7-20

HINTS:

(1) MUST CONSIDER REACTION OF PT. INSIDE AND OUTSIDE OF CURVE.

(2) SINCE STRESS IS COMPRESSIVE ON INSIDE PT. → THE MEAN STRESS HAS NO EFFECT ON ENDURANCE LIMIT.

[redacted] (a) $I = \dfrac{bh^3}{12} = \dfrac{18(3)^3}{12} = 40.5\ \text{mm}^4$

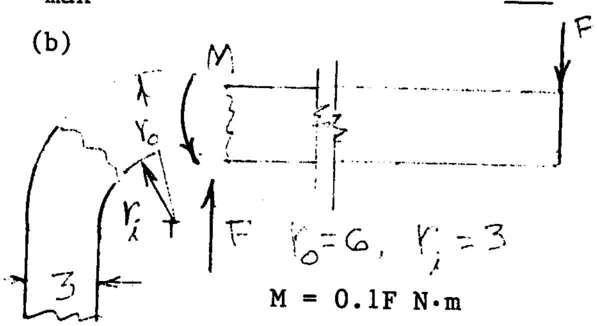
Since $y = \dfrac{F\ell^3}{3EI}$, $F = \dfrac{3EIy}{\ell^3}$

$$F_p = F_{min} = \frac{3(207)(40.5)(2)(10^3)}{(100)^3}$$

$= 50.3\ \text{N}$ <u>Ans</u>.

$F_{max} = 50.3(6/2) = 150.9\ \text{N}$ <u>Ans</u>.

(b)



$M = 0.1F\ \text{N}\cdot\text{m}$

From curved-beam theory

$$r = \frac{h}{\ln \dfrac{r_o}{r_1}} = \frac{3}{\ln 2} = 4.328\ \text{mm}$$

$\bar{r} = 4.5$ mm, so $e = \bar{r} - r = 4.5 - 4.328$

$= 0.172$ mm

$c_o = 1.5 + 0.172 = 1.672$ mm

$c_i = 1.5 - 0.172 = 1.328$ mm

$$\sigma_i = -\frac{Mc_i}{Aer_i} = -\frac{0.1F(0.1328)}{0.3(1.8)(0.0172)(0.3)}$$

$= -4.766F$ MPa

Note that all dimensions have been transformed to centimeters in this computation. Similarly,

$$\sigma_o = \frac{Mc_o}{Aer_o} = \frac{0.1F(0.1672)}{0.3(1.8)(0.0172)(0.6)}$$

$= 3.000F$ MPa

$\sigma_{i,min} = -4.766(50.3) = -239.7$ MPa

$\sigma_{i,max} = -4.766(150.9) = -719.2$ MPa

$\sigma_{o,min} = 3(50.3) = 150.9$ MPa

$\sigma_{o,max} = 3(150.9) = 452.7$ MPa

<u>Inner radius</u>, yielding

Eq. (5-20): $S_u = 3.10H_B = 3.10(490)$

$= 1519$ MPa

Here we estimate that $S_y = 0.9S_u$, so

$S_y = 0.9(1519) = 1367$ MPa

$$n = \frac{S_{yc}}{\sigma_{max}} = \frac{-1367}{-719.2} = 1.90 \quad \underline{\text{Ans}}.$$

<u>The compressive mean stress has no effect on the endurance limit.</u>

$$\sigma_a = \left|\frac{\sigma_{max} - \sigma_{min}}{2}\right| = \frac{-719.2 - (-239.7)}{2}$$

$= 239.8$ MPa

Eq. (7-4): $S'_e = 700$ MPa

Table 7-4: $a = 1.58$, $b = -0.085$

$k_a = 1.58(1519)^{-0.085} = 0.848$

Eq. (7-19): $d_e = 0.808[3(18)]^{\frac{1}{2}} = 5.94$ mm

Eq. (7-15): $k_b = \left(\dfrac{5.94}{7.62}\right)^{-0.1133} = 1.03$

$S_e = 0.848(1.03)(700) = 611.4$ MPa

So $n = \dfrac{611.4}{239.7} = 2.55$ <u>Ans</u>.

<u>Outer radius</u>

$$n_{static} = \frac{S_{yt}}{\sigma_{max}} = \frac{1367}{452.7} = 3.02 \quad \underline{\text{Ans}}.$$

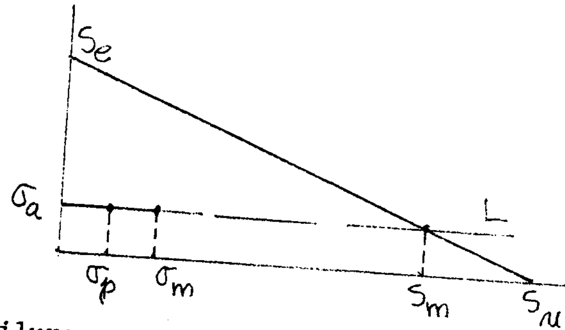
$S_e = 611.4$ MPa unchanged

$$\sigma_a = \frac{452.7 - 150.9}{2} = 150.9\ \text{MPa}$$

$$\sigma_m = \frac{452.7 + 150.9}{2} = 301.8\ \text{MPa}$$

$\sigma_p = 150.9$ MPa

7-25 (Concluded)



Failure occurs when $\sigma_m = S_m$ since $S_a = \sigma_a$.

Eq. (7-35): $S_m = S_{ut}\left(1 - \dfrac{S_a}{S_e}\right)$

$$= 1519\left(1 - \frac{150.9}{611.4}\right)$$

$$= 1144 \text{ MPa}$$

So $n = \dfrac{S_m}{\sigma_m} = \dfrac{1144}{301.8} = 3.79$ Ans.

7-26 Table A-20: $S_{ut} = 64$ kpsi

$S_{yt} = 54$ kpsi for cold drawn steel.

$S'_e = 0.504(64) = 32.3$ kpsi

Table 7-4: $a = 2.7$, $b = -0.265$

$k_a = 2.7(64)^{-0.265} = 0.897$

$k_b = 1$, $k_c = 0.923$ (axial)

$S_e = 0.897(1)(0.923)(32.3) = 26.7$ kpsi

At the fillet

$$\sigma_c = \frac{F_{max}}{A} = \frac{-16}{2.5(0.5)} = -12.8 \text{ kpsi}$$

$$n_{static} = \frac{-S_y}{\sigma_c} = \frac{-54}{-12.8} = 4.22 \quad \text{Ans.}$$

Fig. A-15-5: $D = 3.75$, $d = 2.5$, $D/d = 3.75/2.5 = 1.5$, $r/d = 0.25/2.5$, $r/d = 0.1$, $K_t = 2.1$

$q = 0.78$, $K_f = 1 + 0.78(2.1 - 1) = 1.86$

$$\sigma_{max} = \frac{4}{1.25} = 3.2 \text{ kpsi}$$

$$\sigma_{min} = \frac{-16}{1.25} = -12.8 \text{ kpsi}$$

$$\sigma_a = K_f\left|\frac{\sigma_{max} - \sigma_{min}}{2}\right|$$

σ_a =
S
n = —
σ
At ho
Fig. A
q = 0.
σ_{max} =
σ_{min} =
σ_a = 2.
n = 26./14.
So fail
fillet.

7-27 (a)
σ'_m = [3(1
Eq. (7-45
(b) S_{se} =
Fatigue: n
Static: n =
(c) σ'_m = [3
σ'_a = [(
Eq. (7-45):
σ'_{max} = [(83)
Static: n =