4. Continued: (1) Table 10.1 : $\frac{1}{2}$ in-13 UNC grade 5 bolt steel

$A_t = 0.1419\ in^2$ $S_p = 85\ ksi$ $\Rightarrow$ $F_i = S_p A_t = 12{,}060\ lbs$

But w/ variation /10% Decrease

$\boxed{F_i = 7600\ lbs}$ (Conservative estimate)

(2) Reference (5) pg 78

	Semi polished steel	Sand / grit Blasted steel
f	0.3	0.5

So assume $f = 0.4$

Force required to slip: $F = F_i \cdot f = (7600\ lbs)(0.4) = 3040\ lbs$ (per plane).

So F required to overcome friction $\approx \boxed{6000\ lbs}$

(3) Force that can be transmitted through the bolt itself

$F = 2 S_{sy} A$, A is Area of bolt at shear planes.

So $A = \frac{\pi d^2}{4} = \frac{\pi (.5)^2}{4} = 0.196\ in^2$

Using Distortion Energy Theory $S_{sy} = 0.58 S_y = (0.58)(92\ ksi) = 53\ ksi$

Yielding at 2 shear plane:

$F_y = 2(53000\ ksi)(0.196\ in^2)$

$\boxed{F_y = 21{,}000\ lbs}$

(4) Calc. total failure load w/ $S_u = 74\ ksi$

$\boxed{F_y = 29{,}000\ lbs}$

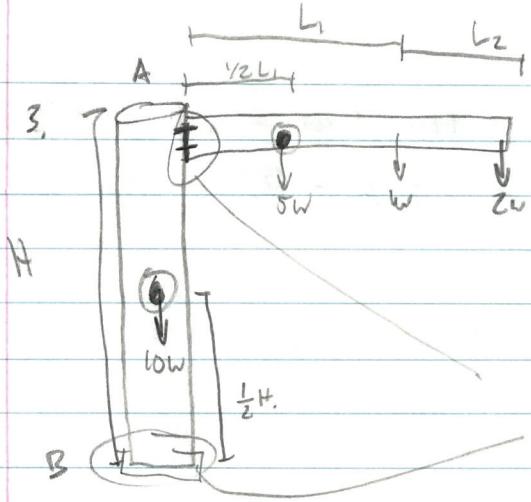
5. $M_{\text{Twist off}} = 25\ Nm$ $\sigma_{tw} = 1.5\ Nm$ $\sigma_{TW} = 2\ Nm$

Find mean value of wrench torque setting that would result in about 7 bolts in 1000 twisting off during assemble

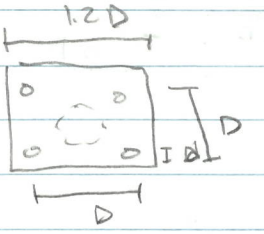
$\boxed{M_{\text{wrench torque}} = 28}$

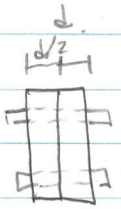
using the MATLAB code 28 gave about 7 bolt fails for every 1000.

3.



Given: $H = 15'$, $L_1 = 17'$, $L_2 = 8'$
$D = 16''$, $d = 2''$, $W = 30$ lbs.





(a.) axial Loads on $A = 8W = 240$ lbs.

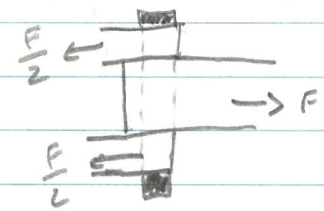
$\sigma = \frac{F}{A} = \frac{240 \text{ lbs}(4)}{\pi(2\text{in})^2} = 60 \text{ lbs/in}^2$

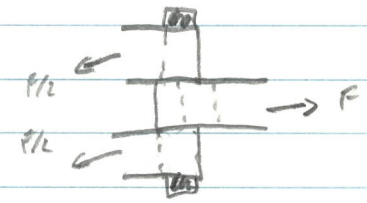
b. axial Loads on $B = 18W = 540$ lbs.

C. you preload the bolts b/c it causes for friction force b/w the threads which helps to keep the nuts from loosening, also it causes a greater force b/w the plates

4. Assumptions: 1. Bolt is tightened to its full proof load: $F_i = S_p A_t$
2. bolt fails in double shear
3. bolt / plates have adequate strength to prevent other failure modes
4. wrench torque variation is $\pm 30\%$
5. 10% initial loss in tension during first weeks of service.

Diagram:





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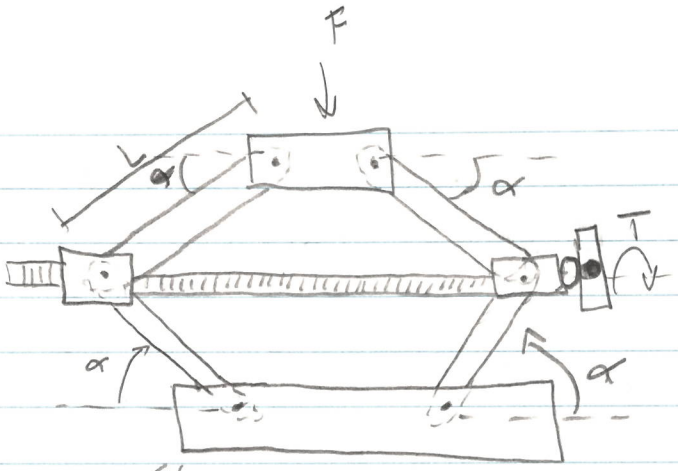
2.



a.

$$\text{Tensile Load} = \frac{F}{2}\cos\alpha$$

b. $F = 3500$ lbs.

$\alpha = 36°$

$L = 12$ in

$P = .2$ in/Thread

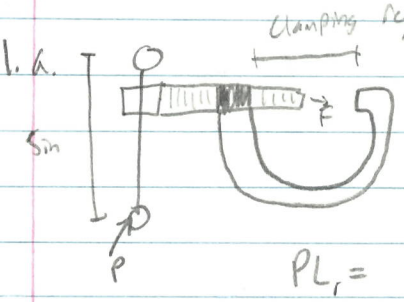
$\eta = .9$

$$T_{screw} = \frac{F_{axial}\, L}{2\pi\eta} = \frac{\left(\frac{3500}{2}\right)\cos 36°\,(12\text{ in})}{2\pi\,(.9)}$$

$$T_{screw} = 3000 \text{ (in-lb.)}$$

Matthew Donaldson

Machine Elements HW 5 Feb. 25, 2020

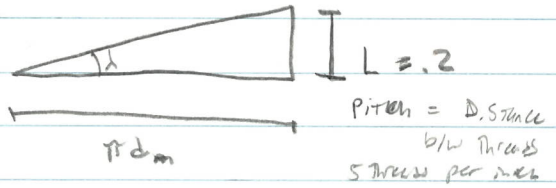
1. a. 

Given: $D = 0.4$ in, $L = 5$ in, AISI 1006 Steel, 3/4"-5 Threads, 10 inches Long Threading. L_{max} in G.L. = 8 in, $f = 0.2$.

$$P L_r = \frac{F d_m}{2}\left(\frac{L + \pi f d_m \sec\alpha}{\pi d_m - f L \sec\alpha}\right), \quad \alpha = 0 \text{ since square bolt so}$$

$$P L_r = \frac{F d_m}{2}\left(\frac{L + \pi f d_m}{\pi d_m - f L}\right)$$

$$F = \frac{\pi d_m - f L}{L + \pi f d_m}\left(\frac{2 P L_r}{d_m}\right)$$



Pitch = D. Distance b/w Threads
5 Threads per inch
so .2

$d_m = .7$ inches. $= \frac{.75 + .65}{2}$

$$\boxed{F = 48.2\ P}$$

b. If the Thread geometry was acme instead of a square the handle force would need to be more because

$$F = \frac{\pi d_m - f L \sec(29/2)}{L + \pi f d_m \sec(29/2)}\left(\frac{2 P L_r}{d_m}\right) = 47.11$$

c. $\sigma_y = 41300$ psi $= \frac{-My}{I} = \frac{-(P(L))(y)}{\pi d^4/64} \Rightarrow P = \sigma_y \frac{\pi d^4}{64 L y} = \frac{(41300)(\pi)(.4)^4}{(64)(5)(.2)}$

$$\boxed{P = 52 \text{ lbs.}}$$

d. $F = (48.2)P = (48.2)(52 \text{ lbs}) = \boxed{2500 \text{ lbs}}$ using Square Threads

e. Rankine Gordon Formula: $\frac{1}{P_{max}} = \frac{1}{P_{cr}} + \frac{1}{P_y} = \frac{1}{\frac{\pi^2 E I}{L_c^2}} + \frac{1}{\sigma_y A}$

$$\frac{1}{F_{max}} = \frac{1}{\frac{\pi^2 (30{,}000 \text{ ksi})(\pi .75^4/64)}{(10 \text{ in})^2}} + \frac{1}{(41300)\left(\frac{\pi (.75)^2}{4}\right)}$$

$$\boxed{F_{max} = 13062 \text{ lbs.}}$$

f: $P = \frac{F}{48.2} = \boxed{271.1 \text{ lbs.}}$