Tutorial 3

Question 1

A mine hoist uses a 2in 6×19 moniter-steel wire rope. The rope is used to haul maximum loads of 4 tones from a 480 ft. shaft. The drum has a diameter of 6 feet and the sheaves are of a good-quality cast steel, and the smallest diameter is 3 feet in diameter

INFORMATION

monitor steel
2-in 6×19
maximum load is 8000lbf

Part a

Using a maximum hoisting speed of 1200 feet/minute and a maximum acceleration of
2ft/s^2, estimate the stresses in the wire rope

INFORMATION

acceleration $= \frac{2ft}{s^2}$
speed $= \frac{1200ft}{\min}$
$1 : F_t \sim$ tension limit
$2 : F_b \sim$ bending
$3 : F_f \sim$ fatigue

Part 1

From equation 17-47: tensile wire load

$$F_t = \left(\frac{W}{m} + wl\right)\left(1 + \frac{a}{g}\right)$$

$W \sim$ weight supported: 8000lbf
$w \sim$ weight of the rope per length

$l \sim$ length of the rope
$m \sim$ number of ropes

From table 17-24: $w = 1.60d^2 = 1.60 \cdot 2^2$
$F_t = 11,760\text{in-lbf}$

$(S_u)_{nom} = 106\text{kpsi}$
$(S_u)_{nom} < S_u$ (on page 922)
$(S_u)_{nom}$ is over entire are, not just area of metal in the rope

From table 17-27
Area of metal
$A_m = 0.40d^2 = 1.6\text{in}^2$

Ultimate load

$F_u = (S_u)_{nom} \times A_{nom}$
$A_{nom} = \frac{\pi}{4}d^2$
$F_u = 333\text{kip}$

Part 2

Equation 17-41: equivalent bending load

$$F_b = \frac{E_r d_w A_m}{D}$$

Better sheave diameter
$D = 45d = 90\text{in}$
$E_r \sim$ Young's modulus $= 12 \times 10^6\text{psi}$
$d_w = 0.067d^2 = 0.0134\text{in}$
$\implies F_b = 28,600\text{lbf}$

Part 3.

From equation 17-44: Fatigue Tension

$$F_f = \frac{\frac{p}{S_u} S_u d D}{2}$$

From figure 17-21: Endurance limit/fatigue life
Pressure-strength ratio: $1000\frac{p}{S_u}$

Assuming a million bends until failure

First calculate for infinite - life $\implies 1,000,000\text{cycles}$

$1000\frac{p}{S_u} = 1.4 \implies \frac{p}{S_u} = 0.0014$

$240 < S_u < 280 \text{ kpsi}$

$S_u = 240 \text{ kpsi}$

$F_f = 30,300 \text{ lbf}$

Part b

Estimate the various factors of safety

Static with bending

$n_{fs} = \frac{F_u - F_b}{F_t} = \frac{333{,}000 - 28{,}600}{11{,}760} =$

$n_{fs} = \frac{F_u}{F_t} = \frac{333{,}000}{17{,}60} = 28.3$ static without bending

Fatigue without bending $n_{fs} = \frac{F_f}{F_t} = 2.57$

Fatigue with bending $n_{fs} = \frac{F_f - F_b}{F_t} = 0.14 < 1$

Lets try $100,000 \text{ cycles}$ instead

$\frac{F_f - F_b}{F_t} = 4.91$

Effective friction equations

Equation 17-7

$$f' = \frac{1}{\phi} \ln \frac{((F_1)_a - F_c)}{F_2 - F_c}$$

If you complete question 2 you get $f' = 0.656 < f = 0.8$ so the belt doesn't slip