1-26-22

1) Suitable length

$$L_{min} = t_1 + t_2 + 2t_w + t_{Nut} + 2p$$

$$= 0.5 + 0.5 + 2(0.095) + (7/16)$$

$$L_{min} = 1.78''$$

$$L_{sel} = L = 2''$$

2) is $L_d < t_1 + t_2 + 2t_w$

$$L_T = 2d + 1/4 = 2(0.5) + 0.25 = 1.25''$$

$$L_d = L - L_T = 2 - 1.25 = 0.75$$

$$\Rightarrow t_1 + t_2 + 2t_w = 0.5 + 0.5 + 0.19$$

$$= 1.19$$

Since $L_d < t_1 + t_2 + 2t_w$ $\quad$ Yes, OK

3) $L_T = 1.25 \qquad L_d = 0.75$

4) $l = t_1 + t_2 + 2t_w = 0.5 + 0.5 + 0.19$

$$l = 1.19''$$

5) $l_d = L_d = 0.75$

$$l_t = l - l_d = 1.19 - 0.75 = 0.44''$$

$$\frac{A_d E}{\ } = \frac{0.196 * (30*10^6)}{\ } = 7.84*10^6 \text{ lbs/in}$$

$\tau$

6) $K_d = \dfrac{A_d E}{\ell_d} = \dfrac{0.196 * (30*10^6)}{0.75} = 7.84*10^6$ lbs/in

where $A_d = \dfrac{\pi d^2}{4} = \dfrac{\pi (0.5)^2}{4} = 0.196$ in$^2$

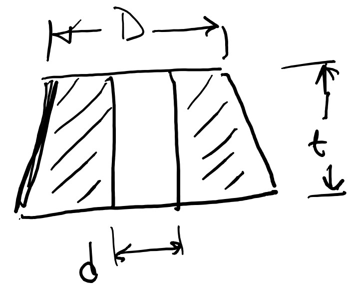
$K_t = \dfrac{A_t E}{\ell_t} = \dfrac{0.142 * (30*10^6)}{0.44} = 9.68*10^6$ lbs/in

where $A_t = 0.142$ in$^2$

7) $\dfrac{1}{K_b} = \dfrac{1}{K_d} + \dfrac{1}{K_t} = \dfrac{1}{7.84} + \dfrac{1}{9.68} = 0.23$

$K_b = 4.33$ Mlbs/in ←

8) $K'_m = f(D, d, E, t)$




where
$d = 0.5$
$D = 1.5\,d = 0.75$
$t = \dfrac{\ell}{2} = \dfrac{1.19}{2} = 0.595$
$E = 30$ mpsi

From Excel Program $K'_m = 30.8$ Mlbs/in

9) $K = \dfrac{K'_m}{2} = 15.4$ Mlbs/in

9) $K_m$

10) $C = \dfrac{K_b}{K_b + K_m} = \dfrac{4.33}{4.33 + 15.4} \cong 0.22$

$C = 0.22 \qquad (1-C) = 0.78$

11) $F_e^{tot} = \dfrac{\pi D_{Seal}^2}{4} P = \dfrac{\pi (10)^2}{4} (3000)$

$F_e^{tot} \equiv 235619.4 \text{ lbs}$

12) $F_e = F_{emax} = \dfrac{F_e^{tot}}{N} = \dfrac{235619.4}{8}$

$F_e = 29452.4 \text{ lbs}$

13) $F_i = 0.75\ F_p = 0.75\ (A_t S_p)$

where $A_t = 0.1419 \text{ in}^2$

$S_p = 85 \text{ ksi}$

$F_p = A_t S_p = 0.1419\ (85000) = 12061.5$ lbs

$F_i = 0.75\ (12061.5) = 9046.1 \text{ lbs}$

14) $F_b = F_i + C\ F_e$

15) $F_p = F_i + C\ F_e^*$

$0.22\ F^*$

15) $F_p = F_i + C F_e$

$12061.5 = 9046.1 + 0.22\ F_e^{*}$

$\Longrightarrow F_e^{*} = 13706.3$ lbs ←

16) $n_{L1} = \dfrac{F_e^{*}}{F_e} = \dfrac{13706.3}{29452.4}$

$n_{L1} = 0.465$ X Not acceptable

option: increase # of bolts
use higher strength bolts
Larger bolts

17) $F_m = F_i - (1-C) F_e$

18) $F_{m,min} = 250$ lbs/bolt

19) $250 = 9046.1 - 0.78\ F_e^{**}$

$\Rightarrow F_e^{**} = 11277$ lbs ←

20) $n_{L2} = \dfrac{F_e^{**}}{\phantom{F_e}}$

$n_{L2} = 0.38$ X Not acceptable

21) Not acceptable

22) $F_{\ } = F_i = 9046.1$ lbs

22) $F_{b,min} = F_i = 90\ldots$

23) $F_{b,max} = F_i + 0.22\, F_{emax}$

$= 9046.1 + 0.22\,(29452.4)$

$F_{b,max} = 15525.6$ lbs

24) $\sigma_{min,nom} = \dfrac{F_{b,min}}{A_t} = \dfrac{9046.1}{0.1419} = 63749.8$ psi

$\sigma_{max,nom} = \dfrac{F_{b,max}}{A_t} = \dfrac{15525.6}{0.1419} = 109412.2$ psi

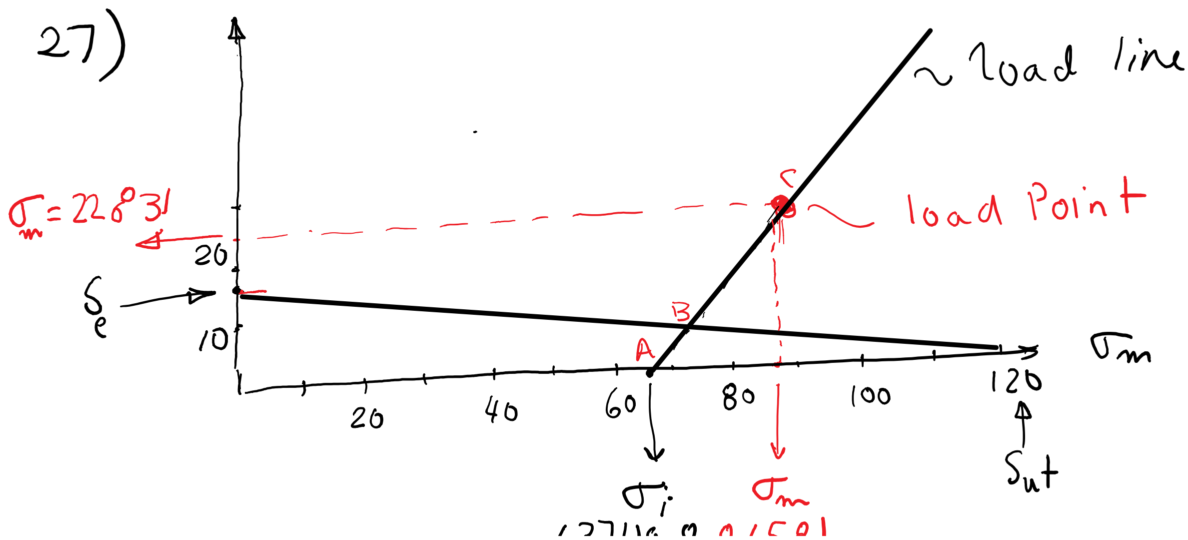
25) $\sigma_m = \dfrac{\sigma_{min} + \sigma_{max}}{2} = 86581$ psi

$\sigma_a = \dfrac{\sigma_{max} - \sigma_{min}}{2} = 22831.2$ psi

26) $S_{ut} = 120$ ksi $\quad \sigma_i = \sigma_{b,min} = 63749.8$ psi

$S_e = 18.6$ ksi

27)



63749.8 86581

28) Done

29) Done

30)

$$\eta_f = \frac{18.6\,(120 - 63.75)}{120\,(22.83) + 18.6\,(86.58 - 63.75)}$$

$$\eta_f = 0.33 \leftarrow$$

31) Not acceptable

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# Weld Analysis

Scope


- Fillet welds
- standard electrodes (steel)
  E60, E70, E80, .. E120
- only weld metal failure
  (no base metal)
- Continuous Weld
- AWS (American Welding Society)
  [Code - Standard]

Q: Fillet weld Analysis is fairly simple

(triangular shape)

True or $\boxed{\text{False}}$

Q: FEA performs well in predicting weld failure

True or $\boxed{\text{False}}$

The reason is the material properties are unpredictable (Solidication + mixing)

- mix of base metal & weld rod
- non-uniform Solidication (residual stresses)

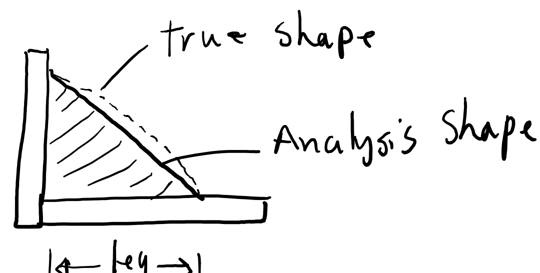
Remedy: Use Welding Code

- Conservative simplifications
- over design
- Developed over 200 years of case studies.

Q: what Parameters a designer would specfy in a fillet-weld design

a) Leg

1/4, 3/4, 1/2, ....




b) Length & geometry

Circular, rectangular, two sided, etc

c) weld electrode E60, etc

d) weld Pattern (Continuous)

e) Post Processing (grinding / heat treatment)

Q: If we follow the AWS Code, (which is conservative), then a factor of Safety of 1 would be adequate

True $\boxed{\text{False}}$

The AWS method only assures that the method is not wrong

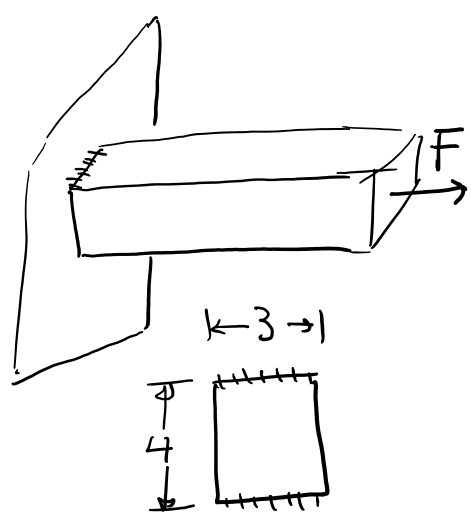
- over load
- geometry
- material

Q: A beam welded to a base plate and is under direct tension. the beam is 3x4 inches and the weld is top & bottom

weld leg is 1/4 inch

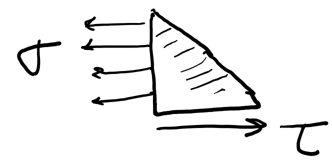
Electrode: E60

Desired factor of Safety ... against static



Desired factor of Safety guarding against static failure (yielding) $\equiv 2$


is this design acceptable if $F = 5000$ lbs




$$\left.\begin{aligned} \tau &= \frac{F}{A} \\ A &\equiv \text{leg area} \end{aligned}\right\} \text{stress}$$

$$\left.\begin{aligned} S_{ys} &= 0.58\, S_y \end{aligned}\right\} \text{strength}$$

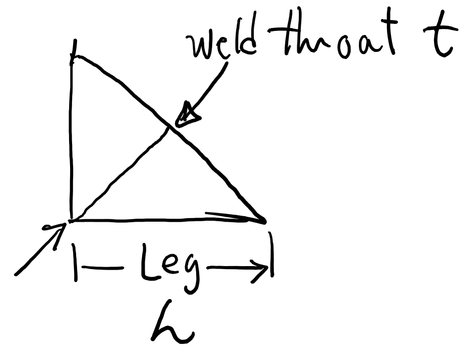
Normal Analysis

## Code Analysis

on the stress side: instead of using the leg area, use the throat area

### Weld throat

$t = 0.707\, h$




on the strength side, instead of using $0.58\, S_y$, the Code uses $0.3\, S_{ut}$

Q: Determine the weld throat

$$t = 0.707(0.25) = 0.177''$$

Q: Calculate weld throat area


$$A_t = (3+3)(0.177)$$

$$A_t = 1.06 \text{ in}^2$$

Q: Find AWS critical stress which is force divided by $A_t$

$$\tau = \frac{F}{A_t} = \frac{5000}{1.06} = 4715 \text{ psi}$$

Q: Look up the yield strength

$S_y = 50$ ksi    $S_{ut} = 62$ ksi

Q: strength based on traditional D.E. theory for comparison to $\tau$

$$S_{ys} = 0.58\, S_y = 0.58\,(50) = 29 \text{ ksi}$$

Q: strength $S_{ys}$ based on AWS Code

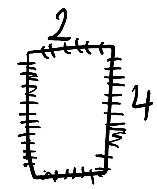
$$S_{ys} = 0.3\, S_{ut} = 0.3\,(62) = 18.6 \text{ ksi}$$

Q: Determine the factor of Safety

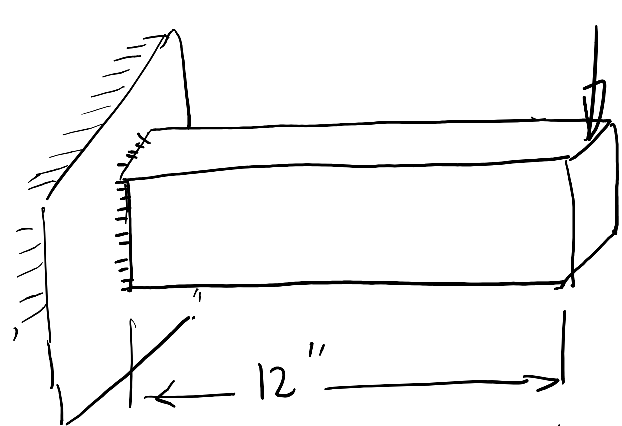
$$n = \frac{S_{ys}}{\tau} = \frac{18.6}{4.715} = 3.9 \leftarrow$$

yes acceptable

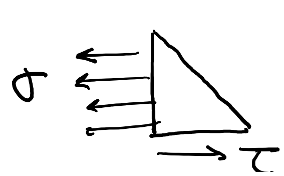
Q: A beam is welded to a base metal with weld leg of 1/4'' using E70 electrode. the beam is 2'' by 4'' and welded all around.

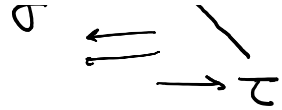


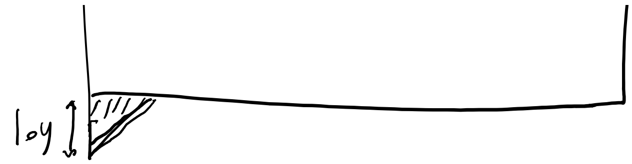

The beam is under a bending force of 1000 lbs and it is 12'' long

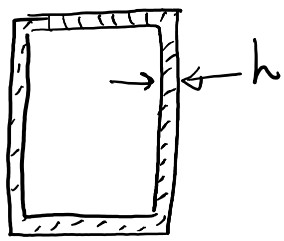



is the factor of safety greater than 3?

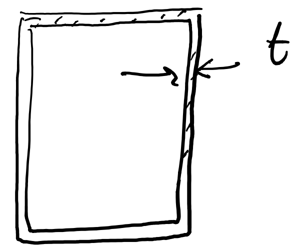



$I_h$




$I_t$