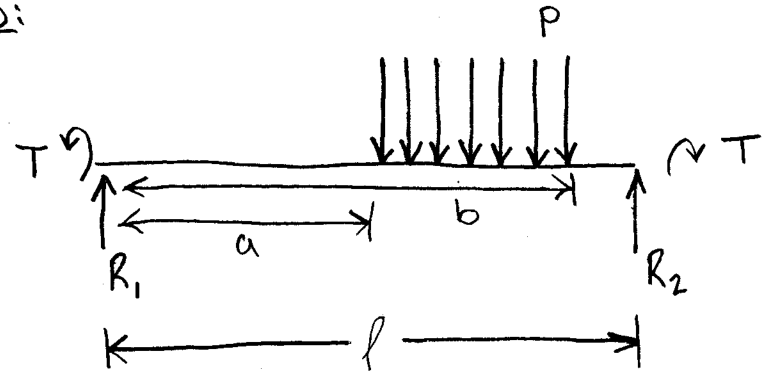
NORTON 9.2

FBD:



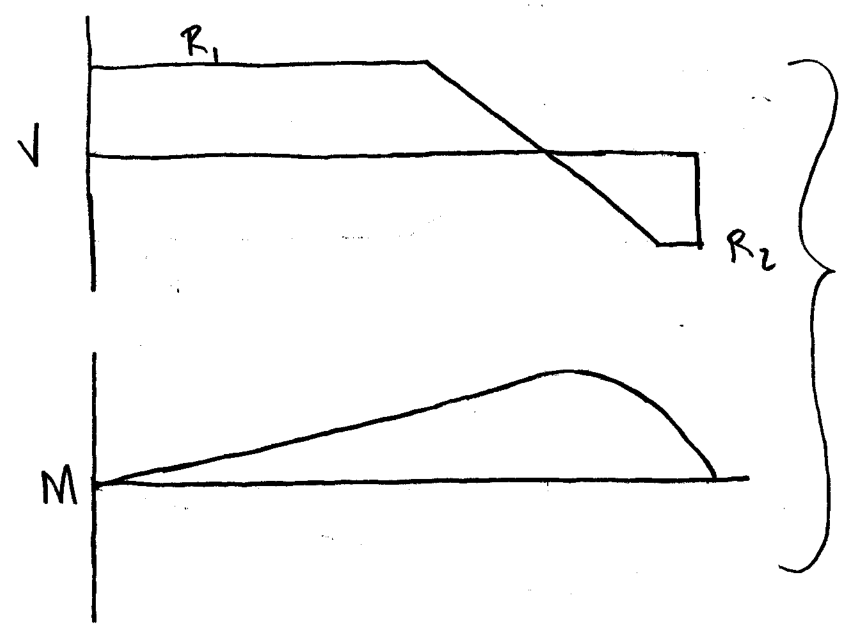
$\Sigma F_y = 0;\ R_1 + R_2 = P(b-a)$

$\Sigma M_{R_1} = 0;\ P(b-a)\left(a + \frac{b-a}{2}\right) = R_2 \ell$

$\therefore\ R_2 = \dfrac{P(b-a)\left(a+\frac{b-a}{2}\right)}{\ell}$

& $R_1 = P(b-a)\left[1 - \frac{1}{\ell}\left(a + \frac{b-a}{2}\right)\right]$

SHEAR AND MOMENT DIAGRAMS:



NOTE: MAX MOMENT IS NOT FOUND AT THE CENTER OF THE DISTRIBUTED LOAD.

USE SINGULARITY FUNCTIONS TO FIND LOCATION AND VALUE OF M_{max}

$$q = R_1\langle x-0\rangle^{-1} - P\langle x-a\rangle^0 + P\langle x-b\rangle^0 + R_2\langle x-\ell\rangle^{-1}$$

$$V = \int q\,dx = R_1\langle x-0\rangle^0 - P\langle x-a\rangle^1 + P\langle x-b\rangle^1 + R_2\langle x-\ell\rangle^0$$

SET $V=0$ TO FIND LOCATION OF M_{max}

$$0 = R_1 - P(x-a) \rightarrow x = \frac{R_1}{P} + a$$

$$M = \int V\,dx = R_1\langle x-0\rangle^1 - \frac{P}{2}\langle x-a\rangle^2 + \frac{P}{2}\langle x-b\rangle^2 + R_2\langle x-\ell\rangle^1$$

$$M_{max} = R_1\left(\frac{R_1}{P}+a\right) - \frac{P}{2}\left(\frac{R_1}{P}\right)^2 = R_1\left(\frac{R_1}{P} + a - \frac{R_1}{2P}\right) = R_1\left(\frac{R_1}{2P}+a\right)$$

NORTON 9.2 CONT'D

SINCE THE BENDING IS FULLY REVERSED,

$$M_{alt} = M_{MAX} \quad \& \quad M_{mean} = 0$$

$$T_{alt} = \frac{T_{MAX} - T_{MIN}}{2} \qquad T_m = \frac{T_{max} + T_{MIN}}{2}$$

ASSUMING A CONSTANT RATIO BETWEEN MEAN AND ALTERNATING STRESSES,

$$d = \left\{ \frac{32 N_f}{\pi} \left[\frac{\sqrt{(k_f M_a)^2 + \frac{3}{4}(k_{fs} T_a)^2}}{S_f} + \frac{\sqrt{(K_{fm} M_m)^2 + \frac{3}{4}(k_{fsm} T_m)^2}}{S_{ut}} \right] \right\}^{1/3}$$

NOTE: $K_f = K_{fs} = K_{fm} = K_{fsm} = 1$ (NO STRESS CONCENTRATION)

$$S_f = S_e = 0.5 S_{ut} C_{LOAD} C_{SIZE} C_{SURF} C_{TEMP} C_{RELIAB}$$

$C_{LOAD} = C_{TEMP} = C_{RELIAB} = 1$

$C_{SIZE} = ? = 1.189 d^{-0.097}$ (HAVE TO GUESS DIAMETER)

$C_{SURF} = .75$ (ASSUME MACHINED)

HAND CALCULATIONS FOR ROW (a)

$$R_1 = 1000\,N/cm\,(18\,cm - 16\,cm)\left[1 - \frac{1}{20\,cm}\left(16\,cm + \frac{18\,cm - 16\,cm}{2}\right)\right] = 300\,N$$

$$R_2 = \frac{1000\,N/cm\,(18\,cm - 16\,cm)\left(16\,cm + \frac{18\,cm - 16\,cm}{2}\right)}{20\,cm} = 1700\,N$$

$$M_{MAX} = 300\,N\left(\frac{300\,N}{2(1000\,N/cm)} + 16\,cm\right) = 48.45\,Nm$$

$T_{alt} = 1000\,Nm \quad T_m = 1000\,Nm$

$C_{SIZE} = 1.189(45)^{-0.097} = 0.82$ (NOTHING WRONG WITH GUESSING CORRECTLY)

$S_e = 0.5(745\times10^6)(.82)(.75) = 229.6\,MPa$

$$d = \left\{ \frac{32(2)}{\pi} \left[\frac{\sqrt{(48.5)^2 + \frac{3}{4}(1000)^2}}{229.6\times10^6} + \frac{\sqrt{\frac{3}{4}(1000)^2}}{745\times10^6} \right] \right\}^{1/3} = 4.65\,cm$$

NORTON 9.2

Row	l (cm)	a (cm)	b (cm)	P (N/cm)	Tmin (Nm)	Tmax (Nm)	R1 (N)	R2 (N)	Mmax (Nm)	Talt (Nm)	Tm (Nm)	Csize	Se (Mpa)	d (cm)
a	20	16	18	1000	0	2000	300	1700	48.5	1000	1000	0.82	229	**4.66**
b	12	2	7	500	-100	600	1563	938	55.7	350	250	0.85	237	**3.27**
c	14	4	12	750	-200	400	2571	3429	146.9	300	100	0.85	237	**3.20**
d	8	4	8	1000	0	2000	1000	3000	45.0	1000	1000	0.82	229	**4.66**
e	17	6	12	1500	-200	500	4235	4765	313.9	350	150	0.84	235	**3.59**
f	24	16	22	750	1000	2000	938	3563	155.9	500	1500	0.84	234	**3.73**

NOTE: THE DIAMETERS SHOWN HERE VARY FROM THE SOLUTIONS MANUAL BECAUSE I ASSUMED 50% RELIABILITY, WHILE THE BOOK ASSUMED 99%. BOTH ANSWERS ARE CORRECT, SINCE THE PROBLEM STATEMENT SAID NOTHING ABOUT RELIABILITY, ANY REASONABLE ASSUMPTION IS VALID.