3.3 RIVETED JOINTS

3.4. 1 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 Fig. 3.58. The rivets are used to make permanent fastening between the plates such as in structural work, ship building, bridges, tanks and boiler shells. The riveted joints are widely used for joining light metals. The fastenings (*i.e.* joints) may be classified into the following two groups :

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

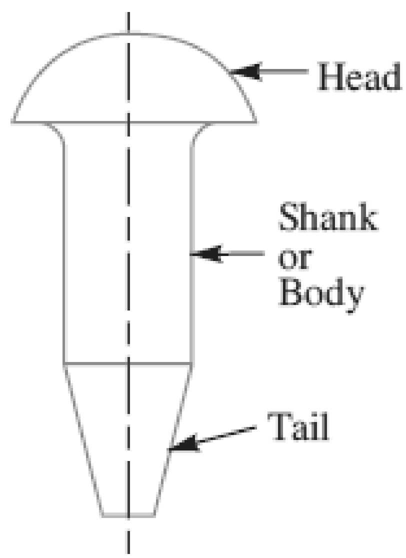


Fig. 3.58. Rivet parts.

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.

3.4.2 Methods of Riveting

The function of rivets in a joint is to make a connection that has strength and tightness. The strength is necessary to prevent failure of the joint. The tightness is necessary in order to contribute to strength and to prevent leakage as in a boiler or in a ship hull. When two plates are to be fastened together by a rivet as shown in Fig. 3.59 (*a*), the holes in the plates are punched and reamed or drilled. Punching is the cheapest method and is used for relatively thin plates and in structural work. Since punching injures the material around the hole, therefore drilling is used in most pressure-vessel work. In structural and pressure vessel riveting, the diameter of the rivet hole is usually 1.5 mm larger than the nominal diameter of the rivet.

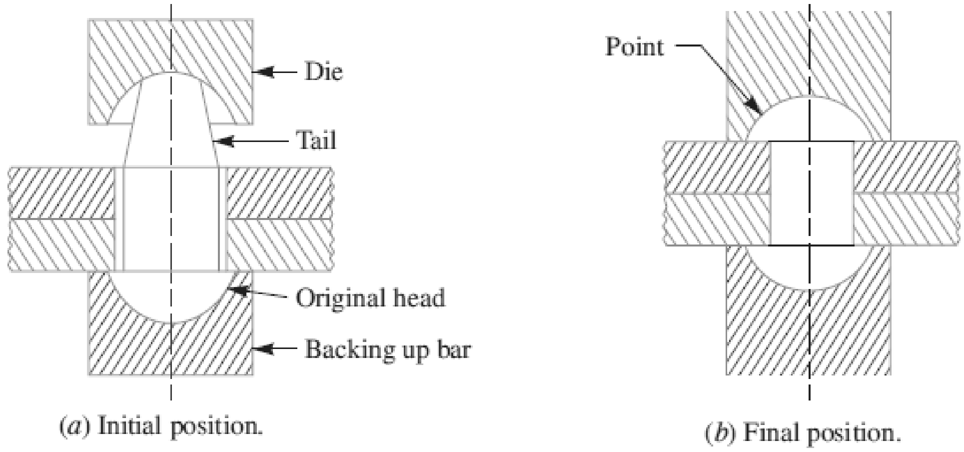


Fig. 3.59. Methods of riveting

The plates are drilled together and then separated to remove any burrs or chips so as to have a tight flush joint between the plates. A cold rivet or a red hot rivet is introduced into the plates and the ***point*** (*i.e.* second head) is then formed. When a cold rivet is used, the process is known as ***cold riveting*** and when a hot rivet is used, the process is known as ***hot riveting.*** The cold riveting process is used for structural joints while hot riveting is used to make leak proof joints The riveting may be done by hand or by a riveting machine. In hand riveting, the original rivet head is backed up by a hammer or heavy bar and then the die or set, as shown in Fig. 3.59 (*a*), is placed against the end to be headed and the blows are applied by a hammer. This causes the shank to expand thus filling the hole and the tail is converted into a ***point*** as shown in Fig. 3.59 (*b*). As the rivet cools, it tends to contract. The lateral contraction will be slight, but there will be a longitudinal tension introduced in the rivet which holds the plates firmly together. In machine riveting, the die is a part of the hammer which is operated by air, hydraulic or steam pressure.

3.4.3 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, but when strength and a fluid tight joint is the main consideration, then the steel rivets are used. The rivets for general purposes shall be manufactured from steel conforming to the following
Indian Standards :

(***a***) IS : 1148–1982 (Reaffirmed 1992) – Specification for hot rolled rivet bars (up to 40 mm diameter) for structural purposes; or

(***b***) IS : 1149–1982 (Reaffirmed 1992) – Specification for high tensile steel rivet bars for structural purposes.

The rivets for boiler work shall be manufactured from material conforming to IS : 1990 – 1973 (Reaffirmed 1992) – Specification for steel rivets and stay bars for boilers.

3.4.4 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. The material must be of such quality that when in cold condition, the shank shall be bent on itself through 180° without cracking and after being heated to 650°C and quenched, it must pass the same test. The rivet when hot must flatten without cracking to a diameter 2.5 times the diameter of shank
.

3.4.5 Manufacture of Rivets

According to Indian standard specifications, the rivets may be made either by cold heading or by hot forging. If rivets are made by the cold heading process, they shall subsequently be adequately heat treated so that the stresses set up in the cold heading process are eliminated. If they are made by hot forging process, care shall be taken to see that the finished rivets cool gradually.

3.4.6 Types of Rivet Heads

According to Indian standard specifications, the rivet heads are classified into the following three types :

1. Rivet heads for general purposes (below 12 mm diameter) as shown in Fig. 3.60, according to IS : 2155 – 1982 (Reaffirmed 1996).

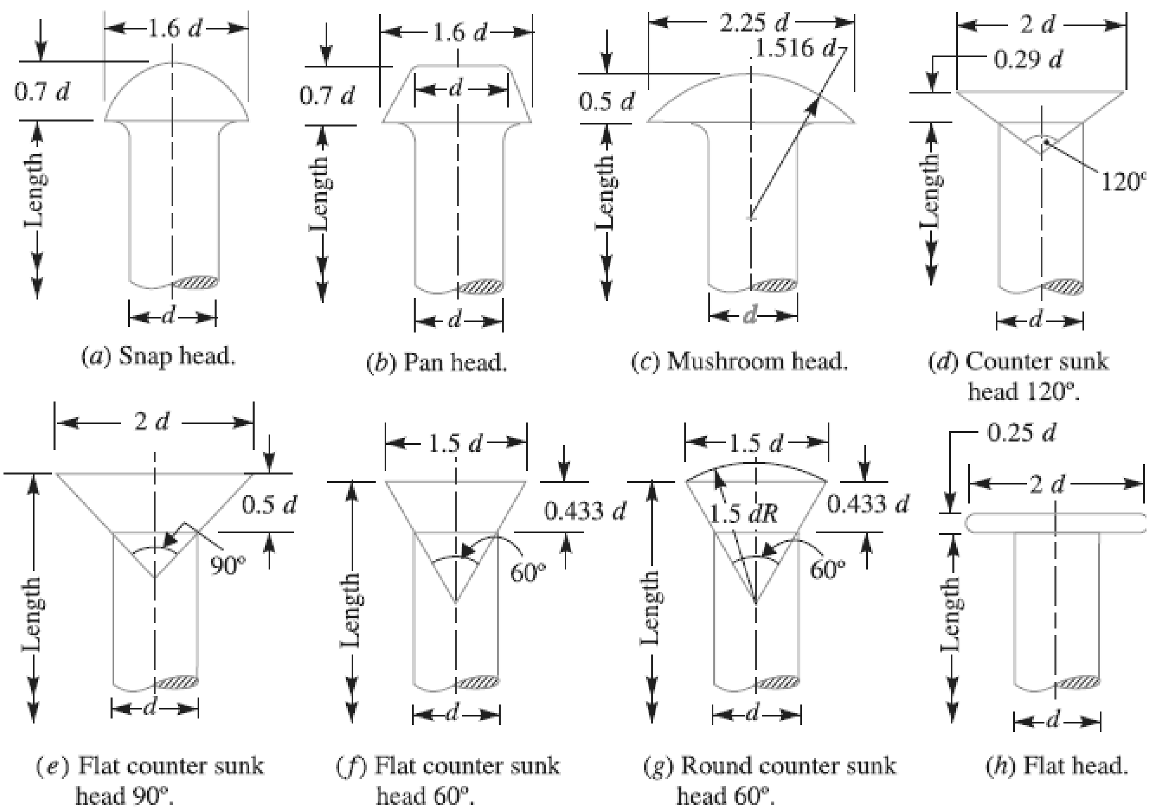
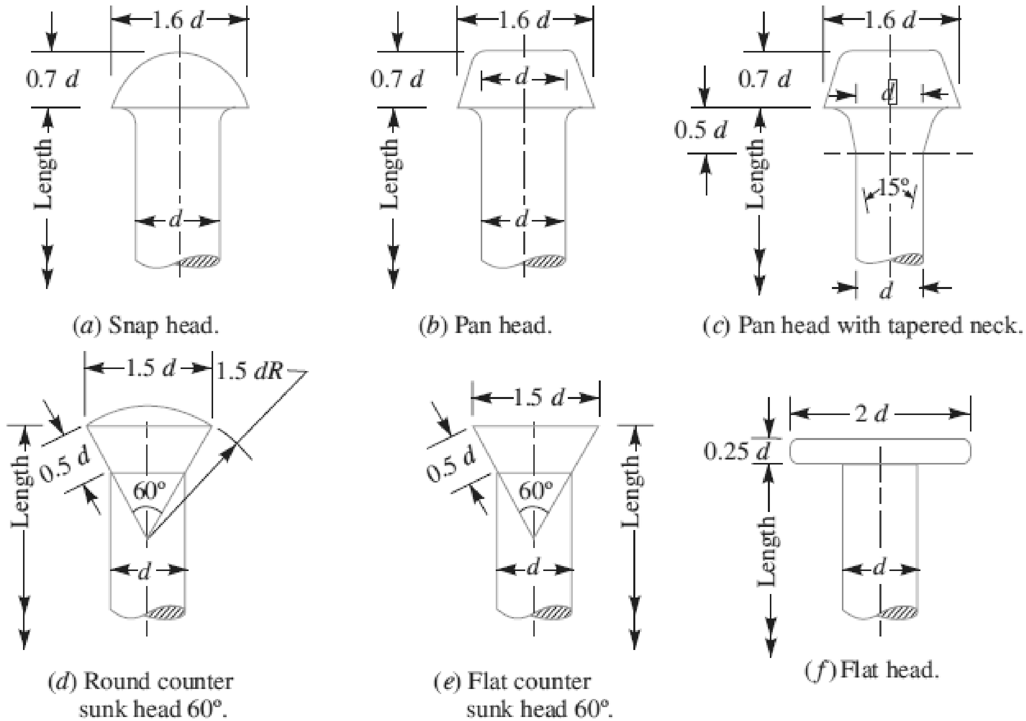


Fig. 3.60. Rivet heads for general purposes (below 12 mm diameter).

2. Rivet heads for general purposes (From 12 mm to 48 mm diameter) as shown in Fig. 3.61, according to IS : 1929 – 1982 (Reaffirmed 1996).

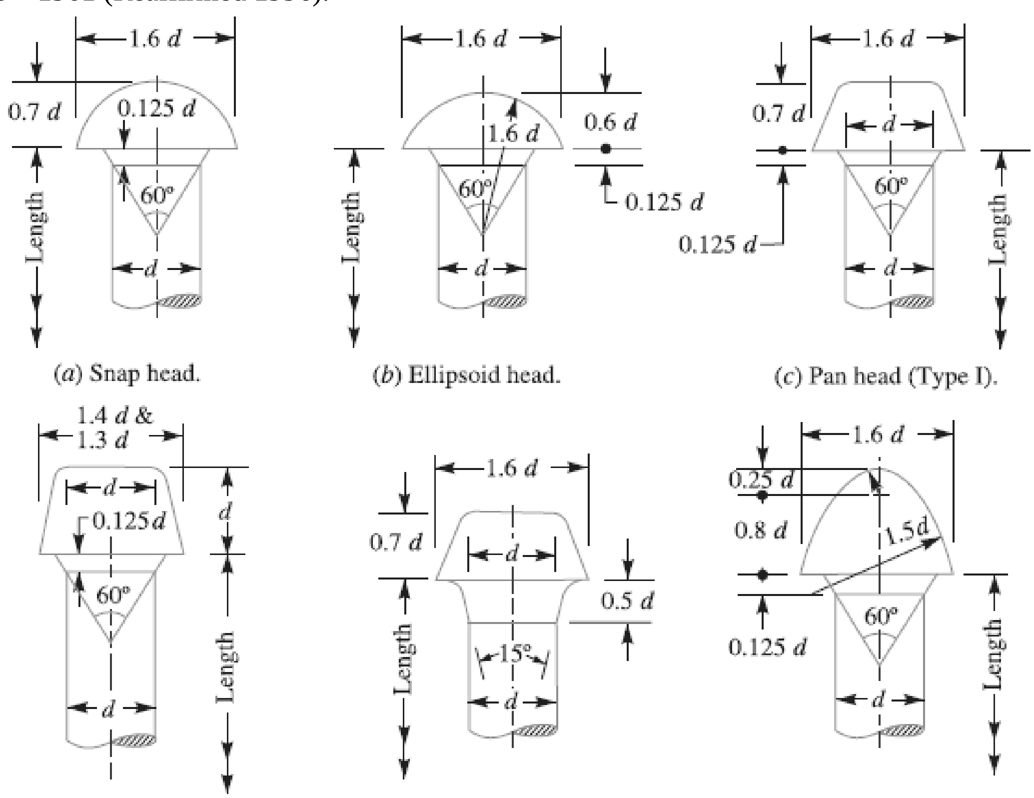


(*a*) Snap head. (*b*) Pan head. (*c*) Pan head with tapered neck.

(*d*) Round counter sunk head 60°. (*e*) Flat counter sunk head 60°. (*f*) Flat head.

Fig. 3.61. Rivet heads for general purposes (from 12 mm to 48 mm diameter)

3. Rivet heads for boiler work (from 12 mm to 48 mm diameter, as shown in Fig. 3.62, according to IS : 1928 – 1961 (Reaffirmed 1996).



(*a*) Snap head. (*b*) Ellipsoid head. (*c*) Pan head (Type I).

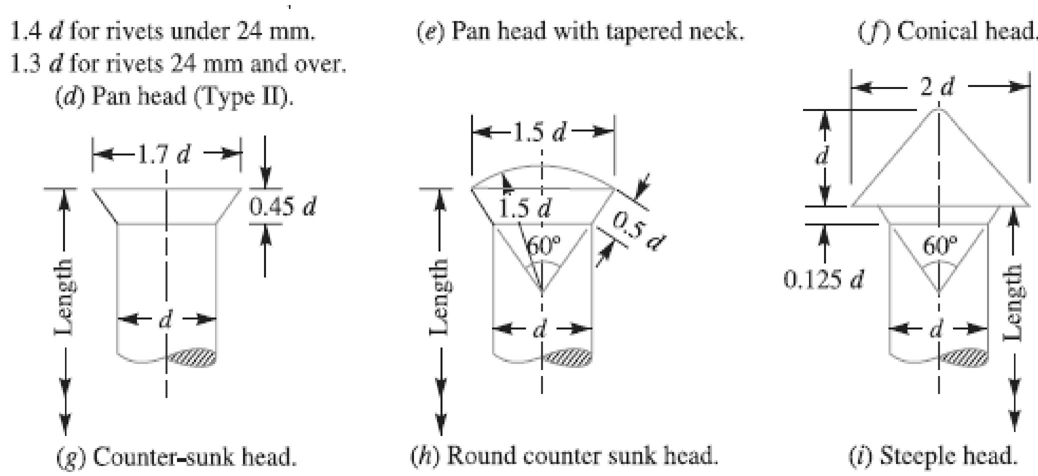


Fig. 3.62. Rivet heads for boiler work.

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** (also known as **conoidal heads)** are mainly used in case of hand hammering. The **pan heads** have maximum strength, but these are difficult to shape.

3.4.7 Types of Riveted Joints

Following are the two types of riveted joints, depending upon the way in which the plates are connected.

1. Lap joint, and **2.** Butt joint.

Lap Joint

A lap joint is that in which one plate overlaps the other and the two plates are then riveted together.

Butt Joint

A butt joint is that in which the main plates are kept in alignment butting (*i.e.* touching) each other and a cover plate (*i.e.* strap) is placed either on one side or on both sides of the main plates. The cover plate is then riveted together with the main plates. Butt joints are of the following two types :

1. Single strap butt joint, and **2.** Double strap butt joint.

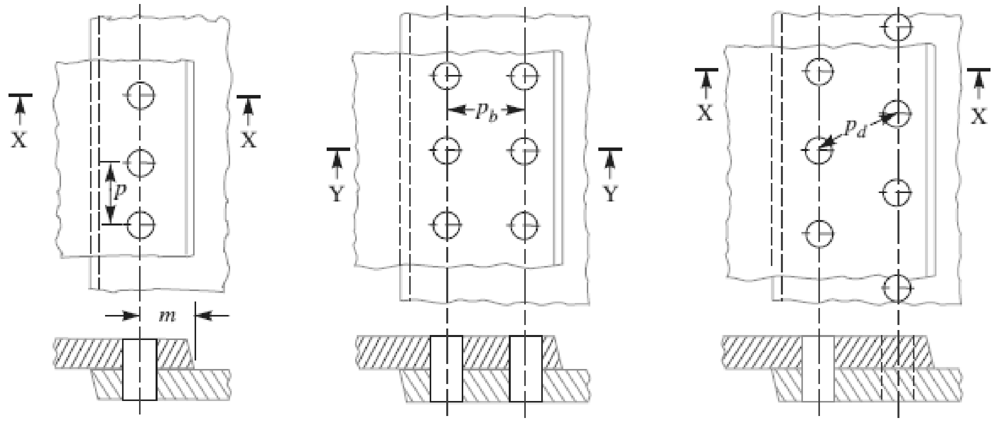
In a ***single strap butt joint,*** the edges of the main plates butt against each other and only one cover plate is placed on one side of the main plates and then riveted together.

In a ***double strap butt joint,*** **t**he edges of the main plates butt against each other and two cover plates are placed on both sides of the main plates and then riveted together. In addition to the above, following are the types of riveted joints depending upon the number of rows of the rivets.

1. Single riveted joint, and **2.** Double riveted joint.

A ***single riveted joint*** is that in which there is a single row of rivets in a lap joint as shown in Fig. 3.63 (*a*) and there is a single row of rivets on each side in a butt joint as shown in Fig. 3.65.

A ***double riveted joint*** is that in which there are two rows of rivets in a lap joint as shown in Fig. 3.66 (*b*) and (*c*) and there are two rows of rivets on each side in a butt joint as shown in Fig. 3.66.

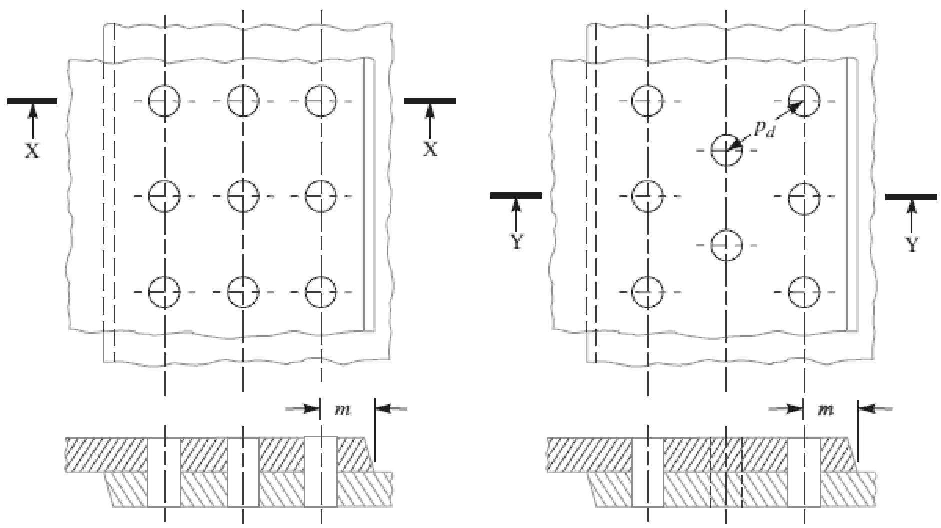


(*a*) Single riveted lap joint. (*b*) Double riveted lap joint (Chain riveting). (*c*) Double riveted lap joint (Zig-zag riveting).

Fig. 3.63. Single and double riveted lap joints.

Similarly the joints may be ***triple riveted*** or ***quadruple riveted*** every rivet is in the middle of the two rivets of the opposite row as shown in Fig. 3.63 (*c*), then the joint is said to be ***zig-zag riveted*.**

2. Since the plates overlap in lap joints, therefore the force *P*, *P* acting on the plates [See Fig. 9.15 (*a*)] are not in the same straight line but they are at a distance equal to the thickness of the plate. These forces will form a couple which may bend the joint. Hence the lap joints may be used only where small loads are to be transmitted. On the other hand, the forces *P*, *P* in a butt joint act in the same straight line, therefore there will be no couple. Hence the butt joints are used where heavy loads are to be transmitted.



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

Fig. 3.64. Triple riveted lap joint.

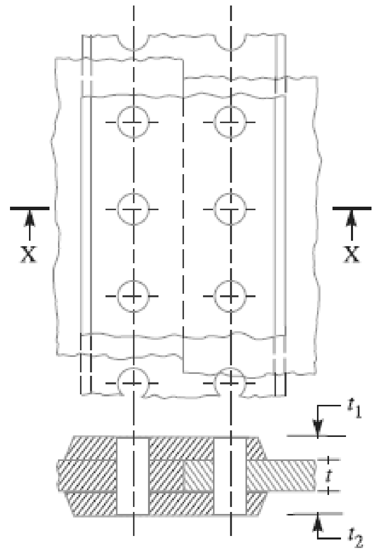


Fig. 3.65. Single riveted double strap butt joint.

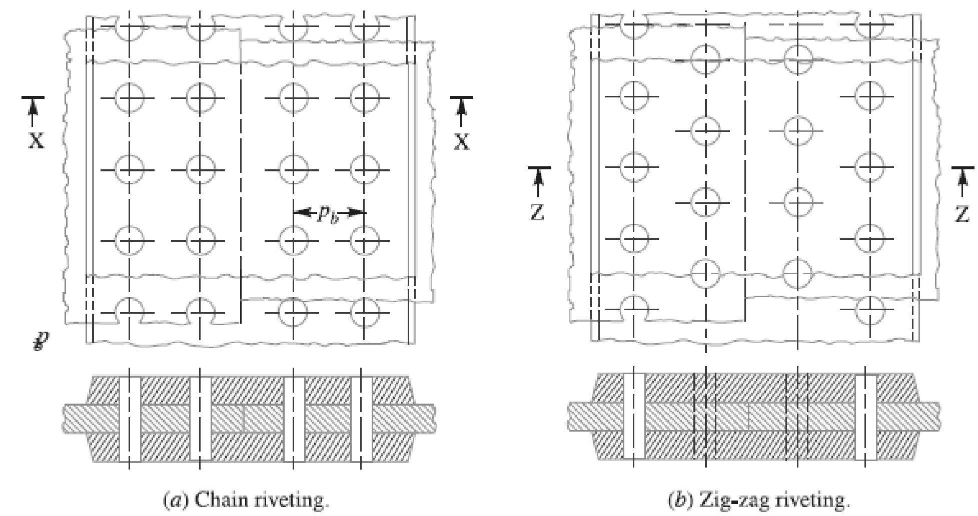


Fig. 3.66. Double riveted double strap (equal) butt joints.
Fig. 3.67. Double riveted double strap (unequal) butt joint with zig-zag riveting.

3.4.8 Important Terms Used in Riveted Joints

The following terms in connection with the riveted joints are important from the subject point of view :

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 Fig. 3.63. 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 Fig. 3.63. It is usually denoted by *pb*.

3. *Diagonal pitch*. It is the distance between the centres of the rivets in adjacent rows of zig-zag riveted joint as shown in Fig. 3.63. It is usually denoted by *pd*.
4. *Margin or marginal pitch*. It is the distance between the centre of rivet hole to the nearest edge of the plate as shown in Fig. 3.63. It is usually denoted by *m*.

EXERCISES

1. Determine the safe tensile load for bolts of M 20 and M 36. Assume that the bolts are not initially stressed and take the safe tensile stress as 200 MPa. **[Ans. 49 kN; 16.43 kN]**

2. An eye bolt carries a tensile load of 20 kN. Find the size of the bolt, if the tensile stress is not to exceed 100 MPa. Draw a neat proportioned figure for the bolt. **[Ans. M 20]**

3. An engine cylinder is 300 mm in diameter and the steam pressure is 0.7 N/mm^2. If the cylinder head is held by 12 studs, find the size. Assume safe tensile stress as 28 MPa. **[Ans. M 24]**

4. Find the size of 14 bolts required for a C.I. steam engine cylinder head. The diameter of the cylinder is 400 mm and the steam pressure is 0.12 N/mm^2. Take the permissible tensile stress as 35 MPa.
[Ans. M 24]

5. The cylinder head of a steam engine is subjected to a pressure of 1 N/mm^2. It is held in position by means of 12 bolts. The effective diameter of the cylinder is 300 mm. A soft copper gasket is used to make the joint leak proof. Determine the size of the bolts so that the stress in the bolts does not exceed 100 MPa. **[Ans. M 36]**

6. A steam engine cylinder of 300 mm diameter is supplied with steam at 1.5 N/mm^2. The cylinder cover is fastened by means of 8 bolts of size M 20. The joint is made leak proof by means of suitable gaskets. Find the stress produced in the bolts. **[Ans. 249 MPa]**

7. The effective diameter of the cylinder is 400 mm. The maximum pressure of steam acting on the cylinder cover is 1.12 N/mm^2. Find the number and size of studs required to fix the cover. Draw a neat proportioned sketch for the elevation of the cylinder cover. **[Ans. 14; M 24]**

8. Specify the size and number of studs required to fasten the head of a 400 mm diameter cylinder containing steam at 2 N/mm^2. A hard gasket (gasket constant = 0.3) is used in making the joint. Draw a neat sketch of the joint also. Other data may be assumed. **[Ans. M 30; 12]**

9. A steam engine cylinder has an effective diameter of 200 mm. It is subjected to a maximum steam pressure of 1.75 N/mm^2. Calculate the number and size of studs required to fix the cylinder cover onto the cylinder flange assuming the permissible stress in the studs as 30 MPa. Take the pitch circle diameter of the studs as 320 mm and the total load on the studs as 20% higher than the external load on the joint. Also check the circumferential pitch of the studs so as to give a leak proof joint.
[Ans. 16; M 16]

15. A pulley bracket, as shown in Fig. 3.68, is supported by 4 bolts, two at *A*-*A* and two at *B*-*B*. Determine the size of bolts using an allowable shear stress of 25 MPa for the material of the bolts.
[Ans. M 27]

16. A wall bracket, as shown in Fig. 3.69, is fixed to a wall by means of four bolts. Find the size of the bolts and the width of bracket. The safe stress in tension for the bolt and bracket may be assumed as 70 MPa.

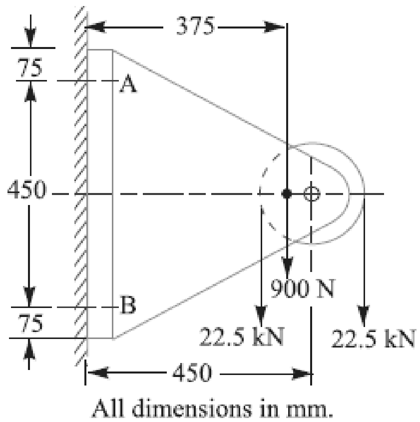


Fig. 3.68

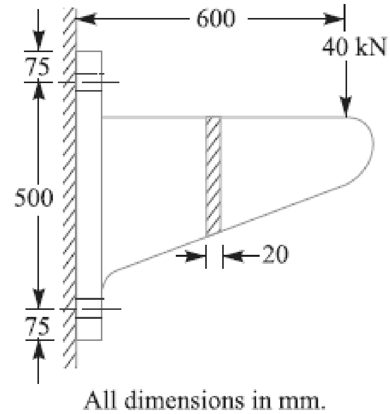


Fig. 3.69

20. A bracket, as shown in Fig. 3.70, is fixed to a vertical steel column by means of five standard bolts. Determine : (*a*) The diameter of the fixing bolts, and (*b*) The thickness of the arm of the bracket. Assume safe working stresses of 70 MPa in tension and 50 MPa in shear. **[Ans. M 18; 50 mm]**

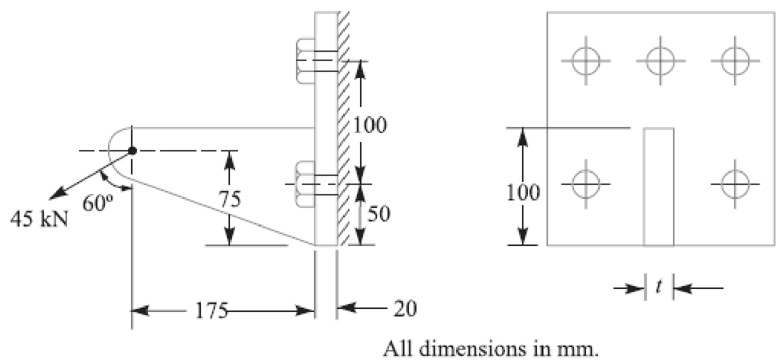


Fig. 3.70

21. Design a cotter joint to connect two mild steel rods for a pull of 30 kN. The maximum permissible stresses are 55 MPa in tension ; 40 MPa in shear and 70 MPa in crushing. Draw a neat sketch of the joint designed.
[Ans. d = 22 mm; $d2$ = 32 mm ; t = 14 mm ; $d1$ = 44 mm ; b = 30 mm ; a = 12 mm ; d_4 = 65 mm ; c = 12 mm ; d_3 = 40 mm ; t_1 = 8 mm]

22. Two rod ends of a pump are joined by means of a cotter and spigot and socket at the ends. Design the joint for an axial load of 100 kN which alternately changes from tensile to compressive. The allowable stresses for the material used are 50 MPa in tension, 40 MPa in shear and 100 MPa in crushing.
[Ans. d = 51 mm ; d_2 = 62 mm ; t = 16 mm ; d_1 = 72 mm ; b = 78 mm ; a = 20 mm ; d_3 = 83 mm ; d_4 = 125 mm ; c = 16 mm ; t_1 = 13 mm]

23. Two mild steel rods 40 mm diameter are to be connected by a cotter joint. The thickness of the cotter is 12 mm. Calculate the dimensions of the joint, if the maximum permissible stresses are: 46 MPa in

tension ; 35 MPa in shear and 70 MPa in crushing.
[Ans. d_2 = 30 mm ; d_1 = 48 mm ; b = 70 mm ; a = 27.5 mm ; d_4 = 100 mm ; c = 12 mm ; d_3 = 44.2 mm ; t = 35 mm ; t_1 = 13.5 mm]

24. Design and draw a cotter foundation bolt to take a load of 90 kN. Assume the permissible stresses as follows :
σ_t = 50 MPa, τ= 60 MPa and σ_c = 100 MPa.
[Ans. d = 50 mm ; $d1$ = 60 mm ; t = 15 mm ; b = 60 mm]

25. Design a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing.
[Ans. $d = d_1$ = 23 mm ; d_2 = 46 mm ; d_3 = 35 mm ; t = 29 mm ; t_1 = 18 mm]

26. A knuckle joint is required to withstand a tensile load of 25 kN. Design the joint if the permissible stresses are :
σ_t = 56 MPa ; τ = 40 MPa and σ_c = 70 MPa.
[Ans. $d = d_1$ = 28 mm ; d_2 = 56 mm ; d_3 = 42 mm ; t_1 = 21 mm]

27. The pull in the tie rod of a roof truss is 44 kN. Design a suitable adjustable screw joint. The permissible tensile and shear stresses are 75 MPa and 37.5 MPa respectively. Draw full size two suitable views of the joint. **[Ans. d = 36 mm ; l = 11 mm ; D = 45 mm ; D_2 = 58 mm]**

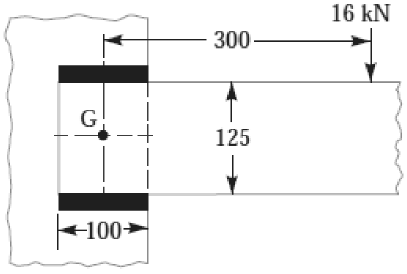
28. A plate 100 mm wide and 10 mm thick is to be welded with another plate by means of transverse welds at the ends. If the plates are subjected to a load of 70 kN, find the size of weld for static as well as fatigue load. The permissible tensile stress should not exceed 70 MPa. **[Ans. 83.2 mm; 118.5 mm]**

29. If the plates in Ex. 1, are joined by double parallel fillets and the shear stress is not to exceed 56 MPa, find the length of weld for (*a*) Static loading, and (*b*) Dynamic loading. **[Ans. 91 mm; 259 mm]**

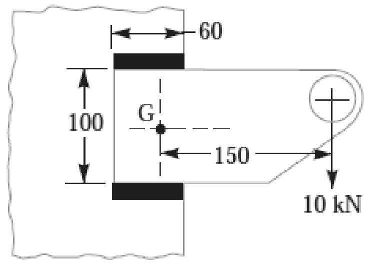
30. A 125 × 95 × 10 mm angle is joined to a frame by two parallel fillet welds along the edges of 150 mm leg. The angle is subjected to a tensile load of 180 kN. Find the lengths of weld if the permissible static load per mm weld length is 430 N. **[Ans. 137 mm and 307 mm]**

31. A circular steel bar 50 mm diameter and 200 mm long is welded perpendicularly to a steel plate to form a cantilever to be loaded with 5 kN at the free end. Determine the size of the weld, assuming the allowable stress in the weld as 100 MPa. **[Ans. 7.2 mm]**

32. A 125 × 95 × 10 mm angle is welded to a frame by two 10 mm fillet welds, as shown in Fig. 3.71. A load of 16 kN is apsplied normal to the gravity axis at a distance of 300 mm from the centre of\ gravity of welds. Find maximum shear stress in the welds, assuming each weld to be 100 mm long and parallel to the axis of the angle. **[Ans. 45.5 MPa]**



All dimensions in mm.

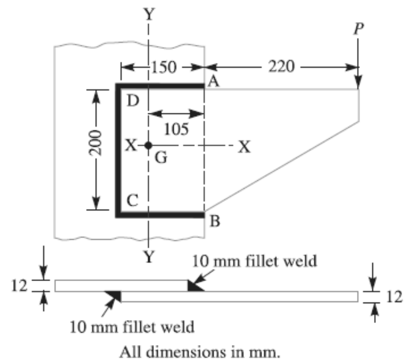


All dimensions in mm.

Fig. 3.71 **Fig. 3.72**

33. A bracket, as shown in Fig. 3.72, carries a load of 10 kN. Find the size of the weld if the allowable shear stress is not to exceed 80 MPa. **[Ans. 10.83 mm]**

34. A bracket is welded to the side of a column and carries a vertical load *P*, as shown in Fig. 3.73. Evaluate *P* so that the maximum shear stress in the 10 mm fillet welds is 80 MPa.
[Ans. 50.7 kN]



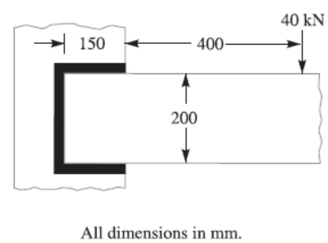


Fig. 3.73 **Fig. 3.74**

35. A bracket, as shown in Fig. 10.39, carries a load of 40 kN. Calculate the size of weld, if the allowable shear stress is not to exceed 80 MPa. **[Ans. 7 mm]**

36. A single riveted lap joint is made in 15 mm thick plates with 20 mm diameter rivets. Determine the strength of the joint, if the pitch of rivets is 60 mm. Take σ_t = 120 MPa; τ = 90 MPa and σ_c = 160 MPa.
[Ans. 28 280 N]

37. Two plates 16 mm thick are joined by a double riveted lap joint. The pitch of each row of rivets is 90 mm. The rivets are 25 mm in diameter. The permissible stresses are as follows :
σ_t= 140 MPa ; τ= 110 MPa and σ_c= 240 MPa Find the efficiency of the joint. **[Ans. 53.5%]**

38. A single riveted double cover butt joint is made in 10 mm thick plates with 20 mm diameter rivets with a pitch of 60 mm. Calculate the efficiency of the joint, if
σ_t = 100 MPa ; τ = 80 MPa and σ_c= 160 MPa. **[Ans. 53.8%]**