Mechanical joints

Welded joints

Methods of joining materials

1. Mechanical joints
2. Adhesives
3. Welding

Uses of welding:

1. Ship building, industrial and commercial buildings.
2. Oil pipe -line construction.
3. Automobile, railways and bridges.
4. Machine tools.
5. Farm equipment, home appliances, and air-conditioning units.
6. Computer components.
7. Mining equipment.
8. Boilers, furnaces and vessels.
9. Maintenance and repair of equipment

Welding and cutting processes:

The most popular processes are:

Oxy-fuel gas welding (OFW)

A mixture of oxygen and acetylene is used to melt both parent metals.

Shield metal arc welding (SMAW) it is the most popular method because:

1. High quality weld
2. Excellent uniformity
3. High rate
4. It can be used for variety of materials and thickness.

Gas tungsten arc welding (GTAW):

Advantages:

1. Clean
2. High quality weld
3. No post weld finishing is required
4. Performed on variety of material

Gas metal arc welding (GMAW):

1. Fast
2. Economical

3. Welding on thin as well as thick plates
4. Reduced post-weld cleanup

Forge welding:

It is an old method of welding where manual or machine hammering is used to weld the two pieces together

Pressure welding or resistance welding

In this method an electric current is passed through the two parent material until it causes a localized melting and a pressure is applied.

1. Spot welding
2. seam welding

Welding joints:

Figure(7.1) shows main types of welding joints

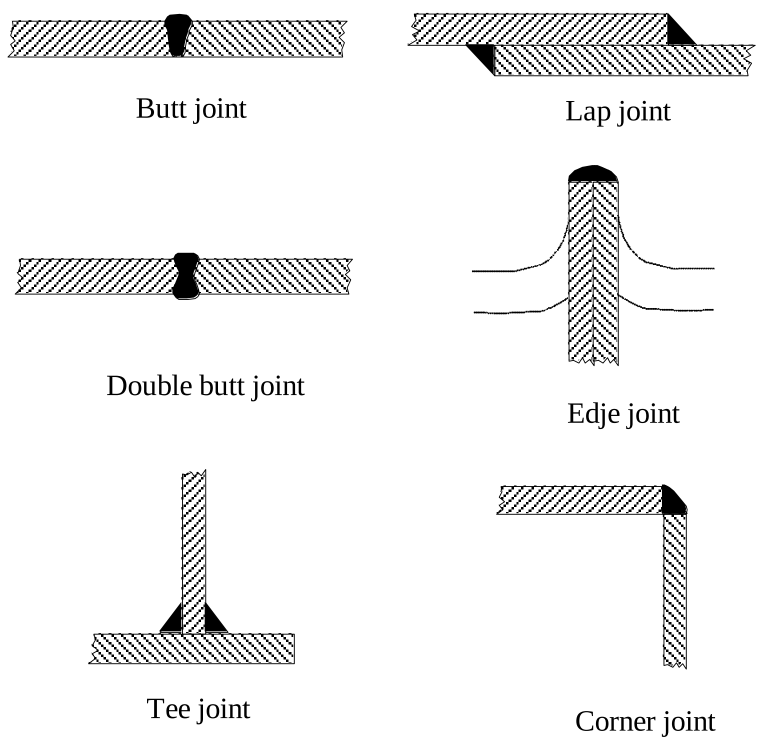

Fig. (7.1)

Welding terminology

Figure (7.2) shows geometrical terminology used in describing welding dimensions

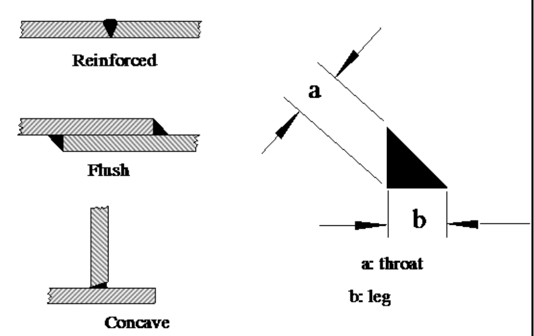

Fig. (7.2)

Illustration of welding in engineering drawing

Figure (7.3) shows how different types of welding are shown in engineering

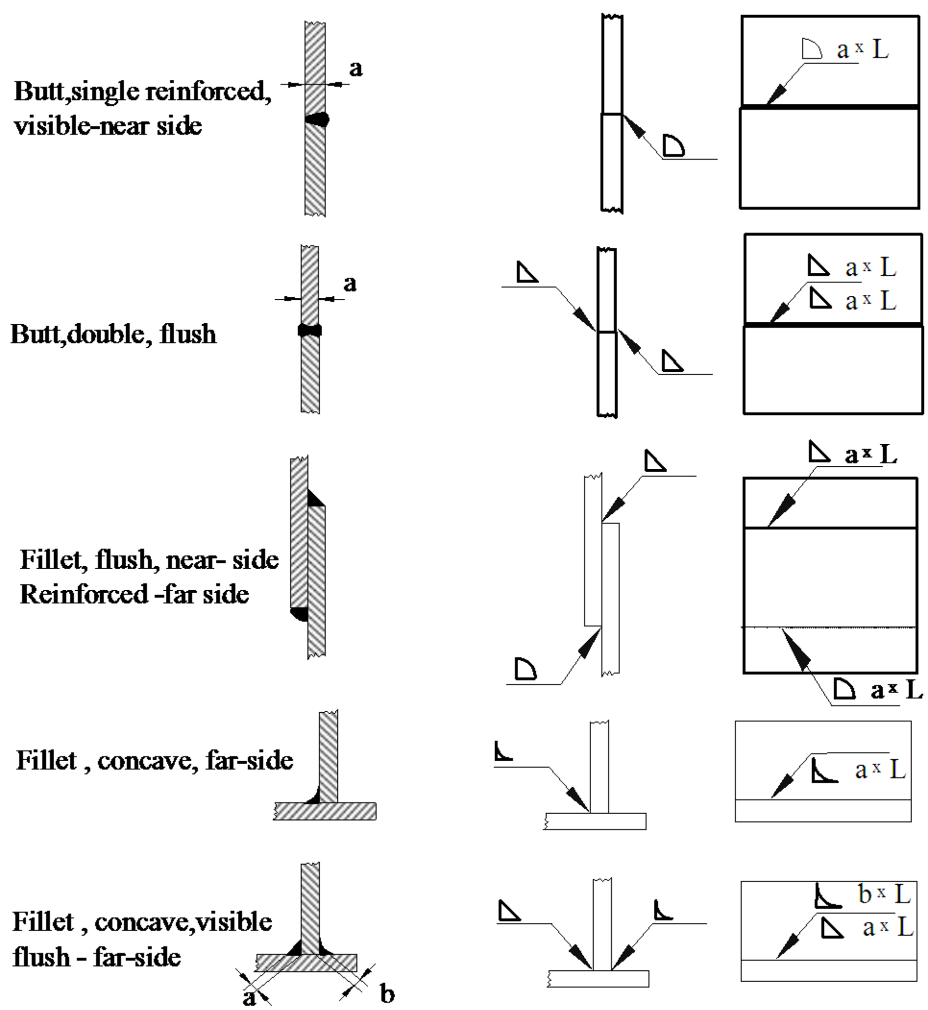

Fig. (7.3) Representaion of welding on an engineering drawing drawings

Welding strength:

In fig.(7.4) Three welding joints subjected to tension are shown. Under such conditions the welding joints are classified under three classes according to the stress exerted on the joint:

Class 1 - Longitudinal shear
Area of shear = 2aL (7.1)

Class 2- transverse shear + tension
Area of shear = 2hL (7.2)

Class3 -pure tension
Area of tension = hL (7.3)
Where,
a = 0.707 h

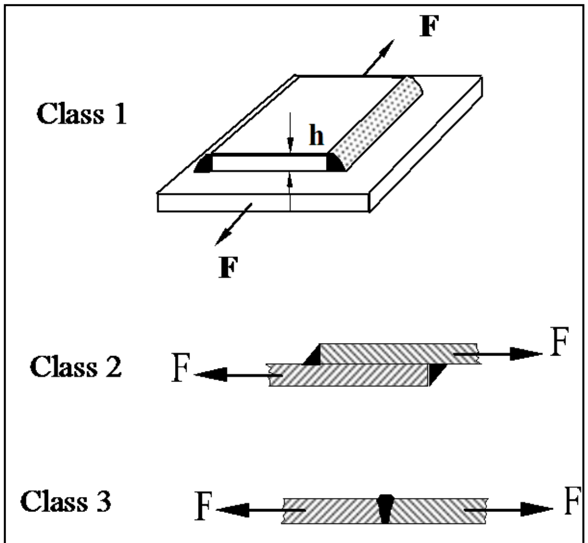

Fig.(7.4)

Design of welding joint:

The allowable stress value shown in table (7.1) are applied in obtaining the dimension of the weld if the welding rods are coated with flux, other wise it should be reduced by 20%. Half of an inch should be added to the length of weld to compensate for the defects which may occur at the beginning and end of welding. For more accurate results Table (7.3) can be used.

Table (7.2) shows the stress concentration factors for various types of joints.

Table (7.1) Allowable loads on mild steel shielded arc-weld in shear

Type of weld	Size of fillet weld (in)							
	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$
Transverse weld	1325	1985	2650	3310	3975	5300	6620	7950
Longitudinal weld	1000	1500	2000	2500	3000	4000	5000	6000

Table (7.2) Stress concentration factor (K) for welds

Type of load	K
Reinforced butt weld	1.2
Toe of transverse fillet weld	1.5

End of longitudinal weld	2.7
T-butt joint with sharp corners	2

Table (7.3) Strength of Shielded-Arc Flush Steel Welds

Kind of Stress	Safety factor 2 Static load	Safety factor 2 Load varies from 0 to F	Safety factor 2.75 Load varies from -F to +F
Tension	16000	14500	8000
Compression	18000	16000	8000
Bending	18000	16000	9000
Shear	11000	10000	5000
Shear and tension	11000	10000	5000

Eccentric loads:

When the load on a welded joint is applied eccentrically, the welds will be subjected to a combination of shear caused by the direct load and shear caused by torque. The state of stress in such a joint is complicated; and in order to determine the value of the significant stress even approximately, it is necessary to assume that the torsional shear stress at any point is proportional to its distance from

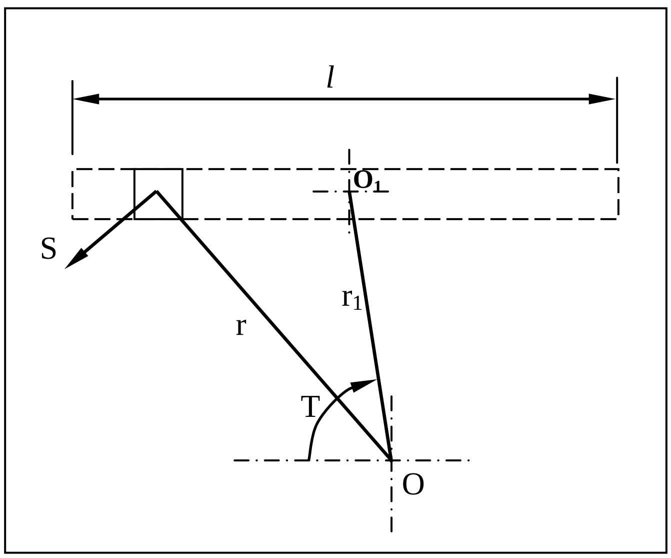

Fig.(7.5) Eccentric loading

centroid of all weld areas.

If the weld shown in fig.(7.5) is one of several forming a joint with the centroid of weld areas at O, the torsional shear stress *s* on an element *dA* of the weld will be perpendicular to r and can be expressed as:

$$s = nr$$

where n is a constant of proportionality and r the distance from the element to O. The external torque T is equal to the torque resistance of the element, *sdAr*, integrated over all the welds in the joint. Thus,

$$T = \int sdAr$$

$$T = n\int r^2 dA = nJ$$

Where J is the polar moment of inertia with respect to O for all elements of the weld. The stress in any element can be found by the relation:

$$s = \frac{Tr}{J} \qquad (7.4)$$

Example(1)

Determine the load which an arc-welded joint of class 1, fig.(7.4), can safely carry if it joints 0.375 in plates and each fillet is 4.5 in long and reinforced. The load varies from zero to a certain maximum value.

Solution:

The cross-sectional area of a flush fillet weld resisting shear would be $a(l-0.5)$, and the area of a fully reinforced fillet may be taken as $1.2\ a(l-0.5)$. Thus the total cross-sectional area of both fillets is:

$A_1 = 0.707h \times 1.2\ a(l-0.5)x2 = 0.707\ x0.375 \times 1.2 \times (4.5 - 0.5) \times 2 = 2.55$

The working stress from table (7.) is S_s = 10000 psi, the safe load is,

$F_1 = A_1S_s = 2.55 \times 10000 =$ **25,500 lb**

Example(2):

Determine the loads which welded joints of class 2 and class 3 Fig.(7.4) can safely carry using the conditions and data of the previous example and compare them with the strength of the strip.

Solution:

In the joint of class 2 the section area in tension is equal to that in shear. Therefore the strength in shear is smaller. The area of the weld is:

$A_2 = 0.375\ (4.5 - 0.5) \times 2 = 3\ in^2$

And the safe load with S =10000 psi is:

$F_2 = A_2xS_s = 3 \times 10000 =$ **30000 lb**

Thus one may say that class 2 joint is considerable stronger than a class 1 joint although they are not quite comparable.

In the joint of class 3 the area of the dangerous section with a reinforced joint is :

$A_3 = 0.375 \times 1.2 \times (4.5 - 0.5) = 1.8\ in^2$

From table (7.) allowable stress in tension is $S = 14500\ psi$ and the safe load is:

$F_3 = A_3S = 1.8 \times 14500 = 26100\ lb$

<u>The class 1 joint is the weakest one, although its strength is only 2% below what of class 3</u>

Assume that the base metal is SAE 1010 steel with endurance limit of S_e= 14500 psi. The safe load amplitude with a safety factor of 2 is:

$$F_a = \frac{0.375x4.5x14500}{2} = 12200lb$$

Hence $F_{max} = 2F_a = 24400\ lb$

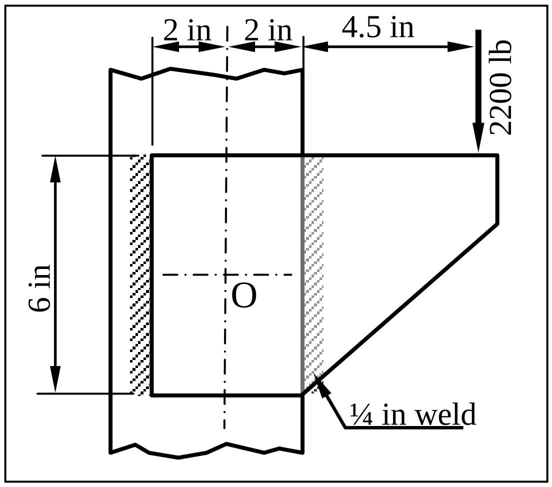

Fig. (7.6)

<u>Thus arc welded joints are theoretically stronger than the strip</u>

<u>Example(3):</u>

Determine the maximum stress in the reinforced weld of the bracket plate in fig.(7.6) . Assume that the load varies from zero to the maximum value

<u>Solution:</u>

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Ex. 1:

Fig. (7.7) below shows a welding joint under a tension of 20000 Lb. The ratio of the weld length (A) to the weld width (B) equals 1.5. The thickness of the plates is $\frac{3}{8}$ Find suitable dimensions for the joint.

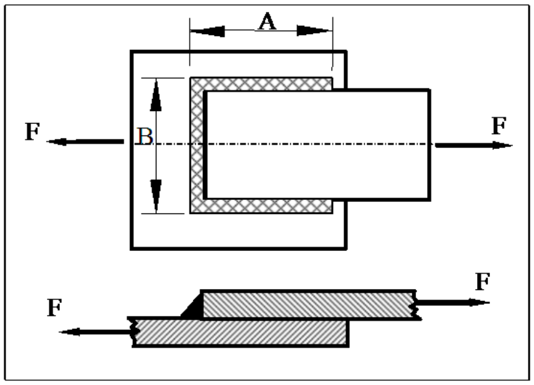

Fig. (7.7)

Ex. 2

A steel bracket is shown in fig.(7.8). The thickness of steel plates is ¼ in. A reinforced weld of ¼ is used to join the two plates. A force which varies from 0 to 2540 Lb is exerted at angle of 30^0 with the horizontal axis of the joint. Find the maximum stress in the weld.

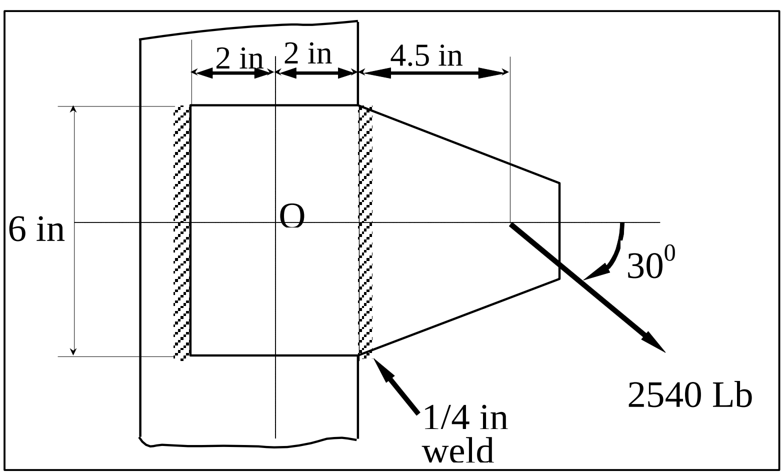

Fig. (7.8)