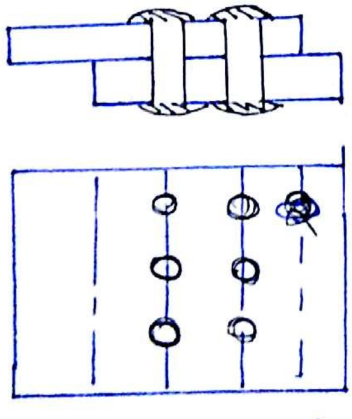
* Riveted Joint *

Joint

- Temporary Joint
  - cotter Joint
  - key Joint
  - bolted Joint
  - Screwed Joint
- Permanent Joint
  - Riveted Joint
  - Welded joint.

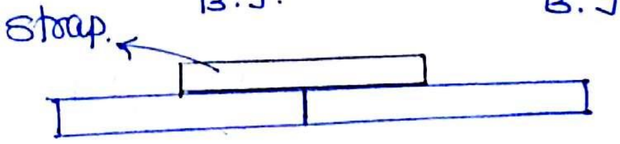
Riveted Joint

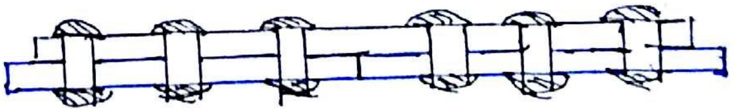
- lap Joint
- Butt Joint.
  - Single Strap B.J.
  - Double Strap B.J.



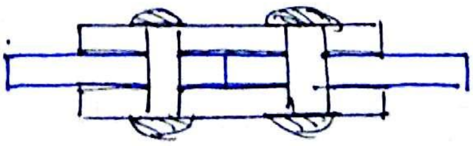
Double raw lap joint

D.R.L.J.

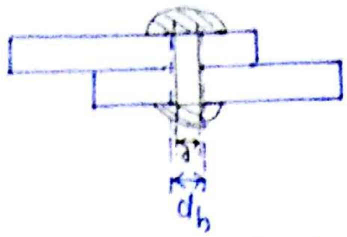




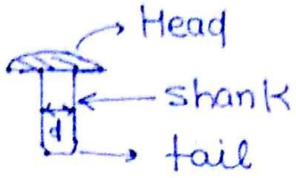
torsory raw ~~Sig~~ single strap BJ



single raw double strap. B.J.



d_h = ~~hode~~ dia
hole



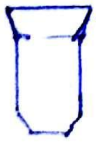
Riveted = shank dia 'd'

- For the safe design of rivet shank dia 'd' will be taken in consideration and for the safe design of plate hole dia 'd_h' will be taken in consideration.

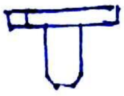
Riveted joint = Rivet + Plate

← Snap head
Used in boilers.
~~Strong~~
Strong in fatigue
& Impact

Pan head
Strength max^m
Manufacturing difficut
Ship builds, boilers.
Coresive ~~sto~~ resistance is
more.



→ Counter
sunk
Manf. simple
(under water work)



Flat head
Thin Plate or
structural work.

By Unwin's Formula

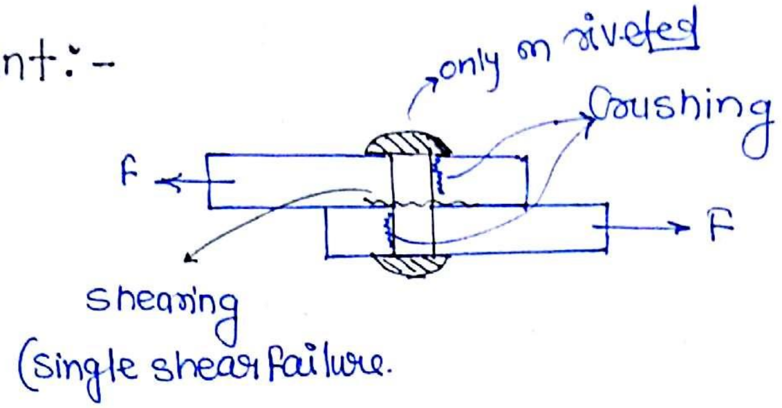
~~Joint~~ Shank diameter $d = 6\sqrt{t}$ (d ↓ mm, t ↑ mm)

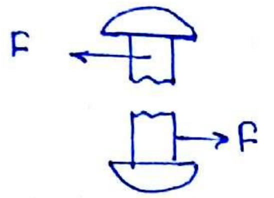
t = thickness of plate

Types of Failure :-

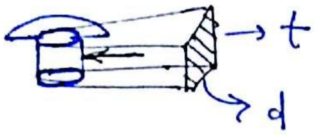
Lap joint
→ shear &
→ crushing

Lap Joint :-





$$\left(\tau_{ind}\right)_{shear} = \frac{F}{\frac{\pi}{4}d^2}$$

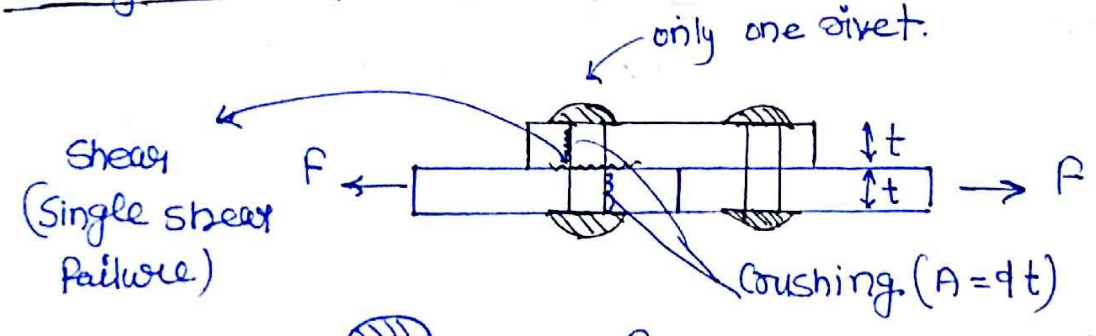


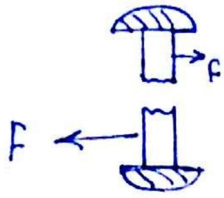
$$\left(\sigma_{ind}\right)_{crushing} = \frac{F}{dt}$$ ← projected area.

Butt Joint :-

single strap
→ shear &
→ crushing

Single strap :-



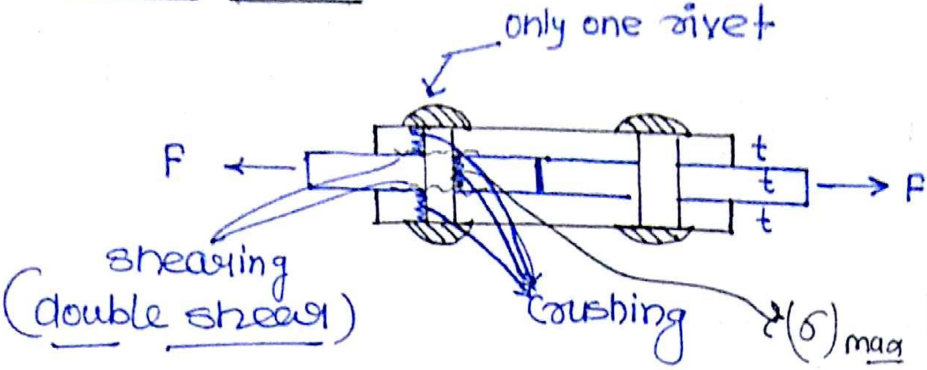


$$\tau_{ind} = \frac{F}{\frac{\pi}{4}d^2}$$

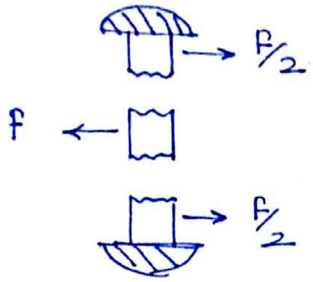
$$\left(\sigma_{ind}\right)_{\underrightarrow{crushing}} = \frac{F}{dt}$$

double strap
- → double shear
- - Crushing.

Double strap



σ_{max} in middle part.



$$\tau_{ind} = \frac{F}{2 \cdot \frac{\pi}{4} d^2}$$

Crushing

$$(\sigma_{ind})_{\substack{crush \\ max}} = \frac{f}{dt}$$

$$\boxed{(\tau_{ind})_{Shear} = \frac{F}{k \cdot \frac{\pi}{4} d^2}}$$

$$\boxed{(\sigma_{ind})_{crush} = \frac{F}{dt}}$$

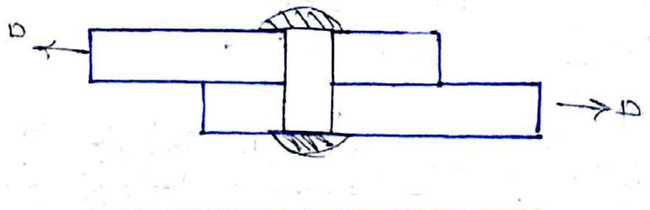
k = 1 Single Shear

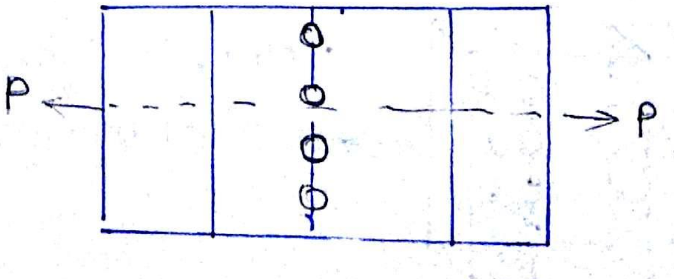
k = 2 double shear

for all Riveted joint.

Design of Riveted Joint :→

Case-1 :- Finite ~~Rie~~ Riveting :-





$$F_{rivet} = \frac{P}{4}$$

↳ load

shear design of Rivet :-

$$\tau_{ind} = \frac{P}{4k\frac{\pi}{4}d^2}$$

safe cond^n

$$\frac{P}{4\cdot k\cdot\frac{\pi}{4}d^2} \le \sigma_{per.}$$

shear strength of Riveted joint

$$\boxed{P_{max} = 4\cdot k\cdot\frac{\pi}{4}d^2\,\sigma_{per.}}$$

↓ no. of rivets.

Crushing design of Rivet.

$$\sigma_{ind} = \frac{P}{4.dt}$$

safe cond^n

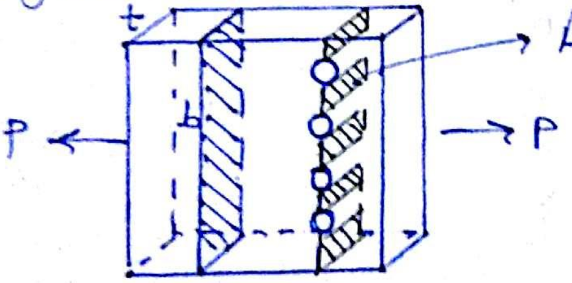
$$(\sigma_{ind})_{crush} \le \sigma_{per.}$$

$$\frac{P}{4dt} \le \sigma_{per.}$$

Crushing strength of Rivet.

$$\boxed{P_{max} = 4dt\,\sigma_{per.}}$$

☆ Tearing/tension strength of joint/Plate



$A_{min} \Rightarrow \sigma_{max}$

→ Minimum area

$$(\sigma_{ind})_{max\ tearing} = \frac{P}{(b-4d_h)t}$$

Consider hole dia. d_h

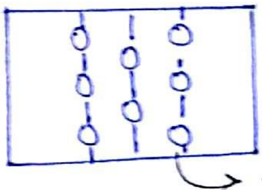
safe condⁿ.

$$(\sigma_{ind})_{max} \leq \sigma_{per.}$$

$$\frac{P}{(b-4d_h)t} \leq \sigma_{per.}$$

tearing strength of Rivet.

$$\boxed{P_{max} = (b-4d_h)t \cdot \sigma_{per.}}$$



take min area.

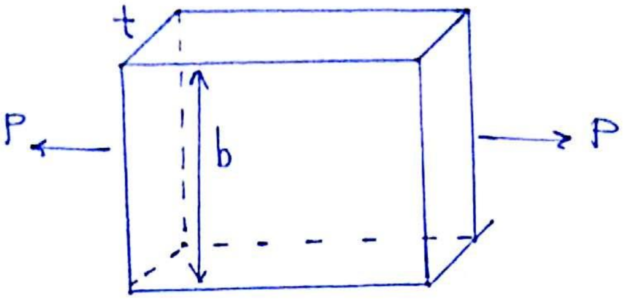
Actual strength of Riveted joint =

$$= \min \text{ of } \left[(P_{max})_{shearing}, (P_{max})_{crush}, (P_{max})_{tearing} \right]$$

Actual strength of Rivet =

$$= \min \text{ of } \left[(P_{max})_{shear}, (P_{max})_{crush} \right]$$

strength of solid plate :-



$$\sigma_{ind} = \frac{P}{bt}$$ Best possible joint.

$$P_{\substack{max\\solid}} = bt\,\sigma_{per}$$

rivet

$$\eta_{shearing} = \frac{(P_{max})_{shear}}{(P_{max})_{solid}} = \frac{4.K.\frac{\pi}{4}d^2.\tau_{per}}{bt\,\sigma_{per}.}$$ → plate.

Rivet

$$\eta_{crushing} = \frac{(P_{max})_{crush}}{(P_{max})_{solid}} = \frac{4\,d\cancel{t}\,[\sigma_{per}]}{b\cancel{t}\,[\sigma_{per}]}$$ → plate

Plate

$$\therefore\ \eta_{tearing} = \frac{(P_{max})\ tearing}{(P_{max})_{solid}} = \frac{(b-4d_h)t\,.\sigma_{per}}{bt\ \sigma_{per}.}$$ → Plate

$$\eta_{tearing.} = 1 - \frac{4d_h}{b}$$

$$\eta_{actual} = \text{min of } [\eta_{shearing}, \eta_{crushing}, \eta_{tearing}]$$

Q.312

② =

3.12 $(P_{max})_{crush} = 3dt\,\sigma_{per.} = 3\times10\times5\times$

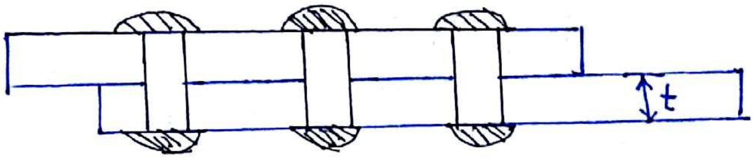
3.13 $(P_{max})_{tearing} = (w-3d_h)\times t\times\sigma_{per}$

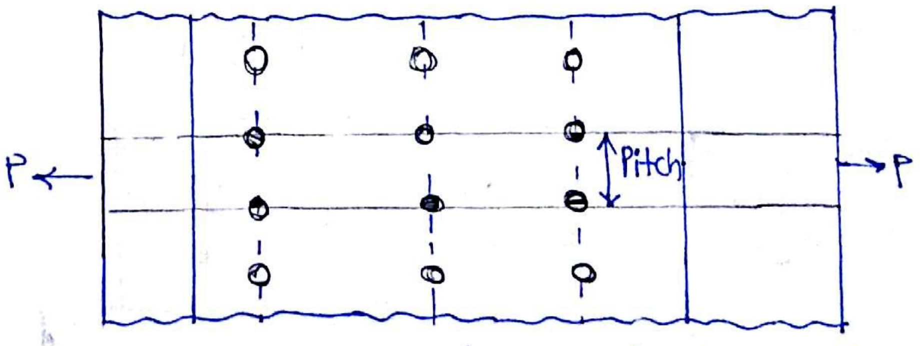
Q.3.14 $P = 19\text{ KN}$

$$\frac{200\times10^6}{2} \geq \frac{19\times10^3}{3\times\frac{\pi}{4}\times d^2}$$

$d = 10\text{ mm}$

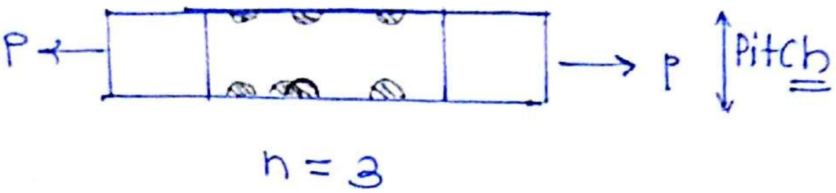
Case-2 ~~Ri~~ Infinite Riveting

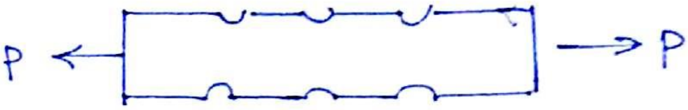




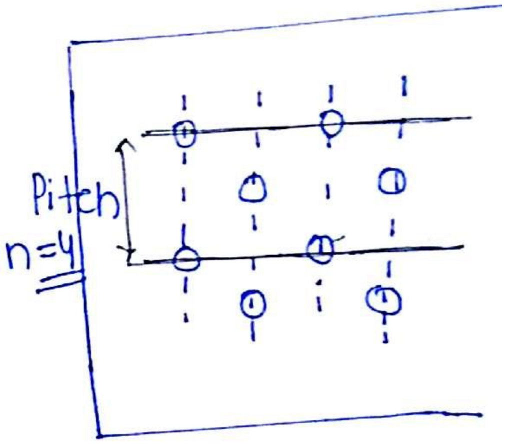
n = no. of ~~pitch~~ Rivet per pitch length

n = 3





$$(P_{max})_{shear} = n.K.\frac{\pi d^2}{4}\tau_{per}.$$



$$(P_{max})_{crush} = n d t \, \sigma_{per}.$$

$$(P_{max})_{tearing} = (p - d_h) t . \sigma_{per}.$$

$$(P_{max})_{solid} = p.t.\sigma_{per}.$$

$$\eta_{shear} = \frac{n.K.\frac{\pi d^2}{4}.\tau_{per}}{p.t.\sigma_{per}} \; ; \; \eta_{crush} = \frac{n d t \, \sigma_{per}}{p t \, \sigma_{per}}$$

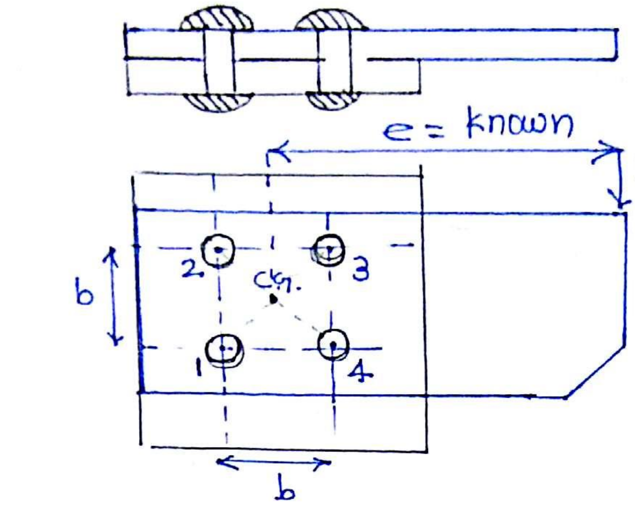
$$\boxed{\eta_{tearing} = \frac{(p - d_h) t \, \sigma_{per}}{p t . \sigma_{per}}}$$ Imp

Case-3

Imp $$\boxed{\eta_{tearing} = 1 - \frac{d_h}{p}}$$ p - pitch

V.V. Imp Gate 2017

Case-3



step ① Find out the c.G. of Group of rivets.

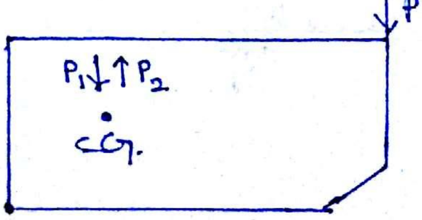
$$\bar{x} = \frac{x_1 + x_2 + x_3 * x_4}{n}, \quad \bar{y} = \frac{y_1 + y_2 + y_3 + y_4}{n}$$

$$\bar{x} = \frac{0+0+b+b}{4} = \frac{b}{2}, \quad \bar{y} = \frac{0+b+b+0}{4} = \frac{b}{2}$$

step② Find out eccentricity

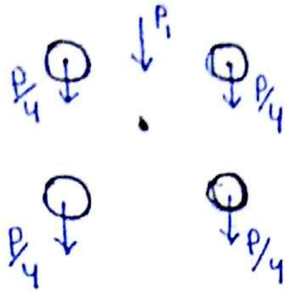
↳ dist. b/w load line of action to CG of group of rivet.

step③ Apply two equavalent ~~Fo~~ & opp. forces P₁ & P₂ Passing through ~~geo~~ CG of group of rivet, parallel to the load such that $P_1 = P_2 = P$



step ④

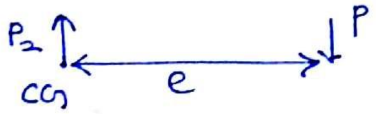
effect of P_1



= primary shear force.

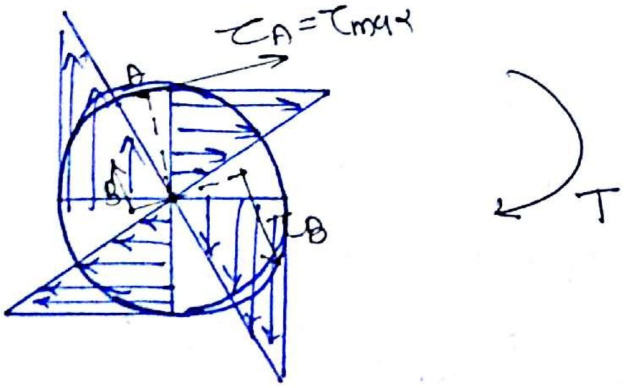
As P_1 passes through C.G. of the group to the rivet, it result primary shear force induced of equal magnitude in each rivet.

effect of P_2 & P

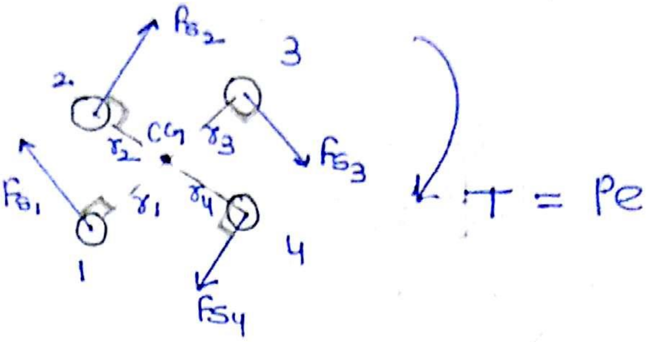


P_2 & P causes are constant twisting couple of 'Pe' in cw dirⁿ about the CG which result twisting in rivets.

twisting in shaft $\tau_{torque} \propto r$



(c) torqe $\propto r$ $\Rightarrow$ $F_s \propto r$ $\Rightarrow$ Sencondary shear Force.



$$F_{s_1}\cdot r_1 + F_{s_2}\cdot r_2 + F_{s_3}\cdot r_3 + F_{s_4}\cdot r_4 = P.e$$

$$F_s \propto r$$

$$\frac{F_{s1}}{r_1} = \frac{F_{s2}}{r_2} = \frac{F_{s3}}{r_3} = \frac{F_{s4}}{r_4} ----$$

$$\frac{F_{s_1}}{r_1}\left[r_1^2 + \frac{F_{s2}\, r_1 . r_2}{F_{s_1}} + \frac{F_{s3}\, r_{\cancel{1}} . r_3}{F_{s_1}} \;\dots \right] = Pe.$$

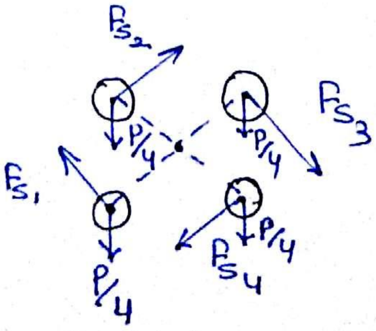
$$\frac{F_{s_1}}{r_1}\left[r_1^2 + r_2^2 + r_3^2 + r_4^2 \right] = Pe$$

F_{s_1} ~~&~~, F_{s_2} , F_{s_3}, F_{s_4} known.

if $r_1 = r_2 = r_3 = r_4$

$$F_{s_1} = F_{s_2} = F_{s_3} = F_{s_4} = \frac{P.e}{4r}$$

Combined effect (P_1 & Couple P_2 P)

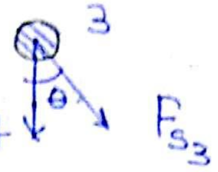


critical rivet
or worst loaded rivet

$R^2 = P^2 + Q^2 + 2PQ\cos\theta$

$\theta \downarrow \rightarrow R \uparrow$

Critical rivets are 3 & 4.



$$R_3 = \sqrt{\left(\frac{P}{4}\right)^2 + \left(F_s\right)^2 + 2 \times \frac{P}{4} \times F_{s_3} \cos\theta}$$

↳ this is the maximum shear.

$$\tau_{max} = \frac{R_3}{\frac{\pi}{4} d^2}$$

safe cond^n

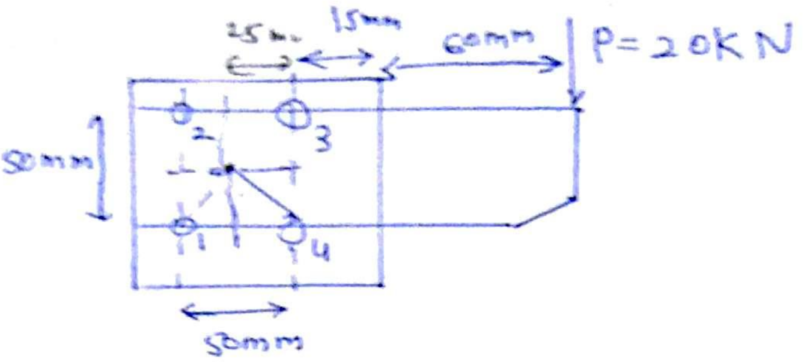
$$\tau_{max} \leq \tau_{per.}$$

$$\frac{R_3}{\frac{\pi}{4} d^2} \leq \tau_{per.}$$

$$d \geq ?$$

~~$(R_3)_{max}$~~ known.

Question



$\tau_{per} = 70\ MPa.$

$C.G. = (25, 25)$

$$P_1 = P_2 = P_3 = P_4 = \frac{20}{4} = 5KN,$$

$$\frac{f_1}{r_1}\left(r_1^2 + r_2^2 + r_3^2 + r_4^2\right) = 20\times10^{3}\times\frac{100}{1000}$$

$$\frac{f_1}{\cancel{25\sqrt{2}}}\left((25\sqrt{2})^{2}\times 4\right)\times10^{-3} = \overset{\overset{2}{\cancel{50}}}{\cancel{20}}\times 100$$

~~$f_1 = 14.14$~~ $f_1 = 14.14kN$

$$\frac{f_1}{r_1} = \frac{f_3}{r_3} \Rightarrow \underline{f_3 = f_1\,\frac{r_3}{r_1}}$$

$$R_3 = \sqrt{(5000)^2 + (14142)^2 + (5000\times14142)\times\frac{1}{\sqrt{2}}\times}$$

$$R_3 = 18.02KN$$

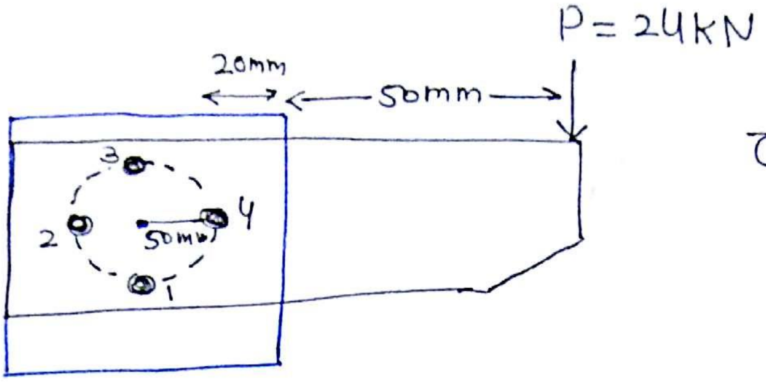
$$\frac{R_3}{\frac{\pi d^2}{4}} \leq \tau_{per}$$

$$d \geq \sqrt{\frac{\theta\tau\pi}{4R_3}}$$

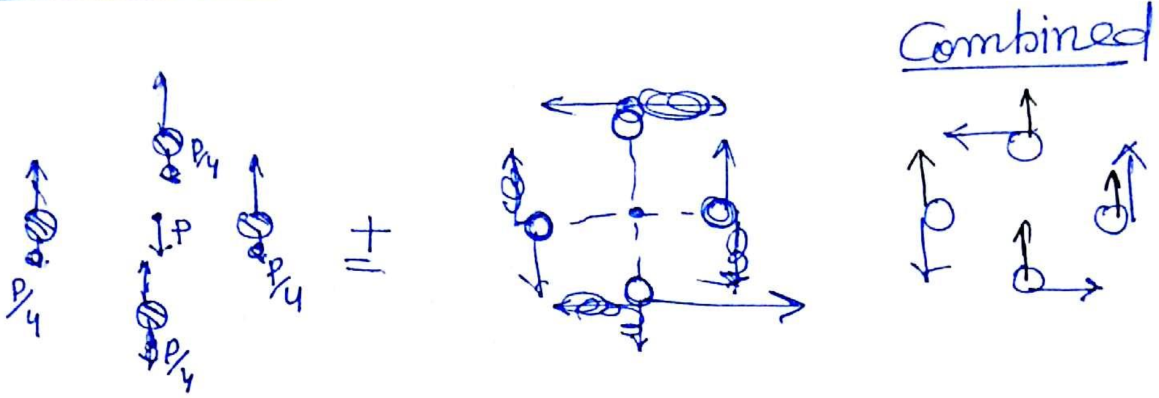
$$\geq \sqrt{\frac{70\times10^{+6}\times\pi}{4\times\cancel{14.142}\;18.08kN}}$$

$d \cong 18.1\ mm$ $\quad d = 19\ mm$

Ques



$\tau_{per} = 75\,MPa$



$$\frac{F}{r_1}\left(r_1^2+r_2^2+r_3^2+r_4^2\right) = 24 \times 120$$

$$4F(50) = 24 \times 120$$

$$F = 14.4\,kN$$

~~$R_{net} = \sqrt{\left(\frac{24}{4}\right)^2 + (14.4)^2} = 27.98$~~

$$(R_{net})_4 = 14.4 + 6 = 20.4\,KN$$

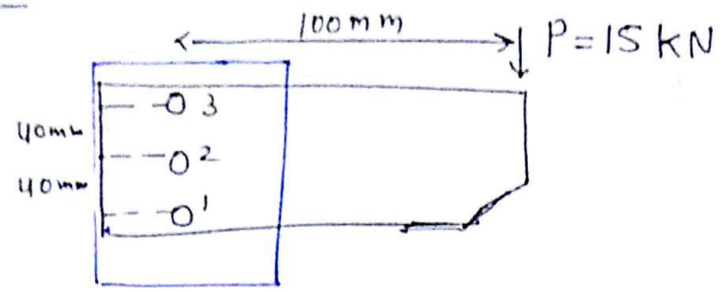
$$\frac{(R)_{max}}{\frac{\pi}{4}d^2} \le \tau_{per}$$

$$d > \sqrt{\frac{R \times 4}{\pi \times \tau}} = \sqrt{\frac{20.4 \times 4 \times 10^3}{\pi \times 75}}$$

$$d = 18.6$$

$$d = 19\,mm$$

Question



$\tau_{per} = 75 MPa$

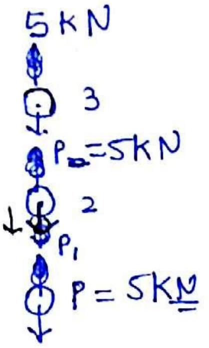
(i) Find out the critical rivet

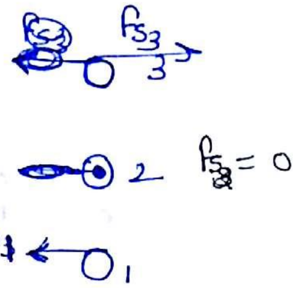
(ii) Resultant force on each rived

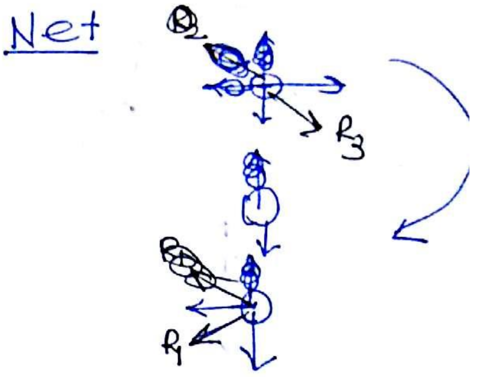
(iii) Safe dia for river.

$P_{each} = \frac{P}{3}$

$P = 5KN$







$(F_{s_3} \times 40) \times 2 = 15 \times 100$

$F_{s_3} = 18.75 KN$

$(R)_{net} = R_1 = R_3 = \underline{19.40 KN}$ $R_2 = 5 KN$

$d = \sqrt{\frac{19.40 \times 4 \times 1000}{\pi \times 75}}$

$d \geq 18.15$

$d = 19 mm$

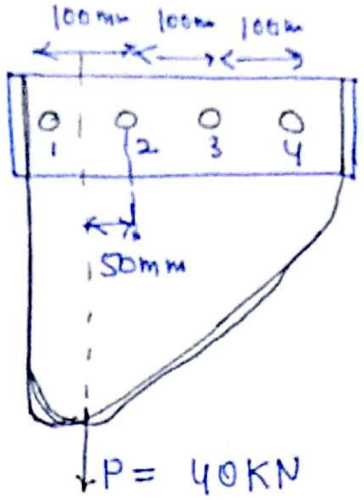
(i) 1, 3

(ii) $R_1 = R_3 = 19.40 KN$

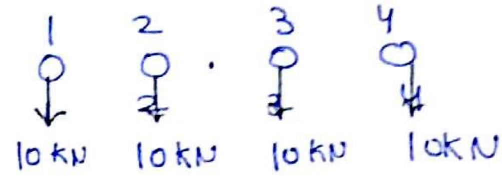
(iii) $d = 18.15 mm$

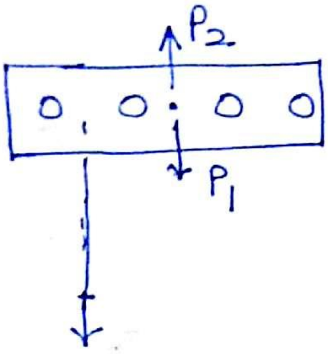
$= 19 mm$

Que



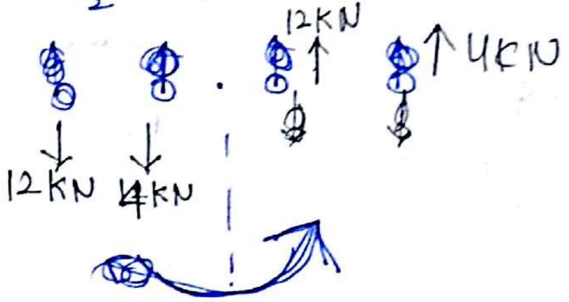
$\tau_{per} = 80$ MPa





$r_1 = 150$ mm $= r_4$

$r_2 = 50$ mm $= r_3$



T = P.e = 40×150 KN mm

$$\frac{F_{s1}}{r_1}\left(r_1^2 + r_2^2 + r_3^2 + r_4^2\right) = P.e.$$

$$\frac{F_{s1}}{150}\left(2\times150^2 + 2\times50^2\right) = 40\times150$$

$F_{s_1} = 12$ KN $\quad F_{s_2} = 12\times\frac{1}{3} = 4$KN

$F_{s_3} = 4$KN $\quad F_{s_4} = 12$KN

Net

$R_1 = 22$ KN

$R_2 = 14$ KN

$R_3 =$ 2KN

$R_4 =$ 6KN

Critical

R_1

$$d \geq \sqrt{\frac{22\times4\times10^3}{\pi\times80}}$$

d = 18.74

d = 19 mm