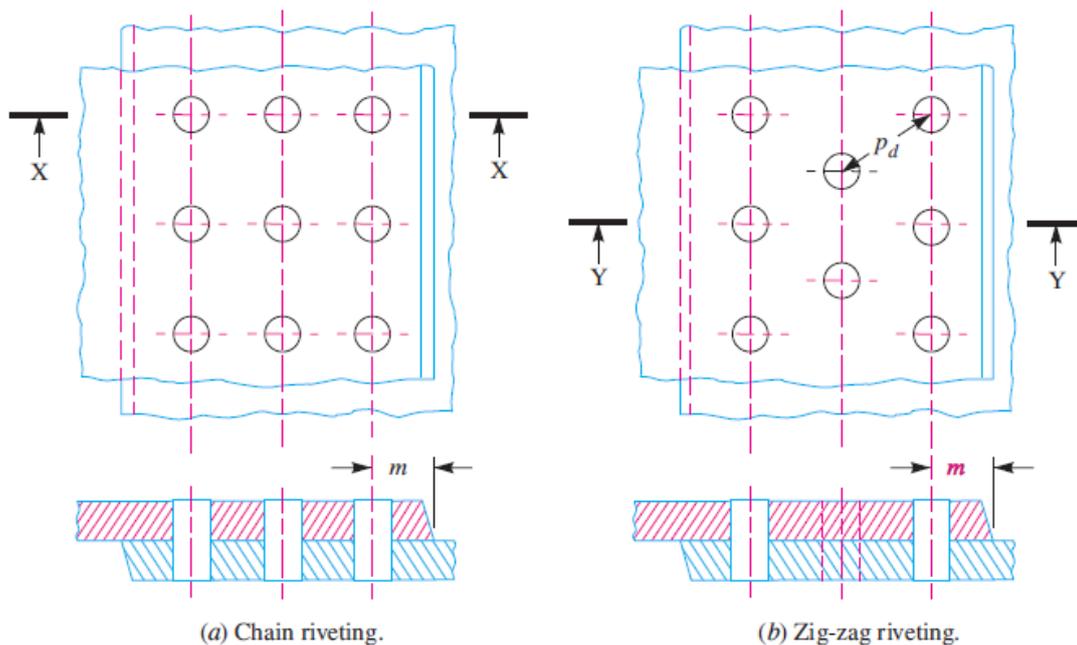
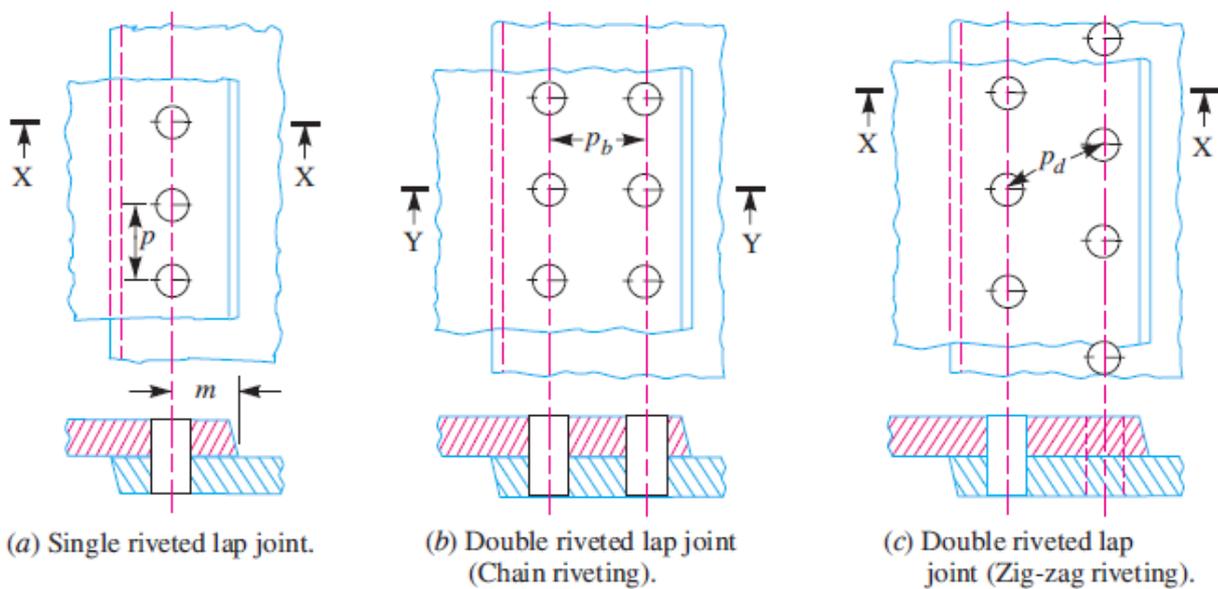


Riveted Joints

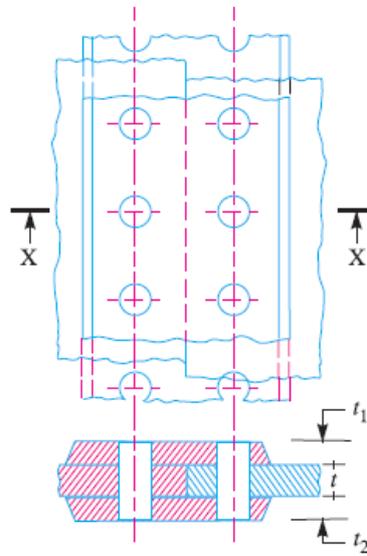
Types of Riveted Joints

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

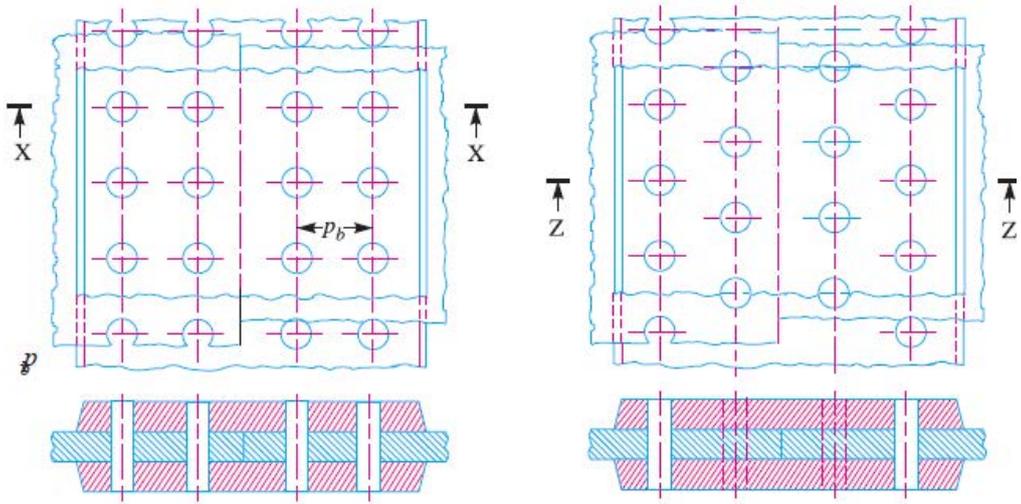
1. Lap joint, and 2. Butt joint.



Triple riveted lap joint.

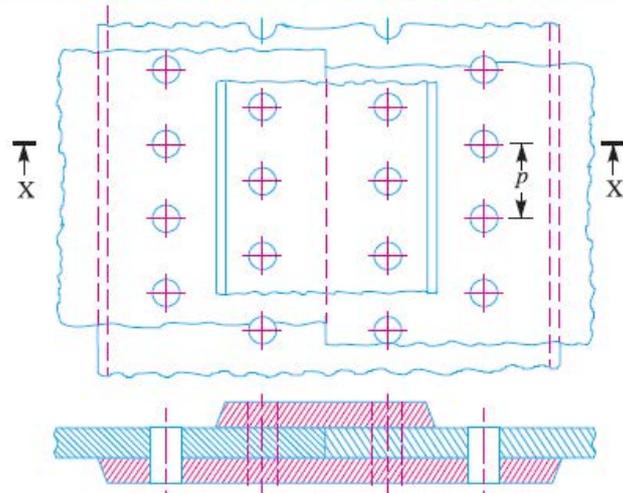


Single riveted double strap butt joint.



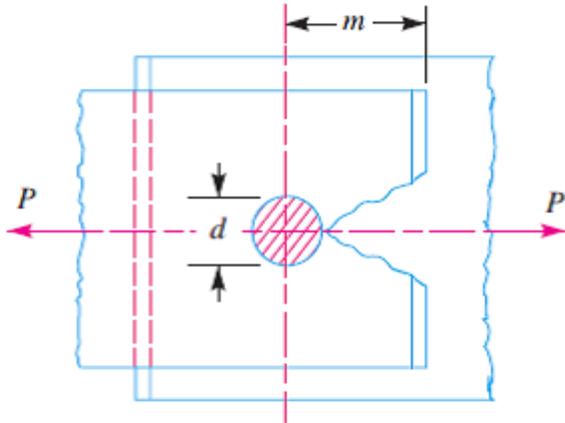
(a) Chain riveting. (b) Zig-zag riveting.

Double riveted double strap (equal) butt joints.

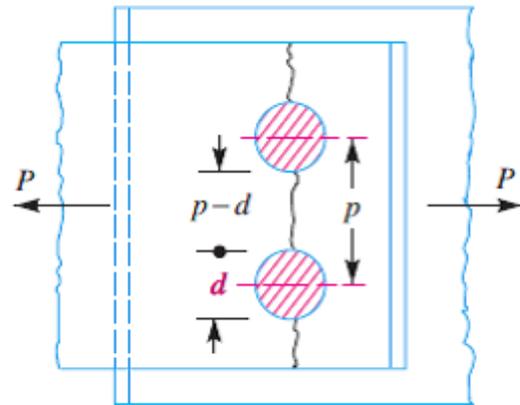


Double riveted double strap (unequal) butt joint with zig-zag riveting.

Failures of a Riveted Joint



Tearing of the plate at an edge.



Tearing of the plate across the rows of rivets.

Tearing resistance

The resistance offered by the plate against tearing is known as **tearing resistance** or **tearing strength** or **tearing value** of the plate.

Let

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.

We know that tearing area per pitch length,

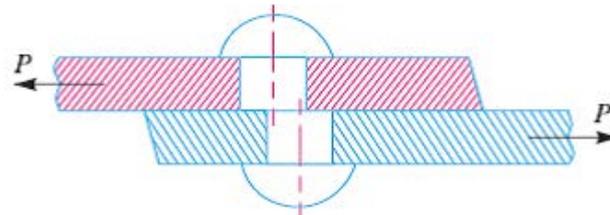
$$A_t = (p - d) t$$

∴ Tearing resistance or pull required to tear off the plate per pitch length,

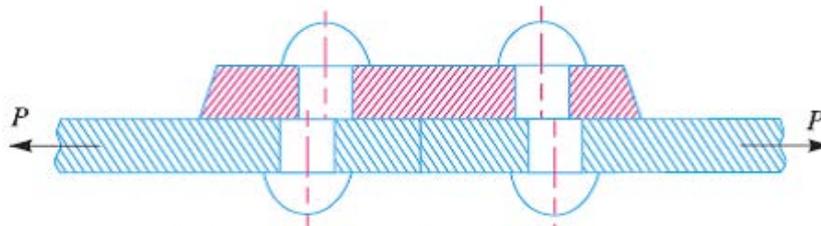
$$P_t = A_t \cdot \sigma_t = (p - d) t \cdot \sigma_t$$

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

Shearing of the rivets

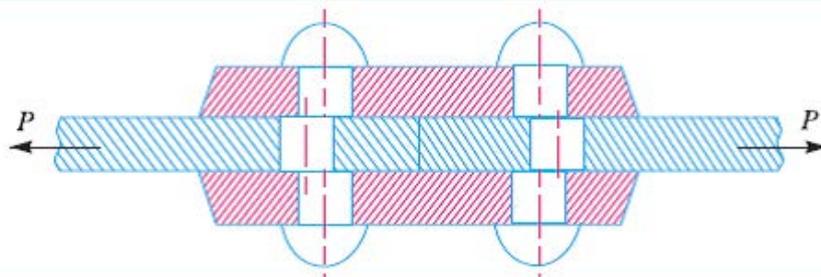


(a) Shearing off a rivet in a lap joint.



(b) Shearing off a rivet in a single cover butt joint.

Shearing of rivets.



1 Shearing off a rivet in double cover butt joint.

Let d = Diameter of the rivet hole,
 τ = Safe permissible shear stress for the rivet material, and
 n = Number of rivets per pitch length.

We know that shearing area,

$$\begin{aligned}
 A_s &= \frac{\pi}{4} \times d^2 && \dots(\text{In single shear}) \\
 &= 2 \times \frac{\pi}{4} \times d^2 && \dots(\text{Theoretically, in double shear}) \\
 &= 1.875 \times \frac{\pi}{4} \times d^2 && \dots(\text{In double shear, according to Indian Boiler Regulations})
 \end{aligned}$$



∴ Shearing resistance or pull required to shear off the rivet per pitch length,

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

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

$$= n \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau \quad \dots(\text{In double shear, according to Indian Boiler Regulations})$$

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

Crushing of the plate or rivets

Let 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.

We know that crushing area per rivet (*i.e.* projected area per rivet),

$$A_c = d.t$$

∴ 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.



Class: 3rd

Subject: Mechanical Engineering Design

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Efficiency of a Riveted Joint

We have already discussed that strength of the riveted joint

$$= \text{Least of } P_t, P_s \text{ and } P_c$$

Strength of the un-riveted or solid plate per pitch length,

$$P = p \times t \times \sigma_t$$

∴ 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.



Problem 1

A double riveted lap joint is made between 15 mm thick plates. The rivet diameter and pitch are 25 mm and 75 mm respectively. If the ultimate stresses are 400 MPa in tension, 320 MPa in shear and 640 MPa in crushing, find the minimum force per pitch which will rupture the joint. If the above joint is subjected to a load such that the factor of safety is 4, find out the actual stresses developed in the plates and the rivets.

Solution. Given : $t = 15$ mm ; $d = 25$ mm ; $p = 75$ mm ; $\sigma_{tu} = 400$ MPa = 400 N/mm² ; $\tau_u = 320$ MPa = 320 N/mm² ; $\sigma_{cu} = 640$ MPa = 640 N/mm²

We know that ultimate tearing resistance of the plate per pitch,

$$P_{tu} = (p - d)t \times \sigma_{tu} = (75 - 25)15 \times 400 = 300\,000 \text{ N}$$

Ultimate shearing resistance of the rivets per pitch,

$$P_{su} = n \times \frac{\pi}{4} \times d^2 \times \tau_u = 2 \times \frac{\pi}{4} (25)^2 320 = 314\,200 \text{ N} \quad (\because n = 2)$$

and ultimate crushing resistance of the rivets per pitch,

$$P_{cu} = n \times d \times t \times \sigma_{cu} = 2 \times 25 \times 15 \times 640 = 480\,000 \text{ N}$$

From above we see that the minimum force per pitch which will rupture the joint is 300 000 N or 300 kN.

Actual stresses produced in the plates and rivets

Since the factor of safety is 4, therefore safe load per pitch length of the joint

$$= 300\,000/4 = 75\,000 \text{ N}$$

Let σ_{ta} , τ_a and σ_{ca} be the actual tearing, shearing and crushing stresses produced with a safe load of 75 000 N in tearing, shearing and crushing.

We know that actual tearing resistance of the plates (P_{ta}),



Class: 3rd

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$$75\,000 = (p - d) t \times \sigma_{ta} = (75 - 25)15 \times \sigma_{ta} = 750 \sigma_{ta}$$

$$\therefore \sigma_{ta} = 75\,000 / 750 = 100 \text{ N/mm}^2 = 100 \text{ MPa}$$

Actual shearing resistance of the rivets (P_{sa}),

$$75\,000 = n \times \frac{\pi}{4} \times d^2 \times \tau_a = 2 \times \frac{\pi}{4} (25)^2 \tau_a = 982 \tau_a$$

$$\therefore \tau_a = 75000 / 982 = 76.4 \text{ N/mm}^2 = 76.4 \text{ MPa}$$

and actual crushing resistance of the rivets (P_{ca}),

$$75\,000 = n \times d \times t \times \sigma_{ca} = 2 \times 25 \times 15 \times \sigma_{ca} = 750 \sigma_{ca}$$

$$\therefore \sigma_{ca} = 75000 / 750 = 100 \text{ N/mm}^2 = 100 \text{ MPa}$$

Problem 2

Find the efficiency of the following riveted joints :

1. Single riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 50 mm.
2. Double riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 65 mm.

Assume

Permissible tensile stress in plate = 120 MPa

Permissible shearing stress in rivets = 90 MPa

Permissible crushing stress in rivets = 180 MPa

Solution. Given : $t = 6 \text{ mm}$; $d = 20 \text{ mm}$; $\sigma_t = 120 \text{ MPa} = 120 \text{ N/mm}^2$; $\tau = 90 \text{ MPa} = 90 \text{ N/mm}^2$; $\sigma_c = 180 \text{ MPa} = 180 \text{ N/mm}^2$

1. Efficiency of the first joint

Pitch, $p = 50 \text{ mm}$

(i) Tearing resistance of the plate

We know that the tearing resistance of the plate per pitch length,

$$P_t = (p - d) t \times \sigma_t = (50 - 20) 6 \times 120 = 21\,600 \text{ N}$$



(ii) *Shearing resistance of the rivet*

$$P_s = \frac{\pi}{4} \times d^2 \times \tau = \frac{\pi}{4} (20)^2 90 = 28\,278 \text{ N}$$

(iii) *Crushing resistance of the rivet*

$$P_c = d \times t \times \sigma_c = 20 \times 6 \times 180 = 21\,600 \text{ N}$$

∴ Strength of the joint

$$= \text{Least of } P_t, P_s \text{ and } P_c = 21\,600 \text{ N}$$

We know that strength of the unriveted or solid plate,

$$P = p \times t \times \sigma_t = 50 \times 6 \times 120 = 36\,000 \text{ N}$$

∴ **Efficiency of the joint,**

$$\eta = \frac{\text{Least of } P_t, P_s \text{ and } P_c}{P} = \frac{21\,600}{36\,000} = 0.60 \text{ or } 60\%$$

2. Efficiency of the second joint

Pitch, $p = 65 \text{ mm}$

(i) *Tearing resistance of the plate,*

We know that the tearing resistance of the plate per pitch length,

$$P_t = (p - d) t \times \sigma_t = (65 - 20) 6 \times 120 = 32\,400 \text{ N}$$

(ii) *Shearing resistance of the rivets*

$$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 2 \times \frac{\pi}{4} (20)^2 90 = 56\,556 \text{ N}$$

(iii) *Crushing resistance of the rivet*

$$P_c = n \times d \times t \times \sigma_c = 2 \times 20 \times 6 \times 180 = 43\,200 \text{ N}$$

∴ Strength of the joint

$$= \text{Least of } P_t, P_s \text{ and } P_c = 32\,400 \text{ N}$$



Class: 3rd

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We know that the strength of the unriveted or solid plate,

$$P = p \times t \times \sigma_t = 65 \times 6 \times 120 = 46\,800 \text{ N}$$

∴ Efficiency of the joint,

$$\eta = \frac{\text{Least of } P_t, P_s \text{ and } P_c}{P} = \frac{32\,400}{46\,800} = 0.692 \text{ or } 69.2\%$$

Homework

A double riveted double cover butt joint in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. The permissible stresses are : $\sigma_t = 120 \text{ MPa}$; $\tau = 100 \text{ MPa}$; $\sigma_c = 150 \text{ MPa}$ Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.