CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 10
WELDING (CONT.)

SEMESTER: SUMMER 2021

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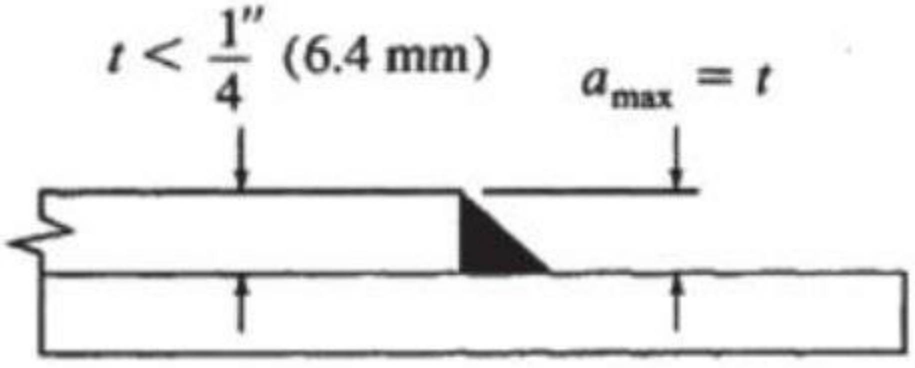
OUTLINE

- Defects of welding
- Fillet weld
- Strength of weld (LRFD)
- Strength of weld (ASD)
- Design capacity of weld member

Possible defects of Welds

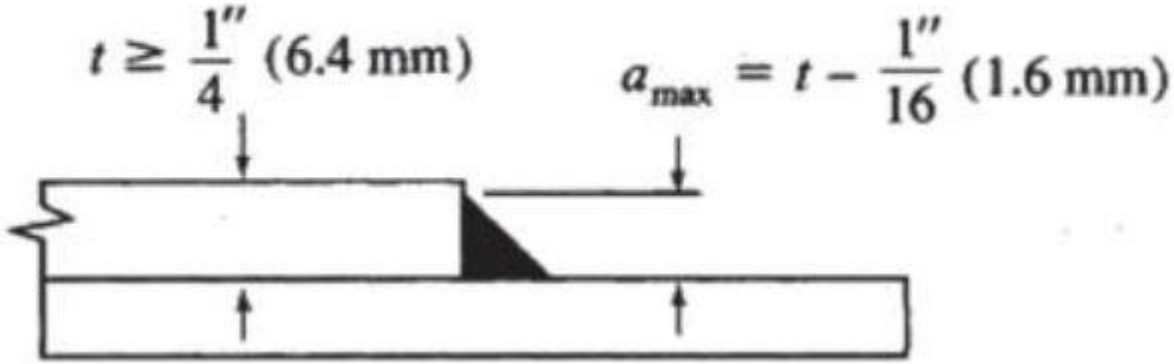
Unless good welding techniques and procedures are used, a number of possible defects may result relating to discontinuities within the weld. Some of the common defects are:

- Incomplete fusion
- Inadequate joint penetration
- Porosity
- Undercutting
- Inclusion of slag
- Cracks.

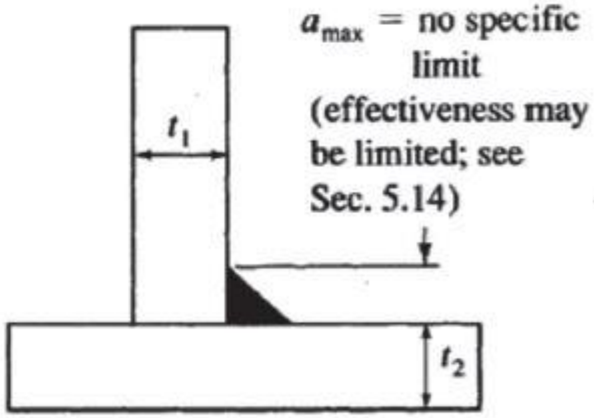


(a)

(a) If plate thickness t < 1/4”,
then maximum weld thickness,
a(max)= t
(b) If plate thickness t >= 1/4”,
then a(max) = t - 1/16” and
a(min) = 1/4”

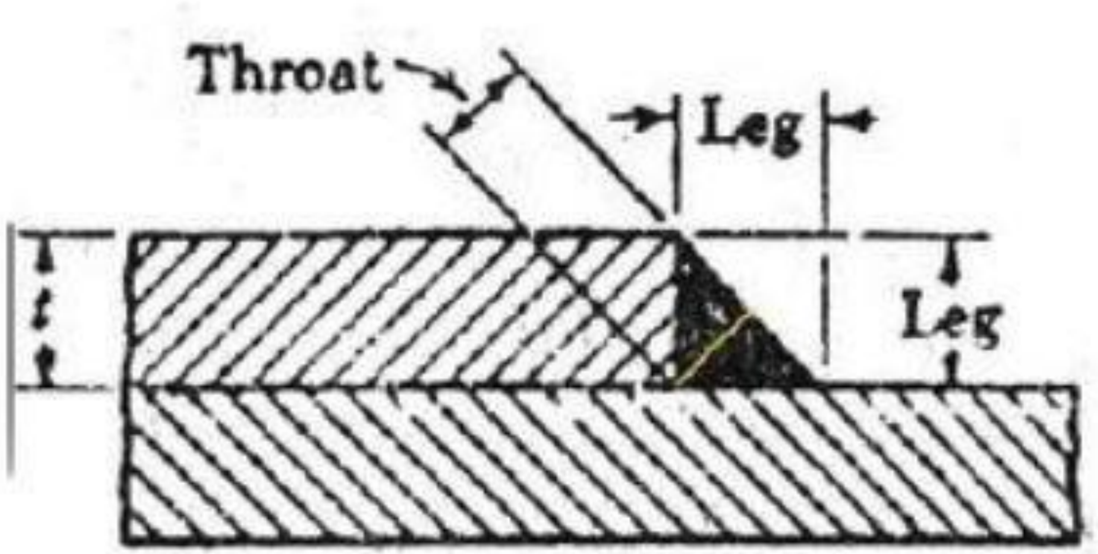


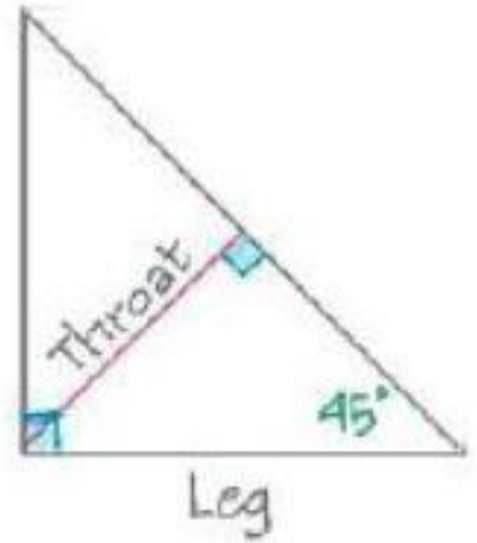
(b)



(c)

Fillet Weld





Effective throat size, te = 0.707a, where a = size of weld.

NOMINAL STRENGTH OF WELDS

Fillet Welds: The nominal strength *per unit length* of weld, R_{nw}, is expressed as,

a. For the weld metal,

$$R_n = F_w A_w = 0.60 F_{EXX} t_e (1 \text{ in.}) = 0.60 t_e F_{EXX} \qquad (5.13.1)$$

b. For the base metal,

$$R_n = F_{BM} A_{BM} = 0.6 F_y t (1 \text{ in.}) = 0.6 t F_y \qquad \text{yielding} \qquad (5.13.2)$$

$$R_n = F_{BM} A_{BM} = 0.6 F_u t (1 \text{ in.}) = 0.6 t F_u \qquad \text{rupture} \qquad (5.13.3)$$

FILLET WELD STRENGTH: LRFD

The design strength (AISC-J2.4.) *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, as follows:

$$\phi R_{nw} = 0.75 t_e (0.60\, F_{\mathrm{EXX}}) \qquad (5.14.4)$$

but not greater than the shear yield or shear rupture strengths of the adjacent base materials. The base material design strength is the lower value of:

$$\phi R_n = 1.0(0.6 F_y) A_{BM} = 0.6 t F_y \qquad \text{yield strength} \qquad (5.14.5)$$

$$\phi R_n = 0.75(0.6 F_u) A_{BM} = 0.45 t F_u \qquad \text{rupture strength} \qquad (5.14.6)$$

t_e = effective throat dimension (see Sec. 5.12)

F_{EXX} = tensile strength of electrode material

t = thickness of base material along which weld is placed

F_u = tensile strength of base metal

FILLET WELD STRENGTH: ASD

The design strength (AISC-J2.4.) *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, as follows:

$$\frac{R_{nw}}{\Omega} = \frac{F_w A_w}{\Omega} = \frac{(0.6F_{EXX})(t_e \times 1)}{\Omega} = \frac{0.6F_{EXX}t_e}{2.00}$$

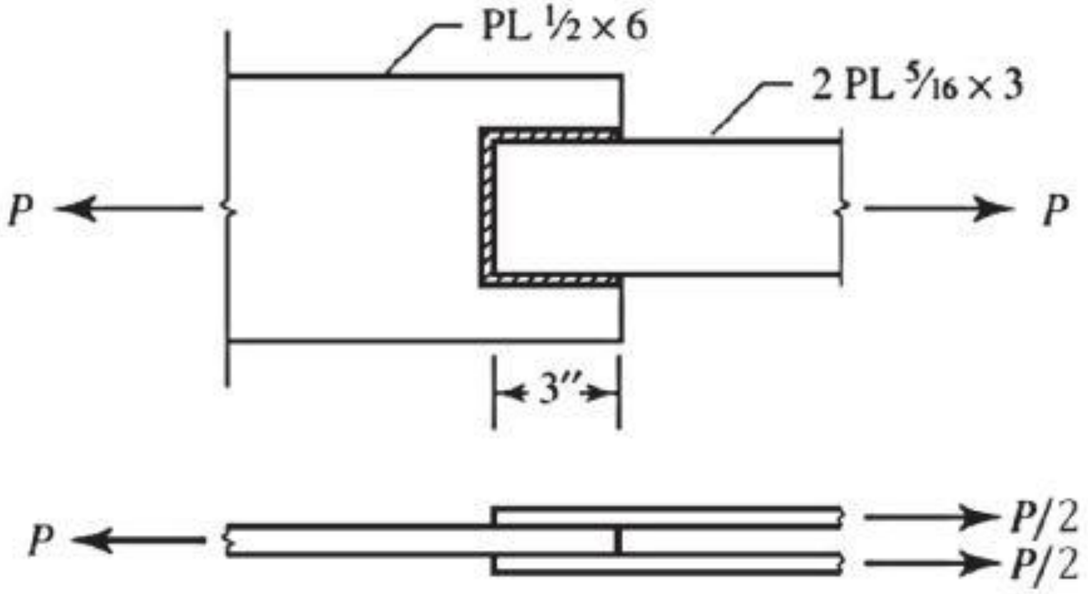
but not greater than the shear yield or shear rupture strengths of the adjacent base materials. The base material design strength is the lower value of:

$$\frac{R_n}{\Omega} = \frac{F_y A_{BM}}{\Omega} = \frac{(0.6F_y)(t \times 1)}{\Omega} = \frac{0.6tF_y}{1.50} \quad \text{yield strength}$$

$$\frac{R_n}{\Omega} = \frac{F_{vu} A_{BM}}{\Omega} = \frac{(0.6F_u)(t \times 1)}{\Omega} = \frac{0.6tF_u}{2.00} \quad \text{rupture strength}$$

Example

A tension member splice is made with ¼-inch E70 fillet welds as shown in Figure. Each side of the splice is welded as shown. The inner member is a PL ½ × 6 and each outer member is a PL 5⁄16 × 3. All steel is A36. Determine the maximum design capacity, ϕP_n, based on weld limit states.



All plates A36:
F_y = 36 ksi, F_u = 58 ksi.

Weld strength: F_{EXX} =70 ksi.
Weld length on each side = 3+3+3
= 9 inch.

Weld size, s = ¼ inch
∴ Throat $t_e = s/\sqrt{2} = 0.25/1.414$
∴ =0.177 inch

Fillet weld capacity: $\phi P_n = \phi R_{nw} L = 0.75[t_e(0.6F_{EXX})]L$

$= 0.75 \times 0.177 \times 0.6 \times 70 \times (9+9) = 100.4$ kip

Base metal - Inner Plate:

Yielding: $\phi P_n = \phi R_n L = 1.0(0.6tF_y)L = 0.6 \times {}^1/_2 \times 36 \times 9 = 97.2$ kip.

Rupture: $\phi P_n = \phi R_n L = 0.75(0.6tF_u)L = 0.75 \times {}^1/_2 \times 58 \times 9 = 117.45$ kip.

Base metal - Outer Plate:

Yielding: $\phi P_n = \phi R_n L = 1.0(0.6tF_y)L = 0.6 \times {}^5/_{16} \times 36 \times 9 \times 2 = 121.5$ kip.

Rupture: $\phi P_n = \phi R_n L = 0.75(0.6tF_u)L = 0.75 \times {}^5/_{16} \times 58 \times 9 \times 2 = 117.45$ kip.

$\therefore$ Base metal (Inner plate) yielding governs.

$\therefore \phi P_n = 97.2$ kip. Ans.