Chapter-8
Rivetted Joints

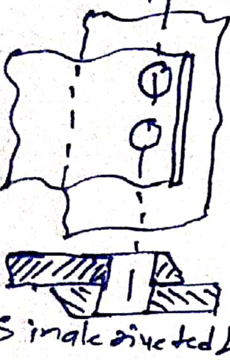
Types of Riveted joints-

① Lap joint- A Lap joint is that in which one plate overlaps the other and the two plates are rivetted together.

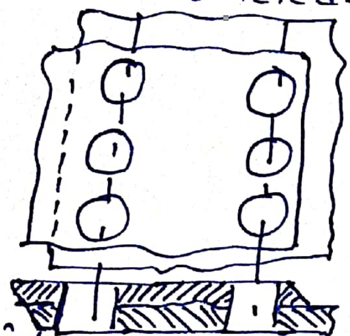
② Butt joint- A Butt joint is that in which the main plates are kept in alignment butting (i.e. touching) each other and a cover plate (strap) is placed either on one side or on both sides of the main plates. Butt joints are following two types-

Ⓐ 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.

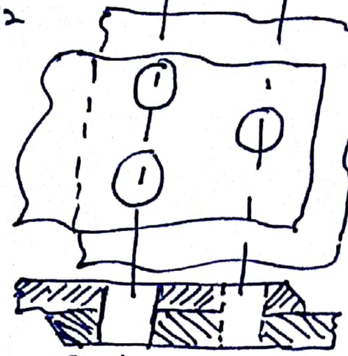
Ⓑ Double strap butt joint- The edges of the main plates butt against each other and two cover plates are placed on both sides of main plates and then riveted together



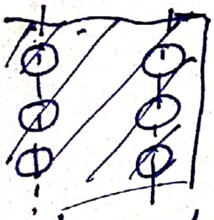
Single riveted Lap joint

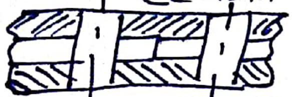


Double riveted Lap joint (Chain riveting)



Double riveted Lap joint (Zig Zag riveting)





Single riveted double strap joint (Butt)

Important Terms Used in Riveted joints-

① Pitch- It is the distance from the centre of one rivet to the centre of the next rivet measured parallel to the seam.

② Back pitch- It's perpendicular distance between the centre lines of the successive rows.

③ Diagonal pitch- It is the distance between the centres of the rivets in adjacent rows of zig-zag riveted joints

④ Margin or marginal pitch- It is the distance between the centre of rivet hole to the nearest edge of the plate.

Q-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 min^m force per pitch which will rupture the joint.

If the above joint subjected to a load such that the FOS is 4. Find out the actual stresses developed in the plates and rivets.

Solution- Given $t = 15\,mm$, $d = 25\,mm$, $p = 75\,mm$

$\sigma_{tu} = 400\,MPa = 400\,N/mm^2$, $\tau_u = 320\,MPa = 320\,N/mm^2$

$\sigma_{cu} = 640\,MPa = 640\,N/mm^2$

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Minimum force per pitch which will rupture the joint
Taking ultimate stresses under consideration -

From table 6.1 page 58

$P_{tu} = (P-d) t \times \sigma_{tu} = (75-25) 15 \times 400 = 300000 N$

$P_{su} = n \frac{\pi}{4} d^2 \tau_u = 2 \times \frac{\pi}{4} \times (25)^2 \times 320 = 314200 N$

$P_{cu} = n \times d \times t \times \sigma_{cu} = 2 \times 25 \times 15 \times 640 = 480000 N$

Minimum force per pitch which will rupture the joint 300000 N or 300 kN.

Actual stresses produced in the plates and rivets -

Since the FOS is 4 then the safe load per pitch length of the joint $= 300000/4 = 75000 N$

Actual tearing resistance of the plates (P_{ta})

$75000 = (p-d) t \sigma_{ta} = (75-25) 15 \sigma_{ta} = 750 \sigma_{ta}$

$\sigma_{ta} = \frac{75000}{750} = 100 N/mm^2 = 100 MPa$

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

$75000 = n \times \frac{\pi}{4} \times d^2 \times \tau_a = 2 \times \frac{\pi}{4} \times (25)^2 \times \tau_a = 982 \tau_a$

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

Actual crushing resistance of the rivets (P_{ca})

$75000 = n \times d \times t \times \sigma_{ca} = 2 \times 25 \times 15 \times \sigma_{ca} = 750 \sigma_{ca}$

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

Q.2 - Find the efficiency of the following rivited joints:

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

Permissible tensile stress in plate = 120 MPa

Permissible shearing stress in rivets = 90 MPa

Permissible crushing stress in rivets = 180 MPa

Given $t = 6 mm$, $d = 20 mm$, $\sigma_t = 120 MPa = 120 N/mm^2$, $\tau = 90 MPa = 90 N/mm^2$, $\sigma_c = 180 MPa = 180 N/mm^2$

Solution - Efficiency of single rivited lap joint.

Given $p = 50 mm$

From table 6.1 page 58 design data book -

1. Tearing resistance of the plate

$P_t = (p-d) t \times \sigma_t = (50-20) \times 6 \times 120 = 21600 N$

2. Shearing resistance of the plate

$P_s = \frac{\pi}{4} \times d^2 \times \tau = \frac{\pi}{4} \times (20)^2 \times 90 = 28278 N$

3. Crushing resistance of the rivet

$P_c = d \times t \times \sigma_c = 20 \times 6 \times 180 = 21600 N$

Strength of the joint
$= \text{Least of } P_t, P_s \text{ and } P_c = 21600\,N$
Strength of the unriveted or solid plate
$P = p \times t \times \sigma_t = 50 \times 6 \times 120 = 36000\,N$
Efficiency of joint
$= \eta = \frac{\text{Least of } P_t, P_s \text{ and } P_c}{P} = \frac{21600}{36000} = 0.600 \text{ or } 60\%$

Efficiency of Double riveted Lap joint -

① Tearing resistance of the plate
$P_t = (p-d) \times t \times \sigma_t = (65-20) \times 6 \times 120 = 32400\,N$

② Shearing resistance of the rivets
$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 2 \times \frac{\pi}{4} \times (20)^2 \times 90 = 56556\,N$

③ Crushing resistance of the rivets
$P_c = n \times d \times t \times \sigma_c = 2 \times 20 \times 6 \times 180 = 43200\,N$

Strength of the joint
$= \text{Least of } P_t, P_c \text{ and } P_s = 32400\,N$
Strength of the unriveted or solid plate
$P = p \times t \times \sigma_t = 65 \times 6 \times 120 = 46800\,N$
Efficiency of the joint
$\eta = \frac{\text{Least of } P_t, P_s \text{ and } P_c}{P} = \frac{32400}{46800} = 0.692 \text{ or } 69.2\%$

Q.3 A double riveted double cover butt joint in plates 20mm thick is made with 25mm dia. rivets at 100 mm pitch. The permissible stresses are
$\sigma_t = 120\,mPa,\ \tau = 100\,mPa,\ \sigma_c = 150\,mPa.$
Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.

Solution: Given $t = 20mm,\ d = 25mm,\ p = 100mm$
$\sigma_t = 120\,mPa = 120\,N/mm^2,\ \tau = 100\,mPa = 100\,N/mm^2,\ \sigma_c = 150\,mPa = 150\,N/mm^2.$

From table 6.1 page 58 from design data book

① Tearing resistance of plate per pitch length
$P_t = (p-d) \times t \times \sigma_t = (100-25)20 \times 120 = 180000\,N$

② Shearing resistance of the rivets
$P_s = n \times 2 \times \frac{\pi}{4} \times d^2 \times \tau = 2 \times 2 \times \frac{\pi}{4} \times (25)^2 \times 100 = 196375\,N$

③ Crushing resistance of the rivets
$P_c = n \times d \times t \times \sigma_c = 2 \times 25 \times 20 \times 150 = 150000\,N$

Strength of joint $= \text{Least of } P_t, P_s \text{ and } P_c$
$= 150000\,N.$

Efficiency of the joint -
Strength of the unriveted or solid plate
$P = p \times t \times \sigma_t = 100 \times 20 \times 120 = 240000\,N$
Efficiency of the joint
$= \frac{\text{Least of } P_t, P_s \text{ and } P_c}{P} = \frac{150000}{240000} = 0.625 \text{ or } 62.5\%$

Q-4 A double riveted lap joint with zig-zag riveting is to be designed for 13mm thick plates, Assume
$\sigma_t = 80 MPa$, $\tau = 60 MPa$ and $\sigma_c = 120 MPa$
State how the joint will fail and find the efficiency of the joint.

Solution- $t = 13mm$, $\sigma_t = 80MPa = 80 N/mm^2$, $\tau = 60MPa = 60 N/mm^2$, $\sigma_c = 120 MPa = 120 N/mm^2$.

① Diameter of Rivet

$d = 6\sqrt{t} = 6\sqrt{13} = 21.6 mm$

From page No.-63 table No.-6.3 the
d = Standard Size of the rivet hole = 23mm and the corresponding diameter of the rivet is 22mm

② Pitch of rivets

p = Pitch of the rivets

From page No.-58 table No.-6.1

$P_t = (p-d)t \times \sigma_t = (p-23) \times 13 \times 80 = (p-23) \times 1040 N$

$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 2 \times \frac{\pi}{4} \times (23)^2 \times 60 = 49864 N$

$p - 23 = \frac{49864}{1040} = 48$

$p = 71mm$

From table 6.2 page 60

$P_{max} = 2.6d + 15$
$= 2.6 \times 23 + 15$
$= 74.8mm$

Since $P_{max} > p$ therefore we will adopt
$p = 71mm$

③ Back pitch P_b
$= 2d = 46mm$

④ Margin: $m = 1.5d = 1.5 \times 23 = 34.5 \approx 35mm$

Failure of joint

$P_t = (p-d) \times t \times \sigma_t = (71-23) \times 13 \times 80 = 49920 N$

$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 2 \times \frac{\pi}{4} \times (23)^2 \times 60 = 49864 N$

$P_c = n \times d \times t \times \sigma_c = 2 \times 23 \times 13 \times 120 = 71760 N$

The least of P_t, P_s & P_c is $P_s = 49864 N$. Hence the joint will fail due to shearing of the rivets.

Efficiency of the joint

$\eta = \frac{P_s}{P} = \frac{49864}{73840} = 0.675 = 67.5\%$

Q-5 Two plates of 7mm thick are connected by a triple riveted lap joint of zig-zag pattern. Calculate the rivet diameter, rivet pitch and distance between rows of rivets for the joint. Also state the mode of failure of the joint. The safe working stresses are as follows-
$\sigma_t = 90\,MPa$, $\tau = 60\,MPa$ and $\sigma_c = 120\,MPa$

Solution - From table 6.1 page 58 from design data book
Given $t = 7mm$, $\sigma_t = 90\,MPa = 90\,N/mm^2$, $\tau = 60\,MPa = 60\,N/mm^2$
$\sigma_c = 120\,MPa = 120\,N/mm^2$

$$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 3 \times \frac{\pi}{4} \times d^2 \times 60 = 141.4 d^2\,N \quad -①$$

$$P_c = n \times d \times t \times \sigma_c = 3 \times d \times 7 \times 120 = 2520 d\,N \quad -②$$

Equating both the equations -

$$141.4 d^2 = 2520 d$$

$$d = \frac{2520}{141.4} = 17.8mm$$

From table 6.3 page 63 from design data book
Standard dia. of rivet hole (d) is 19mm and corresponding diameter of rivet is 18mm

Pitch of rivets - p = Pitch of rivets

$$P_t = (p-d) \times t \times \sigma_t = (P-19) \times 7 \times 90 = 630(p-19)\,N \quad -③$$

$$P_s = 141.4 d^2 = 141.4 (19)^2 = 51045\,N \quad -④$$

Equating both the equations

$$630(P-19) = 51045$$

$$P - 19 = \frac{51045}{630} = 81$$

$$\boxed{P = 100mm}$$

From table 6.2 ~~page~~ 60 from design data book

$$P_{max} = 3d + 22$$
$$= 3 \times 19 + 22$$
$$= 79mm$$

As P_{max} is less than p therefore we will adopt $p = P_{max} = 79mm$

Distance between the rows of rivets for zigzag pattern

$$P_b = 2d = 2 \times 19 = 38mm$$

$$\boxed{P_b = 38mm}$$

Mode of failure of the joint -

$$P_t = (P-d) t \times \sigma_t = (66-19) \times 7 \times 90 = 29610\,N$$

$$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 3 \times \frac{\pi}{4} \times (19)^2 \times 60 = 51045\,N$$

$$P_c = n \times d \times t \times \sigma_c = 3 \times 19 \times 7 \times 120 = 47880\,N$$

From above we see that P_t is less than P_s and P_c. Therefore joint fail due to tearing off the plate

Q-6 Two plates of 10mm thickness each are to be joined by means of a single riveted double strap butt joint. Determine the rivet diameter, rivet pitch, strap thickness and efficiency of the joint. Take the working stresses in tension and shearing as 80 MPa and 60 MPa respectively.

Given $t = 10mm$, $\sigma_t = 80 MPa = 80 N/mm^2$, $\tau = 60 MPa = 60 N/mm^2$

Diameter of rivet $d = 6\sqrt{t} = 6\sqrt{10} = 18.97mm$

From table 6.3 page 63 standard diameter of rivet hole (d) is 19mm and corresponding diameter of the rivet is 18mm

Pitch of rivets -

$P_t = (P-d) \times t \times \sigma_t$

$= (P-19) \times 10 \times 80 = (P-19) 800N$ — (1)

$P_s = n \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau$

$= 1 \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau$

$= 1 \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau$

$= 31900N$ — (2)

Equating (1) and (2)

$(P-19) 800 = 31900$

$p = 58.87mm \cong 60mm$

P_{max} (From table 6.2 page 60)

$P_{max} = 3.5d + 15$

$= 81.5mm$

Since p is less than P_{max} we will select

$P = P_{max} = 60mm$

Thickness of cover plates

Eq. (6.2c) page 61 } $t_1 = 0.625t = 0.625 \times 10 = 6.25mm$

Efficiency of the joint -

$P_t = (p-d)t \times \sigma_t = (60-19) \times 10 \times 80 = 32800N$

$P_s = n \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau = 1 \times 1.875 \times \frac{\pi}{4} \times (19)^2 \times 60$

$= 31900N$

Strength of the joint

$=$ Least of P_t and P_s $= 31900N$

$P = p \times t \times \sigma_t = 60 \times 10 \times 80 = 48000N$

Efficiency of the joint

$\eta = \frac{\text{Least of } P_t \text{ and } P_s}{P} = \frac{31900}{48000} = 0.6650 = 66.5\%$

Q.7 Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5m in diameter subjected to a steam pressure of $0.95 N/mm^2$. Assume joint efficiency as 75% allowable tensile stress in the plate 90MPa, compressive stress 140MPa, shear stress in the rivet 56MPa.

Given $D = 1.5m = 1500mm$, $P = 0.95 N/mm^2$; $\eta = 75\% = 0.75$, $\sigma_t = 90mPa = 90 N/mm^2$, $\sigma_c = 140mPa = 140 N/mm^2$; $\tau = 56mPa = 56 N/mm^2$

① Thickness of boiler shell plate

~~t = P.D~~ From page 61 equation 6.1

$$t = \frac{pD}{2\sigma_t \times \eta} + 0.1cm$$

$$= \frac{pD}{2\sigma_t \times \eta} + 1mm$$

$$= \frac{0.95 \times 1500}{2 \times 90 \times 0.75} + 1 = 11.6 \cong 12mm$$

② Diameter of rivet

$$d = 6\sqrt{t} = 6\sqrt{12} = 20.8mm$$

From table 6.3 page 63 the standard dia. of rivet hole (d) is 21mm and the corresponding diameter of the rivet is 20mm

p: Pitch of rivets

$$P_t = (p-d) \times t \times \sigma_t = (p-21) \times 12 \times 90$$

$$P_t = 1080(p-21) N \quad — ①$$

$$P_s = n \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau$$

$$= 2 \times 1.875 \times \frac{\pi}{4} \times (21)^2 \times 56 N$$

$$P_s = 72745 N$$

$$1080(p-21) = 72745$$

$$p - 21 = \frac{72745}{1080} = 67.35$$

$$p = 67.35 + 21 = 88.35 \text{ say } 90mm$$

$$P_{max} = 3.5d + 15$$

$$= 3.5 \times 19 + 15$$

$$P_{max} = 81.5mm$$

The value of p is more than P_{max} therefore we we adopt

$$P_{max} = p = 81.5mm$$

③ Distance between two rows

$$P_b = 2d = 2 \times ~~19~~ \; 42mm$$

④ Thickness of cover plates.

$$t_1 = 0.625t = 0.625 \times 12 = 7.5mm$$

⑤ margin $m = 1.5d = 1.5 \times 21 = 31.5 \cong 32mm$

$$P_t = (p-d) \times t \times \sigma_t = (84-21) \times 12 \times 90 = 68040 N$$

$$P_s = n \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau$$

$$= 2 \times 1.875 \times \frac{\pi}{4} \times (21)^2 \times 56 = 72745 N$$

$$P_c = n \times d \times t \times \sigma_c = 2 \times 21 \times 12 \times 140 = 70560 N$$

P_t is the strength value of the joint

$$P_t = 68040 N$$

$$P = p \times t \times \sigma_t = 84 \times 12 \times 90 = 90720 N$$

⑥ Efficiency of the joint

$$\eta = P_t/P = 68040/90720 = 0.75 \text{ or } 75\%$$