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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET3042-DESIGN OF STEEL STRUCTURES

III YEAR / VI SEMESTER

Unit 1 :Connections

Types of Steel Connections

In modern times, the most common way to connect structural steel members is to use bolts or welds. Rivets have historically been used as a connecting medium, however they have largely been replaced by bolts for a number of reasons

- Rivited Connections
- Bolted Connections
- Welded Connections

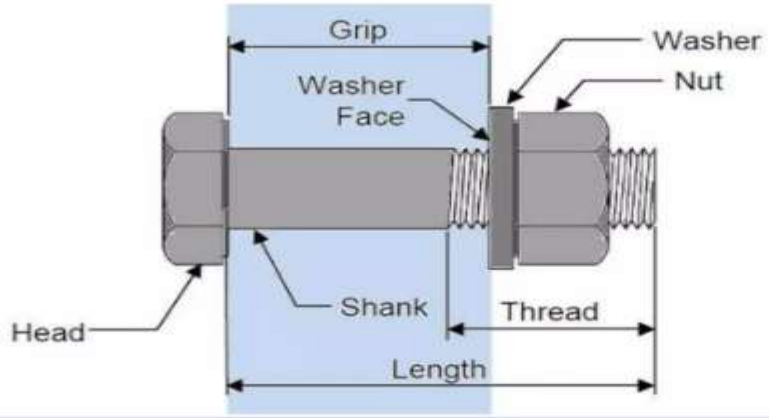
Riveted Connections

- Rivets have a long history as a connecting medium for steel connections. They are made up of a head and a ductile shank.
- The process for installation required the pre-heating of the rivet, and the application of pneumatic pressure.
- This posed a number of disadvantages including the need for pre-heating (extra energy input and process as well as fire risk), high levels of noise during installation, and difficulty in replacing rivets during maintenance.

Bolted Connections

- Bolts have largely replaced rivets due to their lower installation cost, ease of installation and maintenance.
- The two types of bolts commonly used in steel construction include high strength structural steel, and A307 bolts (common bolts). Structural steel bolts are sub categorised into A325 (Group A) and A490 (Group B) and are high strength.
- Bolts however have the notable disadvantage of loosening under vibratory loads resulting in a reduction of strength.

• **Bolts**



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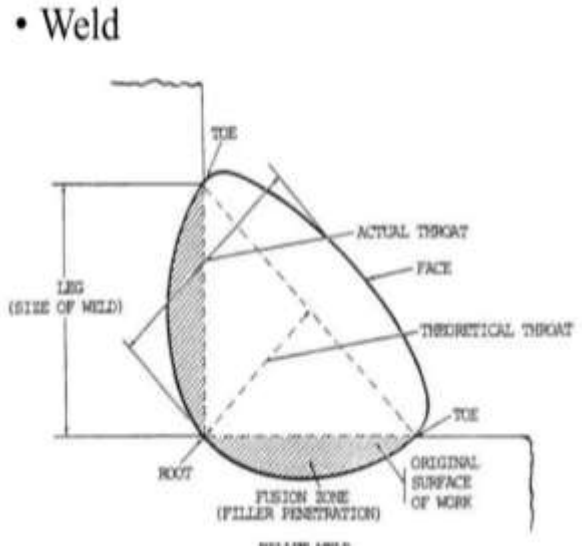
Welded Connections

- Welded connections have the primary advantage of being simple in design, requiring fewer parts and material. Welds however shrink, and this effect needs to be considered in the design particularly for large welds.
- In addition, the inspection of welds is more difficult and hence costlier and more difficult to maintain.
- Variability exists with the quality of the weld being made by the erector. The most common types of welds include fillet, groove, plug, and slot welds.



1.Bolted Connections

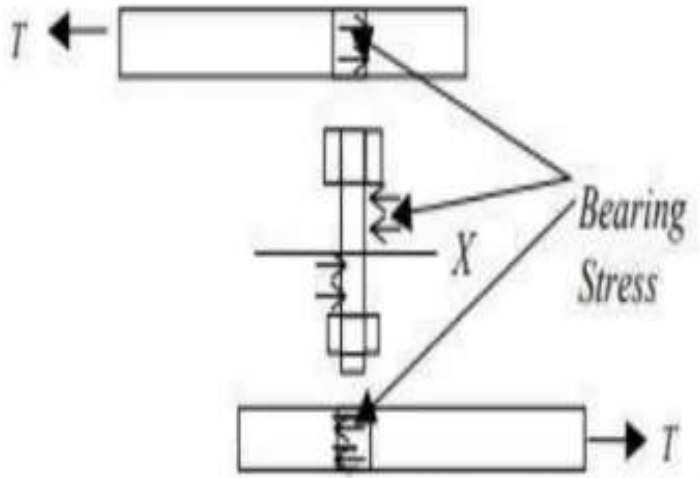
- Bolting is the preferred method of connecting members on the site.
- Several types of bolts are used in bolted connection.

1) Unfinished bolts or black bolts or C grade bolts (IS 1363 : 2002)
2) Turned bolts
   i. Precision bolts or A grade bolts (IS 1364 : 2002)
   ii. Semi-precision bolts or B grade bolts (IS 1364 : 2002)
3) Ribbed bolts
4) High strength friction grip bolts (IS 3757 : 1985 and IS 4000 : 1992)

1. Black Bolts:

- It is the most common type of bearing bolts in clearance holes, often referred to as ordinary bolts.
- They are popular since they are economical, both in terms of material and installation costs.
- The force transfer mechanism under shear is as shown in Fig.

Bolt Shear Transfer Mechanism In Bearing Connections



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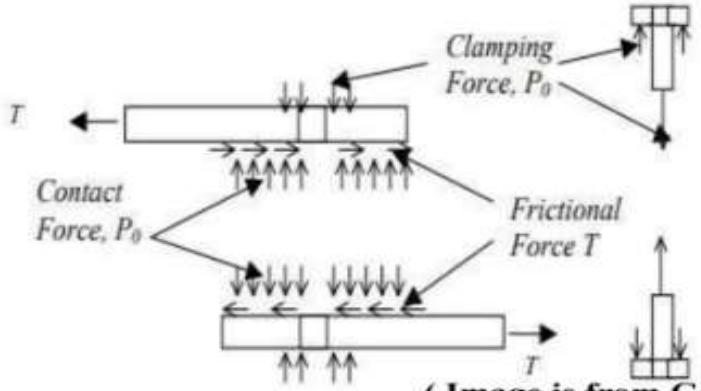
- The force is transferred by bearing between the plate and bolts at the bolt holes. The bolts experience single or double shear depending upon the plate configuration. The failure may be either by shearing of the bolts or bearing of the plate and the bolt.

Disadvantage: Bearing type of bolted connections is that the elements undergo some slip even under a small shear, before being able to transfer force by bearing

2. High strength friction grip (HSFG) bolts.

- In HSFG bolted joints, high strength bolts are pre-tensioned against the plates to be bolted together, so that contact pressure is developed between the plates being joined.
- When external shear force is applied, the frictional resistance to slip between the plates prevents their relative slip. These bolted joints achieve higher stiffness in shear because of frictional resistance between the contact surfaces.

Bolt Shear Transfer Mechanism In HSFB Connections



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- Only when the externally applied force exceeds the frictional resistance between the plates, the plates slip and the bolts bear against the bolt holes. Thus even after slip, there is a reserve strength due to bearing.

Disadvantage: The HSFG bolts are expensive both from material and installation points of view. They require skilled labour and effective supervision.

The advantages of bolted connections are as follows:

- The process of erection of structure can be made faster.
- Skilled labors are not necessary.
- Connections do not involve the noise.
- Requirement of labors is less.
- Immediate use of structure is possible in case of bolted connection.
- The alternative arrangement of structural members is possible if required.
- Lesser working area is required.

The disadvantages of bolted connections are as follows:

- The material cost is very high.
- Due to the area reduction at the root of the thread and due to concentration of stress, the tensile strength of this type of connection is reduced.
- Bolts get loose if it is subjected to vibrations or shocks.

Grade classification of Bolts:

- The grade classification of a bolt is indicative of the strength of the material of the bolt. The two grade of bolts commonly used are grade 4.6 and 8.8.
- For 4.6 grade 4 indicates that ultimate tensile strength of bolt = 4 × 100 = 400 N/mm² and 0.6 indicates that the yield strength of the bolt is 0.6 × ultimate strength = 0.6 × 400 = 240 N/mm²

Grade of bolt	4.6	5.6	6.5	6.8	8.8
F_{yb}(N/mm²)	240	300	300	480	640
F_{ub}(N/mm²)	400	500	600	800	800

Properties of High Strength Friction Grip Bolts

Basic Terminologies in Designing a Bolted Connection

Pitch distance (p)

•centre to centre distance between two adjacent bolt holes in the direction of the applied load

Gauge distance (g)

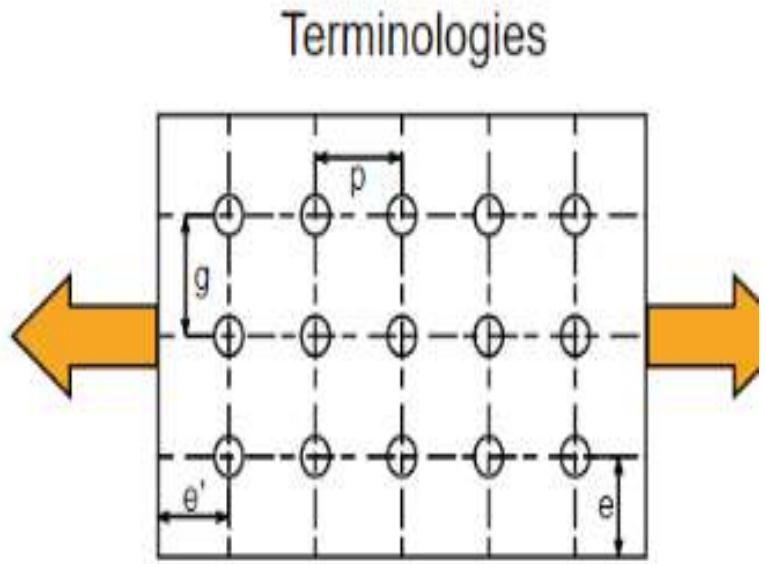
• centre to centre distance between two adjacent bolt holes in the perpendicular direction of the applied load

Edge distance (e)

• the distance between the edge of the plate to the nearest centerline of a bolt hole in the perpendicular direction to the applied load

End distance (e')

•the distance between the end of the plate to the nearest centerline of the bolt hole in the direction of the applied load

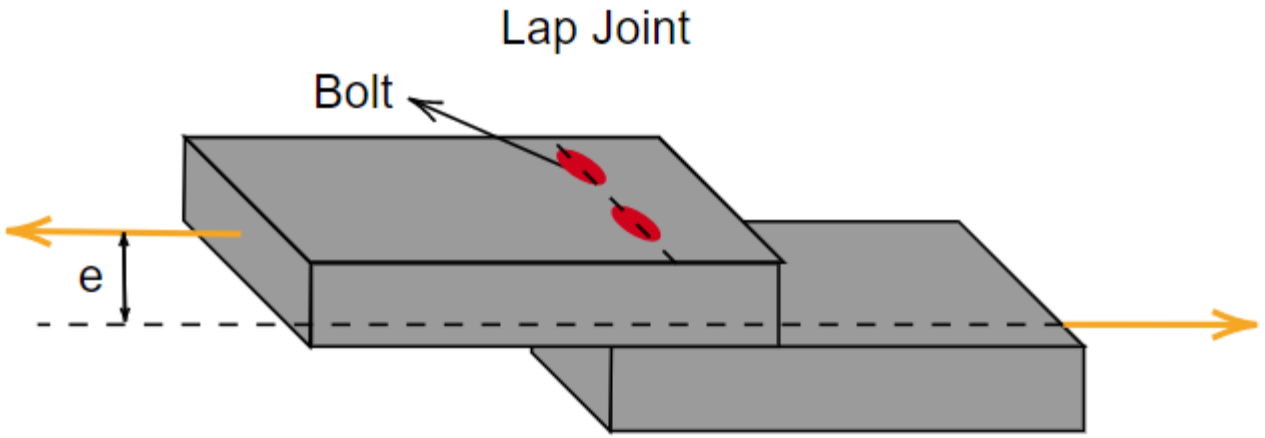


Types of Joints in Bolted Connections

There are two predominant types of joints in a bolted connection namely, lap joint and butt joint. There are sub-types within these two types i.e., eccentric connections, pure moment connections etc. but are beyond the scope of this blog. The nature of the joints and sub-types within these joints are explained as follows.

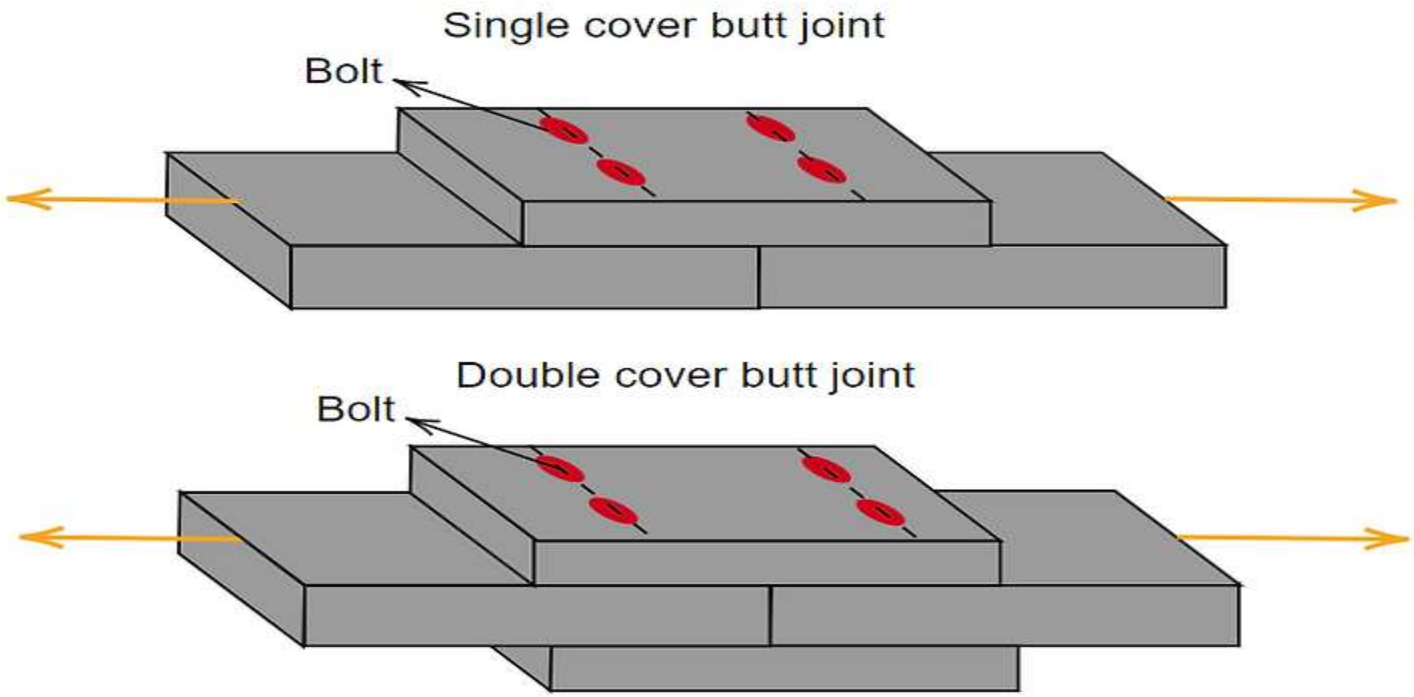
1. Lap Joint

In a lap joint, the main members to be connected are placed over one another to form an overlap between the members, and then the bolting is done on the overlapped portion. Because of the very nature of the connection, an eccentricity is produced.



2. Butt Joint

In this type of joint, a cover plate is used to join two members. Based on the number of cover plates there are two types of butt joint namely, single cover butt joint and double cover butt joint.



Welded Connections

Welded connections are connections whose components are joined together primarily by welds

Advantages

(a)Jointefficiencyis100%.

(b)Fabrication in

difficult structure is easy.

(c) Pure silence prevails during process

(d)No safety precautions are needed.

(e)Welding process is much faster.

(f)Welding process is much economical.

(g)This method always provide rigid joints.

(h)Minimum self weight for structure

Disadvantages

(a)Since welding is a hot process involving in non-uniform heating and cooling, structural members will be subjected to distortion resulting in more unwanted stress.

(b)Welded structures are subjected to cracks due to non provision of expansion and contraction.

(c)Very high labour cost since skilled labour is required.

(d)Checking and verification of welding work is very difficult.

(e)Structure may be subjected to fatigue and susceptible to failure by cracking under repeated cyclic loads.

(f) Tearing of base metal plate may occur beneath the weld known as Lamellar tearing.

Welded Connections

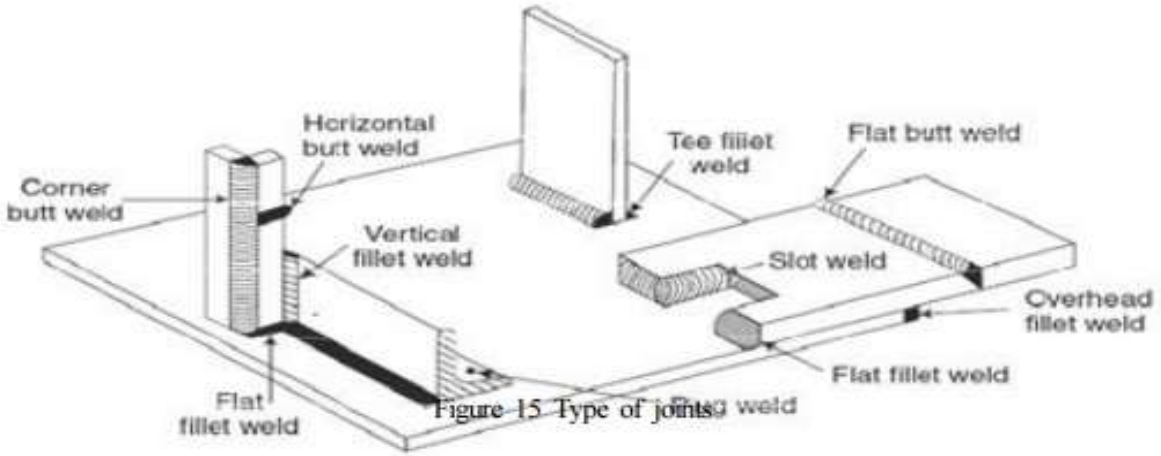


Figure 15 Type of joints

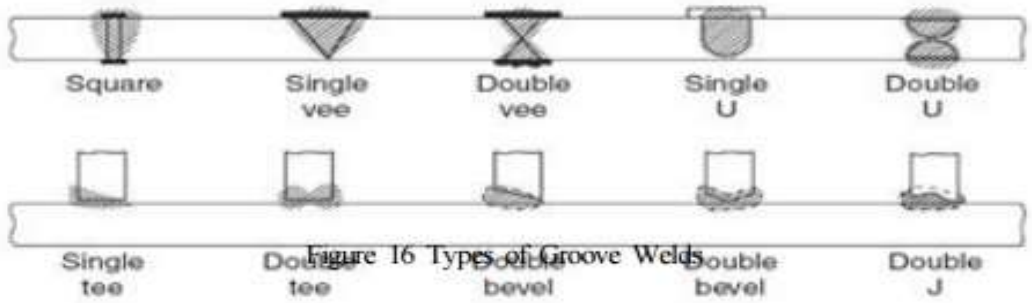


Figure 16 Types of Groove Welds

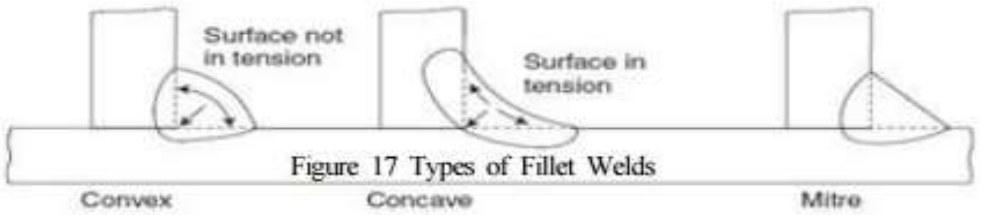


Figure 17 Types of Fillet Welds

TYPES OF WELDED CONNECTIONS

The basic types of welded joints can be classified depending on the types of welds, position of welds and type of joint.

1. Based on the type of weld

Based on type of weld, welds can be classified in to fillet weld, groove weld (or butt weld), plug weld, slot weld, spot weld etc. Various types of welds are shown in Figure 15.

1.1. Groove welds (butt welds)

Groove welds (butt welds) and fillet welds are provided when the members to be joined are lined up. Groove welds are costlier since it requires edge preparation. Groove welds can be employed safely in heavily stressed members. Square butt welds are provided up to a plate thickness of 8mm only. Various types of butt welds are shown in Figure 16.

1.2. Fillet welds

Fillet welds are provided when two members to be jointed are in different planes. Since this situation occurs more frequently, fillet welds are more common than butt welds. Fillet welds are easier to make as it requires less surface preparation. Nevertheless, they are not as strong as the groove welds and cause concentration of stress. Fillet welds are preferred in lightly stressed members where stiffness rather than strength governs the design. The various types of fillet welds are shown in Figure 17.

1.3. Slot and plug welds

Slot and plug welds are used to supplement fillet welds where the required length of fillet weld cannot be achieved.

2. Based on the position of weld

Based on the position of weld, welds can be classified in to flat weld, horizontal weld, vertical weld, overhead well etc.

3.Based on the type of joints

Based on the type of joints, welds can be classified in to butt welded joints, lap welded joints, tee welded joints and corner welded joints.

Difference Between Fillet Weld And Butt Weld

Fillet Weld	Butt Weld
simple, fast and economical to make	more expensive than fillet welds because of the edge preparation required
no prior edge preparation is necessary,	easily designed and fabricated to be as strong as the member
does not require very skilled labour.	require more skilled manpower, than that required for filled welds.
less attractive in appearance.	better appearance, compared to fillet welds, and
poorer performance under fatigue loading, and	better fatigue characteristics, compared to fillet welds,
Throat thickness=0.707 x weld size	Thickness=(5/8) x thickness of thinner plate
not appropriate to transfer forces large in magnitude	easy to detail and the length of the connection is considerably reduced.

THANK YOU