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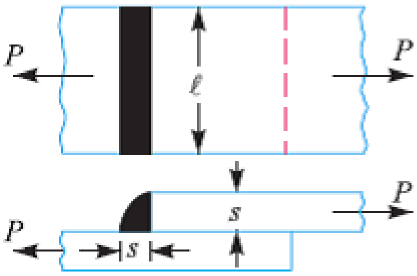
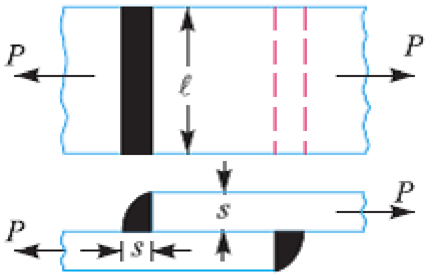
Welded Joints

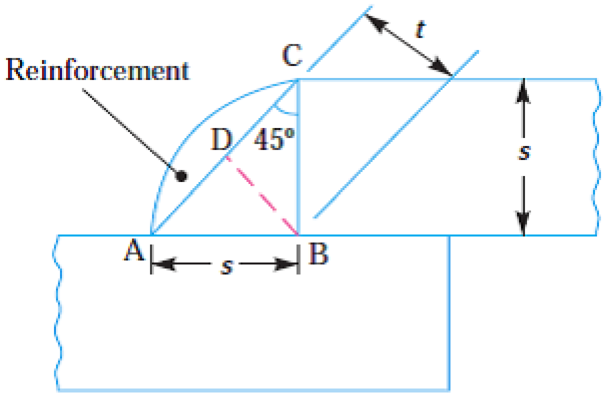
Strength of Transverse Fillet Welded Joints



(*a*) Single transverse fillet weld.



(*b*) Double transverse fillet weld.



The minimum area of the weld is obtained at the throat *BD*, which is given by the product of the throat thickness and length of weld.

Let t = Throat thickness (*BD*),

s = Leg or size of weld,

= Thickness of plate, and

l = Length of weld,

we find that the throat thickness,

$$t = s \times \sin 45° = 0.707\, s$$

∴ *Minimum area of the weld or throat area,

$$A = \text{Throat thickness} \times \text{Length of weld} = t \times l = 0.707\, s \times l$$

If σ_t is the allowable tensile stress for the weld metal, then the tensile strength of the joint for single fillet weld,

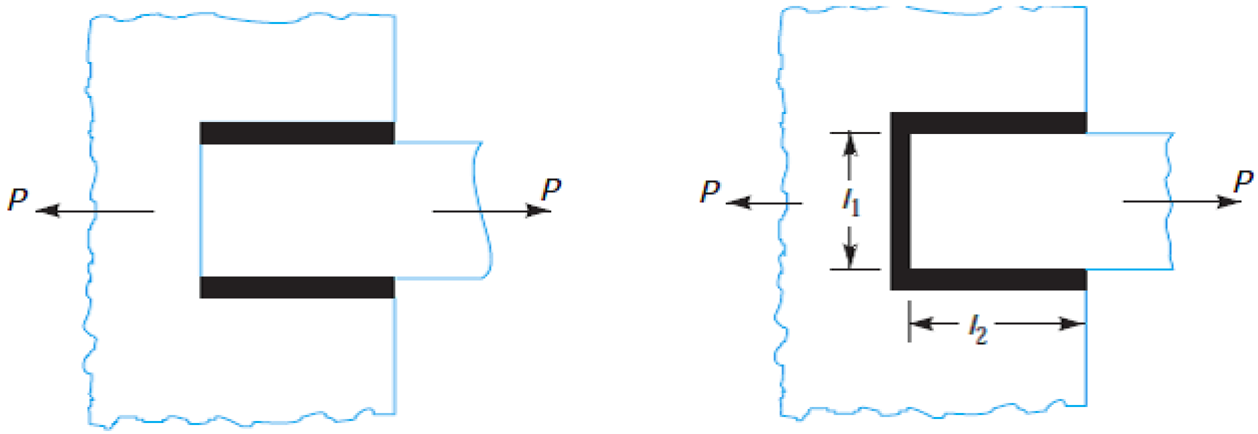
$$P = \text{Throat area} \times \text{Allowable tensile stress} = 0.707\, s \times l \times \sigma_t$$

and tensile strength of the joint for double fillet weld,

$$P = 2 \times 0.707\, s \times l \times \sigma_t = 1.414\, s \times l \times \sigma_t$$

Note: Since the weld is weaker than the plate due to slag and blow holes, therefore the weld is given a reinforcement which may be taken as 10% of the plate thickness.

Strength of Parallel Fillet Welded Joints



(*a*) Double parallel fillet weld.   (*b*) Combination of transverse and parallel fillet weld.

We have already discussed in the previous article, that the minimum area of weld or the throat area,

$$A = 0.707\, s \times l$$

If τ is the allowable shear stress for the weld metal, then the shear strength of the joint for single parallel fillet weld,

$$P = \text{Throat area} \times \text{Allowable shear stress} = 0.707\, s \times l \times \tau$$

and shear strength of the joint for double parallel fillet weld,

$$P = 2 \times 0.707 \times s \times l \times \tau = 1.414\, s \times l \times \tau$$

Notes: 1. If there is a combination of single transverse and double parallel fillet welds as shown in Figure (*b*),then the strength of the joint is given by the sum of strengths of single transverse and double parallel fillet welds. Mathematically,

$$P = 0.707s \times l_1 \times \sigma_t + 1.414\, s \times l_2 \times \tau$$

where l_1 is normally the width of the plate.

Problem 1

A plate 100 mm wide and 10 mm thick is to be welded to another plate by means of double parallel fillets. The plates are subjected to a static load of 80 kN. Find the length of weld if the permissible shear stress in the weld does not exceed 55 MPa.

Solution

Width = 100 mm ; Thickness = 10 mm ; P = 80 kN = 80 × 103 N ; τ = 55 MPa = 55 N/mm^2

Let l =Length of weld, and

s = Size of weld = Plate thickness = 10 mm

We know that maximum load which the plates can carry for double parallel fillet weld (P),

$80 \times 10^3 = 1.414 \times s \times l \times \tau = 1.414 \times 10 \times l \times 55 = 778\, l$

$\therefore l = 80 \times 10^3 / 778 = 103$ mm

Adding 12.5 mm for starting and stopping of weld run, we have

$l = 103 + 12.5 = 115.5$ mm

Special Cases of Fillet Welded Joints

1. ***Circular fillet weld subjected to torsion.*** Consider a circular rod connected to a rigid plate by a fillet weld as shown in Figure.

Let d = Diameter of rod,

r = Radius of rod,

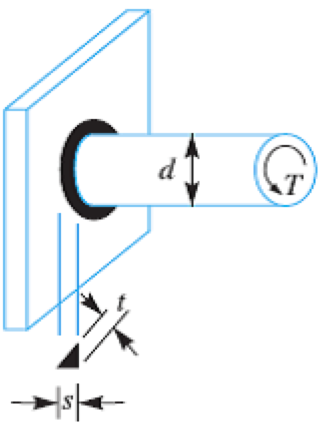
T = Torque acting on the rod,

s = Size (or leg) of weld,

t = Throat thickness,

J = Polar moment of inertia of the

$$\text{weld section} = \frac{\pi t d^3}{4}$$



$$\tau = \frac{T.r}{J} = \frac{T \times d/2}{J}$$

$$= \frac{T \times d/2}{\pi t d^3/4} = \frac{2T}{\pi t d^2}$$

This shear stress occurs in a horizontal plane along a leg of the fillet weld. The maximum shear occurs on the throat of weld which is inclined at 45° to the horizontal plane.

∴ Length of throat, $t = s \sin 45° = 0.707\, s$

and maximum shear stress,

$$\tau_{max} = \frac{2T}{\pi \times 0.707\, s \times d^2} = \frac{2.83\, T}{\pi\, s\, d^2}$$

2. ***Circular fillet weld subjected to bending moment.*** Consider a circular rod connected to a rigid plate by a fillet weld as shown in Figure.

Let d = Diameter of rod,

M = Bending moment acting on the rod,

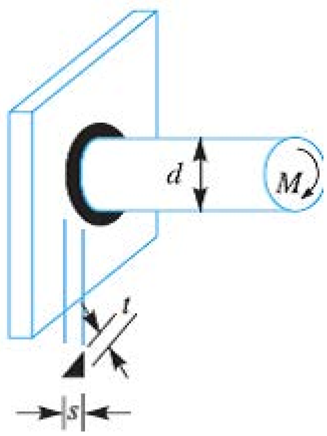
s = Size (or leg) of weld,

t = Throat thickness,

Z = Section modulus of the weld section

$$= \frac{\pi t d^2}{4}$$

$$\sigma_b = \frac{M}{Z} = \frac{M}{\pi t d^2 / 4} = \frac{4M}{\pi t d^2}$$



This bending stress occurs in a horizontal plane along a leg of the fillet weld. The maximum bending stress occurs on the throat of the weld which is inclined at 45° to the horizontal plane.

∴ Length of throat, $t = s \sin 45° = 0.707\, s$

and maximum bending stress,

$$\sigma_{b(max)} = \frac{4\, M}{\pi \times 0.707\, s \times d^2} = \frac{5.66\, M}{\pi s d^2}$$

3. ***Long fillet weld subjected to torsion.*** Consider a vertical plate attached to a horizontal plate by two identical fillet welds as shown in Figure.

Let T = Torque acting on the vertical plate,

l = Length of weld,

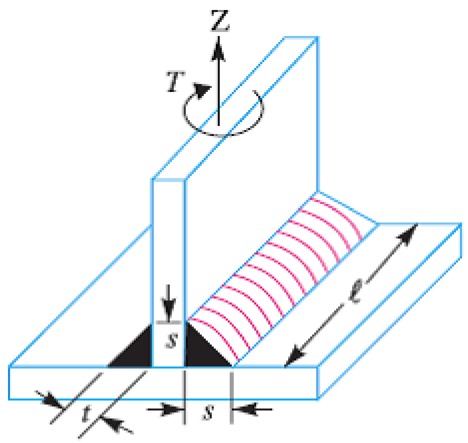
s = Size (or leg) of weld,

t = Throat thickness, and

J = Polar moment of inertia of the weld section

$$= 2 \times \frac{t \times l^3}{12} = \frac{t \times l^3}{6} \quad ...$$

$$\therefore \text{ Shear stress, } \quad \tau = \frac{T \times l/2}{t \times l^3/6} = \frac{3\,T}{t \times l^2}$$



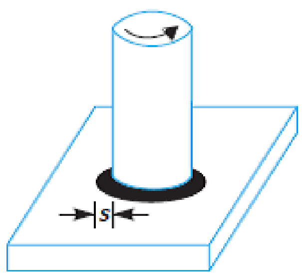
The maximum shear stress occurs at the throat and is given by

$$\tau_{max} = \frac{3T}{0.707\,s \times l^2} = \frac{4.242\,T}{s \times l^2}$$

Problem 2

A 50 mm diameter solid shaft is welded to a flat plate by 10 mm fillet weld as shown in Figure. Find the maximum torque that the welded joint can sustain if the maximum shear stress intensity in the weld material is not to exceed 80 MPa.

Solution



d = 50 mm ; s = 10 mm ; τ_{max} = 80 MPa = 80 N/mm^2

Let T = Maximum torque that the welded joint can sustain.

We know that the maximum shear stress (τ_{max}),

$$80 = \frac{2.83\,T}{\pi s \times d^2} = \frac{2.83T}{\pi \times 10\,(50)^2} = \frac{2.83\,T}{78550}$$

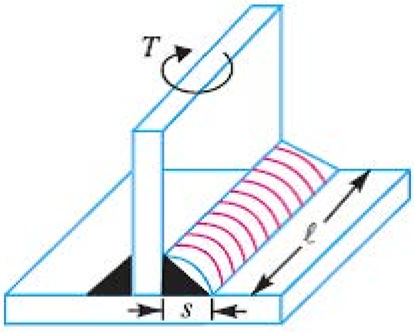
$$T = 80 \times 78\,550/2.83$$

$$= 2.22 \times 10^6 \text{ N-mm} = 2.22 \text{ kN-m}$$

Problem3

A plate 1 m long, 60 mm thick is welded to another plate at right angles to each other by 15 mm fillet weld, as shown in Figure. Find the maximum torque that the welded joint can sustain if the permissible shear stress intensity in the weld material is not to exceed 80 MPa.

Solution



l = 1m = 1000 mm ; Thickness = 60 mm ;

s = 15 mm ; τ_{max} = 80 MPa = 80 N/mm^2

Let T = Maximum torque that the welded joint can sustain

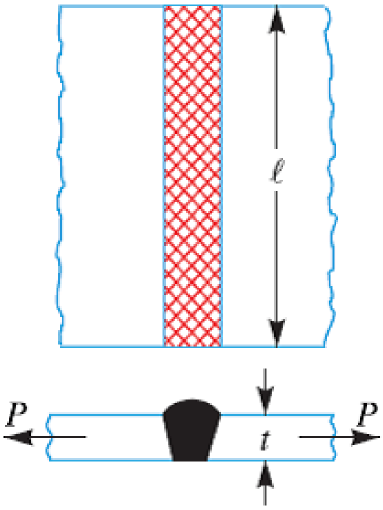
We know that the maximum shear stress (τ_{max}),

$$80 = \frac{4.242\,T}{s \times l^2} = \frac{4.242\,T}{15\,(1000)^2} = \frac{0.283\,T}{10^6}$$

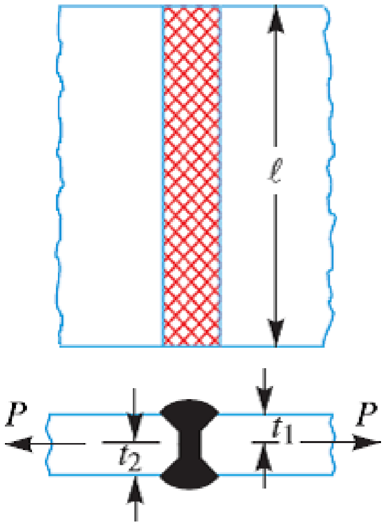
$$T = 80 \times 10^6 / 0.283 = 283 \times 10^6 \text{ N-mm} = 283 \text{ kN-m}$$

Strength of Butt Joints

The butt joints are designed for tension or compression. Consider a single V-butt joint as shown in Figure



(*a*) Single *V*-butt joint.



(*b*) Double *V*-butt joint.

In case of butt joint, the length of leg or size of weld is equal to the throat thickness which is equal to thickness of plates.

∴ Tensile strength of the butt joint (single-*V* or square butt joint),

$$P = t \times l \times \sigma_t$$

Where l = Length of weld. It is generally equal to the width of plate.

and tensile strength for double-*V* butt joint as shown in Figure (*b*) is given by

$$P = (t_1 + t_2)\, l \times \sigma_t$$

Where t_1 = Throat thickness at the top, and

t_2 = Throat thickness at the bottom.

It may be noted that size of the weld should be greater than the thickness of the plate, but it may be less. The following table shows recommended minimum size of the welds.

Recommended minimum size of welds.

Thickness of plate (mm)	3 – 5	6 – 8	10 – 16	18 – 24	26 – 55	Over 58
Minimum size of weld (mm)	3	5	6	10	14	20