Wire Rope:

is made with two types of winding

1 - Regular lay : wire twisted in one direction to form strand
The strand twisted in opposite direction to form the rope.
→ Wires are parallel to rope axis

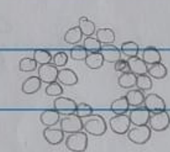
Regular - lay: do not Kink on untwist , easy to handle.

2 - Lang - lay:
wires on strands and strands on the rope twisted in same direction.
→ outer wire are diagonaly a cross the rope axis.

Regular Lay

Lang - Lay.

Lang Lay: are more resistant to abrasive wear and failure due to fatigue than regular Lay but it may Kink and untiwst.



5 X 7

rope designation: $1\frac{1}{8}$ 6 X 7

$1\frac{1}{8}$ rope dia.

6 → no. of strand ; 7 → No. of wire in strand.

The metal area of standard rope , $A_m = 0.38 d^2$

Bending stress of rope wire as it passes around the sheave.

$$M = \frac{E r}{I} , \quad \sigma = \frac{M c}{I}$$

$\rightarrow \sigma = \frac{Ec}{r}$

r = radius of curvature $= \frac{D}{2}$, D = sheave dia.

$c = \frac{d_w}{2}$, d_w = wire dia.

$\sigma = E \frac{d_w}{D}$, E = rope modulus of elasisity.

σ = tensile stress on outer wire.

$D \uparrow \rightarrow \sigma \downarrow$ → Large pulley dia. is recommended.

Table [17-8] available rope with there characteristics
min. sheave dia.
values are based on $\frac{D}{d_w} = 400$

For elevators and mine hoist $\frac{D}{d_w} = 800 - 1000$

Rope failure:
static failure: $P_{static} > S_{ut}$.
Static load calculation:
1- Dead weight
2- Addition load caused by starting and stop.
3- Shock loading
4- Sheave bearing friction.
Summation of these loads $= P_s$
ultimate strength is reduced due to pulley curvature.
Fig. [17-13] % of Sut reduction Vs $\frac{D}{d}$

Reduced $S_{ut} = S_{Rope} \rightarrow S_{Rope} < \frac{P_s}{A}$

2020/4/26 16:32

$n = \frac{F_u}{F_t}$ $\quad$ $F_u = A\, S_u$ $\quad$ S_u = Rope ultimat strength $\quad$ $A_{Rope} = \frac{\pi d^2}{4}$

F_u = ultimate wire load, F_t = largest tension

$n = 5$ for normal condition

$n = 8-9$ for human safety.

Table [17-19] Factor of safety for different wires applications.

Bearing stress:

when rope passes around sheave → cause wear of rope and sheave. Wear depend on pressure between rope and sheaves.

→ Bearing pressure.

$$P = \frac{2F}{dD} \quad \text{— (1)}$$

, F = tensile force on rope

d = rope dia., D = sheave dia.

Table [17-20] allowable Bearing pressure [rough estimation].

Fatigue failure:

Fig. [17-14] S-N diagram for wire rope.

P/Su vs. no. of bends

P = pressure, Su = wire ultimate strength

wire will fail due to fatigue or wear. → No fatigue limit

$\frac{P}{S_u} < 0.001$ → Long life.

using $\frac{P}{S_u} = 0.001$ → $P = 0.001\, S_u$, Subst. in $P = \frac{2F}{dD}$

$$S_u = 2000 \frac{F}{Dd}$$

, S_u = wire ultimate strength.

dividing both sides of eq.(1) by Su. and solving for F

$$\frac{P}{S_u} = \frac{2F}{dD\, S_u} \longrightarrow F_f = \frac{(P/S_u)\, S_u\, dD}{2}$$

F_f = fatigue allowable tension as wire is bend for $\frac{P}{S_u}$ in figure [17-14]

$\rightarrow n = \frac{F_f}{F_t}$, F_t = tension at place of where rope is flexing

In absence of information of $S_u \rightarrow$ use:

Improved	Plow steel (monitor)	$240 < S_u < 280$ kpsi
	Plow st.	$210 < S_u < 240$ kpsi
Mild	Plow st.	$180 < S_u < 210$ kpsi

Rope design:

Static loading : $n = \frac{F_u}{F_t}$, $n = \frac{F_u - F_b}{F_t}$ (with rope bending)

F_b = rope tension caused by stress due to bending

$$\sigma = \frac{E d_w}{D}$$

Fatigue loading : $n = \frac{F_f}{F_t}$

or use n_s X large no. (Table (17-19))

Plow steel is : AISI 1070 , 1080 carbon steel

Fig. [17-15] % Life gain vs D/d

2020/4/26 16:33

P(17-16): Mine host uses 2-in 6x19 monitor steel wire rope load is 4 tons for shaft 480 ft deep. Drum dia = 6 ft smallest sheave d = 3 ft cast Iron

a) Max. hoisting speed of 1200 ft/min, max. accel 2 ft/s2 find stresses on rope.

b) Find factor of safety:

Solution:

From table [17-18] for 6x19 Monitor st. $S_u = 106$ kpsi

From Fig. [17-14] $\left(\frac{P}{S_u}\right)_{0.6} = 0.0014$

$$F_u = S_{u_{nom}} A_{nom} = 106 \frac{\pi d_r^2}{4} = 106 \frac{\pi (2)^2}{4} = 333 \text{ Kip}$$

Rope tension: $F_t = (W + w\ell)\left(1 + \frac{a}{g}\right)$

$W = 4 \times 2 = 8$ kip $\qquad$ 1 ton = 2000 lbm

$w_\ell = 1.6 d^2 \times L$ (Table [17-18]) weight / ft.

$= 1.6 \times (2)^2 \times \frac{480}{1000} = 3.072$ Kip.

$\rightarrow F_t = (8 + 3.072)\left(1 + \frac{2}{32.2}\right) = 11.76$ Kip.

Bending Load F_b:

$F_b = \sigma A_m = \frac{E d_w}{D} A_m$

$A_m = 0.38 d^2$

From table [17-18] outer wire dia. $\frac{d}{13} - \frac{d}{16}$

take $d_w = \frac{d}{13}$

$D = 36$ in $= 3 \times 12 = 36$ in

$E = 12$ Mpsi [Table (17-18)]

$\rightarrow F_b = \frac{12 \times 10^6 \times (2/13)}{36} \times 0.38 \times 2 = 77.9$ Kip.

Wire ultimate strength. $S_u = 240$ for monitor st.

$\left(\frac{P}{S_u}\right) = 0.0014$, $D = 36''$

$$F_f = \left(\frac{P}{S_u}\right)\frac{S_u\, d_r D}{2} = \frac{0.0014 \times 240 \times 2 \times 36}{2} = 12.1 \text{ Kip}$$

Factor of Safety:

1- Static without bending

$$n = \frac{F_u}{F_t} = \frac{333}{11.76} = 28.3$$

2- Static with bending

$$n = \frac{F_u - F_b}{F_t} = \frac{333 - 77.9}{11.76} = 21.7$$

3- Static using $(S_u)_R$

Fig. [17-13] for $\frac{D}{d} = \frac{36}{2} = 18 \rightarrow$ %8 reduction of Su

$$(S_u)_R = (1 - 0.08)\, S_u = 0.92\, S_u$$

$$\rightarrow n = \frac{0.92\, F_u}{F_t} = 26.1$$

4- Fatigue for 10^6 cycles

$$n = \frac{F_f}{F_t} = \frac{12.1}{11.76} = 1.03$$