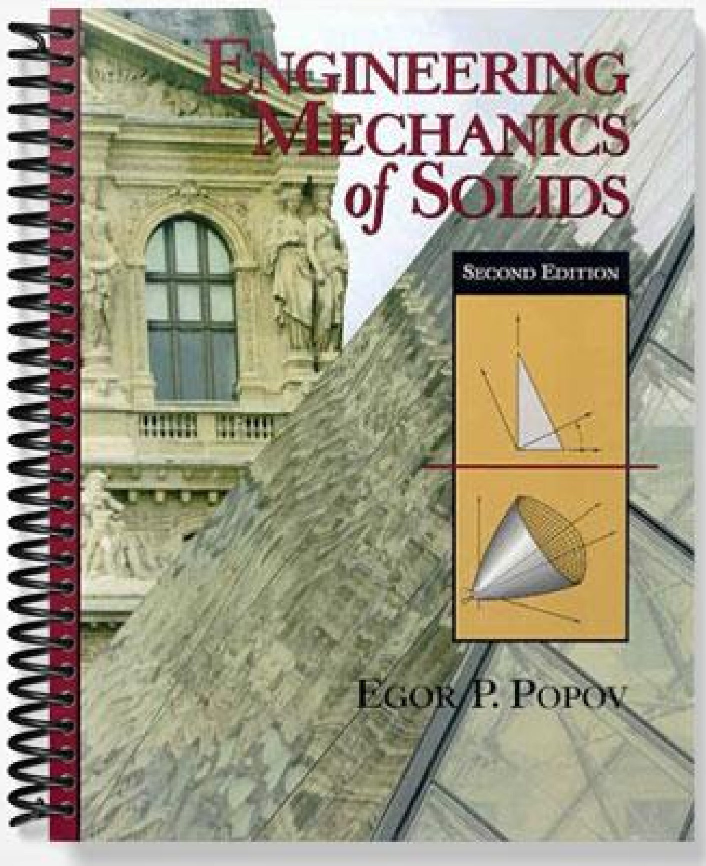
SOLUTIONS MANUAL



2-1

$$E = \frac{\sigma}{\varepsilon} = \frac{P/A}{\Delta/L} = \frac{(29500)/\frac{\pi}{4}(0.013)^2}{(2.2\times10^{-4})/0.2)} = 202\times10^9\ \frac{N}{m^2}$$

2-2

$$A = \max \text{ of } \begin{cases} \frac{P}{\sigma} = \frac{5\times10^3}{150} = 33.33\ mm^2 \\ \frac{PL}{\Delta E} = \frac{(5\times10^3)(10^4)}{(3)(2\times10^5)} = 83.33\ mm^2 \end{cases}$$

$$\frac{\pi}{4}d^2 = 83.33 \longrightarrow d = 10.3\ mm$$

Use 11 mm rod

2-3

(a) $\frac{PL_1}{AE_{st}} = \frac{PL_2}{AE_{Al}}$

$$L_1 = \frac{E_{st}}{E_{Al}} L_2 = \frac{200}{70} L_2$$

$$L_2 = \frac{900}{(1+\frac{20}{7})} = 233\ mm \quad , \quad L_1 = 667\ mm$$

(b) $\Delta = \Sigma \frac{PL}{EA} = \frac{1.2\times10^5}{\pi(25)^2}\left(\frac{667}{2\times10^5} + \frac{233}{7\times10^4}\right)$

$$\Delta = 0.407\ mm$$

2-4

$$\varepsilon = \frac{\Delta}{L} = \text{CONSTANT}$$

$$\frac{0.035}{200} = \frac{600}{L} \quad , \quad L = 3429\ m$$

2-5

$$\bar{\sigma} = \sigma(1+\varepsilon)$$

$$A = A_o/(1+\varepsilon)$$

	compression					tension				
strain (%)	-0.1	-0.2	-1	-2	-4	0.1	0.2	1	2	4
eng. stress	18	36	72	100	128	18	36	72	85	92
true stress	18.0	35.9	71.3	98.0	122.9	18.0	36.1	72.7	86.7	95.7
true area (A_o)	1.00	1.00	1.01	1.02	1.04	1.00	1.00	0.99	0.98	0.96

2-6

$$R_o^2 - (R_o - 300)^2 = (25000)^2$$

$$R_o = 1041816.667\ mm$$

$$\theta_o = 2\sin^{-1}\frac{25000}{R_o}$$

$$L_o \approx R_o\theta = (1041816.667)\left(\frac{\pi}{180}\times\theta_o\right) = 50004.8\ mm$$

$$L = L_o\left[1 + (16\times10^{-6})(70)\right] = 50060.8\ mm$$

$$2R\sin^{-1}\frac{25000}{R} = 50060.8 \longrightarrow R \approx 293163$$

$$(293163)^2 - (293163 - S)^2 = (25000)^2$$

$$S = 1068\ mm$$

Approximate by parabola, $Y = \frac{4H}{L^2}(X-L)X$

$$S \approx \int_0^L \sqrt{1+\left(\frac{\partial Y}{\partial X}\right)^2}\, dX$$

2-7

$$\varepsilon_z = \frac{P}{AE} = \frac{200\times10^3}{\frac{\pi}{4}(60)^2(85\times10^3)} = 8.322\times10^{-4}$$

$$\frac{\Delta d}{60} = \nu\varepsilon_z \longrightarrow \Delta d = 60(0.3)(8.322\times10^{-4})$$

$$= 0.015\ mm$$

2-8

$$P_{st} = \varepsilon E A/\nu = \alpha \Delta T E A/\nu$$

$$= (11.7\times10^{-6})(200)(200)\left(\frac{\pi}{4}\times20^2\right)/0.3 = 490\ kN$$

$$P_{al} = (23.4\times10^{-6})(200)(70)\left(\frac{\pi}{4}\times20^2\right)/0.35 = 294\ kN$$

2-9

(a) $F = \frac{5(9.81)}{\cos 30°} = 56.64$

$$\frac{F}{\sigma_{all}} = \frac{\pi}{4}d^2 \longrightarrow d = \sqrt{\frac{4(56.64)}{\pi(300)}} = 0.49\ mm$$

(b) $\Delta = \frac{\sigma}{E}L_o = \frac{300}{(200\times10^3)}(1.5\times10^3) = 2.25\ mm$

2-10

$U_{T\,(\text{tool steel})} \approx 11$ ksi

$U_{T\,(\text{Low-alloy high-strength steel})} \approx 17$ ksi

$U_{T\,(\text{Low-carbon steel})} \approx 18$ ksi

2-11 (a) $\dot{\sigma} + \frac{E}{\eta}\sigma = E\dot{\varepsilon}$

But $\frac{d\varepsilon}{dt} = Const = c = \dot{\varepsilon}$

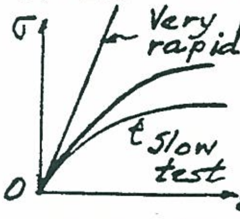
or $\varepsilon = ct$ or $t = \frac{\varepsilon}{t}$

Hence $\dot{\sigma} + \frac{E}{\eta}\sigma = Ec$

Solution: $\sigma = Ae^{-\frac{E}{\eta}t} + \eta c$

or $\sigma = Ae^{-\frac{E\varepsilon}{\eta c}} + \eta c$

Since $\sigma = 0$ for $\varepsilon = 0$, $\sigma = \eta c\left(1 - e^{-E\varepsilon/\eta c}\right)$



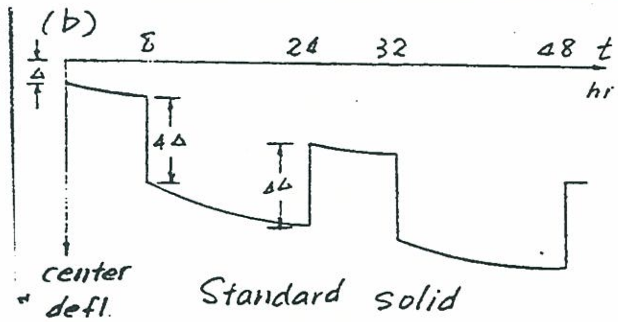
and $\frac{d\sigma}{d\varepsilon} = Ee^{-E\varepsilon/\eta c}$

$= Ee^{-Et/\eta}$

(b) At $t = 0$, $E = Const$

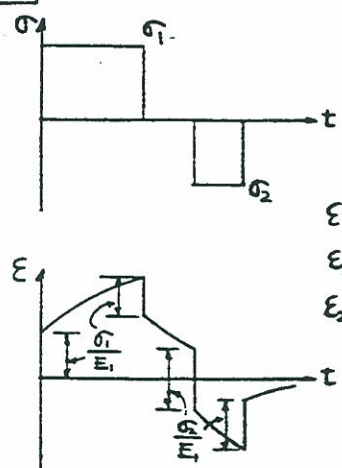
(c) Can be misleading

(b)



Standard solid

2-12

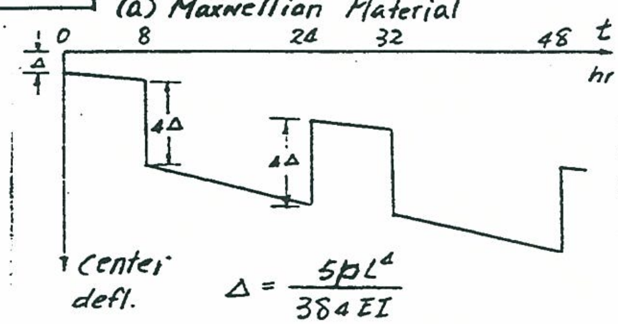


$\varepsilon = \varepsilon_1 + \varepsilon_2$

ε_1 : due to E_1 & η_1

ε_2 : due to E_2 & η_2

2-13 (a) Maxwellian Material



$\Delta = \frac{5pL^4}{384EI}$

p = empty wt. / unit length

2-14 $\dot{\varepsilon} = B\sigma^n$

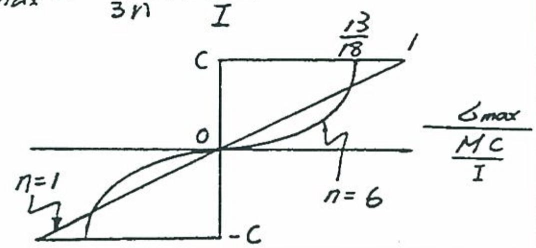
$\frac{\sigma^n}{\sigma_{max}^n} = \frac{\dot{\varepsilon}}{\dot{\varepsilon}_{max}} = \frac{y}{c} \rightarrow \sigma = \left(\frac{y}{c}\right)^{\frac{1}{n}}\sigma_{max}$

$M = 2\int_0^c \sigma y\,dA = \frac{2b\sigma_{max}}{c^{\frac{1}{n}}}\int_0^c y^{\frac{n+1}{n}}dy$

$M = \frac{2b\sigma_{max}}{c^{\frac{1}{n}}}\;\frac{n}{2n+1}\;c^{\frac{2n+1}{n}}$

$M = \frac{n}{2n+1}\,2bc^2\sigma_{max} = \frac{3n}{2n+1}\,\frac{I\sigma_{max}}{c}$

$\sigma_{max} = \frac{2n+1}{3n}\,\frac{MC}{I}$



2-15 from Fig. 2-5, the ultimate stress for steel is 186 Mpa. for aluminum is 150 MPa

2-16 (a) from Fig. 2-5

Al: $\frac{2\times10^6}{5.3\times10^6} + \frac{4\times10^5}{8.7\times10^5} = 0.84 < 1$ (O.K.)

St: $\frac{2\times10^6}{1.1\times10^6} + \frac{4\times10^5}{2\times10^5} = 3.82 > 1$ (N.G.)

(b)

Al: $\frac{5\times10^6}{1.8\times10^7} + \frac{4\times10^8}{5\times10^8} = 1.08 > 1$ (N.G.)

St: $0 + 0 < 1$ (O.K.)