Civil Engineering

Design of Steel Structures

Comprehensive Theory

with Solved Examples and Practice Questions

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Design of Steel Structures

First Edition: 2015
Second Edition: 2016
Third Edition: 2017
Fourth Edition: 2018
Fifth Edition: 2019
Sixth Edition: 2020
Seventh Edition: 2021
Eighth Edition: 2022

Contents

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CHAPTER 02

Rivetted, Bolted and Pinned Connections

2.1 Connections

- Connections are the weakest point of failure in a structure and thus need to be properly analyzed and designed.
- The various types of fasteners available for making connections are rivets, bolts, pins and the welds. Bolting has become so much popular that high strength bolts has almost replaced rivets now.

2.2 Riveted Connection

- Riveted connection has become obsolete now but an idea about its behavior and its design is essential for assessing strength of the joint and also for rehabilitation of old structures.
- Analysis and design of riveted connection is almost same as that of bolted connection.
- A rivet is made up of a round ductile steel bar of mild or high tensile steel which is called as shank with a head at one of its ends. This head can be of different shapes some of them are as shown in Fig. 2.1.

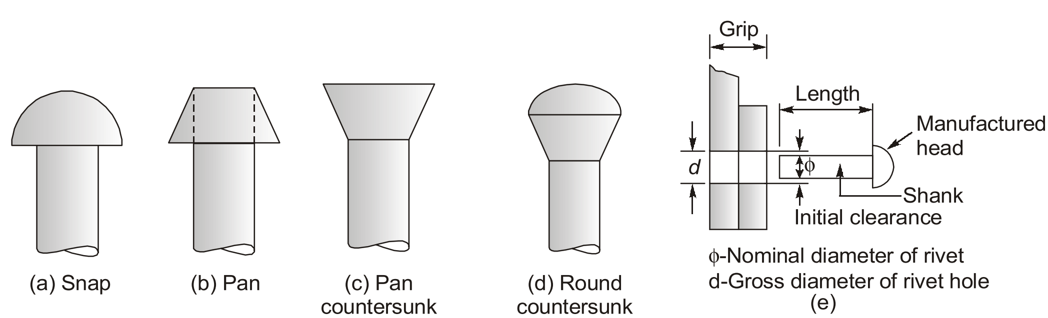


***Fig. 2.1** Types of rivet, their grip and length*

- Cl. 17.4.1 of IS 800 : 2007 states that rivets should be heated uniformly and that too throughout the length without burning or excessive scaling and shall be of standard length to provide a head of standard dimension.
- When rivets are driven then these shall fill the rivet holes completely.

- **Grip:** The **grip** of the rivet is the distance between the undersides of the two heads i.e. shank length inside the connection as shown in **Fig. 2.1(e)**. In case grip of the rivet becomes longer than what is required then rivet will be subjected to flexural stresses in addition to shear and bearing stresses.

NOTE

The grip length of a rivet must not be more than four times the rivet diameter. The diameter of the shank is referred to as **nominal diameter** of the rivet. A hole slightly greater than the nominal diameter is drilled through the parts to be connected, the rivet is inserted and head is formed at the other end of the shank. This whole process is called as **riveting**.

Remember

As per **Cl. 17.4.2** of **IS 800:2007** for connections having multiple rivets, a service bolt shall be provided in every third or the fourth rivet hole. For connections having single rivets, all connected parts must be held firmly before and after the riveting.

- Rivets when heated before driving are called as **hot driven field rivets** (when placed in field) or **hot driven shop rivets** (when placed in workshop).
- The diameter of hot rivet is equal to the rivet hole diameter and is called as **gross diameter.**
- Hot rivet is plastic, expands and fills the hole completely while forming head at the other end of the rivet shank. But on cooling, the rivet shrinks both in diameter and length. Due to this shrinkage in rivet length, the connected parts get stressed resulting in residual tension of unknown amount in the shank and some compression in the plates to be connected.
- Cold driven rivets i.e. rivets driven at room temperature require high pressure for head formation at room temperature and thus its use is limited.

Remember

The strength of cold driven rivet is more than hot driven rivet but their clamping force is less as the cold driven rivets do not shrink like hot driven rivets. Rivet heads for small diameter rivets can be formed manually with an ordinary hammer and are referred to as **hand driven rivets.**

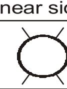
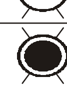
2.2.1 Material of the Rivet

As per **Cl. 2.3.2** of **IS 800:2007,** rivets should conform to **IS 1929:1982** and **IS 2155:1982.**

Cl. 2.3.3 of **IS 800:2007** states that high tensile steel rivets should be made from steel conforming to **IS** 1149:1982.

NOTE: As per **Cl. 17.4.4** of **IS 800:2007,** all loose, burnt and defective rivets must be cut out and get replaced well before the structure is loaded.

2.2.2 Symbols for Rivets

	Rivet Symbol			
Description	Round head both sides	Countersunk near side	Countersunk far side	Countersunk both side
Shop rivets				
Field rivets				

2.2.3 Patterns Used in Riveted Joint

The commonly used rivet patterns are chain riveting (Fig. 2.2 (a)), diamond riveting (Fig. 2.2 (b)), staggered riveting (Fig. 2.2 (c) and (d)).

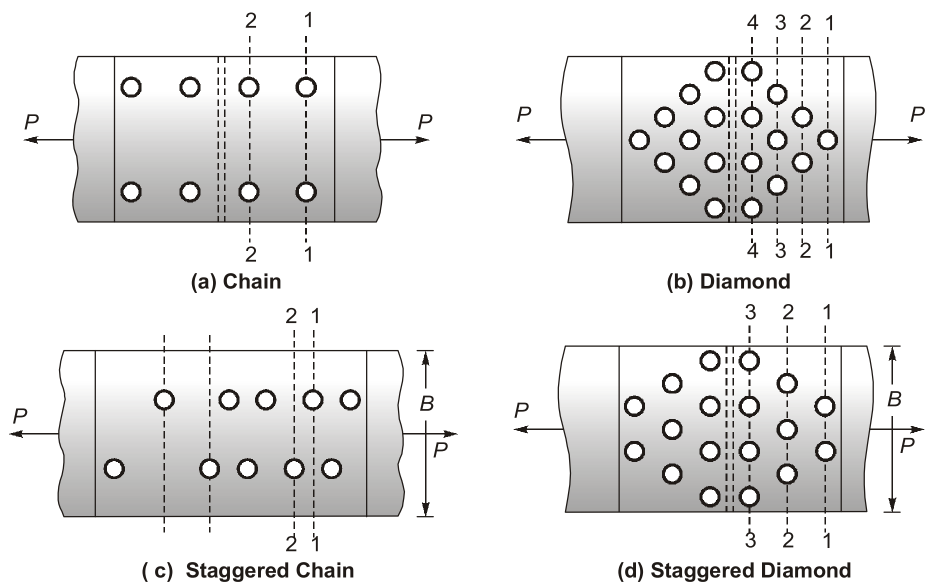


Fig. 2.2 *Patterns used in riveted joint*

> **NOTE**
> The design of riveted connection is almost same as that of bolted connection with the only difference that in riveted connection, the diameter to be used in calculations is the diameter of rivet hole whereas in bolted connection, it is the nominal diameter of the bolt. Apart from that, the requirements for pitch and edge distances are the same as that of bolted connections.

2.3 Bolted Connection

- A **bolt** is a sort of threaded pin with head at one end and threads on other end of the shank to receive nut as shown in **Fig. 2.3 (a).**
- **Bolt Length:** The bolt length is the distance from the bottom of bolt head to the end of bolt.
- **Grip Length:** Grip of the bolt is the distance from bottom of the bolt head to the back of the washer.
- **Steel washers:** The steel washers are provided below the bolt head and under the nut to distribute the clamping pressure on the bolted member and to prevent threaded portion of the bolt from bearing on the connecting parts.
- The holes required for placing the bolts for making connection may either be **drilled** or **punched**. Punching is preferred by commercial fabricators since it is simple, time saving and economic but this reduces the ductility and toughness rendering the material susceptible to brittle fracture.

2.3.1 Uses of Bolts

(a) Connection of tension and compression members.

(b) Fabrication of compound and built-up sections consisting of two or more sections.

(c) As hold down bolts to hold the column bases in position, joining the column caps with shoe plates (of trusses) etc.

2.3.2 Advantages and Disadvantages of Bolted Connections over Riveted Connections

Advantages:

(a) Bolted connections facilitate faster erection of structure.

(b) Not too much skilled labours are required for making the bolted connections.

(c) Bolted connection is more economical than riveted connection because cost of skilled labour is reduced as well as equipment costs are also very less.

Disadvantages:

(a) The cost of material is high almost twice that of rivets.

(b) Because of reduced area at the root of the thread, the tensile strength of the bolt is reduced and also stress concentration occurs.

(c) Bolts are usually of low fit (except the turned bolts) and thus they have reduced strength.

(d) In case of dynamic loads where vibrations occur and also in case of shock loadings, bolts get loosened up.

2.3.3 Classification of Bolted Connections

(a) Classification based on line of action of resultant force transferred

(i) **Concentric connection:** Here the load line passes through the CG of the section. e.g. Axially loaded tension or compression member.

(ii) **Eccentric connection**: Here the load line is away from the CG of the connection. e.g. Bracket connection, moment resisting connection, seat connection etc.

(b) Classification based on the type of force

(i) **Tension connection:** Here the load gets transferred through tension on bolts. e.g. Hanger connection

(ii) **Shear connection:** Here the load gets transferred through shear. e.g. Lap joint, butt joint etc.

(iii) **Combined shear and tension connection:** This type of connection is required when an inclined member is to be connected to a column through bracket. e.g. Connection to bracings

(c) Classification based on the type of force mechanism

(i) **Bearing connection:** Here the bolts bear against the holes to transfer the load. e.g. Slip type connection.

(ii) **Friction connection:** Here the load is transferred by friction between the plates due to tensioning of bolts. e.g. Slip critical connection.

2.3.4 Types of Bolts

(a) Unfinished bolts

- These types of bolts are also called as **ordinary, common, rough** or **black bolts.** These are commonly used in light structures subjected primarily to static loads and for secondary members like purlins, bracings etc.
- They are not suitable and also not recommended for connections subjected to impact loads, vibrations and fatigue.

- These bolts are made from low carbon steel (circular rods) by forging process. The ordinary structural bolts are fabricated from mild steel rods with either a square or a hexagonal head.
- Square headed bolt costs less but hexagonal headed bolt gives better aesthetics, are easier to hold by wrenches and requires less turning space.
- These types of bolts are available in diameters ranging from 5 mm to 36 mm and are designated as M5 to M36.
- It is recommended by **IS 800** that the net tensile area of bolt to be considered is the area of the root of the threads and is given in **Table below.** Sometimes this area is also called as **stress area** or the **proof area.**

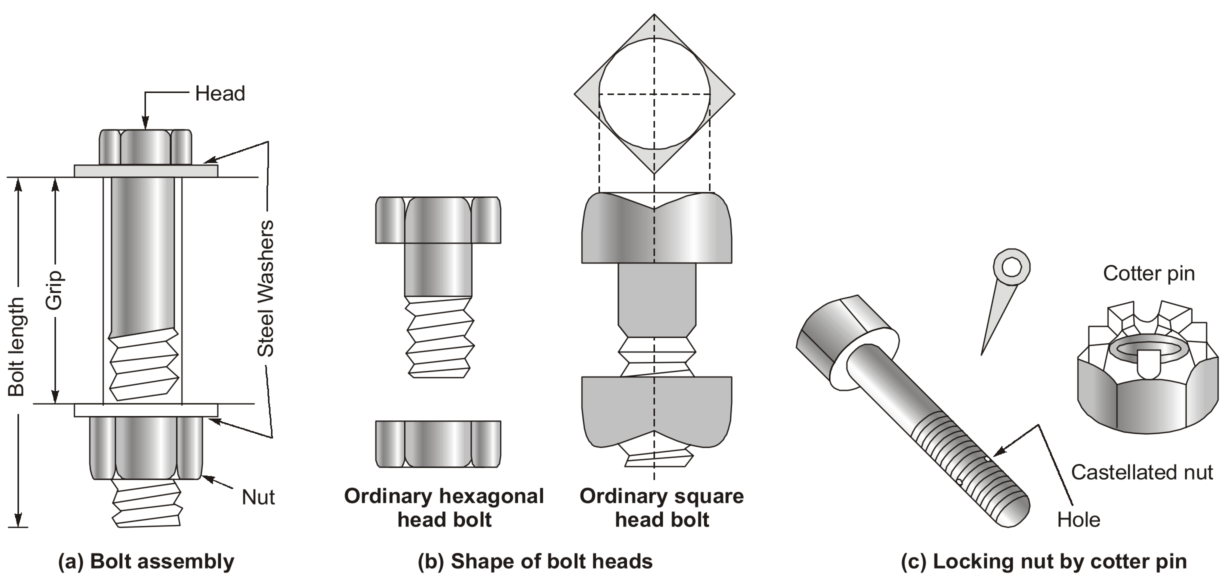


Fig. 2.3 *Unfinished or ordinary bolts*

Tensile Stresses area of bolts								
Bolt size, *d* (mm)	12	16	20	22	24	27	30	36
Tensile stress area (mm^2)	84.3	157	245	303	353	459	561	817

NOTE: In the absence of **Table above,** then as per **IS 1367 (Part 1)** the ratio of net tensile area at root of the threads to nominal plain shank area of the bolt is taken as **0.78** i.e., tensile stress area of bolt $\simeq 0.78\frac{\pi}{4}d^2$.

- The bolts can be placed in standard size, over size, short slotted or the long slotted holes as shown in **Fig. 2.4. Table 19** of **IS 800:2007** gives clearances for the bolt holes.

NOTE: When wind load and earthquake loads are considered, permissible stresses in structural steel and connections (i.e., rivet/bolt or weld) are increased by 33.33% and 25% respectively.

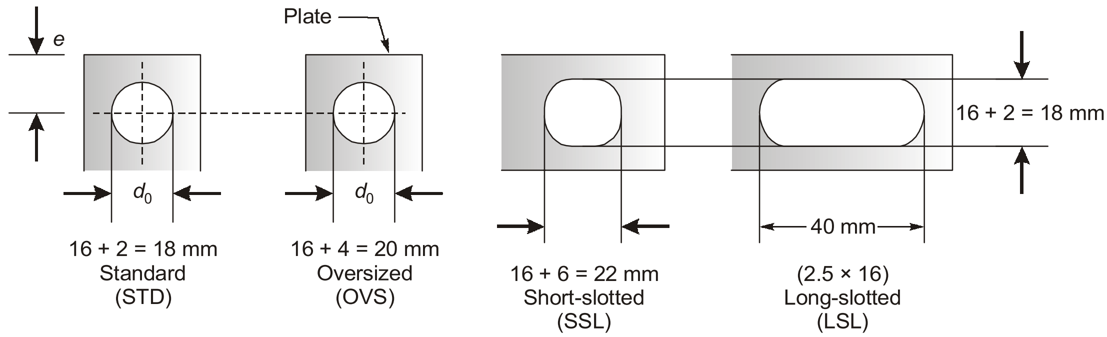


***Fig. 2.4** Representation of a typical bolt hole (for 16 mm diameter bolt)*

- The nuts on bolts are tightened with spud wrenches producing little tension and are referred to as **sung tight bolts.** Sometimes a hole is drilled through the bolt and a cotter pin with castellated nut is used to prevent the nut from turning out from the bolt as shown is Fig. 2.3 (c).
- Bolts of grade (or class) 3.6 to 12.9 are available and among them the most commonly used ones are the grade 4.6 and grade 8.8.

Do You Know?

What does grade (or class) of a bolt imply?

Bolts are classed as *grade x.y* where *x* represents 1/100th of the nominal tensile strength and *y* represents the ratio of yield stress to ultimate stress.

For example: A bolt of grade 4.6 implies that the ultimate tensile strength of the bolt is 400 N/mm^2 and yield strength is 0.6 x 400 = 240 N/mm^2.

Table 2.3: Tensile Properties of bolt

	Grade/Class	Yield stress, f_y(N/mm^2) (min)	Properties Ultimate tensile stress, f_{ub} (N/mm^2) (min)	Elongation percentage (min)
Specification **IS1367 (Part 3)**	3.6	180	330	25
	4.6	240	400	22
	4.8	320	420	14
	5.6	300	500	20
	5.8	400	520	10
	6.8	480	600	8
	8.8(d < 16 mm)	640	800	12
	8.8(d > 16 mm)	660	830	12
	9.8	720	900	10
	10.9	940	1040	9
	12.9	1100	1220	8

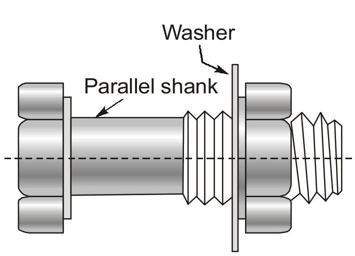
(b) High strength bolts

- High strength bolts are fabricated from bars of medium carbon heat treated steel and from the alloy steel.
- Their high strength is obtained from the quenching process followed by the tempering process or by the alloying steel.

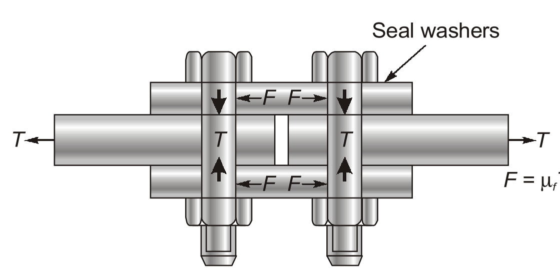
- These types of bolts may be tightened to very high tensile stresses, about twice or more times the ordinary bolts. This allows the load to be transferred through friction and not by shear.
- The contact surfaces must be free of paint, grease, rust or the mill scales which will otherwise prevent the solid contact between the surfaces and thereby lowering the slip factor.
- Due to friction between the contact surfaces, the possible slip in the joint (which is present with ordinary bolts) is entirely eliminated. This friction is developed by applying a normal load to the joint by tightening these bolts to proof load. Thus these bolts are also referred to as **friction type bolts.**
- Joints using high strength friction grip bolts are called as **nonslip connection** or **slip critical connection** or **friction type connection.**
- Steel washers of hard carburized steel are used to uniformly distribute the clamping pressure on the bolted member and to prevent the threaded portion of the bolt from bearing on the connecting points.

***Table 2.4:* Typical Mean Values for Coefficient of Friction (μ_f)**

Sl. No.	Treatment of Surface	Coefficient of friction (μ_f)
(i)	Surfaces not treated.	0.20
(ii)	Surfaces blasted with shot or grit with any loose rust removed, no pitting.	0.50
(iii)	Surfaces blasted with shot or grit and hot-dip galvanized.	0.10
(iv)	Surfaces blasted with shot or grit and spray metallized with zinc (thickness 50-70 μm).	025
(v)	Surfaces blasted with shot or grit and painted with ethylzinc silicate coat (thickness 30-60 μm).	0.30
(vi)	Sand blasted surface, after light rusting.	0.52
(vii)	Surfaces blasted with shot or grit and painted with ethylzinc silicate coat (thickness 60-80 μm).	0.30
(viii)	Surfaces blasted with shot or grit and painted with alcalizinc silicate coat (thickness 60-80 μm).	0.30
(ix)	Surface blasted with shot or grit and spray metallized with aluminium (thickness > 50 μm).	0.50
(x)	Clean mill scale.	0.33
(xi)	Sand blasted surface.	0.48
(xii)	Red light painted surface.	0.1



(a) Types of high-strength bolts



(b) Slip resistance

Fig. 2.5 *Bolted connection of high strength bolts*

Remember In case of high strength bolts, care must be taken to tighten the bolt up to the required tension otherwise slip may occur at service loads and the joint will behave like an ordinary bolted joint. The correct shank tension is achieved either by **part turning method** or by **torque control method** or by employing **load indicating washers.** In case bolts are tightened by part turning method also called as **turn of nut** method, the nut is made snug and is tightened a half turn more by hand wrenches, then the washers are not required. This method is used for making **bearing type connections** where bolts are required to provide enough tension to the contact surfaces so that they bear on each other. In **torque control method,** a power operated or a hand wrench is used to apply a specified torque to the nut. In **load indicating washer** type connection, the washers are projected as shown in **Fig. 2.6 (a)** which crushes down as the bolt is tightened. **Fig. 2.6 (b) and (c)** show the bolted joint surface before and after tightening the bolt respectively.

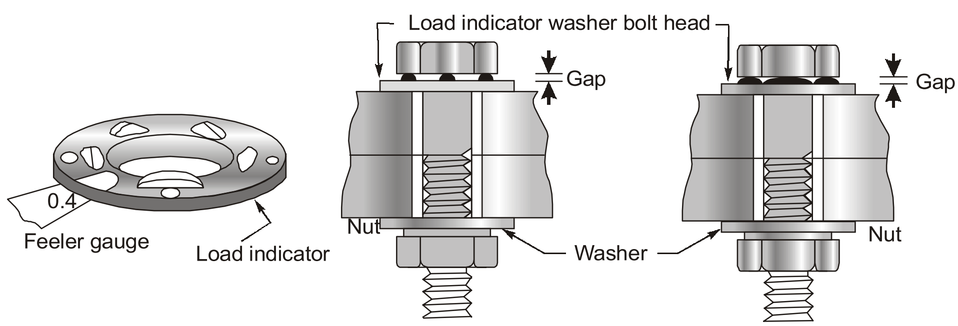


Fig. 2.6 *Fixing of bolts with load indicating washers*

- High strength bolts are available in sizes of 16 mm to 36 mm and are designated as M16, M20, M24 and M30.
- These bolts are identified as **8S, 8.8S, 10S** or **10.9S** marked on the bolt head where the letter **S** represents 'high strength'. Most commonly used bolts are 8.8S and 10.9S.
- **IS 3757:1985** and **IS 4000:1992** lay down the specifications for high strength bolts.

Advantages of high strength bolts:

(a) There is no slip between the members i.e. HSFG bolts provide rigid connection.

(b) Large tensile stresses are developed in the bolt which in turn provide large clamping force to the connecting members and due to which high frictional resistance is developed thereby providing a high strength to the joint.

(c) Because of the clamping action, load is transferred through friction only and no shear or bearing stresses get developed on the bolts.

(d) As frictional resistance is effective outside the bolt hole and thus lesser load is transmitted through the net section which reduces the susceptibility of the failure at net section.

(e) There is no stress concentration in the holes and thus fatigue strength is more.

(f) There is uniform tension in the bolts and more over bolts are tensioned up to the proof load and thus this prevents the nuts from loosening.

(g) Because of the absence of hammering (like in rivets), noise nuisance is low.

(h) It offers easy alterations.

(i) For same strength, less number of bolts are required as compared to the number of rivets or ordinary bolts required thereby offering economy in construction.

(j) This cost further gets reduced as less number of persons are required for making the connection.

2.3.5 Types of Bolted Joints

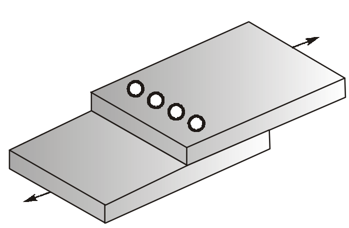
If the load line is assumed to pass through the CG of the bolt group then there are two types of bolted joints viz. **lap joint** and **butt joint.** The other case i.e. when the load line does not pass through the CG of the bolt group gives rise to eccentric connections.

(a) Lap joint

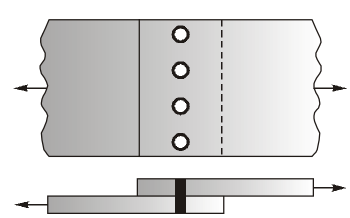
- Here the two members to be connected are overlapped and jointed as shown in **Fig. 2.7 (a).**
- **Fig. 2.7 (b** and **c)** shows respectively the single bolted lap joint and the double bolted lap joint. The load lines in the two members of lap joint do not coincide and hence lap joint has an eccentricity leading to the formation of an undesirable couple there by inducing tension in bolt which may lead to failure of joint as shown in **Fig. 2.7 (d).**
- Due to this eccentricity only, the stresses are distributed unevenly across the contact area between the bolts and members to be connected.
- **Cl. 10.5.1.2** of **IS 800:2007** states that **minimum length of lap shall not be less than four times the thickness of thinner part being jointed or 40 mm, whichever is more.**

(b) Butt joint

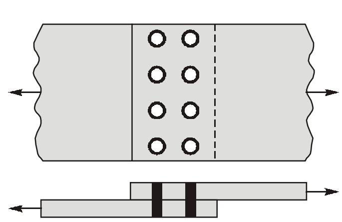
- Here the two members to be connected are placed end to end thereby bringing the load lines in the two members in one line and reducing eccentricity to almost zero.
- Additional cover plate(s) on either side or both sides can be provided to connect the main plates as shown in **Fig. 2.7 (e** and **h).**
- The butt joint is called as **single cover butt joint** if the plate is provided only on one side of the main plate (**Fig. 2.7 (e, f** and **g)**) and is called as **double cover butt joint** if the plates are provided on both the sides of the main plate (**Fig. 2.7 (h, i** and **j)**).
- **Fig. 2.7 (k** and **l)** shows the transfer of forces in lap joint and double cover butt joint respectively.



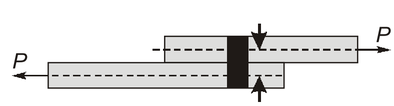
(a) Lap joint



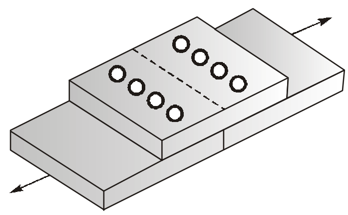
(b) Single bolted lap joint



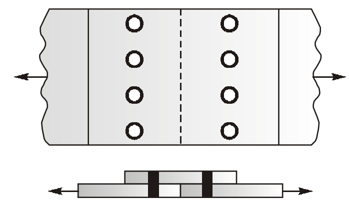
(c) Double bolted lap joint



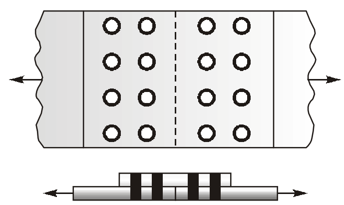
(d) Eccentricity in lap joint



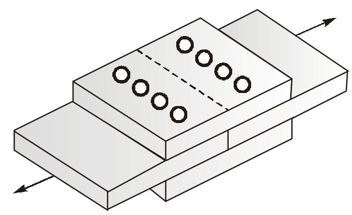
(e) Single cover butt joint



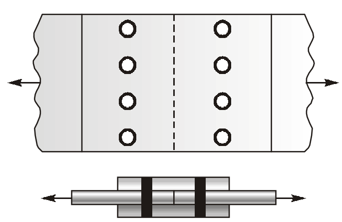
(f) Single-cover single bolted butt joint



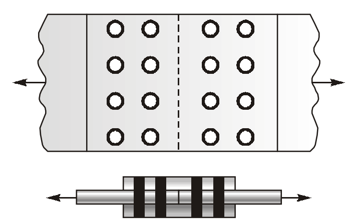
(g) Single-cover double bolted butt joint



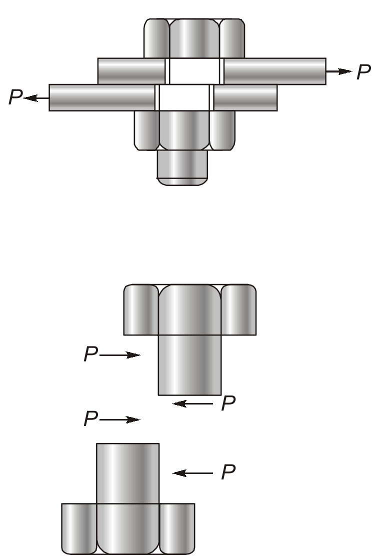
(h) Double cover single bolted butt joint



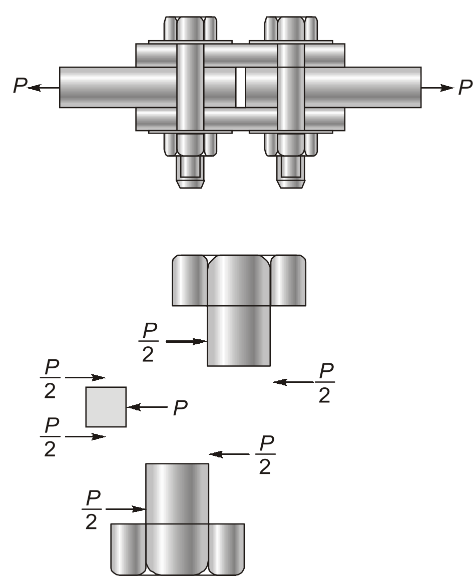
(i) Double-cover single bolted butt joint



(j) Double-cover double bolted butt joint



(k) Lap joint, bolt in single shear



(l) Butt joint, bolt in double shear

Fig. 2.7 *Bolted joints*

Advantages of butt joint over lap-joint:

(a) As shown in **Fig. 2.7 (l),** the total shear that gets transferred through double cover butt joint is almost half of that of lap joint (**Fig. 2.7 (k)**).

(b) In case of double cover butt joint, there does not exist the eccentricity of load line and hence bending is eliminated. But this bending exists in lap joint.

Do You Know?

Why washers are provided in bolted connections?

The bolts are provided with washers where full bearing area of the bolt is to be developed. The washer provided under the nut must be of sufficient thickness so that no portion of threaded bolt comes within the thickness or the parts bolted together unless the same has been accounted for in design (**Cl. 17.5.1** of **IS 800:2007**).

2.4 Mechanism of Load Transfer Through Bolts

- The transfer of force from one member to another depends on the type of bolt being used.
- This transfer of force mechanism may be either **bearing type** where load transfer occurs by shearing and bearing or **slip-critical/slip-resistant** where load transfer occurs by friction.
- In slip resistant connections, the entire force is transmitted through friction and the joints are not really subjected to shear or bearing. The bolts are first brought to sung tight condition and then tightened further. Joints with so tightened bolts are referred to as **pre-tensioned joints.** But when the load exceeds the frictional resistance then slippage occurs and consequently the bolts will be subjected to shear and bearing and will behave like a bearing type joint.
- When high strength bolts are not tightened sufficiently so as to significantly squeeze the plates together, there will be a negligible friction between the plates. On load application, the plates slip a little and the load will tend to shear off the bolts on the interface and press or bear against the side of the bolts. Now the load transfer will be like bearing type connection.

2.5 Failure of Bolted Joints

(a) **Shear failure of bolts :** When plates slip due to the applied forces, shear stresses are generated. It may be possible that maximum factored shear force exceeds the shear capacity of the bolt. Shear failure of bolt takes place at bolt shear plane. However the bolt may fail in single shear or double shear as shown in **Fig. 2.8 (a).**

(b) **Bearing failure of bolts :** Here the bolt gets crushed around a semi-circumference. The plate may be strong in bearing and it may happen that the heaviest stressed plate may press the bolt shank as shown in **Fig. 2.8 (b).** In general bearing failure of bolts do not occur in practice except when the plates are made of high strength steel and the corresponding bolts are of low grade steel.

(c) **Tension failure of bolts :** Bolts subjected to tension may fail at the stress area. In case any of the connecting plates are flexible enough then in that case additional forces due to prying action has also to be considered.

(d) **Tension/tearing failure of plates :** Tension failure of plates occurs when bolts are stronger than the plates. Tension on both the gross area (i.e. yielding) and the net effective area (i.e. rupture) must be considered. **Fig. 2.8 (d)** shows the tension failure of plate in rupture.

(e) **Bearing failure of plates :** When ordinary bolts are subjected to shear forces then slip takes place and bolts come in contact with the plates. It may be quite possible that plate may get crushed if the plate material is weaker than the bolt material as shown in Fig. 2.8 (b). This bearing failure gets complicated further due to the presence of nearby bolt or nearness of an edge in the load direction. The bearing strength gets affected by bolt spacing and the edge distance. One of the possible mode of failure resulting from too much bearing is the shear tear-out at the end of the connected member as shown in Fig. 2.8 (c).

(f) **Block shear failure :** Many a times bolts may have been placed at a lesser end-distance than required which may lead to plates to shear out which can in fact be avoided by adherence to edge distance. Fig. 2.8 (e) shows the failure of joint in block shear failure which may occur when a block of a material within the bolted area breaks away from the remaining of the area. This possibility of failure increases if bolts used are of high strength and fewer bolts are used for making the connection. In this type of failure, shear on one plane and tension on perpendicular plane occurs leading to fall of a portion of plate.

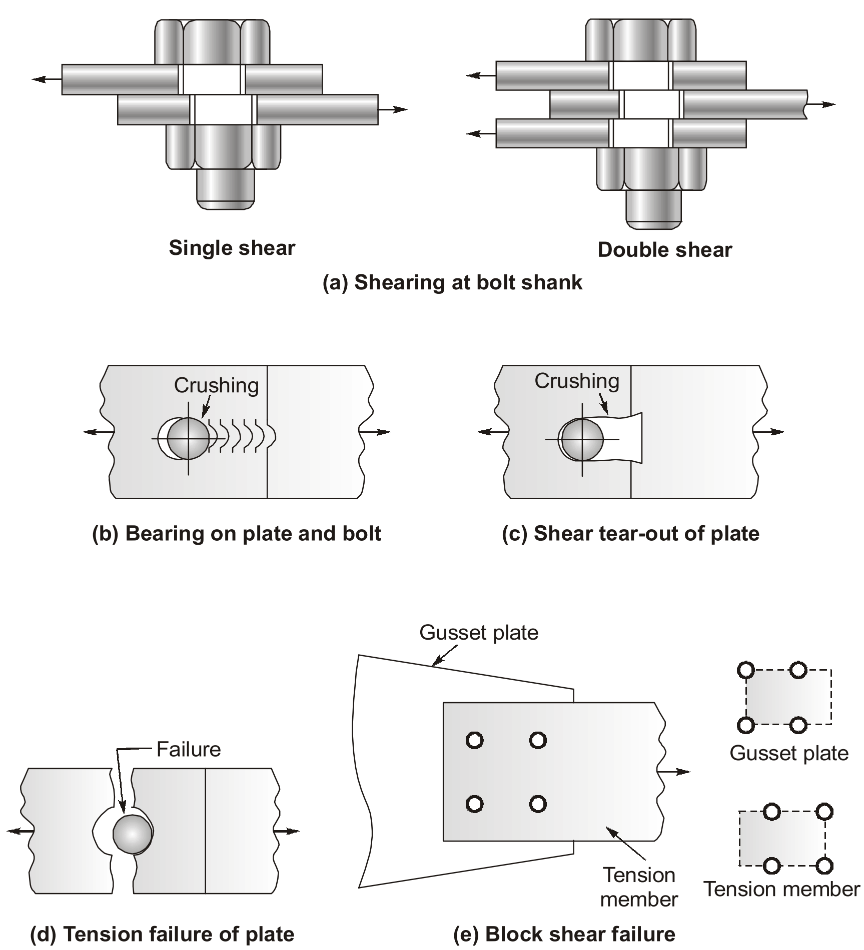


***Fig. 2.8** Various types of failure in bolted joints*

2.6 Specifications for the Bolted Joints

2.6.1 Diameter of the Bolt

- Fewer the number of bolts lesser will the holes required for bolts and less installation work.
- It is more economical to have less number of large diameter bolts than more number of small diameter bolts.
- The large diameter bolts are particularly favorable where shear governs the design because the bolt capacity in shear varies in proportion to the square of the bolt diameter.

2.6.2 Spacing of Bolt Holes

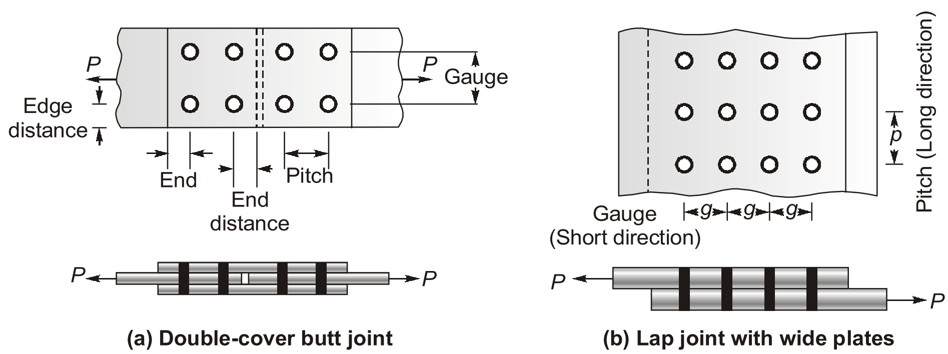


Fig. 2.9 *Spacing of holes in bolted joint*

Pitch

- Pitch (p) is the distance between the centers of two consecutive bolts in the direction of load i.e. along the line parallel to the stress in the member. When bolts are placed in a staggered fashion then it is referred as staggered pitch.

(a) Minimum pitch

- A minimum pitch must be ensured between the bolts because of the following reasons:
  (i) To prevent bearing failure of members between the two bolts.
  (ii) To ease in installation of bolts i.e. sufficient space must be ensured to tighten the bolts, prevent overlapping of the washers and provide adequate resistance to tear-out of the bolts.
- The center to center distance between the holes should not be less than **2.5 times the nominal diameter of bolt**. When bolts are placed at a distance lesser than this then very little clearance is left between the bolts and installation of bolts become difficult.

(b) Maximum pitch

- Maximum pitch is ensured for the following reasons:
  (i) To reduce the length of joint and of gusset plate.
  (ii) To have uniform stress in the bolts. It is assumed that load on the joint is equally distributed among all the bolts. In case of short length joints, a redistribution of forces in the bolts occurs due to plastic action and thus the bolts will share the load equally. However this is true when there are only a few bolts in a line.

$$\therefore \qquad k_b = \text{Minimum of} \begin{cases} \dfrac{e}{3d_0} = \dfrac{33}{3\times 22} = 0.5 \\ \dfrac{p}{3d_0} - 0.25 = \dfrac{70}{3\times 22} - 0.25 = 0.811 \\ \dfrac{f_{ub}}{f_u} = \dfrac{400}{410} = 0.976 \\ 1.0 \end{cases} = 0.5$$

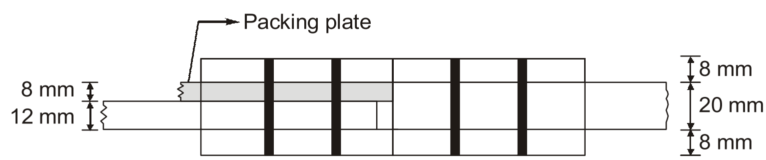
$\therefore$ Per pitch bearing strength of bolt

$$V_{dpb} = 2.5 k_b dt \frac{f_u}{\gamma_{mb}} = 2.5\times 0.5\times 20\times 12\times \frac{410}{1.25} \text{ N}$$

$$= 98.4 \text{ kN}$$

$$> 81.48 \text{ kN } (= V_{dsb})$$

Thus design need not to be revised since bearing strength of bolt is greater than the shear strength of bolt.



Objective Brain Teasers

Q.1 The value of γ_{mb} for bolt material is
(a) 1.1 (b) 1.0
(c) 1.5 (d) 1.25

Q.2 Slip resistant connections at ultimate loads may behave as
(a) slip critical connection
(b) pin connection
(c) bearing type connection
(d) cannot be said with certainty

Q.3 Slip critical connections are designed for
(a) Bearing between the connecting member and bolt
(b) Friction between the connecting members
(c) Compression in bolts
(d) Shear in bolts

Q.4 When a bolt is subjected to combined tension and shear then
(a) $\left(\dfrac{V_{sb}}{V_{db}}\right)^2 + \left(\dfrac{T_b}{T_{db}}\right)^2 \le 1$
(b) $\left(\dfrac{U_{sb}}{V_{db}}\right)^{1.4} + \left(\dfrac{T_b}{T_{db}}\right)^{1.4} \le 1$
(c) $\left(\dfrac{V_{sb}}{V_{db}}\right) + \left(\dfrac{T_b}{T_{db}}\right) \le 1.4$
(d) $\left(\dfrac{V_{sb}}{V_{dsb}}\right)^2 + \left(\dfrac{T_b}{T_{db}}\right)^2 \le 1.4$

Q.5 Which of the following is primarily designed for flexure?
(a) Rivet (b) Bolt
(c) Pin (d) All of these

Q.6 Diamond pattern of bolting is beneficial over chain and staggered bolting because
(a) It transmits maximum force
(b) It has maximum efficiency
(c) It is easy to fabricate
(d) None of the above

Q.7 Which of the following has zero eccentricity with respect to load line?
(a) Single cover butt joint
(b) Double cover butt joint
(c) Lap joint
(d) Insufficient data

Q.8 Prying action is associated with
(a) additional compressive force on bolts due to flexibility of connecting members
(b) reduction in flexure force on bolts
(c) additional shear force on rivets
(d) additional tensile force on bolts due to flexibility of connecting members

Q.9 Which type of bolt hole is more preferable?
(a) Punched hole
(b) Drilled hole
(c) Both (a) and (b)
(d) If depends on nature of force to be transferred and bolt material

Q.10 HSFG bolts are better than ordinary black bolts because
(a) HSFG bolts have high fatigue strength
(b) HSFG bolts are easy to be used for fabrication
(c) HSFG bolts are cheaper than ordinary black bolts
(d) All of the above

Q.11 HSFG bolts can be used for
(a) slip resistant connection
(b) bearing type connection
(c) shear connection
(d) both (a) and (b)

Q.12 Hanger connection is a type of
(a) Compression connection
(b) Tension connection
(c) Shear connection
(d) None of these

Q.13 In which of the following connection, lesser load is transmitted through net section of the bolt?
(a) HSFG bolt (b) Ordinary bolt
(c) Pin (d) All of the above

Answers

1. (d)	2. (c)	3. (b)	4. (a)	5. (c)
6. (b)	7. (b)	8. (d)	9. (b)	10. (a)
11. (d)	12. (b)	13. (a)		

Conventional Practice Questions

Q.1 A column ISHB 300 @ 577 N/m carries an axial compressive load of 3260 kN under working conditions. Design the connection of column section with gusset plates. Use Fe410 Steel.

Q.2 Design a lap joint to connect two plates 310 mm × 8 mm thick using 16 mm diameter bolts of grade 4.6. The load to be transferred through the plates is 350 kN at service conditions.

Q.3 Design a double cover butt joint to connect two plates one 10 mm thick and other 18 mm thick. Both the plates are 280 mm wide. The load to be transferred through the plates is 250 kN under working conditions.

Q.4 A portion of an industrial roof truss is shown in figure. The gusset plate to be used in 120 mm thick. Using 20 mm diameter bolts of grade 4.6, design the connection.