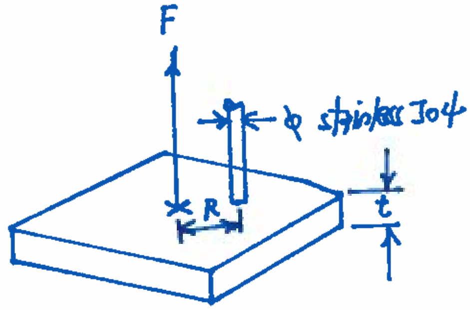


$R = 0.95$ in
$t = 0.25$ in
$\phi = 5/16$ UNC x $4\frac{1}{2}$ thds dp
$F = ?$

Figure 1: geometry of problem

5/16-18 UNC-2A/2B thd @ 4.5 thds engagement

$$\therefore \; l_e = \frac{4.5 \text{ thds}}{18 \frac{\text{thd}}{\text{in}}} = 0.25 \text{ in} \equiv \text{plate thickness.}$$

- the plate is therefore tapped thru and thd engagement is full,
- compute the maximum allowable force on SS 304 rod.
- mat'l spec: SS 304 cold rolled $\sigma_y = 60$ ksi, UTS = 100 ksi

thread in pure tensile load

$$\sigma = \frac{F}{AS} \;\forall\; AS = \text{shear area of thds.}$$

$$\therefore \; \sigma = \frac{F}{A_{box}} \text{ or } \sigma = \frac{F}{A_{pin}}.$$

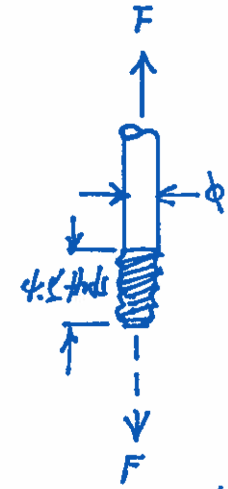


Figure 2: thd rod in tension

5/16-18 UNC-2G
c/w 45° END CHMF

EXTERNAL (2A)		INTERNAL (2B)	
MAJOR DIA.	0.3113/0.3026	MINOR DIA.	0.252/0.265
PITCH DIA.	0.2752/0.2712	PITCH DIA.	0.2764/0.2817
MINOR DIA.	0.2452/0.2365	MAJOR DIA.	0.3125/0.3255

scalar pin

$$AS_s = \pi n L_e K_{n_{max}} \left[\frac{1}{2n} + 0.57735 \left(E_{s_{min}} - K_{n_{max}} \right) \right],$$

$n = 18$ thd/in

L_e = engagement length = $4.5 \text{ thds} \times \frac{\text{in}}{18 \text{ thd}} \equiv 0.25$ in

$K_{n_{max}}$ = max. minor dia. internal = 0.265 in

$E_{s_{min}}$ = min. pitch dia. external = 0.2712 in

$$AS_s = \pi \left(18 \frac{\text{thd}}{\text{in}}\right)(0.25 \text{ in})(0.265 \text{ in}) \left[\frac{1}{2\left(18 \frac{\text{thd}}{\text{in}}\right)} + 0.57735(0.2712 - 0.265) \text{ in} \right],$$

$AS_s = 0.11748 \text{ in}^2$ shear area of external thds

nut or box
$$AS_n = \pi n L_e D_{s_{min}} \left[\frac{1}{2n} + 0.57735 \left(D_{s_{min}} - E_{n_{max}} \right) \right],$$

$n = 18$ thd/in

L_e = engagement length $= 4.5 \text{ thd} \times \frac{1}{18 \frac{\text{thd}}{\text{in}}} = 0.25$ in

$D_{s_{min}}$ = min. major dia. external $= 0.3026$ in

$E_{n_{max}}$ = max. pitch dia. internal $= 0.2817$ in

$$AS_n = \pi \left(18 \frac{\text{thd}}{\text{in}}\right)(0.25 \text{ in})(0.3026 \text{ in}) \left[\frac{1}{2\left(\frac{18 \text{ thd}}{\text{in}}\right)} + 0.57735(0.3026 - 0.2817) \text{ in} \right],$$

$$AS_n = 0.17045 \text{ in}$$ shear area of internal thds

$\therefore \quad AS_n > AS_s$ which is typically the case; weak part of connection is the pin!

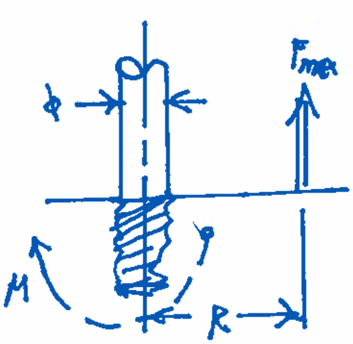
$$\sigma = \frac{F}{AS_s} \Rightarrow F_{max} = \sigma_y \cdot AS_s = (60{,}000 \text{ psi})(0.1748 \text{ in}^2) = \underline{\underline{7049 \text{ lbf}}}$$

I use yield, not UTS because I do not want plastic deformation!

check against bend
$$\sigma = \frac{Mc}{I} \quad \& \quad I = \text{circular rod} = \frac{1}{4}\pi r^4 \equiv \frac{\pi}{64}\phi^4$$

c = distance neutral axis to outside fibers $\equiv \frac{\phi}{2}$

$$M = F_{max} \times R = (7049 \text{ lbf})(0.95 \text{ in}) = 6696 \text{ lbf} \cdot \text{in}$$



$$\sigma = \frac{F_{max} \cdot R \cdot \frac{\phi}{2}}{\frac{\pi}{64}\phi^4} = \frac{32 F_{max} R}{\pi \phi^3},$$

weak connection part

ϕ = pin for thinnest diameter = minor dia. min. external $\equiv 0.2365$ in

$\Longrightarrow$ this would allow for the greatest stress on the rod!

$$\sigma = \frac{32(6696\ lbf \cdot in)}{\pi (0.2365\ in)^3} = 5{,}156{,}109\ psi \gg \sigma_y.$$

so bending at the minor diameter of the threaded rod would be failure mode!

- I need to consider bending as the pre-dominate mode to failure, especially stainless,
- stainless is extremely poor in bending & shear; use factor of safety of two (2),

$$FOS = \frac{\sigma_y}{\sigma} \Rightarrow \sigma = \frac{\sigma_y}{FOS} = \frac{32 F_{max} \cdot R}{\pi \phi^3}$$

$$\therefore \underline{F_{max} = \frac{\sigma_y}{FOS} \cdot \frac{\pi \phi^3}{32 R}}$$ maximum allowable force in bending

$$F_{max} = \frac{60{,}000\ psi}{2.0} \cdot \frac{\pi (0.2365\ in)^3}{32(0.95\ in)} = 41.01011\ lbf.$$

$$\therefore \underline{F_{max} \approx 41\ lbf.}$$

verify against pin shear:

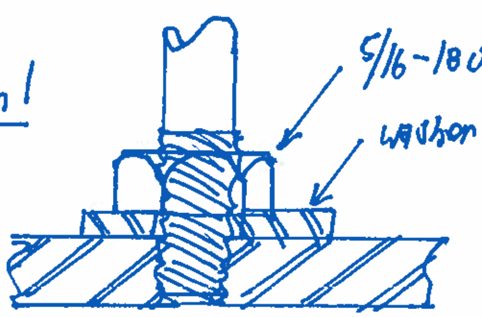
$$\sigma = \frac{F_{max}}{A_s} = \frac{41\ lbf}{0.11748\ in^2} = 349\ psi$$, which is acceptable for $\sigma_y = 60\ ksi$.

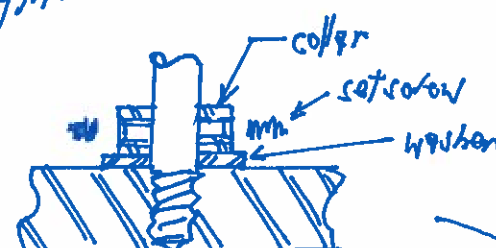
→ the rod is subject to bending failure,

→ on a straight rod, $F_{max} = 41\ lbf$ is the allowable max. force,

→ to improve on the design, I suggest using a shoulder or nut/washer at the plate to assist in bending strength.

option 1





option 2

27 June 10/2