PROBLEM 6-24a

Statement: **The beam in Figure P6-11*b* is subjected to a sinusoidal force-time function with $F_{max} = F$ and $F_{min} = F/2$, where *F* and the beam's other data are given in row *a* of Table P6-5. Find the stress state in the beam due to this loading and choose a material specification that will give a safety factor of 1.5 for $N = 5E8$ cycles.**

Units: $N := newton$ $\quad MPa := 10^6 \cdot Pa$ $\quad GPa := 10^9 \cdot Pa$

Given:

Beam length $L := 1 \cdot m$

Concentrated load $F := 500 \cdot N$

Moment of inertia $I := 2.85 \cdot 10^{-8} \cdot m^4$

Distance to extreme fiber $c := 2.00 \cdot 10^{-2} \cdot m$

Design safety factor $N_d := 1.5$

Cycle life $N_f := 5 \cdot 10^8$

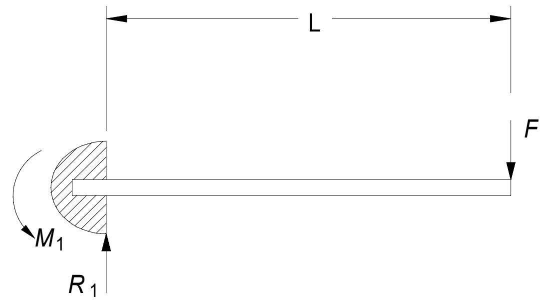

FIGURE 6-24
Free Body Diagram for Problem 6-24

Solution: See Figure 6-24 and Mathcad file P0624a.

1. The minimum, maximum, alternating, and mean components of the loads are:

$F_{max} := F \qquad F_{max} = 500\,N \qquad F_{min} := \frac{F}{2} \qquad F_{min} = 250\,N$

$F_a := \frac{F_{max} - F_{min}}{2} \qquad F_a = 125\,N \qquad F_m := \frac{F_{max} + F_{min}}{2} \qquad F_m = 375\,N$

2. Calculate the alternating and mean components of the maximum bending moment on the beam using the equation in Figure D-1(a) in Appendix D.

$M_a := F_a \cdot L \qquad M_a = 125\,N \cdot m$

$M_m := F_m \cdot L \qquad M_m = 375\,N \cdot m$

3. Calculate the alternating and mean components of the maximum bending stress in the beam using equation (4.11b). These are principal stresses and also von Mises stresses.

$\sigma'_a := \frac{M_a \cdot c}{I} \qquad \sigma'_a = 87.719\,MPa$

$\sigma'_m := \frac{M_m \cdot c}{I} \qquad \sigma'_m = 263.158\,MPa$

4. Calculate the beam cross-section dimensions from *I* and *c*.

Beam depth $h := 2 \cdot c \qquad h = 40\,mm$

Beam width $w := \frac{12 \cdot I}{h^3} \qquad w = 5.344\,mm$

5. Calculate the endurance limit modification factors for a nonrotating rectangular beam.

$$N_d \quad \frac{S_e(S_{ut}) \cdot S_{ut}}{\sigma'_a \cdot S_{ut} + \sigma'_m \cdot S_e(S_{ut})}$$

8. Solve the equations in steps 6 and 7 simultaneously for the desired S_{ut}.

$$S_{ut} := \frac{N_d \cdot \left(2 \cdot \sigma'_a + C_{load} \cdot C_{size} \cdot C_{surf} \cdot C_{temp} \cdot C_{reliab} \cdot \sigma'_m\right)}{C_{load} \cdot C_{size} \cdot C_{surf} \cdot C_{temp} \cdot C_{reliab}}$$

$$S_{ut} = 676\,MPa$$

9. Choose AISI 1060 hot-rolled steel (see Appendix C, Table C-9).