① — ⑥

RIVETS Questions & Solutions.

Q.1.

A double riveted double covered butt joints in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. Permissible stresses are $\sigma_t = 120\ N/mm^2$, $\tau_s = 100\ N/mm^2$ and $\sigma_{b,c} = 150\ N/mm^2$. Compute the pull per pitch length, which the joint can take and hence work out the efficiency of the joint.

Q.2.

A single riveted double cover butt joint in a structure is used for connecting two plates 12 mm thick. The diameter of the rivets is 24 mm. The permissible stresses are 120 N/mm^2 in tension, 100 N/mm^2 in single shear, 200 N/mm^2 in bearing. Calculate the necessary pitch and efficiency of the joint.

Q.3.

Fig. below shows a horizontal arm riveted to a structure support by four (4) equally spaced rivets of 12 mm diameter each. If one end of the arm is subjected to a force of 5000 N at a distance of 200 mm from the centre of the circle, calculate:

(a) The resultant load on rivet A and B.
(b) The maximum shear stress on rivet A.
(C) The maximum bearing stress on rivet A.

The thickness of the arm is 15 mm.

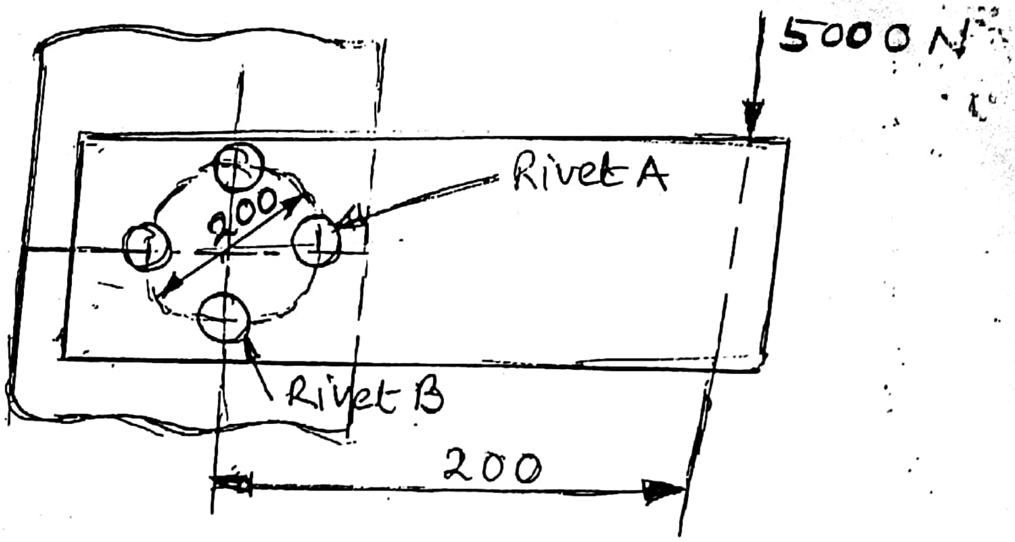


Fig:

Q.4.

The sprocket wheel of a chain drive is riveted to a hub. The chain transmits a power of 0.45 kW at 8 rpm. Determine the number of rivets necessary if the shank diameter is 8 mm. The clearance between rivet shank and rivet hole is 0.2 mm, before riveting.

$\tau_{all} = 35\ N/mm^2$, $\sigma_{c,all} = 60\ N/mm^2$.

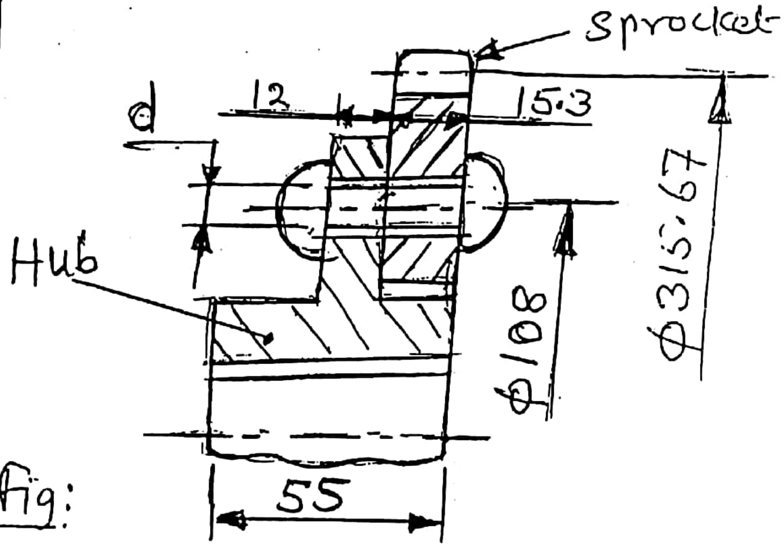


Fig:

Q.5.

On the riveted joint, shown below, is acting a force $F = 95$ kN. Six rivets are used for the joint. They have an allowable shear stress $\tau_{all} = 11{,}800\ N/cm^2$ and an allowable compressive stress $\sigma_{call} = 16{,}000\ N/cm^2$.

Calculate the necessary rivet diameter d_1 (after riveting).

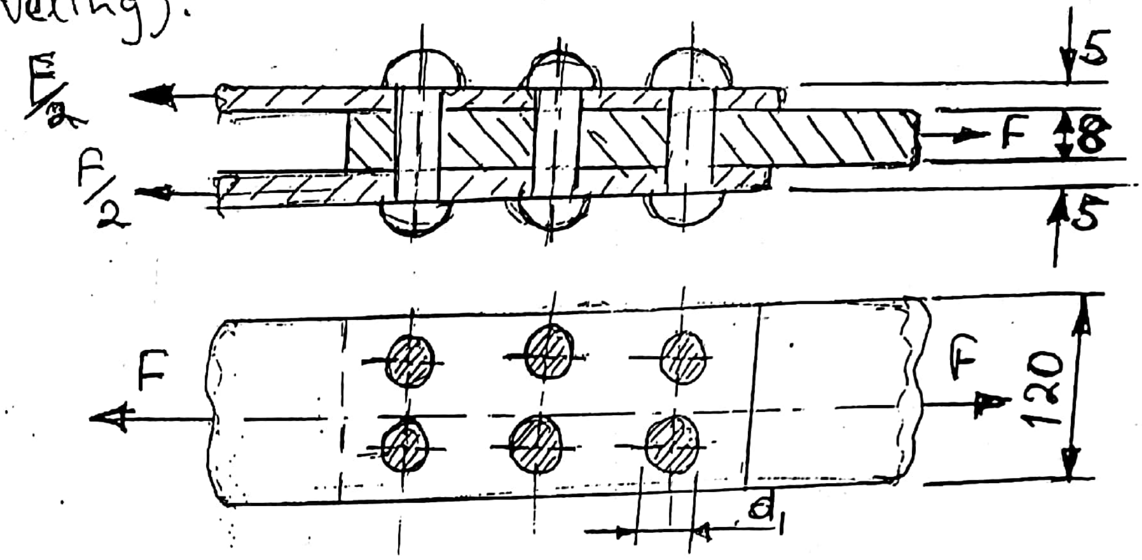


fig:

Q.6:
A double-cover ~~joint~~ butt joint is shown in fig. below. The joint has to carry a pull of 180 kN. The 10 rivets are to be used in the arrangement. The ultimate shear strength of the rivet material is 360 MN/m².
Allowing the factor of safety to be 4,
Calculate the rivets diameter.
(a) Calculate the rivet hole diameter.
(b) Calculate the rivet hole diameter.

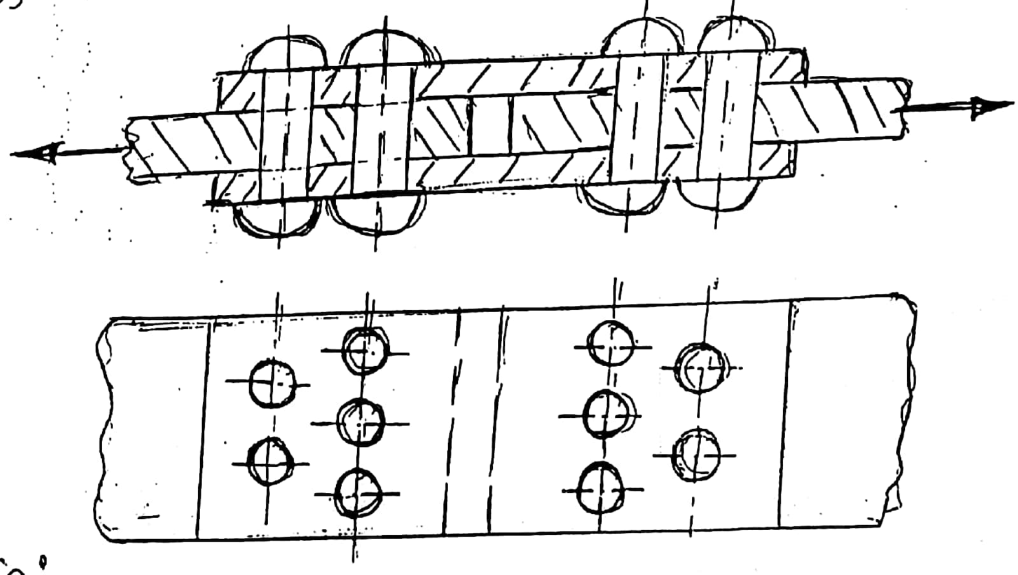


fig:

Q.7.

A lap riveted joint is shown in fig. below:-

Given: $d = 15\,mm$, $[\tau_{sh}]_{all} = 100\ N/mm^2$ for rivet

$[\sigma_t]_{all} = 200\ N/mm^2$ for plates

$F = 40\ kN$, $\delta = 8\ mm$

(a) Applying conventional seam dimensions, determine the minimum dimension b, hence dimension $t/2$ and t.

(b) Check the rivet strength and comment.

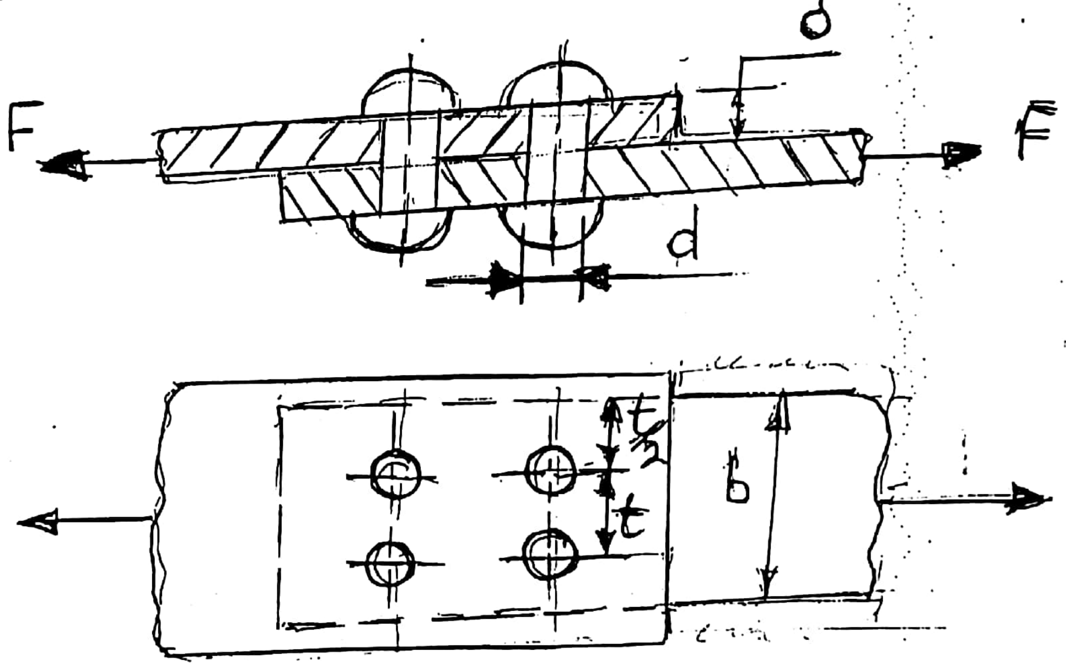
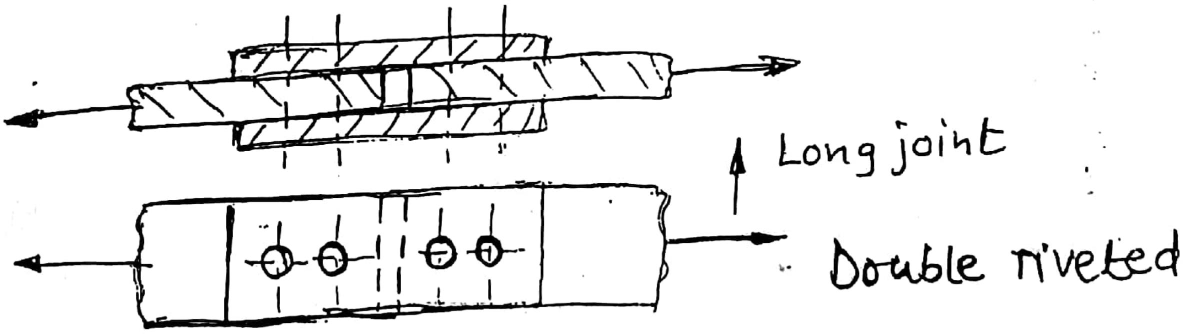


Fig:

SOLUTIONS

Q.1.



Now $t = 20$ mm, $d = 25$ mm, $p = 100$ mm,

$\sigma_t = 120\ N/mm^2$, $\tau_s = 100\ N/mm^2$, $\sigma_{b,c} = 150\ N/mm$

(a)

(i) Shearing of rivets

Strength of two rivets in double shear

$$F_s = \tau_s \cdot A_s \quad ; \quad A_s = \underset{\text{double shear}}{N \cdot 2} \cdot \frac{\pi d^2}{4}, \quad N = 2$$

$$\therefore F_s = \tau_s \cdot 2 \times 2 \times \frac{\pi d^2}{4} = 100 \times \pi (25)^2 = \underline{196350}$$

(ii) Bearing of rivets / plates.

$$F_b = \sigma_b \cdot A_b \quad , \quad A_b = N (t \cdot d) \quad , \quad N = 2$$

$$\therefore F_b = 150 (2)(20 \times 25) = \underline{150{,}000\ N}$$

(iii) Tensile failure of plates.

Tensile strength / pitch is given by :

$$F_t = \sigma_t (p - d) t \qquad \text{(one hole)}$$

$$\therefore F_t = 120 (100 - 25) 20 = \underline{180{,}000\ N}$$

Pull per pitch length is the LEAST of F_s, F_b and F_t

$\therefore$ Pull per pitch $= \underline{\underline{150{,}000\ N}}$ Ans.

(b) Efficiency of the joint

Strength of unriveted plate per pitch length 'F' is given by

$$F = \sigma_t \cdot p \cdot t$$

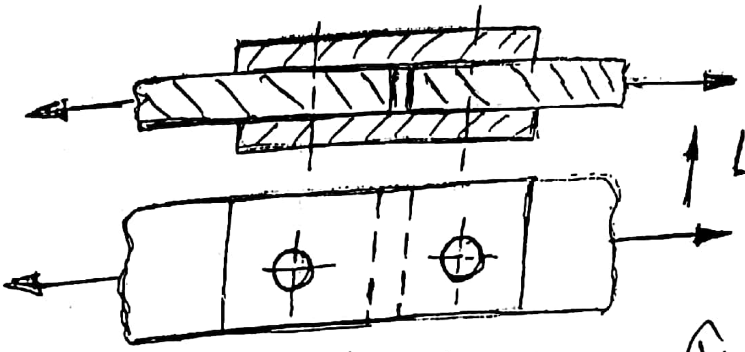
$$\therefore F = 120 (100) 20 = \underline{240{,}000\ N}$$

$$\text{Efficiency } \eta = \frac{\text{Least of } F_s, F_b \text{ and } F_t}{F}$$

$$= \frac{150{,}000}{240{,}000} = \underline{0.625}$$

$\therefore \eta = \underline{\underline{62.5\%}}$ Ans.

Q.2.



$t = 12$ mm, $d = 24$ mm, $\sigma_t = 120\ N/mm^2$

$\tau_s = 100\ N/mm^2$, $\sigma_b = 200\ N/mm^2$

(a) (i) Shearing of rivets

$F_s = \tau_s \cdot A_s$; $A_s = N \cdot 2 \cdot \frac{\pi d^2}{4}$, N=1 one row

double shear

$\therefore F_s = 100(1) \cdot 2 \cdot \frac{\pi}{4}(24)^2 = 90{,}480\ N$

(ii) Bearing of rivets / plates.

$F_b = \sigma_b \cdot A_b$; $A_b = N(t \times d)$; $N=1$

$\therefore F_b = 200(1)(12)24 = 57{,}600\ N$

$\therefore$ Strength of the rivet – Rivet value

$F_v = 57{,}600\ N$

(iii) Tensile failure of plates.

The strength per pitch is given by

$F_t = \sigma_t (p-d)t$

$= 120(p-24)12\ N$

$\therefore F_t \geq F_v$ or $F_{t_{min}} = F_v$

$\therefore 120(p-24)12 = 57{,}600$

$\therefore P_{min} = 64$ mm minimum pitch

but generally $2.5d < p < 4d$

with $d = 24$mm $\therefore 60 < p < 96$ mm

$\therefore p = 64$ mm is O.K.

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Also $p_{min} = 2d + 12 = 60$ mm

again $p = 64$ mm O.K. take $p = 65$ mm.

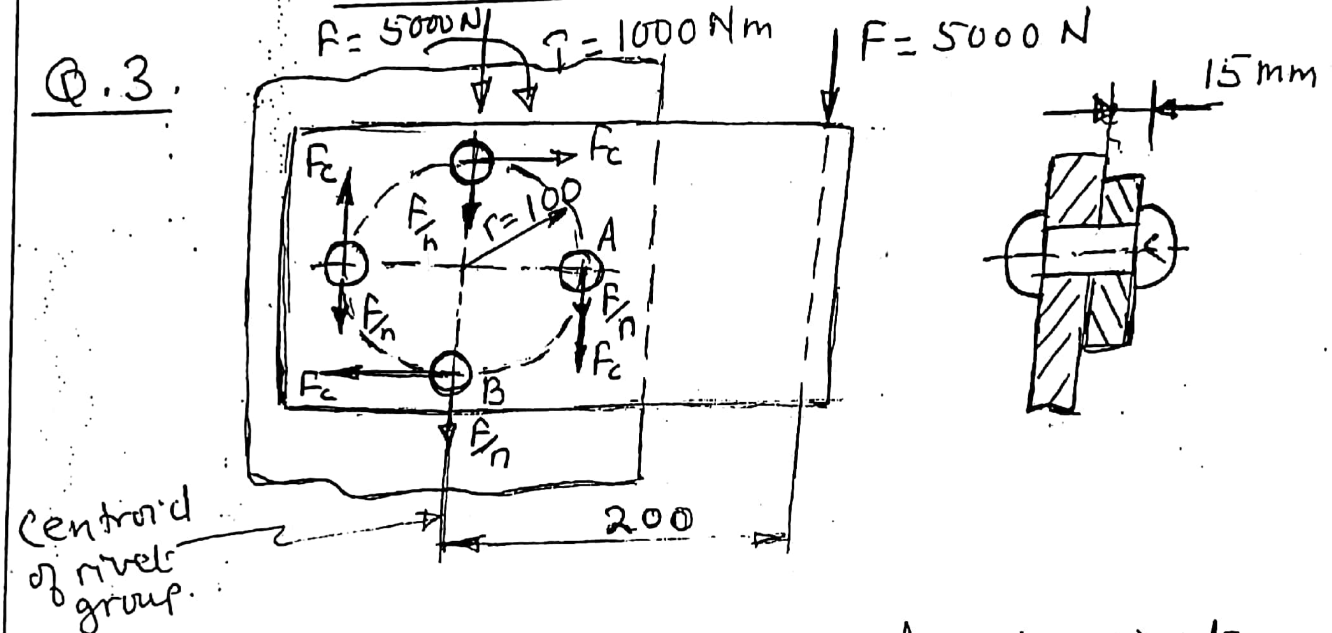
$\therefore$ The required pitch $= 65$ mm Ans.

(b) Efficiency of the joint

$$\eta = \frac{p-d}{p} \quad \therefore \eta = \frac{65-24}{65} = 0.6308$$

$\therefore$ Efficiency $= 63.08\%$ Ans.

Q.3.



Resultant load to the centroid of the rivet group is $F = 5000$ N and a couple $T = F \times 200$

$\therefore T = 1000$ Nm.

$r = 100$ mm, radius of each rivet from centre.

$\therefore r_i^2 = 0.01\ m^2$, $\Sigma r_i^2 = 0.04\ m^2$; 4 rivets.

Direct load to each rivet $F_d = \frac{F}{n} = \frac{5000}{4} = 1250$ N

Couple Loads.

Rivet A $\quad F_{CA} = \frac{T \cdot r_A}{\Sigma r_i^2} = \frac{1000(0.1)}{0.04} = 2500$ N

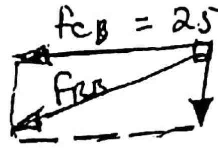
Rivet B $\quad F_{CB} = 2500$ N also

(a) Resultant Loads on rivets A and B

(i) $\vec{F}_{RA} = \vec{F}_{dA} + \vec{F}_{CA}$

$\therefore F_{RA} = 1250 + 2500 = \underline{\underline{3,750\text{ N}}}$ Ans.

(ii) $\vec{F}_{RB} = \vec{F}_{dB} + \vec{F}_{CB}$



$\therefore |\vec{F}_{RB}| = \sqrt{2500^2 + 1250^2} = \underline{\underline{2795.08\text{ N}}}$ Ans.

(b) Max. shear stress on rivet A

Rivet is in single shear.

$\therefore \tau = \frac{F}{A_s}$, $A_s = \frac{\pi d^2}{4}$

$\therefore \tau = \frac{3750\,(4)}{\pi\,(12)^2} = \underline{\underline{33.15\text{ N/mm}^2}}$ Ans.

(c) Max. bearing stress on rivet A

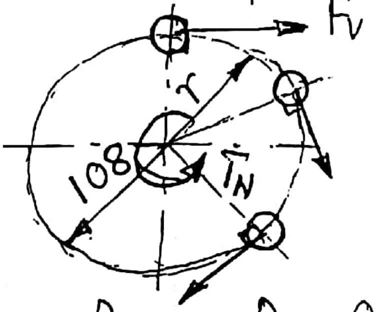
$\sigma_b = \frac{F}{A_b}$, $A_b = d.t$, $t = 15$ mm

$\therefore \sigma_b = \frac{3750}{12 \times 15} = \underline{\underline{20.83\text{ N/mm}^2}}$ Ans.

Note: Rivet A is heavily loaded.

Q.4.

Consider rivet pitch diameter



T_N = total transmitted torque

F_v = Rivet force / Rivet value.

Now $T_N = \frac{P}{\omega}$, $P = 0.45$ kW, $\omega = \frac{\pi n}{30}$; $n = 8$ rpm

$\therefore T_N = \frac{450\,(30)}{\pi\,(8)} = \underline{537.15\text{ Nm}}$

$\tau_A = 35\text{ N/mm}^2$ $\therefore F_s = \tau_A . A_s$,

Rivets are in single shear

$\therefore F_s = 35 \times \frac{\pi}{4} (8.2)^2 = \underline{1848.35 \text{ N}}$ Shear Strength.

<u>Note:</u> $d = 8 + 0.2 = 8.2$ mm hole filled after riveting

and $\sigma_c = 60 \text{ N/mm}^2$

$\therefore F_c = \sigma_c . A_c$; $A_c = d.t$
Note $t = t_{min} = 12$ mm

$\therefore F_c = 60 (8.2) 12 = \underline{5,904 \text{ N}}$ Crushing Strength

$\therefore$ Rivet value is the LEAST OF F_s and F_c

$\therefore \underline{F_V = 1848.35 \text{ N}}$

If N = no. of rivets used

$\therefore T_N = N . F_V . r$; $r = 54$ mm

$\therefore N = \frac{537.15 \times 10^3}{1848.35 (54)} = \underline{5.38}$

So take $\underline{N = 6 \text{ rivets}}$.

$\therefore$ Number of rivets required is 6 Ans.

<u>Q.5.</u>
The joint is a <u>Lap</u> joint and double shear.
6 rivets $\therefore$ each take $F_V = \frac{F}{6}$

$F = 95$ kN

<u>Shearing of rivets.</u>

$F_{s_{min}} = \tau_A . A_s = F_V$,

Rivet is in double shear $\therefore A = 2 \times \frac{\pi d^2}{4}$

$\tau_A = 11,800 \text{ N/cm}^2 = 118 \text{ N/mm}^2$

$\therefore 118 \times 2 . \frac{\pi}{4} d^2 = \frac{95,000}{6}$ $\therefore \underline{d_{min} = 9.24 \text{ mm}}$

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Crushing of rivets.

$F_{c_{min}} = \sigma_c \cdot A_c = F_v$; $A_c = d \times t$

$t = t_{min} = 8$ mm   Note: $\frac{F}{2}$ is for $t = 5$ mm so that F; $t = 10$ mm

$\sigma_c = 16{,}000\ N/cm^2 = 160\ N/mm^2$

$\therefore\ 160\,(8) \cdot d_{min} = \frac{95{,}000}{6}$ $\therefore\ d_{min} = 12.4$ m

Note: tensile stress of plates not given

$\therefore$ diameter $d_1 = 12.4 \simeq 12.5$ mm after riveting

$\therefore$ Necessary diameter $d_1 = 12.5$ mm Ans.

Q. 6.

Note: 5 rivets on each side take a Load of 180 kN

$\therefore$ Load on each rivet $F = \frac{180}{5} = 36$ kN

Now $S_{su} = 360\ N/mm^2$, f.o.s. $N = 4$

$\therefore\ \tau_A = \frac{S_{su}}{N} = \frac{360}{4} = 90\ N/mm^2$

The rivets are in double shear

$\therefore\ F_{s_{min}} = \tau_A \cdot A_s = F$

$A_s = 2 \times \frac{\pi d^2}{4}$

$\therefore\ 90 \times 2 \cdot \frac{\pi}{4} d^2 = 36{,}000$

$\therefore\ d_{min} = 15.95$ mm $\simeq 16$ mm

Is the diameter after riveting = dia. of hole.

$\therefore\ d_h = 16$ mm

$d_h = d + 1$ mm   drilled hole.

$\therefore\ d = 15$ mm   dia of rivet.

$\therefore$ (a) Diameter of rivets $d = 15$ mm Ans

(b) Diameter of rivet hole $= 16$ mm Ans.

Q.7.

(a) Tensile strength of plates.

$F_{t_{min}} = \sigma_t (b - 2d)\,\delta = 40{,}000$ N

Note: 2 holes.

$\sigma_t = 200$ N/mm^2 , $d = 15$ mm

$\therefore$ $200\,(b - 30)\,8 = 40{,}000$

$\therefore$ $b_{min} = 55$ mm.

$\therefore$ $b_{min} = 55$ mm Ans.

but $b = 2t$ $\therefore$ $t = 27.5$ mm

and $t/2 = 13.75$ mm.

$\therefore$ $t = 27.5$ mm and $t/2 = 13.75$ mm Ans.

(b) Strength of the rivet

Note: Shear only. Crushing or bearing not given

Rivets are in single shear.

$\therefore$ $F_s = \tau_A \cdot A_s$ ~~$F_s = 40{,}000$~~

$A_s = N \cdot \frac{\pi d^2}{4}$; $N = 4$ rivets.

$\tau_A = 100$ N/mm^2 ; $d = 15$ mm

$\therefore$ $F_s = 100 \times 4 \times \pi \frac{(15)^2}{4} = 22500\,\pi$ N

$\therefore$ $F_s > 40{,}000$ N the applied force.

$\therefore$ Rivets are strong enough Ans.

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