specimen of starting cross-sectional area = 1000 mm² and height = 75 mm is compressed to a height of 58 mm. Determine the force required to achieve this compression, assuming that the cross section increases uniformly.

3.20 A steel test specimen (modulus of elasticity = 205 × 10³ MPa) in a compression test has a starting height = 5 cm and diameter = 3.75 cm. The metal yields (0.2% offset) at a load = 63500 kg. At a load of 117,900 kg, the height has been reduced to 4 cm. Determine (a) yield strength and (b) flow curve parameters (strength coefficient and strain-hardening exponent). Assume that the cross-sectional area increases uniformly during the test.

$\sigma_t = K\varepsilon^n \qquad \varepsilon = \ln(1+0.24) = 0.215.$

$620.5 \times 0.215^{0.26} = 416.08\,\text{MPa}$

$\sigma_t = \sigma_e(1+e)$

$416.08 = \sigma_e(1+0.24) \qquad \boxed{\sigma_e = 335.55\,\text{MPa}}$

b) $h = 37.5\,\text{mm}$

$A_o = 490.87\,\text{mm}^2$

$\sigma_e = \dfrac{F}{A_o} \longrightarrow 313.96 = \dfrac{F}{490.87} \qquad \boxed{F = 154114.36\,\text{N}}$

$\sigma_t = K\varepsilon^n \qquad \sigma_t = 620.5 \times 0.503^{0.26} = 518.98\,\text{MPa}$

$e = \dfrac{\Delta h}{h_o} = \dfrac{62 - 37.5}{37.5} = 0.653$

$\varepsilon = \ln(1+e) = \ln(1+0.653) = 0.503$

$\sigma_t = \sigma_e(1+e)$

$518.98 = \sigma_e(1+0.653) \rightarrow \boxed{\sigma_e = 313.96\,\text{MPa}}$

during the test.

Bending and Shear

3.21 A bend test is used for a certain hard material. If the transverse rupture strength of the material is known to be 1000 MPa, what is the anticipated load at which the specimen is likely to fail, given that its width = 15 mm, thickness = 10 mm, and length = 60 mm?

3.22 A special ceramic specimen is tested in a bend test. Its width = 1.25 cm and thickness = 0.625 cm. The length of the specimen between supports = 5.0 cm. Determine the transverse rupture strength if failure occurs at a load = 770 kg.

3.23 A torsion test specimen has a radius = 25 mm, wall thickness = 3 mm, and gage length = 50 mm. In testing, a torque of 900 N-m results in an angular deflection = 0.3°. Determine (a) the shear stress, (b) shear strain, and (c) shear modulus, assuming the specimen had not yet yielded. (d) If failure of the specimen occurs at a torque = 1200 N-m and a corresponding angular deflection = 10°, what is the shear strength of the metal?

3.24 In a torsion test, a torque of 6780 N-lb is applied which causes an angular deflection = 1° on a thin-walled tubular specimen whose radius = 3.75 cm, wall thickness = 0.25 cm, and gage length = 5.0 cm. Determine (a) the shear stress, (b) shear strain, and (c) shear modulus, assuming the specimen had not yet yielded. (d) If the specimen fails at a torque = 10850 N-m and an angular deflection = 23°, calculate the shear strength of the metal.

3.21: TRS = 1000 MPa
$w = 15\,\text{mm} \quad t = 10\,\text{mm} \quad L = 60\,\text{mm}$

$TRS = \dfrac{1.5FL}{bt^2}$

$1000 = \dfrac{1.5F \times 60}{15 \times 10^2} = F = 16666.67\,\text{N}$

3.23: $R = 25\,\text{mm} \quad t = 3\,\text{mm} \quad L = 50\,\text{mm}$

3.23 : $R = 25\,mm$ $t = 3\,mm$ $L = 50\,mm$

$T = 900\,N.m$ $\alpha = 0.3°$

a) $\tau = \frac{T}{2\pi R^2 t} = \frac{900}{2\pi \times 25^2 \times 3} =$ 76.4 MPa

b) $\gamma = \frac{R\,\alpha}{L} = \frac{25 \times 0.3 \times \frac{\pi}{180}}{50} = 2.618 \times 10^{-3}$

c) $\tau = G\gamma$

$76.4 = G \times 2.618 \times 10^{-3}$

$G = 29.18\,GPa.$

d) $T = 1200\,N.m$ $\alpha = 10°$

$\tau = \frac{T}{2\pi R^2 t} = \frac{1200}{2\pi \times 25^2 \times 3} =$ 102 MPa.