

RPSC 2024

Rajasthan Public Service Commission

Assistant Engineer

CIVIL ENGINEERING

Design of Steel Structures



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STRUCTURAL FASTENERS AND ECCENTRIC CONNECTIONS

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INTRODUCTION

- The various elements of a steel structure like tension member, compression member and flexural member are connected by fasteners (connectors). Different types of fasteners available are rivets, bolts, pins and welds. The forces exerted by one element on another are transferred through these fasteners, which should therefore be adequate to transmit the forces safely. Often much attention is not given to the design of connections. If the necessary connections are inadequate, the result will be a poor structure in spite of the most efficiently designed member. Therefore the design of connections must be given due importance. The nature of forces and stress distributions also need to be properly evaluated and established .
- Of the various types of simple connections used in structure, riveted, bolted and pinned connections behave alike, and are therefore grouped together.

RIVETING

- The size of the rivet is the diameter of the shank.
- The size of holes are 1.5 mm larger than the size of rivets upto 25 mm, for rivets of diameter more than 25 mm, the diameter of the holes should be 2 mm larger than the diameter of the rivets.
- Rivets may be driven by hydraulic or pneumatic power.
- The rivets may be classified according to the method of driving them.
 - (i) Power-driven shop rivets are power-driven in the fabrication shop.

- (ii) Power-driven field rivets are power driven at site. Their strength is less than the strength of power driven shop rivets.
- (iii) Hand-driven rivets have less strength than power driven rivets.
- (iv) Cold-driven rivets of diameter more than 10 mm are not permitted by specifications.

BOLTED JOINTS

- Bolts may be used in place of rivets for structure not subjected to vibrations. The following types of bolts are used in structures:
 - (i) **Black bolts**
 - Hexagonal black bolts are commonly used in steel works.
 - They are made from low or medium carbon steels.
 - They are designated as black bolts $M \times d \times l$, where d = diameter, and l = length of the bolts.
 - (ii) **Precision and Semi Precision Bolts**
 - They are also known as close tolerance bolts.
 - Sometimes to prevent excessive slip, close tolerance bolts are provided in holes of 0.15 to 0.2 mm oversize. This may cause difficulty in alignment and delay in the progress of work.
 - (iii) **High-strength friction grip bolts**
 - HSFG bolts have a high yield strength.
 - There are washers to induce initial tension, which causes friction between the plate surface.
 - Due to friction, there is no slip in the joint and therefore the joints with HSFG bolts are called friction type or nonslip type joints.

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TYPES OF RIVETED AND BOLTED JOINTS

There are two types of riveted or bolted joints.

(i) Lap joint

- The lap joint is that in which the plates to be connected overlap each other.
- The lap joint may have single-row, staggered or chain riveting.

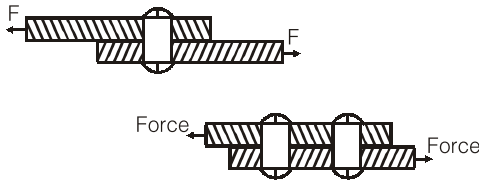


Fig. Lap Joint

(ii) Butt Joint

- The butt joint is that in which the plates to be connected butt against each other and the connection is made by providing a cover plate on one or both sides of joint.
- The butt joint may have a single row or staggered or chain riveting.

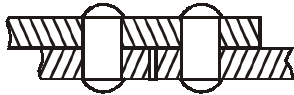


Fig. (a). Single-riveted single-cover butt joint

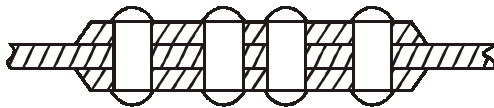


Fig. (b). Double-riveted double-cover butt joint

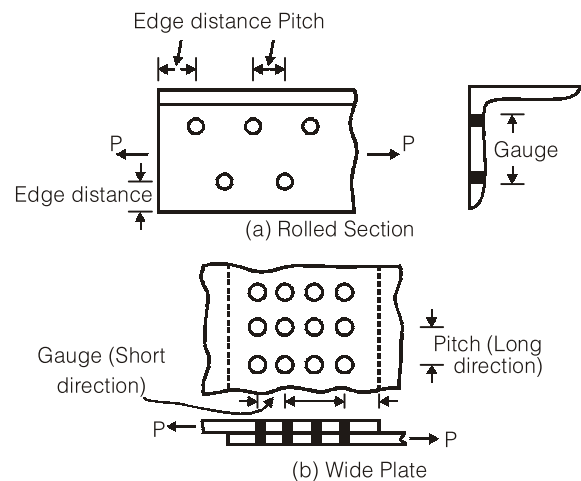
Do you know?

In the case of a double cover butt joint, eccentricity of force does not exist and hence bending is eliminated, whereas it exists in the case of a lap joint.

IMPORTANT DEFINITIONS

- (i) **Nominal diameter (d):** The diameter of the shank of a rivet before riveting, is called the nominal diameter. For a bolt, the diameter of the unthreaded portion of the shank is called its nominal diameter.

- (ii) **Effective diameter or gross diameter:** The effective or gross diameter of a rivet is equal to the diameter of the hole it fills after riveting. For a bolt, the nominal diameter is same as the gross diameter.
- (iii) **Net area:** The net area of a bolt is the area at the root of the thread.
- (iv) **Pitch:** The distance between centres of any two adjacent rivets parallel to the direction of force is called pitch. Diagonal pitch is the distance between centres of any two adjacent rivets in the diagonal direction is called diagonal pitch.

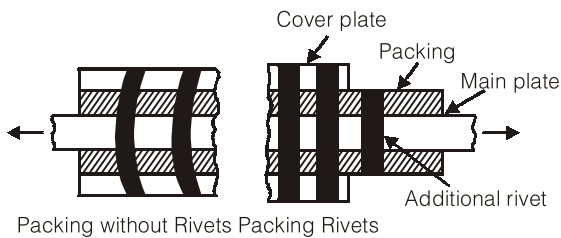


- (v) **Gauge:** A row of rivets parallel to the direction of force is called a gauge line. The normal distance between two adjacent gauge line is called the gauge.
- (vi) **Edge distance:** It is the distance between the edge of a member or cover plate and the centre of the nearest rivet hole.
- (vii) **Proof load :** Initial tension in HSFGB bolts is known as proof load of the bolt.
- (viii) **Tacking Rivets:** Tacking or stitch rivets are used to make the sections act in unison and to prevent buckling in compression members, where two or more sections are in contact. When the distance between the centres of two consecutive rivets in such cases exceed the maximum specified pitch of 12t or 200 mm, whichever is less, in compression members and 16t or 200 mm, whichever is less in tension members, additional rivets are provided. These are not

subjected to calculated stresses and are called tacking or stitch rivets.

1. Tacking rivets should have a pitch in line not exceeding $32t$ or 300 mm, whichever is less. Where it is exposed to weather, pitch in line should not exceed $16t$ or 200 mm.
2. For compression members maximum pitch of tacking rivets should be 600 mm.
3. In case of tension the tacking rivets should be provided at a pitch in line not exceeding 1000 mm.

Packings : Packings or filler plates are used to make the surfaces of the main plates to be jointed, flush. In the figure a joint has been shown with packings. The left-hand side portion of the joint is shown with rivets which have bent due to flexure.



- According to I.S. specifications, rivets or bolts carrying a calculated shear stress through a packing more than 6 mm thick should be increased (from the numbers of rivets require by normal calculation) by 2.5% for each 2 mm thickness of packing. The extra rivets or bolts should be placed on the packing extension. When packings are subjected only to direct compression, the specification for tacking rivets as cited here should not apply.

(viii) **Slip Factor:** Coefficient of friction in friction type joint is known as slip factor.

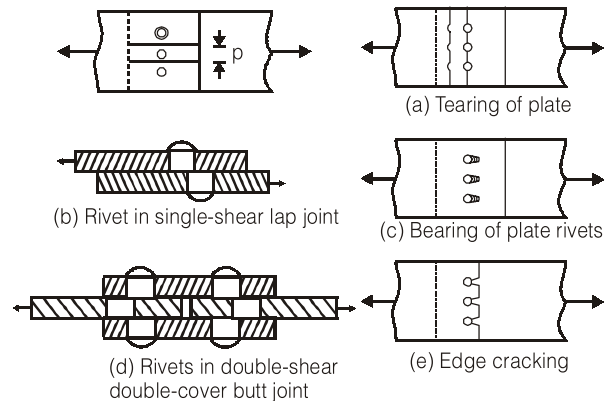
Table 1 : Rivet diameter, Pitch

Minimum pitch	2.5 times the diameter of the rivet hole
Maximum pitch for	
(i) any two adjacent rivets (including tacking rivets)	$32t$ or 300 mm, whichever is less
(ii) rivets lying in a line parallel to the force in the member:	
(a) in tension	$16t$ or 200 mm, whichever is less
(b) in compression	$12t$ or 200 mm, whichever is less

where t = thickness of thinner outside plate

FAILURE OF RIVETED/BOLTED JOINTS

(i) **Tearing of the plate between rivet holes:** The strength of the plate is reduced by rivet holes and the plate may tear off along the line of the rivet holes as shown in fig. (a)



- This type of failure is for tension members only.
- (ii) **Shearing of rivet :** The rivets fail by shearing if the shearing stress exceeds their shearing strength.
- In lap joints and single-cover butt joints, the rivets are sheared at one plane only as shown in fig (b).
 - In double-cover butt joint, the rivets are sheared at two planes as shown in fig. (d).
- (iii) **Bearing of plate or rivet:** The plate or rivet is crushed if the compressive stress exceeds the bearing strength of the plate or the rivet, as shown in fig. (c).
- (iv) **Edge cracking:** The plate will crack at the back of a rivet if it is placed very near to the edge of the plate as shown in fig. (e).
- This failure is prevented if the minimum edge distance is provided.

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.

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