Structural Welds

Nominal strength of Welds

Fillet weld:

The nominal strength per unit length of weld, R_{nw}

$L = 1$ inch

a) For Weld metal

$$R_n = F_w A_w = (0.60\ F_{EXX})(t_e \times 1\ in)$$

$$\boxed{R_n = 0.60\ F_{EXX}\ t_e}$$

$$\boxed{t_e = \frac{a}{\sqrt{2}}}$$

effective throat dimension

b) For Base metal

$$R_n = F_{BM} A_{BM}$$

(i) Yielding

$$R_n = (0.60\ F_y)(t \cdot 1\ in)$$

$$\boxed{R_n = 0.60 F_y\ t}$$

(ii) Rupture

$$R_n = (0.60\ F_u)(t \cdot 1\ inch)$$

$$\boxed{R_n = 0.60\ F_u\ t}$$

t = thickness of base metal

Fillet weld Strength : LRFD

The design strength per unit length of a fillet weld is based on the shear resistance through the throat of the weld, regardless of the direction of the applied load.

$$\phi R_{nw} = 0.75(0.60 F_{Exx} t_e) = 0.45 F_{Exx} t_e$$

But not greater than the shear yield or shear rupture strength of the adjacent base materials

The base material design strength is the lower value of,

Yield strength

$$\phi R_n = 1.0(0.60 F_y t)$$

$$\phi R_n = 0.60 F_y t$$

Rupture strength

$$\phi R_n = 0.75 (0.60 F_u t)$$

$$\phi R_n = 0.45 F_u t$$

Fillet weld strength: ASD

$$\frac{R_{nw}}{\Omega} = \frac{F_w A_w}{\Omega} = \frac{(0.60 F_{Exx})(t_e \times 1)}{\Omega}$$

$$\frac{R_n}{\Omega} = \frac{0.60 F_{Exx} t_e}{2.0} = 0.30 F_{Exx} t_e$$

Yield strength

$$\frac{R_n}{\Omega} = \frac{0.60 F_y t}{1.5}$$

$$\frac{R_n}{\Omega} = \frac{0.60 F_y t}{1.5} = 0.40 F_y t$$

Rupture strength

$$\frac{R_n}{\Omega} = \frac{0.60 F_u t}{2.0}$$

$$\frac{R_n}{\Omega} = \frac{0.60 F_u t}{2.0} = 0.30 F_u t$$

Groove Weld Strength : LRFD

The design strength of Complete Joint Penetration groove (CJP) welds,

whether loaded in shear, tension or compression,

is governed by the strength of base metal

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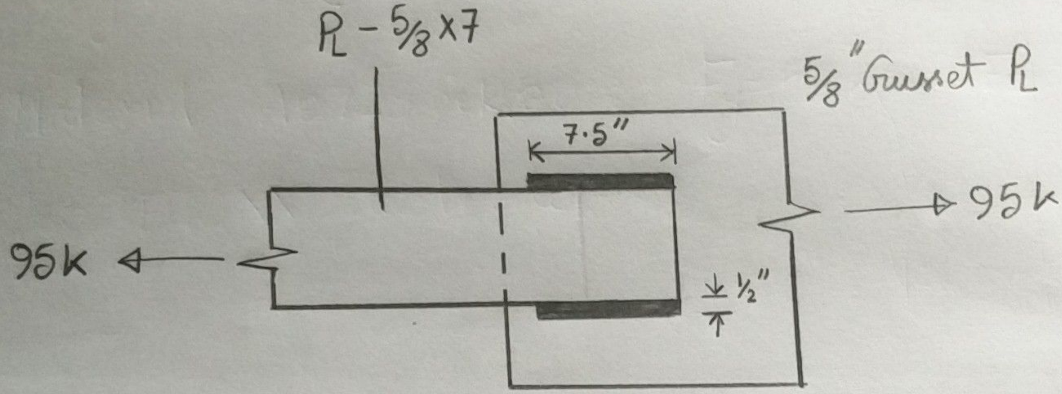
Example

Determine the size and length of the fillet weld for the lap joint shown in the figure. (By ASD method).
All plates are A36 steel ($F_y = 36$ ksi, $F_u = 58$ ksi)



Maximum size of weld $= \frac{5}{8} - \frac{1}{16} = \frac{9}{16}$ inch

Minimum size of weld $= \frac{1}{4}$ inch $= \frac{4}{16}$

Let us use, $\frac{8}{16}$ inch $= \frac{1}{2}$ inch fillet weld.

The effective throat dimension,

$\therefore$ The effective throat dimension,

$$t_e = 0.707\,a = 0.707 \times \frac{1}{2} = 0.354 \text{ inch}$$

Let us choose, E60XX weld, $F_{EXX} = 60$ ksi

So,

The nominal strength of ½ inch fillet weld per ~~to~~ inch of length is,

$$R_{nw} = 0.60 F_{EXX} t_e$$

$$= 0.60 \times 60 \times 0.354$$

$$= 12.744 \text{ kip/inch}$$

∴ Allowable strength of weld, $\frac{R_{nw}}{\Omega} = \frac{12.744}{2.0} = 6.372$ kip/in

Now, Plate shear, $\frac{R_n}{\Omega} = \frac{0.60 F_y t}{1.5} = \frac{0.60 \times 36 \times 5/8}{1.5}$

$= 9$ kip/in

Plate rupture, $\frac{R_n}{\Omega} = \frac{0.60 F_u t}{2.0} = \frac{0.60 \times 58 \times \frac{5}{8}}{2.0} = 10.875$ kip/in

So, Weld strength controls.

∴ Weld length, $L = \frac{95k}{6.372 k/in} = 14.91$ inch

So, let us use, $7\frac{1}{2}$ inch weld on each side of the plate of ½ inch size.

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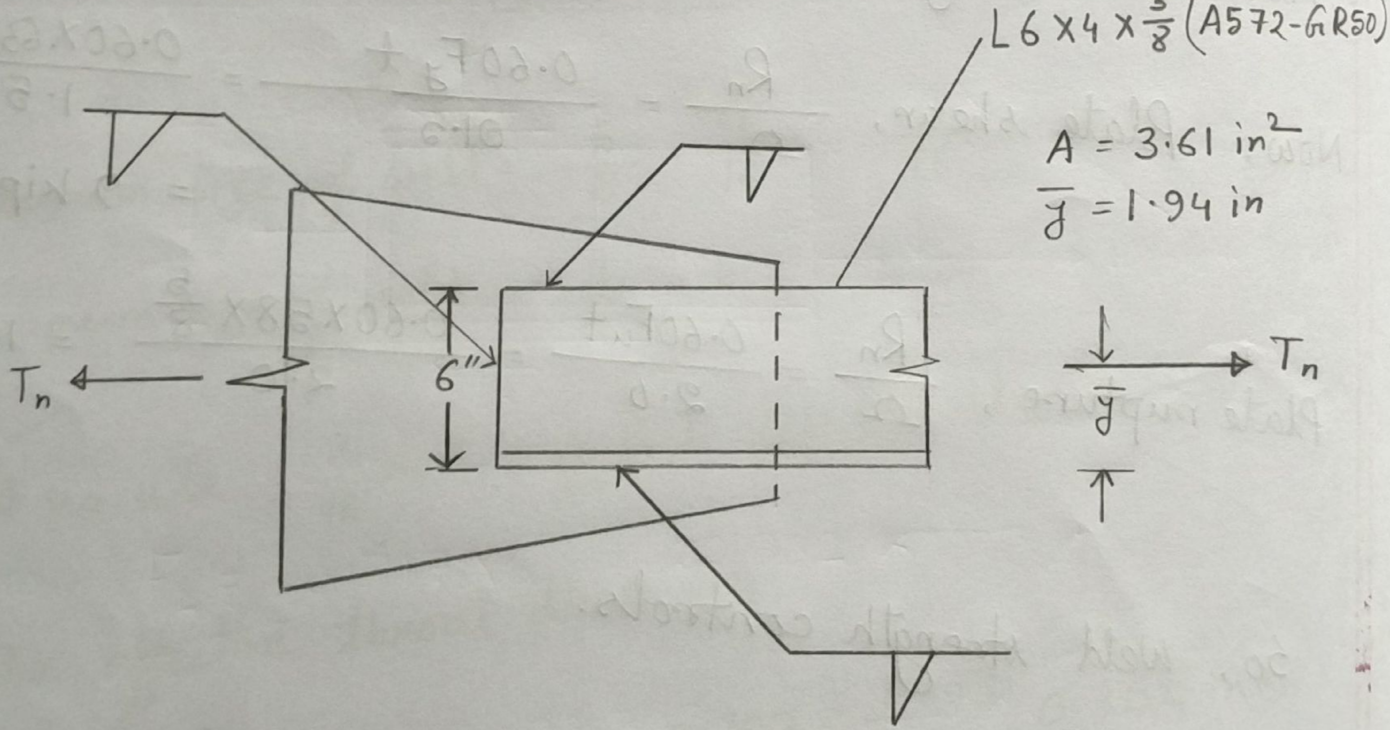
Example

Design the fillet welds to develop the full strength of the angle shown in the figure minimizing the effect of eccentricity. Assume that the gusset plate does not govern. (Use AISC ASD method)

Material A572-GR50 : $F_y = 50$ ksi , $F_u = 65$ ksi

Use E70XX electrode.



Determine strength of the angle:

Yield on gross area

$$\frac{T_n}{\Omega} = \frac{F_y A_g}{\Omega} = \frac{50 \times (3.61)}{1.67} = 108.084 \text{ kip}$$

Rupture on effective area

$$\frac{T_n}{\Omega} = \frac{F_u A_e}{\Omega} = \frac{F_u (U A_g)}{\Omega}$$

Let us assume $U = 0.9$ [As length of weld is not known]

$$\therefore \frac{T_n}{\Omega} = \frac{65 \times 0.9 \times 3.61}{2.0} = 105.6 \text{ kip (governs)}$$

Select weld size:

Min^m size of fillet weld $= \frac{3}{16}$ in

Max^m size of fillet weld $= \frac{3}{8} - \frac{1}{16} = \frac{5}{16}$ inch

Let us use $\frac{1}{4}$ inch fillet weld with E70XX electrode.

So, $t_e = \frac{a}{\sqrt{2}} = \frac{1}{4\sqrt{2}} = 0.177$ in

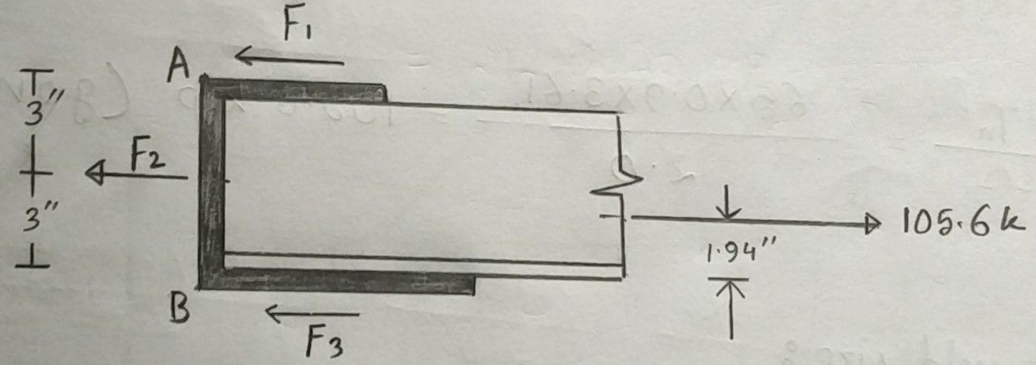
Now,

$$\frac{R_{nw}}{\Omega} = \frac{0.60 F_{Exx} t_e}{2.0} = \frac{0.60 \times 70 \times 0.177}{2.0}$$

$$\therefore \frac{R_{nw}}{\Omega} = 3.717 \text{ kip/inch}$$

Total weld length required $= \frac{105.6}{3.717}$

$= 28.41$ inch



Now, $F_2 = 3.717 \times 6 = 22.302$ k

So, $F_1 + F_3 = 105.6 - 22.302 = 83.298$ k

$\therefore F_1 + F_3 = 83.298$ k

Taking moment about point B,

$$-6F_1 - 3F_2 + 105.6 \times 1.94 = 0$$

or, $6F_1 + 3F_2 = 204.864$

or, $6F_1 = 137.958$

$\therefore F_1 = 22.993k$

So, $F_3 = 83.298 - 22.993$

$\therefore F_3 = 60.305k$

So, $L_1 = \frac{22.993}{3.717} = 6.186 \text{ in} \approx 6.5 \text{ in}$

$L_3 = \frac{60.305}{3.717} = 16.22 \text{ in} \approx 16.5 \text{ in}$

So, Final allowable weld capacity $= 3.717(6 + 6.5 + 16.5)$

$= 107.79$ kip

Check U

Average length of weld in the direction of load

$l = \frac{1}{2}(6.5 + 16.5) = 11.5$

$U = 1 - \frac{\bar{x}}{l} = 1 - \frac{0.933}{11.5} = 0.9189 > 0.9$

$\therefore \frac{T_n}{\Omega} = \frac{F_u U A_g}{\Omega} = \frac{65 \times 0.9189 \times 3.61}{2.0} = 107.8$ kip (just ok)

Check base material strength

Yielding

$$\frac{T_n}{\Omega} = \frac{(0.60F_y)tL}{\Omega} = \frac{0.60 \times 50 \times \frac{3}{8} \times (6.5+6+16.5)}{1.50}$$

$$= 217.5 \text{ kip}$$

Rupture

$$\frac{T_n}{\Omega} = \frac{(0.60F_u)tL}{\Omega} = \frac{0.60 \times 65 \times \frac{3}{8} \times (6.5+6+16.5)}{2.0}$$

$$= 212.0625 \text{ kip}$$

∴ Base material strength is higher than the connection strength (OK)