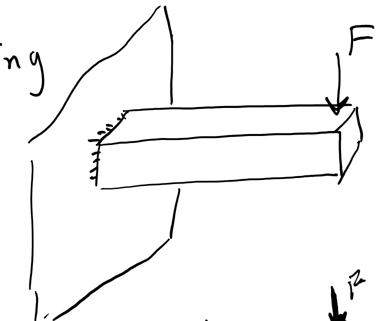
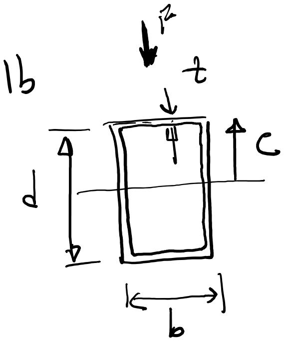
1-31-22

For the beam under bending



$$\tau_b = \frac{Mc}{I_t}$$



Where

$$M = FL = 1000(12) = 12000 \text{ in-lb}$$

$$c = 4/2 = 2''$$

$$I_t = I_u \cdot t = 26.67(0.177)$$

$$I_t = 4.72 \text{ in}^4$$

where I_u = unit (or Per inch)

$$I_u = \frac{d^2}{6}(3b + d) \qquad \text{[Table 9-2]}$$

where

$$b = 2$$

$$d = 4$$

$$I_u = \frac{4^2}{6}(3 \cdot 2 + 4) = 26.63 \text{ in}^3$$

where

$$t = 0.707\, h$$

$$= 0.707(0.25) = 0.177''$$

Therefore

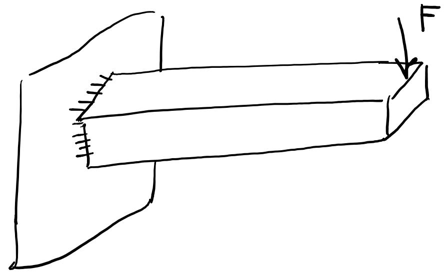
$$\tau_b = \frac{Mc}{I_t} = \frac{12000(2)}{4.72} = 5085 \text{ Psi}$$

Calculating shear stress due to direct shear force

$$\tau_d = \frac{F}{A_t} = \frac{1000}{2.124} = 470.8 \text{ Psi}$$

where
$$A_t = (2+2+4+4)(0.177)$$
$$A_t = 2.124 \text{ in}^2$$

How Do we Combine the Two τ_b and τ_d ?



$\tau_b \equiv$ out of Plane of weld (OOP)

$\tau_d \equiv$ in plane of weld (IP)

Code says: Combine these stress vectorially

$$\tau = \sqrt{\tau_b^2 + \tau_d^2} = 5106.7 \text{ psi}$$

Strength

$$S_{ys} = 0.3 \, S_{ut}$$

Code says use S_{ut} associated with the weakest of weld rod or base metal in its Hot-rolled condition

Assuming base metal is stronger than weld rod metal

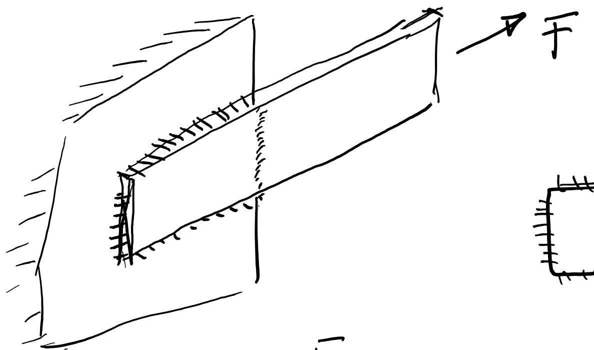
$$S_{ys} = 0.3\,(70) = 21 \text{ KSi}$$

$$n = \frac{S_{ys}}{\tau} = \frac{21000}{5106.7} = 4.1 \leftarrow$$

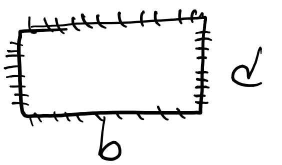
. . .

Acceptable

Direct shear loading (no bending / torsion / tension)



welded all around



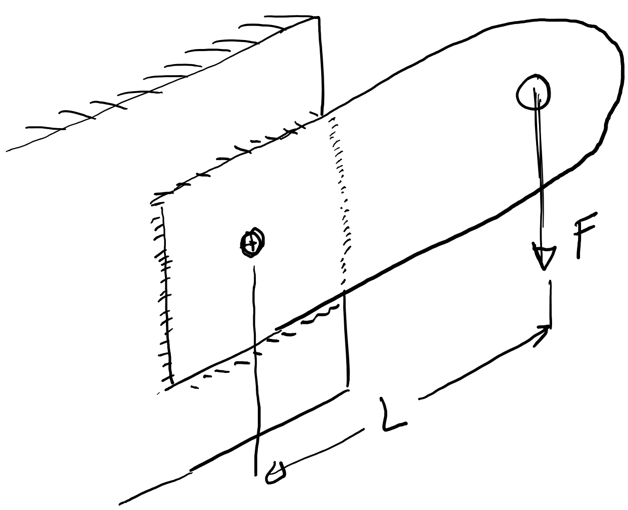
(In-plane direction)

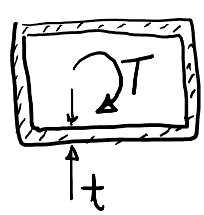
$$\tau = \frac{F}{A_t}$$

$$A_t = 2(b+d)\,t$$

and $t = 0.707\,h$

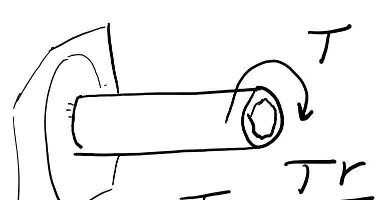
Torsional loading





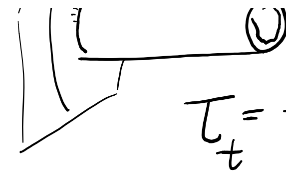
$$T = FL$$

$$\tau_t = \frac{Tr}{J_t}$$



Where

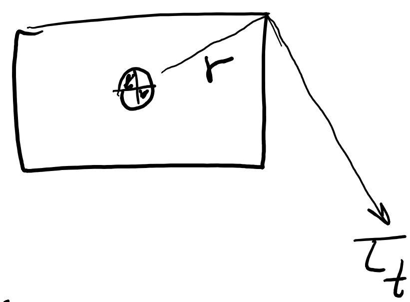
Where T = torsional moment (torque)



$$\tau_t = \frac{Tr}{J}$$

$\equiv$ Force $*$ distance from force to the Centroid of the weld pattern

$r \equiv$ the distance between the Centroid to any Point that is being analysed $(r = r_{max} \equiv max\ \tau)$

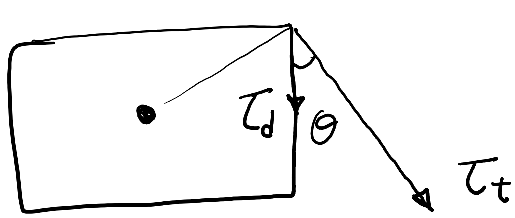


$\tau_t \equiv$ In-plane

$J_t \equiv$ Polar area moment of inertia of the weld with thickness of t

$$J_t = J_u t = J_u (0.707h)$$

J_u = Unit polar area moment of inertia

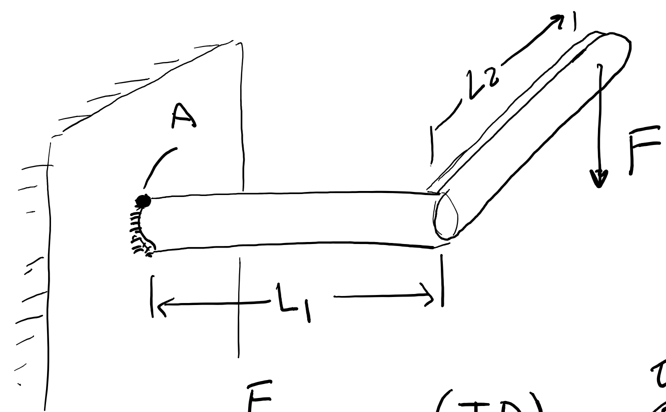


$$\tau_x = \tau_t \sin\theta$$

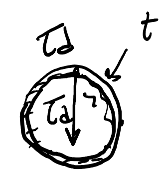
$$\tau_y = \tau_t \cos\theta + \tau_d$$

$$\tau = \sqrt{\tau_x^2 + \tau_y^2}$$

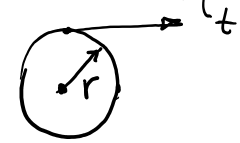
Combined Loading



Direct shear $\tau_d = \dfrac{F}{A_t}$ (IP)



Torsion $\tau_t = \dfrac{Tr}{J_t}$ (IP)



Bending $\tau_b = \dfrac{Mc}{I_t}$ (OOP)

$$T = FL_2$$

$$M = FL_1$$

Combine all IP stresses

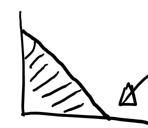
$$\tau_{IP} = \sqrt{\tau_d^2 + \tau_t^2}$$

$$\tau_{OP} = \tau_b$$

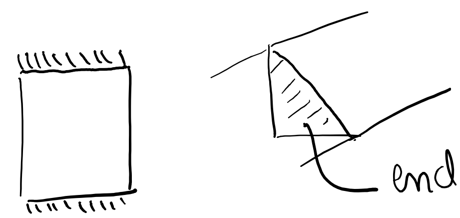
$$\Rightarrow \tau_{Res} = \sqrt{\tau_{IP}^2 + \tau_{OP}^2}$$

Compare to 0.3 S_{ut}

Do we take into account stress concentration factor?



toe of weld
$K_t = 1.5$



end of the weld
$K = 2.$

Answer: Stress raisers are ignored for static loading but must be included for cyclic loading

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Tables from the book

Table 9-1, 9-2 (I_u and J_u)
Table 9-3 Strength of the weld
(Last line fillet weld $S_{ys} = 0.3 S_u$)

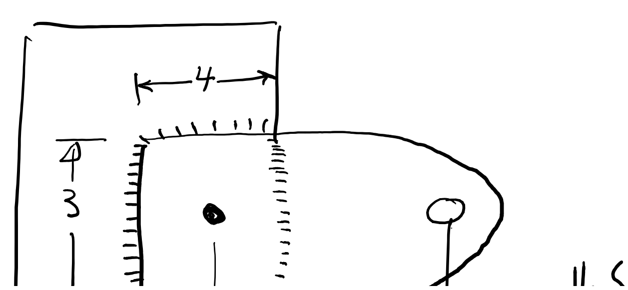
Table 9-5 Fatigue stress concentration factor

Example

E120 electrode

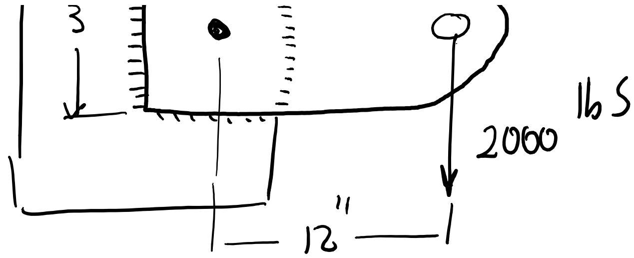
$h = 0.25''$

is $n > 3.5$?



$h = 0.25$

is $n > 3.5$?



1) Find the throat

$$t = 0.707h = 0.177''$$

2) Find Weld Area (throat)

$$A_t = t\,(3+3+4+4) = 2.475 \text{ in}^2$$

3) Calculate τ_d

$$\tau_d = \frac{F}{A_t} = \frac{2000}{2.475} = 808.2 \text{ psi} \downarrow$$

4) Find the torsional moment

$$T = FL = 2000\,(12) = 24000 \text{ in-lb}$$

5) Calculate τ_t

$$\tau_t = \frac{Tr}{J_t}$$

where $T = 24000$

$$r = \sqrt{2^2 + 1.5^2} = 2.5''$$

$$J_u = \frac{(d+b)^3}{6} = \frac{(3+4)^3}{6}$$

$$J_u = 57.17 \text{ in}^3$$

and $J_t = J_u \cdot t$ in^4

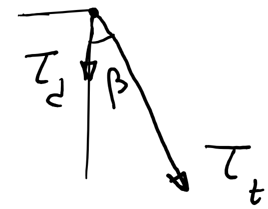
and

$$J_t = J_u \cdot \tau \quad in^4$$
$$= (57.17)(0.177) = 10.1$$

$$\tau_t = \frac{Tr}{J_t} = \frac{24000\,(2.5)}{10.1} = 5940.6 \text{ psi}$$

from geometry

$\beta = 36.87$ degrees



6) Calculate resultant τ

$$\tau_{res}^2 = \tau_d^2 + \tau_t^2 + 2\,\tau_d\,\tau_t \cos\beta$$

<u>or</u> $\tau_x =$ $\quad$ $\tau_y =$ $\quad$ $\tau = \sqrt{\tau_x^2 + \tau_y^2}$

$$\Rightarrow \tau = 6605 \text{ psi}$$

7) find weld strength in shear

$S_{ys} = 0.3\,S_{ut}$

$S_{ys} = 0.3\,(120) = 36$ ksi

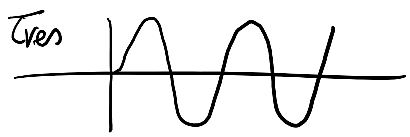
8) Factor of Safety

$$n = \frac{S_{ys}}{\tau_{res}} = \frac{36000}{6605} = 5.44 \leftarrow$$

yes - acceptable

Weld Fatigue Analysis

- Find nominal stress as before τ_{nom}
- Apply stress concentration factor τ_{act}



Fully alternating stress

- Calculate S_{es} : endurance limit in shear

Calculating Ses

From fatigue analysis

$$S_e = K_a K_b K_c K_d K_e K_f S_e'$$

where $S_e' \equiv$ rotating bending endurance limit
(bending stress - Normal stress)

For steels

$$S_e' \cong 0.5 \; S_{ut} \qquad (S_{ut} \leq 200 \text{ ksi})$$

Also $K_a \equiv$ Surface factor
