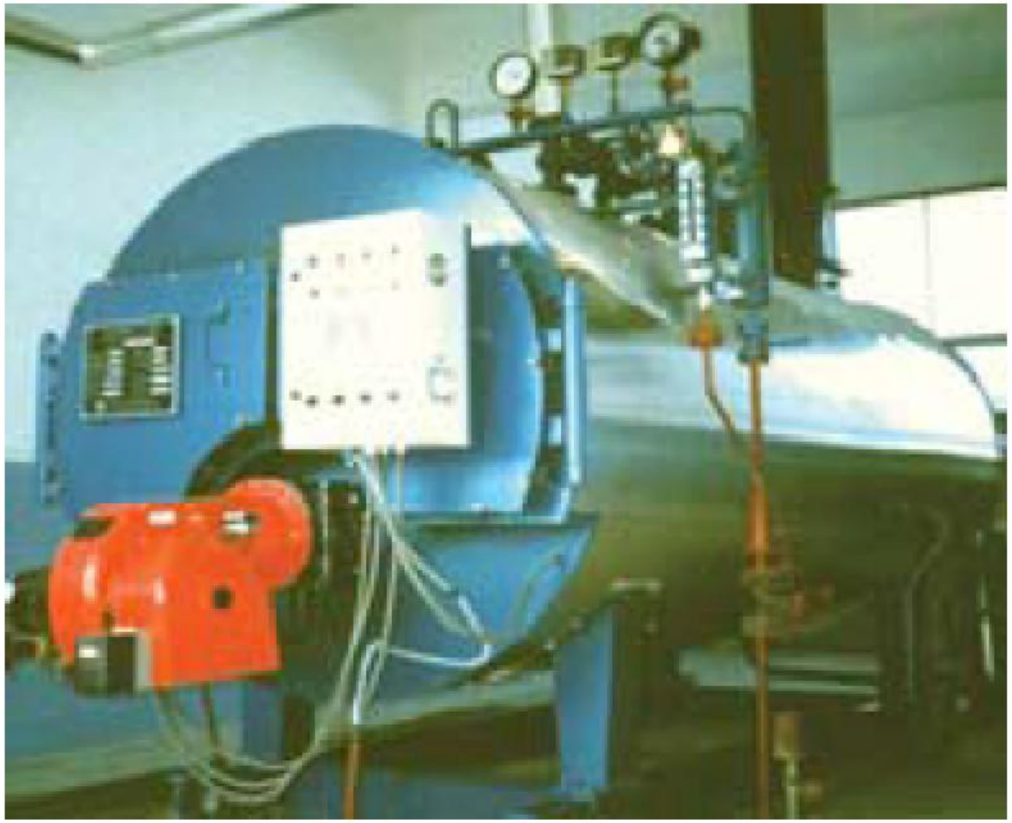
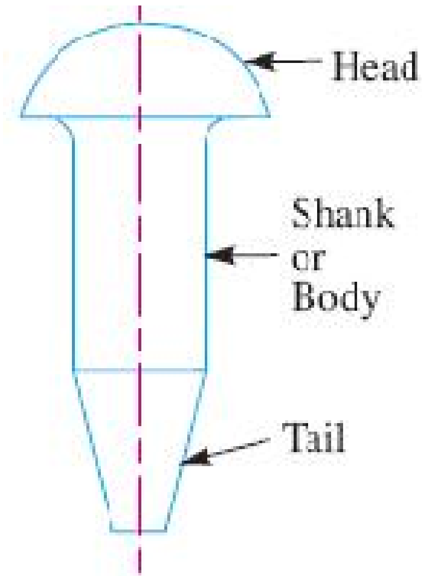
MACHINE DESIGN

Riveted Joints



Introduction

A rivet is a short cylindrical bar with a head integral to it. The cylindrical portion of the rivet is called shank or body and lower portion of shank is known as tail, as shown in Figure. The rivets are used to make permanent fastening between the plates such as in structural work, ship building, bridges, tanks and boiler shells.



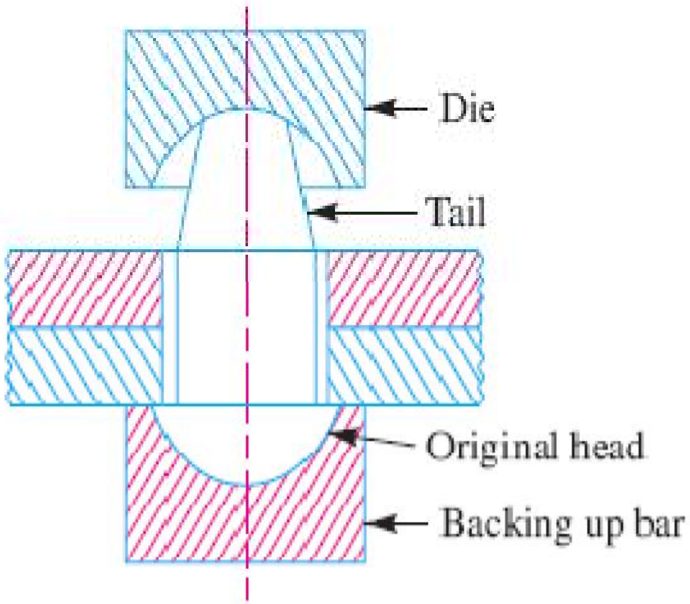
The fastenings (i.e. joints) may be classified into the following two groups :

1. Permanent fastenings, and
2. Temporary or detachable fastenings.

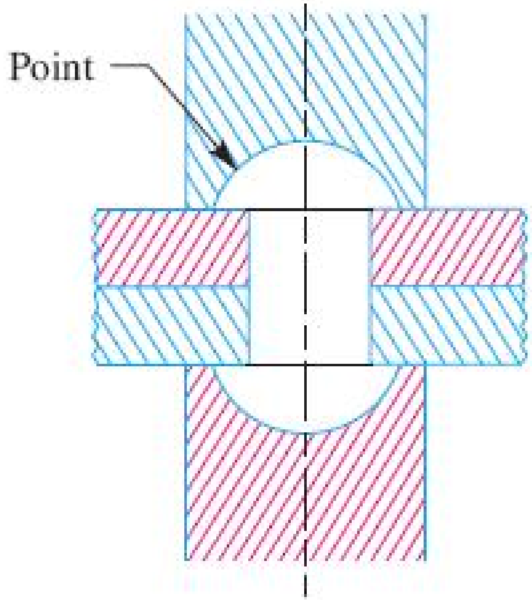
The permanent fastenings are those fastenings which can not be disassembled without destroying the connecting components. The examples of permanent fastenings in order of strength are soldered, brazed, welded and riveted joints.

The temporary or detachable fastenings are those fastenings which can be disassembled without destroying the connecting components. The examples of temporary fastenings are screwed, keys, cotters, pins and splined joints.

Methods of Riveting



(a) Initial position.



(b) Final position.

Material of Rivets

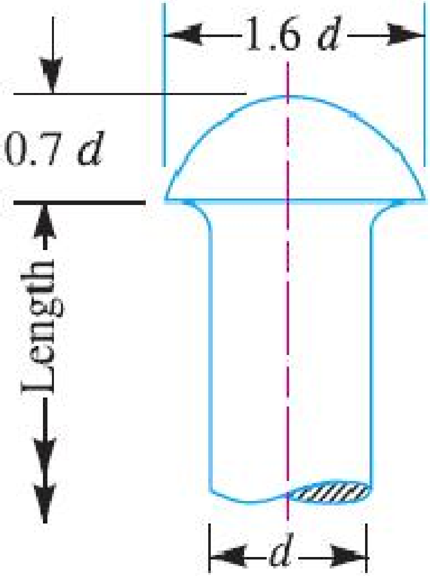
The material of the rivets must be tough and ductile. They are usually made of steel (low carbon steel or nickel steel), brass, aluminium or copper.

Essential Qualities of a Rivet

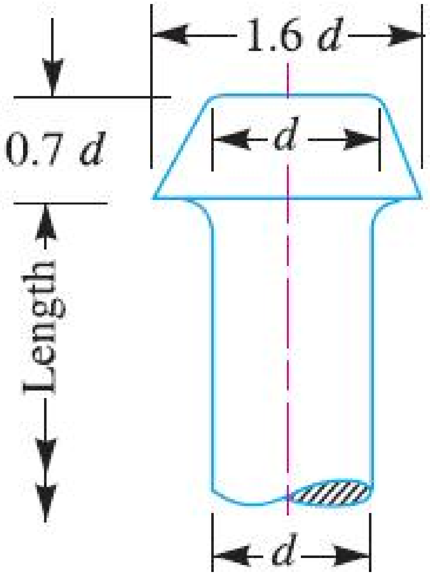
According to Indian standard, IS : 2998 – 1982 (Reaffirmed 1992), the material of a rivet must have a tensile strength not less than 40 N/mm2 and elongation not less than 26 percent.

Types of Rivet Heads

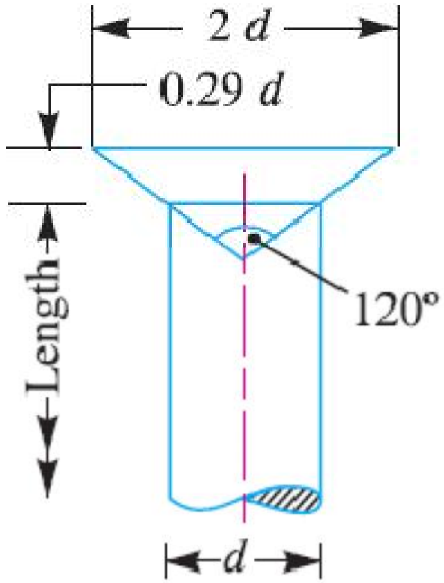
1. Rivet heads for general purposes (below 12 mm diameter) as shown in Figure.



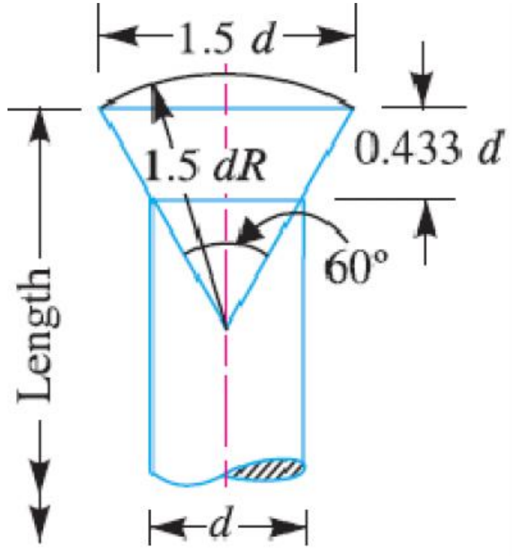
Snap head.



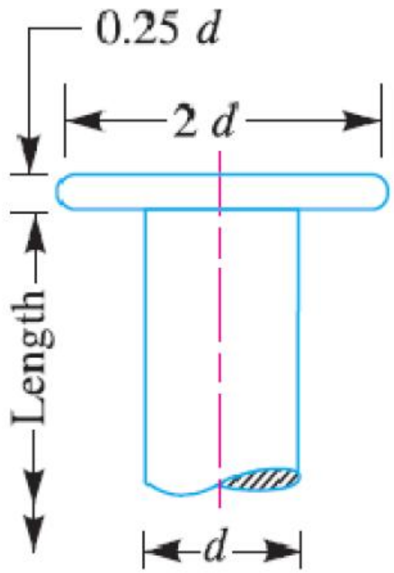
Pan head.



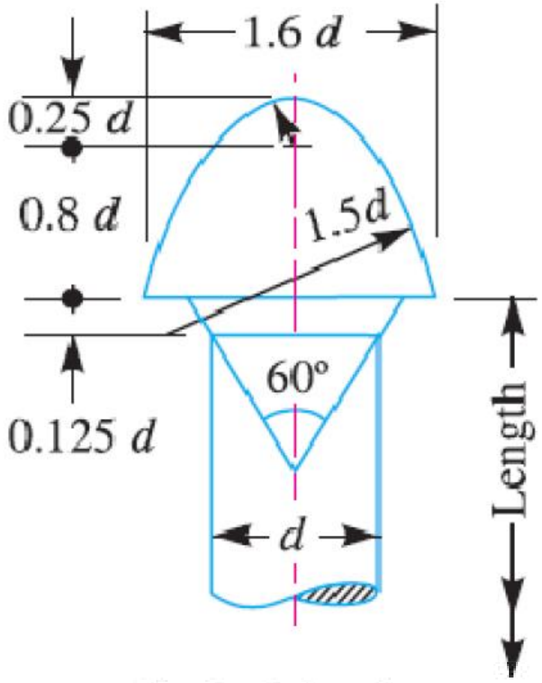
Counter sunk head 120°.



Round counter sunk head 60°.



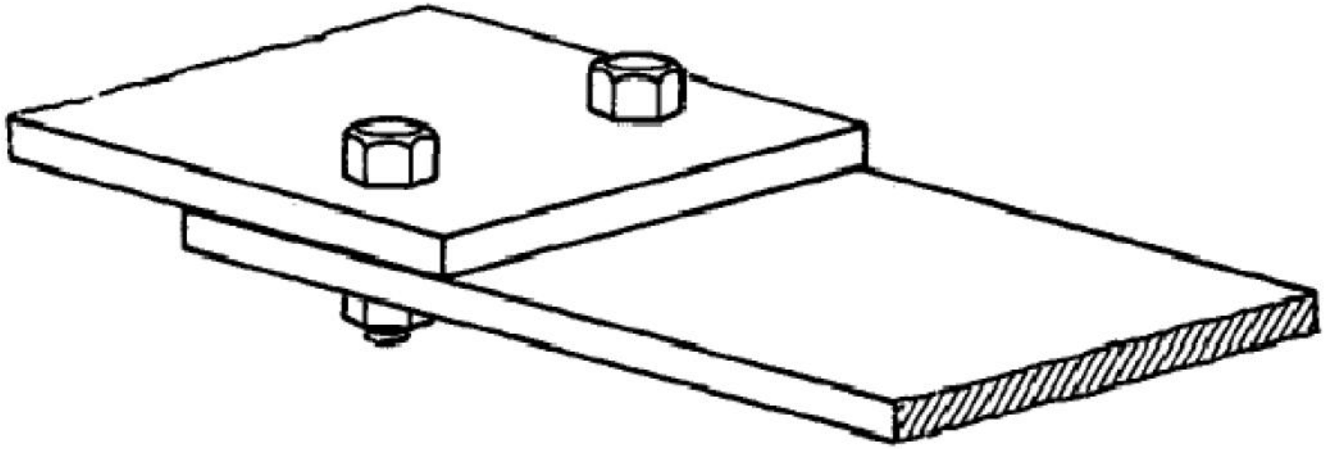
Flat head.



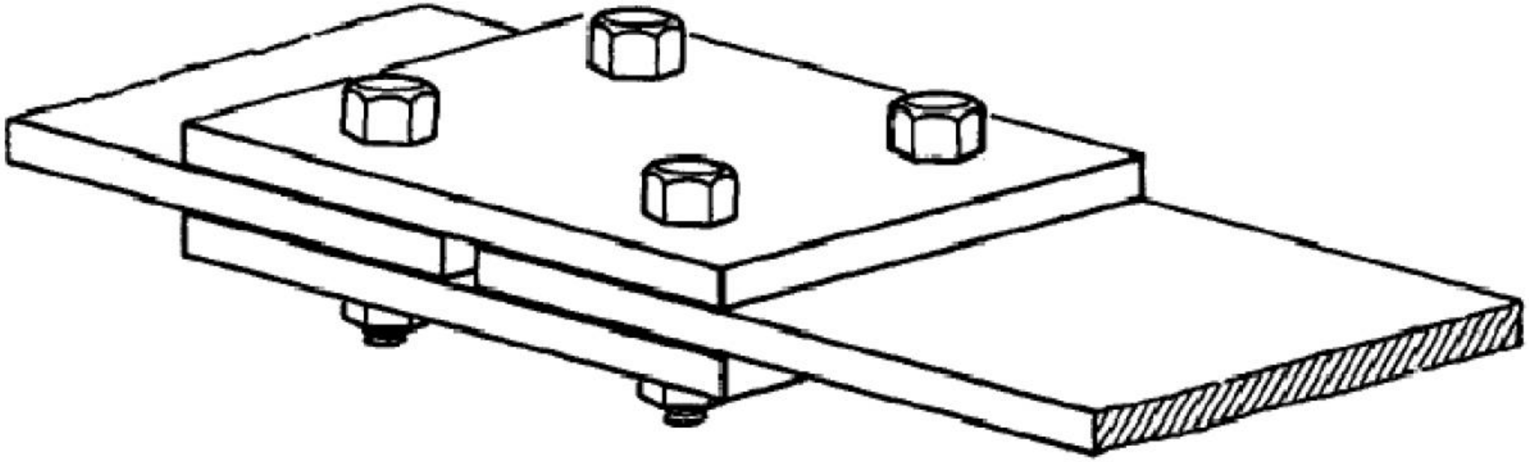
Conical head.

The snap heads are usually employed for structural work and machine riveting. The counter sunk heads are mainly used for ship building where flush surfaces are necessary. The conical heads are mainly used in case of hand hammering. The pan heads have maximum strength, but these are difficult to shape.

Types of Riveted Joints

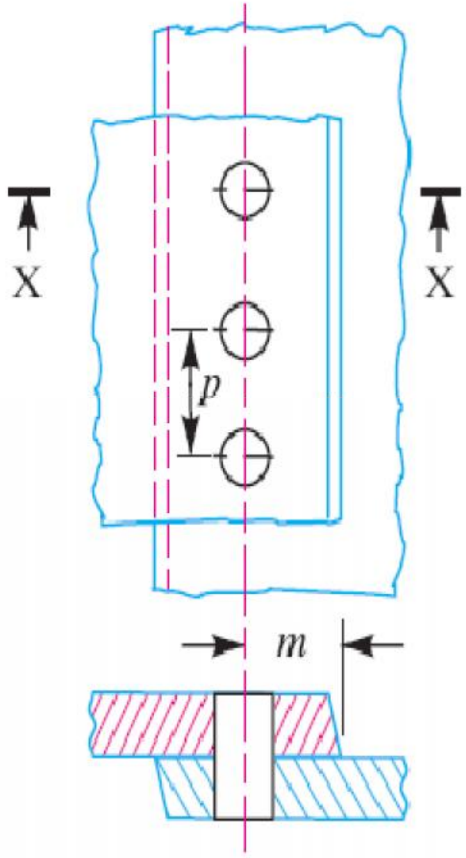


(*a*) Lap joint:

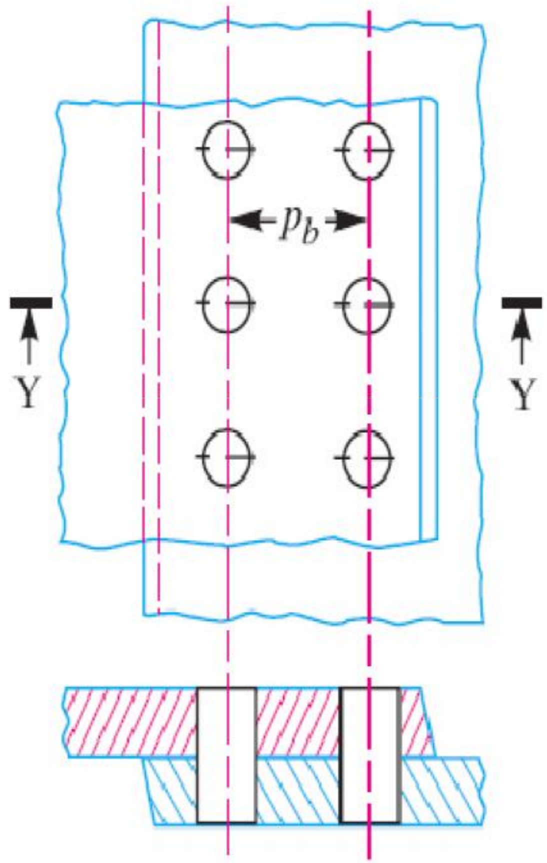


(*b*) butt joint.

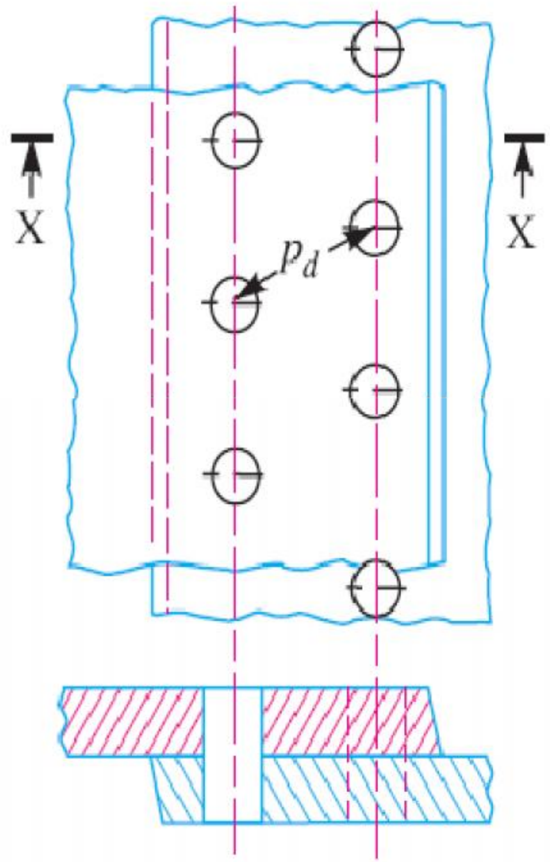
Single and double riveted lap joints.



(a) Single riveted lap joint.

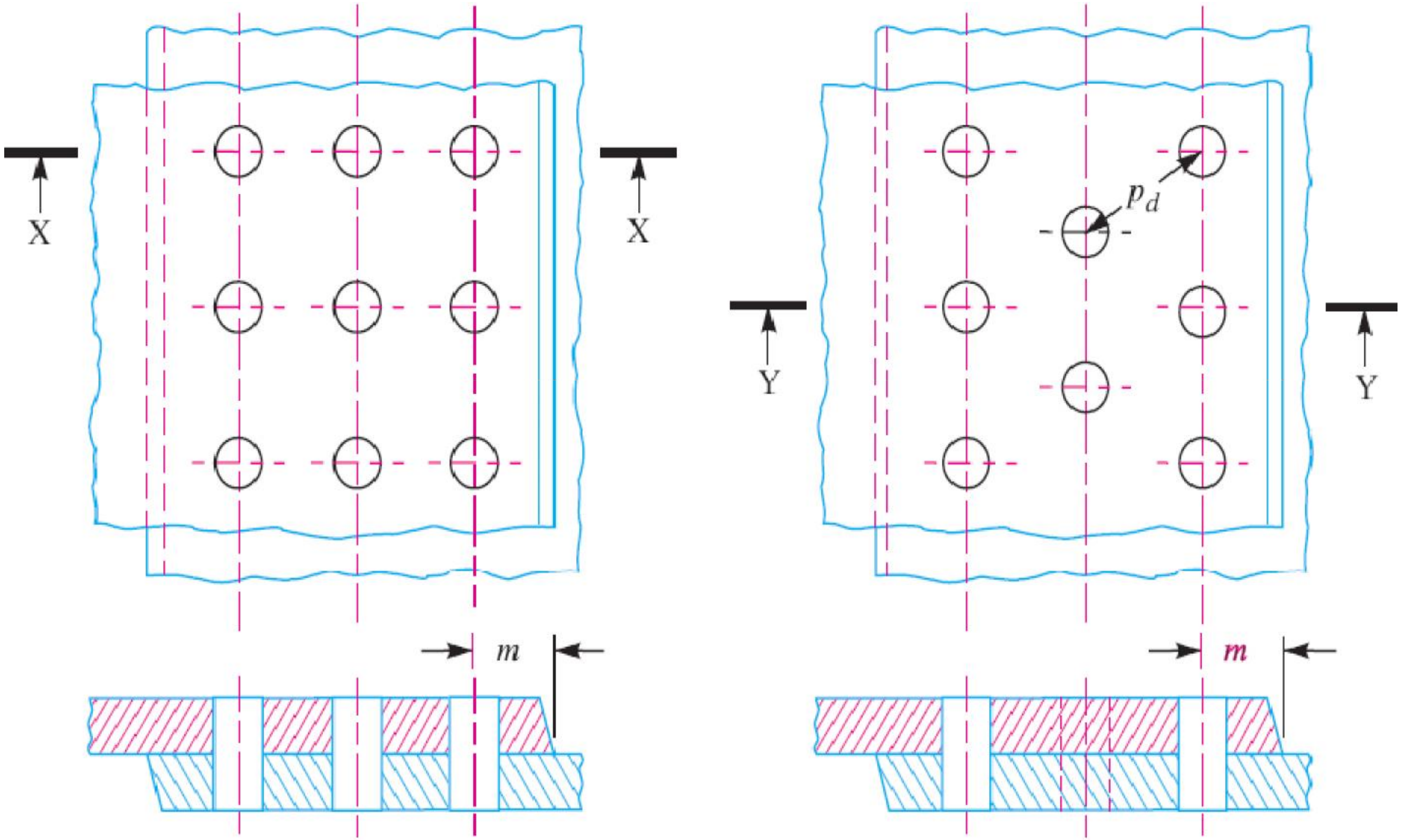


(b) Double riveted lap joint (Chain riveting).



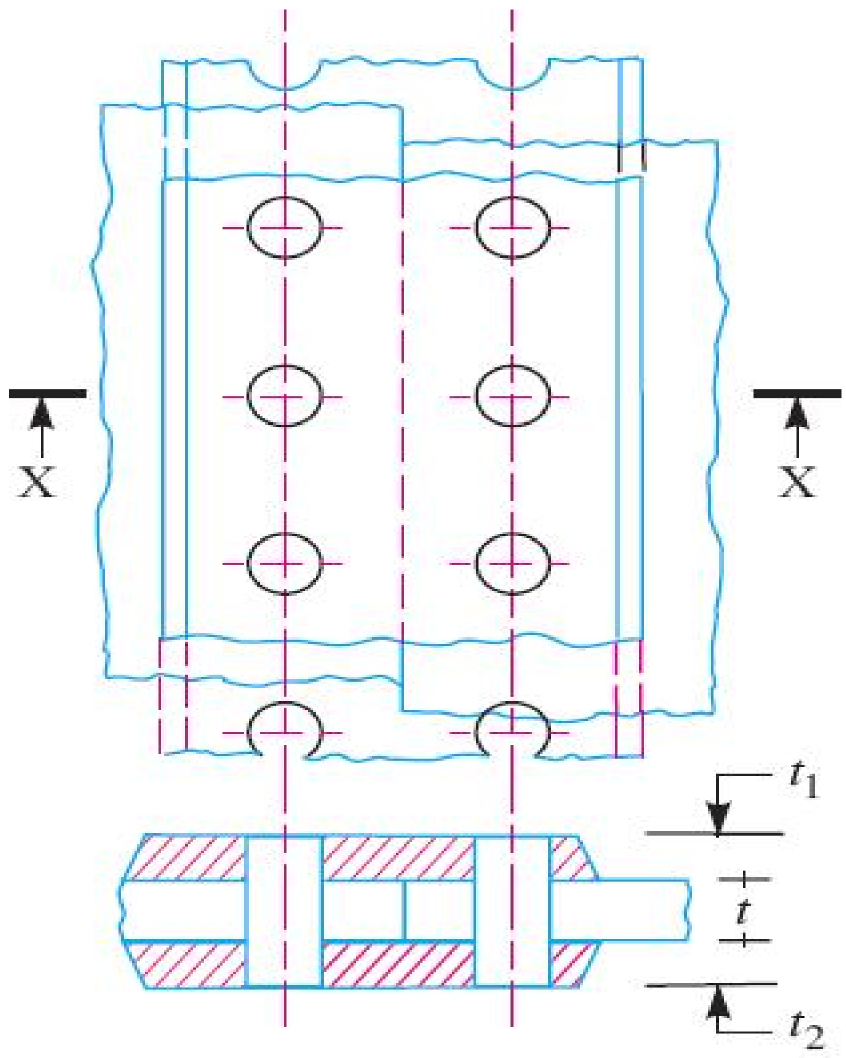
(c) Double riveted lap joint (Zig-zag riveting).

Triple riveted lap joint.

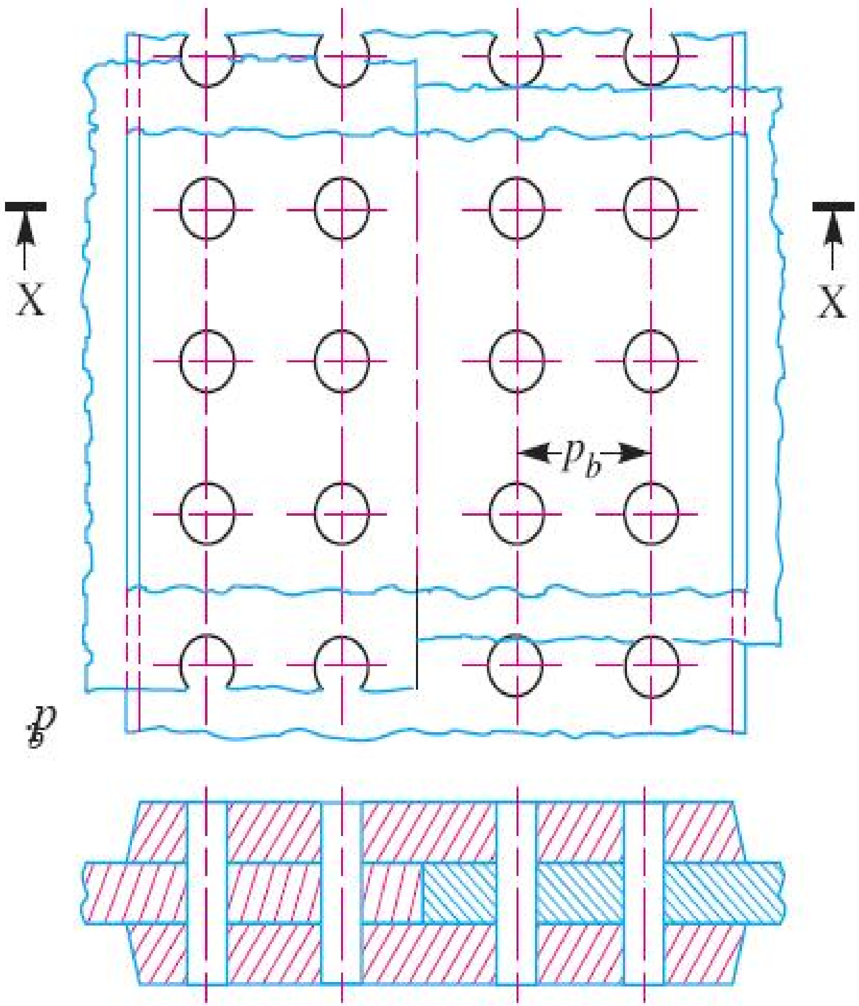


(*a*) Chain riveting. (*b*) Zig-zag riveting.

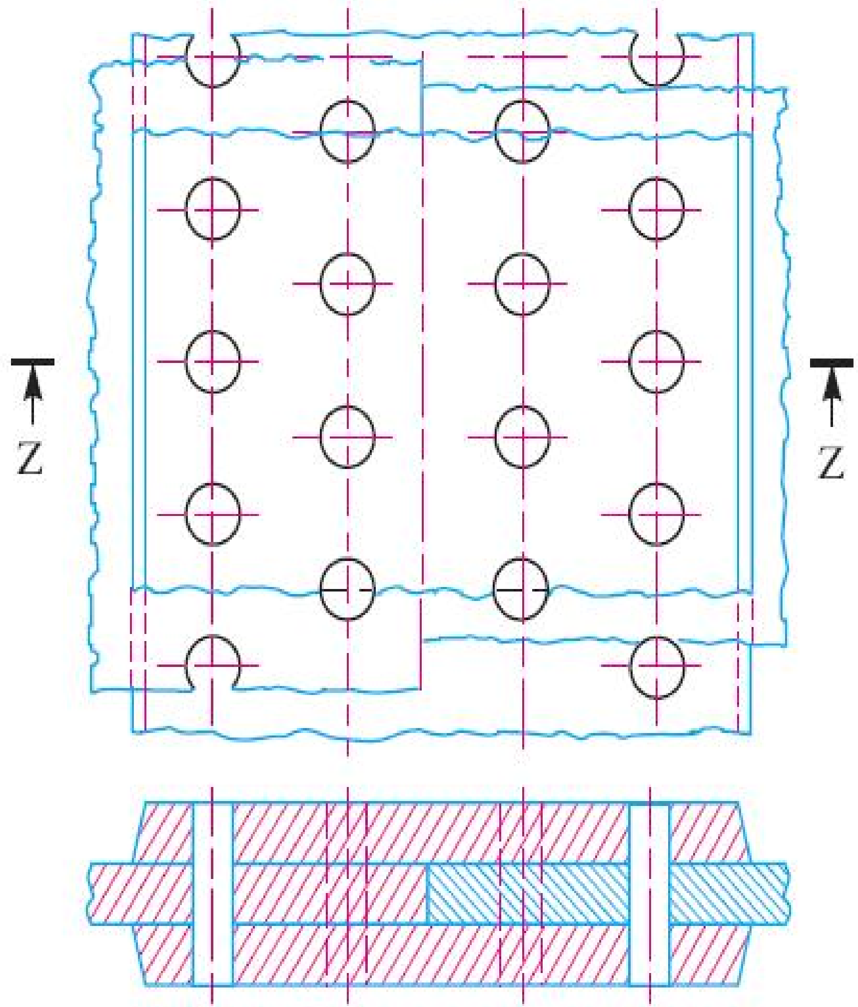
Single riveted double strap butt joint.



Double riveted double strap (equal) butt joints.

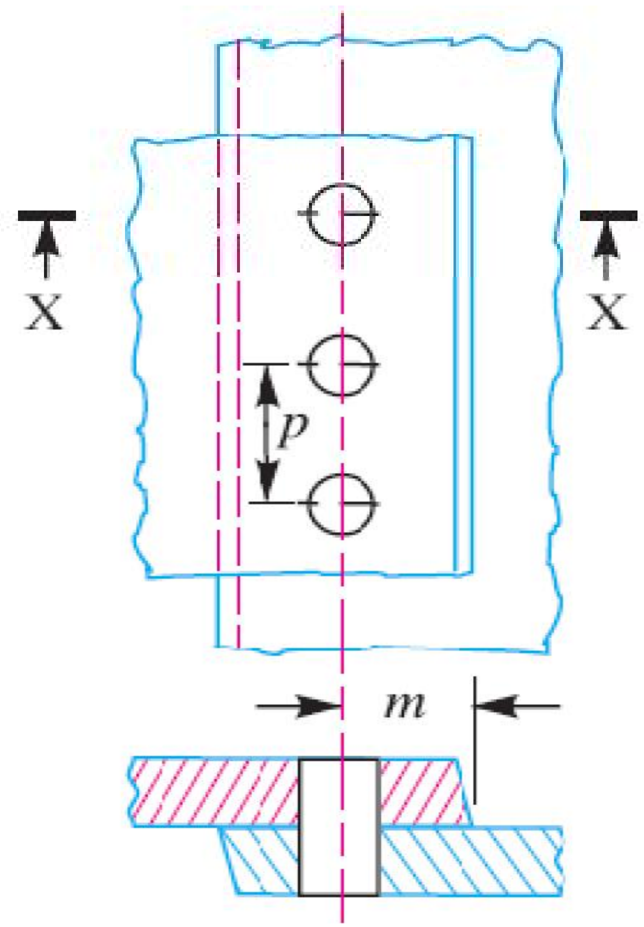


(*a*) Chain riveting.

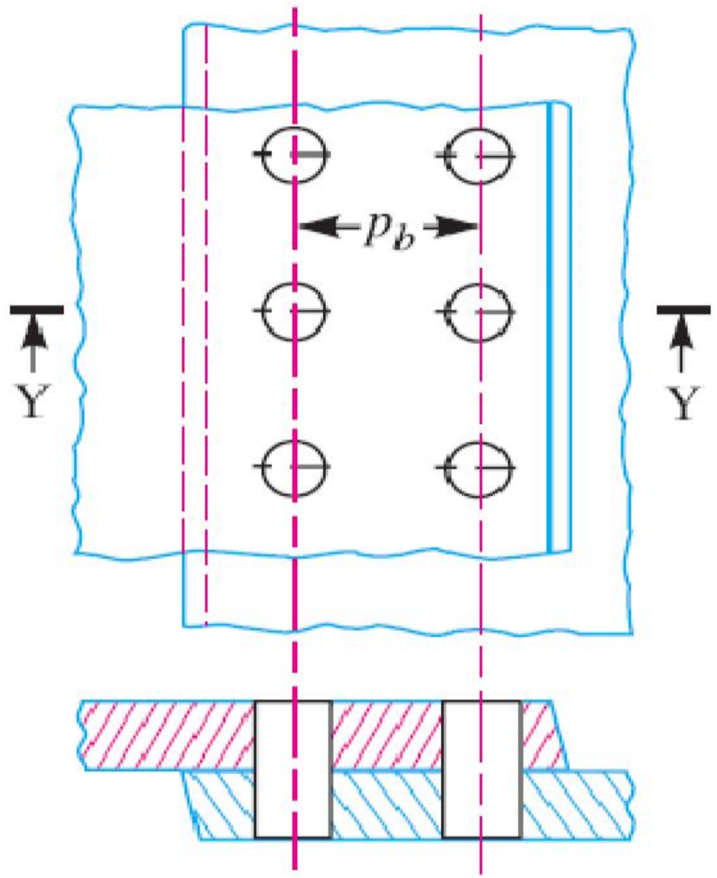


(*b*) Zig-zag riveting.

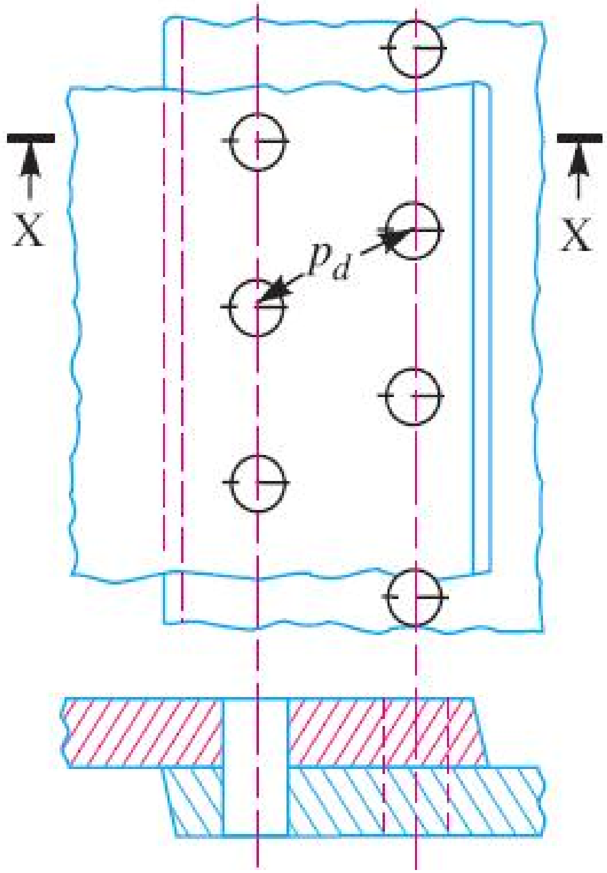
1. Pitch. It is the distance from the centre of one rivet to the centre of the next rivet measured parallel to the seam as shown in Figure. It is usually denoted by p.



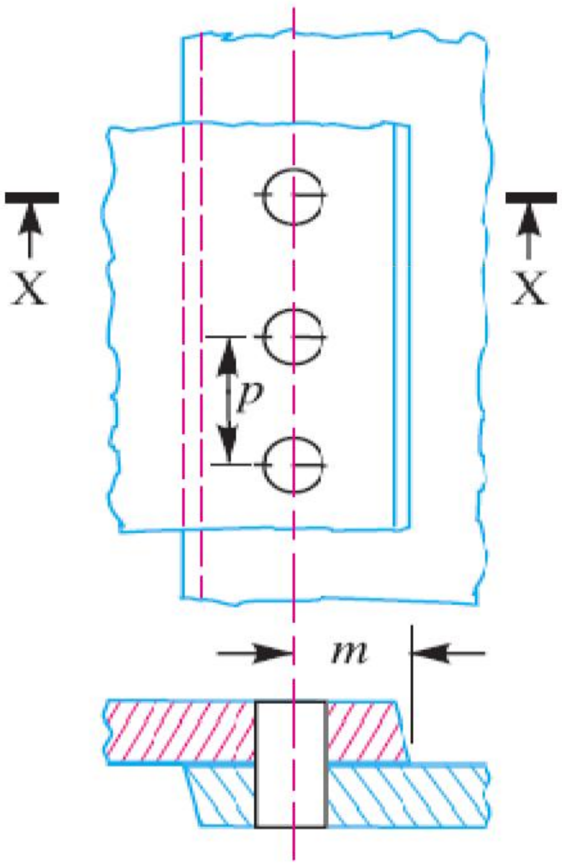
2. Back pitch. It is the perpendicular distance between the centre lines of the successive rows as shown in Figure. It is usually denoted by p_b.



3. Diagonal pitch. It is the distance between the centres of the rivets in adjacent rows of zig-zag riveted joint as shown in Figure. It is usually denoted by p_d.

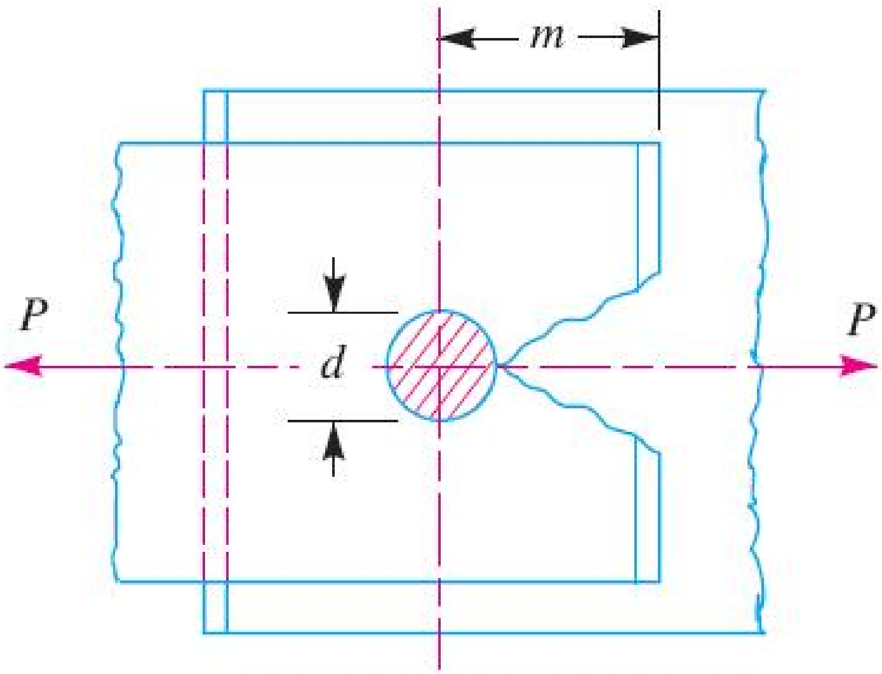


4. Marginal pitch. It is the distance between the centre of rivet hole to the nearest edge of the plate as shown in Figure. It is usually denoted by m.

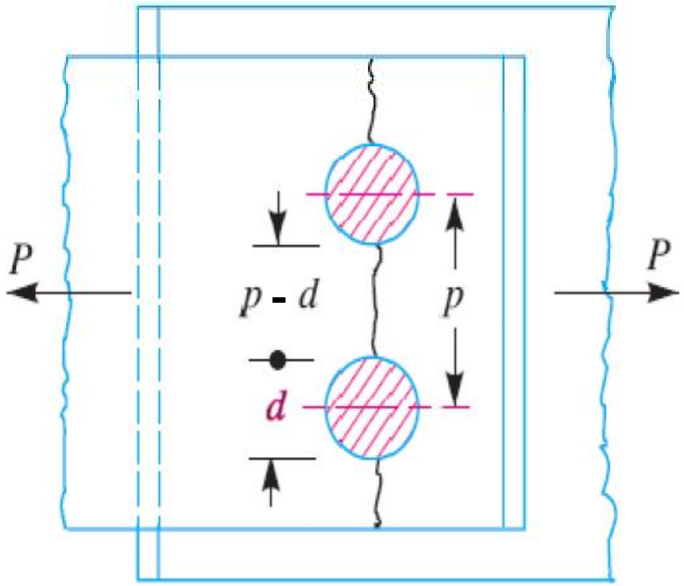


Failures of a Riveted Joint

1. Tearing of the plate at an edge. A joint may fail due to tearing of the plate at an edge as shown in Figure. This can be avoided by keeping the margin, m = 1.5d, where d is the diameter of the rivet hole.



2. Tearing of the plate across a row of rivets. Due to the tensile stresses in the main plates, the main plate or cover plates may tear off across a row of rivets as shown in Figure. In such cases, we consider only one pitch length of the plate, since every rivet is responsible for that much length of the plate only.



$$A_t = (p - d)t$$

$$P_t = A_t.\sigma_t = (p - d)t.\sigma_t$$

p = Pitch of the rivets,

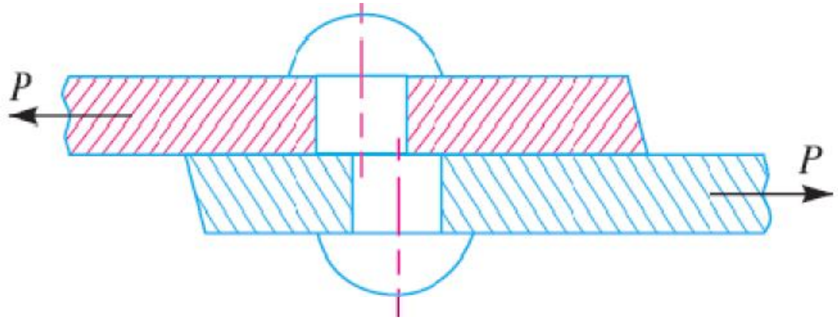
d = Diameter of the rivet hole,

t = Thickness of the plate, and

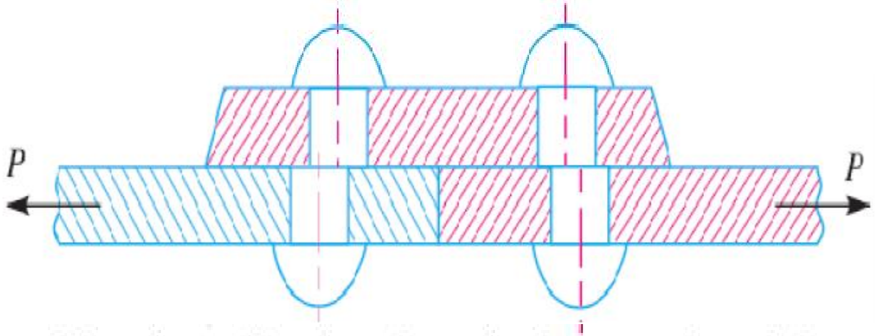
σ_t = Permissible tensile stress for the plate material.

When the tearing resistance (P_t) is greater than the applied load (P) per pitch length, then this type of failure will not occur.

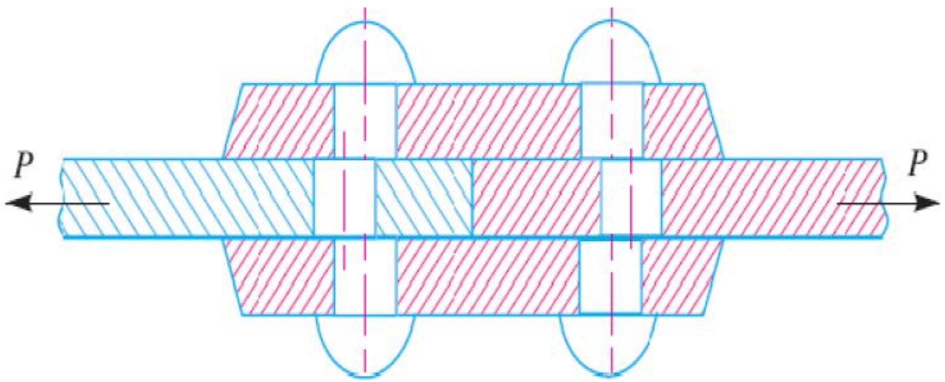
3. Shearing of the rivets. The plates which are connected by the rivets exert tensile stress on the rivets, and if the rivets are unable to resist the stress, they are sheared off as shown in Figure.



Shearing off a rivet in a lap joint.



Shearing off a rivet in a single cover butt joint.



Shearing off a rivet in double cover butt joint.

We know that shearing area,

$$A_s = \frac{\pi}{4} \times d^2 \qquad \text{...(In single shear)}$$

$$= 2 \times \frac{\pi}{4} \times d^2 \qquad \text{...(Theoretically, in double shear)}$$

$\therefore$ Shearing resistance or pull required to shear off the rivet per pitch length,

$$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau \qquad \text{...(In single shear)}$$

$$= n \times 2 \times \frac{\pi}{4} \times d^2 \times \tau \qquad \text{...(Theoretically, in double shear)}$$

When the shearing takes place at one cross-section of the rivet, the rivets are said to be in single shear. Similarly, when the shearing takes place at two cross-sections of the rivet, then the rivets are said to be in double shear.

When the shearing resistance (P_s) is greater than the applied load (P) per pitch length, then this type of failure will occur.

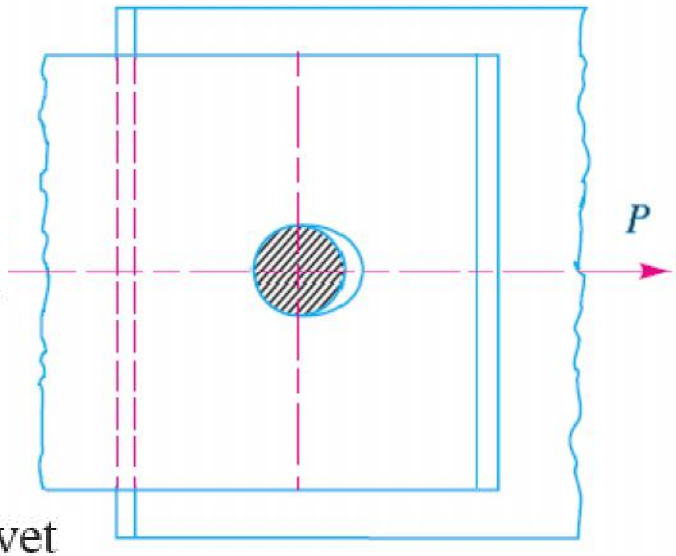
4. Crushing of the plate or rivets. the rivets do not actually shear off under the tensile stress, but are crushed as shown in Figure. Due to this, the rivet hole becomes of an oval shape and hence the joint becomes loose. The failure of rivets in such a manner is also known as bearing failure.

d = Diameter of the rivet hole,

t = Thickness of the plate,

σ_c = Safe permissible crushing stress for the rivet or plate material, and

n = Number of rivets per pitch length under crushing.



$$A_c = d.t$$

Total crushing area $= n.d.t$

and crushing resistance or pull required to crush the rivet per pitch length,

$$P_c = n.d.t.\sigma_c$$

When the crushing resistance (P_c) is greater than the applied load (P) per pitch length, then this type of failure will occur.

Efficiency of a Riveted Joint

The efficiency of a riveted joint is defined as the ratio of the strength of riveted joint $(P_t \ or \ P_s \ or \ P_c)$ to the strength of the un-riveted or solid plate.

∴ Efficiency of the riveted joint,

$$\eta = \frac{\text{Least of } P_t, P_s \text{ and } P_c}{p \times t \times \sigma_t}$$

where

p = Pitch of the rivets,

t = Thickness of the plate, and

σ_t = Permissible tensile stress of the plate material.