Fig. 10.12

Solution. Given : $d = 50$ mm ; $s = 10$ mm ; $\tau_{max} = 80$ MPa $= 80$ N/mm^2

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

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

$$80 = \frac{2.83\ T}{\pi\, s \times d^2} = \frac{2.83\, T}{\pi \times 10\ (50)^2} = \frac{2.83\ T}{78\,550}$$

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

$ = 2.22 \times 10^6$ N-mm $= 2.22$ kN-m **Ans.**

Example 10.3. *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 Fig. 10.13. 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.*
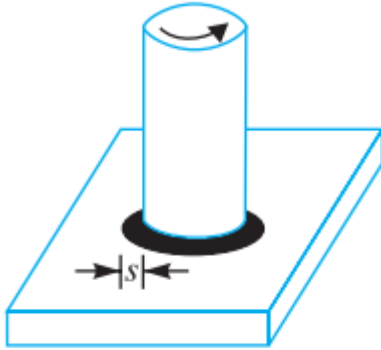
Solution. Given: $l = 1m = 1000$ mm ; Thickness $= 60$ mm ; $s = 15$ mm ; $\tau_{max} = 80$ MPa $= 80$ N/mm^2

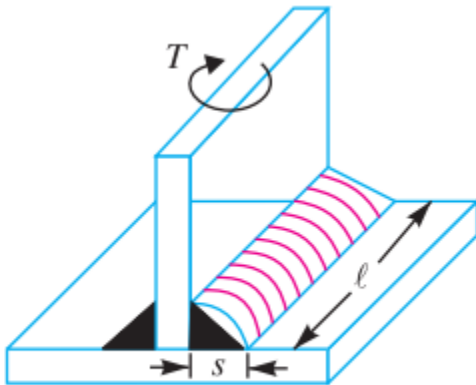Let T = Maximum torque that the welded joint can sustain.

Fig. 10.13

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

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

∴ $T = 80 \times 10^6 / 0.283 = 283 \times 10^6$ N-mm $= 283$ kN-m **Ans.**

10.19 Strength of Butt Joints

The butt joints are designed for tension or compression. Consider a single V-butt joint as shown in Fig. 10.14 (a).

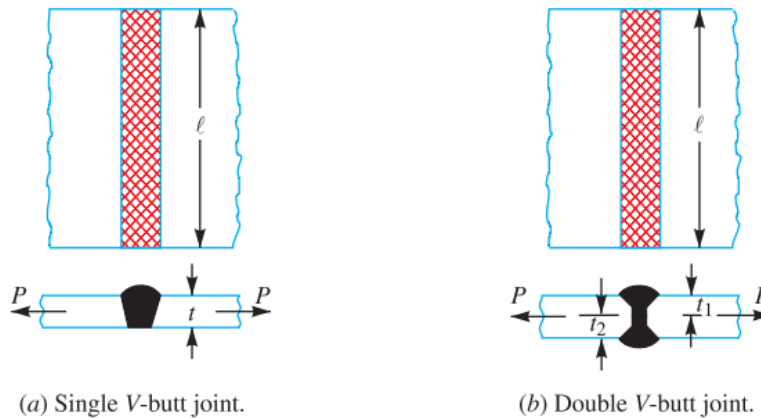(a) Single V-butt joint. (b) Double V-butt joint.

Fig. 10.14. Butt joints.

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 Fig. 10.14 (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.

Table 10.4. 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

10.20 Stresses for Welded Joints

The stresses in welded joints are difficult to determine because of the variable and unpredictable parameters like homogenuity of the weld metal, thermal stresses in the welds, changes of physical properties due to high rate of cooling etc. The stresses are obtained, on the following assumptions:

1. The load is distributed uniformly along the entire length of the weld, and

2. The stress is spread uniformly over its effective section.

The following table shows the stresses for welded joints for joining ferrous metals with mild steel electrode under steady and fatigue or reversed load.

Table 10.5. Stresses for welded joints.

Type of weld	Bare electrode		Coated electrode	
	Steady load (MPa)	Fatigue load (MPa)	Steady load (MPa)	Fatigue load (MPa)
1. Fillet welds (All types)	80	21	98	35
2. Butt welds				
Tension	90	35	110	55
Compression	100	35	125	55
Shear	55	21	70	35

10.21 Stress Concentration Factor for Welded Joints

The reinforcement provided to the weld produces stress concentration at the junction of the weld and the parent metal. When the parts are subjected to fatigue loading, the stress concentration factor as given in the following table should be taken into account.

Table 10.6. Stress concentration factor for welded joints.

Type of joint	Stress concentration factor
1. Reinforced butt welds	1.2
2. Toe of transverse fillet welds	1.5
3. End of parallel fillet weld	2.7
4. T-butt joint with sharp corner	2.0

Note : For static loading and any type of joint, stress concentration factor is 1.0.

Example 10.4. *A plate 100 mm wide and 12.5 mm thick is to be welded to another plate by means of parallel fillet welds. The plates are subjected to a load of 50 kN. Find the length of the weld so that the maximum stress does not exceed 56 MPa. Consider the joint first under static loading and then under fatigue loading.*

Solution. Given: *Width = 100 mm ; Thickness = 12.5 mm ; P = 50 kN = 50 × 10³N ; τ = 56 MPa = 56 N/mm²

Length of weld for static loading

Let l = Length of weld, and

s = Size of weld = Plate thickness

= 12.5 mm   ... (Given)

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

$50 × 10^3$ = 1.414 $s × l × \tau$

= 1.414 × 12.5 × l × 56 = 990 l

∴ l = 50 × 10³ / 990 = 50.5 mm

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

l = 50.5 + 12.5 = 63 mm **Ans.**

Length of weld for fatigue loading

From Table 10.6, we find that the stress concentration factor for parallel fillet welding is 2.7.

∴ Permissible shear stress,

$$\tau = 56 / 2.7 = 20.74 \text{ N/mm}^2$$

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

$$50 \times 10^3 = 1.414 \, s \times l \times \tau = 1.414 \times 12.5 \times l \times 20.74 = 367 \, l$$

∴ $l = 50 \times 10^3 / 367 = 136.2$ mm

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

$$l = 136.2 + 12.5 = 148.7 \text{ mm} \quad \textbf{Ans.}$$

Example 10.5. *A plate 75 mm wide and 12.5 mm thick is joined with another plate by a single transverse weld and a double parallel fillet weld as shown in Fig. 10.15. The maximum tensile and shear stresses are 70 MPa and 56 MPa respectively.*

Find the length of each parallel fillet weld, if the joint is subjected to both static and fatigue loading.

Solution. Given : Width = 75 mm ; Thickness = 12.5 mm ; $\sigma_\tau = 70$ MPa = 70 N/mm^2 ; $\tau = 56$ MPa = 56 N/mm^2.

The effective length of weld (l_1) for the transverse weld may be obtained by subtracting 12.5 mm from the width of the plate.

∴ $l_1 = 75 - 12.5 = 62.5$ mm

Fig. 10.15

Length of each parallel fillet for static loading

Let l_2 = Length of each parallel fillet.

We know that the maximum load which the plate can carry is

$$P = \text{Area} \times \text{Stress} = 75 \times 12.5 \times 70 = 65\,625 \text{ N}$$

Load carried by single transverse weld,

$$P_1 = 0.707 \, s \times l_1 \times \sigma_t = 0.707 \times 12.5 \times 62.5 \times 70 = 38\,664 \text{ N}$$

and the load carried by double parallel fillet weld,

$$P_2 = 1.414 \, s \times l_2 \times \tau = 1.414 \times 12.5 \times l_2 \times 56 = 990 \, l_2 \text{ N}$$

∴ Load carried by the joint (P),

$$65\,625 = P_1 + P_2 = 38\,664 + 990 \, l_2 \quad \text{or} \quad l_2 = 27.2 \text{ mm}$$

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

$$l_2 = 27.2 + 12.5 = 39.7 \text{ say } 40 \text{ mm} \quad \textbf{Ans.}$$
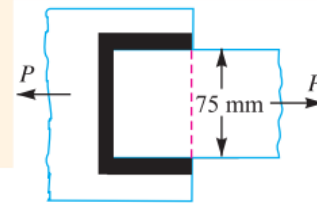
Length of each parallel fillet for fatigue loading

From Table 10.6, we find that the stress concentration factor for transverse welds is 1.5 and for parallel fillet welds is 2.7.

∴ Permissible tensile stress,

$$\sigma_t = 70 / 1.5 = 46.7 \text{ N/mm}^2$$

and permissible shear stress,

$$\tau = 56 / 2.7 = 20.74 \text{ N/mm}^2$$

Load carried by single transverse weld,

$$P_1 = 0.707\ s \times l_1 \times \sigma_t = 0.707 \times 12.5 \times 62.5 \times 46.7 = 25\ 795 \text{ N}$$

and load carried by double parallel fillet weld,

$$P_2 = 1.414\ s \times l_2 \times \tau = 1.414 \times 12.5\ l_2 \times 20.74 = 366\ l_2 \text{ N}$$

∴ Load carried by the joint (P),

$$65\ 625 = P_1 + P_2 = 25\ 795 + 366\ l_2 \quad \text{or} \quad l_2 = 108.8 \text{ mm}$$

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

$$l_2 = 108.8 + 12.5 = 121.3 \text{ mm} \quad \textbf{Ans.}$$